

Abstracts of Students' Research Projects



**International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India**

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Global Theme on Biotechnology and Crop Improvement

**Abstracts of Students Research Projects
2003-2008**

**Abstracts of Research Scholars of Global Themes on Biotechnology
and Crop Improvement during 2003-2008**

Title	:Optimization of <i>Helicoverpa armigera</i> NPV <i>invivo</i> mass production and regulation of malodor associated with the process
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Supervisor	:GV Ranga Rao
Submitted	:2003

Abstract

The indigenous production of *Helicoverpa armigera* nuclear polyhedrosis virus (NPV) has been proficiently employed by several farmers after realizing its prominence as a prospective bio-pesticide. The only issue of concern outlined by them being the malodor associated with the recovery process, which the other farmers in the community often complained with. Also the recovery of the virus needed to be quantitatively optimized to enhance its efficiency and economy as a microbial bio-pesticide.

An endeavor has been made in this regard to quantify the viral recovery at different post inoculation (PI) days to obtain the maximum poly inclusion bodies (PIBs) and to regulate the malodor through several techniques. These studies were conducted at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.

Maximum larval mortality was found to be 88% on 7th day of PI followed by 50% on 6th day of PI. The NPV yield was maximum, 0.70 LE/larva at 7th day followed by 0.64 LE/larva at 6th day of PI. The ideal period of viral harvest can be suggested to be 6th day of PI when the mortality percent and NPV yield were in accord for optimal viral recovery to avoid the constraint of malodor associated with the *Helicoverpa armigera* NPV production.

Title	: Bio-efficacy of certain new insecticides against pest complex of groundnut
Name	: Y Venkanna
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: GV Ranga Rao
Period	: 19-12-2002 to 31-7-2003
Submitted	: 2003

Abstract

In field experiments, systemic insecticides viz., imidacloprid 17.8 S L (Stallion), acetamiprid 20 S P (Pride), thiamethoxam 25 W G (Actara) and monocrotophos 36 WSC were applied as foliar sprays at 25, 40 and 55 days after sowing. The results indicated that two sprays of imidacloprid 0.00534 per cent at 25 and 40 days after sowing were effective in reducing the thrips and leafhopper population. Where as the same insecticide at 0.00445 per cent concentration was also effective against these two insects but 3 sprays were needed to keep the population below economic threshold level. Monocrotophos at 0.0576 per cent was found least effective against both thrips and leafhopper.

The results about relative toxicity of larvicides to third instar larvae of *H. armigera* indicated that indoxacarb (LD₅₀: 0.08108 J.1g ai per larva) was highly toxic followed by spinosad (LD₅₀: 0.18011 ug ai per larva) and thiodicarb (LD₅₀: 1.34852 ug ai per larva).

The toxicity of same insecticides to third instar larvae of *S. litura* indicated that spinosad (LD₅₀: 0.18902 ug ai per larva) was highly toxic followed by indoxacarb (LD₅₀: 0.20298 J.1g ai per larva) and thiodicarb (LD₅₀: 1.18816 ug ai per larva).

Title	:	Validation of available IPM components against groundnut pest complex in Andhra Pradesh
Name	:	D Guruva Reddy
Institute	:	Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	:	GV Ranga Rao
Period	:	19-12-2002 to 31-7-2003
Submitted	:	2003

Abstract

A field experiment entitled "Validation of available IPM components against groundnut pest complex in Andhra Pradesh" was conducted during *rabi* season, 2002-03 at ICRISA T, Patancheru. During the study, the effect of various IPM components such as seed treatment with carbosulfan, growing sunflower as trap crop, erecting bird perches, and need based application of insecticides, independently and in different combinations, against pest complex of groundnut was undertaken. In addition to that the effect of weather parameters on incidence of different insect pests was also studied.

Seed treatment (carbosulfan @ 5g/kg) along with foliar application of insecticides (monocrotophos applied once at 33 DAS @ 3 ml/lit and imidacloprid applied twice at 40 & 47 DAS @ 0.25 ml/lit.) induced maximum of 42.8% reduction in thrips population over the control. Seed treatment alone offered only 6.1 % reduction while foliar application of insecticides alone (farmers' practice) recorded 34.3% reduction in thrips population over the control.

Regarding defoliators, IPM consisting sunflower as trap crop and bird perches proved promising with 46.4% reduction in larval population of *Spodoptera litura* over the control. Sunflower alone contributed for 36.0% reduction while farmers' practice with an additional spray of fenvalerate and monocrotophos given at 50 and 74 DAS respectively resulted in 28% reduction in larval population over the control.

Maximum yields were recorded in farmers' practice (23.9 q/ha) and IPM (23.8 q/ ha) against 18.6 q/ha recorded in control.

In terms of economic feasibility, IPM ranks first with highest cost benefit ratio of 1:3.83 followed by farmers' practice (1 : 3.50) and seed treatment + insecticides (1: 2.98). Correlations of incidence of pests with weather factors brought out negative effects of maximum and minimum temperatures on thrips and larval population of *S. litura*. Relative humidity (at 7.00 and 14.00 hrs) had positive correlation with thrips and it showed positive at 7.00 hrs and negative at 14.00 hrs with *S. litura* larval population.

Title	: Identification of QTLs for yield and its component traits, and downy mildew [<i>Sclerospora graminicola</i> (Sac.) J. Schrot.] resistance in pearl millet [<i>Pennisetum glaucum</i> (L.) R. Br.]
Name	: T Nepolean
Institute	: Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
Supervisor	: CT Hash
Period	: 18-3-2002 to 30-4-2003
Submitted	: 2003

Abstract

The study was formulated to improve the yield potential of hybrids of PT 732A/B, which is one of the elite and important male-sterile lines used in hybrid breeding program in Tamil Nadu. Identification of downy mildew resistance genomic regions was also set as an additional objective. One hundred and thirty six F_2 derived F_4 self-bulks of a pearl millet mapping population (skeleton-mapped F_2 individuals) derived from PT 732B x P 1449-2 were used as the basic source population for this study. PT 4450, an elite pollinator inbred was used for producing testcross hybrids for each of the 136 F_4 self-bulks. To identify the QTLs for yield and its component traits, the testcross hybrids were raised at two locations in Tamil Nadu namely, at Tamil Nadu Agricultural University, Coimbatore and at Regional Research Station, Bhavanisagar during October 2001. Disease resistance screening was also conducted at these two locations using selfed seeds of F_4 self-bulks during October 2001. Eighteen QTLs were identified from the two locations for nine agronomic traits using plant height, time to 50% stigma emergence and plant height together with time to 50% stigma emergence as predictors of the remaining yield-related traits. Among these nine traits, time to 50% stigma emergence, panicle circumference, plant height, panicle length and grain yield per season registered one QTL, thousand-grain mass registered two QTLs, grain yield per day registered three QTLs and single-panicle grain mass registered four QTLs. The across-locations data set produced six QTLs for five traits. Genomic regions on LG 4 and LG 7 controlled these traits. For downy mildew resistance, five different QTLs were detected on four linkage groups using disease incidence percentage and arc-sin radians values. Of these two QTLs were identified from the Coimbatore data set on LG 2, two from the Bhavanisagar data set on LG 1 and LG 4 and one from the across locations data set on LG 7. Grain yield performance of hybrids for Tamil Nadu conditions can be improved by marker assisted back crossing of these QTLs regions into seed parent pair PT 732A/B. Marker-assisted transfer of resistance QTLs and pyramiding of resistance genes may improve resistance to downy mildew disease.

Title	: Marker–assisted backcrossing of stay-green QTLs into elite sorghum lines
Name	: Punna Ramu
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: Jonathan H Crouch
Period	: 21-2-2003 to 31-12-2003
Submitted	: 2004

Abstract

Sorghum (*Sorghum bicolor* (L.) Monech) is the fifth most important cereal crop globally. This C4 grass is grown in more than 80 countries mostly in tropical and subtropical regions. After soil nutrient deficiencies, drought stress is the most important abiotic constraint to sorghum production globally. Dryspells can occur at any stage of the crop growth period. In sorghum, rapid premature leaf death generally occurs when water is limiting during the grain filling stage. Therefore drought stress during the grain filling period is referred to as “post-flowering drought or terminal drought”. The plant character associated with post flowering drought tolerance is called “stay-green”. Stay green is associated with functional green leaf area (GLA) during and after the grain filling period. Stay-green in sorghum is associated with charcoal rot, lodging resistance and superior ruminant quality. This complex trait is difficult to score.

Genetic mapping of QTLs associated with stay-green is an important step towards developing drought tolerant hybrids. Different sources of stay - green have been identified in sorghum. The most commonly used lines in breeding program are B35 and E36-1.

Different research groups independently developed QTL maps for stay-green using different donor parents and marker systems. After identifying the consistent QTLs markers, these can be tested through introgression of QTLs from their mapped sources into sorghum elite breeding lines. This can be accomplished by cloning the genes expressing QTLs and transferring these genes to recipient breeding lines or thorough marker-assisted breeding (MAB) program, where QTLs are introgressed into elite breeding lines using molecular markers. MAB is the most appropriate technique when traits are complex and difficult to score/measure like yield, abiotic stress tolerance, where the genes contributing to QTLs expression have not yet been identified, and where plant transformation systems are not well established.

With the development of molecular tools and molecular genetic linkage maps for plants, marker-assisted selection (MAS) has become much more broadly applicable. From the last decade, developing ability to transfer target genomic regions using DNA markers resulted in extensive mapping experiments aimed at development of MAS.

Molecular marker based genetic linkage map of sorghum has permitted the identification of six QTLs for stay-green (post flowering drought tolerance) in sorghum like B35. This project aimed at transfer/introgression of these QTLs from B35 to recurrent parents, ISIAP Dorado and R16. BC3 and BC4 generations from each recurrent parent were genotyped with the markers linked to stay-green QTLs for foreground selection and evenly distributed unlinked markers for background selection to speed the recovery of recurrent parent genotype in genomic regions that are not associated with the target stay-green QTLs. Genotypes with desired marker allele profiles were selected and advanced to next generations. Further studies are necessary to confirm the introgression of QTLs and expression patterns for stay-green by phenotypic evaluation of selected genotypes.

Title	:	Effect of ecofriendly insecticides on <i>Helicoverpa armigera</i> (Hubner) and its natural enemies in chickpea (<i>Cicer arietinum</i> Lin.) ecosystems
Name	:	K Loka Reddy
Institute	:	Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	:	GV Ranga Rao
Period	:	2004

Abstract

A field experiment entitled "Effect of ecofriendly insecticides on *Helicoverpa armigera* (Hubner) and its natural enemies in chickpea (*Cicer arietinum* Lin.) ecosystem" was conducted during post-rainy season, 2003~04, at International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh. The relative efficacy of nine treatments were evaluated to study the ovipositional preference and mortality of small (first and second instar), medium (third and fourth instar) and large (fifth and sixth instar) sized larvae of *I-I. arll/igera* on chickpea. The effect of above treatments on the soil inhabiting natural enemies and larval parasitization by *Call/pole/is ch/orideae* Uchida. A lab experiment was conducted with four selected commercial neem oil formulations along with the control against the larval growth and development of *I-I. arll/igera* in ICRISA T- Patancheru.

The maximum reduction in egg laying was observed with flufenoxuron + HNPY, flufenoxuron and neem fruit extract (28, 27 and 26 per cent reduction over control respectively). For managing all the stages of larvae (small, medium and large) novaluron and novaluron + HNPY were found to be the best treatments which resulted in 62 and 58 per cent reduction of larval population over control.

Endosulfan treatment reduced the soil inhabiting natural enemies population to an extent of 65 per cent over control, followed by novaluron. Flufenoxuron and their combination with HNPV (34 to 44 %). Neem products were also found to have moderate effect with 22 to 28 per cent reduction in natural enemies over control.

Endosulfan had adversely affected the larval parasitization of *C. chlorideae* (60% reduction over control) followed by novaluron, flufenoxuron and their combination with HNPV (2X to 42% reduction over control) where as neem products reduced the parasitization of *C. chlorideae* to an extent of 5 to 17 per cent over control.

Novaluron treatment registered the least per cent of pod damage (7.43), followed by novaluron + HNPV (8.26) as against 25.50 per cent of pod damage in control. The maximum yield of 1715 kg ha⁻¹ was obtained with novaluron, followed by novaluron + HNPV (1665 kg ha⁻¹) as against 1166 kg ha⁻¹ in the control plot. The relationship between yield and pod damage was observed to be negative and significant. Endosulfan was adjudged as the best treatment in terms of cost benefit ratio (1:5.75). The second best treatment was Neem fruit extract (1:3.79) followed by novaluron + HNPV (1:2.58).

The laboratory findings revealed that the Neemark oil (300 ppm) @ 70 ml litre⁻¹ was very effective in suppressing the growth and development of the larvae of *H. armigera*.

Title	: A diversity analysis of early-maturing groundnut germplasm using SSR markers
Name	: Chanda Ashok Kumar
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: Jonathan H Crouch
Period	: 21-2-2003 to 31-12-2003
Submitted	: 2004

Abstract

Groundnut (*Arachis hypogaea* L) is an important crop internationally for both direct human consumption and as an oilseed crop, which is being cultivated in 108 countries of the world. About two thirds of world groundnut production comes from the semi-arid (SAT) regions which are characterized by uncertain rainfall and frequent droughts. Groundnut yields are low and average about 0.8 t/ha in the SAT countries compared to more than 2.6t/ha of the developed world.

One contribution to increasing yield is development of early maturing, high yielding cultivars that are needed for short growing seasons, multiple cropping systems and which avoid late season droughts. In most breeding programs few sources of early maturity have been used resulting in the narrow genetic base of groundnut cultivars. There is a need for broadening the genetic base to enhance groundnut breeding prospects. The high diversity detected by SSR markers is consistent with the known characteristics- that they are more variable and high expected heterozygosity than the RAPDs, or AFLPs. The high levels of polymorphism associated with SSRs are expected because of unique evolution of these genomic regions: replication slippage rather than mutations, insertions or deletions.

The present study was initiated to assess diversity using SSR markers among 29 groundnut accessions belonging to two subspecies *fastigiata* and *hypogaea* and three botanical varieties *vulgaris*, *fastigiata* and *hypogaea*, originating from fifteen countries which include 25 early-maturing and 4 late- maturing accessions. Initially 7 to 10 individual plants from each of ten accessions were assayed for intra-accession variation using 5 SSR primer pairs. These ten accessions include ICG 3540, ICG 4558, ICG 4890, ICG 9427, ICG 11914, ICG 14814, Gangapuri, JL 24, Chico and TMV2. UPGMA clustering of the SSR band profiles revealed significant variation within the accessions. A total of 22 alleles were detected by five primer pairs with an average number of 4.4 alleles per primer pair. The number of alleles ranged from 2 alleles for 2B10 to 8 alleles for 2D12B. To capture this intra- accession diversity in the main study equal amounts of DNA from individual plants were pooled for each accession.

Inter-accession diversity analysis of 29 accessions was performed using 20 SSR primer pairs, which detected a total of 57 alleles with an average of 2.85 alleles per primer pair. The number of alleles per marker ranged from two to five. The PIC values, ranged from 0.53 (17F6) to 0.93 (15C12), with an average of 0.78. The AMOVA analysis indicated 42% of variation in SSR markers used between early and later-maturing accessions. The clustering revealed significant diversity among the 29 accessions used for this study. The different

botanical varieties were grouped into 3 different clusters except one accession. The MDS analysis supported the clustering obtained by UPGMA. Clustering also revealed significant diversity among accessions within a particular country. Comparison of Genotypic data with Phenotypic data for these accessions may project the complete picture of diversity. This analysis will assist groundnut breeding programs aimed at improving early- maturity to maximize the genetic base of their breeding populations.

Title	: Marker assisted backcrossing of stay-green QTL'S into elite sorghum lines
Name	: R Chandra Mouli
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: CT Hash
Period	: 9-12-2003 to 31-12-2004
Submitted	: 2004

Abstract

Sorghum [*Sorghum bicolor* (L.) Moench] is the 5th most important cereal crop globally after wheat, maize, rice and barely (FOA, 2003; FAO and ICRISAT, 1996). This C₄ grass is grown in more than 80 countries, mostly in tropical and sub-tropical regions. The average annual sorghum area cultivated amounts to 44 M ha, with an average annual grain production of 63 M tons, and average grain yield of 1.4 t ha⁻¹ (FAO, 2003; FAO and ICRISAT,) 1996). Sorghum was domesticated in Ethiopia and part of Congo, with Secondary centers of origin in India, Sudan and Nigeria.

Production of sorghum in semi-arid regions of the world is limited by drought. Developing plants that have an advantage under water-limited conditions is a major challenge for sorghum improvement programs globally. There are three distinct stages in which drought affects sorghum: vegetative (GS1); Pre-flowering (GS2); and Post-Flowering (GS3). The best characterized form of drought stress tolerance in sorghum during this post-flowering stage of growth is called "stay green". Stay-green is a drought-tolerance trait in grain sorghum. When water is limited during the grain filling period, genotypes possessing this trait maintain more photosynthetically active leaves compared with genotype not possessing this trait.

Putative QTL for stay-green traits from B35 have been identified in five recently published studies (Tuinstra et al., 1997; Crasta et al 1999; Xu et al 2000; Tao et al, 2000 and Subudhi et al 2000). Using the linkage map developed by Bhattaramakki et al (2000) identified six genomic regions associated with stay-green trait in B35 parent. The identification of these QTL provided us an opportunity for marker assisted breeding (MAB) for introgression of QTL from B35 to recurrent parents.

We aimed at transfer of QTL from B35 to recurrent parents, S35 and ICSV111. Both recurrent parent have been advanced to BC3 and BC4 generations for introgression of QTL from donor parent using SSR marker assisted selection(MAS), targeting six QTL detected. In this study, all genotypes in two generations from each recurrent parent were screened with foreground markers to identify the genotype for QTL of our interest and also screened with

background markers to select the genotypes for all other loci from recurrent parent. Selected individuals are advanced to next generation.

Title	: Effects of cytoplasmic male-sterility on expression of resistance to sorghum shoot fly, <i>Atherigona soccata</i> (Rondani) (Muscidae: Diptera)
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Institute	: CCS Haryana Agricultural University, Hisar 125 004, Haryana, India
Supervisor	: HC Sharma
Period	: 22-7-2002 to 31-3-2005
Submitted	: 2004

Abstract

The present studies were undertaken to identify alternate male-sterile cytoplasm with less susceptibility to sorghum shoot fly, *Atherigona soccata* (Rondani) than the *Milo* (A₁) cytoplasm, and the effects of *Milo* cytoplasm on expression of resistance to sorghum shoot fly. The studies focused on mechanisms and inheritance of resistance, nature of gene action, and genetic divergence. The experiments were carried out at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India. The studies on resistance/susceptibility of CMS (A-lines) and their maintainers (B-lines) [7 shoot fly-resistant and 5 -susceptible A- and B- lines] indicated that CMS lines were preferred for oviposition and suffered more deadheart formation than the B-lines. The larval period was shorter and fecundity was greater on A-lines than on the respective B-lines. In general, larval survival, adult emergence, pupal weights, fecundity, and overall antibiosis index were greater on A-lines than on the B-lines. The differences in susceptibility and antibiosis between CMS and B-lines were greater in shoot fly-resistant genotypes as compared to the susceptible genotypes.

The investigations on the effects of cytoplasmic male-sterility on expression of resistance to shoot fly (using line x tester mating design) suggested that the hybrids based on shoot fly-resistant female and male parents suffered significantly less damage than the hybrids based on other cross combinations. Hybrids based on shoot fly-resistant females and the susceptible males were less susceptible to shoot fly than the hybrids based on susceptible females x resistant or susceptible males. These findings have clearly demonstrated the effect of CMS on the expression of resistance to shoot fly in sorghum.

The expression of leaf glossiness and trichomes was better in the B-lines as compared to the respective CMS lines. However, the reverse was true in case of seedling vigor, leaf surface wetness, and chlorophyll content. The hybrids based on the glossy and trichomed female x glossy and trichomed male parents were glossy and trichomed, while the hybrids based on non-glossy and non-trichomed female x non-glossy and non-trichomed male parents were always non-glossy and non-trichomed. The male and female parents took more time to 50% flowering as compared to the respective F₁ hybrids across seasons. In general, the agronomic performance of the hybrids was better than their parents, except the hybrids based on ICSV 700 and IS 18551 as the male parents.

Egg laying and deadheart formation were significantly and negatively correlated with leaf glossiness, trichome density, leaf sheath pigmentation, and waxy bloom; and positively correlated with seedling vigor and chlorophyll content. Seedling vigor, plumule and leaf sheath pigmentation, and chlorophyll content were positively correlated with productive tillers. The multiple and stepwise regressions, and path coefficient analysis suggested that leaf glossiness, chlorophyll content, waxy bloom, trichomes on the adaxial surface of the leaf, plants with eggs, and deadhearts can be used as a reliable criteria for developing shoot fly-resistant sorghums.

Studies on inheritance and nature of gene action suggested epistatic gene action for oviposition and recovery resistance, while additive gene effects were observed for shoot fly deadhearts on the main plants and the tillers. The genetic advance for leaf glossiness, seedling vigor, plumule and leaf sheath pigmentation, waxy bloom, days to 50% flowering and agronomic desirability was very low suggesting involvement of recessive genes. For trichome density, chlorophyll content and plant height, the genetic advance was very high indicating additive type of gene action. Shoot fly damage on main plants and tillers (except number of eggs on main plants and tillers), leaf glossiness, trichome density on both the leaf surfaces, chlorophyll content, plumule and leaf sheath pigmentation, waxy bloom, days to 50% flowering, plant height, productive tillers, and recovery resistance were governed by additive type of gene action; while the seedling vigor and number of eggs were governed by dominant and codominant type of gene action. Specific combining ability (SCA) effects and heterosis indicated that exploitation of heterosis is not a rewarding approach in breeding for resistance to shoot fly.

Genetic diversity studies on the F₁ hybrids and their parents employing the QTLs mapped SSR loci associated with shoot fly resistance characterized the shoot fly-resistant and -susceptible parents and their hybrids into different groups. Maximum diversity was observed in the susceptible parents and their hybrids than in the resistant parents and other hybrids. The phenotypic and genotypic observations suggested that shoot fly-resistant parents were closest to the hybrids based on them, while the shoot fly-susceptible parents were closer to the hybrids based on them. The morphological and genetic distinctness of certain resistant and susceptible cross combinations was more than their resistant and susceptible parents. Hybrids were closer to CMS lines than the testers, indicating the influence of cytoplasmic male-sterility on the expression of resistance/susceptibility to sorghum shoot fly.

The evaluation of alternate cytoplasm using 6 isogenic lines in 6 cytoplasmic backgrounds indicated that CMS and their maintainer lines were non-glossy, trichomeless, and were susceptible to sorghum shoot fly. Among male-sterile cytoplasm, A₄M suffered low deadheart incidence than the other cytoplasm tested.

The reactions of CMS and maintainer lines, and the hybrids based on them indicated the influence of cytoplasmic and nuclear genes in expression of resistance/ susceptibility to sorghum shoot fly. The alternate male-sterile cytoplasm A₄M was less susceptible to shoot fly damage, and this can be exploited for developing hybrids for resistance to *Atherigona soccata*.

Title	: Marker-assisted selection for terminal drought tolerance in pearl millet (<i>Pennisetum glaucum</i> (L.) R. Br.)
Name	: P Sathish Kumar
Institute	: Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India
Supervisor	: CT Hash
Period	: 7-1-2002 to 31-8-2004
Submitted	: 2004

Abstract

Drought at the crop's reproductive stage is one of the most important environmental factors limiting pearl millet productivity; improved adaptation to such drought stress is an important breeding objective. DNA-based marker tools facilitated better understanding of the inheritance and expression of grain and stover yield-related traits in three moisture regimes differing in the intensity and duration of late reproductive-stage stress with different tester backgrounds. In the present study, an attempt was made to transfer consistent drought-tolerance associated major QTLs on LG2 from 863B derived from (the *Iniadi* landrace material from Togo) to the cultivated elite recurrent parents ICMB 841, which is the maintainer of the female parent of several high yielding hybrids that are widely grown in India. Previously a linkage map of loci detected with 28 polymorphic SSR primer pairs and 23 RFLP probe-enzyme combinations was used in a mapping population based on these parental lines. Here these markers were used to for background selection in the initial stages of the backcrossing programmes. Easily scorable morphological markers and SSR markers (for foreground selection) helped to select 13 segmental introgression homozygotes involving various sections of the LG2 donor genome to study this genomic region responsible for drought tolerance contributing characters. Production of testcross hybrids from these homozygotes with relatively different testers for drought tolerance was followed by their screening in three moisture regimes. To study marker-phenotype associations, the parents were crossed with these testers and evaluated for grain and stover yield-related characters viz., flowering time (FT), plant height (PH), panicle length (PL), panicle diameter (PD), plant count (PC), head count (HC), effective tiller (ET), panicle yield (PY), grain yield (GY), stover yield (SY), hundred-grain mass (HGM), harvest index (HI), and biomass yield (BY). The field evaluation revealed that testers H 77/833-2 and PPMI 402 were the best testers respectively for stover and grain yield-related characters suitable for late-onset terminal drought stress conditions. Association of genomic regions with drought tolerance characters confirmed a role of the genomic regions between SR markers *Xpsmp2066* and *Xpsmp2255* on pearl millet LG2 for genomic performance under relatively mild late-onset terminal drought stress conditions. Similarly, different genomic regions associated with superior performance with testers such as PPMI 301, H 77/833-2 were between SSR markers *Xpsmp2072* to *Xpsmp2231*; whereas for RIB 335/74 genomic regions between *Xpsmp2066* to *Xpsmp2059* (lower arm of LG2). Association of similar genomic regions for grain and stover yield-related characters revealed that simultaneous improvement of grain and stover yield could be possible.

Title	: Marker assisted introgression of the stover quality QTL in pearl millet
Name	: N Sridevi
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: CT Hash
Period	: 9-12-2003 to 31-12-2004
Submitted	: 2005

Abstract

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is an important staple crop of the semi-arid regions of India and Africa. It is a dual- purpose crop grown both for its grain and

fodder/stover. Crop residues provide the bulk of the livestock feed across South Asia, but their nutritive value is so low that farmers must supplement these with feed grains and other concentrates. Improving the nutritive value of straw/ stover and the efficiency of their use in mixed diets is an important option for increasing livestock production in the region. Genetic variation in the quality of pearl millet stover can be exploited to develop improved crop germplasm with stover of high nutritive value and good digestibility. In this context, marker-aided selection is found an ideal approach to transfer stover quality traits to elite genetic backgrounds through backcrossing with minimum linkage drag. To exercise marker-aided selection, a well-saturated molecular marker linkage map and tightly linked markers are a prerequisite. The first molecular- marker- based genetic linkage map of pearl millet was generated by Liu et al. (1994). That map consisted of 181 RFLP markers covering the 7 pearl millet chromosomes and spanning a genetic distance of a 303 cM, and has been extended with AFLP and SSR markers (Breese et al., submitted). A subset of these markers has subsequently been transferred to a series of different crosses that segregate for agronomically important traits. Quantitative trait loci have been mapped for downy mildew resistance (Jones et al., 1995, 2002), drought tolerance and other genotype x environment interactions of grain and stover yield (Yadav et al., 2002, 2003, 2004) and for characters involved in domestication (Poncet et al., 2000, 2002).

ICRISAT and ILRI Scientist (Hash et al., 2003) have attempted to map the QTL associated with stover quality as well as grain and stover yield and aspects of drought tolerance using the RFLP- and SSR-based linkage map of ICMB 841x 863B. Testcross hybrids of 79 progenies from this population were evaluated for stover traits at ICRISAT, Patancheru. Stem sheath and blade fractions of stover samples taken from different parts of the plant were evaluated for a number of *in vitro* estimates of ruminant nutritional quality. Subsequent QTL analysis detected a putative major QTL for leaf blade quality from parental line 863B (Hash et al., 2003). This putative QTL has subsequently been partially introgressed into the genetic background of the more elite parent 841B = ICMB 841 by marker-assisted backcrossing.

Genetic linkage maps have been developed in various pearl millet crosses and used to detect and map qualitative trait loci (QTLs) contributing to various traits including stover quality. Information on the position of QTLs relative to marker loci provides a basis for marker-assisted selection (MAS) for quantitative traits. In crops like pearl millet, barley etc MAS is of particular interest for the development of genotypes stover quality, grain and malt quality etc because (1) through assessment of grain yield and quality traits is expensive and requires larger grain samples than are normally available in the early stages of a breeding program. (2) grain yield and quality traits are subject to considerable environmental variation and genotype x environment interaction.

With MAS for QTLs affect grains and stover quality, pearl millet breeders could limit breeding populations to those progeny with the highest probability of having superior stover quality. Our object is to assess whether marker-based selection could be effective in manipulating a QTL region in pearl millet breeding population in which the QTL region had originally been detected and mapped.

Title	: Genetics of resistance to pod borer, <i>Helicoverpa armigera</i> in chickpea (<i>Cicer arietinum</i>)
Name	: V Lakshmi Narayanamma
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisors	: CLL Gowda and HC Sharma
Period	: 8-10-2003 to 31-12-2005
Submitted	: 2005

Abstract

The present research was undertaken to elucidate the “Genetics of resistance to pod borer, *Helicoverpa armigera* in chickpea (*Cicer arietinum*)”. These studies were focused on the nature of gene action and maternal effects, plant resistance mechanisms and inheritance and interaction of different components of resistance and grain yield. These studies were carried out at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India, during 2003-05.

Eight desi (ICC 12475 or ICC 506, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 4918, ICC 12426 or ICC 37 and ICC 3137) and one kabuli (ICCV 2 or ICC 12968) parents were selected based on earlier screening trials to study the genetics of resistance to pod borer, *Helicoverpa armigera*, using full diallel cross. The genotype, ICCV 2 was the earliest to flower and mature followed by ICC 4918, ICC 37, ICC 12478 and ICC 12477, while ICC 12479, ICC 12476 and ICC 3137 were late to flower and mature. These genotypes can be effectively utilized in breeding programmes for early maturity.

The genotype, ICC 12478 suffered significantly lower damage followed by ICC 506, ICC 12479 and ICC 12477. ICC 3137 was highly susceptible to *H. armigera* and recorded lowest seed yield. Most of the crosses with ICC 506, ICC 12478 and ICC 12479 suffered lower damage due to pod borer, while those with ICC 3137 suffered higher damage. ICC 37 recorded higher yield followed by ICC 12479 and ICC 12476.

A full diallel trial was conducted to know the gene action and maternal effects, if any. Additive gene action was predominant for days to initial flowering, days to 50% flowering, days to maturity, pod borer damage (%), pods plant⁻¹, seeds plant⁻¹, seeds per pod and 100-seed weight, while non-additive gene action was important for yield plant⁻¹, total plot yield and yield (kg ha⁻¹). The additive : dominance (A : D) ratio is greater than unity for the characters days to initial flowering, days to 50% flowering, days to maturity, pod borer damage (%), pods plant⁻¹, seeds plant⁻¹, seeds per pod and 100-seed weight indicating over dominance, while for yield plant⁻¹, total plot yield and yield (kg ha⁻¹) the ratio is less than unity, indicating partial dominance.

There was no maternal inheritance for maturity traits, pod borer damage, grain yield and yield (kg ha⁻¹). The hybrid, ICC 12476 × ICC 37 showed positive and significant SCA effects for seeds per pod, but ICC 37 × ICC 12476 showed negatively significant SCA effects for number of seeds pod⁻¹. So the hybrid ICC 37 × ICC 12476 may be showing cytoplasmic inheritance for the number of seeds/ pod.

The three mechanisms of resistance viz., non-preference for oviposition, antibiosis and tolerance to *H. armigera* in chickpea genotypes were studied under laboratory, green house and field conditions. Oviposition studies under no choice, dual choice and multi choice laboratory and multi choice field conditions revealed that the resistant genotype, ICC 506

recorded lowest number of eggs, followed by ICC 12476, ICC 12477 and ICC 12478. The susceptible genotypes, ICC 12426 and ICC 4918 recorded the highest oviposition. The genotypes ICC 12475, ICC 12476, ICC 12477, ICC 12478 and ICC 12479 were least preferred by *H. armigera* females for oviposition compared to ICC 4918, ICC 3137 and ICCV 2.

The detached leaf assay not only gives an idea of the relative feeding by the larvae on different genotypes, but also provides useful information on antibiosis component of resistance in terms of larval weight. Survival rate and larval weights were lowest on the resistant check, ICC 12475 followed by ICC 12476, ICC 12477, ICC 12478 and ICC 12479, suggesting that water soluble compounds in the leaf exudates (malic and oxalic acid) were primarily responsible for the resistance of the genotypes to *H. armigera*.

The genotypes ICC 12476, ICC 12477, ICC 12478 and ICC 12479 were found to be resistant and their levels of resistance were comparable to the resistant check, ICC 12475 under no-choice caged conditions. Under un-infested conditions, the per plant yield was greater in ICC 12426 followed by ICC 12478 and Annigeri. The resistant cultivars ICC 12478 and ICC 12475 recorded total higher yield. At the podding stage of the crop, when plants were infested with the third instar larvae, the recovery resistance was very poor, as most of the plants were damaged.

Larval biology on leaf material and on artificial diet with lyophilized leaf and pod powder recorded lowest larval and pupal weights and prolonged larval and pupal periods on the resistant genotype, ICC 506. Highest growth index, adult index, oviposition index and pupal index were recorded on ICC 12426 and ICC 4918, while the lowest on resistant check, ICC 12475.

HPLC profile of leaf exudates showed that the malic acid was negatively correlated with damage rating at flowering (-0.28*), at maturity (-0.32**) and pod damage (-0.22*). Oxalic acid showed negatively significant correlation with damage rating during detached leaf assay (-0.22*). Acetic acid showed a negative correlation with larval weight (-0.45*), damage rating at flowering (-0.33**) and maturity (-0.26*). Citric acid showed negative and significant correlation with damage rating at flowering (-0.23*). Oxalic acid and malic acids has been reported to have an antibiotic effect on larvae, and it is possible that the antibiotic properties of oxalic acid may negate differences due to ovipositional antixenosis and determine the size of the larval population and therefore pod damage on a particular genotype.

The genotypes, ICC 12476, ICC 12477, ICC 12478, ICC 12479 and ICCV 2 were on par with the resistant check, ICC 12475 for pod borer damage under protected conditions. ICC 12475, ICC 12426, ICC 12478 and ICC 12479 recorded higher grain yield under unprotected conditions. The genotypes ICC 12475 (3.77) and ICC 12478 (6.59) recorded the lowest reduction in grain yield under unprotected conditions, as compared to ICC 3137, ICC 12476, ICC 12477, ICC 12479, ICCV 2, ICC 4918 and ICC 12426, indicating the presence of tolerance mechanism in chickpea to *H. armigera*. The tolerant lines can be used in further breeding programs and the mechanisms responsible for the resistance can be exploited to develop resistant varieties.

Interaction of different components of resistance with grain yield showed, significant and positive correlation under protected conditions between larvae and eggs (0.89**), leaf damage and egg number (0.82*), yield per plant and egg number (0.77*), yield per plant and larva number (0.76*), yield per plant and egg number (0.82*) and pod damage (%) and larva number (0.91**). Significantly negative correlation was recorded between yield per plant and borer damage (%) (-0.79*), under unprotected conditions. These correlations and interaction of different components of resistance and grain yield will help in gene pyramiding.

Title	: Advancing of SSR based marker assisted backcrossing of stay green QTLs into elite sorghum lines, S 35 and IRAT 204
Name	: Sripathi Venkateswara Rao
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: CT Hash
Period	: 8-11-2004 to 3-11-2005
Submitted	: 2005

Abstract

Sorghum bicolor (L.) Moench (2n=20) is the most important drought tolerant cereal crop and is the crop of choice in semi arid tropics. After soil nutrient deficiencies, drought stress is the major constraint limiting the sorghum production. Drought that effects during post flowering stage is often referred as terminal drought. The trait associated with terminal drought tolerance is stay green, which is complex and difficult to score with normal breeding approaches. Using MAS in breeding programs it is possible to introgress drought tolerant QTLs (*stg1*, *stg2*, *stg3*, *stg4*, *stgA*, and *stgB*) from the donor parent (B35) into the genetic backgrounds of elite parents like S35, ICSV 111, and IRAT 204. The homozygous QTL introgression lines in the background of S35 and ICSV 111 were generated as a part of the present investigation by using MAB. Based on marker data obtained the seeds of self-selected plants are send to Ghana for initial phenotypic evaluation trails. In addition, the selected backcross progenies of the recurrent parent IRAT 204 were advanced to BC₃F₁ and BC₄ F₁ generations. Sorghum is the logical complement of other important cereal crops and has unique contributions in understanding the genetic basis of cereal domestication. The sequencing of sorghum will definitely help the plant breeders and molecular biologists in tracking out the unknown agronomically important genes or QTLs.

Title	: Studies on the development of abiotic stress tolerance in groundnut (<i>Arachis hypogaea</i> L.) by genetic transformation
Name	: Pooja Bhatnagar-Mathur
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisor	: KK Sharma
Period	: 9-6-2003 to 4-2-2005
Submitted	: 2005

Abstract

The transgenic events of groundnut carrying the introduced *DREB1A* transcription factor that is expressed either constitutively by the *CaMV* 35S promoter or specifically by the stress responsive *rd29A* from *A. thaliana* were successfully developed in the present study. The stress-inducible expression of *DREB1A* in these transgenic plants did not result in any

growth retardation or phenotypic alterations as was observed with the 35S:DREB1A plants. The transgenic events with low copy number (one to two) of the transgene were used for phenotyping. Fourteen transgenic events in T3 generation were phenotypically evaluated in dry down experiments to study various physiological parameters including plant responses to soil drying as measured by the fraction of transpirable soil water (FTSW), stomatal conductance and transpiration efficiency (TE). The selected events exhibited a diversity of stress response patterns, especially with respect to the NTR-FTSW relationship. All the selected transgenic events differed from the wild type parent in their normalized transpiration rate response to FTSW, showing a decline in transpiration at lower FTSW values (drier soil). Various transgenic events exhibited increased transpiration efficiency (TE), which is an important component of plant performance under limited moisture conditions. Two of the selected transgenic events showed up to 50% higher transpiration efficiency under drought stress, which is an important component trait of crop water productivity and plant performance under water-limited conditions. The differences in TE observed in the transgenic groundnut events, both under well watered and water stress conditions offered an ideal material to re-explore the relation between the different surrogate traits and TE. There was a significant variation amongst the tested events under drought stress for TE ranging between 4.211 and 5.796 that had a significant positive correlation with SCMR ($r=0.7359$) and a negative correlation with SLA ($r=0.8237$). However, the TE did not significantly correlated with $\Delta^{13}\text{C}$ thus suggesting a lack of relationship between TE and $\Delta^{13}\text{C}$. This relationship between TE and $\Delta^{13}\text{C}$ could not be established in this study, which could be due to the fact that the transgenic material used in this study was basically isogenic to JL 24 and differed only due to the insertion of *DREB1A*.

A significant negative correlation between the proline levels and MDA production indicated that the elevated proline reduced the free radical levels in response to osmotic stress, and significantly improved the ability of the transgenic plants for better survival under water stress. Proline accumulation was more pronounced and increased significantly in leaves of the transgenic events than in the wild-type JL 24 plants exposed to water deficit conditions. The transgenic plants maintained a ratio of SOD:APOX specific activity that was essentially identical to that in wild type JL 24 plants under well watered conditions. However, this ratio differed in the transgenics and the wild type plants at extreme water stress at 12 days after stress. Thus, the elevated levels of APOX and GR in water-stressed plants suggested that these transgenic events may contribute to stress tolerance.

Based on the results observed in the present study, it can be concluded that engineering for abiotic stress tolerance by using the *DREB1A* transcription factor from *A. thaliana* has the potential to contribute towards knowledge on the physiological basis of drought stress tolerance, as well as the development of stress tolerant genotypes of groundnut in the near future.

Title	: Allelic relationships, penetrance and expressivity of genes controlling number of flowers per axis in chickpea (<i>Cicer arietinum</i> L.)
Name	: S Srinivasan
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: PM Gaur
Period	: 18-5-2004 to 17-11-2005
Submitted	: 2005

Abstract

Studies were carried out to investigate the allelic relationships, penetrance and expressivity of genes controlling number of flowers per axis in chickpea (*Cicer arietinum* L.) at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, A.P, India during the post rainy season 2004/05.

The material for the present investigation comprised of a double-flowered line (ICC 4929), a triple-flowered line (IPC 99-18) and a multi-flowered line (JGM 7), and six F_1 s derived from all possible combination of crosses between these lines, and three F_2 populations of crosses ICC 4929 x IPC 99-18, IPC 99-18 x JGM 7 and ICC 4929 x JGM 7. These were sown in unreplicated block with a spacing of 60 x 20 cm on 9th October 2004. ICC 4929 has pink-veined white flower, while IPC 99-18 and JGM 7 have pink flower. Standard crop production practices were used and plant protection measures were taken to grow a healthy crop. One light irrigation was given to overcome moisture stress during early flowering stage.

The F_1 s from double-flowered x triple-flowered cross were double-flowered, whereas F_1 s from double-flowered x multi-flowered and triple-flowered x multi-flowered crosses were single-flowered. The F_2 from double-flowered x triple-flowered cross gave a good fit to a 3:1 ratio for double-flowered and triple-flowered plants. The F_2 from double-flowered x multi-flowered cross segregated in a ratio of 9:3:3:1 for single-flowered, double-flowered, multi-flowered and double-multi-flowered plants. The F_2 from triple-flowered x multi-flowered cross segregated in a ratio of 9:3:4 for single-flowered, triple-flowered and multi-flowered plants. The results clearly established that two loci control number of flowers per axis in these genotypes. The double-flowered and triple-flowered traits are controlled by a single locus (**Sfl**) and the allele for double-flowered trait (**sfl_d**) is dominant over the allele for triple-flowered trait (**sfl_t**). The multi-flowered trait in JGM 7 is controlled by a different gene (**cym**). Single-flowered plants have dominant allele at both the loci (**Sfl_ Cym_**).

Complete penetrance (100%) was recorded for double-flower, triple-flower and multi-flower traits in respective parental lines. However, variable expressivity was observed for flowering and podding traits. The highest expressivity (96.34%) was observed for double-flower trait in ICC 4929, followed by triple-flower trait (81.15%) in IPC 99-18 and multi-flower trait (51.33%) in JGM 7. the double-pod trait showed higher expression (76.36%) than multi-pod trait (24.7%). The triple-flower line IPC 99-18 did not produce triple-pod at any of the nodes thus the expressivity of triple-pod trait was 0.00%. Average number of flowers per axis and average number of pods per axis were higher in multi-flowered line JGM 7 than other flowering types.

Inheritance studies on flower colour showed the presence of a single gene (**Ifc**) that inhibits the flower colour. This gene in homozygous recessive condition (**ifc ifc**) changes the pink colour petals to white colour without changing the vein colour. Similarly green foliage colour was found dominant over purple foliage. Thus monogenic inheritance was confirmed for two morphological traits, flower colour and foliage colour. Joint segregation analysis showed the presence of a common gene that exhibit pleiotropic effects on flower and foliage colours.

Variability studies showed significant differences among flowering types for characters number of flowers per axis, number of pods per axis, yield per plant and 100-seed weight. Double-multi and multi-flowering types were superior to other flowering types in yield per plant and 100-seed weight.

Title	: QTL analysis for shoot fly resistance in sorghum [<i>Sorghum bicolor</i> (L.) Moench]
Name	: SP Deshpande
Institute	: Marathwada Agricultural University, Parbhani 431 302, Maharashtra, India
Supervisor	: CT Hash
Period	: 16-1-2003 to 31-8-2005
Submitted	: 2005

Abstract

Present investigation was aimed at characterization of RILs developed from cross 296B (susceptible) \times IS 18551 (resistant) to understand the genetics of shoot fly resistance and to locate the chromosomal regions harboring the quantitative trait loci (QTLs) of shoot fly resistance and related component traits in sorghum. Mapping population consisting 259 RILs was evaluated with standard shoot fly resistance screening procedures in two screening environments. A reduced set of 213 RILs was used for linkage and QTL mapping with SSR markers. The two parents differed for the trait studied. Variance due to genotypes and $G \times E$ interaction were significant for the trait studied. Correlation and path analysis studies revealed that glossiness expression in seedlings can be utilized as simple and reliable selection criteria for the identification of shoot fly resistant plants.

Continuous distribution of RILs suggested quantitative nature of the traits studied. The resistant traits like glossiness intensity, seedling vigor, oviposition (%) and dead heart (%) recorded consistent heritabilities (broad-sense) estimates in individual screening environments and also in across season analyses indicating stability of these traits as reliable parameters of shoot fly resistance. Trichome density (both upper and lower leaf surface) recorded high estimate of heritability (broad-sense), but exhibited more $G \times E$ interaction. Transgressive segregants with phenotypic values outside the parental limits were observed for glossiness, seedling vigor, oviposition (%), dead heart (%) and trichome density.

Parental polymorphism with 248 SSR markers showed 46% of these markers to be polymorphic. A genetic linkage map was constructed with 111 SSR markers having map length of 2165.8 cM and markers were assigned to 10 LGs A through J. QTL analyses revealed presence of putative QTLs for all important shoot fly resistance traits with observed phenotypic variance ranging from 5.7 to 36.0 per cent. One major QTL for glossiness was detected on LG J, accounting for 32.7 % of observed phenotypic variation. Minor QTLs for seedling vigor, dead heart (%) and seedling height were also detected. Co-localization of a QTL for trichome density on upper leaf surface (explaining 19.5% observed phenotypic variance) with a QTL for trichome density on lower leaf surface (explaining 25% of observed phenotypic variation) indicates similarities in genetic control of trichome densities on either side of sorghum leaf. Utilization of agronomically adaptable RILs (like RIL No. 67 and 122) carrying QTLs for shoot fly resistance and its component traits in sorghum breeding programs using marker assisted selection to improve the shoot fly resistance in elite cultivars and hybrid parental lines will be more fruitful than direct use of an agronomically defective source like IS 18551.

Title	: Molecular mapping of Ascochyta blight resistant in chickpea (<i>Cicer arietinum</i> L.)
Name	: Pratibha Ramakuri
Institute	: Indira Gandhi Agricultural University, Raipur, Chattisgadh, India
Supervisor	: PM Gaur
Period	: 28-7-2003 to 31-3-2006
Submitted	: 2005

Abstract

Chickpea (*Cicer arietinum* L.) a self pollinated diploid ($2n=2x=16$) cool season food legume of the family Fabaceae, is grown in about 45 countries and mainly used for human consumption. The average yield of the chickpea is discouragingly low (750ha^{-1}), which has stagnated over the past three decades due to the abiotic and biotic constraints limit chickpea productivity. Several abiotic and biotic constraints limit chickpea productivity. Ascochyta blight (AB) caused *Ascochyta rabiei* (Pass) laboratory is the most serious disease globally. Developing chickpea varieties with the resistance to AB has been challenging because of 1) Non availability of high level of resistance in the germplasm 2) Conditioning of the resistance by several quantitative trait loci (QTLs) 3) High degree variability in pathogen. Molecular markers linked to major QTLs conferring AB resistance can greatly accelerate the breeding for development of resistant chickpea cultivars and can facilitate pyramiding of resistance genes in short time for the development of AB resistant/tolerant crop varieties. In spite of the availability of several chickpea maps of most of genomic region harboring genes for important traits, are not yet, sufficiently saturated with co-dominant markers to routinely apply MAS in breeding programs. Therefore developing an intraspecific, high density saturated genetic and validation of the reported markers linked to QTLs conferring AB resistance for utilization in MAS, have been chosen as the major objectives of this study.

An intraspecific linkage map of chickpea genome was constructed based on Simple Sequence Repeats (SSR) and Expressed Sequence Tags (EST) markers using F₂ population derived from a cross between ICC4491 x ICC04516. A total of 84 markers (82 SSRs and two ESTs) were mapped into ten linkage groups at a LOD score of 3.0 using Join map 3.0 software. The total map length spanned a distance of 724.4 cM with an average marker density of 8.62 cM. A cut twig method of screening of AB disease was employed to screen an F₂ mapping population of ICC4491 x ICC04516 at 80 days after sowing whereas seedling screening method was used at 14 days after sowing for screening of the F₂:3 families (24 plants in each line). The scoring for disease was scored on a 1-9 scale (1= resistant, 9= susceptible), when the susceptible check was completely dried out i.e, on 10 DAI. Single marker analysis, interval-mapping methods was employed for QTL detection using QTL Cartographer Version 2.0. Three QTLs conferring resistance to AB, QTL1 on LG3 and QTL2 and QTL3 were mapped on LG4 were mapped on the linkage map constructed. QTL1 was positioned at 95.11 cM on LG3 close to TR58 at a LOD of 2.03 explaining phenotypic variance (R^2) 18.62% as detected by CIM method. IM allowed mapping of QTL2 and QTL3 on LG4 with regions covered by SSR markers TA146, TS53, TA2 and TAA170. The QTL2 and QTL3 accounted for 7.74% and 9.28% of total phenotypic variance, respectively, and together explained a total phenotypic variance of 17.02% for seedling resistance to AB in F₂:3 populations.

Attempts of validating the earlier reported QTLs gave interesting results. The marker TA146 detected was associated to seedling resistance in the F₂:3 mapping population of ICC4491 x ICC04516 was found significantly associated with the seedling resistance in a validation

population of CC4491 x ICC04516 developed using the same resistant parent, explaining 18.89 percent of phenotypic variance. The validation studies of reported AB resistance QTL markers in F2 and F2:3 mapping population of ICC4491 x ICC04516 confirmed the earlier reports. The marker GA20, TA37 on LG2 and TA146, TS54, TA2, TAA170 and TR20 in LG4 are the candidate markers for employing MAS and MAB for *Ascochyta* disease resistance in chickpea. Therefore, in chickpea the markers have been validated across environments, using diverse intraspecific mapping population and using a different isolate of the pathogen. The AB resistance QTLs markers thus validated are candidate QTLs markers for MAS and MAB.

Title	: Mapping of Simple Sequence Repeats (SSRs) and marker assisted Interrogation of Quantitative Trait Loci (QTLs) for Stay green in [<i>Sorghum bicolor</i> (L). Moench]
Name	: Kassahun Bantte Bisetegn
Institute	: University of Agricultural Sciences, Dharwad, Karnataka, India
Supervisor	: Vincent Vadez
Period	: 18-1-2005 to 17-11-2006
Submitted	: 2006

Abstract

With the objective of increasing the marker density in the linkage map of the stay-green mapping population ninety-four individuals from N13 x E36-1 sorghum recombinant inbred population were genotyped with 78 EST makers and 55 makers (70%) gave reliable and scorable amplification. The genotypic data from these markers was integrated with the genotypic data of 164 previously mapped RFLP, AFLP, RAPD and SSR markers to produce the genetic maps. The genetic map constructed has a total length of 2838 cM. The number of EST-SSR markers mapped per linkage group ranged from 2 (linkage group H) to 9 (linkage group F). Some of the markers such as *Xisep841*, *Xisep0733* and *Xisep0938* mapped in the stay green QTL regions making them good candidate markers to be used in fine mapping of the QTLs and the marker-assisted selection of the stay-green trait.

In a marker-assisted backcrossing programme, four stable stay- green QTLs (StgB, Stg1, Stg3 and Stg4) were selected to be transferred from the stay-green donor parent (B35) to the senescent recurrent parent (R16). After two additional marker-assisted backcrossing and two selfing generations, four backcross families with single (Stg1, stg3, Stg4, and StgB) and five backcross families with double putative QTLs (Stg1+stg3, Stg1+Stg4, and Stg3+ Stg4 Stg3+stgB, Stg4+StgB) have been selected.

Previously generated, early generation stay-green introgression lines (BC2F2/BC1F3) were evaluated for their agronomic and stay-green related characters under well watered and water-stress conditions both in field (in the post rainy season) and greenhouse condition for two seasons. Among the introgression lines, RSG 04001/RSG 05001 was found to be the most promising line both in the terms of its grain yield and stay-green related characters.

Besides high% green leaf area, the stay-green genotypes had high chlorophyll content and leaf nitrogen concentration compared with the senescent lines showing the relationships among these traits. The correlation of relative grain yield to relative % GLA in the stress

environments was highly significant ($R^2 = 0.47$ in 2004-05 and $R^2 = 0.77$ in 2005-06) indicating the contribution of stay-green to grain yield.

Title	: Biochemical mechanisms of resistance to shootfly, <i>Atherigona soccata</i> (Rondani) in sorghum, <i>Sorghum bicolor</i> (L.) Moench.
Name	: Ch Siva Kumar
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisor	: HC Sharma
Period	: 2-1-2004 to 31-12-2006
Submitted	: 2006

Abstract

Sorghum is the fifth major cereal crop after wheat, rice, corn and barley, and third important cereal crop after rice and wheat in India. Nearly 150 insect species have been reported on sorghum, of which sorghum shoot fly, *Atherigona soccata*, is an important pest. Host plant resistance is one of the important components for managing this pest, and therefore, the present studies were undertaken on biochemical mechanisms of the resistance to shoot fly to strengthen host plant resistance to this insect for sustainable crop production.

Genotypes IS 2312, SFCR 125, SFCR 151, ICSV700, IS18551 exhibited antixenosis antibiosis, and tolerance components of resistance to shoot fly *A. soccata*. There was a significant variation in the leaf surface wetness, leaf glossiness, Trichome density, seedling vigor plumule and the leaf sheath pigmentation, days to 50% flowering and the plant height among the test genotypes.

Transplanting and clipping of sorghum seedling reduced shoot fly damage. There was no effect of *p*-Hydroxy Benzoic acid (PHBA), *p*-Hydroxy Benzaldehyde (PHB), C_2SO_4 , KI and 2,4-D on shoot fly damage. However application of PHBA showed increase in egg laying by shoot fly females.

Sorghum genotypes with high amounts of soluble sugars, more leaf surface wetness and fats and better seedling vigor were susceptible to shoot fly; while those with glossy leaf treat, pigmented plumule and leaf sheath, tall with high trichome density; and high tannin, Mg and Zinc contents showed resistance to shoot fly. Leaf surface wetness, Mg, Zn, soluble sugars, tannins, fats, leaf glossiness, leaf sheath, and plumule pigmentation and trichome density, explained 99.8% of the variation for dead hearts, of which leaf glossiness, plumule pigmentation, trichomes and fat content had direct effects and correlation coefficient for dead hearts in the same direction and can be used to select for resistance to shoot fly.

Leaf glossiness, leaf sheath and plumule pigmentation, high trichome density, tannins, moisture, total soluble polyphenols, lignin's, and Mg were associated with antibiosis to shoot fly.

Phenolic compounds: *p*-hydroxybenzaldehyde, *p*-hydroxy benzoic acid, luteolin and unknown peaks at RTs 24.38 and 3.70 were associated with susceptibility to shoot fly, whereas, protocatechuic acid, *p*-coumaric acid, cinnamic acid, and apigenin were associated with resistance to shoot fly, *A. Soccata*.

Protein peaks 1, 2, 3, 4, 7, 12, 14 16 and 17 were positively associated with susceptibility to shoot fly. Peaks 5, 8, 9, 11 and 15 were associated with resistance to shoot fly. Peaks 1,2,3,4,6,7,10,12,14,16, and 17 were negatively correlated with developmental period, pupal period, and female pupal weight, but positively correlated with larval survival, adult emergence and male pupal weight, indicating that those were associated with susceptibility to shoot fly. On the other hand, peaks 8,9,11 and 15 were associated with antibiosis to shoot fly.

Compounds undecane 5- methyl, decane 4-methyl, hexane 2, 4-methyl, pentadecane 8-hexyl and dodecane 2,6,11 –trimethyl,present on the leaf surface of sorghum seedlings, were associated with susceptibility to shoot fly, while 4, 4-dimethyl cyclooctene was associated with resistance to shoot fly.

There was considerable diversity among the sorghum genotypes used in the present studies based on the morphological, biochemical, and molecular characterization, and can be used in shoot fly resistance breeding program to broaden the genetic base and increase the levels of resistance to this pest.

Title	: Development of trap markers for <i>tb 1</i> gene and <i>brown midrib</i> genes in pearl millet
Name	: V Rajaram
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: CT Hash
Period	: 4-11-2004 to 15-2-2006
Submitted	: 2006

Abstract

Gene-specific markers linked to major genes controlling a trait will have a major impact in understanding and improvement of the respective traits in an efficient manner. Target region amplification polymorphism (TRAP), an efficient PCR-based marker system, offers a great potential to develop markers targeting candidate gene sequences. Using this marker technique, TRAP markers have been developed for the *teosinte branched 1 (tb1)* gene (thought to be involved in stress responsive apical dominance in teosinte and pearl millet), and *brown midrib 1 (bm1)* and *brown midrib 3 (bm3)* genes (thought to be involved in lignin biosynthesis and straw digestibility in maize, sorghum, and in pearl millet) in pearl millet. While the former gene is a candidate for a major drought tolerance quantitative trait locus (QTL), the latter two genes are candidates for stover yield and quality QTLs. Twenty TRAP marker bands were developed from PCR products of 6 TRAP primer pairs (fixed + arbitrary primer combinations) when visualized using the silver staining procedure for the three genes under study. All 20 TRAP markers were mapped using 'Mapmaker' software in a framework linkage map consisting of 31 RFLP, 28 SSR and 19 SSCP-SNP markers on a mapping population (ICMB 841-P3 × 863B-P2), which was previously used to map the targeted drought tolerance and stover yield and quality QTLs. Two out of 10 developed TRAP markers for the *tb1* target mapped to a major drought tolerance QTL on linkage group 2, similarly, 2 out of 10 developed for the two brown midrib gene targets mapped to a consistent stover quality QTL on linkage group 3, finally resulting in high (20% in this case) efficiency in producing trait specific markers associated with candidate genes.

The TRAP protocol successfully generated trait-specific markers. TRAP markers offer a potentially inexpensive means for preliminary evaluation of candidate genes during development of near-perfect selectable markers for species with limited sequence information.

Title	: Development of transgenic Peanut (<i>Arachis hypogaea</i> L.) plants for induced resistance against Peanut Bud Necrosis Disease (PBND)
Name	: S Chander Rao
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisor	: KK Sharma
Period	: 4-8-2003 to 31-3-2006
Submitted	: 2006

Abstract

Peanut Bud Necrosis Disease (PBND) is an economically important viral disease of peanut (*Arachis hypogaea* L.) caused by the Peanut Bud Necrosis Virus (PBNV), a member of the group tospovirus for which no durable resistance has been found amongst the available germplasm accessions. The utilization of viral coat protein (cp) or the nucleocapsid protein gene (ng) as transgene in plants against virus resistance is one of the most spectacular successes achieved in plant biotechnology. The present study was undertaken to develop transgenic plants of peanut for resistance to the PBNV by genetic engineering. In the present, thirty-five independent transgenic events of peanut were developed by using the plasmid pRTL2:PBNVng and the binary vector pCambia1301:PBNVng carrying the 831 bp nucleocapsid N gene of PBNV through micro-projectile bombardment or biolistics and *Agrobacterium*-mediated transformation methods by using cotyledons and embryonic leaflets as explants. The integration and stable expressions of the transgene in the putative transgenics in T₀ generation and in subsequent generations were confirmed by PCR, RT-PCR and Southern blot analysis. The ELISA and Northern analysis carried out in T₁ generation showed low to moderate levels of protein and mRNA transcript. The segregation analysis of PBNV-N gene from the progeny of 16 transgenic events in T₁ generation and 24 events in T₂ generation showed 3:1 Mendelian inheritance. Thirty-five transgenic events included 20 events obtained through biolistics and 15 events through *Agrobacterium tumefaciens*-mediated gene transfer. The seeds in T₁ generation were tested for virus resistance by mechanical inoculation of PBNV at 1:100 (w/v) concentration in the containment greenhouse that resulted in 16 events as virus free and 8 events with mild initial symptoms. These 24 events were further advanced and the progeny in T₂ generation was challenged with PBNV at 1:50 (w/v) concentration that showed varied levels of disease incidence and intensity. Although, all the 24 events acquired the virus following mechanical inoculation, the virus symptoms and mortality of all the tested events was delayed ranging from 4 to 9 weeks when compared to the untransformed controls that showed 100 percent mortality within 2 weeks after inoculation. Simultaneously, these 24 events were also evaluated under contained field testing in PBND epidemic area after obtaining due approval from the Institutional Biosafety Committee of ICRISAT. The results obtained from field experiment were comparable with greenhouse experiments in terms of disease incidence. The preliminary studies showed three transgenic event, GNPBNV B1-2-1, GNPBNV AK-3-4; GNPBNV B11-2-3 to be superior. These showed better performance over untransformed controls in terms of disease incidence. In conclusion, this study established the development of transgenic peanut plants for inducing resistance to PBNV followed by their molecular and genetic analysis. Based on the greenhouse studies and one year contained

field testing, three transgenic events carrying the PBNV nucleocapsid gene showed 40 to 67% decrease in disease incidence when compared to the untransformed controls. However, the study warrants further detailed evaluation of the selected transgenic events for the detailed characterization of virus resistance and the mechanisms involved.

Title	: Varietal screening and insecticidal evaluation against <i>Maruca vitrata</i> (GEYER) in pigeonpea
Name	: V Sunitha
Institute	: Acharya NG Ranga Agricultural University, Hyderabad, AP, India
Supervisor	: GV Ranga Rao
Period	: 14-9-2004 to 13-10-2005
Submitted	: 2006

Abstract

The present study was under taken on the “Varietal screening and insecticidal evaluation against *Maruca vitrata*(Geyer) in pigeon pea” at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh during 2004-2005 crop season. Six selected short duration pigeon pea genotypes viz., ICPL 98001, ICPL 98002, ICPL 98003, ICPL 98008, ICPL98012 and ICPL 88034 were tested against *M. Vitrata* in the field, greenhouse and laboratory conditions. The relative efficacy of six insecticides were evaluated against 3rd instar larvae of *M. vitrata* under laboratory conditions.

The pod damage by *M .Vitrata* on pigeonpea genotypes in the field ranged from 5.80 to 68.00 per cent. Based on the resistance rating, ICPL 98003 and ICPL 98008 were categorized as highly resistant and ICPL 98012 as moderately resistant genotype. The genotype ICPL 98001 and ICPL 98002 showed intermediate reaction and ICPL 88034 was categorized as susceptible genotype.

Greenhouse and laboratory studies showed less consumption of food and reduced larval and pupal weights of *M. vitrata* when reared on highly resistant genotypes (ICPL 98003 and ICPL 98008), while the larvae reared on the susceptible genotype ICPL 88034 consumed more food showed more larval and pupal weights and recorded highest growth rate as compared to the highly resistant genotypes.

The morphological and chemical parameters of the genotypes viz., trichome length, density, pod wall thickness, sugars, proteins and phenols were responsible for resistance/susceptibility of the genotypes to *M. vitrata*.

The laboratory studies conducted with newer and ecofriendly insecticides against *M. vitrata* revealed that the indoxacarb and spinosad were highly effective at recommended doses. The biopesticides, *Bacillus thurigiensis* and *Metarhizium anisopliae* showed moderate efficacy and the botanical insecticide neem fruit extract was least effective to *M. vitrata*.

Title	:	Determination of efficacy of different <i>Helicoverpa armigera</i> nucleopolyhedrovirus (HaNPV) strains and standardisation of production procedures
Name	:	K Sireesha
Institute	:	Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisor	:	GV Ranga Rao
Period	:	17-11-2003 to 30-6-2006
Submitted	:	2006

Abstract

Investigations were carried out on the “Determination of efficacy of different *Helicoverpa armigera* nucleopolyhedrovirus (HaNPV) strains and standardisation of production procedures” during 2003-2005 at ICRISAT, Patancheru centre.

Quality and efficacy of HaNPV multiplied on field collected larvae as well as laboratory reared larvae were assessed by conducting bioassay studies and by estimating bacterial population. For mass multiplication of HaNPV, fourth instar larvae were inoculated with 10^8 POBs/ml and reared in the laboratory. There was 75.6% mortality with field collected larvae where as laboratory reared ones recorded 72.6% mortality. The highest cadaver weight (282.89 mg), highest POBs/larva (5.9×10^9) and the highest POB yield/g body wt. (2.54×10^7) were recorded from the field collected larvae where as laboratory reared ones recorded cadaver weight of 270.12mg, POBs/larva of 5.02×10^9 , POB yield/g body wt. of 1.94×10^7 . Observations on the bacterial contamination levels indicated the highest number of colony forming units per ml (2.33×10^6 CFU/ml) for the sample multiplied on field collected larvae. Where as HaNPV multiplied on laboratory reared larvae recorded 2.06×10^6 CFU/ml.

Bioassays conducted to test the efficacy of HaNPV multiplied on field collected larvae and laboratory reared larvae showed the LC_{50} values of 1.78×10^3 POBs/ml and 2.15×10^3 POBs/ml, respectively. However both the samples have overlapping fiducial limits which showed that there was no significant difference in virulence of both the samples multiplied on field collected larvae as well as on laboratory reared larvae.

Bioassays were conducted with second and third instar larvae of *H. armigera* to study the virulence of six HaNPV isolates from different places of India. Among the six isolates ICRISAT-HaNPV was found superior which was followed by GAU-HaNPV, PAU-HaNPV, TN-HaNPV, AK-HaNPV, UASD-HaNPV. The LT_{50} values also revealed the same. Further SDS-PAGE analysis revealed that the presence of four to five major polypeptides viz., VP42.32 (± 0.92) kDa, VP34.74 (± 0.27) kDa, VP31.77 (± 0.44) kDa, VP30.66 (± 0.27) kDa in all the isolates except GAU-HaNPV which had an extra polypeptide with 19 (± 1.41) kDa and several minor polypeptides.

Under TEM observation, the extract of the diseased larvae showed the presence of large polyhedral particles of diameter ca. 78 nm. After the dissolution with alkali, empty polyhedral sacs of 2.31 μ m length and 2.05 μ m width were observed. Observations on final purified sample revealed bacilliform to cylindrical rod shaped particles with 282 x 49 nm. The concentration of DNA of all the isolates ranged between 104.84 μ g/ml to 481.96 μ g/ml and A_{260/280} ratio ranged between 0.87 to 1.186 and no conclusions were drawn from restriction endonuclease analysis of DNA of the six HaNPV isolates using *Eco* RI, *Pst* I and double digestion with *Eco* RI and *Pst* I.

Harvesting of NPV infected larvae before 9th day after inoculation was better to get the maximum virus yield as well as to reduce the development of bacterial contamination. Early harvesting of NPV infected larvae on 5th and 6th days was also not feasible. Harvesting of all the infected larvae after 7th or 8th day and immediate processing helped to decrease the bacterial contamination level instead of waiting for the complete death of all the larvae.

NPV sample stored under refrigerated condition was found more virulent, which gave 97.50% mortality after a period of ten months. Where as, the samples stored in earthen pot, amber colored bottle and glass bottle at room temperature gave 87.5%, 70.0% and 67.5% mortality, respectively. Development of bacterial contamination was 3.47 times more in samples stored under room temperature compared to refrigerated condition.

Chemicals used, as preservatives for NPV were effective in minimizing the bad odour problem in storage and reduced the bacterial contamination level. NPV samples treated with acetone, ethyl alcohol and phenyl gave 73.33%, 70.00% and 63.33% mortality, respectively at the end of one year of storage and phenyl was found effective in suppressing the bacterial growth, which was followed by ethyl acetate. All the chemicals used were cost effective with an extra cost involvement of Rs.3-12.5 ha⁻¹ only.

Title	: Genetic variability, stability and inheritance of grain iron and zinc content in pearl millet [<i>Pennisetum glaucum</i> (L.) R. Br.]
Name	: G Velu
Institute	: Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
Supervisor	: KN Rai
Period	: 19-4-2004 to 30-9-2006
Submitted	: 2006

Abstract

The present study was undertaken to determine the magnitude of genetic variability for grain iron (Fe) and zinc (Zn) among a diverse range of breeding lines, improved populations (among and within populations) and germplasm accessions; to assess the stability across different environments; to examine the relationships between them and with days to 50% flower and 1000-grain mass; and to determine the nature of inheritance and heritability.

Over two-fold variation was found for both grain Fe (30.1–75.7 mg kg⁻¹) and Zn content (24.5–64.8 mg kg⁻¹) with medium to high broad-sense heritability in different classes of breeding materials and improved populations (42.0–79.9 mg kg⁻¹ Fe and 24.2–51.7 mg kg⁻¹ Zn), indicating large genetic variability for the improvement of grain Fe and Zn content and the scope for effective selection. The highest levels of Fe and Zn content were observed in well-adapted commercial varieties and in the parental lines of released hybrids, which had large *indica* germplasm base in their parentage, suggesting the possibility of making immediate impact on the nutritional security. Large within-population variability of over two-fold for grain Fe (40.9–118.9 mg kg⁻¹) and Zn (31.8–82.7 mg kg⁻¹) content was detected in progenies derived from two open-pollinated varieties (AIMP 92901 and GB 8735), indicating possibility of selection within-population and the prospects of enhancing grain Fe and Zn levels by recurrent selection. The difference between the summer and rainy season for grain Fe and Zn content among the entries was largely due to the soil Fe and Zn content of the fields used in the experiments.

The positive and highly significant correlation between Fe and Zn content in all the experiments, indicated the possibility of simultaneous genetic improvement for the elevated levels of both micronutrients. Significant positive correlations of 1000-grain mass and negative correlation of days to 50% flower with Fe and Zn content suggested good prospects of combining high Fe and Zn with farmers-preferred traits such as large seed size and early maturity.

Significant differences existed among the entries and environments with respect to all the four traits. Differential response of entries towards varying environments was evident as the genotype \times environment interaction for grain Fe and Zn content and, days to 50% flowering was significant. Such statistical interactions were of non-cross over types as there was highly significant positive correlations of grain Fe and Zn among seasons. The high Fe and Zn content seed parents 863B, 843B and ICMB 88004 were identified which were also stable across environments, and thus could be used as good sources for further genetic improvement.

The genetic component analysis indicated absence of epistasis for all traits. The Wr-Vr graph revealed presence of partial dominance for grain Fe and Zn content, 1000-grain mass and over-dominance for days to 50% flowering. The predictability ratio measured by $2\sigma^2_{gca}/(2\sigma^2_{gca} + \sigma^2_{sca})$ was around unity for both grain Fe and Zn content, implying preponderance of additive gene action. Also, there was highly significant positive correlation between the mid-parental value and hybrid performance, and no correlation between mid-parent value and mid-parent heterosis for both Fe and Zn showed an additional indication of the predominant role of additive gene action for these traits. The high grain Fe and Zn content in parents were governed by recessive alleles with increasing effects and the low content was due to excess of dominant alleles with decreasing effects. The grain Fe and Zn content in parents were correlated with their *gca* effects. The average heterosis was negative for grain Fe and negligible for grain Zn content. In general, this study suggested the effectiveness of pedigree/recurrent/progeny selection or backcross breeding to develop lines with increased levels of grain Fe and Zn content.

The simple, rapid and cost-effective Prussian blue staining method for qualitative assessment of grain Fe was efficient in distinguishing the entries with high and low Fe content, that could be used for discarding entries with low Fe content while screening large number of germplasm accessions and breeding lines.

Title	: Genetic transformation for pod border resistance through <i>Agrobacterium</i> in pigeonpea (<i>Cajanus cajan</i> L.)
Name	: G Sreelatha
Institute	: Osmania University, Hyderabad, AP, India
Supervisor	: KK Sharma
Period	: 3-3-2003 to 30-4-2006
Submitted	: 2006

Abstract

The transgenic events of pigeonpea were successfully developed through *Agrobacterium tumefaciens*-mediated transfer of the Bt *cry1Ac* gene using an efficient, reproducible and

genotype independent protocol involving seedling leaf petiole explants. A total of 50 independent transgenic events; 20 events of ICPL 88039, 25 of ICPL 87 and 5 of LRG 41 were produced and successfully transferred to the greenhouse. The primary transformants were characterized using Polymerase chain reaction (PCR) and RT-PCR analyses to confirm the presence and expression of *npII* and *cry1Ac* genes in transformants. The expression of *cry1Ac* gene was confirmed using ELISA where the amount of the protein in the transgenic events ranged from 0.0009 to 0.002 % of total soluble protein. The copy number of the transgenes was confirmed by Southern hybridization and this was reconfirmed using Inverse PCR analysis. Mendelian inheritance pattern of 3:1 was observed for both *cry1Ac* and *npII* genes in T₁ and T₂ generations indicating the stable and successful inheritance of transgenes. Insect feeding assays carried out on leaves and pods of fifteen transgenic events indicated a significant reduction in the larval survival and weights under green house conditions. A contained field trial was conducted with nine selected events of ICPL 88039 and ICPL87 where, two events of ICPL 88039 viz., 13-1-1 and 15-4-2 showed consistency in their performance against *H. armigera* in the leaf, pod and inflorescence bioassays of the field grown transgenics. The results of this study clearly indicated that insect larvae when fed on the transgenic plants showed a considerable reduction in larval survival (53%) on leaves and larval weights on pods. However, the information on effective levels of Bt protein required for insect resistance in pigeonpea need to be generated and the unknown factors that reduce the efficient expression of the insecticidal gene should be further probed.

Title	: Genetic and biochemical basis of grain mold resistance in sorghum (<i>Sorghum bicolor</i> (L.) Moench)
Name	: V Thirumala Rao
Institute	: Acharya N G Ranga Agricultural University, Hyderabad, AP, India
Supervisors	: RP Thakur and Belum VS Reddy
Period	: 13-8-2004 to 12-8-2007
Submitted	: 2006

Abstract

The present investigation was undertaken to understand the mechanisms, characters associated with resistance and their interactions for developing grain mold resistant hybrids.

Eight CMS lines (ICSA 369, ICSA 370, ICSA 371, ICSA 400, ICSA 384, ICSA 382, ICSA 52 and ICSA 101) were crossed with twenty one restorers (IS 41720, IS 41397, IS 41675, IS 18758C-618-2, IS 18758C-618-3, IS 30469C-140-2, IS 30469C-1508-2, ICSV 96105, ICSV 96094, IS 84, SPV 462, ICSR 89013, ICSR 91011, ICSR 89018, ICSR 89058, PVK 801, GD 65028, GD 65055, ICSR 92001, ICSR 91019 and ICSR 91029) and the resultant 168 crosses along with six checks viz., Bulk Y, IS 25017, IS 20, IS 14384, PVK 801 and CSH 16 were evaluated for combining ability (Line × Tester design), heterosis and stability (Eberhart and Russel, 1966) at two locations in two years viz., Patancheru 2004 *kharif* and 2005 *kharif*, Rajendranagar 2004 *kharif* and 2005 *kharif*.

The pooled analysis of variance for combining ability revealed significant differences due to environments, parents, hybrids and various interactions indicating the existence of wide variability in the material under study. The ratios of additive to dominance variances revealed that additive gene action was predominant for inheritance of PGMR, TGMR, days to 50%

flowering, plant height and 100 grain weight. Influence of both additive and non-additive gene actions were observed for grain yield per plant.

The *gca* effects in pooled analysis revealed that the parents IS 30469C-140-2, SPV 462, ICSR 91011, PVK 801, GD 65028 and GD 65055 were good general combiners for yield and grain mold resistance. Based on significant *sca* effects sixteen hybrids were identified as promising for grain mold resistance, and grain yield and its components.

Based on *per se* performance, *sca* effects and standard heterosis, the hybrids ICSA 384 × GD 65028 and ICSA 384 × GD 65055 for grain mold resistance, ICSA 101 × PVK 801 and ICSA 101 × GD 65028 for grain yield were found superior.

Based on stability analysis, thirty nine hybrids exhibited stable performance for disease resistance across locations in which ICSA 384 × GD 65028, ICSA 370 × GD 65028 and ICSA 384 × GD 65055 were with low PGMR scores. The hybrids ICSA 384 × SPV 462, ICSA 400 × IS 41720, ICSA 384 × IS 30469C-140-2, ICSA 101 × ICSR 92001 and ICSA 101 × ICSR 89013 were suitable for favourable environments and ICSA 369 × GD 65055, ICSA 369 × ICSR 89058 and ICSA 371 × IS 18758C-618-3 were suitable for unfavourable environments.

Studies on morphological traits indicated that more glume cover, loose and semi-compact nature of panicle, brown and red glume colour are most desirable for resistance against grain mold.

Studies on biochemical and physical properties of kernel revealed that resistant hybrids are having low ergosterol, high flavan-4-ols, more density and high germination percentage compared susceptible hybrids.

The association of various traits to grain mold resistance indicated that mold resistance positively associated with germination percentage, grain density and flavan-4-ols and negatively with ergosterol.

An attempt was made to understand the relationship between parents and hybrids for grain mold resistance revealed that more chances of producing GMR hybrids from crosses of R × R followed by S × R, R × S and S × S parents. It indicates the diverse and complementary mechanisms, each with small effect may be acting synergistically in hybrids leading to higher levels of resistance in some crosses. So it is more promising to develop one of the parents with resistance is useful in developing resistant hybrids.

Based on present study, it can be concluded that the hybrids ICSA 101 × PVK 801, ICSA 101 × GD 65028 and ICSA 384 × GD 65028 were stable with desirable *sca* effects, *per se* performance, heterosis for grain mold resistance and yield. These hybrids may be further tested over environments and may be recommended for commercial release.

Title	:	Study on genetics, cytology and stability of cytoplasmic-genic male-sterility system in pigeonpea
Name	:	VA Dalvi
Institute	:	Marathwada Agricultural University, Parbhani 431 402, Maharashtra, India
Supervisor	:	KB Saxena
Period	:	2-8-2004 to 1-8-2007
Submitted	:	2007

Abstract

Pigeonpea (*Cajanus cajan* (L.) Millsp) is an important crop of Asia and Africa. It is the fourth most important pulse crop in the world with almost all production coming from the developing countries. It is a hardy, widely adapted and drought tolerant crop. In this crop there is large variation for maturity that offers its cultivation under various environments and cropping systems. Besides its main use as *dhal* (dehulled split peas), its immature green seeds and pods are also consumed as vegetable. The crushed dry seeds are fed to animals, while green leaves form a quality fodder. The dry stems of pigeonpea are used as fuel wood. Apart from these uses, perennial type pigeonpea is grown on sloppy mountain and bunds for reducing soil erosion. Efforts have been made in past to increase the average productivity by developing high yielding varieties. In spite of release of over 100 good varieties, yield levels did not increase significantly. Perhaps the other reason for low yields of pigeonpea was susceptibility to diseases and pod borer complex. In order to maintain self-sufficiency in pulses production for the ever-increasing population in India, a proportionate increase in their production is essential. In this endeavour, the use of hybrid pigeonpea technology has potential. The stable male-sterility system in conjunction with natural out-crossing will make the hybrid pigeonpea seed production easy and affordable. Since in pigeonpea no stable male-sterility system was available at the commencement of hybrid programme, a deliberate search for male-sterile genotypes was made at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in the germplasm that led to the identification of male-sterile plants in ICP 1596. Further it was need to study the major cause of male-sterility and its stability over seasons and locations. Therefore, an experiment was planned in order to study these basic aspects. The results revealed that ICPA 2039 is the stable male-sterile line over locations and season followed by ICPA 2052. Further it was observed that the breakdown of tapetum was the major cause of male-sterility in pigeonpea. Various experimental hybrids were tested for their yield and stability performance and few hybrids were superior to the control cultivar as well as stable over locations. The genetics of fertility restoration was studied and it showed the possibility of monogenic to trigenic control of fertility restoring gene. This study needs to be conducted with iso-nuclear CMS lines to get the exact number of genes controlling fertility restoration.

Title	:	Evaluation of transgenic chickpea for resistance to pod borer, <i>Helicoverpa armigera</i> (Hubner) (Noctuidae: Lepidoptera))
Name	:	Rama Krishna Babu Ayyaluri
Institute	:	Acharya NG Ranga Agricultural University, Hyderabad, AP, India
Supervisor	:	KK Sharma
Period	:	14-2-2003 to 31-5-2006
Submitted	:	2007

Abstract

Evaluation of transgenic chickpea for resistance to pod borer *H. armigera* was carried out in Genetic Transformation and Insect Rearing Laboratory at ICRISAT, Patancheru, Hyderabad. The transgenic chickpea plants were developed through *Agrobacterium* – mediated gene transformation method using a binary plasmid vector pBS 2310 carrying *Bt cry1 Ac* gene for insect resistance and *gus* gene as a selectable marker constituted with dual enhancer CaMV 35S promoter harboring in *Agrobacterium* strain C 58. Axillary meristem explants of

C235 were infected and co-cultivated with *Agrobacterium*. The infected explants were selected stringently by culturing on the medium containing kanamycin (50, 80, and 100 mg/l) in stepwise manner and as a result 21 well established putative transformants were produced with 12.11 per cent and 2.87 per cent regeneration and transformation efficiency respectively.

Molecular analysis of these plants through PCR, RT-PCR, and southern blot indicated the integration of *transgene cry1Ac* in to the genomic DNA of T₀, T₁, and T₂ putative transgenic chickpea plants. Variation in the segregation pattern of transgene was observed in the population of T₁ and T₂ generations. RT-PCR of cDNA from randomly selected T₀ and t₁ plants showed expression at mRNA level. The ELISA studies of T₁, T₂ and T₃ generation putative transgenic chickpea plants revealed that accumulation of Bt cry1Ac protein which varied from 0.035 to 1.86 ng/100 mg of leaf tissue as against 5-19 ng/100mg leaf in Bt cotton.

Bioassay of putative transgenic cry1Ab chickpea plants against the 1st instar larvae of pod borer *H.armigera* showed considerable variation in terms of larval survival, leaf damage and larval weight gain. Detached leaf bioassays of T₁ generation transgenic chickpea plants with *cry1Ac* gene at vegetative stage (40-45 DSE) revealed that the plants CPAC 1-4, 19-4, 20-1, 5-4, 6-2, 7-1, 7-2, 8-5, 9-2, 19-6, 19-8, 20-7, 21-8 and 21-9 showed lower larval weight and at flowering stage (60-65 DSE) most of them significantly differed in terms of larval weight, larval survival and leaf damage.

The progeny of nine events of *cry1Ac* (T₃) and *cry1Ab* (T₃) plants grown in contained field trial were evaluated and the entire plants showed variable results in terms of larval survival, leaf damage and larval weights at the vegetative and flowering stages. The *cry1Ac* plants performed better compared with *cry1Ab* T₃ plants. Pod bioassays of *cry1Ac* transgenic chickpea with 3rd instar larvae of *H.armigera*, the plants APAC 5-7 and 7-7 of T₁ generation and plants CPAC 20-7-7 of T₂ generation showed significant reduction in larval weight gain compared with non-transformed plants. Pod bioassay of *cry1Ab* in T₃ transgenic chickpea plants did not vary with control plants. Some of the plants of T₁ and T₂ generation of *cry1Ac* showed resistance and moderately resistance.

Bioassays of *cry1Ac* (T₃) and *cry1Ab* (T₄) transgenic plants indicated that the larval survival, leaf damage and larval weights of 1st instar *H.armigera* were greater when compared with *Bt* cotton.

In the present study, some of the plants of the progeny of T₀ CPAC 1,5,7,8,9,19, and 20 affected the larval weight gain, but consistency was not observed in the antibiosis performance against *H. armigera* larvae in subsequent generations. It is presumed that, the physiology of the plant, interaction of toxic protein with acid metabolic cycle with in the plant and internal gut environment of the larva due to consumption of the acid exudates of the plant may influence the potency of the Bt toxin in the chickpea. Hence to produce transgenics with higher level of expression of Bt toxins in chickpea plants, the research need to be oriented with due consideration to all the above factors.

Title	: Identification and isolation of putative disease resistance gene homologues from groundnut and studies on regulatory gene expression in transgenic groundnut under abiotic stress
Name	: D Srinivas Reddy
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisor	: KK Sharma
Period	: 1-3-2003 to w31-12-2006
Submitted	: 2007

Abstract

Degenerate primers were designed based on the conserved regions of Nucleotide Binding Site (NBS) in disease resistance genes characterized from various plant spp. and used to isolate Resistance Gene Candidates (RGCs) from cultivated groundnut. Out of eight primer combinations tested, four combinations (S2/AS1, S2/AS3, LM638/LM637 and P-loopAA/GLPL3) amplified an expected 500 bp fragment. Out of the 29 clones sequenced 19 clones showed sequence similarity to TIR (Toll Interleukin I Receptor)-type R-genes and R-gene homologues from legumes and others that suggested the existence of common ancestors. RGCs characterized in the present study were classified in to eight clusters based on the homology at nucleotide level and these were compared with groundnut RGCs available in the databases to find out relation among them. All available groundnut RGCs were classified in to 38 clusters including eight clusters identified in the present study, based on the similarity of the NBS region between P-loop and GLPL motifs. The present work on RGCs in groundnut is the first of its kind, and cloned groundnut RGCs will serve as a valuable resource for future applications, such as map-based cloning and marker assisted selection.

In a separate study, groundnut transgenics carrying *DREB1A* transcription factor driven by *rd29A* gene promoter (both from *Arabidopsis thaliana*) developed in ICRISAT were used to study the gene expression under salt and drought stress conditions. Five transgenic events having single integration of the transgene were selected based on physiological and molecular analysis. Salt stress was given to the three weeks old *in vitro* grown plants and expression of *DREB1A* transcript was observed 30 min after salt stress. Dry down experiments were carried out in greenhouse and the expression of *DREB1A* transcript was observed three days after drying. Total RNA from the plants expressing *DREB1A* under stress were used for studying the gene expression using differential display (DDRT) assay. A total of 48 primer combinations were tested in DDRT and 51 differentially expressed transcripts were identified. The sequence analysis of the cloned differentially expressed transcripts showed similarity to the abiotic stress-responsive genes available in the EST database. Majority of the cloned cDNAs showed sequence similarity with stress responsive *Arachis* ESTs, where as other cloned cDNAs showed high level of sequence similarity with mitochondrial genes, chloroplast maturase gene. In the present study, 65% of the cloned cDNAs showed similarity with the drought and other abiotic stresses responsive ESTs, thereby indicating that these may play a role in enhancing the abiotic stress tolerance in the transgenic groundnut. Further expression analysis of these genes under stress will provide important insights into the molecular mechanisms of drought tolerance in transgenic groundnut.

Title	: Characterizing responses to population improvement for grain- and stover-yield related traits in pearl millet [<i>Pennisetum glaucum</i> (L.) R. Br.] using SSR markers
Name	: K Baskaran
Institute	: Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India
Supervisor	: CT Hash
Period	: 17-11-2004 to 31-12-2006
Submitted	: 2007

Abstract

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the sixth most important cereal globally. It is the staple food crop for poor farmers in the semi-arid regions of sub-Saharan Africa and in the Indian subcontinent. Grain yields are generally low, mainly because this crop is often cultivated for subsistence farming under extremely harsh conditions, on marginal soils, in areas of low rainfall and with a little or no input. Open-pollinated variety breeding has been practiced in pearl millet using recurrent selection to produce high yielding random mating populations or composites. The availability of vast untapped genetic resources and continuing yield gains indicate that there are good prospects for continued genetic improvement in the productivity of this crop. The present study, involving the development of 50 full-sib progenies each from recently released pearl millet composite CO (Cu) 9 and four of its immediate progenitors (ICMP 87750, ICMP 91751, ICMV 93752 and UCC 23), was undertaken to detect the response to selection in phenotypic traits and frequencies of simple sequence repeat (SSR) marker alleles; and to identify the genomic regions associated with grain- and stover-yield related traits (QTLs). Full-sib progenies were evaluated for agronomic traits in replicated field trials (3 replications) conducted over two seasons (*kharif* 2005 and summer 2006) at ICRISAT-Patancheru. The phenotypic evaluation revealed that most of the grain- and stover-yield related traits have been improved over the recurrent selection cycles.

Significant genotype \times environment interaction was observed for all the agronomic traits studied indicating substantial effects of environment on expression of these phenotypic traits. Using molecular markers, effects of population improvement have been studied in several crops. This is the first such report in pearl millet. Allele frequencies at each SSR locus (34 loci distributed across all 7 pearl millet linkage groups) were estimated based on relative peak heights detected by an ABI 3700 genetic analyzer and Genotyper software using DNA samples from pooled plant tissues of about 20 seedlings per full-sib progeny. A total of 159 alleles were detected for these 34 SSR loci. The number of SSR marker alleles ranged from 2 (*Xpsmp2059* and *Xpsmp2202*) to 8 (*Xpsmp2069*) with an average of 4.68 alleles per locus. The effect of recurrent selection on the frequency of SSR marker alleles differed, depending on the allele. Marker alleles present at 17 SSR loci showed significant changes in their frequencies between initial (ICMP 87750) and advanced recurrent cycle [CO (Cu) 9] populations. Non-significant reduction of mean unbiased heterozygosity revealed that further cycles of recurrent selection should give substantial gain in the improvement of yield and its component traits. Regression analysis was performed using allele frequencies and corresponding phenotypic scores of the full-sib progenies to identify genomic regions putatively associated with grain- and stover-yield related traits. Genomic regions controlling variation in flowering time were located on LG1, LG5, LG6 and LG7 and plant height was influenced by regions on LG1, LG4, LG5, LG6, and LG7. Genomic regions on LG1 (*Xpsmp2069_214*), LG5 (*Ximep3027_202*) and LG6 (*Xpsmp2248_162*) were

associated with stover yield. Variations in panicle and grain yield were associated with LG2 (*Xpsmp2225_220*) and LG7 (*Xpsmp2224_159*). Panicle threshing percentage QTLs were mapped to LG2, LG3 and LG7. Genomic regions on LG6 (*Ximep3058_193*) and LG7 (*Xpsmp2027_229*) were associated with 1000-grain mass, and on LG7 (*Xpsmp2224_159*) with panicle grain number. Harvest index QTLs were mapped to LG4, LG5, LG6 and LG7. Specific genomic regions associated with QTLs for one trait can be identified that have co-mapped with those for highly correlated traits. The genomic regions identified were largely in agreement with previous pearl millet studies involving more conventional QTL mapping approaches. Superior alleles at these QTLs could be used for the improvement of yield across breeding populations. Full-sib progenies that registered consistently higher mean values for grain- and stover-yield related traits in both seasons' trials could be ideally exploited for the development of parental lines for uses in future hybrid/composite breeding programs.

Title	: Development and evaluation of diagnostic tools for <i>Nucleopolyhedroviruses</i> (NPVs) infecting major Lepidopteran pests of legume crops in the Semi-Arid Tropics
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Supervisor	: GV Ranga Rao
Period	: 5-12-2005 to 12-4-2007
Submitted	: 2008

Abstract

Investigations were carried out towards the “Development and evaluation of diagnostic tools for *Nucleopolyhedroviruses* (NPVs) infecting major lepidopteran pests of legume crops in the semi-arid tropics” during 2005-2008 at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru centre.

Nucleopolyhedroviruses (NPVs) were isolated from three major lepidopteran pests of legume crops during natural epizootic conditions at ICRISAT farms. They are: 1) From *Helicoverpa armigera* (Legume pod borer) larvae on pigeonpea and chickpea crops; 2) From *Spodoptera litura* (Tobacco caterpillar) and 3) From *Amsacta albistriga* (Red hairy caterpillar) larvae on Groundnut crop and their mass multiplication was standardized at ICRISAT-NPV production laboratory. During mass multiplication of *H. armigera* NPV (HaNPV), there was a significant difference in parameters like POBs/ml and POBs/larvae which showed that NPV multiplied on field collected larvae recorded significantly higher yield ($5.35 \pm 0.31 \times 10^9$ POBs/larva) compared to laboratory reared larvae ($5.18 \pm 0.45 \times 10^9$ POBs/larva). While $5.73 \pm 0.17 \times 10^9$ POBs/larva for *S. litura* NPV (SINPV) and $7.90 \pm 0.54 \times 10^9$ POBs/larva for *A. albistriga* NPV (AmalNPV) were recorded when multiplied on laboratory reared larvae emerged from field collected egg masses.

Under scanning electron microscope (SEM) the POBs of NPVs appeared as crystalline structures of variable shapes (irregular) of size 0.5 to 2.5µm (HaNPV), 0.9 to 2.92µm (SINPV) and 1.0 to 2.0µm (AmalNPV) in diameter. Under transmission electron microscope (TEM) the cross-sectioned POB revealed multiple nucleocapsids in each envelop, which

were of bacilliform shaped structures of $277.7 \times 41.6\text{nm}$ (HaNPV), $285.7 \times 34.2\text{nm}$ (SINPV) and $228.5 \times 22.8\text{nm}$ (AmaNPV) in size. The POBs of HaNPV and AmaNPV contained 2 to 6 and SINPV contained 5 to 7 nucleocapsids per envelope.

Purification protocol for polyhedrin protein of NPVs was standardized by initial heat inactivation of endogenous proteases; alkali disruption of POBs and release of virions, and ultracentrifugation to pellet virions. Further purification was achieved by either of the following approaches: (i) in one approach polyhedrin was further purified through centrifugation by layering on 10-40% linear sucrose gradient; and (ii) in second approach through precipitation of polyhedrin at isoelectric pH. In 10-40% linear sucrose gradient centrifugation, the polyhedrin formed one diffused light scattered zone in 10% sucrose region. In isoelectric precipitation method the polyhedrin of all the three NPVs was precipitated at pH between 5.5 and 5.6. In 12% SDS-PAGE analysis, the molecular weight of major polyhedrin of three NPVs revealed that 31.65kDa (± 0.00) of HaNPV, 31.29kDa (± 0.00) of SINPV and 31.67kDa (± 0.295) of AmaNPV respectively. In addition, these preparations contained some minor molecular weight peptides of about 7-27kDa and a high molecular weight peptide of about 60-70kDa fragment. This has revealed that three NPVs have 6-8 minor polypeptides.

Polyclonal antibodies were raised in New Zealand White rabbits against polyhedrin protein of NPVs isolated in the present study. The concentration ($500\mu\text{g}$) of polyhedrin of NPVs used for immunization gave an antibody titer of 1:5000 dilution, 18 weeks after immunization. In western immunoblotting all three antibodies were specifically reacted with polyhedrin (31kDa) and did not cross-reacted with healthy larval proteins indicated that the antibodies are highly specific to polyhedrin. In addition to the major polyhedrin (31kDa), the polyclonal antibodies recognized some minor low molecular weight polypeptides of about 11-27 kDa and high molecular weight peptides of about 43.6-99.14kDa proteins when sufficient amounts of samples were loaded in to wells. Some of these proteins could not be aligned with those polypeptides in silver stained gels of polyhedrin preparations examined previously. The antibodies were highly specific to polyhedrin protein and did not cross-reacted with healthy larval proteins but, each antiserum had shown different degrees of cross reactivity with heterologous polyhedrins in Direct antigen coating (DAC) Enzyme-linked Immunosorbent assay (ELISA) and western immunoblotting.

Various immunochemical tools were developed using the polyclonal antibodies raised against the polyocclusion body (POB) protein (polyhedrin) and evaluated for the detection and quantification of NPV in insect larvae and viral insecticide preparations. Indirect immunofluorescence assay and western immunoblot assay were developed for detection of POBs in homogenates of NPV-infected larvae. DAC-ELISA and Indirect Competitive (IC)-ELISA were developed for detection and quantification of polyhedrin protein in insect extracts. The sensitivity of DAC-ELISA is 30ng/ml of polyhedrin in $5\mu\text{g/ml}$ of insect total protein extracts. But in DAC-ELISA there was competition between insect and viral proteins for binding to the ELISA plate surface reducing the sensitivity of the assay. To eliminate this, IC-ELISA was developed, which has sensitivity of $0.156\mu\text{g/ml}$ of polyhedrin in 25 or $50\mu\text{g/ml}$ of alkali dissolved total insect protein extracts. The 50% competitive inhibition (IC_{50}) values for HaNPV polyhedrin polyclonal antiserum were calculated to be $1.10\mu\text{g/ml}$ of homologous polyhedrin and heterologous polyhedrins were calculated to be $2.0\mu\text{g/ml}$ of SINPV polyhedrin and $2.20\mu\text{g/ml}$ of AmaNPV polyhedrin. For SINPV-polyhedrin polyclonal antiserum, IC_{50} was calculated to be $1.26\mu\text{g/ml}$ of homologous polyhedrin and heterologous polyhedrins were calculated to be $2.25\mu\text{g/ml}$ of HaNPV polyhedrin and $2.85\mu\text{g/ml}$ of AmaNPV polyhedrin. For AmaNPV-polyhedrin polyclonal antiserum, IC_{50} was calculated to be $1.19\mu\text{g/ml}$ of homologous polyhedrin and heterologous polyhedrins were calculated to be $1.82\mu\text{g/ml}$ of Ha NPV polyhedrin and $2.32\mu\text{g/ml}$ of SINPV polyhedrin. The percent cross-reactivity of each antiserum with their homologous polyhedrins was calculated to be 100% while with heterologous polyhedrins the antisera showed differential cross-reactivity. The

HaNPV- polyhedrin polyclonal antiserum has showed 54.72% and 50.0% of cross-reactivity with SINPV and AmalNPV polyhedrins. The SINPV- polyhedrin polyclonal antiserum showed 56.0% and 43.85% of cross-reactivity with HaNPV and AmalNPV polyhedrins. Similarly, AmalNPV-polyhedrin polyclonal antiserum showed 65.38% and 51.29% of cross-reactivity with HaNPV and SINPV polyhedrins. In recovery experiments, 25 and 50µg/ml of insect body proteins did not show interference with artificially spiked polyhedrin and the percent of amount of polyhedrin spiked in to 25 or 50µg/ml of larval protein extract was 82.1 to 116.8%.

Among these tools the DAC-ELISA is a rapid and highly sensitive tool, which can detect low levels of NPV at early stages of infection in larvae as well as latent infection in pupae. While competitive-ELISA, western immunoblotting and indirect immunofluorescence tools were highly specific but not much sensitive than DAC-ELISA to detect low levels of NPV infection. Both DAC-ELISA and IC-ELISA tools were sensitive to the analysis of alkali dissolved protein extracts of POBs or infected larval extracts than direct POBs or larval extracts. Whereas, western immunoblotting and indirect immunofluorescence tools were specific to both. As part of the quality control during mass production of NPVs used for commercial viral insecticide preparations at ICRISAT, Patancheru, India, the present study developed some sensitive immunochemical methods such as DAC and IC-ELISA and evaluated their performance in quantification of POBs in commercial NPV preparations. A simple purification protocol was standardized for extraction of total polyhedrin from NPV preparations of 6×10^9 to 2.34×10^7 POBs/ml. The purity of the extracted polyhedrin was assayed in SDS-PAGE and evaluated in both DAC as well as IC-ELISA with sensitivity of 4.68×10^7 POBs/ml (0.015LE/ml). The ELISA results were comparable to light microscope counting of POBs.

Application of ELISA and western immunoblot assay in bioassay experiments during optimization of conditions for the productivity and quality of NPVs suggested that 4th instar larvae is suitable for *H. armigera* and 5th instar larvae suitable for *S. litura* and *A. albistriga* for virus inoculation, and virus harvesting 9 days after inoculation from both live and dead larvae was better to get the maximum virus yield as well as to reduced bacterial contamination. Application of ELISA tools at field level evaluation of efficacy of NPV against *H. armigera* on pigeonpea crop showed that the concentration of NPV (250 LE/ ha) used for field spray was successfully infected the field population. The infection was initiated in field population on 3 days post application (dpa) and percent of infection in field sampled larvae was peaked at 8 and 9 dpa and started declining on 10 dpa.

A double round PCR protocol was standardized using degenerate primer set to isolate the full-length polyhedrin gene of NPV isolated from *H. armigera*. This resulted in ~ 750 bp product which was cloned and sequenced. Gene sequencing analysis of selected clones resulted in 744 bp nucleotide long ORF with a predicted coding capacity for a polypeptide of 247 amino acids. In BLASTX search the sequence showed homology with baculovirus occlusion body protein domain of known polyhedrin and granulin proteins from the GenBank data base. The sequence was deposited in GenBank with a public accession number of EU047914.

The nucleotide sequence of HaNPV-P polyhedrin gene had a high homology with polyhedrins of several NPVs. Among which, it was showing maximum homology of 98.2% with *Mamestra configurata* NPV, 98% with *Mamestra brassicae* NPV, 96.1% with *Leucania seperata* NPV and 90.6% with *Panolis flammea* NPV. At the same time with minimum homology of 72.4% was noticed with WsNPV. Similarly, the amino acid sequence of HaNPV-P polyhedrin protein was showed maximum homology of 95.5% with *Mamestra configurata* NPV and *Mamestra brassicae* NPV, 93.9% *Panolis flammea* NPV and 93.5% with *Leucania seperata* NPV and minimum homology of 79.4% with *Wiseana signata* NPV and 81.8% with *Spodoptera littoralis* NPV. Phylogenetic analysis at nucleotide as well as amino acid levels showed that the virus belongs to group-II NPVs and the virus was named as *H. armigera* NPV, Patancheru strain (HaNPV-P). This is the 1st report from the Indian

subcontinent and 8th report worldwide to be described the complete polyhedrin gene of a NPV isolated from *H. armigera*.

In the present investigation the HaNPV-P strain was distinguished from other NPVs by developing PCR-RFLP marker based on its unique restriction sites present in the amplified portion of the polyhedrin gene. Restriction mapping analysis of HaNPV-P polyhedrin gene along with other known published polyhedrin sequences showed that one unique restriction sites present at particular nucleotide positions in polyhedrin gene of HaNPV-P and other NPVs. This has showed that one unique restriction site, *Xho*-I at nucleotide position 131 was found in NPV from *M. brassicae* and *M. configurata*, and at position 671 in NPV of *L. seperata*. Whereas in HaNPV-P, the *Xho*-I site was found at both 131 and 671 base pairs. But, the *Xho*-I site was not found in any of the HaNPV polyhedrin gene sequences deposited earlier in the GenBank. This indicates that the HaNPV-P is a unique strain among earlier reported HaNPV isolates.

Title	: SSR polymorphism survey in parental genotypes of chickpea mapping populations
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Supervisor	: Rajeev K Varshney
Period	: 2008

Abstract

Chickpea (*Cicer arietinum*) is one of the important pulse crops grown across the world. However, due to low level of DNA polymorphism in cultivated genepool of chickpea, dense molecular genetic maps based on intraspecific mapping populations are not available. Nevertheless, several hundreds of microsatellite markers have been developed in chickpea worldwide. Majority of these SSRs however have not been integrated into intraspecific genetic maps of chickpea. Hence the present study was initiated to assess the polymorphism of two sets of microsatellite markers developed at NIPGR, India (NIPGR series) and Hebrew University of Jerusalem, Israel in collaboration with Texas University, USA in 12 genotypes. These genotypes included the parental genotypes of four intraspecific (*C. arietinum* x *C. arietinum*) crosses i.e. ICC 506EB x Vijay, ICC 4958 x ICC 1882, ICCV 2 x JG 62, ICC 283 x ICC 8261 and three interspecific (*C. arietinum* x *C. reticulatum*) crosses i.e. ICC 4958 x PI 489777, ICC 3137 x IG 72953, ICC 3137 x IG 72933. Out of 513 microsatellite markers screened, 271 markers showed polymorphism between parental genotypes of at least one mapping population. The maximum number of alleles detected by NIPGR and H markers were 8 and 12 respectively with an average of 3.5 and 3.9 alleles per marker. The polymorphism information content (PIC) values for NIPGR markers (average 0.49) were comparatively higher than H series markers (average 0.47). High degree of correlation (0.98) was observed between the two sets of microsatellite markers studied, although they were developed from different sources.

As expected, the level of polymorphism in interspecific crosses was higher compared to intraspecific crosses. The parental genotype combinations ICC 4958 x PI 489777 and ICC 283 x ICC 8261 showed highest level of polymorphism among interspecific and intraspecific crosses, respectively. The cluster analysis, multidimensional scaling and factorial analyses based on microsatellite allelic data revealed a distinct grouping of nine genotypes of *Cicer arietinum* and two genotypes of *C. reticulatum*, but one *C. reticulatum* genotype (IG 72933) was positioned between genotypes of two *Cicer* species.

Title	: Genetic and QTL analyses of sink size traits in pearl millet (<i>Pennisetum glaucum</i> (L.) R. Br.)
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Supervisor	: KN Rai
Period	: 5-9-2005 to 4-9-2008
Submitted	: 2008

Abstract

This study was carried out to characterize the genetic architecture of three sink size component traits (panicle length, panicle diameter and grain size) through genetic and QTL analyses. The plant materials for genetic analysis consisted of two crosses for the generation means and variance analyses, and one cross for triple test cross (TTC) analysis for each of three traits. The material for QTL analysis consisted of 188 F_2 and their $F_{2:3}$ progeny mapping populations of a cross between the two inbred lines. The plant materials were developed during the 2005-06 and the field experiments were conducted during the 2006 rainy and 2007 summer seasons.

Scaling and joint scaling tests revealed that a simplistic additive-dominance model did not adequately explain the observed variation for all the three traits in both seasons, providing an evidence for the presence of epistasis. The six-parameter model and the TTC analysis revealed significance of both additive and dominance effects for cross 1 of panicle length, panicle diameter and grain size. However, cross 2 of panicle length and panicle diameter revealed only additive effects and grain size showed the presence of both additive and dominance gene effects. All three types of interactions (additive x additive, additive x dominance and dominance x dominance) were found to be significant in cross 1 for all the traits across seasons using generation means analysis. However, TTC analysis revealed the presence of all types of epistasis for panicle length and panicle diameter. For grain size, it revealed the presence of only additive x dominance and dominance x dominance (j + l) epistasis. In cross 2, additive x additive (i) interaction alone was significant for panicle length and panicle diameter, whereas for grain size, dominance x dominance (l) followed by additive x dominance (j) contributed significantly across seasons. The estimates of broad and narrow-sense heritability were high for all the traits. Correlation coefficient estimates revealed that panicle length, panicle diameter and grain size were positively and significantly associated with grain yield in their respective trait-specific crosses.

The linkage map constructed using 44 markers (SNP, SSR, EST-SSR and STS markers) with 188 $F_{2:3}$ progenies had a total length of 1018.7 cM. The average distance between the marker pairs was 23 cM. QTL analysis performed as composite interval mapping (CIM) identified eight genomic regions for panicle length, one each on LG 1, 2, 4 and 7; and two each on LG 3 and 6. The variation explained by these QTLs ranged from 6.1 to 18.2%. For panicle diameter, five QTLs were found across LG 2, 3, 5, 6 and 7 and the variation explained by these individual QTLs ranged from 6.3 to 30.2%. For grain size also five QTLs were identified across LG 1, 3, 5, 6 and 7 and the individual QTLs explained 6.1 to 21.2% of the observed phenotypic variation across F_2 and $F_{2:3}$ data sets. From the mapped QTLs, one QTL on LG 2 for panicle length, two QTLs each on LG 2 and 3 for panicle diameter and one QTL on LG 3 for grain size are identified as candidate QTLs for marker-assisted selection.

Abstracts from
GT-Crop Improvement
Eastern and Southern Africa

Mary A Mgonja

Title	: Characterization of sorghum ([Sorghum bicolor (L) Moench] landraces collected from central and southern Tanzania
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Institute	: University of Zambia
Supervisors	: C Gwanama, MA Mgonja, M Chisi and R Folkertsma
Period	: January 2004 –December 2005
Submitted	: 2005

Abstract

Sorghum is one of the five most important cereal crops in the world. It is a major source of food in Africa and India. In Tanzania, sorghum is one of five principal cereal crops. Improved varieties and landraces are both available in the country. Production and utilisation of sorghum has been affected by biotic, abiotic and socio-economic factors. Utilisation of available landraces needs identification of desirable traits through characterisation. Thus a study on sorghum characterisation was conducted. The general objective of the study was to characterise potential breeding materials by (1) determining the genetic relationships (2) assessing important agronomic traits for sorghum classification.

Fourty, 38 from Tanzania and two (Local 1 and Local 2) from Zambia landraces were morphologically evaluated at Mansa Technical Assessment Site in Zambia. These landraces were planted in two blocks and measurements were recorded following the International Board for Plant Genetic descriptive list. A total of 44 morphological descriptors were used: 17 qualitative and 27 were quantitative. Data were analysed by SPSS and Genstat softwares.

Five principal components accounted for 53.64% of the total variability. Grain lustrousness, threshability, days to maturity, hundred grain weight, juice flavour, tillers, leaf number per stem, flowered stems per planting station, tillers per planting station, juice flavour, tiller leaf length senescence, grain cover, grain yield, grain number per panicle, plant height, midrib colour, average weight of five panicles, grain number per panicle, and leaf senescence contributed significantly to the variability. Cluster analysis based on morphological characters revealed two major distinct groups with two subgroups each. However, most landraces within cluster were not separable. This can be attributed to selfing and seed exchange among farmers.

Molecular marker analysis using SSR revealed variations among 41 genotypes, which were grouped into eleven clusters and was able to separate all the landraces. Three sorghum controls, N13, Ochuti and Adiwo each formed independent clusters. Markers Xgap84 and Xtxp320 had high alleles than other markers. These had 7 and 8 alleles respectively. There were no genotype specific makers with the exceptions of Ochuti and N13 controls.

Generally, the two dendrograms from morphological and molecular marker analysis were concordant for most groups conserved. The results of this study revealed that, significant genetic variation of sorghum landraces exists in Zambia and central and southern Tanzania and that genetic improvement through breeding is possible. Analysis further revealed that, clustering was not based on area of collection. Results also showed that, molecular markers are more efficient than morphological characterization. Therefore, molecular markers or combination of both should be used according to availability of resources. Based on these

results it was recommended that, morphological characterization should be done for more than one season and that, area of collection should be widened. For molecular markers, more studies should be conducted for identification of more genotype specific markers. In future more primers should also be included for sorghum genotyping.

Key words: Sorghum [*Sorghum bicolor* (L) Moench], morphological and molecular markers characterization, SSRs, genotyping

Title	: Participatory variety selection and evaluation of sixteen sorghum (<i>Sorghum bicolor</i>) varieties grown on the flat and tied ridges
Name	: Tegwe Soko
Institute	: University of Zimbabwe
Supervisors	: C Mutengwa, MA Mgonja and C Musvosvi
Period	: Jan 2006-August 2008
Submitted	: 2007

Abstract

Sorghum [*Sorghum bicolor* (L.) Moench] is a crop of great diversity, mainly grown in semi-arid and arid areas because of its adaptability to moisture stress and low fertility. In Zimbabwe, sorghum production is affected by use of traditional varieties, lack of access to improved varieties, drought, and HIV and AIDS. At the same time, sorghum remains an important component in production systems and in human diets. Some of the constraints to sorghum production are due to contemporary plant breeding approaches used by researchers that have led to low adoption rates of improved technologies such as improved varieties.

A study was carried out at Chiredzi Research Station and Gwebi Variety Testing Centre to find out if some of the constraints to sorghum production could be addressed using Participatory Variety Selection (PVS). Sixteen sorghum varieties (Subplot factor) were planted in a Split Plot Design, replicated three times using two water management systems (Main plot factor, i.e, Flat and Tied ridges). The station trial was used as a site for the communal trial during the Participatory Variety Selection process with farmers and extension officers from Chikombedzi. Data was analysed using Genstat Version 8.

Results showed significant differences ($P < 0.001$) between varieties in agronomic traits (flowering, maturity, plant height, plant lodging and head exertion) and yield components (number of grains/panicle, mass of 1000 grains and grain yield). There were no advantages in using either Flat or Tied ridges as a water management system. Through PVS diagnostic and field discussions, earliness to maturity, grain yield and grain colour were established as the three most important sorghum selection characteristics by farmers in Chikombedzi. Mahube was identified as a very early maturing variety but was low yielding with low grain numbers per ear. Sima was very good after organoleptic tastes with Sila being recommended because of its white grain and high yield.

Richard B Jones

Title	:	Groundnut seed systems: Evaluating seed management and quality in Western Kenya
Name	:	Emily Dunn Jerve
Institute	:	Faculty of Graduate School, Cornell University, USA
Supervisors	:	Peter Hobbs, Steven Kyle and Richard Jones
Period	:	August to September 2007
Submitted	:	May 2008

Abstract

Seed security is a critical issue in Sub-Saharan Africa. Agricultural research has provided valuable insight into the effectiveness of high-yielding variety seeds, yet 60-70% of the seed used by African smallholders is saved on-farm. An initiative called Lucrative Legumes Project (LLP) explored these seed access and quality issues with groundnuts, and this study focused on seed use and its implications for seed quality. Field research was undertaken in Western Kenya in two components: focus group discussions and survey administration. The results were drawn from questionnaires with 81 groundnut farmers who grew a mixture of groundnut varieties and had a range of interaction with the LLP. Information was also collected from representatives of various public and private institutions that have linkages with seed system development and sustainability.

One of the important findings was that groundnut cultivation is still a new endeavor to a majority of farmers. Sufficient time has not been allowed to establish markets, develop associated technology such as shelling and grinding, and create opportunities and linkages with value added ventures. Groundnut experiences high handling loss because it is edible at nearly every stage, and other cultural norms, such as sharing the harvest, are embedded in farm management decisions and have an effect on seed production though this may be mediated through continued training and linkages with existing institutions. Saving seeds from a previous harvest was the most common seed source for both the long rains (33%) and short rains (86%) of 2007.

Title	:	Effect of social capital on performance of smallholder producer organizations: the case of groundnut growers in western Kenya
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Institute	:	Agricultural Economics Department, University of Nairobi, Kenya
Supervisors	:	Julius Juma Okello, Rose, A Nyikal and Bekele Shiferaw
Period	:	October 2005 to September 2008
Submitted	:	September 2008

Abstract

Due to poor market and physical infrastructure, high transaction costs, price risk, and information problems, past liberalization and structural adjustment policies have not been able to improve market access, hence decreased commercialization for smallholder farmers.

The private sector that replaced public sector has largely failed to make the investments needed for effective market coordination. Consequently, over the past few decades, scientists and development agencies have highlighted production and marketing challenges faced by smallholder farmers and suggested various forms of policy intervention. Collective action has been one of the recommended interventions in production and marketing through producer and marketing organizations. Collective action arises when people come together because of constraints and to take joint action and decisions to accomplish an outcome. Hence, it is vital to know what governments can do to better support the farmer organizations.

Collective action (in form of farmer organizations) is widely recognized as a positive force for rural development in Africa. However emerging empirical evidence suggests that farmer organizations perform differently. Are there certain structural factors or characteristics of farmer organizations that contribute to or inhibit effective performance? The current study therefore seeks to examine the role of social capital on the performance of farmer organizations. Social capital refers to the quality and depth of the relationships between people in a group or community. It is the obligations and expectations, information channels and social norms. In particular, the study assesses the effect of various dimensions of social capital on (i) commercialization of smallholders' produce and (ii) on the performance of the farmer organizations' marketing function. It uses data collected in 2007 from 225 farmers selected by membership to farmer organizations in 45 farmer organizations in western Kenya. The effect of social capital on commercialization and performance of the organizations' marketing role is tested using econometric techniques. Two econometric models are estimated. Both objectives of the study were addressed by estimating ordinary least squares (OLS) regressions.

The findings of the study suggest that, among the social capital dimensions, diversity among members in the farmer organization, frequency of attendance to the farmer organization's meetings, level of solidarity and level of trust in the organization positively influenced household's level of commercialization. Level of democracy in decision making and density of membership to other formal and informal organization did not spur commercialization at household level. The findings of the second objective indicated that diversity among members in the farmer organization, frequency of attendance to the farmer organization's meetings, level of democracy in decision making, level of solidarity and density of membership to other formal and informal organization positively influenced the performance of a farmer organization. An increase in the level of trust among the members in the farmer organization had a negative influence on its performance. The conclusion derived from the results therefore indicate that, smallholder farmers participating in farmer organizations' activities and with higher levels of social capital were more commercially oriented in their production. Social capital also enhances the performance of farmer organizations as marketing intermediaries. The findings highlight the role of social capital on farmers' access to lucrative markets and hence integration into the market economy.

Title	:	Diagnosis of soil and plant nutrient constraints in small-scale groundnut (<i>Arachis hypogaea</i>) production systems of western Kenya using infrared spectroscopy
Name	:	Stephen M Ichami
Institute	:	Department of Land Resource Management and Agricultural Technology (LARMAT), University of Nairobi, Kenya
Supervisors	:	Charles KK Gachene, Geoffrey Kironchi and Keith D Shepherd
Period	:	October 2006 to March 2007
Submitted	:	September 2008

Abstract

Soil fertility degradation is a major problem in Africa leading to food insecurity, ecosystem degradation and poverty. Nutrient depletion and disease epidemics have contributed to a decline in groundnut yields of 25% in the past decade in Sub-Saharan Africa. Studies have demonstrated that infrared spectroscopy (IR) may permit rapid and cost effective analysis of tropical soil nutrients. Trial and error and field observations methods used by farmers are inefficient and have led to inappropriate soil nutrient management strategies and options in small-scale crop production systems. This study sought to survey the prevalence of soil nutrient constraints in the small-scale groundnut production systems of western Kenya and explore the potential of IR as a diagnostic tool for soil nutrient constraints. The soil properties examined were soil pH_w, total carbon (TC), total nitrogen (TN), extractable phosphorus (Ext. P), exchangeable potassium (K), exchangeable calcium (Ca), exchangeable magnesium (Mg) and particle size distribution (PSA). While for plant macronutrients, nitrogen (N), phosphorus (P) potassium (K) were examined and micronutrients, copper (Cu), zinc (Zn) iron (Fe) and manganese (Mn). Reference data that was used for developing calibration models was analyzed using standard laboratory methods widely used for tropical soils and plants. Soil pH was determined using an electrode pH meter for saturated soil paste. Exchangeable Ca and Mg were determined atomically by the atomic absorption spectrometry (ASS). The Olsen method was used to colorimetrically determine Ext.P. Total carbon (TC) and (TN) were determined using the C: N analyzer and PSA were determined using the hydrometer method. The plant macronutrients N, P, K, were determined by Kjeldahl distillation method, while the micronutrients Cu, Zn, Mn and Fe were analyzed by ashing prior to determination by ASS. The reference data was then calibrated to soil and plant reflectance. Stable calibration models were developed for several key soil nutrients using the near-infrared (NIR) and mid-infrared (MIR) diffuse reflectance spectroscopy and partial least square regression (PLSR) statistical analysis. Robust calibration model were obtained; soil pH_w ($R^2=0.85$), TC ($R^2=0.98$), TN ($R^2=0.97$), Ca ($R^2=0.95$) and Mg ($R^2=0.94$), sand $R^2=0.85$) silt $R^2=0.82$ and clay $R^2=0.81$ for the MIR spectral region. Extractable P and Exch.K had weak calibration models with R^2 values of 0.66 and 0.50 for MIR, 0.50 and 0.32 for NIR. Similar results were obtained for above-ground groundnut biomass although P and K yielded robust good calibration models. Attenuated total reflectance (ATR) yield robust calibration for TN from saturated soil pastes with R^2 values of 0.94. The study demonstrated the utility and potential of IR spectroscopy as a diagnostic screening tool for soil and plant nutrition in small scale production systems. Principal component analysis (PCA) was used to summarize the variability in soil properties. Soil fertility indicators (SFIs) that were developed from the principal components were then used to evaluate soil nutrient levels based on critical nutrient levels. The SFIs were successfully calibrated to soil reflectance measured in the laboratory with cross validated R^2 values of 0.97 and 0.87 for MIR and NIR respectively. Groundnut farms were critically deficient of principal nutrients; TN (75%), Ext.P (65%), and Exch. Ca (100%) which fell below the critical nutrient levels based on soil and plant MIR spectral predictions and replenishment of these principle nutrients is crucial for sustainable groundnut productivity.

Abstracts from
GT-Crop Improvement
West and Central Africa

Tom van Mourik

Title	:	The role of sorghum genotype in the interaction with the parasitic weed <i>Striga hermonthica</i>
Name	:	Jonne Rodenburg
Institute	:	Wageningen University and Research Centre
Supervisor	:	MJ Kropff
Period	:	01-11-2000 to 01-11-2004
Submitted	:	2005

Abstract

This thesis presents a study on the interaction between the parasitic weed *Striga* (*S. hermonthica* [Del.] Benth.) and the cereal crop sorghum (*S. bicolor* [L.] Moench). Its main objective was to find suitable measures for the selection of breeding material (crop genotypes) with superior levels of resistance or superior levels of tolerance to *Striga*. To meet this objective the physiological background of tolerance, the relation between *Striga* infestation, infection and yield loss and the effect of host genotype on *Striga* parasitism and reproduction were studied.

These host-parasite interactions were studied with 4-10 different sorghum genotypes differing in level and mechanism of defense against *Striga*. Field experiments carried out in Mali were used for yield assessments and development and validation of selection measures. Through pot and agar-gel experiments, aboveground resistance measures were validated with observations on belowground stages. Pot experimentation was also used to create infection response curves and to measure photosynthesis and chlorophyll fluorescence to develop tolerance measures.

Striga parasitism and reproduction, and the detrimental effect of *Striga* on crop yield can significantly be reduced through crop genotype choice. Maximum aboveground *Striga* number is a reliable selection measure for resistance. *Striga* flowerstalk dry weight can be used to identify genotypes that reduce *Striga* reproduction. The maximum relative yield loss is a suitable selection measure for tolerance in susceptible genotypes, while for more resistant genotypes the relative yield loss per *Striga* infection seems more appropriate. For these tolerance measures, yield assessment of nearby uninfected controls is indispensable. Chlorophyll fluorescence, more precisely photochemical quenching and electron transport rate, may enable screening for tolerance without this requirement.

Title	: Striga hermonthica seed bank dynamics process quantification and modeling
Name	: Thomas Alexander van Mourik
Institute	: Wageningen University and Research Centre
Supervisor	: MJ Kropff
Period	: 01-11-2001 to 01-11-2005
Submitted	: 2007

Abstract

This thesis presents a study on the quantification of seed bank dynamics of the parasitic weed *Striga hermonthica*. The main objectives were to quantify transition rates between different stages of the life cycle, determine these under different conditions and control strategies and to develop and use a population model to project long-term seed bank dynamics. To this end, field experiments were performed in Mali, with sorghum in 2002, 2003 and 2004, and Niger, with millet in 2004.

Three demographic processes behind *Striga hermonthica* seed bank replenishment were determined and quantified, namely (1) recruitment of Striga plants, (2) survival of emerged Striga plants to maturity and (3) fecundity (number of seeds produced per mature plant). Striga seed production was highly variable between years and sites, because of high variability in recruitment. Different control strategies reduced Striga at different stages in the life cycle. Intercropping the host cereal with non-host trap crops mainly reduced recruitment and survival while late weeding acted almost solely on survival to maturity.

A critical re-assessment of the seed bag method used to determine Striga seed mortality in the soil, led to the conclusion that the method overestimates seed mortality. It was suggested to adapt the seed bag method in order to measure seed mortality more accurately.

An adapted seed bag burial method and a soil sampling method were used simultaneously to determine processes and rates of seed bank depletion under bare soil, fallow and different crop covers. Results suggested that the main cause of seed bank depletion was germination of seeds. Both methods yielded similar seed bank depletion percentages and most germination was found in soil under host crops, sorghum and millet, followed by intercrops of a host and a non-host trap crop, non-host crops, fallow and bare soil.

The information and insights obtained were used to develop a spatially explicit, stochastic Striga population model, with which long-term effects of crop systems and control was modelled. The spatial patterns of emerged Striga plants after point inoculation with stochasticity in the attachment stage of Striga resembled spatial distribution of Striga that is typically observed in farmers' fields. Sensitivity analysis showed that only two slope parameters for the dispersal curve of seeds and seed death other than germination in response to millet roots were of minor importance for population growth. The model indicated that intercrops of host cereals and non-host crops showed higher potential to reduce the Striga seed bank than did rotations of these. The implications of the findings are discussed in the context of integrated Striga management and participatory research.

Eva Weltzien-Rattunde

Title	: Sorghum production by Malian women – its role and importance
Name	: Eva van den Broek
Institute	: Wageningen University, The Netherlands
Supervisor	: Margret Loeffen and Eva Weltzien
Period	: 01-11-2006 to 01-05-2007
Submitted	: 2008

Abstract

This paper seeks to contribute to ICRISAT's knowledge on sorghum farmers' conditions and needs by providing an insight in the sorghum production by women on their individual fields. Until today, women's sorghum production has been a rather neglected topic within professional breeding programs. Women are argued to play a different role than men in the sorghum production system. Based on a field research in two regions in the South West of Mali, this paper shows comparative data for sample women from twelve different settlements on cropping patterns, inputs, seed acquisition, varietal choice and sorghum consumption. Next to this it describes women's position in the seed supply system and their opportunities and constraints to engage in a commercial market for sorghum seed. The main argument is that women's sorghum production is restricted due to a lack of resources like fertile soils, labor, fertilizer, a plough and access to sorghum seed. These factors should be taken into account in the development of improved varieties, in order to also make women profit from this.

Title	: Dissecting heterosis in guinea race sorghum: Simultaneous analysis by conventional breeding and molecular marker approaches
Name	: Sokona Dagnoko
Institute	: Cornell University, USA
Supervisor	: Fred Rattunde
Period	: 01-08-2003 to 01-01-2008
Submitted	: 2008

Abstract

In western Africa, there is a growing interest in guinea sorghum hybrids as a means to boost yield while maintaining the desirable features of guineas. New inbred lines have been recently developed. In the present research, we used a combination of conventional breeding, quantitative genetics, and molecular marker approaches to dissect heterosis for grain yield in 112 sorghum hybrids, mostly of the guinea background. These hybrids were assigned to six sets, with hybrids in set 1 through 4 obtained from crossing four female A-lines to 31 pollinator R-lines in a factorial mating design and hybrids in set 5 and set 6 obtained from elsewhere. Across four environments, hybrids significantly out-yielded the mid-parent value by 46.3%, the best parent by 27.5%, and the best open-pollinated check by

33.1%. Best parent heterosis for yield was accompanied by best parent heterosis in four panicle components (number of grains/panicle and per branch, degree of branching, and seed weight), indicating the importance of these four components for yield performance of hybrids and yield heterosis. The genetic control of these panicle components was primarily by dominance of the high trait-value parent although a few instances of additive gene action were found in some genetic backgrounds for some traits. Microsatellite marker genetic diversity analysis of the inbred lines used to make hybrids included in set 1 through set 4 revealed a high allelic variation in the gene pool, with 131 alleles detected at 21 marker loci examined and an average of six alleles/locus. Analysis of molecular variance indicated that most of the genetic variation was contributed by the “among inbred” source of variation. Principal component analysis of the inbreds’ dissimilarity matrix revealed six genetic groups based on both racial and eco-geographic origins. An analysis of variance indicated significant differences among the six genetic groups for yield performance and yield heterosis. Inter-cluster crosses gave the best performing hybrids and the highest levels of heterosis. Spearman’s rank correlation coefficients of parental Rogers’ genetic distance with heterosis were positive and significant for grain yield, degree of panicle branching, and number of grains/panicle. This indicated the importance of parental genetic distance for heterosis. In general, this study has shown the attractiveness of guinea hybrid breeding to boost sorghum yield while maintaining desirable features of guineas and the possibility of using molecular markers to identify and establish heterotic groups in sorghum.

Title	: Strengthening Local Seed Systems: Options for Enhancing Diffusion of Varietal Diversity of Sorghum in Southern Mali
Name	: Sonja Slart
Institute	: Universitaet Hohenheim, Stuttgart, Germany
Supervisor	: E Weltzien
Period	: 01-09-2003 to 01-01-2008
Submitted	: 2008

Abstract

The aim of this study is to identify the strengths and weaknesses of the local seed systems for sorghum in Mali as a basis for collaboration between plant breeders and farmers. The main focus of the research was to describe the local seed systems of sorghum in the project regions as well as to evaluate the dissemination efforts of improved sorghum varieties of local project partners. The research was implemented in the framework of a participatory sorghum breeding project managed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Mali and financed by the German Ministry of Economic Cooperation and Development (BMZ).

As farmers lack access to modern varieties (MV) of cereals in Mali, new approaches are needed to improve farmers’ variety access. The majority of farmers have no information about officially released varieties, releases are infrequent and official varieties cover only small areas of Mali, often linked to the regional research stations. Furthermore, farmers have had to face agro-ecological changes in recent decades, such as decreased rainfall and alteration of soil fertility. These changes increase farmers’ demand for new varieties with traits that respond better to new conditions to complement their existing variety portfolio.

Chapter 2 introduces the theory of seed systems, participatory plant breeding, agrobiodiversity and farmers’ local knowledge. The concepts of behaviour change and the diffusion of innovations are explained. In addition, an overview of sorghum production and

breeding, as well as the agriculture and seed sectors in Mali in general is given. Finally the project regions are presented. Qualitative (expert interviews, focus groups and participatory rural appraisal-tools) and quantitative (questionnaires) methods were combined to assess the local seed systems and the project activities related to seed production and dissemination (Chapter 3). These activities were addressed by action research, accompanying the local project partners over 2 years.

In chapter 4, the results for the local seed systems in the two project regions are presented. Analysis of the seed systems is based on the Seed Security Framework formally published by REMINGTON *et al.* (2002). The main components of the Framework are variety choice, seed management including seed availability, and seed access. To assess the basic conditions in the regions socio-economic data and data related to the farming system were also collected.

The two project regions, Dioïla and Mandé, are located in southern Mali. They are similar in terms of agro-ecology and rainfall pattern (800–1000 mm) with the staple crop sorghum, but differ widely in the degree of mechanization of agriculture, market-orientation, infrastructure and organizational environment. In Dioïla, cotton is the cash crop, produced with the support of the parastatal textile company (CMDT). Here farmers are better equipped, cultivated areas (including those for sorghum) are larger, and commercialization of sorghum grain is more developed than in Mandé. The variety classification used by Malian farmers is not consistent. Classification criteria are mainly based on phenotypic differences between *Sorghum bicolor* races and on the different uses of the varieties to satisfy their multiple needs. Variety diversity is high in both regions, especially at village level, with about 10 varieties. Farming households cultivate on average two varieties with diverse traits that correspond with their requirements. Diversity at household level increased after a drought year via seed supply from outside the household through local channels, but also through access to improved varieties from the project. Farmers change varieties regularly. Sources of new varieties are first their own family, supplemented mainly by neighbours in Dioïla and by friends in Mandé. Seed transaction for variety introduction is primarily realized by exchanges (Dioïla) or gifts (Mandé). Seed selling from farmer to farmer is regarded as a social taboo in both regions. Information about new varieties is primarily obtained from other farmers, through observation in neighbours' fields or by travelling in the country. For a majority of households (about 90%), seed management is based on seed of their own production. The numbers of households able to save their own seed were slightly lower after a drought year. Seeds are selected in their own field and stored as sheaves or panicles in secure places, such as a granary or in the house. Seed access is also based on transactions in the social network.

Women also cultivate sorghum in over 80% of households in Mandé and in about 50% in Dioïla. Women are interested in new varieties and especially in the possibility of having access to seeds through channels other than the husband or the extended family.

Chapter 5 presents the seed dissemination activities conducted by different project partner organizations in the two zones. In the project, seed production was initialised for improved varieties, which were evaluated with farmers' participation. Adequate seed dissemination activities as well as farmer-preferred traits of the varieties are crucial for a successful diffusion of these products. Different approaches and diverse varieties were chosen by the local partner organizations for respective activities. In Dioïla, seed production and dissemination is mainly based on the members of the local cereal producer organizations (OPCs) of the project partner ULPC. At community level, seed producers were designated and seeds were sold by the community-level organizations. In Mandé, activities started more proactively with the successful organization of a seed fair in the first year. Success of seed sale activities prompted the participants to create a cooperative in the second year. Moreover, the participation of a vegetable seed trader linked the activities to partners of the

commercial sector from the beginning, and the strong support of an NGO with long local experience made a difference in the implementation of the activities. The weak point in both regions is the financial dependence of seed commercialisation on project credits that initially were not scheduled. In the 2 years of the study, the partners found no solution to the problem of financial support. The financial insecurity also hindered costly investments for seed treatment and storage, as well as purchase of inputs for production, like fertilizers. The seed fair 2005 and the seed sale in 2005 were evaluated from the seed buyers' perspective. The seed fair was a success mainly as a promotion activity to make the new varieties and the availability of seed known in the communes. Further, it was a first experience for the farmer organizations to learn that seed sale is possible, even at a higher 151 price. Seed sale in 2005 continued well in both regions and the new varieties appealed to the customers.

It can be concluded that the local seed systems fulfill farmers' seed security requirements, as a high diversity of adapted varieties is available and accessible. This diversity helps farmers to react to challenging conditions. The flexibility can be enhanced by increasing the diversity by modern varieties, adjusted to farmers' preferences and requirements. The access to seeds (including those of MVs) can be improved through better information exchange in the local systems. The existing systems must be supported by better cooperation with formal research facilities to achieve a stable cereal production. The efficient use of varieties (including MVs) that are based on local germplasm, contributes to *in situ* conservation of agro-biodiversity.

Approaches to improved seed dissemination of MVs depend on specific conditions in the regions, like seed demand, organizational development, and economic situation of farmers. To sustain seed production and diffusion, it will be crucial to integrate the activities into the existing systems and to further develop links to research institutions, the seed sector and the actors in the sorghum value chains.

In Chapter 6, an outlook and recommendations are given, especially for the integration of new approaches to seed supply into the local seed systems, what requires maintaining, and establishing linkages for seed production and diffusion. Finally, suggestions for diversity conservation and further research are made.

Bettina Haussmann

Title	: Evaluation participative des préférences paysannes pour les variétés de mil (Sud Ouest Niger) : Cas de Sadoré et Léléhi.
Degree	: Diplôme d'ingénieur de l'IPR/IFRA de Katibougou
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Institute	: Institut Polytechnique Rural de Formation Et de Recherche Appliquée (IPR/IFRA) de Katibougou, Mali
Supervisor	: Bettina IG Haussmann
Period	: July 2005 to December 2005
Submitted	: 2005

RESUME

Le Niger est l'un des grands producteurs de mil [*Pennisetum glaucum* (L.) R. Br.] en Afrique de l'ouest. Son déficit alimentaire se creuse depuis 30 ans à cause de la stagnation du rendement de mil. Le Centre International de Recherche dans les Zones Semi-Arides (ICRISAT) souhaite de réorienter son programme de sélection du mil vers une approche participative, pour augmenter le têt d'adoption des variétés améliorées. Donc l'objectif de cette étude était d'évaluer les préférences paysannes pour le mil dans les villages de Sadoré et Léléhi au sud-ouest Niger (zone Soudano-Sahélienne). Neuf variétés améliorées et la locale étaient cultivées au milieu réel, sous gestion des paysans. L'évaluation était couplée à des enquêtes socio-économiques pour déterminer si les facteurs comme genre, age, taille de la ferme, présence du bétail etc. jouent un rôle dans le choix des variétés du mil. Pour l'ensemble des enquêtés le système de production se fait sur des petites exploitations de 1 à 3 ha généralement pauvres. L'agriculture est essentiellement basée sur la culture du mil, souvent associée à des légumineuses. Le choix des variétés est basé sur des caractères phénologiques et surtout morphologiques: précocité, hauteur, tallage, grosseur des tiges, longueur des épis, rendement en grain et rendement après décorticage, et couleur de la farine. Les épis longs sont préférées pour leur adaptation à la confection des bottes, l'unité principale de mesure de production. Les variétés généralement les plus appréciées étaient ICMV IS 9222, ICMV IS 94206 et la locale à Sadoré, et ICMV IS 89305, ICMV IS 94206, et ICMV IS 92222 à Léléhi. Les femmes affirment, que l'utilisation de la variété GB8735 qui est extrêmement précoce peut réduire les difficultés alimentaires qui s'affichent en période de soudure. L'age et autres facteurs socio-économiques n'ont pas eu un effet sur le choix des variétés.

Title	: Caractérisation des Ressources Génétiques du Mil de l'Afrique de l'Ouest pour les Caractères Morphologiques et Phénologiques
Degree	: Diplôme d'Ingénieur des Techniques Agricoles, Option : Productions Végétales
Name	: AMADOU Boubacar
Institute	: Université Abdou MOUMOUNI, Faculté d'Agronomie, Centre Régional d'Enseignement Spécialisé en Agriculture (CRESA), Niger
Supervisor	: Bettina IG Haussmann
Period	: July 2005 to February 2006
Submitted	: 2006

Abstract

Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] represents a fundamental cereal for many populations of the semi-arid and arid zones of Africa and India. West Africa is a center of diversity of pearl millet. In 1976 and 2003, the Institute of Research for Development (IRD) with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and other national research centers, undertook collections of pearl millet in West Africa. The objective of this thesis is to characterize samples of these collections (1) for morphological and phenological characters and (2) for resistance to Striga [*Striga hermonthica* (Del.) Benth.].

In the first test of morphological and phenological characterization, 281 accessions were cultivated at the research station of ICRISAT at Sadoré (Niger) in plots of 3 to 10 lines, without repetition. This study showed a great diversity of the pearl millets of West Africa for all the evaluated characters, with a particular geographical differentiation for the days to flowering and length of the panicle. The accessions originating from the North have a shorter cycle and also a shorter panicle compared to the accessions coming more from the South of the sampled area in West Africa.

In the second experiment on resistance of pearl millet to Striga, 64 accessions from Niger were screened at the research station of ICRISAT-Sadoré in four (4) repetitions under artificial infestation with seeds of Striga. These accessions showed significant genetic differences for the number of emerged Striga, the severity and the number of Striga with flowers. Relatively resistant accessions with reduced numbers of emerged Striga and a grain yield higher than the average of the test were identified. These accessions can constitute important sources to increase the resistance of pearl millet to Striga.

This multiplication and characterization of pearl millet accessions from West Africa, which were rather stored in the gene banks, is a first step towards a better use of these invaluable genetic resources in the genetic improvement of pearl millet in West Africa.

Key words: *Pennisetum glaucum*, *Striga hermonthica*, Genetic Resources, Characterization, Screening, Niger, West Africa.

Title	: Estimation de la vigueur hybride et de l'aptitude à la combinaison des accessions de mil [<i>Pennisetum glaucum</i> (L.) R. Br.] de l'Afrique de l'Ouest »
Degree	: Diplôme d'Etudes Supérieures Spécialisées, Protection de l'environnement et amélioration des systèmes agraires sahéliens
Name	: GUIRA Basga Seydou
Institute	: Université Abdou MOUMOUNI, Faculté d'Agronomie, Centre Régional d'Enseignement Spécialisé en Agriculture (CRESA), Niger
Supervisor	: Bettina IG Haussmann
Period	: July 2006 to April 2007
Submitted	: 2007

Abstract

Pearl millet [*Pennisetum glaucum* (L.) R.Br.] forms the staple food for people in the semi-arid regions of the world.. Pearl millet is an allogamous species and landraces are heterozygous and heterogeneous populations. This heterozygosity permits it to take advantage of hybrid vigour. Heterosis effects and combining ability serve as a guide for choice of parents for intra- and inter-population millet improvement programmes, which are open-pollinated varieties or hybrids varieties. This study was conducted to test the hypothesis that the hybrid vigour in pearl millet should be related to the geographic distances, phenologic and morphologic differences of the parents.

In the present study, one hundred and twenty one entries containing ten males' accessions, ten females, their 100 inter- population's crosses and a control (SOSAT C88) were evaluated during the rainy season 2006 in a 11 x 11 lattice design with three replications at ICRISAT sahelian center located in Sadoré (Niger). The crosses superiority compared with their parental populations as well as their general combining ability (GCA) and their specific combining ability (SCA) were estimated for different traits to identify the best parents and crosses in Sadoré location. The crosses mean superiority compared with their parents was 120% for grain yield. Very significant GCA effects were detected in all traits indicating the importance of additive effects of these traits. The SCA effects were also significant for some traits indicating non additive effects of these traits. The best cross exhibit a potential grain yield of 1230 kg/ha.

The following crosses recorded the highest superiority over their parental populations for grain yield: F8 x M4 (180%); F8 x M10 (157%); F7 x M4 (129%); F7 x M3 (115%) et F7 x M10 (114%). The relative performance of crosses compared with the control is 105% for grain yield. These populations and their crosses can be successfully exploited as base material for development of hybrids programmes and improvement of open-pollinated varieties.

Key words: *Pennisetum glaucum*, Sadoré, factorial crosses, GCA, SCA, heterosis.

Title	: Phenotypic characterization of a pearl millet [<i>Pennisetum glaucum</i> (L.) R. Br.] core collection under field conditions in Niger
Degree	: M.Sc.
Name	: Jenny Coral Padilla
Institute	: University of Hohenheim, Stuttgart, Germany
Supervisor	: Bettina IG Haussmann
Period	: August 2006 to November 2006
Submitted	: 2007

Summary

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is an important staple crop of arid regions in Africa and Asia with a mean grain yield of 668 kg/ha and 939 kg/ha, respectively. Evaluation of genetic diversity conserved in genebanks is a prerequisite for successful use of germplasm for crop improvement. The objective of this study was to characterize the core collection consisting of 504 accessions for six categorical and 21 quantitative traits and to identify useful accessions for the West and Central African pearl millet breeding programs. Studying the geographical pattern of the variation for these traits was of additional interest. For these purposes the accessions of the core collection were evaluated with local and Indian standards in a field trial on the ICRISAT research station Sedore in Niger, Africa.

The study revealed a large variation for nearly all traits indicating the potential of the core collection germplasm to serve as sources for crop improvement. For several traits a clear geographical distribution of the germplasm was found. The most striking geographical pattern was revealed for maturity. Three principle components were found to explain 63 percent of the total variation. Major sources of separation between the accessions were grain weight, days to 50 percent flowering, panicle length and leaf length.

For various traits geographical regions could be identified with promising germplasm sources, for broadening the pearl millet breeding material. Besides, three accessions with a direct potential use in West African breeding programs were found.

Title	: Analyse de l'hétérosis, des aptitudes générales et spécifiques à la combinaison, et des effets maternels dans un diallèle complet entre sept variétés locales de petit mil (<i>Pennisetum glaucum</i> (L.) R.Br.)
Degree	: Diplôme d'Études Supérieures Spécialisées (D.E.S.S.) , Protection de l'Environnement et Amélioration des Systèmes Agraires Sahéliens
Name	: MOUMOUNI HASSANE Kadidiatou
Institute	: Université Abdou MOUMOUNI, Faculté d'Agronomie, Centre Régional d'Enseignement Spécialisé en Agriculture (CRESA), Niger
Supervisor	: Bettina IG Haussmann
Period	: 01-07-2007 to 31-12-2007
Submitted	: 2008

Abstract

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is grown as a rain-fed staple cereal by millions of poor subsistence farmers in the semi-arid tropics of Sub-Saharan Africa. The overall aim of this study was to explore the usefulness of inter-population crosses for the development of improved pearl millet open-pollinated – and hybrid varieties.

Seven pearl millet populations originating from Senegal, Mali, Burkina Faso, Niger, Nigeria, Benin and Sudan, respectively, were crossed in a diallel manner including reciprocals, thus generating 42 hybrid populations. The 42 hybrids were evaluated together with their 7 parents and 7 standards in the rainy season 2007 in a 3-fold replicated field trial at the ICRISAT Sahelian Centre in Sadoré, near Niamey (NIGER).

Initial analysis of variance showed significant differences among the entries for all agronomic characters. High grain yield was related to relatively early flowering, high plant height, long panicles, good tillering, large number of grains per panicle, high 1000-grain weight, high threshing percentage and high harvest index. Thus, a simultaneous selection for these characters can lead to improvements in overall grain yield performance.

Relative superiority of the population hybrids over their parental populations ranged from -34 to 1407 % for grain yield, thereby confirming the high potential usefulness of inter-population crosses in pearl millet improvement. The hybrid superiority was not linked to the geographic distance of the parental populations. Two hybrids, P1 x P3 (PE02967 x PE03942) and P4 x P5 (Kapelga x ICMV IS 92222) out-yielded both their parents and the local check, and are therefore promising candidates for the development of new, improved open-pollinated cultivars *via* recurrent selection. The corresponding parents may actually belong to different heterotic groups that should be further exploited.

Genetic analysis of the diallel revealed predominance of general combining ability (GCA) or additive effects for the majority of traits. However, specific combining ability (SCA) and therefore dominance effects were also significant, especially for traits linked to yield performance. Maternal effects were significant in certain crosses. Parents P1 (PE02987, Senegal) and P5 (ICMV IS 92222, Niger) presented the best GCA and revealed the best maternal effects. They should be exploited in further crosses towards development of improved pearl millet cultivars. High and positive SCA effects were found in the two highest yielding population hybrids, derived from the crosses P1 x P3 and P4 x P5. The importance

of SCA effects in these population hybrids points to the necessity of testing and exploiting SCA effects in final stages of a potential hybrid breeding program.

Key words: Pearl millet, West Africa, Diallel, heterosis, combining abilities

Title	:	Evaluation of photoperiodic response and characterization of population structure of pearl millet germplasm from West and Central Africa
Degree	:	M.Sc.
Name	:	Raj Kishore Pasam
Institute	:	University of Hohenheim, Stuttgart, Germany
Supervisor	:	Bettina IG Haussmann
Period	:	01-07-2007 to 31-12-2007
Submitted	:	2008

Abstract

Pearl millet (*Pennisetum glaucum*) is one of the staple crops of the arid and semi-arid tropics of Africa and Asia with high adaptability to harsh climatic conditions. The Photoperiodic sensitivity observed among local land races in one of the adaptation traits of this cultivars over generation in marginal environments. The flowering time response of 200 inbred lines derived from local cultivars grown across West and Central Africa to photoperiod were evaluated in field experiments at two different planting dates. The difference in the vegetative cycle between the first planting (July 16th corresponding to short day to treatment) was used as photoperiod response index (PRI) which indicates the sensitivity of the genotype and which were categorized into eight groups from 0-7. The mean values of two vegetative cycle. Approximately 61% of the inbred lines from West and Central Africa were found to be photoperiod sensitive and the sensitivity varied quantitatively showing a large range of PRI values. We observed a vast variation for flowering response and other morphological traits among inbred lines from the same country of origin. Lines were characterized for their diversity in “flag leaf emergence”, “flowering”, “plant height” and “panicle length”. The flowering response showed an north south latitude gradient, with early flowering lines were found more towards north and late flowering types were found more towards south. We observed an enormous range of morphological diversity among pearl miller inbred lines across WCA and also among inbred lines within one country of origin for “flowering”, “plant height” and “panicle length” characters.

In the second part of the study, these two hundred inbred lines were subjected to a genetic diversity analysis using 22 molecular markers (SSR) including the investigation of the population structure of these materials. We detected 347 alleles over 22 loci and the selected markers were proven to be highly informative i.e., showing high PIC values. The results showed high genetic diversity among the inbred lines across WCA and also within their countries of origin using statistical values like “gene diversity”, “allele polymorphism” and performed to group all the inbred lines into clusters. A model based cluster analysis assigned all the inbred lines to five distinct groups based on their inferred ancestry with 41% of the accessions being identified as admixtures. Clustering using Roger’s genetic distance gave similar results, with some inbred lines grouping differently from that of the model based clustering. The genetic distance (DR) values observed between the inbred lines and also among sets of inbred likes varied highly. Principal coordinate analysis performed with all the accessions using allelic data again demonstrated the diversity of these inbred lines within their countries of origin and across WCA.

The study constitutes a part of larger joint research project titled “Availability of allele specific molecular markers for genes controlling photoperiod sensitivity of flowering time in pearl millet and sorghum” at University of Hohenheim in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) centre in Niamey, Niger. The study results established here will be further used in the project as the basis for an association mapping study to identify the molecular variation responsible for photoperiod sensitivity at the genome level among inbred lines. Further, the germplasm which has been characterized both phenotypically and genotypically in this study can be used in future breeding programmes for the selection of varieties with enhanced adaptation to local environments and for production of hybrids.

Title	: Eco-Physiological Studies on Germination of the Hemi-Parasitic Weed Species : <i>Striga hermonthica</i>
Degree	: M.Sc.
Name	: Randy Nijkamp
Institute	: Wageningen University, The Netherlands
Co-Supervisor	: Bettina IG Haussmann (supervised research work in Niger)
Period	: May 2007 to December 2007
Submitted	: 2008

Abstract

Striga hermonthica (Del.) Benth is a root hemi-parasitic weed and a major biotic constraint to cereal production in sub-Saharan Africa, endangering the livelihood of many subsistence farmers. *Striga* problems are often associated with marginal environments with high cropping intensities and therefore mostly affect resource poor subsistence farmers who cannot afford the least input on their land. Severity of the parasite however, can vary tremendously between years and fields of cultivation. The presence of the parasite can be so abundant that it literally covers the field in purple. In other years through, almost no *Striga* can be observed and farmers can look forward to crop yields four to five times higher as compared to crop yields with severe *Striga* infection. We have termed this phenomenon as “*Striga* years and non *Striga* years”. The occurrence of *Striga* free years imply a huge opportunity for *Striga* control programs and unraveling the mechanisms that lead to non *Striga* years might reveal clues that lead to the development of environmentally sound control options which are within reach for poor subsistence farmers. This thesis has sought to understand, at least in part, some of the aspects that could explain the unpredictable emergence of the parasite. Hereby the focus was put on the early stages in the parasite's life cycle: seed conditioning and seed germination.

Unpublished data revealed that delayed sowing, caused by insufficient rainfall, of millet in 2007 at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger, considerably reduced emergence of *Striga hermonthica*. In our first experiment we hypothesized that during this lag period: the period where no host crop is present, *Striga* seeds are pushed back into dormancy and are no longer sensitive to stimulants. This experiment revealed that loss of sensitivity was best demonstrated with low concentrations of the stimulant simply because high concentrations are saturating and, hence induce maximal germination for a prolonged period of time even when the sensitivity to the stimulant has changed. With a GR24 dose of 0.01 mg L⁻¹, signs of secondary dormancy already became visible after 25days of conditioning. This is 30 days earlier then observed when we applied a more commonly used GR24 dose of 1 mg L⁻¹ to the seeds. Because we do not

know the quantity of stimulants excreted in the plants rhizosphere, we can not directly prove that patterns of secondary dormancy of the seed population play a role in *Striga* free years.

To examine *Striga* seed conditioning under circumstances that resemble natural conditions, a second experiment was conducted at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger.

A pre determined amount of *Striga* seeds were buried in soil samples and subjected to different soil moisture regimes for a period of 35 days. To recover the *Striga* seeds from the soil without influencing their germinability, a new seed recovery technique was developed. This technique is based on the ability of *Striga* seeds to float in a 1.28 g cm^{-3} MgSO_4 solution, followed by sieving over 100 micron sieve. The new technique was able to recover 90% of the buried seeds, without influencing their germ inability. We examined seed viability and seed mortality in closer detail by use of the seed press test as described by van Mourik (2007). We found that *Striga* seed conditioning is unaffected as long as soil moisture levels maintain between 20% to 80% of the soils water holding capacity(WHC).Furthermore the parasites seed exhibit an enormous flexibility to extreme weather conditions with periods of severe drought (0% WHC of the soil) and periods of heavy rains. Under these conditions seeds are able to repeatedly condition and decondition. During the experiment it became evident that constant high soil water levels and heavily fluctuating soil water levels led to a growing fraction of disintegrated seeds. As the experiment came to an end after 35 days, already 16% of the seed population had disintegrated seeds. Seed disintegration might therefore well play a role in the positive effect of delayed sowing by reducing the parasites seed bank.

As a final experiment we examined the germination inducing potential of common sub-Saharan field weeds. 27 weeds species that were picked from an experimental field at ICRISAT, Niger were screened 25 out of 27 species triggered *Striga* seed germination, but a direct comparison of *Striga* seed germination was obscured by differences in root mass of the species. To objectively assess the seed inducing germination potential of these weeds we introduced the term germination inducing capacity (GIC). Expressing the *Striga* seed germination per gram of root dry weight (GIC) was found a suitable solution, as stable values for GIC were obtained within species, despite considerable variation in root dry weight. 4 out of 6 species that ranked highest in GIC belong to the family of *Poaceae*.

In conclusion the results of the current experiments revealed that disintegration of *Striga* seeds may partly explain the correlation between late planting and *Striga* free years. Furthermore, we may conclude that germination of the parasite is not a host specific step. The seeds germination behavior might be characterized as opportunistic, rather than host specific. This opportunistic germination behavior of the parasite could lead to suicidal germinating *Striga* seeds in the presence of weeds which may partly explain the correlation between late planting and *Striga* free years. The role of secondary dormancy patterns in *Striga* free years however, did not became clear from our experiments. We therefore recommend future studies that quantify the stimulant production rate in the plants rhizosphere.

Title	:	Legume rhizodeposition as N source in cropping systems of the West-African savannahs
Degree	:	PhD
Name	:	Guillome Laberge
Institute	:	University of Copenhagen
Co-Supervisor	:	Bettina IG Haussmann (local supervisor of work done in Niger)
Period	:	Rainy season 2006
Submitted	:	2008

Abstract

The thesis presents the research in its West-African context along with a discussion of its findings and their implications. The methodological background is also presented. The critical reflection of the research consists in a discussion of the results embedded with in a hierarchical construction of West- African agro ecology. The hierarchical setting is inspired by system theories on the unification of ecology with scales as an organizing principle. It is generally argued that a three level discussions is needed when focusing on a given problems or subject of study: 1) the scale of interest, in this case the cropping system and the role of legumes. 2) The scale lower, in this case a plot scale or field scale with its phenomena acting as mechanisms of the upper level. 3) And yet another level above giving the research its context and significance, in this case the wider agro ecosystems scale. The results reported in the thesis on below ground N dynamics are explanatory mechanisms for upper level phenomena such as cereal legume facilitation and the potential role of legume in agricultural intensification. The wider agro-ecosystems properties are giving the research its significance.

This contextualization is followed by a review on N rhizodeposition and the potential role of legume below-ground N in the N cycle of various savannah environments. The thesis aimed at studying legume-cereal systems in the Guinean and Sudano–Sahelian zones with a special focus on the below-ground N contribution of legumes. Legumes symbiotic N fixation is potentially a large source of N in the various agricultural systems of the West-African savannahs. But the knowledge of N dynamics in soils following legume cultivation is limited due to the lack of information regarding the significance of legume roots and its associate rhizosphere as sources of N in the soil.

Past research on N dynamics following legume cultivation has thus focused on the decomposition of above-ground residues left in the field or incorporated in the soil and their impact on soil N pools. The research presented in the thesis shows that a large proportion of legume N is found below-ground at harvest in different African contexts: the rhizodeposition of N-rich compounds and the constant turnover of fine roots is a large source of N in the soil and it has been little studied. In African environments where N is often limiting crop growth and access to fertilizers is limited, legume below-ground N pools deserve greater attention from researchers as economical, easily available and potentially large source of N.

The synopsis is followed by four appendices, each presenting field experiments studying legume N dynamics. The PhD thesis is the result of three years of cooperation between of Faculty of Life Sciences of the University of Copenhagen, the Technical University of Denmark (Risoe/DTU), the International Institute of Tropical Agriculture (IITA) in Nigeria and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in the Republic of Niger.

Title	: A systematic approach to analyze the eco-geographical origin of germplasm exemplified for pearl millet [<i>Pennisetum glaucum</i> (L.) R. Br.] in the gene bank of ICRISAT Niger
Degree	: M.Sc.
Name	: Judith Miriam Elisabeth Jäger
Institute	: University of Hohenheim, Stuttgart, Germany
Supervisor	: Bettina IG Haussmann
Period	: January-April 2008
Submitted	: 2008

Abstract

Changes in climate and agricultural structures are major reasons for biodiversity decline. Food security is seen to be negatively affected above all in resource-poor regions, which are exposed to harsh climatic conditions, like the semi-arid regions of West Africa. Measures to counteract the negative impacts of this genetic erosion are examined and supported by governmental and non-governmental organizations. Also agricultural research centres all over the world are trying with local genebanks to preserve genetic material of important staple food crops growing in these harsh and vulnerable regions, most threatened by erosion. The present study was done in cooperation with the regional genebank of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Sadoré (Niger) and aims to help ICRISAT-Niger to conserve local landraces of pearl millet (*Pennisetum glaucum*) in its West African centre of origin in a complete and most efficient manner. On the basis of a newly drafted documentation system, a spatial analysis was performed to illustrate the current distribution of the collection sites of the stored accessions. Potential geographical gaps within the present collection were described, to allow ICRISAT to complete the collection of this staple cereal which is most important for food security in the West African region.

The presented work is divided into two parts – data base and spatial analysis - that are depending on each other. The spatial analysis needs as foundation a good data framework, whereas the database benefits from the information extracted by the spatial analysis. The production of the catalogue was based on data of several sources, including passport, characterization and conservation data, which were assembled on-site in the genebank in Sadoré into a database of Access®. Besides the improved handling of information for internal use as shown in several examples, the catalogue offers the possibility to integrate data into the worldwide network of SINGER, to make the germplasm data accessible all over the world. Moreover, accessions which occur more than once in the genebank were identified intending to save storage costs by removing them from the genebank. To examine completeness of the collection, gaps were identified, by a GIS-based, spatial analysis. In the geographical extent of West- and Central Africa, different attribute layers were compared with the origins of the accessions to detect attributes which were not covered by any accession in the collection. Prediction maps of pearl millet were calculated in DIVA-GIS, by means of climatic variables to indicate probabilities, where the identified gaps could be actually be filled in. Gaps could be noted within different countries, regions and soils. Moreover, all wild forms of pearl millet form a big gap, as they do not exist in the entire collection. The work is presented in a form, which helps to introduce the same methods to genebanks with similar challenges. Also a short guideline is included, to provide an overview about the methods used, to ease standardization of the procedure for other collections.

Title	: Méthodes de sélection indirecte pour l'Amélioration de la Lutte Intégrée contre le <i>Striga hermonthica</i> au Mali
Name	: Montaga Kayentao
Institute	: Université du Mali (ISFRA)
Supervisors	: Dale E Hess and Mahamoudou Traoré
Period	: 05-2002 to 12-2002
Submitted	: 2002

Abstract

Le Mali pays sahélien a une économie essentiellement basée sur l'agriculture. Cette activité qui joue un rôle de premier plan dans le développement du pays reste dominée par les cultures vivrières, notamment les céréales qui constituent la base de l'alimentation de l'ensemble de la population. Cette agriculture est caractérisée par sa faible production due à la faible utilisation des entrants agricoles à cause des moyens financiers limités, mais surtout à cause de facteurs environnementaux qui concourent à diminuer fortement les niveaux de productions. Ces facteurs sont d'ordre abiotique et biotique. Les facteurs abiotiques sont essentiellement climatiques (insuffisance ou mauvaise répartition des pluies, sécheresse etc.) et pédologiques (faible fertilité naturelles des sols). Pour les facteurs biotiques, il y a la pression des ravageurs de cultures : insectes, oiseaux, rongeurs, les maladies des cultures et les mauvaises herbes.

Les mauvaises herbes responsables des dégâts énormes chez les céréales sont les phanérogames parasites. Le *Striga* spp fait partie des adventices les plus redoutables, il parasite les céréales et les légumineuses. L'espèce *Striga hermonthica* provoque des dégâts qui peuvent aller jusqu'à 40% voire 100% de rendements. Les études de Sauerborn(1991) estimaient à 21 millions d'hectares des cultures céréalières infestées par le *Striga* en Afrique à plus de 41 millions de tonnes de pertes annuelles.

Face à ce problème plusieurs méthodes de lutte contre la plante parasite *Striga* ont été développées dans les dernières décennies. La recherche des plantes non-hôtes capables de stimuler la germination des graines de *Striga* a été explorée. Les cultures telles que le coton, l'arachide, le niébé, le sésame et le soja se sont montrées très intéressantes. L'identification de plantes non-hôtes capables de stimuler la germination des graines de *Striga*, a été réalisée en laboratoire grâce à l'application des méthodes de sélection indirecte. Celles ci constituent un moyen sûr, qui permettent un criblage rapide des faux hôtes du *Striga hermonthica*. La présente étude sur les méthodes de sélection indirecte a permis le criblage des variétés, d'arachide, de niébé, de coton, de sésame et de soja pour leur capacité à stimuler la germination des graines de *Striga* par les procédés de test des racines coupées, le test d'exsudat racinaires et le test d'Agar gel. L'identification précoce du mécanisme de résistance post infection du *Striga* sur trois variétés de sorgho a été effectuée par le test du rouleau de papier. Le but de cette étude est de contribuer de façon générale à l'amélioration des connaissances sur les techniques de lutte et de façon particulière la lutte intégrée contre le *Striga hermonthica* au Mali.

L'utilisation des faux hôtes entraînera la germination suicidaire des graines de *Striga*, en rotation ou en association avec les cultures hôtes, ce qui conduirait à la diminution des graines du parasite dans le sol

Title	:	Evaluation de nouvelles variétés de sorgho pour le rendement et la résistance au <i>Striga hermonthica</i>, ICRISAT, Samanko
Name	:	Gaoussou Diallo
Institute	:	l'Institut Polytechnique Rural de Formation et de Recherche Appliquée IPR/IFRA
Supervisors	:	Eva Weltzien and Mamoutou Seydou Traoré
Period	:	05-2004 to 12-2004
Submitted	:	2004

Abstract

Le sorgho (*Sorghum bicolor*, L Moench), constitue l'une des principales sources d'alimentation de la population malienne en particulier et celle de la population sahélienne en générale. Cependant sa production est confrontée à une contrainte biotique majeure, le *Striga hermonthica* compromettant ainsi sa productivité. Pour palier aux effets néfastes de ce parasite sur les céréales, plusieurs travaux ont été envisagés ; jusque là, ils offrent des solutions limitées pour les paysans à faible revenu. Le recourt à la caractérisation des nouvelles variétés s'avère indispensable pour accroître le rendement.

A la recherche d'une ou des variétés capables de donner un bon rendement parmi les multiples choix opérés par les paysans sous une infestation artificielle de graines de *Striga hermonthica*, un essai pour la résistance a été implanté en plein champ à la station de Samanko. Cet essai a pour objectif d'évaluer la productivité des nouvelles variétés de sorgho et identifier les variétés résistantes ou sources de résistance au *Striga hermonthica*.

Cinq nouvelles variétés ont donné un bon rendement par rapport à l'ensemble ; il s'agit de 98SB-F2-82 (2,044 t/ha) ; 02F4DT-272 (1,862 t/ha) ; GPN01-267-9 (1,843 t/ha) ; GPN01-266-2 (1,778 t/ha) et GPN01-260-27 (1,777 t/ha). Toutes ces variétés sont de courte taille et présentent un niveau acceptable de résistance par rapport au témoin résistant.

Plusieurs variétés ont manifesté un niveau acceptable de résistance par rapport au témoin résistant, la variété la plus résistante a été 5147OR (1353), suivi de IS 25650 (1492), IS 26077 (1952) etc.

Parmi les variétés nouvellement sorties des programmes de sélection, il y avait quelques-unes qui présentaient une susceptibilité élevée à l'infestation du *Striga hermonthica* comme exemple GPN01-261-1 (7280). Il est essentiel que les nouvelles variétés soient évaluées par rapport à au rendement et à la résistance au *Striga hermonthica* avant qu'elles soient mises à la disposition des paysans.

Title	:	Evaluation variétale chez le sorgho géré par les producteurs de Kossourou, Cercle de Dioila, Mali
Name	:	Sissiman Abdoul Karim Ky
Institute	:	l'Institut Polytechnique Rural de Formation et de Recherche Appliquée IPR/IFRA
Supervisor	:	Eva Weltzien Rattunde
Period	:	01-05-2005 to 30-09-2005
Submitted	:	2005

Abstract

Le sorgho (*Sorghum bicolor*), culture principale des régions semi-aride tropicales et subtropicales, occupe la 5^{ème} place de la production céréalière après le blé, le riz, le maïs, l'orge dans le monde (House, 1988).

En Afrique de l'Ouest, le sorgho occupe plus de 30% de la production de céréale (Kanouté, 2003). Au Mali, le sorgho constitue la base alimentaire des populations et est cultivé entre les isohyètes de 400 mm à 1300 mm. Autrefois cité comme le grenier de l'Afrique de l'ouest, le Mali est un pays à vocation céréalière, le mil vient en tête, suivi du sorgho, et des autres céréales (riz, maïs) (ICRISAT/IER, 1988). Aujourd'hui, ce pays à l'instar des autres pays sahéliens, traversent d'énormes difficultés en ce qui concerne la sécurité alimentaire. La faiblesse de la progression des productions céréalières (avec un taux d'accroissement de 1,5%), conjuguée à la forte poussée démographique estimée à 2,5% par an, ces deux facteurs combinés aux contraintes biotiques et abiotiques rendent la situation encore plus inquiétante. Selon des études démographiques, (Cours Expérimentation Agricole IPR) l'Afrique subsaharienne importera à l'horizon 2020, plus de 30 millions de tonnes de céréale par an. Dans un tel contexte, l'augmentation de la production agricole dépendra beaucoup plus de l'intensification de la production, dont l'utilisation de nouvelles variétés ayant un potentiel plus élevé de production et bien adaptées aux conditions agro-écologiques.

C'est dans ce cadre que l'ICRISAT-Mali, en collaboration avec l'IER, conduit depuis 1979 un programme d'amélioration variétale de sorgho. Ces deux instituts ont donc mis au point, un certain nombre de variétés nouvelles qui font l'objet d'évaluation dans les champs paysans pour le rendement et l'adaptabilité. C'est sur la conduite de cette évaluation que j'ai eu à effectuer mon stage de fin de cycle sur thème « Evaluation Varietale sur le Sorgho géré par les paysans de Kossourou » dans le cercle de Dioila.

Title	: Evaluation de variétés de Sorgho pour le rendement grain, la biomasse et la teneur en sucre, Samanko (Mali)
Name	: TCHIDJOLBE Fatime DAGOU
Institute	: Université de Bamako Faculté des Sciences et Techniques DER Sciences Biologiques Appliquées Amélioration des Végétaux
Supervisors	: Eva Weltzien and Ousmane Niangaly
Period	: 05-2007 to 12-2007
Submitted	: 2007

Abstract

L'objectif de notre étude était d'identifier les variétés de sorgho sucré pour un rendement en sucre, en quantité du jus et pour des adaptations à des zones agro climatiques du Mali. L'ICRISAT, par ces techniques d'amélioration variétale a pu mettre au point un certain nombre de variétés agronomiquement et physiologiquement intéressantes pour la production du bioéthanol. En effet, pour que ces variétés puissent être diffusées au Mali, une étude d'accompagnement d'abord en station, en sous station et en milieu rural doit être faite. C'est dans ce cadre que nous avons réalisé une étude sur des variétés hybrides et à

pollinisation libre de l'Inde complétées avec les variétés locales du Mali. Le dispositif expérimental utilisé est un lattice carré dix fois dix (10 x 10). Les entrées étaient au nombre de cent (100) en trois répétitions.

L'essai a été conduit sur un sol ferrugineux caractérisé par une texture argilo-sableux. La superficie totale de l'essai était de 1512 m² avec des parcelles élémentaires de deux lignes de 3m de longueur. Une pluviométrie annuelle de 809,4 mm a permis à nos variétés de boucler leur cycle. Nos observations ont porté sur vingt quatre paramètres parmi lesquelles la vigueur à la levée et au développement, la date d'épiaison, la hauteur des plants, la teneur en sucre (Brix), le poids et le volume du jus, le nombre de poquets et plants à la levée et à la récolte, le nombre et le poids des tiges et des panicules. Les résultats présentés dans le document portent sur les paramètres énumérés et la biomasse sèche.

Il ressort de cette analyse une différence significative entre les variétés. Les hybrides ont produit une grande quantité de jus par rapport aux variétés locales de l'Inde et du Mali. Parmi les variétés hybrides certaines sont bien adaptées aux conditions agro climatiques de la zone de test. Les variétés locales du Mali ont produit un jus qui contient une teneur en sucre plus élevée, suivies des locales de l'Inde et des hybrides.

Le pourcentage de Brix, facteur déterminant la teneur en sucre dans le jus de sorgho est fortement corrélé à la date d'épiaison (0,85) à la hauteur des plants (0,74) chez les variétés locales de l'Inde et à la date d'épiaison (0,736) chez les locales du Mali. La corrélation pour ces mêmes paramètres est très faible pour les variétés hybrides (0,2). Le volume du jus de sorgho n'est un facteur très important pour la teneur en sucre chez les variétés hybrides et locales provenant de l'Inde. Par contre chez les variétés locales du Mali il ya eu une corrélation moyenne entre le volume du jus et la valeur du Brix (0,491).

Enfin Ces données peuvent aussi servir d'information pour la nécessité de la reprise de l'étude pour une confirmation

Title	: L'Evaluation Participative des Nouvelles variétés de Sorgho pour l'Adaptation et le Rendement dans deux Zones dans la Zone Soudanienne du Sud du Mali
Name	: Moussa Kanouté
Institute	: l'Institut Polytechnique Rural de Formation et de Recherche Appliquée IPR/IFRA
Supervisors	: Eva Weltzien and Alhousseini Bretaudeau
Period	: 05-2003 to 12-2003
Submitted	: 2003

Abstract

Le sorgho est une des principales céréales cultivées dans le monde. Il occupe la cinquième position après le blé, le riz, le maïs et l'orge. Il constitue avec le mil la base de l'alimentation de la majorité de la population africaine notamment celle des zones arides et semi – arides et du Mali en particulier.

Statistiques de production du sorgho en 2001 (FAOSTAT, révisé)

La production mondiale de sorgho était de 58 ,1 MTM en 2001. Cette production provenait de 100 pays. Les principaux pays producteurs de sorgho, par ordre décroissant, étaient les États-Unis (13,1 MTM), le Nigeria (7,7 MTM), l'Inde (7,4 MTM), le Mexique (6,7 MTM), la Chine (2,9 MTM), l'Argentine (2,9 MTM) et le Soudan (2,5MTM). La superficie plantée de sorgho était d'environ 42,6 millions d'hectares en 2001 et le rendement moyen de production par hectare de 1,36 TM. Les pays comme les États-Unis, la Chine, Israël, la France et l'Italie produisaient entre 4 et 7 TM/Ha tandis que le Mexique, le Panama et le Nicaragua avaient un rendement entre 1 et 2 TM/ha La plupart des pays en développement d'Afrique avaient des taux de production inférieurs à 1 TM/ha.

Bien que le sorgho soit devenu un important composant dans l'agriculture des pays industrialisés, il reste cependant l'une des principales cultures céréalières des pays en développement. La production mondiale du sorgho pour l'année 2005 était de 56957314 tonnes sur une superficie de 42.685.302 ha avec un rendement moyen de 1334,4 Kg/ha (FAO, 2005).

Au Mali, le sorgho et le petit mil constituent l'aliment de base de plus de 80 % de la population (ICRISAT 1988). Il est cultivé en conditions pluviales entre les isohyètes 400 et 1300 mm et en condition de décrue dans le Nord du pays. En 2004, le Mali a produit 664083 tonnes de sorgho sur une superficie de 1 million d'hectares avec un rendement moyen faible de 664,1 kg/ha (FAO, 2004). Ce faible rendement est surtout dû à des contraintes de nature abiotique et biotique tels que la mauvaise répartition des pluies, le faible niveau de fertilité des sols, la dégradation accélérée des terres cultivées, les conditions socio-économiques, le faible potentiel productif des variétés locales, les insectes, les mauvaises herbes, les maladies, etc.

Pour améliorer ce faible niveau de productivité des variétés locales, plusieurs travaux de recherches ont été entrepris dans le domaine des techniques culturales, de lutte contre les ennemis mais surtout de l'amélioration variétale afin d'augmenter la productivité et assurer une sécurité alimentaire durable dans le pays.

C'est dans cette perspective que le Programme Sorgho de l'ICRISAT a initié un nouveau projet dénommé « Accès a la diversité variétale du sorgho ». A travers ce projet des nouvelles variétés ont été crée mis à la disposition des paysans dans deux localités du Mali : Dioïla et Mande. C'est dans ce cadre que se situe le présent travail dont le thème est : « Evaluation participative des nouvelles variétés de sorgho pour l'adaptation et le rendement dans deux zones soudanienne du sud du Mali »

Cette étude porte sur 16 traitements en tailles courtes et en tailles hautes dans neuf zones agro-écologiques (Magnambougou, Seribila, Tonka, Banco et Seyla, Teneya, keniero, Siranikoro et Siby). Les 16 variétés sont en deux répétitions chez chaque paysan. Un dispositif alpha design est utilisé pour tous les sites. Des paramètres agronomiques et des appréciations paysannes ont été mesurés dans chaque site.

Cette étude permet éventuellement de dégager les meilleures variétés nouvelles de sorgho qui s'adaptent mieux dans chaque zone ou chaque village avec un potentiel productif plus élevé et une meilleure qualité culinaire afin d'améliorer une sécurité alimentaire du monde paysan.

Global Theme on Agroecosystem

**Abstracts of Students Research Projects
2002-2008**

**Abstracts of Students' Research Projects
(Research Scholars, Apprentices, Research Fellows and Trainees)**

2008:

Title	: Mapping spatial variability of micronutrients in Tumkur district
Name	: Tina Geisler
Institute	: Germany
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2008

Abstract

One of the major reasons for low rainwater use efficiency in the micro watersheds is inappropriate soil fertility management practices followed by farmers. In the community watershed management, it is a challenging task to provide soil health information to farmers in the SAT as there are large numbers of smallholder farmers in the region.

It is difficult to do agricultural management in a whole district without having fundamental information base of physical conditions of the area. To support improved and balanced nutrient management decisions, the present work deals with the spatial variability of boron, sulfur and zinc in Tumkur district of Karnataka in South India. In order to interpolate the results of stratified soil sampling in the villages, an interpolation method in the Geographical Information System (GIS) at a suitable scale was standardized and the results were validated. Through the standardized GIS-based interpolation method, agricultural extension personnel and farmers, watersheds can be provided with reliable and cost efficient soil analysis results of total Tumkur district for developing balanced nutrient management strategies.

Title	: Crop simulation modeling
Name	: B Gangaiiah
Institute	: Indian Agricultural Research Institute, Pusa, New Delhi
Supervisors	: Suhas P Wani and Piara Singh, Principal Scientists
Year	: 2008

Abstract:

This study was undertaken to assess the crop simulation model. It has been found that the DSSAT and APSIM models are useful tool for predicting the effects of climate change on agricultural production, productivity vis-à-vis the food security of the world. For example, the effects of high temperatures at grain filling stage on performance of wheat can be simulated by using APSIM. The models help in estimating potential yields and in conducting the yield gap

analysis. Because of the availability of these models, experimentation at all location where information on soil and weather are not available can be avoided. Thus, models can be handy in evaluation of breeders. However, there are drawbacks like the usefulness of the models has to be judged by the user for his situation and they cannot be applied for all situations. It also requires knowledge of programming (FORTRAN/ C++) skills to develop or modify models.

Title	: Impact of climate change on agricultural productivity in India's semi-arid tropics
Name	: Todd Matthew Wynn
Institute	: USA
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2008

Abstract:

Climate change is predicted to negatively affect agricultural productivity in India's semi-arid tropics. The possible damaging effects vary depending on the magnitude of the changes in temperature, rainfall, and standard deviation of rainfall. Irrigation is one method that potentially offsets negative effects of climate change by as much as 30% in the aggregated regression.

Disaggregating the model by income tercile showed similar negative effects of climate change on land values but with differing marginal effects of irrigation. The tercile analysis showed that the lowest income households are the most negatively affected. Add to that, they also have the least capacity to adapt to these changes. The highest income households are likely to suffer because a large part of their income (56%) comes from agriculture. However, these households have a higher capacity to adapt by implementing irrigation.

This paper also revealed some misgivings about the Ricardian method as the magnitude of the effect of atmospheric CO₂ differs from plant to plant, especially with regard to their ability in using CO₂. Despite these misgivings, the analysis through this method shows that by holding technology and CO₂ fertilization constant, a temperature increase of only 1° Celsius will have considerable negative effects on agricultural productivity, with increasing damages as temperatures continue to increase.

Since dryland agriculture is so susceptible to climate change, farmers in India should irrigate their land to mitigate the risks of climate change. The Government of India should influence farmers to irrigate their land through subsidies on well digging, bore-well drilling, and by funding effective watershed projects. In addition, effective meteorological reports should be made available to farmers to help them decide the best time to plant and harvest. Access to weather forecast reports could greatly increase the farmer's ability to react to upcoming weather anomalies and effectively plan for the upcoming growing period.

Title	: Study of vermicompost for <i>Jatropha</i> de-oiled cake and its effect on tomato plants in green house
Name	: K Anuradha
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani, Principal Scientist and team
Year	: 2007

Abstract

The continuous use of chemical fertilizers over a long period may cause imbalance in the micro flora and thereby, indirectly affect the biological properties. Ultimately, it may have an adverse effect on the soil, leading to land degradation.

There is a need to improve soil fertility by using available resources of the farm for increasing crop yield. One of the ways would be by utilization of waste through recycling for environmental safety, economic stability and ecological sustainability. Several methods have been developed to convert bio-wastes into organic manure. Vermicomposting is one such method that uses earthworms as biological agents.

Increasing industrialization in the developing world is leading to increase in the demand of fossil fuel. Several crop and tree species are good source of products that can be processed to produce bio-fuel on a sustained basis.

Bio-diesel is a renewable fuel that can be produced from vegetable oils, animal fats, used cooking oil, and waste from the pulp and paper industry. In the arid and semi-arid regions, particularly on the degraded lands and lands affected by moving sands, *Jatropha curcas* L. has proved to be a promising oil-bearing tree. The seeds of this Euphorbiaceae tree contain more than 30% oil, which can be used for making bio-diesel. The solid residue that is left after oilseed has been pressed free of oil is used as good organic manure through vermicomposting.

The present study on vermicompost from *Jatropha* de-oiled cake and its effects on the yield of tomato plant also deals with the evaluation of microbial population, analysis of all biological parameters and chemical properties and comparison of all the above parameters with different organic matter used (grass and millet + sorghum husk).

Vermicomposting bins were prepared with *Jatropha* de-oiled cake along with different concentrations of cow dung slurry, organic matter (grass and millet + sorghum husk) and earthworms.

The samples were collected from the bins before releasing the earthworms and at the time of harvest for microbial, biological and chemical analysis. The microbial population of bacteria, fungi and actinomycetes were more in the vermicompost samples collected before releasing earthworms (S₁).

In the study of biological parameters, soil respiration, microbial biomass C and microbial biomass, N were recorded high in the samples collected before releasing earthworms (S_1) and in the sample that were collected at the time of harvesting (S_2) of T_2 where the vermicompost has been prepared from de-oiled cake with sorghum + millet husk as an organic matter.

The effect of vermicompost on the growth of tomato plant was studied. Among all the treatments, when compared to biological, morphological and microbial analysis, treatment T_2 showed good results in terms of height of the plant, number of flowers, number of branches, production of fruits in early stage and in number of fruits.

Year 2007

Title	: Effect of <i>Gliricidia</i> (<i>Gliricidia sepium</i>) on quality of Vertisols and Alfisols
Name	: M Dinesh Babu
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani and Ch Srinivasa Rao, Principal Scientist & Scientist
Year	: 2007

Abstract

Global climate change due to the greenhouse effect and its impact on plant productivity is a major issue of concern to the scientific community. CO_2 is one of the principal greenhouse gases and global warming is a major consequence. Soil organic carbon is a key part of carbon cycle, which also plays an important role in crop production. Green manuring is a time-tested strategy to produce organic matter for the soil amelioration and nutrient supply. In this regard, this project focuses on identifying farming systems that can reduce CO_2 concentration in the atmosphere and increase the stocks of soil organic carbon and other nutrients while maintaining or increasing the systems' productivity. The main objective of the present study was to study the influence of the long-term effect of *Gliricidia* plantations on soil health parameters as *Gliricidia* is best known for its carbon and nitrogen fixing property.

Five soil cores were collected at each grid point from rhizosphere and non-rhizosphere, from different depths 0 - 20, 20 - 40, 40 - 60, 60 - 80 and 80 - 100 cm and analyzed for microbiological, physical and chemical properties of the soil. Enumeration of microbes (bacteria, fungi and actinomycetes) was done by the dilution plating technique using appropriate media, respiration rate of the soil sample, which indirectly reflects the amount of carbon present in the soil. Microbial biomass carbon, microbial biomass nitrogen measurements were carried out by chloroform fumigation and incubation method, and mineral nitrogen and net N mineralization measurements were done by steam distillation method.

Significant differences were observed between rhizosphere and non-rhizosphere soil with regard to microbial and biological parameters in the 0 – 20 cm depth and 20 – 40 cm depth, respectively, and for chemical parameters at all the depths. Microbial population in the rhizosphere and non-rhizosphere soils averaged 1.2×10^4 and 0.8×10^4 cfu g^{-1} of soil, which showed a twofold significant difference. SOC accounted to 36.4 tonnes per hectare in rhizosphere while it recorded at 30.6 tonnes per hectare in non-rhizosphere. A significant

correlation ($r = 0.40^*$) was observed between the soil organic carbon (SOC) and the microbial biomass carbon because of increase in microbial population, which in turn showed a gradual increase in C:N ratio in the soil.

Clearly, the increase in SOC is significant contribution to the overall carbon sequestration potential. Further research is needed to identify the mechanisms responsible for the observed patterns of soil organic carbon within and adjacent to the *Gliricidia* bunds and to quantify the C in biomass and deeper soil layers.

Title	: Heavy metal contamination in various soil types under rain-fed production systems of India
Name	: S Rama Gayathri
Institute	: Jawaharlal Nehru Technological University
Supervisors	: Suhas P Wani & Ch Srinivasa Rao, Principal Scientist & Scientist
Year	: 2007

Abstract

Rain-fed agriculture in India extends over 97 m ha, consisting nearly 67 per cent of the net cultivated area, contributing 44 per cent of the country's food production and supporting 40 per cent of the country's human population. Agriculture in rain-fed areas is uncertain because of its full dependence on rain and generally poor fertility of soils. For higher yields, nutrients like nitrogen, phosphorous and potassium are essential. However, the heavy metal contamination could also lessen the yields. An attempt has been made to study the heavy metal concentrations in various soil types under rain-fed production systems of India. The soils that occur in rain-fed areas include Alfisols, Vertisols, Aridisols, and Inceptisols.

Soil samples from 21 locations of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) were characterized for availability of total Cd, Co, Cr, Ni, Pb, Cu, Mn, Zn and Mo based on profile sampling. These 21 locations covered agroecological regions from 2.3 to 12.3, semi-arid, arid and sub-humid climate, soils of Vertisols, Vertic sub-groups, Alfisols, Inceptisols and Aridisols. Rainfall ranged from 412 to 3178 mm among locations. Various physico-chemical properties of 21 profiles indicated that most of the locations were low in organic carbon, showing less than 0.5 per cent. Clay content varied widely among soil types. Low organic matter in these soils is one of the important factors contributing to low soil fertility.

The concentration of heavy metals (Cd, Co, Cr, Ni, Pb, Cu, Mn and Zn) in all the soil samples in India was found to vary between 0.05 and 2681 mg/kg. The concentration of Cd was low compared to other heavy metals and ranged between 0.8 and 4.9 mg/kg. The concentration of cobalt ranged from 4.8 to 46.6 mg/kg, chromium between 31.6 and 246.9 mg/kg, nickel between 10.2 and 102 mg/kg, lead between 0.05 and 6.8 mg/kg, copper between 4.2 and 114.3 mg/kg, manganese between 136 and 2681 mg/kg and zinc ranged between 8.1 and 129.3 mg/kg in soils. These results suggest that soils from different locations under rain-fed production systems of the country vary widely in heavy metal status.

Title	: Assessing the feasibility of organic farming in the peri-urban watersheds of Andhra Pradesh
Name	: Ishani Pruthi
Institute	: Teri School of Advanced Studies, New Delhi, India
Supervisors	: Suhas P Wani and K L Sahrawat, Principal Scientist & Visiting Scientist
Year	: 2007

Abstract

Sustainable agriculture is the need of the hour. The present system of agriculture which we call 'conventional' and practiced world over, evolved in the West as a product of their socio-economic environment, which promoted an overriding quest for accumulation of wealth. This method of farming adopted by other countries, is inherently self-destructive and unsustainable.

Organic farming is a sustainable way with use of natural products, both in case of inputs and for pest control. However, its economic feasibility and practicability in densely populated India depends on availability of huge quantities of organic matter to sustain higher yields. Peri-urban agriculture can greatly contribute to this by the supplement of sewage and sludge from the city as well as market for organically-produced foods. The report analyzes the feasibility of organic farming in Kothapally village, a peri-urban watershed of Andhra Pradesh. After careful analysis and observations with the aid of extensive surveys, the development of watershed consortium could be linked with farmer awareness levels. A control village was surveyed and the results were analyzed. In the immediate context, after having a discussion with farmers, keeping in mind their concerns, constraints and food security issues, it can be concluded that conversion to organic farming will not be feasible in the peri-urban villages. It would be possible only after proper awareness programs.

The concept of eco-farming is introduced where the input systems are chemical as well as organic but the chemicals are used judiciously. A form of this system is seen in Kothapally. This can be further refined and implemented as a sustainable system to meet the ever-growing food demand in India.

Title	: Soil microbial-diversity as influenced by the cropping systems
Name	: T Keerthi
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani & KL Sahrawat, Principal Scientist & Visiting Scientist
Year	: 2007

Abstract

Soil microorganisms vary widely in semi-arid soils as compared to other tropical soils due to the poor vegetation, which is the result of erratic and scanty rainfall. The treatment of soil by chemical fertilizers, bio-fertilizers not only enhances soil fertility but also enriches microbial life.

Microbial diversity, being an integral part of biodiversity includes bacteria, fungi, actinomycetes, etc. New strains for crop improvement, sustainable agriculture, land reclamation and use of rhizosphere bacteria for disease suppression have been the most sought after scientific arenas.

This project involves the study of microbial diversity, influenced by the cropping systems in the soil samples collected from Kothapally, Andhra Pradesh. Microbiological and chemical properties of the soil samples were analyzed to study the microbial diversity of the cropping systems. Enumeration of microbes (bacteria, fungi and actinomycetes) was done by dilution plating technique, using appropriate media; microbial biomass carbon and microbial biomass nitrogen were determined by chloroform fumigation and incubation method, mineral nitrogen and net nitrogen mineralization by steam distillation method. Diversity in the colony morphology of bacteria and fungi were recorded, different staining techniques were performed and the results were recorded.

Population of bacteria, fungi and actinomycetes were affected significantly with different rates of fertilizer treatments at all the crop growth stages. Increasing trend of microbial population was noticed after 30 days of sowing and was reduced to half of the initial population at the flowering stage. Significant increase in actinomycetes population and a decline were observed in bacterial and fungal population as the crop was growing. Percentage of carbon and nitrogen content were reduced with the growth of the crop i.e., from pre-sowing (T0) to vegetative stage (T1) and to flowering stage (T2) from 84% - 77% and 87% - 80% which correlated with the decline in microbial population, especially as it reached flowering stage due to the maximum utilization of the soil nutrients by the plants.

This study enabled us to partially unravel the synergistic interactions of microbial population and the five cropping systems (cotton, maize-pigeonpea, maize, chrysanthemum and tomato). The outcome of this experiment necessitates further studies in exploiting the complex processes, which regulate the dual impacts of micronutrients and beneficial soil organisms to derive a technology for sustainable crop production.

Title	: Impact of integrated pest management (IPM) practices on the occurrence of pesticide residues in watersheds
Name	: K Kiran Kumar Reddy
Institute	: Jawaharlal Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani & Ch Srinivasa Rao, Principal Scientist & Scientist
Year	: 2007

Abstract

The present study was undertaken to assess the “Impact of integrated pest management (IPM) practices on the occurrence of pesticide residues in watersheds” at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, in 2007. Pesticide residues analysis was done in two vegetable crops (tomato and cucumber), collected from different fields and water samples from bore wells and open wells of Kothapally village. The residues were estimated using a quick, simple, inexpensive and effective sample preparation method, followed by concurrent analysis with gas chromatography-mass spectrometry (GC-MS).

The results indicated the presence of residues of monocrotophos, chlorpyrifos, cypermethrin and endosulfan in both vegetable and water samples. The monocrotophos residues ranged from 0.001 to 0.011 mg kg⁻¹, chlorpyrifos from 0.001 to 0.330, endosulfan from 0.001 to 0.466, and cypermethrin from 0.001 to 0.118 mg kg⁻¹. In all the samples, the residue levels of four chemicals were less than the maximum residue limit (MRL), except in one where the residue of chlorpyrifos in cucumber (0.330) was more than MRL (0.2 ppm).

As the season advanced the residues increased considerably. This may be due to the use of pesticides during the harvest period by the conventional farmers. In case of IPM farmers, the presence of residues may be due to the leftover residues in the soil and water. Another reason may be the presence of non-IPM farmers beside their fields.

The water samples from open/bore wells revealed the presence of pesticide residues though the residue levels were below MRLs. Open wells had more residues than bore wells due to direct exposure of open wells to air. This is a preliminary study carried out at the village. Further detailed studies covering more crops and products need to be conducted for better results.

Title	: Study of vermicompost prepared from <i>Pongamia</i> de-oiled cake and its effect on tomato plant in greenhouse experiment
Name	: A Lalitha Bhargavi
Institute	: Jawaharlal Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani, Principal Scientist and team
Year	: 2007

Abstract

Chemical fertilizers used on a large scale result in leaching and volatilization, causing groundwater pollution and environmental degradation. Bio fertilizers can be a big boon for our country where farmers are marginal landholders. Use of organic and bio fertilizers offer a great opportunity for sustainable crop production.

Bio fertilizers are better alternatives for reclamation of wasteland when compared with chemical fertilizers. For most of the crops and soil condition, up to 20% of the nitrogen requirement can be met through bio fertilizers, which can be best replacement for chemical fertilizers. It may help to reduce the cost on chemical fertilizers and avoid soil problems.

There is need to improve soil fertility by using available resources on the farm for increasing crop yield. Some of the obnoxious weeds and crop residues can be converted into value added farm compost through enrichment with rock phosphate (RP) and biological agents such as phosphate solubilizing microorganisms such as, *Aspergillus awamori*, free-living nitrogen-fixing bacteria such as *azospirillum* species, fungi and earthworms.

Organic fertilizers include both plant and animal bi-products. They act slow. Organic nitrogen fertilizers include oil cakes, fish manure, dried blood from slaughter houses, etc., whereas organic phosphorous are from bones and organic potassium are from cattle dung ash, wood ash, leaf mould, tobacco stems and water hyacinth.

Bio-diesels are ester-based oxygenated compounds derived from natural, renewable biological sources such as vegetable oils.

Pongamia pinnata is one of the major bio-diesel yielding plants. Vermicompost was prepared from de-oiled cake of *Pongamia* and includes different types of organic matters like grass and millet husk. Later, the vermicompost was analyzed biologically and microbially. It was found that vermicompost prepared from *Pongamia* de-oiled cake and grass as an organic matter gave good results among other treatments.

Title	: Studies on microbial parameters and dehydrogenase enzyme in the soils under <i>Jatropha</i> and <i>Pongamia</i>
Name	: D Narasimha Reddy
Institute	: Vellore Institute of Technology, Tamil Nadu, India
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2007

Abstract

Rhizosphere and non-rhizosphere soil samples from watersheds of different locations - ICRISAT, Siddapur, Velchel, Kothlapur - were collected from fields under different plantations. Rhizosphere and non-rhizosphere soil samples were collected from *Jatropha* and *Pongamia* plantations. Microbial population was recorded in both rhizosphere and non-rhizosphere soils. Microbial population was greater in the rhizosphere soil samples than in non-rhizosphere soil samples. High counts of microbial population were observed in soils with the pH in the range of 6.5-8.0. The numbers of fungi, bacteria and actinomycetes were greater in the rhizosphere than in non-rhizosphere soil samples. Soil samples collected from ICRISAT, Siddapur, Velchel, Kothlapur were analyzed for microbial activity (bacteria, fungi, actinomycetes) and dehydrogenase enzyme activity. Biomass C was estimated using chloroform fumigation and incubation method. Soil respiration was also estimated.

The results obtained were in turn correlated with rhizosphere and non-rhizosphere samples. The results showed that mean values of biological parameters were found to be higher in the rhizosphere than in non-rhizosphere of *Pongamia* and *Jatropha*. Biomass C as well as microbial population was more in *Pongamia* soil samples than the *Jatropha* soil samples, which may be because of the presence of alkaloid called jatrophin in *Jatropha* seeds. Soil enzymes in dehydrogenase activity were more in *Pongamia* soil samples than the *Jatropha* soil samples.

Title	: Identification and quantification of vesicular-mycorrhizae in the rhizosphere of <i>Jatropha</i> and <i>Pongamia</i>
Name	: Nida Hasan
Institute	: TERI University, New Delhi, India
Supervisors	: Suhas P Wani, Principal Scientist and team
Year	: 2007

Abstract

The various genera of vesicular-arbuscular mycorrhizae were identified and quantified from root and soil samples of *Jatropha* and *Pongamia*. Samples were obtained from Kothapally village (a managed watershed) and various accessions were collected from the ICRISAT campus. VAM were identified by spore morphology studies and quantified by using the gridline intersect method. VAM diversity was low as only three genera viz. *Glomus*, *Acaulospora* and *Scutellospora* were identified. Also spore counts were low. But the spore counts showed a significant correlation with root colonization, yielding an R^2 value of 0.9. The highest colonized accessions were from Mumbai and a few districts of Andhra Pradesh. Dependence of root colonization was also studied with respect to various physico-chemical parameters of the soil. The correlation between available phosphorous and root colonization was high with an R^2 value of 0.9. Similarly, the R^2 values for root colonization vs. exchangeable potassium and available sulphur were also high.

Title	: Characterization Of <i>Jatropha</i> De-Oiled Cake And <i>Pongamia</i> De-Oiled Cake Vermiwash And Its Effect On Tomato Plants In Greenhouse
Name	: A Rama Devi
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani, Principal Scientist and team
Year	: 2007

Abstract

Soil degradation and environmental pollution due to the use of chemical fertilizers is of major concern in the present day life. This problem can be overcome by use of balanced nutrient and maximum use of available organic materials. Compost or organic manure plays an important role as plant nutrients and is therefore a sustainable alternative to chemical fertilizers.

Vermicomposting is a process by which all types of biodegradable wastes such as farm wastes, kitchen wastes, market wastes, biowastes of agro-based industries, live stock wastes etc., are converted into nutrient-rich vermicompost by using earthworms. Vermicompost improves growth, quality and yield of different crops.

Vermiwash is a lechate collected after the passage of water through a column of worm culture. It is a collection of excretory products and excess secretions of earthworms along with micronutrients from soil organic molecules, and organic matter. Vermiwash has a pH of 8.5 and N, P₂O₅ and K₂O content 200, 70 and 1000 mg/l, respectively.

It is useful as a foliar spray.

The present study deals with microbial, biological, chemical analysis of vermiwash samples. The samples were collected at weekly intervals for microbiological analysis. Growth promoting and antagonistic properties were also studied using different dilutions of vermiwash samples.

Different plastic bins were filled with *Jatropha* and *Pongamia* de-oiled cake along with different concentrations of cow dung slurry, organic matter and earthworms (vermicompost). Vermiwash was collected from the bins for biological, microbial, chemical analysis, hormonal assay and also to study the antagonistic properties of plant pathogens.

The effect of vermiwash on the growth of tomato plants was studied. Vermiwash collected from the bin of *Pongamia* de-oiled cake (V W₂) was found to be more effective in stimulating the growth of tomato plant compared to other vermiwash samples (V W₁, V W₃, and V W₄). Germination efficiency of seeds (chickpea and pearl millet) was found to be more in diluted samples of vermiwash than pure samples (100%). Among the test organisms used in antagonistic properties, only one organism (*Curvularia lunata*) showed inhibition with vermiwash.

Title	: Health enhancing foods: Availability and use in Andhra Pradesh villages: A case study
Name	: Aditi Vidyarthi
Institute	: University of Cork, Cork, Ireland
Supervisors	: Suhas P Wani & T K Sreedevi, Principal Scientist & Scientist
Year	: 2007

Abstract

Nutritive traditional food is being substituted by high calorie diet that is rich in fats and carbohydrates. However, the high calorie diet will have a slow and deteriorating effect on the human body. This trend is more prominent in developing countries like India where fast commercialization is compelling people to change their lifestyle and compromise with their own old cultural and traditional practices. The study based in Deccan region of India attempts to find out local availability and awareness of health foods, the market demand and agricultural practices of farmers in the region. The study also found out that traditional nutritious food in this region is being replaced by fast food, leading to a shift in the cropping pattern of farmers.

Title	: Community watersheds for enhancing environmental quality
Name	: R Shilpika
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisors	: Prabhakar Pathak, Principal Scientist and team
Year	: 2007

Abstract

Soil plays a key role as the interface between terrestrial and aquatic ecosystems on the one hand and the atmosphere on the other. Soil is a major sink for global gases and its appropriate management affects the carbon dioxide (CO₂) balance that is important in combating global warming. If mismanaged, soil can work against us; it can pollute the air and water and lead to a fall in agriculture production. Natural resource management (NRM) interventions in terms of fertility, soil and water management practices in various farming systems have become necessary to address the problem of soil degradation. Reliable soil and water quality indicators are necessary to analyze and quantify the impacts of soil degradation. Impact assessment is essential for the development of suitable management strategies for soil and water quality.

The main objective of the present study was to evaluate the impact of watershed interventions on environmental quality - soil and water quality.

Sediment samples were collected from check dams, mini percolation tanks and soil samples were collected from its adjacent fields from nine different locations of Kothapally. The samples were analyzed for microbiological, physical, and chemical properties. Enumeration of microbes (bacteria, fungi and actinomycetes) was done by dilution plating technique; microbial biomass carbon, microbial biomass nitrogen were carried out by chloroform fumigation and incubation method and mineral nitrogen, net N mineralization were done by steam distillation method. Water samples (surface water and groundwater) were collected from check dams and mini percolation tanks where the sediment samples were collected and groundwater from nearby wells and analyzed for chemical properties.

The results revealed that the mean microbial population was recorded higher in the sediment samples (7.8%) rather than in the soil samples. All the other physical parameters and chemical composition also showed higher values in the sediment samples than in the soil samples collected from the adjacent fields. The percentage of silt and clay were 12.5% and 11.4% higher in sediment samples to that of soil samples. The percentage of difference among all the micro and macronutrients studied, nitrogen (25.8%) recorded maximum difference in the sediment samples over the soil samples. Future research is needed for developing more effective and measurable indicators of soil and water quality for the purpose of monitoring the biophysical impacts of watershed management.

Title	: Community institutionalization and post-project sustainability in participatory integrated watershed development in semi-arid India: A case study of the Adarsha watershed in Kothapally, Andhra Pradesh
Name	: Shinya Abe
Institute	: Cornell University, USA
Supervisors	: T K Sreedevi, Scientist
Year	: 2007

Abstract

Eighty percent of the world's arable land depends on rainfall. However, rain-fed agriculture is traditionally low yielding and poverty prevails in low and unreliable rainfall areas. This also happens in India and improving productivity of rain-fed systems is of utmost importance. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) developed a farmer-participatory-consortium model for sustainable natural resource management based on its long-term experience in watershed development. It implemented an integrated program with its national partners to improve rain-fed agriculture and reduce poverty in the Adarsha watershed in Kothapally, Andhra Pradesh, from 1999 to 2004. The research outlined in this paper attempted to identify mechanisms and critical factors that determine the sustainability of natural resource management and explored a new framework to improve post project sustainability and on how to expand the program to other dryland areas of India.

First, key informant interviews were conducted to obtain basic and current information with respect to community institutionalization. The interviews ascertained significant information regarding post-project sustainability in Kothapally. It was found that most types of farmers groups (FGs) are not currently active nor do they have frequent group meetings. Proper maintenance of water harvesting structures is also a concern. On the other hand, some groups, especially self-help groups (SHGs) that manage group saving and loans and other livelihood enhancement activities, demonstrate stable sustainability. They have developed their groups and activities even though there is no major watershed project in the village. Critical factors that affect post-project sustainability were consequently identified, including regular routine work, financial activities, external linkages, honor, hierarchy, caste, and dependency.

Second, the research conducted further interviews with Kothapally farmers, key consortium persons, and NGO staff and farmers in Ponganur, Andhra Pradesh, to improve the post project sustainability and scaling-up of watershed development. The research presents a new sustainable institutional model that is comprised of five main components. The first component suggests integrating all stakeholders into SHGs at the village level. The second component proposes the release of watershed development funds as community-based revolving funds to maintain water harvesting structures and upgrade SHGs. The third component advocates establishing area-wide federations as the umbrella organizations of SHGs to provide various revolving loans and insurance schemes for SHG members and to organize monthly and annual meetings. The fourth component proposes selecting village volunteers (VVs) for post-project phases. The last component recommends establishing watershed communication cafés in order to facilitate farmer extension and scaling-up. This component also involves utilizing the

communication cafés to assist SHG meetings and mobilizing VVs for scaling-up. All the components above will be able to create synergies to accomplish enhanced post project sustainability of watershed development.

Marketing, however, is the next agenda item after water availability is increased through watershed projects and groups for sustainability are established. Even with varied social assistance in Ponganur, villagers still grow the same crops as second crops with the increased water supply. Farmers are affected by market conditions in decision-making even when new crops and initiatives could be considered. This paper also deals with marketing interventions that can be integrated into the new sustainable institutional model of watershed development for farmers to benefit and improve their livelihoods.

Title	:	Biological studies in rhizosphere soil of <i>Jatropha</i> and <i>Pongamia</i>
Name	:	P Suneeta
Institute	:	Gitam College of Science, Andhra University, AP, India
Supervisors	:	T K Sreedevi, Scientist
Year	:	2007

Abstract

National Planning Commission of India has decided to have a multi-dimensional program to replace 20% of the diesel consumption through bio-diesel by integrating the Ministries of Petroleum, Rural Development, Poverty Alleviation, Environment and others. *Jatropha curcas* and *Pongamia pinnata* have been identified as potential species for bio-diesel. In ICRISAT, study is in progress on the plants of *Jatropha* and *Pongamia* for the extraction of bio-fuels. The rhizosphere can be described as the longitudinal and radial gradients occurring with expanding root growth, nutrient and water uptake, exudation, and subsequent microbial growth. With this background, the present study has been attempted to compare the microbial population, microbial biomass and soil enzymes activity (dehydrogenase) between the rhizosphere and non rhizosphere soils of *Jatropha* and *Pongamia* plantations collected from Kothapally (Rangareddy), Kadapa (Rangarajupally, Chitakommadinne mandal) and Kurnool (Sudepally, Veldurthy mandal) districts of Andhra Pradesh. Experimental design was a 2 X 3 factorial design with two soil treatments beneath and outside the influence of the root and three locations. Microbial counts were done by serial dilution and plate method. The microbial population density was 50% more in rhizosphere than in non rhizosphere, which was also confirmed by higher values of soil respiration (17.6%), biomass C (18.3%), biomass N (15.5%) than to that of the non-rhizosphere soil samples collected from all three locations. This may be due to the higher amount of roots, higher amount of amino acids in root secretions, extra matricular mycelium as in the case of fungi, inorganic matter, roots and root tips, nitrogen-fixing bacteria, more root exudation or rhizo deposition, root peelings, quantity of carbon release of enzymes from plant roots in the rhizosphere soils. From Kadapa, microbial population (55.5×10^3 cfu g⁻¹ soil) was recorded, which was two fold higher to that of microbial population found in Kothapally and Kurnool (30.8×10^3 cfu g⁻¹ soil). In *Jatropha* plantations, microbial population of (31×10^3 cfu g⁻¹ soil), soil respiration of 93.40 µg CO₂ g⁻¹ soil, biomass of C of 174.10 µg C g⁻¹ soil, biomass of N of 12.68 µg N g⁻¹ soil, mineral N of 7.71 µg N g⁻¹ soil, net N mineralization of -0.40 g⁻¹ soil 10 d⁻¹, dehydrogenase activity of 40.69 µg TPF g⁻¹ 24 h⁻¹ were found. In *Pongamia* plantations, microbial population of 46×10^3 cfu g⁻¹ soil, soil respiration of 121.69 µg CO₂ g⁻¹ soil, biomass of

C of 191.72 $\mu\text{g C g}^{-1}$ soil, biomass of N of 13.27 $\mu\text{g N g}^{-1}$ soil, mineral N of 8.02 $\mu\text{g N g}^{-1}$ soil, net N of -0.45 g^{-1} soil 10 d^{-1} , dehydrogenase activity of 45.87 $\mu\text{g TPF g}^{-1}$ 24 h^{-1} were found. The results obtained were in turn correlated with the treatments to know the soil samples that have the better biological activity. Rather than the results showed at Rangarajupally (Kadapa) and Sudepally (Kurnool), rhizosphere soil samples of *Pongamia* at Rangareddy (Kothapally) have been found to have better treatment by the high values recorded for all the parameters than that of the non rhizosphere soil of *Pongamia* and as well as the rhizosphere and non rhizosphere soil samples of the *Jatropha* plantations of all the three villages studied. In Kadapa, microbial populations and biological parameters were found to be higher than the population recorded in the other two locations - Kothapally and Kurnool.

Title	: Impact of management strategies for enhancing soil quality in Vertic Inceptisols
Name	: Vincent Richer
Institute	: CAH, Dronten, The Netherlands
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2007

Summary

Rain-fed areas constitute about two-thirds of the total 142 million hectares cultivated in India. These areas represent only 45% of Indian agricultural productivity and allow low livelihoods for farmers. Furthermore, Vertic Inceptisols cover 60 million ha out of 72 M ha of Vertisols in central peninsular Indian landscape. That is why it is important to develop and test new ways of growing higher yields. This report assessed the impact of the ICRISAT improvement package as compared to traditional management during a long-term experiment. The study focused on the biological (microbial biomass nitrogen and carbon, net nitrogen mineralization and soil respiration), physical (particle size distribution and bulk density) and chemical properties (pH, EC, the different plant available form of nutriment and micro-nutrient and the total nitrogen and phosphor).

The long-term field experiment was initiated in 1995 rainy season at the ICRISAT research station, Patancheru (78 16' longitude, 17 32' latitude and 540 m elevation), Andhra Pradesh, India. The experiment was conducted on Vertic Inceptisols from the Kasireddipally series with a general slope of 2% and a variation in soil depth from 30 cm to 90 cm (depth of black soil). After many years of grassed-fallow, the land was developed in a 15 ha watershed. For this experiment, four hydrological units were selected, depending on soil depth (90 cm to 50 cm and <50 cm) and system management (improved and traditional) : 1) medium depth improved management, 2) medium depth traditional management, 3) shallow depth improved management, 4) shallow depth traditional management.

Results from this 11-year long-term experiment indicated that improved management options allow a higher TOC content in medium depth soil. Those results cannot be confirmed on shallow deep soil because of leaching phenomena. The TOC content was directly or indirectly contributing to several available forms of nutrient and micro-nutrients. These findings have demonstrated that by adopting holistic approach with legume, land, water and nutriment

management options potential of Vertic Inceptisols can be harnessed for increasing soil quality and productivity for sustainable livelihoods.

2006:

Title	: Carbon and nitrogen stocks of the soils of varying climates and land uses, Golestan Province, Iran
Name	: Farhad Khormali
Institute	: Gorgan University of Agricultural Sciences and Natural Resources (GUASNR), Iran
Supervisors	: C L L Gowda, Suhas P Wani , Principal Scientists & Ch Srinivasa Rao, Scientist
Year	: 2006

Abstract

Selected biological soil quality indicators i.e. soil respiration, microbial biomass, biomass nitrogen, C: N, net mineralization, population of the microorganisms together with total carbon, organic carbon, inorganic carbon and total nitrogen were studied to investigate their variability in soils of different climatic regions and also to evaluate the role of landuse change and deforestation on their dynamics. Twenty soil profiles, ten as a climosequence and ten pedons from different geomorphic units of a hillslope (summit, SU, shoulder, SH, backslope, BS, footslope, FS and toeslope, TS) of both forest landuse (FO) and an adjacent deforested cultivated land (DeF) were dug and described. The results of analyses of soil samples showed that OC, TC, TN increased with increasing precipitation, while inorganic C (IC) decreased. Mineral N did not show any significant difference with rainfall variation. Leaching of IC as carbonate was responsible for the decrease of IC with the increase in rainfall. IC in the subsurface horizons therefore had accumulated. OC, TN and mineral N in the subsurface horizons did not show any significant differences. In the studied forest and cultivated land use systems, OC, TC, TN and mineral N were higher in forest in all the different geomorphic surfaces. IC was absent in all the different geomorphic surfaces of forest indicating its downward leaching due to higher infiltration of rainfall in this land use. In addition, analysis showed that soil respiration values were significantly different between two land uses in all geomorphic positions, in the 0-30 cm soil layer.

Title	: Is short-duration pigeonpea the right choice for poor farmers in Bundi watershed?
Name	: Jørgen Hugo Jensen SLing
Institute	: Forest & Landscape, Nødebo, Denmark
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2006

Abstract

Pigeonpea is one of the five mandate crops of ICRISAT. Improvement in varieties has been done since 1972. In Rajasthan, it has not been cultivated traditionally. ICRISAT and partners are trying to transfer their knowledge to poor farmers of the semi-arid tropics through integrated watershed management approach. They are interested in up-scaling cultivation of short duration pigeonpea in the Eastern Rajasthan watershed area, because it is suitable for the agroecological conditions in the area; and the crop fits in the present double cropping pattern and has multipurpose potential as risk minimizing by crop diversification.

The potential advantages and disadvantages of SDP were assessed through literature and a questionnaire study of twenty-eight local farmers. The study also revealed farmers' willingness to adopt previously introduced agricultural technologies and improved crops/varieties. Calculations on four farmers' field were made, comparing the possible net profit of SDP with maize, sesame or soybean cultivation.

Many farmers wanted to try this crop, even though they do not consume pigeonpea regularly. Some other major constraints identified were that farmers' seed bank has no seeds, they have little knowledge of cultivation practices and their expectations seem unrealistic.

Title	: Enumeration of microorganisms and characterization of enzyme
Name	: Jyoti Agarwal
Institute	: Indian Institute of Technology, Kharagpur, India
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2006

Abstract

Microorganisms perform a key role in nutrient cycling for sustaining the productivity of the soils. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has been working on biodiesel plantations of *Jatropha curcas* and *Pongamia pinnata*. In addition to this, different experimental trials were conducted at ICRISAT (special, manurial trials with and without irrigation, pruning) for *Jatropha*. The experiments were conducted to find a strategy to adopt

suitable soil and water conservation measures for growing bio-diesel plantations and management practices that can increase the yield and oil content. With this view, soil samples were collected from *Jatropha* plantations at ICRISAT with different fertilizer applications. In order to compare the microbial population and enzyme activities, soils from three different districts (Kadapa, Medak and Kurnool) that have bio-diesel plantations without fertilizer application, were collected. It was observed that microbial population was higher in soil samples at ICRISAT with fertilizer application. High counts of microbial population were recorded in Medak district, followed by Kurnool and Kadapa. Soil samples collected from ICRISAT showed maximum dehydrogenase activity with applied fertilizer. The lowest level of activity was observed when no fertilizer was applied. A significant relationship was also established between dehydrogenase activity and microbial population in soil samples collected ICRISAT farm.

Title	: Estimation of carbon sequestered in <i>Jatropha</i> and <i>Pongamia</i>
Name	: Lukhamlu Golmei
Institute	: Jawaharlal Nehru Technological University, Hyderabad, AP, India
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2006

Abstract

The increase in atmospheric concentration of CO₂ from fossil fuel combustion and landuse change necessitates identification and implementation of strategies for mitigating the threat of the attendant global warming. Forests absorb CO₂, and convert it to carbon that is stored in its wood, thus acting as carbon sinks. Estimation of aboveground biomass is an essential aspect of studies of carbon stocks and the effects of deforestation and carbon sequestration on the global carbon balance. Hence, carbon sequestration is increasingly advocated as a potential strategy for mitigating global climate change and at the same time reclaiming degraded lands, particularly in semi-arid regions of the developing world. This study attempted to estimate carbon sequestered by bio-energy plantations for rehabilitating degraded lands and for providing livelihood opportunities to farmers. The central objective was to estimate the carbon sequestered in bio-diesel plants, *Jatropha curcas* and *Pongamia pinnata*. The study was conducted for Kothlapur and Velchal villages in Ranga Reddy district of Andhra Pradesh. The methodology involved sampling of plants, which were one-year-old, by random branch sampling for the estimation of carbon concentration.

The results showed that more carbon was sequestered in *Jatropha* plants in Kothlapur village when sole *Jatropha* plants were grown as compared to Velchal village, where its plantations was mixed with *Pongamia* plants. The results were extrapolated for *Pongamia* plants of varying ages and it was found that the carbon sequestered was low during early growth, followed by exponential increase with growth until a plateau was reached.

Title	: Simulating carbon sequestration at micro-watershed scale with changes in cropping pattern and management systems
Name	: Monika Shrivastava
Institute	: TERI School of Advanced Studies, New Delhi, India
Supervisors	: Suhas P Wani, Principal Scientist
Year	: 2006

Abstract

Carbon sequestration is known to be the potential win-win strategy, as it is an option to mitigate the climate change as well as the solution to soil degradation problem by decreasing the C concentration in atmosphere and increasing the organic carbon in soil, which in turn increases soil fertility. This report explained the need of carbon sequestration, focusing on semi arid regions. It described different management practices and cropping patterns, which increase the carbon sequestration potential in soil. These practices were found to be crop residue application, no tillage organic manure addition, crop rotation, fallowing, stubble grazing, etc.

A simulation study was also conducted for Kothapally village, under different management practices (referred as eight scenarios in the report) and best management practices were identified. The results were also extrapolated for Kothapally to assess the effects of management practice and cropping pattern. The crop and the duration for which model has simulated were pigeonpea and 30 years, respectively. The model used was century (version 5), initially developed for temperate regions.

The result of simulation study had shown that there is significant increase in SOC from initial to final under four scenarios: no tillage practice, low intensity grazing, double organic manure addition (including vermicompost) substituting inorganic fertilizer and the fourth that included all the improved practices. The century model had also simulated the N in soil organic matter. The trend for N was also in correspondence with the SOC, though not completely. The inter-annual variability was difficult to explain as data for initialization were not sufficient. Two landform systems - flat and BBF were also compared for the ICRISAT campus. Simulation result showed that BBF system was more efficient in sequestering carbon in soil than flats system. From the result, it can be predicted how much carbon would be sequestered in 30 years under different agricultural practices, which will help in formulation of strategies for the future.

Title	: Influence of peri-urbanization on rural livelihoods
Name	: Priyanka Kapoor
Institute	: TERI School of Advanced Studies, New Delhi, India
Supervisors	: T K Sreedevi, Scientist
Year	: 2006

Abstract

Peri-urban regions are areas of exchange of people, goods, money and information. They act as essential entities since they are mediators between urban and rural areas. Rural areas are dependent for job opportunities, transportation, distribution and marketing systems, health and education services, private services and household consumption goods on peri-urban areas. They act as direct market for agriculture produce.

But the development of the peri-urban areas and extensification of urban areas impact the livelihood of rural people, who not only depend on the availability of natural resources but also on a number of services provided by such areas in order to earn living. Urban and peri-urban areas add to intensification on extensification of agriculture by acting as centers for technological innovation, leading to livelihood diversification and acting as centers for migrants.

A qualitative study was conducted for two villages: Kothapally and Channa Reddy Guda in Andhra Pradesh. Lack of community participation and initiatives, absence of knowledge about agriculture practices and over-exploitation have often led to degradation of natural resources in rural areas. Pressure on such resources is increasing due to increase in expansion of urban areas. Integrated watershed management taken up by government agencies, national and international organizations and NGOs play a vital role in bringing community together and reviving water and land resources. Both Kothapally and Channa Reddy Guda were extremely poor villages in Telangana region of Andhra Pradesh. With ICRISAT's intervention at Kothapally and watershed program under APRLP, and other attempts to improve the natural resources had enhanced the income levels and improved the livelihood of the villagers. Watershed programs have acted as engines of growth for villages, resulting in increased income and higher standards of living. It was found more rural people have access better job opportunities, medical services, higher education opportunities and social networks. The access to resources and services are dependent on several factors, gender being one of them. The improved standards of living impacted women differently. It was seen during this project that watershed management under APRLP was not able to deliver the desired result.

All of the above, raises the issue of sustainability of natural resources that play an integral part in the development of rural as well as urban centers. With the ever-increasing food demand in the urban centers, the agricultural production is also increasing every year to feed the growing population. Agriculture has become more intensive as is the case in Kothapally. Relevant policy measures should be taken by the government in order to maintain a balance between improving livelihoods, sustainability of natural resources and equitable access to resources by men and women.

Title	:	Effect of amendments (Mo, P and fungicides) added through seed priming on chickpea-rhizobium symbiosis
Name	:	Ch. Sravanthi
Institute	:	Jawaharlal Nehru Technological University, Hyderabad, A.P., India
Supervisors	:	JVDK Kumar Rao, Special Project Scientist
Year	:	2006

Abstract

Rice, the most extensively grown crop in South Asia, is cultivated on approximately 50 M ha. Despite growing demand for food production because of increasing population in South Asia, there is little scope for expansion of cropping into new areas and therefore, there is need to increase cropping intensity, along with rising of yields on existing agricultural lands. Rice fallows, covering an area of 14.3 M ha, present considerable scope for crop intensification and diversification along with likely improvement in soil fertility for the succeeding cereal crop with the introduction of second crop such as chickpea during post-rainy (*rabi*) season and the application of appropriate technology.

The present study has examined some aspects of growing chickpea in rice fallows, particularly the occurrence of native chickpea rhizobia vis-à-vis determine the need for seed inoculation with effective rhizobium and the interaction of rhizobium, molybdenum, phosphorus and seed dressing fungicide (captan) that are added through seed priming on chickpea-rhizobium symbiosis.

The native chickpea rhizobial populations of selected rice fallow soils of different states of India were estimated using bacteriologically controlled plant infection technique. The study examined selected rice fallow soils where there were either no previous chickpea cropping history or with a recent legume history i.e. for the last 2-3 years. The soil profiles of chickpea rhizobia in rice fallows varied across states of eastern India: Chattisgarh (3.1×10^2 to 1.7×10^5) g^{-1} dry soil; Orissa (0.0 to 1.7×10^5) g^{-1} dry soil; West Bengal (3.1×10^3 to 5.9×10^5) g^{-1} dry soil; Madhya Pradesh (1.0×10^2 to 3.1×10^5) g^{-1} dry soil and Uttar Pradesh 0.0 . These results suggest the need for rhizobium inoculation on chickpea rhizobia for obtaining good nodulation and nitrogen fixation, which in turn influence the final yields. Correlations between MPN counts of chickpea rhizobia and corresponding soil chemical parameters such as pH, E.C, Olsen – P, total – N, organic – C, B, Zn and Mo were not significant.

In conclusion, the study provided a better understanding of rice fallow soils in terms of fertility and rhizobial status and the need for micro and macronutrients like molybdenum, phosphorus and fungicide (captan), rhizobium inoculation for growing chickpea, the beneficial effect of phosphorus, molybdenum on chickpea nodulation and growth and also the possibility of combining seed priming, rhizobium inoculation and seed treatment with fungicide (captan) into a simple operation so that it can be adopted by resource-poor farmers.

Title	: Assessing the impact of technological and policy interventions for micro-watershed management in semi-arid India: a bio-economic modeling approach
Name	: S Nedumaran
Institute	: Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
Supervisors	: Bekele Shiferaw, Suhas P Wani & MCS Bantilan, Principal Scientists
Year	: 2006

Abstract

A watershed level, dynamic and non-linear bio-economic model, incorporating both economic and biophysical aspects, was developed to assess the impact of technological and policy interventions on social well being of rural poor and condition of natural resource base in a micro-watershed of SAT region of India. For the study, socio-economic and biophysical data was collected from Adarsha watershed in Kothapally village, Rangareddy district, AP. This watershed model was developed by ICRISAT and its consortium partners to evaluate new integrated watershed development approach. The model maximized the income of the whole watershed, which included three types of households based on land endowment (small, medium and large) that were spatially disaggregated into six different segment in the watershed landscape, namely shallow, medium and deep based on soil depth under two types of land (dryland and irrigated land). The model maximized the aggregate net present value of incomes of three household groups in the watershed over a 10 year planning horizon.

The model used simplified production function to represent farmers' response to different factors of production. The crop production in the model was affected by change in soil depth, which was reduced by soil erosion. The erosion level in the watershed was estimated by using USLE model. The yield-soil depth response for different crops grown in the watershed was estimated by using econometric method.. The bio-economic model was used to assess the impact of alternative scenarios like change in the yield of dry land crops, irrigated area in the watershed, output price policies, output based water charges, improving non-farm employment opportunities and high population pressure.

The model predicted that the increase in the yield of dryland crops can lead to increase in area under sorghum/pigeonpea and maize/pigeonpea intercropping systems and reduce the area under cotton, resulting in higher income for all the household groups. The increase in yield of dryland crops will have positive effect on conserving land, resulting in less soil erosion and the nutrient mining in the watershed.

This study can be useful to policy makers and other development professionals seeking to improve the welfare of farmers and natural resource base in SAT rain-fed region in India and other countries

2005:

Title	: A study of ICRISAT's Adarsha consortium model of watershed development as initiated at Kothapally, Andhra Pradesh, India. Its contribution to watershed development in India and its potential for scaling-up.
Name	: Stephen NB Waldron, BA (Hons) Barch ARB
Institute	: International and Rural Development Department, The University of Reading, UK
Supervisors	: Suhas P Wani, Principal Scientist
Period	: 8 – 30 June 2005

Abstract:

Watershed Development (WD) has since 1994 been the Government of India's principal agricultural development strategy in its effort to assist poor rural farmers. Complementary to 'The Green Revolution', it concentrates more on marginal rainfed lands, rather than irrigated, and works with an entire rural community rather than a set of fields. Its central focus is water. Amongst many models of watershed development, ICRISAT'S Adarsha consortium model (ACM) emerged from 1999–2001 with a unique feature of a team of backstopping scientists rather than a single agency. As with many other schemes, intertwined with its apparently straightforward 'water+soil' focus, was the creation of simple livelihoods, capacity-building, and institutional support. It has been relatively easy for WD to improve productivity in the short-term, but maintaining this has proved more elusive. To sustain new livelihoods and community institutions has been a challenge once again. Beyond these, over time, have emerged a whole set of less 'scientific' challenges such as accessing 'fair' markets for farmers' improved crops. The ACM has also sought to tackle these. The fact that it has been invited to scale-up its model across India and into China, Thailand, Vietnam and the Philippines suggests that major funding organizations see the ACM as an exemplar. This work analyses the history and philosophy of WD, focusing on the ACM, viewed both from within and without. Time was spent in India, interviewing ACM team members and visiting ACM watersheds in Andhra Pradesh, Rajasthan and Karnataka. The field trips enabled direct discussion with senior politicians through farmers in these states. The study examines how the ACM has fared, and how it is viewed. It lists the challenges that ICRISAT now faces and concludes with a raft of measures for improved performance. Above all it finds that there is a need for a clear strategy as to the extent the ACM will diversify away from its core strengths, and in doing this whether it will bring in specialist partners or continue to try to develop these skills in-house. It sees dangers in the latter course of action.

Title	: Impact of integrated watershed management on water availability and uses: A case study of Kothapally, Andhra Pradesh, India
Name	: Kyota Lizuka
Institute	: International Agriculture and Rural Development at Cornell University, Cornell, USA
Supervisors	: Prabhakar Pathak and Suhas P Wani, Principal Scientists
Period	: 4 July – October 2005

Abstract :

Increasing population pressure mostly taking into consideration the developing countries, imposes an enormous drain on our ecosystem today, especially the fresh water resource, which is one of the most important natural resources on this planet. Water scarcity prevailing in arid developing areas is a huge obstacle for increasing agricultural productivity to feed this growing population and to suppress chronic malnutrition in the areas. However, the major measures that have been taken to cope with the situation before construction of large-scale water harvesting structures to secure water availability have caused a significant impact on the ecosystem. It has decreased productivity and greatly influenced large amounts of water to flow into downstream areas. Efficient utilization of water resources to recharge aquifer without further environmental degradation would improve the livelihood of poor rural households in the drought-prone regions. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and its partners evaluated a new science-based farmer participatory integrated watershed management program in a model watershed in the semi-arid tropics of India.

The integrated watershed management implemented by ICRISAT and the partners at Kothapally village has turned out be a success story. The program has improved and optimized utilization of rainfall water with minimized environmental degradation and secured water availability for domestic and agricultural use. The villagers have successfully risen from a miserable penurious situation by taking advantage of water resource betterment programs. One aspect that draws a clear distinction between this project and other community development measures is the accomplishment that raised the standard of living of the lower strata of society. Usually, relatively wealthy people derive maximum advantage from such type of assistance and the poorer sections are not aware of the benefits. However, though there is still a huge gap between rich farmers (large land owners) and the poor (marginal land owners) in terms of income in the Kothapally village, the benefits that have been brought about from the program to the poor are proportionate to that of the rich farmers or more. The livelihood amelioration on the whole that took place in Kothapally is not only due to physical or structural advancement in the village, but also due to the efforts of the persons involved and the participation of the locals.

Title	: Sujala watershed project: Analyze diagnostic and prospects regarding the institutional mechanisms
Name	: Paul Arsac
Period	: 23 June – 31 August 2005
Institute	: Institute of National Agronomique Paris-Grignon
Supervisor	: Suhas P Wani, Principal Scientist

Abstract:

Watershed management is well-recognized and accepted approach for sustainable development of dry and wetlands. The overall objective of this study is to enhance the impact of watershed programs on a sustainable basis. The specific objectives are to study in detail the existing institutions and their functioning in Sujala watershed and to study their functioning and their assessment by the stakeholders and possible ways to enhance the impact of Sujala project further. The study was undertaken at micro and macro levels, ie, at community, civil society district level and at state level. The existing institutions and their functioning in respect to the expected roles/function, their feedbacks and their suggestions were to impact their functioning based on our interactions with the stakeholders one level below and one level above the particular institution.

Links between different levels of institutions are personal and structural. The current operation of the institutions and the institutional mechanisms installed to manage the project has been successful. The execution of the project does not seem to suffer from gaps as for the organization of the institutions that frame it. However, if the system set up around the project seems on ground, the future of the mechanisms of management and valorization of the territory by the communities remains rather dubious and vague. Actually, the current functioning of self-help-groups does not allow them to do “heavy” investment in order to become more autonomous compared to agencies, which gives them money currently. Otherwise, it appears that a better interaction based on a better communication in particular between Lied Non-Governmental Organization (LNGO) and Field Non-Governmental Organization (NGO) could improve the effectiveness of the undertaken action. It seems that the sustainability of community-based organizations (CBO) depends on their aptitude to generate money and to manage it in a sustainable way.

Title	:	Estimation of carbon sequestered in <i>Pongamia pinnata</i> and <i>Eucalyptus spp.</i>
Name	:	Arun G Nair
Institute	:	Forest Research Institute, Deemed University, Dehradun, UP, India
Supervisor	:	Suhas P Wani, Principal Scientist
Period	:	1 February – 30 June 2005

Abstract:

In an era in which, increasing temperature and changing climate is becoming one of the major concerns of humanity, methods and means which can help in reducing or slowing down the rate of an increase temperature or change in climate carries immense importance. One of the major means of reducing this effect is to identify and carry out means to sequester carbon. The present study was one such attempt to find out the amount of carbon or carbon dioxide sequestered by two main tropical species, which is being planted in a large scale in India, ie, *Pongamia pinnata* and *Eucalyptus spp.* The study was carried out in the Adilabad district, Andhra Pradesh in India. Through this study an attempt was made to identify the actual amount of carbon sequestered across different age groups in these species, which was estimated at about 1.79 kg in 3rd year *Pongamia* tree to 331 kg in 15th year old tree. Similarly, in the case of *Eucalyptus spp.* the carbon sequestered was estimated to be about 9.5 kg at 5th year to 94 kg in its 19th year. Also the study tried to estimate the density values of *Pongamia pinnata*, which was calculated at about 0.65 m³/t. Thus this study attempted to open the gateway for earning

the much valued carbon credits and provide the rural poor a better way to enhance their income by planting and protecting these species.

Title	: Training on integrated watershed management
Name	: Ali Heshmatpoor
Institute	: Gorgan University of Agricultural Sciences and Natural Resources, Iran
Supervisors	: Suhas P Wani and Prabhakar Pathak, Principal Scientists
Period	: 4 January – 4 February 2005

Abstract:

The researcher was working as faculty in Watershed Management Department at Gorgan University of Agricultural Sciences and Natural Resources, Iran. He was interested in learning and developing latest technologies in the field of watershed management. Learnt many topics such as topographic survey, watershed planning, basic on contour map, runoff and soil loss measurement methods, rain water harvesting structures, improved land and water management systems, agroclimatic data collection and analysis, integrated nutrient management, crops and about the cropping systems which were covered at ICRISAT. Visited Adarsha watershed Kothapally and CR Analytical laboratory at ICRISAT. His training program covered field practice and lectures. According to him, it was useful and a great learning as most of the IWM techniques learned were appropriate to Iran situation and to teach undergraduate students at Gorgan University, Iran.

Title	: Remote Sensing and GIS for Assessing the Impact of Integrated Watershed Management
Name	: Ms Leya Sathyan
Institute	: Centre For Environment, Institute of Science and Technology, JNTU, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 5 January 2004 – 25 June 2005

Abstract:

The ever-growing population and the resultant demand led to over exploitation of the finite natural resources in most parts of India in general and in Madhya Pradesh and Rajasthan in particular. The Indian economy is largely a rural one, hence the development of rural areas depends upon the optimum management of natural resources particularly the water resources. A drainage basin or water shed can be considered as a preferable unit for initiating water conservation and management practices. Watershed management is an integration of technology within the natural boundaries of a drainage basin for land, hydrological, biotic and vegetative resources development to fulfill the population needs on sustainable basis. In the present work an attempt is made to create resource information system and to make an impact assessment study of watershed activities in selected watersheds spread in two states of India using the satellite data interpretation technique and GIS tools. In the study area ICRISAT with Bharatiya Agro Industries Foundation (BAIF) initiated watershed treatment activities in the year 1998, consisting of structures – earthen check dam, permanent check dam, farm ponds and

stop dams. This work created a database both spatial and non-spatial with the help of Survey of India (SOI) topo sheets and Indian remote sensing satellite imageries for the period 2004. The data base consisted of drainage map (representing all the streams up to 4th order, landuse/ land cover map, etc. All the thematic layers are integrated with socioeconomic attribute information detailing the socioeconomic status of the area. To evaluate the impact of the structures constructed, the Remote Sensing Technology (ERDAS Software 8.7) and GIS tools (Arc-Info 8.0) were used to create the Normalized Differential Vegetative Index (NDVI) to understand the change in terms of vegetative indices. Satellite imageries of 1997 prior to the commencement of watershed treatment activities and images of 2004 (that is after five years of initiation of watershed treatment), are interpreted adopting digital image processing concept to generate the NDVI. The positive and negative impacts can be clearly established with this approach. In terms of socioeconomic status also the impact created is examined considering the parameter, basic amenities, literacy rate, migration of labor, per capita income etc., for the same periods.

A cursory examination of the water level data along with change in number of wells demonstrates that in spite of significant increase in the number of open wells, tube wells and hand pumps from 1997–2004, there was a remarkable increase in the groundwater table level though there was no considerable change in the average annual rainfall. The NDVI study also reveals that there was a significant drift towards the positive value conveying an increased greenness index. The yield impacts of certain identified crops like jowar, maize and bajara express an average increase from five to ten quintals per hectare

The impact assessment indicators developed in this study will serve as a model to be replicated elsewhere under similar environments.

Title	: Planning of water resources in an agricultural watershed at Devanakonda, Kurnool District, Andhra Pradesh
Name	: K Rama Satyanarayana
Institute	: Centre For Water Resources, Institute of Science and Technology, JNTU, AP, India
Supervisor	: Prabhakar Pathak, Principal Scientist
Period	: 10 October 2004 – 31 August 2005

Abstract:

Low and erratic rainfall, frequent droughts, low productivity, high risk and uncertainty, low level of technological changes and degraded natural resources generally characterize the semi-arid tropics (SAT). These regions are home for sizable poverty-stricken and undernourished populations and the unemployed. These regions face harsh climatic conditions and the majority (about 75%) of the population depend on agriculture. To combat the problems faced by such harsh areas, watershed programs are recognized as the ideal approach for integrated natural resources management in rainfed areas. About 51% of India's geographical area (329 million ha) is degraded, most of which occurs in rainfed agroecosystems.

Due to frequent droughts in Andhra Pradesh, the Government of Andhra Pradesh launched different programs, for example, Andhra Pradesh Rural Livelihood Programme (APRLP) and Drought Prone Area Programme (DPAP) as an integrated area development program. During

2002, watershed development activities were initiated under APRLP project involving Government of Andhra Pradesh and ICRISAT, Hyderabad.

A scientifically sound watershed planning requires the analysis of the present status (or) condition of its natural resources such as soils, topography, climate, drainage, land use pattern and water resources and the extent of land degradation, which improves the effectiveness of watershed development program. But unfortunately in most of the watersheds, the important information required for planning such as hydrological and soil related data area not available. In such cases, due to difficulty in actual measurement by installing runoff and soil loss measuring equipment, calibrated simulation models play a vital role in getting hydrological data, which provides basic information for planning and development of a watershed.

Title	: Assessment of Run off Water Harvesting Potential in an Agricultural Watershed at Devarakonda, Kurnool District, Andhra Pradesh
Name	: B Satyanarayana
Institute	: Center For Water Resources, Institute of Science and Technology, JNTU, AP, India
Supervisor	: Prabhakar Pathak, Principal Scientist
Period	: 10 October 2004 – 31 August 2005

Abstract:

Rainfall is the only source of water in the semi-arid tropics (SAT). The rainfall data, evaporation, humidity and soil properties are easily available but hydrological data is not available for every area. This necessitated the use of runoff simulation models for hydrological analysis in a watershed. In the present study Soil Conservation Services (SCS) curve number runoff simulation model is used to assess the harvesting potential of a watershed. The model is developed at ICRISAT, Hyderabad. The runoff simulation is helpful for planning of a watershed, to improve the crop productivity and for proper planning of crops.

The present study mainly concentrates on assessment of runoff water harvesting potential of Devanakonda watershed of Kurnool district, Andhra Pradesh, India. This watershed is spread over 564 ha at latitude $15^{\circ}30'1''N$ to longitude $77^{\circ}15'1''E$. To assess the runoff water harvesting potential, past hydrological data of runoff of the watershed is not available. Only daily rainfall data is available for the past 19 years. Along with the help of this, assessing the runoff water harvesting potential of watershed, the SCS curve number runoff model is applied for the past 19 years of daily rainfall data. This model was developed at ICRISAT, Hyderabad, for small and medium watersheds.

Soil samples are collected from the watershed to find soil parameters. To use the SCS curve number runoff model, rainfall data, pan-evaporation and soil parameters are taken as inputs. Calibration is done for last two years of seasonal actual runoff data (available) and seasonal predicted runoff. The regression coefficient (R^2) value of the runoff data is obtained as 0.8636 for polynomial correlation. The 'SCS curve number runoff model' is applied for 19 years (1986–2004) of daily rainfall data to predict runoff. With the help of predicted runoff data, the harvesting runoff potential is assessed. Using statistical analysis, the probability of run off is also assessed.

Mean annual rainfall of Devanakonda watershed is 617.54 mm. From the present study, the mean annual runoff is found to be 59.47 mm for predicted runoff data (1986–2004). Runoff harvesting potential of watershed is 335410m³. The probability of occurrence of 59.47 mm of mean annual runoff is 47.37%. From the statistical analysis it is established that the maximum runoff is likely to occur between last week of May and October second week.

Title	: The present situation and current transfiguration of farming system of indigenous people in Andhra Pradesh: A case study in Koya villages.
Name	: Mr Tsunashima Hiroyuki
Institute	: Graduate school of Asian and African Area Studies Kyoto University, Japan.
Supervisor	: Suhas P Wani, Principal Scientist
Period	: September 2004 – May 2005

Abstract:

Most of the ethnic minorities in India have been making their livelihood by agriculture. Studies on the Koya community's unique culture or poverty refer to aspects of their agriculture too. An agroeconomical study about Koya in Warangal District precisely describes their problems of cultivation. The study village, Chalampalem belongs to former Bhadrachalam agency area, present Bhadrachalam *mandal*, Khammam District, Andhra Pradesh. The village consists of three hamlets named Erragattu, Chalampalem and Bandarigudem. The first and the second fieldwork were conducted from December 2002 to August 2003 and from September 2004 to April 2005, respectively. These fieldworks consisted of various components: Observation of farm works, casual interviews with the villagers, soil profile observations, land exploration and household survey. Based on the all-household survey, there were 188 households or 856 people totally in the study village, of which 183 households or 838 people were Koyas. However, most of them are small-scale landholders, 30% had no cultivated land area or were sharing lands with relative households, and another 60% were marginal or small-scale farmers, whose cultivated land area was less than 2 ha. Lands were leased out rather than leased in and considerable amount of cultivable lands were leased out to outsiders.

The main cropping patterns adopted in the study site were paddy rice, sorghum + green gram, chili, red gram and red gram+upland rice. Cotton, black gram, pearl millet and little millet were also cultivated. Chili and cotton are the main commercial crops as harvests of those were entirely sold, while rice and millets was domestically consumed. Economical land productivity of chili is overwhelmingly higher than those of other crops, considering its selling price and yield. Grouping all the crops into 4 categories (ie, staple, leguminous, oil and commercial), combination of crops in each household farming were summed up according to their operational land size. Most households combined staple and leguminous. Only some of the small-scale farmers concentrate on crops of one single category. As for chili cultivation, larger the operational land size, the proportion of farmers who cultivate chili is also larger. However, the larger farmers assigned less proportion of their lands for chili cultivation.

Title	: Groundwater prospecting using remote sensing and GIS in agricultural watersheds in Madhya Pradesh and Eastern Rajasthan, India
Name	: Ms B Shruthi
Institute	: Centre for Environment, Institute of Science and Technology JNTU, Hyderabad, AP, India
Supervisors	: Suhas P Wani, Principal Scientist
Period	: 5 January 2004 – 28 June 2005

Abstract:

Groundwater not only supplements canal irrigation but also serves as a source of drinking water and is used for other domestic usages. Since the groundwater occurrence is controlled by lithology, geo-morphology, structures, soils, land use/land cover, recharge condition and rainfall, its development calls for a multi disciplinary and holistic approach. Space borne multi-spectral measurements offer immense potential in deriving information on lithology, geo-morphology, structures, soils and land use/land cover. Geographic information system (GIS) provides an ideal platform for integrating information on above mentioned features with a rainfall on recharge condition and to arrive at the groundwater potential zones. In the study reported here, an assessment of groundwater resources of parts of Bundi watershed, Bundi District, eastern Rajasthan, Guna and Milli watershed, Guna and Lalatora District, Madhya Pradesh was made using Indian Remote Sensing Satellite (IRS-P6), Linear Imaging Self- Scanning Sensor (LISS-IV) data and ancillary information like published geological maps from Geological Survey of India (GSI), topographic maps from Survey of India and other legacy data. Initially, information on lithology, geomorphology, structures, soils and land use/land cover was derived through monoscopics visual interpretation approach. Subsequently such information was integrated with the slope, drainage and recharge conditions in a GIS environment to delineate (i) groundwater potential zone and (ii) suitable site for groundwater recharge.

Bundi watershed was categorized into four land forms/geomorphic units. Valley fill, pediplain moderate, pediplain shallow, pediment inselberg complex, pediplain with moderate weathering, pediplain with shallow weathering and valley are most prominent units in Bundi watershed. Groundwater occurs in these geomorphic units under both in confined and semi-confined conditions from the weathered and fractured/jointed rocks. Rainfall is the principal source of recharge in the study area. The drainage is sparse in the watershed and represents dendritic pattern. The land use land cover analysis indicated that more than 50% is wasteland such as barren stony area. Soil and water conservations measures, optimal land use patterns were suggested for the overall sustainable economic development of the watershed. Desilting of tank and check dams are recommended based on the slope, land use/land cover and hydrogeomorphological criteria, to obstruct the surface water flows and thereby increasing its influence over the command area and the groundwater levels.

Guna watershed was categorized into 5 land forms/geomorphic units. Plateau moderately weathered, plateau slightly dissected and Mesa are the most prominent units in the Guna watershed. Groundwater occurs in these geomorphic units. Recharge conditions are moderate and are of low priority, percolation tanks/check dams are recommended in this watershed. Dug wells are also preferred. Milli watershed has been categorized into Valley and Pediplain with moderate weathering. Valley is the most prominent unit in this watershed. Groundwater prospects are good to very good; recharge structure like check dam and percolation tanks are of high priority.

Title	: Estimation of runoff from small agricultural watersheds using remote sensing and GIS (Geographical Information Systems)
Name	: Ms BH Sandhya Rani
Institute	: Centre for Environment, Institute of Science and Technology, JNTU, Hyderabad, AP, India
Supervisors	: Suhas P Wani, Principal Scientist
Period	: 5 January 2004 – 27 June 2005

Abstract:

In this study Remote Sensing technology (ERDAS Software 8.7) and GIS tools (Arc-Info 8.0) are used to estimate the runoff. The base maps, slope maps, drainage maps were prepared from Survey of India (SOI). Toposheets, land use/land cover maps which are an important input for Soil Conservation Service model (SCS) were prepared from IRS P6-LISS IV satellite images. GIS, which has been designed to restore, manipulate, retrieve and display spatial and non-spatial data, is an important tool in analysis of parameters such as land use/land cover, soils, topographical and hydrological conditions. The Digital Elevation Model (DEM) was generated in this study with the topographic information and 20 m interval contours have been used.

The type of soil present in Lalatora (Milli) and Guna watersheds Vertisols and Bundi watershed consist of silt clay/sandy clay. With the help of SCS model, in conjunction with Remote Sensing and GIS it is possible to make management plans for usage and development of a watershed.

Runoff and consequent soil erosion are inevitable under a tropical monsoon. These need quantification for the design and adaptation of control measures, which can be done by monitoring the soil and runoff losses on watershed basis. Watershed is an area that drains to a common point. It may be managed for various objectives, depending on local needs, including capturing runoff, minimizing erosion and reducing non point source pollution.

In the present study the runoff is modeled using SCS Curve Number, which is best estimated for agricultural watersheds. This study area revealed that predicted runoff values are underestimated compared to the observed values in the three watersheds (Bundi, Guna and Lalatora) for normal green cover. The predicted runoff values are from smaller area, ranges from 20 to 500 ha. The measured runoff value is for a larger area (9000ha). Remote Sensing and GIS are used to spatially visualize the runoff estimates over the whole watershed. Using conventional methods, it becomes highly difficult to collect the data from remote and inaccessible places. Remote sensing and GIS provides an alternative. Black soils are more prone to runoff compared to red soils – hence effort should be made to take up short duration cover crops so as to minimize the raindrop impact or runoff in the *kharif* season.

Title	: Modification of Microcontroller unit of automatic pumping type sediment sampler
Name	: Jayashree Kulkarni
Institute	: Vardhaman College of Engineering, JNTU, AP, India
Supervisors	: Prabhakar Pathak, Principal Scientist
Period	: 9 January – 9 February 2005

Abstract:

Soil erosion is one of the major problems confronting agriculture worldwide. The measurement of soil erosion is one of the important components of studies aimed for effective management practices for controlling soil erosion. Therefore, a sediment sampler is made available for monitoring sediment loss from watershed/plot depending upon the specific needs of the location.

The sediment sampler was devised to take the samples at a fixed sampling interval for estimating the soil loss. Farmers were facing a lot of difficulty in choosing the control unit of time span for switching on and off the motor and pump. They were not aware about which one to choose among different time spans, ie, 7s, 10s, 13s and 15s, which were provided in the same control unit in the project. The researcher provided a toggle switch to select the appropriate pumping duration depending on section head of drain/*nala*. This facilitates the user to have a control unit which suits a location where the sample suction head varies 1–2'm depth and allows user to collect sufficient quantity of runoff water sample for sediment analysis.

Title	:	Practices in Soil Microbiology
Name	:	R S Anand
Institute	:	Bharatiya Vidya Bhavan New Science College, Hyderabad, AP, India
Supervisor	:	Suhas P Wani, Principal Scientist
Period	:	16 May – 15 June 2005

Abstract:

Two varieties of soil samples (Vertisols and Alfisols) were collected from the fields of ICRISAT and were enumerated for microbial populations and colonies with different morphologies of bacterial and fungi to be studied further. Rhizobium from the root nodules of *Pongamia* was isolated and preserved. In the soil samples collected from fields of ICRISAT Vertisols recorded high counts of bacteria (64×10^3 cfu/g soil), fungi (13×10^2 cfu/g soil) and then Alfisols. Fungi isolated from the soil sample were identified as Alternaria, Penicillium, Aspergillus and Cladosporium. The bacteria (15 isolates) with different morphologies were isolated and were exposed to different staining techniques and IMViC test.

Five isolates out the 15 were reported to be Gram positive and the rest were negative. All the isolates were negative for capsule formations. Majority of the organisms were cocci and few were bacilli. Almost all the isolates were negative for IMViC test except one or two isolates. The Rhizobium from the root nodules of *Pongamia* plant was also isolated and was preserved in 20% glycerol solution at -18°C temperatures. If further studied this has scope to be used as a biofertilizer from the nodule formation of *Pongamia* plant through which the yield can be increased.

Title	: Microbiological studies on soil samples from rice fields using SRI method of cultivation
Name	: Ms M Kranthi
Institute	: Centre For Environment Institute of Science and Technology Jawaharlal Nehru Technological University, AP, India
Supervisors	: OP Rupela, Principal Scientist
Period	: February 2005 – September 2005

Abstract:

SRI (system of rice intensification) is an innovative method of rice cultivation developed in 1980s in Madagascar by Father Henri de Laulanie. It is different from the normal method of cultivation of rice mainly in 3 ways. This system includes transplantation of young seedlings (8–10 days), wider spacing between plants (25x25 cm) and in non-flooded conditions. The study was done to understand the soil microbiological and biological parameters and examine if these were associated with the high yields of rice generally reported with this method.

Soil samples were collected from three districts of Andhra Pradesh (West Godavari, Medak and Anantapur), India during postrainy season 2004, in SRI and conventional rice plots of 21 farmers' fields at vegetative and harvesting stages of rice using appropriate sampling methods. All the soil samples were processed for six microbiological (total bacteria, total fungi, plant growth promoters, *Pseudomonas* fluorescence, P-solubilizers) and three biological (biomass carbon (MBC), biomass nitrogen (MBN), dehydrogenase activity) parameters.

It was apparent that the mean data values of all the six microbiological parameters were similar in SRI and control plots except for the population of plant growth promoting bacteria which was significantly higher for SRI than in control plots at harvesting stage. This was the major difference observed between SRI and control plots for the microbiological studies.

Soil biological properties were significantly higher for SRI plots than that of relevant control plots. On mean basis, dehydrogenase activity was higher in SRI by 14% at vegetative and 7% at harvesting stage when compared to that of control plots. Microbial biomass carbon was significantly more by 7% at vegetative and 11% at harvesting stage than that of control plots. Microbial biomass nitrogen was significantly higher by 25% at vegetative stage than that of control plots. Since the study has been carried out for only one season, further studies are needed to substantiate the present findings.

Title	: Efficacy of Microorganisms and Botanicals for Managing Helicoverpa armigera
Name	: Ms J Rama
Institute	: Dept. of Biotechnology, Bharathidasam University, TN, India
Supervisor	: OP Rupela, Principal Scientist
Period	: January 2005 – October 2005

Abstract:

A best-bet protocol of crop protection was one of the factors under evaluation in an ongoing (since June 1999) long-term field experiment at ICRISAT. Bacterial (*Bacillus subtilis* BCB 19) and fungal (*Metarhizium anisopliae*) strains were the two important components of the protocol along with two botanicals (*Neem* and *Gliricidia*) and traditional knowledge products. The protocol was evaluated on-farm to protect vegetables (tomato, bitter-gourd and ridge-gourd) from insect-pests. Nine farmers of Adarsha watershed, village Kothapally, Ranga Reddy district, Andhra Pradesh agreed to participate in the evaluation. Each farmer had two treatment plots, one using biopesticides (= 'Bio', involving the protocol) and the other using chemical pesticides (= 'Chem', decided by farmers). The experiment was conducted during January 2005 to June 2005 and cost of products provided by the ICRISAT project was charged on no-profit no-loss basis.

Area for the treatment plots was decided by farmers. It ranged from 308 to 2450 m² in the case of 'Bio' and 316 to 1850 m² in 'Chem'. The 'Bio' plots received a total of ten (a mean of nine farmer) sprays inclusive of products (example: wash of compost of *Neem* and/or *Gliricidia*), which were noted to have plant growth promoting bacteria and Chem plots received four sprays. Mean (tomato, bitter-gourd and ridge-gourd) yield of the nine farmers (treated as replication) was 37% more in the 'Bio' than that of the 'Chem' (0.84 t ha⁻¹) plots. The mean expenditure of the nine farmers for protecting the crops in 'Chem' plots was Rs 1054/- per ha (range Rs 949/- to 1186/-) and that of 'Bio' plots was Rs 833/- per ha for the whole season.

Sixteen products representing 14 botanicals were evaluated for efficacy to kill neonates of *Helicoverpa armigera*, in three different batches. Commercially available oil of *neem* seeds (*Azadirachta indica*) was used as reference. Washed and boiled water-extract of seven botanicals (*Annona*, *Calotropis*, Chilli, Chrysanthemum, *Parthenium*, *Pongamia* and *Prosopis*) killed the neonates at levels close to or better than *neem* oil (3% suspended in water). Storability of the wash of compost and hot water-extract of 29 products involving 25 botanicals in clear bottles of glass was measured by turbidity of the liquid and was indicated by growth of microorganisms and/or growth of fungi on surface of the liquid in bottles. Wash of all the 29 products remained clear for whole duration of the study (90 days) without any growth on their surface while only 19 were clear when prepared as hot-water extracts. *B. subtilis* (BCB 19) survived well for eight days in all the three botanicals (*Nerium*, *Pongamia* and *Dhatura*) that were studied, when mixed with their compost-wash hot-water extract. But *M. anisopliae* survived well for eight days only in the compost-wash of the three botanicals. This compatibility between microorganisms and botanicals has implications on reducing the total number of sprays on a crop and/or enhancing their efficacy. Also, freshly collected wash of four of the five botanicals (*Calotropis*, Chilli, *Nerium*, *Parthenium*, *Prosopis*) that were studied had 2.5 to 3.8 log₁₀ mL⁻¹ siderophore producing bacteria, indicated their ability to promote plant growth. Such bacteria were absent in the hot water extracts of these botanicals.

Even though the studies are preliminary, effective protection of crops by using eco-friendly materials at low-cost was achieved. Further studies are recommended.

Title	:	Biological analysis of <i>Pongamia</i> and <i>Jatropha</i> cake conventional compost and vermicompost
Name	:	P Jyothsna
Institute	:	Chaitanya PG College for Women, Vishakapatnam, Andhra University, AP, India
Supervisors	:	Suhas P Wani, Principal Scientist
Period	:	April – November 2005

Abstract:

The hike in fuels consumption, increasing air pollution, environmental degradation demands a multidisciplinary research approach in different countries of the world today. The measures taken to promote the use of biofuels or other renewable fuels to replace diesel or petrol for transport purpose can to some extent achieve sustainability and bring down public health problems.

In ICRISAT, study is in progress with the plants of *Jatropha* and *Pongamia* for the extraction of biofuels. Research is also in progress for the utilization of the waste materials obtained after the biodiesel extraction from the seeds. The present study deals in utilizing and standardizing the deoiled cakes of *Pongamia* and *Jatropha* using conventional composting and vermicomposting methods. Different cement bins were filled with *Pongamia* (1 to 4 bins) and *Jatropha* (5 to 8 bins) deoiled cake along with different concentration of rock phosphate, dung slurry and earthworms (for vermicompost), which resulted in different treatments. The composting as well as vermicomposting methods were in progress for 3 months from May to August for *Jatropha* deoiled cake and from April to July for *Pongamia* deoiled cake. The samples for the analysis of biological (soil respiration, biomass C) as well as microbiological (enumeration of bacteria, fungi and actinomycetes) parameters were collected at monthly intervals along with the control sample.

Soil respiration was estimated according to the method of Anderson (1982) and biomass C was estimated using chloroform fumigation and incubation method. The results obtained were in turn correlated to know the best treatment as well as the composting method. The results showed that vermicomposting method recorded high values of all the parameters than the conventional composting method. Biomass C as well as microbial populations were more in *Pongamia* cake vermicomposting than the *Jatropha* cake vermicomposting, which may be because of the alkaloid called jatrophin present in the *Jatropha* seeds which was proved to be a toxic chemical.

Title	: Medicinal and aromatic plants: Potential and efficient use of distillation methods
Names	: Prakash Nijalingappa Mylar and Amit K Soni
Institute	: Dept. of Chemical Engineering, Rural Engineering College, Bhalki, Visweswaraiah Technological University, Belgaum, Karnataka, India
Supervisors	: Suhas P Wani, Principal Scientist
Period	: 20 April – 10 June 2005

Abstract:

Natural essential oils extracted from the Medicinal and Aromatic Plants (MAPs) are extensively used in fragrance, flavor, aromatherapy and pharmaceutical industries and are widely grown in semi-arid tropics. The main constituents of the oils extracted from these plants are 75–80% citral, 10% neral, up to 25% myrcene and few carbonyl compounds (aldehydes & ketones), alcohols and esters. Some of the Mass Transfer Operations are used to extract the oil like Distillation, Extraction and Fractional Distillation and the main oil removed is only 80%.

In the present work, Steam Distillation is used for the extraction of oil from lemongrass *Cymbopogon citratus*, which is a medicinal and aromatic plant. The cost and time required for the extraction of oil is less when compared to other processes. Steam distillation of lemongrass, in a commercial way, is done by using the 450 kg of lemongrass leaves and the pressure and temperature were respectively 2 Psi and between 95 °C to 100 °C. The recovery of primary oil is up to 3 l with consumption of 2–3 hrs of time. By steam distillation 92% of oil is extracted. The major byproducts from this distillation are deoiled grass and condensate or distillation water. In condensate water nearly 8% of oil is mixed and this is removed by Hexane method (Method 1664). The solvent recovery is 4 to 7% and analysis and comparison of the primary and secondary oil is then done. De oiled grass is used in preparing vermicompost.

The use of steam distillation will increase the recovery of oil up to 92% and it is cost effective. The obtained oil using steam distillation consists of all the essential chemicals. The citral percentage is about 90% and 10% neral. The sample of vermicompost was analyzed for N, P, and K compositions. The difference between compost and vermicompost is being demonstrated to the farmers. Research has been initiated on water analysis to detect any harmful chemicals that affect plant growth.

2004:

Title	: Low cost materials for managing insect-pests in farmer's fields: A case study on cotton
Name	: Jagarlapudi Sri Sasi Jyothsna
Institute	: Environmental Biotechnology, JNTU, Hyderabad, AP, India
Supervisor	: OP Rupela, Principal Scientist
Period	: 21 July 2003 – 31 May 2004

Abstract:

Crop production and protection strategies developed during the Green revolution depended mainly on chemicals like fertilizers, fungicides, pesticides and herbicides. During the subsequent years problems of insect-pests, diseases and weeds emerged in different forms. Alternative

pest management strategies, using microorganisms and plant products, have long been proposed. Using these alternatives, organic farmers (the farmers dependent on non-chemical means of crop production and crop protection) have been reported to protect their crops efficiently and even harvest good yields. Researchers at ICRISAT, Patancheru identified several microorganisms, plant products and items of traditional knowledge of farmers with potential to manage insect-pests.

A protocol of crop protection using six different items was assembled and evaluated at research station for three years. At least four (cow urine, wash of neem (*Azadirachta indica*) foliage, wash of Gliricidia foliage and curd-based recipe) of the six items of protocol, can be prepared at village level while the other two (microorganisms as biopesticides and biofertilizers (bacillus strain BCB 19, and *Metarrhizium anisopliae*) have to be prepared by a biopesticides industry. In 2003–04, this protocol was evaluated in the village Kothapally, Ranga Reddy district, Andhra Pradesh, India. The thesis describes this evaluation experience. The focus of the study was to evaluate: whether chemical pesticides could be replaced by low cost, non-chemical means for effectively protecting crops.

All the families in the village (Kothapally) were informed of ICRISAT's experience of protecting crops by non-chemical means at research station through two different meetings in the village. Twenty farmers registered their names to evaluate the crop protection protocol and agreed to put one-acre area under the experiment having two treatments on about 2000 m² (=1/2 acre each). Chemical pesticides were used as 'control' treatment, normally used by the farmers and was called 'CHEM' in the first treatment. Biopesticides (provided by ICRISAT) were used in the other treatment and was called 'BIO'.

CHEM plots received nitrogen and phosphorus (as DAP, 36 kg N and 92 kg P ha⁻¹ by different farmers) while the BIO plots received 5.9 kg P ha⁻¹ (as SSP). Both the plots of all farmers received boron (as borax powder 4.9 kg ha⁻¹). A bacterial strain CDB 35 (*Pseudomonas spp.*) having properties to promote plant growth and solubilize the insoluble phosphorus in soil was applied as sand coated inoculum, at 12 to 15 days after sowing. Pigeonpea cultivar ICPL 88039 was sown (only in the BIO plots) as trap crop after every eight rows of cotton. Pigeonpea seeds were placed along with cotton because farmers did not wish to reduce the population of cotton plants. Despite no application of nitrogen to cotton in the BIO plots, the Spadmeter reading (a measure of photosynthetic activity that gets adversely affected by N deficiency) was similar in both the treatments (CHEM-29.3 and BIO-29.0). In most fields, growth of cotton was generally slow in the BIO plots.

Visual observations suggested that except in four fields (field of 1. Balwanth Reddy, 2. Mahipal Reddy, 3. Manik Reddy and 4. Hanumanth Reddy) the growth of cotton was visibly less in the BIO plots at least up to 60 days after sowing (DAS). Flower count, bolls count and number of internodes per plant were measured at 90, 75 and 60 DAS respectively and were similar in both the treatments at 21 (19 in CHEM and 22 in BIO plots). Plants in the BIO plots in all the fields continued growing longer than in the CHEM plots and yielded one additional picking in most cases. On mean basis BIO plots yielded 30% more cotton than the CHEM plots that received chemical pesticides (1.87 t ha⁻¹) which was statistically significant at 5% probability level (LSD=0.238). Eleven of the 17 farmers harvested significantly more cotton in the BIO plots than that in the relevant CHEM plots. In addition, all the participant farmers saved at least Rs 5000/- ha⁻¹ (1US\$ =Rs 45/- approximately) in the BIO plots, even if cost of the material was charged. This was because, on an average, 17 farmers spent Rs 14250/- ha⁻¹ (range Rs 8500 to Rs 19850 ha⁻¹ includes the cost of chemical fertilizers) on the CHEM plots.

A questionnaire was prepared to study the present status of using synthetic pesticides and fertilizers (especially for cotton), socioeconomic status, awareness regarding biopesticides and potential health implications of synthetic pesticides used by the partner farmers. Average holding of the partner farmers was 2.5 ha. Most (95%) knew about major pests of crops (particularly of cotton) but not of agriculturally beneficial predators and parasites of insect pests. The choice of chemical pesticides used was generally decided on the advice of pesticide dealers (in 50% cases) and peers plus dealers (in 67% cases) and the decision to spray did not follow any threshold levels for insects. Pesticides were invariably purchased on credit and were used on all crops by all farmers. Application of NPV (nuclear polyhedrosis virus) in the past was tried by 5.5% and handpicking of leaves as a pest-management practice was practiced by 5.5% as the other potential non-chemical means of protecting crops. Skin rashes and eye irritations were the most observed effects after using chemical pesticides. No protective clothing/gears were used while spraying chemicals by any of the farmers. No noticeable adverse effect of biopesticides was reported at the end of experiment in March 2004.

Most of the farmers (72%) were completely satisfied with the BIO method while 17% wished to try once more before they were convinced of the method, and 11% were not convinced at all. The study also included laboratory and glasshouse experiments to learn the larvicidal, ovicidal and plant growth promotion properties of some herbal extracts, besides those supplied to the participant farmers. Six herbs (each as compost wash and as hot-water extract) were included in the study. Wash of *neem* compost only marginally improved total plant weight of millet cultivar (ICMV 155) used as a test crop in a glasshouse experiment. The need for some more studies on this subject is suggested.

Title	: Approaches for Increasing Crop Productivity in Semi-Arid Tropics of India
Name	: Mr P Sundeep Tagore
Institute	: Allahabad Agricultural Institute (Deemed University), Allahabad, Uttar Pradesh, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 1 June – 1 July 2004

Abstract:

The semi-arid tropics (SAT) are generally characterized by highly variable and low rainfall, low productive soil and poor development infrastructure. Moreover the fragile ecosystem of the dry area is prone to degradation. Water and soil are important natural resources required for crop production. In order to enhance and sustain productivity in the soils of semi-arid tropics (medium to high levels of production), the integrated use of various components such as farmer evaluated improved crop management practices like use of INM, (Integrated nutrient management) IPM, (Integrated pest management) soil management, water management and watershed management together with various other factors are essential. The following are the strategies used by resource management group to improve land productivity of semi-arid tropics.

The broad-bed-and-furrow system of cultivation prepared by an animal-drawn ridger, mounted on a tool carrier (eg, Tropicultor or Agribar), or by tractor-drawn implements with ridgers is more suitable for Vertisols (deep black soils) since it optimizes water use, where furrows drain away excess water, yet allowing enough water to soak into the soil. Integrated Soil Fertility

Management is an approach for sustainable and cost-effective strategy which attempts to make the best use of inherent soil nutrient stocks, locally available soil amendments and mineral fertilizers to increase land productivity while maintaining or enhancing soil resource base. Non Pesticidal Management (NPM) is a recent concept in pest management in which indigenous technical knowledge is fully utilized in a participatory mode. The importance of biological control and inputs has made bio-diversity an essential component in this approach. Crop diversification has also proved to be an attractive option for restoring soil fertility, increasing farm income and improving the nutrition of farm families in watersheds of semi-arid tropics.

Title	: A brief report on the hands-on training on Agricultural Production Systems sIMulator (APSIM)
Names	: 1. Dr VS Bhatia, NRCS, Indore (MP) 2. Dr SK Krishnamurthy, Sr Scientist, ARS, Anantapur (AP) 3. Dr P Munirathnam, Sr Scientist, RARS, Nandyala (AP) 4. Dr G Srinivas, Scientist, ARI, ANGRAU, Hyderabad
Institute	: NARS, India
Supervisor	: Suhas P Wani (Principal Scientist) and team
Period	: 19 – 23 January 2004

Abstract:

Four Scientists from different parts of the country came together and undertook a course on Hands-on training in the use of APSIM (System simulator) for cropping systems modeling from 19th to 23rd January 2004 at systems modeling/GT-Agroecosystems, ICRISAT, Patancheru. During this training, they were introduced to systems modeling and APSIM framework. During the course of training we were taught the basics of handling the model through APSFRONT. Creation of new met files, soil, crop, and management input templates were taught and practical exercises were given. Along with the APSIM simulator, we were also trained on the use of different editors/viewers for APSIM. These editors/viewers were used for creation of APSIM input/management template files such as *.ini, *.par, *.man and *.con files. In a general way the working of the model, the inputs that go into the model and the outputs generated as summary files and in graphic forms were explained and discussed.

Besides the theoretical lectures on the above aspects, the scientists also spent quality time in handout practices on APSIM model. During this practical training we were able to modify the existing input files and to derive desired output files as per the conditions at our respective locations. The above training will be useful in our research efforts aimed at understanding the constraints to productivity potentials, to develop effective management strategies and forecasting the future scenario at our respective centers. The keen interest with which Mr V Nageswara Rao conducted the training was appreciated. The discussions they had with him were thought provoking.

Title	: Vermicomposting: A boon to the farmers
Name	: Punyakishore Maibam
Institute	: Allahabad Agricultural Institute Deemed University, UP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 1 June 2004 – 30 July 2004

Abstract:

Earthworms play a vital role in the process of nutrient recycling in soils. However the use of chemicals in modern agriculture drastically reduced the earthworm activities in soils. The realization of ecologically sound sustainable farming practices in reversing the decline of global productivity brought back the earthworms (vermicomposting) to be an integral part of soil fertility management. Vermicomposting is the process wherein earthworms convert solid organic wastes into nutrient rich worm casts. The project is carried out at Adarsha watershed, where a self-help group (SHG) consisting of four members is undertaking vermiculture technology by acquiring training on vermicomposting from ICRISAT. SHG set up vermicomposting enterprise using farm wastes with an output of 400kgs compost/month by availing loans from local *panchayat* and earn Rs 2000 and Rs 450/month through selling of vermicompost and worms respectively. This venture by SHGs earned the self-respect of society and also contributed to the family income. Vermicomposting technology help women to empower themselves through their earning and moreover, application of vermicompost enhances soil quality as a whole.

Title	: Methods of soil, plant and water analysis using ICP-AES Autoanalyser and Atomic Absorption Spectrophotometer
Author	: Vishakha Panchbhai
Institute	: College of Agriculture, Nagpur, Dr PDKV, Akola, Maharashtra, India
Supervisors	: Suhas P Wani and KL Sahrawat
Period	: 21 July – 20 October 2004

Abstract:

The training taken at ICRISAT was on soil, plant and water analysis using Inductively Coupled Plasma Argon Emission Spectrophotometer (ICP-AES), Autoanalyser and Atomic absorption spectrophotometer (AAS). ICP-AES is high quality multi-element simultaneous analyzer, where refractory elements like P, B, Zr and U can also be determined with an over all excellent limit of elements upto 0.1 to 10 ppb. The sample in ICP-AES is aspirated through a stream of argons towards nebulizer, where it is atomized and excited which are then detected through ICP spectroscopy. Autoanalyser is a continuous flow method of analysis where many analytical measurements can be made simultaneously. The consumption of chemical reagents in autoanalyser is reduced, when it is compared with manual analysis. The analytical results are accurate and provided in a single report. Atoms in particular element emit radiation of characteristic wavelength when they are excited and intensity of radiation is measured with and without the sample in terms of absorption, which is the underlying principle of AAS. The concentration of elements can be obtained by calibrating instrument against standards. AAS is highly specific for the particular element and there are no spectral interferences.

Title	: Enumeration of native chickpea rhizobial populations with reference to growing chickpea in rice-fallows
Name	: Padma Parvathi
Institute	: Centre For Environment, Institute Of Science And Technology, JNTU, Hyderabad, AP, India
Supervisors	: JVDK Kumar Rao
Period	: July 2003 – May 2004

Abstract:

Rice, the most extensively grown crop in South Asia, is cultivated on approximately 50 million ha. Despite growing demands for food production because of an increasing population in South Asia, there is little scope for expansion of cropping into new areas and therefore an increase in cropping intensity, along with rising of yields, needs to take place on existing agricultural lands. Rice fallows covering an area of 14.3 m ha, present considerable scope for crop intensification and diversification along with likely improvement in soil fertility for the succeeding cereal crop, by introducing second crop such as chickpea during postrainy (*rabi*) season if the appropriate technology is applied.

The present study has examined some aspects of growing chickpea in rice fallows, particularly the occurrence of native chickpea rhizobia vis-à-vis determine the need for seed inoculation with an effective Rhizobium; chemical properties of rice fallow soils and their correlation with chickpea rhizobia; effect of micronutrients, eg, molybdenum on chickpea growth and nodulation, and seed dressing fungicides on chickpea rhizobia.

The native chickpea rhizobial populations of selected rice fallow soils of different states of India and High Barind Tract of Bangladesh were estimated by using bacteriologically controlled plant infection technique. Soils were classified depending on rhizobial population g^{-1} dry soil as high (above 10,000), medium (100 to 10,000), low (below 100) and nil (no populations). In Chattisgarh, 70% of soils at 0–15 cm depth and 90% of soils at 16–30 cm depth showed the absence of native chickpea rhizobia, while 10% of soils had low populations at 0–15 cm depth. In Jharkhand, 37% of soils at 0–15 cm and 42% of soils at 16–30 cm depth had no native chickpea rhizobia, while 10.5% soils had low populations at 0–15 cm depth. In Madhya Pradesh, 34% of soils at 0–15 cm depth and 28% of soils at 16–30 cm depth had no native chickpea rhizobia while 12.5% of soils had low populations at both depths. In Orissa, 46% of soils at 0–15 cm depth and 50% of soils at 16–30 cm depth did not have native chickpea rhizobia. In West Bengal, native rhizobial populations were completely absent. In Bangladesh, 26% of soils at 0–15 cm depth and 20% of soils at 16–30 cm depth showed the absence of native chickpea rhizobial populations while, 20% soils at 0–15 cm depth and 13.3% of soils at 16–30 cm depth had low populations. These results suggest the need for Rhizobium inoculation of chickpea with effective chickpea rhizobia for obtaining good nodulation and nitrogen fixation, which in turn influence the final yields. Even in soils where the populations were high, seed inoculation with effective rhizobia is recommended as insurance for good nodulation. The MPN counts of chickpea rhizobia were correlated against various soil chemical parameters such as pH, E.C., Olsen-P, total-N, organic-C, B, Zn and Mo of the corresponding soil to know their interrelationships and no significant correlations were found. It is assumed that factors such as soil pH; previous cropping history and clay content etc., might have some influence on the native rhizobia.

As most of the rice fallow fields are acidic in nature, where the availability of Mo is limited, a pot experiment was conducted in glass house using two soils with a pH 4.9 and 5.0 to confirm the beneficial effect of Mo added through seed priming on chickpea. At pH 4.9, where usually the chickpea rhizobia were not capable of forming nodules, were able to form nodules successfully by the interaction with added molybdenum. But the formed nodules were not capable of fixing atmospheric nitrogen significantly. On the other hand, at pH 5.0 where the chickpea rhizobia formed relatively less number of nodules, showed an increase in number of nodules and a significant increase in acetylene reductase activity due to the interaction with the added molybdenum. In addition to this, a significant increase in the biomass yield, nodule weight and the ability to fix nitrogen at pH 5.0 indicated that the soil pH must be above 5.0 in order to obtain good nodulation and nitrogen fixation. The experiment also indicated that the optimum pH for growing chickpea must be above 5.0. The results were also supported by two laboratory experiments in which an increase in Rhizobium population in molybdenum added treatments was observed which may be attributed to their interaction with molybdenum. The ultimate aim is to combine seed priming, rhizobial inoculation along with Mo in a single operation, which can be easily adopted by the resource poor farmers.

The relative sensitivity of chickpea rhizobial strains IC 59 and IC 76 was evaluated against commonly used/ recommended fungicides, namely thiram, benlate, bavistin, captan and dithane M 45, for chickpea seed treatment. The ultimate aim of this study was to explore the possibility of combining seed priming, Rhizobium inoculation and seed treatment with fungicide all into one operation so that the farmers can safely adopt it. IC 59 strain was relatively more compatible with the fungicides tested than IC 76. Further, IC 59 exhibited good compatibility with the fungicide bavistin, very less sensitivity to Benlate. Mere compatibility based on growth alone cannot confirm the use of the strain (IC 59) at the time of seed priming. It is also necessary to test the effect of fungicides on nodulation and nitrogen fixation ability of chickpea inoculated with IC 59 before they can be effectively used during seed priming.

In conclusion, the present study has provided a better understanding of rice fallow soils in relation to the need for Rhizobium inoculation of chickpea, possible soil pH limits for growing chickpea, the beneficial effect of molybdenum on chickpea nodulation and growth and also the possibility of combining seed priming, Rhizobium inoculation and seed treatment with fungicides into one simple operation so that it can be adopted by the resource poor farmers.

Title	: Role of Legumes in Semi-Arid Tropics of India
Name	: Vaidurya Pratap Sahi
Institute	: College of Agriculture, Allahabad Agricultural Institute (Deemed University), Allahabad, Uttar Pradesh, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 1 January – 1 June 2004

Abstract:

Farming of pulses is an integral part of subsistence and sustainable production systems in the semi-arid regions of India as they are cheap and an excellent source of dietary proteins. They are also feed and fodder for animals besides their capability of restoring soil fertility through N fixation. However, there was a paradigm shift towards chemical fertilizer dependant - cereal based cropping systems during green revolution era in India to meet the demand of food grains resulting in an imbalanced production of pulses and cereals. The important consequences of shift in cropping systems, devoid of legumes, results in widespread decline of organic matter,

depletion of nutrients and alteration in rhizosphere activities. The inclusion of legumes in cropping systems has become imminent, as N dependant agriculture in India has deteriorated soil resource base reflecting decreased factor productivity.

The ability of legumes to fix atmospheric N and the addition of significant amount of organic matter to the soil through leaf fall and root biomass are distinct characters of legume culture, which helps in reversing soil deterioration. Pulses can utilize N from atmosphere for their growth through Biological Nitrogen fixation (BNF) involving symbiotic relationship between pulses and rhizobia that lives in root nodules. The quantity of N fixed by legumes varies greatly and runs up to several hundred kgs per ha, depending on legumes/cultivar, soil type and texture, soil pH, soil nitrate level, soil temperature and water regimes. Many soils do not have the sufficient numbers of appropriate rhizobia for effective symbiosis. Hence the practice of seed inoculation with species-specific rhizobia while sowing ensures maximal N fixation. Pulses also have the ability to reduce soil pH making the favorable condition for nutrient availability. Legumes facilitate recycling of nutrients from deep soil layers through deep rooting and have greater mobilization of insoluble P in soil through root exudates, which in turn serve as a substrate for microbial proliferation influencing biological properties of the soil. Crop rotations having legumes also influence soil physical properties such as the aggregate stability, hydraulic conductivity, bulk density, etc.

Title	: Techniques in Molecular Biology (Molecular Techniques in Gene Transformation)
Name	: Amruta Prakash Barhanpurkar
Institute	: University of Pune, Pune, Maharashtra, India
Supervisors	: Suhas P Wani and KK Sharma (Principal Scientists)
Period	: 14 June – 9 July 2004

Abstract:

Biotechnology offers a wide potential for application of molecular biology techniques for human welfare. The development of improved crops includes those conferring resistance to fungal pathogens, virus and the nutritional improvement, eg, the golden rice. The objectives of plant biotechnology is to identify the agricultural problems that can be solved by complementing classical plant breeding and thus, reducing the time scale required to produce a genetically enhanced germplasm. The development of the transgenic plants depends upon plant transformations that rely on introduction of the plasmid construction or segments of plasmid constructs into the genome of plant cell that confers resistance to disease. Transgenic plants are generated from the transform cells, as most of the plant cells are totipotent and hence posses the ability to generate the whole plant from a single cell. In this project different techniques (natural methods of DNA transfer) like isolations of plant DNA, isolation of plant total RNA, amplification of the gene of interest by using PCR/RT-PCR, restriction analysis of the DNA, and southern blot were studied. These techniques can provide knowledge regarding the molecular methods used in plant biotechnology.

Title	: Role of biofertilizers and their impact on productivity of field crops in semi-arid tropics
Name	: Kunal Ranjan Tiwari
Institute	: College of Agriculture, Allahabad Agricultural Institute (Deemed University), UP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 1 June – 25 June 2004

Abstract:

Chemical fertilizers used on a large-scale result in leaching and volatilization and are the main cause for ground water pollution and environmental degradation. In dryland agriculture inadequate moisture is also a limitation in the use of inorganic fertilizers. Biofertilizers can be a big boon for our country where the farmers are marginal having smallholdings. Use of organic and biofertilizers offer a great opportunity for sustainable crop production. Sustainable agriculture means, to sustain or stabilize the agro system and to minimize the industrial input demands. There are several reports of free living and symbiotic bacteria, which fix atmospheric nitrogen and are used as biofertilizers as a supplement for nitrogenous fertilizers.

Biofertilizers are better alternatives for reclamation of wasteland when compared with chemical fertilizers. For most of the crops and soil condition up to 20% of the nitrogen requirement can be met through biofertilizers, which can be the best replacement for chemical fertilizers. It may help to reduce the cost on chemical fertilizers and avoid soil problems. The use of biofertilizers (although not spread on a wide scale for all crops) is dominantly seen to respond in case of groundnut, brinjal, onion and sugarcane. Many researchers have proved that there is an increase in yield of field crops by 7–17.86% due to use of biofertilizers. Biofertilizers cannot replace chemical fertilizers, but certainly are capable of reducing their inputs. The response of application varies with various agro-ecological conditions suggesting evolving region-specific quality biofertilizers. Therefore by assessing their potentials this cheap and ecofriendly technology need to be transferred to farmers.

Title	: Modification of microcontroller-based sediment sampler
Names	: G Narasimha and M Yugandar
Institute	: Vignan Jyothi Institute of Engineering and Technology, JNTU, Hyderabad, AP, India
Supervisor	: P Pathak, Principal Scientist
Period	: December 2003 – March 2004

Abstract:

The sediment sampler was developed to take soil samples at a fixed sampling interval for estimating soil loss. The sampling periods required to be changed manually. There was a need to improve this instrument, which could give more accurate data. Three more sensors were required to be installed and the sampling period to change the accordance with the sensors sensed. As the flow rate of runoff water increases the height of water level also increases. Hence taking more samples during runoff rates could give us more reliable data for soil loss estimation. The control unit is the heart of the sediment sampler and a 12v car battery is used to give the necessary power supply to it. The battery is charged automatically by using a solar panel, which consists of about 36 solar cells. But when we use these solar panels in rural areas, it is quite difficult to protect them from strangers. It is unfavorable to use the costly collar panels

in the rural areas and an indication of the battery voltage is required to judge whether the battery is fit to be used. We have designed a battery monitor to get an indication of battery voltage so that we can recharge a battery whenever its voltage falls below a selected cut off value.

Title	: Interaction of micronutrients with beneficial microorganisms - <i>Rhizobium</i> and <i>Azospirillum</i>
Name	: Ms G Deepika
Institute	: Jawaharlal Nehru Technological University, Kukatpally, Hyderabad, AP., India
Supervisors	: Suhas P Wani, Principal Scientist
Period	: 23 July 2003 – 22 January 2004

Abstract:

Human interventions for increased agricultural productivity through introduction of high-yielding varieties and increased fertilizer use, has resulted in land degradation. Chemical fertilizers played a major role in the past two decades, mainly as a source of macronutrients and thereby offsetting the use of organic manures, resulting in deficiencies of nutrients that are required for plant growth and productivity. As a result there is a gradual decline in crop yields and fertilizer productivity and subsequent depletion of soil fertility. This concern has led to an ever-increasing emphasis upon means of conserving the limited supply of nutrients and also on sustaining soil fertility. Therefore the processes that regulate nutrient release and plant uptake in soil are considered as an essential prerequisite for sustainable agricultural management. Hence, more recently there has been increased interest in studies concerning the roles of beneficial soil microorganisms in enhancing soil productivity.

Studies conducted by ICRISAT on soil samples collected from watershed areas of Nalgonda and Mahabubnagar districts indicated micronutrient deficiencies especially B, Zn and secondary nutrient S. Amendments of these nutrients have shown increased growth and yield of the rainfed crops grown in the respective districts. In regard of this hypothesis that amendments of deficient micronutrients enhanced the yields of the crops the present study has been conducted.

The present investigation was conducted to study the effects of micronutrients on growth and yield of short-duration pigeonpea through process mediated by beneficial microbes like *Rhizobium* and *Azospirillum* under controlled and field conditions. Observations on bacterial populations, nitrogenase activity, biological activities in the soil, total dry matter were recorded at flowering and total dry matter and grain yield were recorded at maturity for the pot culture experiment. Field observations were made at vegetative for medium-duration pigeonpea and groundnut in Nalgonda and Mahabubnagar districts.

Application of boron equivalent to 2.5 kg/ha resulted in highest numbers of rhizobia and azospirilla in the soil, maximum TDM and grain yield (117%). Enhanced biological activity was observed with the application of optimal rate of boron. Sulphur application enhanced the nitrogen fixing potential for the pot culture experiment. High concentration of zinc in the soil might have rendered a toxic effect on the yield of pigeonpea. Application of micronutrients to the soil in field trials resulted in higher responses over control, in terms of microbial colonization, nodulation status while varied response among treatments was observed. Increase in grain yield and total dry matter was observed in the treatment All+NP followed by All, B, S and Zn in

both the districts. Practices that sustain crop productivity and soil fertility should be implemented for long-term benefits.

Title	: Interaction of micronutrients with beneficial soil organisms – <i>Mycorrhiza, Azotobacter and Azospirillum</i>
Name	: Ms N Linthoingambi Devi
Institute	: Jawaharlal Nehru Technological university, Kukatpally, Hyderabad, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 23 July 2003 – 22 January 2004

Abstract:

Anthropogenic reductions in soil health and individual components of soil quality are a pressing ecological concern and also influential on crop production. Soil is the basis of agricultural benefits. Improving soil fertility is a means of developing sustainable crop management systems. Although soil's contribution to plant productivity is widely recognized, present cultivation practices have a great impact on maintaining the soil's fertility. Amendments of soil with major fertilizers (NPK) are no longer the only means of enhancing soil fertility. The role of micronutrients in crop production is often neglected. An attempt was made in this study to have a perspective of the dynamic interactions between micronutrients and the soil beneficial populations, which aid crop growth and development.

In order to establish a comparative study with the field trial conducted by ICRISAT, short duration maize was selected as the host crop for the greenhouse experiment. Treatments of the red soil (RW2 of ICRISAT) with tripartite inoculation of VAM fungi, Azotobacter and Azospirillum along with micronutrient amendments (B, Zn and S) indicated an advantage in terms of grain yield over the control where the micronutrients were not supplied. Treatments consisted of a single application of each micronutrient at optimal and sub optimal dosages, combination of all the three optimal dosages and also the combination of all the sub optimal dosages. Optimal dosage of boron and sub optimal dosage of Sulphur were observed to favor the VAM fungi colonization along with increased populations of beneficial organisms such as Azotobacter and Azospirillum. There was also an indication of enhanced biological activities with maximum response in the amendment of sub optimal dosage of sulfur (T6). When overall plant growth response was estimated, higher improvements were recorded in the sub optimal dosages of the micronutrients. Though maximum grain yield was obtained in the soil amendment of optimal dosage of boron (T2), a considerably high yield could be obtained with Sulphur treatment. Zn definitely indicated an improved soil condition with improved crop yield but marked response was not noticed which could be attributed to its excessive availability in the soil. This study enabled us to partially unravel the synergistic interactions of micronutrients and the three beneficial inoculants. The outcome of this experiment necessitates further studies in exploiting the complex processes, which regulate the dual impacts of micronutrients and beneficial soil organisms to derive a technology for sustainable crop production.

Title	: Evaluating the ability of microorganisms to kill larvae of <i>Helicoverpa armigera</i>
Name	: B Vidya Suman
Institute	: Dept. of Microbiology, St. Francis College for Women, Osmania University, AP, India
Supervisor	: OP Rupela, Principal Scientist
Period	: 1 June – 16 July 2004

Abstract:

Three different experiments focusing on evaluating microorganisms for its ability to kill young larvae (neonate or 3rd instar larvae) of *Helicoverpa armigera* (Hubner) were conducted as part of this project. *H. armigera* or legume pod borer is a polyphagous insect attacking more than 182 host plants. Considering the harmful effects of chemical pesticides, widely used by farmers, microbial pesticides should be an eco-friendly option. Of the seven bacterial isolates, which killed *H. armigera* in previous studies, four isolates namely HIB 19, HIB 28, LS 12 and SB 17 were compatible with *Metarrhizium anisopliae*, a fungus with ability to kill insect pests. This was determined by co-habitation (growing together on a given medium) studies. In another experiment *M. anisopliae*, multiplied in potato dextrose broth, killed neonate larvae of *Helicoverpa* more strongly (100% mortality) than the 3rd instar larvae (75% mortality), indicating their susceptibility. Maximum mortality (83.3%) of 3rd instar larvae was recorded due to *M. anisopliae* multiplied on rice straw powder+rice grain at 10⁻³ dilution when compared to that multiplied in PDB (10⁻¹ dilution), in the third experiment. *M. anisopliae* was re-isolated from the dead larvae in order to maintain its virulence. Its identity was confirmed by microscopic examination.

2003:

Title	: WEB page designing
Name	: Mridula Cherukuri
Institute	: Villa Marie Post Graduate College for Women, Osmania University, AP, India
Supervisor	: Piara Singh, Principal Scientist
Period	: 18 March 2002 – 15 February 2003

Abstract:

In line with the new vision of ICRISAT, and consequent changes of research priorities organized into global themes, there is a need to reflect those changes on their web site at <http://www.icrisat.org>. Among several research and administrative divisions, some research components of Natural Resource Management Program (NRMP) have been regrouped into Global theme 3 – research, water, soil and agro biodiversity management for eco system health. Accordingly the Web pages on Internet and Intranet versions of the ICRISAT web site would need modifications. This includes new additions, modifications to existing pages on both the versions of the web site.

The web pages are designed as per the requirements specified by the global theme team. We have designed the page with the combination of rich text and a bit of graphics. The graphic file

types used are*.GIF,*. JPEG. The page is designed with tables. The reason tables are so popular with web page designers is that they let you arrange the elements of a web page in such a way that the browser will not rearrange them. Often, it is good to let the browser do the rearranging, especially when it reformats text to fit the available display area.

Title	: Watershed Development Program: Communications System
Name	: B Sivakumar
Institute	: Patnam Rajender Reddy Memorial Engineering College, Shabad, (RR Dist.) Affiliated to JNTU, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 6 January – 5 April 2003

Abstract:

The project was aimed at improving communication between the groups of ICRISAT through network software systems. The communication system was developed using ASP (Active Server Pages), VBScript (Visual Basic) and Oracle. The front end of the module consists of log on page with user id and password, which was created using ASP. The back end of the module consists of two WebPages indicating role and responsibilities, work schedule and work progress of the user logged. The developed pilot runoff model on communication system was tested and validated.

Title	: Interactive Communication Network
Names	: K Vanaja and K Neeraja
Institute	: Post Graduate college, Mahabubnagar, Osmania University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 3 March – 31 May 2003

Abstract:

The project was aimed at developing Interactive Communication Network on tour programs for NRM group, ICRISAT. This has been achieved by using software, in which all individuals of the group are interconnected through intranet. The front end of the module consists of user log on to the site, which was created by ASP. The back end of the module developed by MS-Access have WebPages indicating the proposed tour by user in group detailing about name, place of visit, starting and ending date of the tour, number of days, persons accompanied and objective of the tour and information about completed tour with observations and recommendations. This software allows authorized users to add/modify the information on tour programs. The developed system has been tested and implemented on a pilot scale.

Title	: Hydrological and economical assessment of water harvesting structures at Adarsha watershed
Name	: Mr K Srinivasa Raju.
Institute	: Faculty of Agricultural Engineering, Indira Gandhi Agricultural University, Raipur, Chattisgarh, India
Supervisors	: Suhas P Wani and Prabhakar Pathak, Principal Scientists
Period	: 17 February – 29 August 2003

Abstract:

The hydrological aspects and cost evaluation of different water harvesting structures viz, masonry and earthen check dams and sunken pits, as constructed at Adarsha watershed in Rangareddy district of Andhra Pradesh, were investigated. The modified SCS Curve Number runoff model developed by Pathak et al. (1987) had been modified to suit the topographic conditions of Adarsha watershed. From the runoff simulation studies over the past 15 years, it has been observed that there is a 59% probability of getting run off of more than 1,32,000m³ which can be generated taking into account, the existing capacity of 11,000 m³. Numerical modeling of tank had been used for making an estimate of artificial groundwater recharge. From the water balance studies of a 255 m³ capacity check dam, the contribution of water harvesting structures to ground water was assessed as 26000 m³ and 15000 m³ in the years 2000 and 2001 respectively.

Analysis of cost and storage capacity of water storage structure at Adarsha watershed revealed that, on an average, one cubic meter of water storage capacity cost Rs 8 for earthen check dams, Rs 27 for sunken pits and Rs 112 for masonry check dams. The high unit costs of masonry check dams outweigh the benefits of durability and stability. On the other hand, sunken pits have the limitation of storage capacity. Earthen check dams prove to be the most cost effective method, if precautions against overtopping are taken care. Earthen check dams are simple and easy to construct and hence can be implemented on a large scale, also without any hassles resulting in direct benefit to the local community. However, other aspects such as suitability, equity for harvested water and the purpose of a particular type of storage structure need to be further considered along with the economic assessment.

Title	:	Prospects of water harvesting in three districts of Andhra Pradesh
Name	:	P Sireesha
Institute	:	Center for Water Resources, Institute of Post Graduation Studies and Research, JNTU, Hyderabad, AP, India
Supervisor	:	Prabhakar Pathak, Principal Scientist
Period	:	24 February - 28 August 2003

Abstract

Lack of water at times of need is the dominant constraint to increasing productivity in most of the rainfed areas. In India tanks are traditional method for water harvesting to mitigate the drought problem. Three watersheds – Kacharam (red soil), Nandavaram (black soil), and Sripuram (red soil) have been selected from Nalgonda, Kurnool and Mahabubnagar district, Andhra Pradesh. Twenty-six years daily rainfall and evaporation data for each watershed have been collected. Soil samples from each watershed have been collected and analyzed in the laboratory for texture analysis and soil moisture at field capacity and wilting point.

Information on soils, long-term rainfall amounts and open-pan evaporation measurements from three watersheds has been used as input to water harvesting model developed at ICRISAT. It calculates daily net inflow and outflow from the tank by subtracting daily evaporation and seepage losses from the watershed runoff. Water harvesting model has been used for a year that has produced twenty-six years mean annual runoff based on simulated runoff data using runoff model developed at ICRISAT.

Each watershed has been tested for two soil types (A and B) taking spatial variability of soil into account. Statistical analysis has been done for simulated runoff for 26 years. Probabilities of getting 20, 40, 60 and 100 mm runoff have been estimated. Catchment area of 10 ha and three seepage rates in the range of 18– 8.8 L m⁻² day⁻¹ (red soil) and 4– 1.3 L m⁻² day⁻¹ (black soil) have been used for water harvesting structures in the model. Tank capacity was estimated based on the inflow for each watershed. In each watershed two soil types (A and B) showed variation in producing runoff that in turn affects the net inflow to the tank. Red soil watersheds have high potential for harvesting runoff than black soils. In black soils seepage losses are low whereas in red soils losses are high and need lining material for control. A series of such tanks can be proposed for watershed regions based on the area under irrigation and requirement.

Title	: Native <i>Cicer-Rhizobium</i> populations of rice fallows
Name	: M Srikanth
Institute	: Nagarjuna University, Andhra Pradesh, India
Supervisors	: JVDK Kumar Rao
Period	: February 2003

Abstract:

Rice fallows are lands used to grow rice in *kharif* (rainy season) and then left uncultivated (for no crop to grow) during *rabi* season (postrainy season). These rice fallows hold promise to grow a short-duration legume, eg, chickpea, on residual moisture. Chickpea is nodulated by a host of specific *Rhizobium*. The present study aims to study the population of chickpea rhizobia in some rice fallows of Chattisgarh, Jharkhand states of India and Nepal. The native chickpea *Rhizobium* populations were estimated by serial dilution-plant infection and most probable number methodology using chickpea genotype K 850 as test legume. A total of 52 soil samples were analyzed. Two samples from Nepal, four samples from Jharkhand, and 14 samples from Jagdalpur, had no chickpea rhizobia, while the remaining 32 soils had fairly good number of chickpea rhizobia. The population ranged from 0.38 x 10² to 1.43 x 10⁵ chickpea rhizobia per gram dry soil. These results indicate that chickpea is to be grown in rice fallows, and then it needs to be inoculated with an effective chickpea *Rhizobium* strain, ie, that the plant can fix atmospheric nitrogen and thereby increase grain yield and income to the farmers. Also it might contribute to soil fertility thus enhancing the sustainability of the rice-based systems.

Title	: Enumeration of microflora in vermicompost and its impact on different crops
Name	: Mr G Naveen
Institute	: University College of Science, Osmania University, Hyderabad, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 23 June – 22 August 2003

Abstract:

Vermicomposting is a process involving a wide array of microorganisms, converting organic wastes into valuable organic fertilizers. In this process microorganisms initiate the composting process. Earthworms when added, act as catalyst to the process and affix the nutrients that are readily available for the uptake of the plant in the form of castings when applied as manure. The

present study was aimed at minimizing the use of the compost by adding organic manure in suited proportions to the crop.

The studies carried out are mainly based upon the biological and applied aspects of vermicompost. The experiment mainly emphasized upon the microbial enumeration (fungi, bacteria, actinomycetes) with contrast to soil microflora that resulted in the higher counts such as, in vermicompost 57×10^6 bacteria per gram and in soil samples collected from *godown* and fields of ICRISAT have shown 45×10^6 bacteria per gram respectively. These experiments were carried out in two sets that had application of vermicompost in one set and vermicompost water in another. In the first set, vermicompost was applied at the rate of 2, 3, 4 and 5 t ha⁻¹ [T-1, T-2, T-3, T-4 respectively] and the effect of treatments on plant growth in vegetable and cereal crops in a green house was studied. The results showed a positive response with treatments T-3 and T-4 over control. In the second set, vermicompost water was used for irrigating the plants at the rate of 1, 5, 10% (10 g of vermicompost in 100ml water) [V-1, V-2, V-3 respectively]. The results showed that V-2 (5%) treated plants had better growth over control and comparative control (where vermicompost treatments was used), than the best treatment having vermicompost alone [T-4] added at a rate of 5 t ha⁻¹. The impact of the addition of vermicompost water on plant growth and chlorophyll content, when irrigated with concentrations containing high dose (10%; 10g vermicompost in 100ml water), (5%) moderate dose and (1%) low dose, 5% dose gave good response compared to the other treatments. An experiment was conducted to know the presence of the plant growth promoting substances in vermicompost and the results showed a positive confirmation.

Title	: Making collective action work in the watershed development program in India
Name	: Mr Raul Abreu-Lastra
Institute	: Kennedy School of Government, Harvard University, Cambridge, UK
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 9 June – 30 August 2003

Abstract:

The Watershed Development Program implemented by the Ministry of Rural Development in India aims to increase productivity in rainfed agriculture, reduce land degradation and combat rural poverty in small villages in drought prone areas. Currently it is implementing the program under a participatory approach. Beneficiaries are considered in the decision-making process and granted with the ownership of the project. They are responsible to engage in collective action for maintaining the project over time once the implementation period has finished.

This report analyses evidence from the Adarsha Watershed in Andhra Pradesh. The main findings are that in the absence of clear guidelines for creating rules to assess contributions and to share natural resources such as soil and water, the beneficiaries are not able to establish them. If this situation persists, sustainability of the project is at risk. Levels of inequality and social capital affect the likelihood and intensity of participation. One of the most important conditions for beneficiaries to cooperate is to guarantee equal opportunity for appropriating the natural resources that the project is collecting. The main challenge for the local institution that manages the watershed is to assess the cost and amount of soil and water used and make sure that the beneficiaries contribute proportionally to their usage of the resources. Implementation of these rules depend on the ability to observe how much soil and water is being consumed and punish the defaulters.

Title	: Microbial variety in the watershed
Name	: Ms B Sushma Vinaya
Institute	: Chaitanya College for Women, Andhra University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 8 May – 15 July 2003

Abstract:

Soil microorganisms especially vary widely in semi-arid and desert soils compared to other climatic zones. The microbial populations in arid soils are generally low as compared to other tropical soils; mainly due to the poor vegetation, which is the result of erratic and scanty rainfall. The treatment of soil by chemical fertilizers, bio-fertilizers not only enhance soil fertility but also enriches microbial life as it would bring high population of microorganisms with it.

In this project the quantity and the type of bacteria, fungi and actinomycetes in treated soil samples (CG) from the watersheds of Gokulpura *charagah* were studied. Enumeration of microbial population was done with these samples. Diversity in the colony morphology was recorded and different staining techniques and bio chemical tests were performed and the results were recorded.

Soil samples were grouped according to the area and the plots from where the soil samples were collected. From these groups colony morphology with diversity were recorded and different staining and biochemical tests were performed and results were recorded.

Title	: Spatial variability of beneficial organisms in rehabilitated common grazing lands in the watersheds, isolation and evaluation of microorganisms
Name	: Ms Y Srujani
Institute	: Chaitanya College for Women, Andhra University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 5 May – 10 August 2003

Abstract:

Due to low rainfall and low organic matter content microbial biomass of tropical soil is more varied in comparison to semi-arid tropic soil. This is a preliminary study of beneficial microorganisms in response to various treatments given to the soil.

Treatment with various agents not only enhances soil fertility but also enriches microbial activity. The presence of microorganisms will help for better vegetation especially in semi-arid tropics, in which cultivation is watershed dependent. This is by the presence of microbial biomass at rhizosphere, which can influence the vegetation on a particular soil. Similarly the growth of microbes will also be influenced by vegetation, as nutrients required will be met by roots of the plants in the soil and the litter.

This study emphasizes that the presence of beneficial microorganisms is due to enhancement of soil fertility as a result of better conservation methods. After enumeration, isolation and evaluation of microorganisms of treated soil samples, the results were compared with the results of non-treated soil samples, which were also studied. High variation was observed between these two types of soil samples.

Title	: Hands-on training using 'Agricultural Production Systems sIMulator (APSIM) for Cropping Systems Modeling'
Name	: MV Venugopalan
Institute	: NBSS & LUP, Nagpur, Maharashtra, India
Supervisor	: Suhas P Wani (Principal Scientist) and team
Period	: 7 – 11 April 2003

Abstract:

The training program arranged on my request was a unique learning experience. It exposed me with the capabilities offered by APSIM in comparison to other contemporary models like DSSAT and INFOCROP. The central concept of APSIM with soil as the base and weather and crop altering its properties is an exemplary feature. Since it considers the system as a whole without bias to soil, water or crop simulations, it aroused keen enthusiasm in me through out the training sessions.

The sessions on basic APSIM framework, APSFRONT interface and data needs and format were well structured. The hands on session through the tutorial, for performing simple simulations followed by exercises were very handy in getting a feel of the model. The following sessions on the preparation of new met, w2soil and w2 water files were thoroughly covered. Modifications that can be made in cultivar parameters for simulating new cultivars were interesting. These sessions induced confidence and infused enthusiasm for making simulations using our own experimental data. The structure for preparing .obs (observed data) and its utilization for comparing it with simulated outputs was lucidly explained. This is a commendable feature of the model. The time available was adequate not only for creating meaningful simulations using simple management options but also to study their long-term impact using historical met data.

Title	: A project report on sustainable integrated watershed management by using remote sensing and GIS
Name	: Ms K Samatha
Institute	: Centre for Environment, Institute of Postgraduate Studies and Research, Jawaharlal Nehru Technological University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 3 February – 25 September 2003

Abstract:

The study deals with sustainable management of Malleboinapalli watershed, a part of drought prone area of Mahabubnagar district using the resource database acquired from IRS-1D PAN and LISS-III merged data. To aid, drainage morphometry, hypsometry and the quantity of sediment yield and socioeconomic data from survey of the Malleboinapalli of this watershed was also used. Base map, contour map, slope map, drainage network and watershed boundary were prepared from Survey of India toposheets. The remotely sensed data in the form of geocoded false color composite of IRS-1D PAN and LISS-III satellite sensing system, obtained from National Remote Sensing Agency was used to prepare thematic maps of drainage network and watershed boundary, slope, land use/ land cover, geology, hydrogeomorphology, groundwater prospect, soil, land capability and land irrigability and transport network.

Settlements and village boundaries were also surveyed by using ARC/GIS 8.1.2. The drainage morphometry including hypsometric analysis was applied on the study area for deriving the erodability characteristics of the watershed based on the contour and drainage maps. The sediment yield was computed for the watershed by using Garde's formula. An attempt was also made to study the status of groundwater potential by the success of wells in contraction with slope and hydrogeomorphology of Malleboinpalli suffering from drought during the summer season. It was suggested that this could be achieved by constructing the suggested water harvesting structures for the augmentation of groundwater potential. The integrated study of all this led to the preparation of erosion intensity zone map. Finally master action plan was prepared for both land and water resources development by integrating the entire theme maps in conjunction with the results acquired from drainage morphometry, hypsometry, sediment yield and socioeconomic data of the Malleboinpalli village.

Title	: Evaluation of spatial and temporal changes in groundwater levels using RS and GIS - A case study of Malleboinpally area, Mahabubnagar district, AP, India
Name	: Ms V Ramalakshmi
Institute	: Center for Environment, Institute of Postgraduate Studies and Research, JNTU, Hyderabad, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 3 February - 25 September 2003

Abstract:

This study was carried out to delineate and characterize ground water prospect zones during the year 2002 and 1998 using PAN and LISS-III merged data, MSS geocoded data on a 1:50,000 scale. The information on geology, geomorphology, land use/land cover, slope were generated and integrated to prepare ground water prospect map for the area of Malleboinapalli in Mahabubnagar district. The information on type of well depth range, yield range, pumping time, and well position were supplemented to form a good database for identification of favorable zone. Geographical information system was used to prepare database on the above layers and composite map. On the basis of geomorphology, six categories of ground water prospect zones: excellent, good, moderate, normal to poor, poor very poor were delineated. The high prospect zones valley fills yield in 2002.15.8 bgl (m). The pediplain with moderate weathering, pediplain with shallow weathering, pediplain residual hills, inselburgs indicate good, moderate, normal to poor, very poor ground water prospects zones. In the study area ground water levels were seen to decrease compared to the years 1998 and 2002. Recommended a few ground water recharge structures and also suggested the suitable site for digging of wells.

Title	: Implementation of irrigation groundwater markets to increase efficiency and equity in semi-arid India
Name	: Ms Melanie Elizabeth Fedri
Institute	: University of Pennsylvania
Supervisors	: Bekele Shiferaw and Suhas P Wani
Period	: 21 January – 8 May 2003.

Abstract:

This study was an attempt to integrate all relevant issues into one coherent solution over how to practically implement water market mechanisms in a drought prone village such as Kothapally.

The introduction of water market mechanisms for irrigation purposes in low potential, high utilization areas requires careful contextual integration with watershed management activities. Watershed management focuses on natural resource conservation, cost-effective agricultural techniques and technologies, and widespread community participation. These activities increase the stability of agricultural productivity and availability of water through conservation techniques. Although these management activities play a vital role in improving the well being of villagers, they do not directly include individual decision making as a means of improving resource use and allocation. Introducing market mechanisms for irrigation water may lead to more efficient and equitable distribution among competing users.

First, scientific information on water table depth must be regularly tracked using a monitoring system. Without this information, no rational decisions can be determined regarding the amount of groundwater available for consumption in the village. Second, a monitoring group must be formed under the direction of the Watershed Committee. The monitoring group must consist of diverse community members, including members of all castes, women, and landless farmers. The diversity of the group will help to minimize favoritism and/or discrimination during the monitoring process. The group's training must be thorough and professional so as to ensure their competency and acceptance by the farmers they will be monitoring. The first task of the monitoring group should be to educate the villagers on the method of initial water rights allocation as described below.

Water rights should be initially distributed among the villagers independent of land ownership. Although incentive allocation was not the most preferred option among surveyed farmers, it seems to be the most equitable and supportive of watershed management activities. It puts all farmers on equal footing in the sense that each has the choice to engage in as many activities as they wish to earn initial rights. A one-year time frame should be specified, during which farmers have the opportunity to earn incentive points that secure initial water rights. The opportunity cost of not earning incentive points is higher for poor farmers and lower for rich farmers. In this way, poor farmers who tend to be less involved in watershed management activities may increase their participation. Landless farmers may also earn points through their involvement with self-help groups or the building of community water conservation structures. At the conclusion of the year, initial water rights should be distributed according to the points earned by each farmer.

Water rights should be granted in terms of points with no specific amount of water attached to each point. Periodically, such as at the start of each season, scientific data on water table depth should be collected to estimate the amount of available groundwater. The estimated available groundwater, estimated volume pumped per unit of time, and the total recorded number of water right points should be used to calculate the value of each water right point for that season. For example, in a drier season, one water right point may be worth 1 hour of pumping, while in a wetter season, that same water right point may be worth 2 hours of pumping. In cases of severe water shortage, the value of each water right point may become temporarily worthless. Under these circumstances, the focus of the village should be on basic survival and government intervention should prevail. Once water levels are restored to an adequate level, water rights correspondingly increase in value. Monitoring should be carried out each day during growing seasons to ensure that well owners do not pump more than their fair share. Success monitoring can be ensured if all wells are fitted with electric pumps and the amount of time electricity is provided to the pumps is carefully controlled. Regularity and reliability of electricity supply is also important, so that monitors know when they should be working and farmers know when they may operate their pumps. Control over electricity supply is one of the most important areas of government involvement in the protection of water rights.

Before initiating the trade of water rights, more extensive and reliable delivery systems must be laid down to connect well owners to potential buyers. The improvement of infrastructure benefits both parties, so that sellers have more potential buyers and buyers have more potential sellers to choose from. The increased competition among sellers to secure buyers helps to lower prices and improve service quality. Once sufficient delivery systems are in place, water trading may be initiated. When a potential seller and buyer of irrigation groundwater come into contact, several different transactions may occur. The buyer may exercise his right to purchase his allotted amount of water for the season for a negotiated price subject to a community-wide price cap. Alternatively, the non-well owner may permanently sell his water rights to the well owner. The well owner may have an interest in buying more water rights because he no longer has unlimited rights to illustrate as much water as he pleases. Although he continues to own his well, the water drawn through his well no longer automatically belongs to him. A member of the monitoring group must record any water purchase or permanent exchange of water rights.

To encourage continued involvement with watershed management activities, the monitoring group will periodically review farmers' involvement. If farmers maintain their previous involvement, they may keep their initially allocated amount of water rights plus any more acquired through permanent rights transfers. If their involvement increases, they earn additional water rights. If their involvement decreases, they lose water rights.

Finally, conflicts over transactions must be brought before the Watershed Committee and the records taken by the monitoring group used to help determine a proper ruling. Penalties must also be determined by the Watershed Committee and consist of a combination of cash payment and community service. The legal enforcement of water rights is the other area of government involvement that is of crucial importance in the functioning of water markets.

In conclusion, the implementation of irrigation water markets to improve equity and efficiency of semi-arid India requires a careful balancing of complex, intertwined issues and integration with current watershed management efforts. The particular conditions and preferences of a given community must be considered before introducing water market mechanisms.

Title	: Report on Hands-on training using 'Agricultural Production Systems sIMulator (APSIM) for Cropping Systems Modeling' at ICRISAT
Name	: T Giridhar Krishna
Institute	: Regional Agricultural Research Station, Nandyala, ANGRAU, AP, India
Supervisors	: Suhas P Wani (Principal Scientist) and team
Period	: 7 – 11 April 2003

Abstract:

Introduction to the background about the need to use software in cropping systems modeling was quite good. About APSIM framework, data required for running/simulating a model situation using APSIM/APSFRONT Interface was dealt with in detail.

The data needs and formats of APSIM input and observed files, their use in creation of templates, their location identification, view/graph APSIM simulation outputs, their plotting etc., which are highly essential to understand and run independently the simulation models were given priority and were taught thoroughly.

Modification of .ini files and creation of APSVIZ compatible .obs files and making new cultivar/soil/soil water parameters, etc, required for creating new templates as per the

requirement/situation and to run them with APSIM were practiced. The exercises on already available templates, creation of new templates, creating .met files with the available weather data, use of several management options in the simulations etc. were all organized in a proper sequence for easy following and doing simulations with APSIM.

The following suggestions are made:

More time might be devoted for the creation of templates as per different management options. All APSIM related files, their location paths and their retrieval paths etc., should be given as a hand out which help in handling the files independently.

This five-day (7th – 11th April 2003) training in APSIM gave good knowledge about simulation cropping system modeling and the use of APSIM software confidently for simulating crop/soil related management conditions and to understand the research results better.

Title	: Computer Program of water harvesting model for small agricultural watersheds
Name	: K Sushma Kiran
Institute	: Rural Engineering College, Bhalki, affiliated to Visweswaraiah Technological University, Belgaum, Karnataka, India
Supervisor	: Prabhakar Pathak, Principal Scientist
Period	: 24 March – 4 July 2003

Abstract:

In semi-arid tropics (SAT) timely availability of water to the crops is a major problem. As a consequence, crops suffer low and unstable yields. A suitable water source can be provided during the season by harvesting the runoff emanating from high intensity, short duration storms to augment the crop yields. The knowledge of potential for runoff harnessing is crucial in deciding the type and design of water-harvesting structures.

A runoff water-harvesting model was developed by ICRISAT, which could be used for assessing the prospects of water harvesting and its utilization for agriculture in the SAT. The model originally was developed in Turbo Basic, a DOS based language used in early 1980s. This works for a single year and one set of input parameters such as soil depth and seepage rate. The model can estimate the probability of runoff and water availability in a tank when long-term daily climatic data are available. Using this model the probabilities of getting different amounts of water from the runoff water harvesting system during the drought stress at critical periods can be determined. It was found that considerable information on various aspects of runoff water harvesting could be obtained. The chances of adequate stored water being available for supplemental irrigation during moisture stress periods can also be determined.

As the present model in Turbo Basic has its own limitations of not being user friendly, the researcher was assigned to convert the model to a user friendly, window-based application using CPP language in which suitable modifications were incorporated so that it works for multiple set of input parameters facilitating the user to enter any number of years, soil depths and seepage rates. By virtue of its simplicity and physical concept, it is convenient to use the model for various other purposes besides the calculation of net store in the tank. It can also be used for scheduling irrigation, determining effective rainfall and determining the overflow from the tank.

Title	: Sediment sampler modifications
Name	: M Venkateshwara Rao
Institute	: Madras University, TN, India
Supervisor	: P Pathak, Principal Scientist
Period	: November 2002 – January 2003

Abstract:

The sediment sampler was devised to take the samples at a fixed sampling interval for estimating the soil loss. The sampling periods have to be changed manually. There was a need to improve this instrument, which could give more accurate data. Three more sensors were required to be installed and the sampling period to change the accordance with the sensors sensed. Hence taking more samples during runoff rates could give us more reliable data for soil loss estimation.

The researcher modified the system unit by adding two new switches to the existing circuit. At present the pump ON time period is with the time span of 15 seconds, which is a constant one. By using these two switches one can select the required time span as per the positions of the switches given in the table. By this arrangement, required amount of samples can be collected in the sampler unit.

Title	: Microbial Diversity in Watersheds
Name	: Charu Rani
Institute	: Dept. of Microbiology, Kanaya Gurukula Mahavidhyalaya, UP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 7 February – 11 April 2003

Abstract:

Soil microorganisms especially in number vary widely in semi-arid and desert soil than in any other climatic zone. The microbial populations in arid soil are generally low as compared to any other tropical soil mainly due to poor vegetation, which is the result of erratic and scanty rainfall. The treatment of soil by chemical fertilizers, bio-fertilizers not only enhance soil fertility but also enriches microbial life as it would bring high population of microorganism with it.

This project studied the quantity and types of bacteria fungi and actinomycetes in non-treated soil sample (NTGC) of the Gokulpura *charagah* in Rajasthan. Almost five to twelve different types (based on colony morphology) of bacteria were identified from each of the nine different soil samples. Representative of each type from each of the nine samples were picked up for further studies. A total of 101 isolates were assembled. All 101 isolates were characterized morphologically. However only thirty-eight isolates underwent Gram staining, Spore staining, Acid-fast staining and catalase test. Only sample NO. 6-NTGC was characterized biochemically by casein hydrolysis test. Maximum population of bacteria was in sample NO. 2-NTGC (82×10^3). Minimum population of bacteria was in sample NO. 9-NTGC (47×10^2). Maximum population of fungi was in sample NO. 2-NTGC (8×10^3). Minimum population of fungi was in sample NO. 10-NTGC (0). Maximum population of actinomycetes was in sample NO. 7-NTGC (42×10^3). Minimum population of actinomycetes was in sample No. 9-NTGC (11×10^2). Of the thirty-eight bacteria twenty-two were gram-negative rods and sixteen were gram-negative cocci. Out of twenty-two rods only sixteen were gram-negative spore forming rods and six were gram-

negative non-spore forming rods. Apparently, all the bacteria were aerobic. Occurrence of gram-negative spore forming and aerobic rod forming bacteria seem to be a unique finding.

2002:

Title	: Understanding requirements of in-situ decomposition of rice–straw
Name	: Kesapragada Sujatha
Institute	: College of Science and Technology, Vishakapatnam, Andhra University, AP, India
Supervisor	: OP Rupela, Principal Scientist
Period	: 1 June 2001 – 15 September 2001 and 18 January 2002 – 15 March 2002

Abstract:

Most farmers in intensively cropped areas of at least four Asian countries burn rice and/or wheat-straw. Composting of any plant biomass (including rice and wheat-straw) is possible. It would require collection of biomass at composting point and is an expensive step particularly when a crop is harvested by combine. Composting of rice-straw as spread in a field after combine harvest, if possible, is an attractive proposition. Focus of the experiments reported here was to understand how to achieve moisture, temperature, humidity as required for efficient decomposition of rice-straw if spread in a field. Nine fungal isolates from decomposing plant materials were evaluated for this interaction between and among each other before their use as mixed inoculants in the two pot experiments that were conducted.

The interaction test indicated that seven cellulose degrading fungal strains (*Aspergillus awamori*, CDF 1, CDF 2, CDF 3, CDF 4, CDF 5, CDF 8) grew well on plate culture even in the presence of the other isolates and were used as mixed inoculant in both the experiments. *Trichoderma viridae* was suppressed by four of the nine fungi (CDF 2, CDF 3, CDF 4 and CDF 5) that were included in the test, and was not included in the mixed inoculant for the two experiments. All the fungal cultures remained pure in the inoculant packets (70 g each) for at least one month. *Trichoderma viridae* and *Aspergillus awamori* were pure even for two months of the study.

Experiment 1 evaluated four different materials as covers ('black polyethylene', transparent polyethylene, 'black polyethylene' with lower layer of white cloth, transport polyethylene with lower layer of black cloth) and uncovered (control) for their ability to retain moisture in the rice-straw placed on top of moist soil in pots. Moisture in rice-straw reached less than 50% in 24 hrs in all except in the pots covered with 'black polyethylene' and 'black polyethylene with lower layer of white cloth. About 20–23% moisture remained in the rice-straw in pots covered with 'black polyethylene with lower layer of black cloth up to 5 days. Temperatures above rice-straw during the day (for at least 6 hours per day) was above 40°C. Maximum temperature on the 15 days ranged 40–46°C inside pots while in the glasshouse it ranged from 36.5–45.9°C and was close to the long-term average (maximum 33.9–35.3, minimum 17.5–23.9 in Ludhiana) of the maximum ambient temperatures during September and October (when rice is harvested and its straw is burnt) in Punjab. Therefore temperature inside the pots was unfavorable for decomposition for at least six hours per day and moisture in the rice-straw was unfavorable for most of the 15 days of the experiment. As a result the researcher did not notice any good growth of fungi at end of the experiment, ie, on day 15 in any treatment. Humidity inside the pots

covered with 'black polyethylene' sheet was generally above 50% (range 51–100%) for whole of the experimental period suggesting that for microbial growth wetness of the straw was essential.

Microbial population in the straw at end of the experiment ranged from $4.60\text{-log}_{10}\text{ g}^{-1}$ rice-straw. Marginally reduced microbial population in rice-straw covered with polyethylene than control also indicates unfavorable conditions inside with polyethylene than control also indicates unfavorable conditions inside covered pots. Five of the seven fungi were very apparent in the plates used for counting due to their characteristic color of colonies. Their population in the rice-straw covered with 'black polyethylene' ranged from $4.31\text{-log}_{10}\text{ g}^{-1}$ dry rice-straw of strain CDF 5 to $\text{log}_{10}\text{ g}^{-1}$ dry rice-straw of strain CDF 3.

The second experiment studied if partial burying of rice-straw, with or without inoculation would result in decomposition of the rice-straw in pots covered with 'black polyethylene'. Rice –straw (15 g per pot) was sprayed by a suspension (600 ml per pot) of the 6 fungal strains. 0.5% of methyl cellulose (as a wetting agent) was sprayed on rice-straw in the soil surface place. Rice straw was sprayed with 25 ml of deionised water per pot on day 6 and on every third day subsequently. Moisture percentage measured at different days indicated that rice-straw had 31.5 to 60.9% moisture about 24 hrs after spraying. Partially buried straw had less water (range 31.5 to 40.3%) and moisture in surface placed straw ranged between 44.4 to 60.9% on one day after spraying. Much of the moisture seemed to have been lost within 5 days after spray despite cover of 'black polyethylene' (28% in surface and 37.2% in partially buried straw remained on day 5. Humidity was retained inside pots in the glasshouse. Temperature of rice-straw inside pots ranged from 31.2–32.73 during the day (1000 hrs to 1600 hrs) (measured by micro logger) and was similar with or without burying of rice-straw. Air temperature in glasshouse was about 25–30° C during day and about 22–24° C during nights.

Temperature recording by HOBO data logger inside pots indicated maximum temperature range of 30–57° C and minimum of 23–27° C during the experiment period. Microbial population measured at the termination was marginally higher in surface placed rice-straw. Most of the recovered population of bacteria was on $\frac{1}{4}$ PDA (mean population 10.43– 14.51 $\text{log}_{10}\text{g}^{-1}$) in dry rice-straw. Similar was the case with the fungal population. Still on day 10, there was not much visible growth of fungi on the rice strands. It may have been due to very high temperature inside pots at least for significant parts of day on the 10 days of the experiment. This suggests that microorganisms survived the conditions but did not function. Representative colonies of each type of bacteria, actinomycetes and fungi on all the four media were pocked up and purified for further studies. A total of 50 bacteria, 17 actinomycetes and 19 fungi were assembled. Morphological characters of bacteria and actinomycetes were studied on $\frac{1}{4}$ PDA and cellulose bacterial medium (CBM) and fungi on $\frac{1}{4}$ PDA and cellulose fungal medium (CFM with antibiotic streptomycin). Their growth on $\frac{1}{4}$ PDA was generally abundant and rapid than on cellulose-based media.

Further studies on understanding the environment for in-situ degradation for rice-straw may be done in field and not in pots. Holding 50–70% moisture considered desirable for rice straw degradation may not be possible in pots particularly when one is trying to use the external environment close to what exists in areas that burn rice-straw.

Title	: Developing procedure for effective sterilization of rice-straw compost
Name	: P Syama Chand
Institute	: Dept. of Microbiology, GVR and S Degree College for Women and Post Graduate Courses, Nagarjuna University, AP, India
Supervisor	: OP Rupela, Principal Scientist
Period	: 2 May – 31 July 2001 and 1 January – 31 January 2002

Abstract:

Preparation of compost from rice-straw for field application may not be economically viable. But its uses as carrier of agriculturally beneficial microorganisms may be a viable proposition. For long-shelf life of the inoculants use of sterilized carriers is a must and was the focus of this project. A series of five experiments were performed to arrive at a protocol for effective sterilization. The variables attempted in these experiments involved, a range of moisture levels (0%, 20% and 30%) in the compost (added before autoclaving), number of cycles of autoclaving (1 to 4), incubation period between cycles (12, 24 and 48 hrs) and duration of autoclaving (20 and 60 minutes). At start of the study, the researcher hoped that sterilization of compost by autoclaving might be very easy. But with every next experiment, this proved wrong. The autoclaving protocol was modified with minor changes (in the variables indicated above), in an exigent manner. Future experiments have to study the variables more systematically to develop a protocol of autoclaving for effective killing of all microorganisms in the rice-straw compost.

Focus of the project was to evaluated rice-straw as a carrier for *Aspergillus awamori* a fungus known to solubilize insoluble form of phosphorus in soil. As it was accepted that the researcher failed to effectively sterilize the carrier, the focus of the study was shifted to effective sterilization of the rice-straw compost. One experiment where the compost was used as a carrier for *A. awamori*, the fungus did survive well for 15 days of the study.

Title	: Microbiological and enzyme studies for characterization of APRLP watersheds
Name	: Vijaya Lakshmi M
Institute	: Dept. of Microbiology, Montessori Mahila Kalasala, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 13 May – 14 July 2002

Abstract:

Soil samples (total of 55 samples) from watersheds of Nalgonda district (WS 1 and 2) and Mahabubnagar district (WS 3 and 4) were collected and were analyzed for total microbial populations, spores counts, alkaline phosphatase and acid phosphatase activity. High counts of fungi were recorded in WS 2 (17×10^3 cfu/g soil) and low counts were observed in WS 4 (3×10^3 cfu/g soil). Bacterial populations were high in WS 3 (11×10^4 cfu/g soil) and low counts of bacteria were recorded in WS4 (39×10^3 cfu/g soil). Counts of actinomycetes were more in WS 2 (24×10^3 cfu/g soil) and low counts were recorded in WS1 (2×10^3 cfu/g soil). High counts of *Rhizobium* were recorded in WS 3 (10×10^3 cfu/g soil) and low counts were recorded in WS 4 (3×10^3 cfu/g soil). Spore counts were more in WS 2 (34 spores/g soil) when compared with other locations. Alkaline phosphatase activity was more in WS 1 ($784.5 \mu\text{g g}^{-1}$ of soil) and low was recorded in WS 3 ($10.52 \mu\text{g g}^{-1}$ of soil). Acid phosphatase value was high in WS 4 ($533.5 \mu\text{g g}^{-1}$ of soil) and low in WS 3 ($81.04 \mu\text{g g}^{-1}$ of soil). Results in the four watersheds recorded a great diversity in

microbial populations and enzyme activity. These studies explained the biological status of the soil in that area which is helpful to understand the soil health which in turn is related to plant growth.

Title	: Biological characterization of APRLP watersheds
Name	: Nagadeepika K
Institute	: Dept. of Microbiology, Montessori Mahila Kalasala, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 13 May – 13 July 2002

Abstract:

Soil samples (total of 55 samples) from watersheds of Nalgonda district (WS 1 and 2) and Mahabubnagar district (WS 3 and 4) were collected and were analyzed for total soil respiration, biomass C, mineral N, biomass N, net N and dehydrogenase activity.

High value of soil respiration was recorded in WS 1 (153 mg of C Kg⁻¹ of soil) and low value was recorded in WS 3 (79 mg of C Kg⁻¹ of soil). Biomass C was high in WS 1 (446 mg of C Kg⁻¹ of soil) and low value was observed in WS 4 (141 mg of C Kg⁻¹ of soil). Mineral nitrogen was high in WS 1 (29.7 mg of N Kg⁻¹ of soil) and low value was recorded in WS 2 (2.9 mg of N Kg⁻¹ of soil). High value of biomass N was recorded in WS 1 (27.6 mg of N Kg⁻¹ of soil) and low value was recorded in WS 4 (6.6 mg of N Kg⁻¹ of soil). Net N was high in WS 3 (6.7 mg of N Kg⁻¹ of soil) and low value was observed in WS 4 (0.5 mg of N Kg⁻¹ of soil). De hydrogenase activity was high in WS 3 (396.79 µg) and low value was recorded in WS 2 (11.04 µg). By studying these parameters the nutritional status of the soils can be estimated and their effect on the other soil parameter like microbial populations can be studied which in turn will help in improving the crop yield and will also be helpful in developing various biofertilizers for healthy crops.

Title	: Biological and enzyme studies for characterization of APRLP watersheds
Name	: Swamy Krishna T
Institute	: Dept. of Biotechnology, Nagarjuna University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 6 May – 23 July 2002

Abstract:

Soil samples from watersheds of Nalgonda district (WS 5 and 6) and Mahabubnagar district (WS 7 and 8) were collected and were analyzed for soil respiration, mineral N, biomass C, biomass N, net N, dehydrogenase activity. Soil respiration was high in WS 5 (186 mg C Kg⁻¹ soil) and low value was recorded in WS 7 (79 mg C Kg⁻¹ soil). High value of mineral N was recorded in WS 6 (22.6 mg N Kg⁻¹ soil) and low value was recorded in WS 5 (1.7 mg N Kg⁻¹ soil). Biomass N was high in WS 6 (9.2 mg N Kg⁻¹ soil) and low value was recorded in WS 8 (6.6 mg C Kg⁻¹ soil). Biomass C was high in WS 7 (576 mg C Kg⁻¹ soil) and low in WS 8 (141 mg C Kg⁻¹ soil). High value of net N was recorded in WS 7 (6.7 mg N Kg⁻¹ soil) and low value was recorded in WS 6 (4.7 mg N Kg⁻¹ soil). High value of dehydrogenase activity was recorded in WS 5 (430.3 µg) and low value was recorded in WS 7 (52.8 µg).

These results give us the characteristic of soils in these watersheds, if worked out further can be used to increase the crop yield. The microbial activity can also be studied as all these parameters are directly or indirectly related to the population counts of the microorganisms in the soil.

Title	: Microbiological and enzyme studies for characterization of APRLP watersheds
Name	: Sai Lakshmi A
Institute	: Dept. of Biotechnology, Nagarjuna University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 6 May – 23 July 2002

Abstract:

Soil samples from watersheds of Nalgonda district (WS 5 and 6) and Mahabubnagar district (WS 7 and 8) were collected and were analyzed for microbial activity (bacteria, fungi, actinomycetes, Rhizobium) and acid and alkaline phosphatase activity. High counts of bacteria were recorded in WS 7 (10×10^5 cfu/g soil) and low bacterial populations were recorded in WS 6 (3×10^3 cfu/g soil). Fungal populations were high in WS 6 (46×10^4 cfu/g soil) and low counts were recorded in WS 5 (1×10^3 cfu/g soil). Counts of actinomycetes were high in WS 7 (81×10^3 cfu/g soil) and low counts were recorded in WS 6 (1×10^3 cfu/g soil). Rhizobium populations were high in WS 7 (16×10^4 cfu/g soil) and low populations were recorded in WS 6 (1×10^3 cfu/g soil). Spore count was high in WS 5 followed by WS 6, WS 7 and WS 8. Alkaline phosphatase activity is high in WS 6 (1050.3 μ g) followed by WS, WS 5 and low were recorded in WS 7 (41.43 μ g). Acid phosphatase activity was high in WS 6 (1431.1 μ g) and low activity was recorded in WS 8 (53.80 μ g).

Soil microbial and enzymatic studies help us in understanding the soil health and they help in indicating the nutrient availability for plant growth and increase plant production.

Title	: Enumeration of microbial populations in different carbon sequestering systems in the semi-arid tropics.
Name	: Vineela C
Institute	: Andhra University, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 18 June 2001 – 25 March 2002

Abstract:

The project on 'Microbial Status in Different Carbon Sequestering Systems in the Semi-Arid Tropics' deals with the influence of the cropping system and management practices on microbial activity and its role in carbon sequestration in soils. The specific objectives of this investigation were: To study the relationship between soil microorganisms and management practices and their role in the SAT systems.

Elevated counts of microbial populations were recorded with the treatments where both organic and inorganic sources of Nitrogen, Phosphorous and Potassium were applied. Individual addition of organic or inorganic fertilizers did not record high counts of microbial populations as in the combination of organic plus inorganic fertilizers. Microbial population counts were more in Vertisols than in the Alfisols. High counts of microbial population were observed in the pH range 6.5–8.0 than under highly acidic or alkaline soil pH. It was observed that highly acidic conditions were tolerated by fungi as a result in soils where population of fungi were more the counts of bacteria and actinomycetes were low. It was observed that the counts of actinomycetes were more in the treatments with farmyard manure (FYM), Crop Residue and Green Leaf Manure than with chemical fertilizers.

Further studies on these may help in improving the soil carbon pool for better sequestering systems.

Title	: Estimation of biological properties in BW –7 watershed
Name	: Padma Madham
Institute	: Central Research Institute for Dryland Agriculture (CRIDA), AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 27 August – 10 October 2002

Abstract:

Soil samples from different plots of BW-7 were collected and were analyzed for different parameters like soil respiration, biomass C, mineral N and net N and enzymatic activity. Variations of values in the parameters with different depths were observed. These experiments provide information on different methods used for analyzing biological parameters.

Title	: Training on integrated watershed management.
Name	: Mr Vu Ngoc Thang and Vu Van Ba
Institute	: Vietnam Agricultural Sciences Institute (VASI), Vietnam.
Supervisor	: Suhas P Wani (Principal Scientist) and team
Period	: 10 January – 9 February 2002

Abstract:

We researchers participated in the training course on integrated watershed management during 11th January 2002 – 8th February 2002 at ICRISAT, Patancheru, Andhra Pradesh, India. The training was on the following issues:

- General watershed layout, management, runoff and sediment sample and data collection.
- Agroclimatic data management and analysis and soil moisture measurement.
- Crop growth and yield measurement.
- Soil and plant sampling and nutrient balance.
- Integrated nutrient management vermicomposting, composting and visit to Kothapally watershed.
- IPM and NPV production.
- Introduction to statistical field designs and data analysis.

2001:

Title	: Effect of soil type, cropping system and seed treatment on vesicular – arbuscular mycorrhiza
Name	: V Asha Jyothi
Institute	: GVR and S Degree college, Guntur, Andhra University, AP, India
Supervisor	: JVDK Kumar Rao
Period	: 2 May – 31 July and 1 October – 31 October 2001

Abstract:

Studies on VA mycorrhizal spore count of selected soils and root colonization of pigeonpea, chickpea and millet crops were conducted to know the effect of soil type, cropping system and seed treatment (seed priming and Rhizobium inoculation) on VAM during May 2001 and July 2001 at ICRISAT Centre, Patancheru, Andhra Pradesh, India. The native VA mycorrhizal population was less in Vertisol as compared to Alfisol. The soil collected was at the beginning of *rabi* (postrainy) crop as compared to the soil collected at the beginning of the *kharif* (rainy season) crop. The VAM spore count decreased with increasing soil depth. Effect of cropping system was tested in two different Alfisol fields (RP9B and RCE3) at ICRISAT Centre. Fallow decreased the spore count in RP9B but not in RCE3. Millet did not affect the native VAM spore count in RP9B while it increased in the RCE3. The study on the effect of seed priming and Rhizobium inoculation on VA mycorrhizal infection of chickpea genotypes ICCV2 and ICC37 was made in pots and at farmer field conditions. There was a significant difference in treatment effect on both cultivars. The cultivar and treatment also affected the percentage VAM infection. ICC37 showed higher percentage of VAM infections than that in ICCV2. In pot and field trials the control treatments, ie, T4 and T6 where there was no seed priming and Rhizobium inoculation, showed higher percentage of VAM infection than that of Rhizobium inoculated treatment.

In a different study on the effect of pigeonpea based cropping system on VAM infection of pigeonpea roots, sole pigeonpea showed higher percentage of VAM infection compared to the pigeonpea intercropped with sorghum. In another study on the effect of plant density on VAM infection of nodulating and non-nodulating pigeonpea genotypes it was observed that there was no significant change between nodulating and non-nodulating genotypes. However, the treatment having 4 plants/m² showed highest VAM infection and 8 plants/m² showed least VAM infection while the treatments having 33 plants/m² and 16 plants/m² had infection levels in between the former two.

Title	: Participatory evaluation of land and water management system at Kothapally watershed
Names	: Raphaele Devemy Deleau and Peyra Emilie
Institute	: Institut Superieur d'Agriculture Rhone –Alpes, 30eme Promotion, and ISTOM promotion 90, France
Supervisor	: Prabhakar Pathak, Principal Scientist
Period	: June - October 2001

Abstract:

The objective was mainly to help the farmers increase their field production by proposing to use best-bet techniques with best advices. For two months the researchers worked in Kothapally, located 40 km south of ICRISAT Center, Patancheru.

Their objective was to establish an agricultural and economic listing and compile the results. The idea was to know the structure of the different crops sown in the three different land management techniques, to understand the market's perception and to judge the farmer's perception about the new initiatives. A questionnaire was prepared with a list of farmers growing similar types of crops and a comparison was prepared in three parts: a comparison with the same technique in different soils, the comparison between the traditional and the ICRISAT

techniques and a comparison between the ICRISAT techniques and different soils. After dividing the work different reports were individually.

Title	: Program for the analysis of the rainfall data
Name	: G Arun Kumar
Institute	: HRD Degree and PG College, Osmania University, AP, India
Supervisor	: KPC Rao, Sr Scientist
Period	: 21 March – 31 July 2001

Abstract:

This program contained information about the rainfall recorded in different districts and their corresponding stations.

If the rainfall is not recorded then the RFALL field is kept as negative value. There are 46 tables in one mdb file, 23 tables corresponding to the recorded rainfall, 23 tables to rainfall that are not recorded. The table structure follows the guidelines. This application is:

- Used to retrieve the information.
- Used for searching data by selecting options.
- Monthly selection is used to calculate the monthly totals and the yearly rainfall.
- Seasonal selection is used to calculate the rainfall between the two dates.
- Kartes selection helps you to get the data when you select the kartes corresponding to traditional calendar and displays according to Christian calendar.
- Saving the required information either to a text file or to an excel file.
- Taking the print of the required information.

A Program for the Analysis of the Rainfall Data system has been developed, using visual basic 6.0 environment along with activex data objects. The backend database has been stored in MS Access97. Users cannot access this database as this was provided with a password protection. The user can view the details only by running the application.

Title	: Crop Data Base Management System
Name	: Murali Krishna
Institute	: Makhanlal Chaturvedi Rashtriya Patrakarita Vishwa Vidyalaya, MP, India
Supervisor	: Piara Singh, Principal Scientist
Period	: 19 March – 18 August 2001

Abstract:

Crop database management is a web-based system and is designed completely to be menu driven. This system provides the required information about the details of all the crops. It is user friendly, easy to access, retrieve and manipulate data. This system is designed in such a way that all the new and latest information will be immediately available to the researchers.

Title	: Watershed Management at ICRISAT and Kothapally – A Microbiological Perspective
Name	: Mr Xavier Sarda
Institute	: ISTOM, Cedex, France
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 6 July – 7 September 2001

Abstract:

In the watersheds, the runoff water carries along with it the finer fractions of soil – the silt and clay which get deposited in the tanks and reservoirs as sediment. The sediment at the bottom of the tanks reduces the storage capacity of the tank and could affect the water quality. Also the sediment is reported to contain high nutrient status and this in turn could affect the environmental quality. The sediment if found to be fertile, could be used as a natural fertilizer by adding it back to the field.

This study was conducted to have a clear insight into the sediment quality and its effect on the environment in the microbiological perspective and carbon dioxide emission from the sediment deposited at different sites of Kothapally watershed tanks. Regarding bacteria, fungi and actinomycetes, the bacterial population was found to be higher in comparison to fungi and actinomycetes. The CO₂ emission studies indicate that the increasing level of sediments did not significantly alter the rate of carbon dioxide emissions and also was not very different from the control treatment where no sediment was added to the experimental setup. This indicates that the water in the tanks do not alter the rate of respiration of biological life.

Title	: Effects of vermicompost amendments on soil microbiological properties, growth and yields of soybean and chickpea crops in Vertic Inceptisols under semi-arid tropical conditions
Name	: Bhavna Priyanka Pershadi
Institute	: Dept. of Biology, RD University, MP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 5 February – 7 September 2001

Abstract:

There is a need to improve soil fertility by using available resources on the farm for increasing crop yield in SAT. Some of the obnoxious weeds and crop residues can be converted into value added farm compost through enrichment with rock phosphate (RP) and biological agents such as phosphate solubilizing microorganisms, eg, *Aspergillus awamori*, free living nitrogen fixing bacteria such as azospirillum species, fungi and earthworms which can convert farm residues to value added vermicompost. This study was conducted for assessing the potential of using vermicompost for increasing soil fertility in terms of biological, physical and chemical properties, which would consecutively lead to increase in crop yield. On the whole the effect of vermicompost alone was not that beneficial for crops in terms of yield, nutrient uptake and soil biological properties. However, when applied in combination with chemical and biological fertilizers it was found to be highly beneficial in enhancing soil health, yield attributes and nutrient value of crops both qualitatively and quantitatively.

Title	: Improvement of farmyard manure for a sustainable agriculture
Name	: Burel Benoit
Institute	: ISTOM, 32, Boulevard du port, 95094 Cergy-Pontoise Cedex, France
Supervisor	: Suhas P Wani, Principal Scientist
Period	: 21 June – 19 September 2001

Abstract:

Burel Benoit participated in a research work on Natural Resource Management Program, on 'On-farm integrated nutrient management and quality of manure/compost used in Kothapally watershed'.

During the training period, he learnt the farming systems in the village by doing a survey on farmyard manure (FYM) with the active involvement 20% of Kothapally farmers. It was observed that as the years progressed, the number of animals per farm decreased, and as a consequence, the nutrient value of FYM declined. This hypothesis is unfortunately proved right after a comparison with the manure used at ICRISAT.

The farmers have now realized the potential of FYM on their cash crops and are out to find ways of enhancing their production, for example by integrating weeds residues in their farmyard manure pits and by making vermicompost.

Title	: Simulation of the effects of manure quality, soil type and climate on N and P supply to sorghum and pigeonpea in semi-arid tropical India
Name	: R Sucharitha
Institute	: Dept. of Agronomy, Sri Venkateshwara Agricultural College, ANGRAU, AP, India
Supervisor	: RJK Myers, Principal Scientist
Period	: 18 May 1998 – 20 February 2002

Abstract:

The semi-arid tropics cover almost 20 million km² in 55 developing countries, and are home to one-sixth of the world's population. Crop yields in semi-arid tropics fall short of their potential because of inadequate nutrient supply from the generally poor and infertile soils of SAT, inappropriate quality of the organic materials and inefficient combinations of organic and inorganic nutrient inputs. The farmers in this region are left with few options for investing on soil fertility. They would benefit from access to alternative cropping systems like including legumes in the rotation and by using quality manures that could reduce the rate of soil fertility decline, or even raise soil fertility.

Simulations play a key role in resolving the problems of intensive farming since, they can simulate long time periods and large numbers of alternative situations. Of the different models used, APSIM (Agricultural Production Systems Simulator) acts as a tool to improve the effectiveness of research by taking into account the long-term seasonal variability and by filling gaps in the experimental period. APSIM is a state of art modeling package that has been developed in and for tropical farming systems. This study attempted to understand the best way of managing the manure inputs in SAT cropping systems taking into account the manure quality, cropping systems, two major soil types (Alfisols and Vertisols) and climatic risk. The simulation was done within the APSIM framework package for use in agriculture.

The experiments were carried out during the *kharif* and *rabi* seasons of 1998 and 1999 on shallow Alfisols and medium-deep Vertisols at ICRISAT, Patancheru near Hyderabad, India. Manures were classified as low and high quality based on different quality parameters viz., NO₃⁻-N, NH₄⁺-N, total nitrogen, total phosphorus, Olsen-P, organic carbon, polyphenols, lignin, and

acid-detergent-fiber (ADF). Manures with high N and P content, low lignin, low C:N ratio, and low polyphenols are designated as high quality and vice versa. Though the manures were characterized on different parameters, the important factors controlling N release from manure considered in the present study were the carbon and nitrogen contents (C:N ratio only).

Of the two cropping systems examined viz., the pigeonpea - sorghum and sorghum - sorghum system, the amount of available - N ($\text{NH}_4^+ + \text{NO}_3^-$ -N) remaining in the soil after *kharif* pigeonpea was more than after *kharif* sorghum. This was readily available at the beginning of the cropping season for the subsequent crops. The apparent benefit of legumes in crop rotations may be due to the legume 'sparing' soil N by fixing the majority of the N removed at harvest, rather than the legume directly contributing N to the soil.

In field experimentation the sorghum after sorghum was not grown owing to resource constraints. This gap in the experimental treatments for cereal - cereal rotation was filled using APSIM-maize model as a surrogate. The contribution (or) beneficial residual effect of extra-short-duration pigeonpea to the succeeding sorghum when compared with simulated cereal - cereal rotation, was equivalent to 22 kg N ha⁻¹ in the Alfisol and 14 kg N ha⁻¹ in the Vertisol. Though it is not large, even a moderate input is valuable for a crop such as sorghum in semi-arid tropics. The study also proved that the response of pigeonpea to manure inputs was more than that of sorghum. It was more by 28% in the Alfisol and 16% in the Vertisol. The improved efficiency of applying manures to the legumes might be attributed to quality manures acting not only as a source of nutrients, but probably stimulating biological nitrogen fixation activity of the legume. The simulated results indicate that the higher water holding capacity of the Vertisol, in conjunction with *kharif* rainfall pattern, make legume-cereal rotation a reliable option for this environment. For Alfisol, with a relatively higher risk of moisture stress for the legume-cereal rotation, the yield benefit to the following cereal is much less.

The inclusion of extra-short duration variety in the system was preferred over short duration varieties because the former matures two weeks earlier, which enables earlier sowing of *rabi* - sorghum. Thus legumes in a cropping system can improve a strategy of integrated soil fertility management aiming at an optimal recycling of nutrients via crop residues, manures, and biological nitrogen fixation.

Pigeonpea responded well to P application at 20 kg ha⁻¹ (P20) in Alfisol and Vertisol. The manure treatments also influenced the total biomass, yield, N and P uptake than control at flowering and harvest in both soils. Of the manure treatments, the response to high quality was more compared to low quality. The crop's response was more in Alfisol than in Vertisol. The positive interaction between Alfisol and P20 application during *kharif* 1999 indicates the synergistic effect of the treatment and a considerable response from the soil to the added P.

The response of *rabi*-sorghum in terms of its biomass, yield, and N and P uptake was more in the plots applied with high quality manure (MB) followed by P application at 20 kg ha⁻¹ and low quality manure (MA). The P application to pigeonpea might have activated the development of P solubilizing organisms in the root zone of this crop and also to Fe_3PO_4 solubilizing activity of certain components of their root exudates, namely piscidic acid and its derivatives, thus increasing the available P pool. Consequently, succeeding sorghum in the rotation may access such P.

The N fertilizer substitution value of high quality manure was 28 kg ha⁻¹ and low quality was 15 kg ha⁻¹. This has significantly influenced the biomass, yield, and N and P uptake. The higher lignin and polyphenols concentration in low quality manure resulted in poor decomposition of

this manure, thus affecting the release of nutrients. However, the model suggests little residual benefit of manure for *rabi* cereal. This might be due to little rainfall in *rabi* to drive further decomposition and N release (since manure is in surface layer that is seldom re-wet by rain in *rabi*). Addition of nitrogen to *rabi* sorghum was associated with significant increase in growth, N and P uptakes and yield. Quantitatively the benefits preceding from high and low quality manures in both soils were equivalent to 40–80 kg N ha⁻¹ applied. The low fixation or adsorption of phosphorus (both applied and manure P) in Alfisol than that of Vertisol has improved the P status of the soil, thereby resulting in the increase of biomass, yield and N and P uptake of sorghum grown.

The simulations slightly overestimated the total biomass for the control and P treatments because the model was not P aware. Nevertheless, the model ensured the best representation of the legume effects on soil N and residue inputs (roots and leaf litter) for the legume with subsequent effects on N supply to the *rabi* cereal crop.

Higher biomass, yield, and N and P uptake was obtained in the irrigated plots of sorghum than rainfed plots during *rabi* 1999. Irrigation at critical stages of crop growth increased water use and nutrient uptake over rainfed thereby increasing the biomass production and grain yield. The response of sole sorghum to combined application of N+P was more compared to other treatments at flowering and final harvest in both soils. The increase in N and P uptake due to N+P application could be attributed to the favorable effect of nitrogen application on dry matter production. The reduction in soil nitrate N from flowering to harvest indicates higher uptake of N and P by the crop thus resulting in higher biomass production and yields.

The response of sorghum to high quality manure (MB) indicates that the higher N and P concentration and low C:N ratio of MB increases the decomposition rate, resulting in the quick release of available nutrients to the plant throughout the growth period.

The response of sorghum to manure and fertilizer applications was more in Alfisols compared to Vertisols. The apparent lack of fertilizer responses on Vertisols has been attributed to their high fixation (adsorption) of added P, caused by their high clay content, dense and compact nature, and low porosity.

As the APSIM sorghum module is not P aware, the maize module was used as a surrogate for sorghum. It was assumed here that the maize surrogate behaved similarly to the sorghum used in the field. The model was better at predicting the responses of sorghum to organic and inorganic fertilizer application in terms of its biomass. The accuracy of prediction was 88%, which explained that the experimental data was in error of 12%, which was quite feasible (or acceptable) for a field experiment. The slope of close to 1.0 suggests little bias in the model for simulating low or high yields. The regression equation indicates that APSIM was adequate for simulating the biomass yields of maize or sorghum. The results of the present study help us to develop guidelines for fertilizer/manure applications for farmers in semi-arid tropics by combining field research and simulation

Title	:	Technology development for the degraded Himalayan slopes based on VAM and some useful herbs of Central Himalayas
Name	:	Dr Poonam Mehrotra
Institute	:	Center for Scientific and Industrial Research (CSIR), New Delhi, India
Supervisor	:	Suhas P Wani, Principal Scientist
Period	:	10 September – 12 October 2001

Abstract:

The study area chosen was situated at the vicinity of Nainital Township. Four sites were selected, ie, two under dense forest cover and the other two are degraded slopes, located at 1900–2200 m altitude, 29° 22'–23' N' latitude and 79° 26'–79° 29' E longitude. The hill slopes were moderate to steep (25° and 40°).

The plant species selection was done by phytosociology of a site, by randomly placing 20 quadrats (1x1m). Species richness was studied at all sites, ie, two forest sites (Canopy of *Quercus leucotrichophora*, (Oak) and two at degraded sites. The phytosociology of herb layers was done during post-rainy season because of optimum conditions of environment. Total 49 species were reported and 27 were common at both sites. These herbs belonged to 19 different families, ie, *Labatae*, *compositae*, *Poaceae*, *Polygonaceae*, etc.

The maximum number of species was observed in composite family (14 species/at both sites). The selected species contained a wide range of uses for local as well as for outsiders. They were not only a valuable source for medicines but also used as raw material, for different industries, eg, in preparing fibre, paper and perfume (data not given here). More than 50% species present at each site provided various chemical compounds for manufacturing of different pharmaceutical products. All 48 plants species were examined for VAM status and all of them resulted in positive and showed a wide range of percentage of colonization in their roots. The extent of colonization differed within family/genus. None of single species showed similar colonization values in same families. A significantly higher number of vesicles were present in the inner and outer layer of root cortex and some showed arbuscules. It may be related to leaf life span of a plant. Long leaf life span may cause delay in the formation of vesicles and a long active exchange stage arbuscules remained for a considerable period. The present study reports the association of AM fungi in these plants of central Himalayas tropical regions.

This extent shows considerable promise for selection of suitable endomycorrhizal fungi for improving the establishment and productivity of economically important herbs, especially in nutrient deficient soils. Further studies of characterization of VAM fungi in herbs are needed. To combat land degradation, better management of natural resources is essential to achieve sustainable development. There is a need for models, which interact with scientific and traditional practices to prevent land degradation. It is essential therefore to analyze local indigenous knowledge of the environment, land and plant resources and to integrate it with existing technologies for conservation of hill biodiversity. The aim of this research is a development of new agro-medicine forestry techniques on the basis of the indigenous knowledge of the hill people.

Title	:	Development of a computer program /model for designing the check dams
Names	:	D Naga Jyothi and T Naga Mallika
Institute	:	Vignana Jyothi Institute of Engineering and Technology, Hyderabad, affiliated to JNTU, AP, India
Supervisor	:	Prabhakar Pathak, Principal Scientist
Period	:	February – June 2001

Abstract:

The program/model was for developing and designing check dams (one of the most popular structure in watershed development project). A most user-friendly application, which will not only serve the needs of the people at ICRISAT but watershed implementing agencies nationally and internationally. Watershed management involves a combination of practices, which include agriculture, forestry and engineering measures to achieve certain objective of land and water management on a regional basis. The objectives could be flood control, water conservation or sediment reduction. The total application was divided into two modules. Initially the first module involves the development of hydrologic model to predict the runoff (ie, excess water or the overflow of rain water) based on SCS–curve number technique which involves various formulae to calculate runoffs based on the rain water on a particular day considering the rain pan evaporation constant coefficient as inputs from text files.

The second module involved linking of GIS (Digital Elevation Model) to the hydrologic model (first module) to determine the check dam's water storage capacity. Once the application is developed it will help the engineers to identify the proper location for constructing the check dams. This will help them to work out the designing details effortlessly with the help of the output and graphs provided by the application. The application is developed in such a manner that it can estimate the check dam's effectiveness in harvesting water and ground water efficiently.

Title	: Microcontroller-based sediment sampler for agricultural watersheds.
Name	: Mukesh Tomar
Institute	: Deccan College of Engineering and Technology, Hyderabad, affiliated to Osmania University, AP, India
Supervisor	: Prabhakar Pathak, Principal Scientist
Period	: January – June 2001

Abstract:

The sediment sampler was devised to take the samples at a fixed sampling interval for estimating the soil loss. Earlier the sampling periods had to be changed manually. There was a need to improve this instrument, which could give one a more accurate data. Three more sensors were required to be installed and the sampling period to change in accordance with the sensors sensed. As the flow rate of runoff water increases the height of water level also increases. Hence taking more samples during high runoff rates could give us more reliable data for soil loss estimation.

The researcher improved the sampling unit by adding three new sensors and thereby changed the sampling period for each sensor. These sensors were placed at different heights. The device is programed in a manner where it chooses a different sampling period for different sensor, and represents different flow rates. As the flow of water increases the height of water in flume increases and when the sensor comes in contact with water it automatically shifts to a timing cycle assigned for that particular sensor. Thus, we obtain different sampling periods for different flow heights. As the runoff water height increase the sampling intervals are reduced. This helps in estimating soil loss with greater accuracy.

Title	: Watershed Database Management System
Name	: G Naga Satish Reddy
Institute	: Nizam Institute of Computer Sciences, AP, India
Supervisor	: Suhas P Wani, Principal Scientist
Period	: September – October 2001

Abstract:

The project was carried to develop Data Management System (DMS) for watershed research for Kothapally village, Ranga Reddy district, Andhra Pradesh. The project was aimed at saving data under various modules, access for updating and validating the data and retrieving the data in the form of reports. DMS was developed using Visual Basic programming for Windows Operating System incorporating SQL server 7.0. A developed DMS consists of four modules viz., data entry module (farmer details, climate, hydrological details, cropping system, soil) utilities module (adding/updating, data back up and update data base), report module (farmer details and weather details) and help. The DMS developed was tested and validated with the data collected from watershed project. The system was incorporated with online processing, aiming at maintaining the data collected under different categories from various locations and making the data available for different users and retrieving the same in a well formatted form.

2000:

Title	: A survey of farmers and land degradation
Name	: Christian Gruhlich
Institute	: Dept. of Geography, University of BONN, Germany
Supervisor	: Prabhakar Pathak, Principal Scientist
Period	: 1 August – 31 October 2000

Abstract:

The target of this apprenticeship was 'Study of land degradation' in the Adarsha watershed, Kothapally. Christian Gruhlich studied soil and water conservation technologies, which helped to increase productivity of rainfed agriculture and maintain the natural resource base. Integrated pest management (IPM) is another aspect of this project.

Watershed management is an approach of area planning of natural resources, especially land, water and plants to subserve the socioeconomic needs of human society of community concerned. Sustainability in terms of ecosystem principles, meetings sustenance and trade-off needs of the household or livelihood of its members require to be guaranteed.

Title	: Practical and analytical procedures of parameters - protein, oil by NMR and Soxhlet, fatty acid composition, sugars and starch, fiber, lignin, ash, moisture, minerals and trace elements
Name	: Bishnu Pada Lahiri
Institute	: Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh
Supervisor	: Prabhakar Pathak and P V Rao
Period	: May –July 2000

Abstract:

Bishnu acquired good practical knowledge on the modern methods of quality assessments of crops through this training. After gaining knowledge of biochemical analyses, some chickpea, groundnut and millet fodder samples were taken for analysis of their chemical composition such as protein, starch, soluble sugars, oil, fatty acids, fibers, ash, minerals and trace elements by the modern methods of respective parameters.

**Global Theme
on
Institutions, Markets,
Policy and
Impacts**

Abstracts of Students Research Projects

2003-2008

Abstracts of research undertaken by research scholars, 2003-08

Year 2008

Title	: Analyzing dietary diversity of agrarian households and their female members in rural south India – a case study of four villages
Name	: Deeptha Chittoor Umapathy
Institute	: Cornell University, USA
Supervisors	: MCS Bantilan, Global Theme Leader and R Padmaja, Sr. Scientific Officer
Period	: 2008

Abstract:

This thesis attempts to identify some of the important determinants of dietary quality in South Indian rural agrarian households. It uses dietary diversity score as a measure of dietary quality. One of the key issues analyzed is the impact of seasonality on dietary quality of households. It particularly analyzes the diet quality of women to see if they are the most vulnerable group in the household with regard to access to nutrients.

The analysis shows that seasonality does not have a large impact on household or individual dietary diversity, however we can see weekly diversity scores increase during the lean season. Religion (Hinduism) and village level differences have the largest impact on diet quality along with child and adult female status. There is evidence that women in large families and richer households have lower diversity scores than other members in the household. Finally, the study shows that women and children are not the most vulnerable section in the household but due to lack of data on other members of the household, the thesis was unable to identify the group that was eating at the lowest level of diversity in the household.

Title	: Understanding the Role of Social Learning, Imitation and Social Norms in Bacillus thuringiensis Cotton Technology Adoption Decisions
Name	: Annemie Julie Maertens
Institute	: Cornell University
Supervisors	: KPC Rao, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2008

Abstract:

The research analyses quantitatively the effects of identity and social network on educational investment, agricultural technology adoption and market participation decisions and differentiates these effects along pathways (Social learning, discrimination, social norms, imitation, price- scale effects on the agent's resource constraints) using data from six villages in the Indian states of Maharashtra and Andhra Pradesh. The villages selected for this study have been studied before by ICRISAT in its Village Level Studies (VLS) during the period 1975-1985, and detailed background information and data on household and village level characteristics are available.

The dissertation research theory thereby addresses an important gap in the development economics literature. Recent studies in economics acknowledge the importance of (non-productive) identity and social networks in economic decision-making. Social networks and identity mediate the mapping from the resources into outcomes through their effects on preferences, constraints and expectations, thereby influencing economic decisions such as participation decisions. However, none of the existing studies have differentiated these effects along the following pathways: learning from one's contacts (often referred to as social learning), discrimination (i.e., prices or access to certain goods is different for members of differently identified groups), price-scale effects (i.e., the value/cost of a good depends on the number of users), social norms (i.e., a rule in a certain locality that is socially enforced through sanctions), imitation (i.e., copying the actions of certain people one observes), and easing of labor, capital and credit constraints (e.g., friends and family give a helping hand on the land during harvest , lend machinery or provide loans). Differentiating these effects along these different pathways is important from a policy perspective as the right strategy to stimulate educational investment, increased and quicker uptake of promising technologies, and market participation depends fundamentally on the structure of the decision process at household level.

Concretely, the goal of research is threefold: first, to contribute to the methodological development of the field of development economics by introducing a set of relatively new-data collection techniques, such as 1) the within –sample random technique where individuals who are part of a random sample are randomly matched with other individuals within the same sample and asked about past and present links, their willingness to establish a (hypothetical) link with him/her and their perception of his/her ability and social and cultural attributes and 2) the collection of information on subjective expectations and 3) the capacity to mobilize information by conducting small experiments: second, to develop an identification strategy to separate out the different social network and identity effects in the data: and third, to make the data and the data collection methodology publicly available, thereby ensuring that the policy implications of this study extend beyond the Indian case. Recent studies in social sciences show that there exist important effects of social networks on technology adoption decisions. None of these studies have differentiated these social interaction effects along pathways. Using quasi-panel data, uniquely collected for this purpose in three villages in rural India during 2007-2008, economic theory, and advanced applied econometric methods; one can distinguish between the influences of social learning, imitation and social norms on *Bacillus thuringiensis* cotton technology adoption decisions.

Title	: Livelihood insecurities in SAT: Migration, risk behavior and impact of HIV on rural households in Andhra Pradesh
Name	: BVJ Gandhi
Institute	: Indian Institute of Technology, Bombay
Supervisors	: MCS Bantilan, Global Theme Leader
Period	: 2008

Abstract:

This thesis looks at issues related to livelihood insecurities in the Semi Arid Tropics (SAT); the risks and vulnerabilities that hinder the growth process of households, with particular reference to sexual risk behavior and HIV linkages of migrant workers. A livelihood comprises of the capabilities, assets and activities required for people's means of living. In conditions of drought, Migration is a major alternative livelihood strategy in the marginal semi arid environments of rural India,. Recent reports by National AIDS Control Organization's sentinel surveillance indicate that the semi arid tropics fall under high prevalent zones in terms of HIV. It also lists migrant workers as a high-risk group prone for the epidemic. Livelihoods can be destroyed by the impact of HIV/AIDS when economically active people succumb to the disease and die. Consequently, children drop out of school to cultivate the land and care for ill parents. This hampers the children's ability to acquire skills that could make them employable in the formal sector. To pay for medicines, hospital care or other expenses due to HIV/AIDS, a family may sell stocks of food, land or other property, farming tools, or send their sons and daughters to the city to find work. This again leads to labor migration and hence leads to risk of infection again. These impacts of the poverty-livelihood-HIV nexus are clearly documented in studies in Africa. However, in India though there are sparse micro level information, an in depth analysis is yet to begin. Given the fact that HIV has high prevalence in the Semi Arid Tropics and is increasing constantly, this study aims at understanding the role of migration in the spread of the HIV epidemic in the rural SAT and aims to understand the socioeconomic conditions of the rural households involved in this process of migration. This kind of information is aimed at enabling policy makers to make informed decisions when it comes to planning for rural development or disease control for that matter.

The broad objective of this thesis is to understand the role of migration in enhancing the risk behavior of migrants and in the spread of the HIV epidemic among rural households in the SAT. The specific objectives are to understand 1) to what extent the livelihood insecurities in Dokur lead to migration, 2) to understand the risk behavior of migrant workers in the context of livelihood insecurities and 3) to map and analyze the patterns of migration and risk behavior.

The area of study planned is from the high prevalence state of Andhra Pradesh. Samples will be chosen from Dokur village in the heart of the rural SAT with high incidence of migration. Secondary data from Voluntary Counseling and Testing Centre will also be analyzed to gain more insight.

2007:

Title	: Study of poverty and under nutrition by size group in six VLS villages
Name	: D. Vara Lakshmi
Institute	: University of Hyderabad
Supervisors	: KPC Rao, Principal Scientist MCS Bantilan, Global Theme Leader D.Kumara Charyulu, Consultant
Period	: 2007

Abstract:

The data for three years, 2001-02 to 2003-04, were analyzed to study poverty and under nutrition among different size groups of sample in the six VLS villages. The expenditure on food grains was relatively higher in the two AP villages (Aurepalle and Dokur) when compared with that in the four Maharashtra villages. But the expenditure on other food grains and non-food items were far much higher in Maharashtra villages than in AP villages. In case Kinkheda and Kalman, their consumption expenditure is very high compared to the other villages. On an average, the expenditure percentage on total food grains and non-food items are same i.e.44% and 40% respectively in the entire VLS villages. The per capita average consumption of calories is less than 2000 per day in all villages except Aurepalle and Dokur. It was lowest in Shirapur and Kalman villages in Maharashtra. Perhaps the scheme to supply rice at a cheaper rate is responsible for the higher levels of calories in AP. In Maharashtra villages, sorghum and wheat are the main grains of consumption. Their ability to quench the hunger perhaps is not reflected adequately in their calorific value. In case of proteins Maharashtra households had higher per capita consumption than the AP villages. In terms of households experiencing calories under nutrition, Aurepalle seems to be best placed with only a quarter of households having calories consumption of less than 2000 calories per day. But proteins are not having that much satisfaction. In the other AP villages, Dokur, one half of the households were facing calories and protein deficiency. In Maharashtra village, more than sixty percentage of households faced calorie deficiency but only around 30% of the households faced protein deficiency. In the total sample households from the six villages, more than one half of the households faced calorie deficiency while less than one fourth of the households experienced protein deficiency.

Title	: Forests and common property resources in India: Aurepalle case study
Name	: Emily Leon
Institute	: San Francisco University
Supervisors	: KPC Rao, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2007

Abstract:

In the face of rapid industrialization, endemic poverty and population pressure, India faces a balancing act between economic development and environmental conservation, goals that are rarely compatible in the short run. The government of India has a goal of reaching 33% forest cover by 2012.

Aurepalle is a rural village in the Mahbubnagar District of Andhra Pradesh, about 70 km south of Hyderabad, it is within India's semi-arid tropical region and like much of this region, rain-fed agriculture is the primary source of income. Livelihood, therefore, is extremely vulnerable to variability in the annual monsoon. In many ways the green revolution bypassed this climatic region. New varieties of high yielding crops could not necessarily be cultivated so extensive agriculture was needed to support growth. As land became increasingly scarce more marginal land was cultivated. Today, no forest cover can be found in Aurepalle. Discussions with locals reveal that much of the land at the base of the hills was once forest area that provided many important common property resources to the local people.

In Aurepalle, privatization and land reform provided incentives to irrigate and cultivate any fertile land; this increased output and income and improved food security over the last 30 years. Landless labor was once heavily dependent on common land, now they are land owners themselves or have left the village. While common land is no longer a productive available resource, there are new opportunities and welfare has improved as the commons have disappeared.

The story in Aurepalle initially appears to be a win for poverty alleviation and loss for the environment. Extensive and intensive agriculture have grown and increased food security and incomes. However, extensive agriculture appears to have reached its limit, as only the most marginal and unproductive land remains uncultivated. Today, the locals do not complain about the loss of common land because they are now almost all land owners. They complain about a labor shortage.

Has privatization benefited Aurepalle's most marginal groups by making them land owners? The change that has occurred in this village appears to have increased equality. But simultaneous changes in the economic situation may mask the truth. If privatization was inequitable, those who did not benefit may have chosen to leave in search of better opportunity. Further analysis of data collected in Aurepalle will shed light on the relationship between rural poverty and environmental degradation. The relationship has drastically changed in recent years as extensive agriculture reaches its limit and market forces bring new opportunities.

2006:

Title	: Exploring the dynamics of poverty in India's Semi Arid tropics
Name	: Kathryn A Boys
Institute	: Purdue University
Supervisors	: MCS Bantilan, Global Theme Leader and KPC Rao, Principal Scientist
Period	: 2006

Abstract:

The general trends which were found to be of particular relevance to the visited communities are issues related to water scarcity, urbanization, and globalization. Also crucial recent village transformation is the decreased interest in the agriculture, due to the lower potential for profits in this sector.

Overall it would seem that the welfare of households in the villages of Aurepalle and Dokur has increased since the last VLS iteration. It is impossible to draw any conclusions on the basis of such a short visit and limited number of observations. Through these visits one, however, is left with the general impression that income and access to public goods has improved, and that income disparity has not increased and potentially may be decreasing. While poverty rates are useful indicators of the level of poverty in a country during a specific period of time, they do not provide the information concerning the extent of mobility in and out of poverty or about the length of time people remain in poverty. The degree and cause of poverty experienced by individuals and households has important policy implications, but is frequently masked by data aggregation and dependence upon stylized 'facts'. The purpose of this study is to compliment and extend previous work on trends in poverty and income distribution. By more closely examining the dynamics of poverty, one can explore which types of households stay longest below the poverty threshold and whether certain changes in household status are associated with transitions into or out of poverty.

Conclusions: Results suggest this analytical approach can offer useful insight into poverty dynamics. Differences exist in the type of events correlated with entry, exit and duration of poverty spells. Suggest alternative policies needed to remedy each 'phase' of poverty. Results suggest policies may be more effective at preventing entry into poverty than facilitating exit or shortening duration. 'Medium Term' poverty appears to be correlated with different events than long and short term poverty. Further consideration of issue needed.

Title	: Village Level Impacts of Trade liberalization: A look at Dokur
Name	: Ammad Naeem Bahalim
Institute	: Cornell University
Supervisors	: KPC Rao, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2006

Abstract:

This paper is intended to be a village level analysis of trade liberalization. Methodological questions were raised and data collection methods will be analyzed. The tenuous causal linkages between macro-level trade policy and micro-level village impacts ought to be critically analyzed to determine in what manner current theoretical frameworks are being extended. By using integrated regional and national commodity markets for common crops some have

translated relative price changes directly into village level analysis including impact on income, employment, and migration. How is this meaningful? What social indicators ought to be reviewed? What are some questions and conclusions that current analysis poses?

Conclusion: Kuiper and van Tongeren (2005) is perhaps the most robust model in the literature examined. Current literature on village level impact analysis, at least amongst Economists concerned with trade, are developing new models that are more robust but also more real. Issues such as missing markets, imperfect markets, or inadequate access to markets hinders the level of analysis given current data. New realms to explore would include more complex analyses of social indicators such as the HDI. However, on the whole devising tools that look beyond macro-level growth would give policy makers and scholars better insight into impacts, furthering the decision making process.

Title	: Searching for appropriate institutional arrangement for common watershed management in the semi-arid tropics in India.
Name	: Andreas Gramzow
Institute	: IAMO
Supervisors	: MCS Bantilan, Global Theme Leader
Period	: 2006

Abstract:

This study aims to analyze institutional arrangements regarding their contribution to a successful implementation of watershed projects in the semi-arid tropics. In three in-depth case studies we discuss the impact of market relations between watershed appropriators, governmental interventions and the local community on the implementation process of watersheds. While in all three cases no market based relations between watershed appropriators existed, governmental assistance in terms of funding and administrative support seems to be essential for the construction of watersheds. All three cases show a lack of community involvement, which led to emerging possibilities for rent-seeking processes and reduced the local appreciation of the watershed investments. However, the most successful project featured a more widespread distribution of benefits, a more homogeneous income and caste structure and a lower employment of the local elite in the watershed implementation process. Furthermore, it also seems to be of importance that farmers are willing to continue farming regardless if they produce for own consumption or for regional markets as well as that all villagers were able, irrespective of their occupation, to benefit from the watershed project.

For the development of further watershed programmes it seems to be more promising to implement more market competition within the application process for watershed programmes. Communities should be encouraged to organize themselves to elaborate concepts for watershed projects and to compete with such concepts with other communities for a certain state budget. This may lead to a more efficient distribution of public funds and a stronger community involvement. Moreover, a more indirectly governmental support in terms of trainings for farmers to enhance their awareness for monoculture and negative external effects of

irrigation water overexploitation as well as the provision of regionally adjusted seeds and improved animal genetics seems to be promising as funds spent only directly on watershed constructions. Further indirect governmental assistance could be given as financial and administrative support for founding agricultural co-operatives and the use of water use efficient crops.

Title	: Provision of public goods through participatory planning: an experimental exploration of the deliberative process
Name	: Martina Pignatti Morano
Institute	: Siena University
Supervisors	: KPC Rao, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2006

Abstract:

Rural areas in developing countries mostly suffer from a dramatic underprovision of public goods. The widespread failure of central governments in meeting peoples' demand led to a debate on the respective advantages and risks of privatization and regulation, but a third option still needs to be seriously analyzed: locally-based collective action to mobilize financial resources and local labour. This research project aims at evaluating the potential of village meetings to mobilize collective action for the provision of local public goods, in heterogeneous communities of rural India. Through variants of the public good game that will be played in the ICRISAT villages, there is a plan to assess in which measure the possibility of deliberation facilitates the realization of outcomes that are closer to the social optimum rather than the inefficient Nash equilibrium. The weight of caste/income/gender inequality and social norms on the possibility of achieving higher social efficiency throughout the deliberative process will be measured. The results could provide interesting suggestions for policy improvements regarding the organization and delivery of responsibilities to Gram Sabhas (GS), the grassroot institutions of decentralized economic planning according to the Indian Constitution.

Preliminary interviews in three VLS villages of Dokur (Mahboobnagar district in Andhra Pradesh), Shirapur and Kalman (Sholapur district of Maharashtra) were carried out to collect information regarding functioning and performance of local Gram Panchayat (GP), tax collection and the need for public meetings in the villages. Individuals were asked whether they performed any activity for the welfare of the village, especially as volunteers, and whether they participated in public meetings (formal or informal) where matters of public interest were discussed. The aim was to collect their perceptions on how decision-making was carried on in the village on matters that regarded groups of people or the entire village population, to understand if they had the option of participating in decision making, and to learn more about interaction and power balance between people of different castes. Direct evidence on the amount of taxation that is locally extracted and the money saved through voluntary labour in collective activities for cleaning and maintaining village infrastructure was collected.

Title	: Effect of social capital on performance of smallholder producer organizations: the case of groundnut growers in western Kenya
Name	: Wambugu Njoki Stellan
Institute	: University of Nairobi, Nairobi
Supervisors	: Bekele Shiferaw, Principal Scientist
Period	: 2006

Abstract:

Due to poor market and physical infrastructure, high transaction costs, price risk, and information problems, past liberalization and structural adjustment policies have not been able to improve market access, hence decreased commercialization for smallholder farmers. The private sector that replaced public sector has largely failed to make the investments needed for effective market coordination. Consequently, over the past few decades, scientists and development agencies have highlighted production and marketing challenges faced by smallholder farmers and suggested various forms of policy intervention. Collective action has been one of the recommended interventions in production and marketing through producer and marketing organizations. Collective action arises when people come together because of constraints and to take joint action and decisions to accomplish an outcome. Hence, it is vital to know what governments can do to better support the farmer organizations.

Collective action (in form of farmer organizations) is widely recognized as a positive force for rural development in Africa. However emerging empirical evidence suggests that farmer organizations perform differently. Are there certain structural factors or characteristics of farmer organizations that contribute to or inhibit effective performance? The current study therefore seeks to examine the role of social capital on the performance of farmer organizations. Social capital refers to the quality and depth of the relationships between people in a group or community. It is the obligations and expectations, information channels and social norms. In particular, the study assesses the effect of various dimensions of social capital on (i) commercialization of smallholders' produce and (ii) on the performance of the farmer organizations' marketing function. It uses data collected in 2007 from 225 farmers selected by membership to farmer organizations in 45 farmer organizations. The effect of social capital on commercialization and performance of the organizations' marketing role is tested using econometric techniques. Two econometric models are estimated. Both objectives of the study were addressed by estimating ordinary least squares (OLS) regressions.

The findings of the study suggest that, among the social capital dimensions, diversity among members in the farmer organization, frequency of attendance to the farmer organization's meetings, level of solidarity and level of trust in the organization positively influenced household's level of commercialization. Level of democracy in decision making and density of membership to other formal and informal organization did not spur commercialization at household level. The findings of the second objective indicated that diversity among members in the farmer organization, frequency of attendance to the farmer organization's meetings, level of democracy in decision making, level of solidarity and density of membership to other formal and informal organization positively influenced the performance of a farmer organization. An

increase in the level of trust among the members in the farmer organization had a negative influence on its performance. Therefore, smallholder farmers participating in farmer organizations' activities and with higher levels of social capital were more commercially oriented in their production. Social capital also enhances the performance of farmer organizations as marketing intermediaries. The findings highlight the role of social capital on farmers' access to lucrative markets and hence integration into the market economy.

2005:

Title	: Temporary and permanent migration in six villages in the semi-arid tropics
Name	: Reena Badiani
Institute	: Yale University
Supervisors	: KPC Rao, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2005

Abstract:

This study has examined changes in the magnitude and duration of migration in the six Indian ICRISAT villages between 1975 and 2005. Migration has been split into two components: temporary migration, which consists of short-term periods of work, related migration and permanent migration consisting of individuals who are no longer considered residents of the villages. At the outset of the VLS, permanent migration predominantly consisted of migrants for marital purposes. The stream of individuals and households permanently leaving the villages for work purposes has increased considerably since this stage, from just under 3 work related migrants per year between 1975 and 1980 to 10 between 1995 and 2005.

Temporary migration flows have also changed considerably since surveying began. At the outset of the survey in 1975, the rates of temporary migration within the villages were viewed as minimal enough to not be of concern. By 1992 the proportion of households conducting temporary migration reported in some villages was over 40%; the data collected in the village since 2002 support the view that temporary migration has become a substantial source of income for some households. Temporary migrants are almost exclusively male and have higher levels of education at the time of undertaking migration. Whilst at the time of migration in 1992 there are insubstantial income and asset differences between households who have a temporary migrant and those who do not, by 2002 the income and non-productive asset differences between the two groups are substantial: the income and assets per capita of households who temporarily migrated are respectively 30% and 50% higher than those who did not. The substantial differentials in growth between the two groups raises interesting questions about the cause and consequences of temporary migrants, notably whether it is the process of engaging in temporary migration which allows households to gain a higher level of income or whether the households who choose to engage in this income generating activity are different, for example in their motivation or ambition, from those who don't. Households that engage in temporary migration in 1992 have substantially higher rates of temporary migration and

permanent migration by 2005 than those who do not, suggesting that temporary migration may be something more than a short-term income generating phenomena.

Title	: Migration in the VLS : The missing link
Name	: Reena Badiani
Institute	: Yale University
Supervisors	: KPC Rao, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2005

Abstract:

The paper focuses predominantly on permanent migration; temporary migration in the context of trends in the VLS. Within the VLS villages, income and consumption has risen significantly between 1975-1984 and 2001-2004. The preliminary data has shown that the migrants differ from non-migrants in salient socioeconomic characteristics. Without data on the standard of living of migrants, attrition bias is likely to be substantial. The impact of migration on consumption and income trends is likely to be a function of the reason for migration; whilst the size and direction of the bias can be estimated as a function of observable characteristics for some migrant populations (notably those migrating for work), for other migrant populations (including migrants for marital reasons or those repatriating with family) estimates of attrition bias using currently available data are likely to be inaccurate. By tracking migrants, the VLS has taken a step forward to understanding better the nature of poverty and income dynamics.

From a policy perspective, migration is increasingly being seen as an important livelihood option for poorer groups, and as a means of poverty reduction (Deshingkar, 2005). The data on migration will help us to better evaluate the alternative frameworks within which migration has been placed. Migration has been posited to take a myriad of different forms: as a coping mechanism (Bantilan and Anupama, 2002), as an income diversification strategy (i.e. a long term plan, a permanent strategy to diversify income in the village) or as a permanent route out of poverty (i.e. permanent migration out of the village). Whilst econometrically the full identification of the different mechanisms would not be possible given that the sample consists of only six villages, from a more qualitative perspective the data will give us insight into the different forces driving migration.

Migration in the VLS – how to study it?

Migrant tracking was planned in three main phases. The first phase was to prepare the surveys and to pilot test the new modules. The first phase was coordinated to coincide with a festival in one of the villages to ensure that questions could be pre-tested on both temporary and permanent migrants (both of whom are likely to return at festival time). The second phase involved an incubation period of 6 months during the period of festivals in the village, to capture all migrants who returned to the villages. The third phase entailed finding the migrants at their current place of residence. The preliminary data has shown that the migrants are different in salient socio-economic characteristics. Most notably, migrants can be identified by age, sex and educational attainment. Since educational attainment is likely to be linked to unobservable

ability and innovation, and has also been shown to contribute directly to income growth (Mankiw et al, 1992), it is likely that the consumption and income trends for these individuals is different from those who have stayed in the village. Very little is currently known about the migrants for non-marital purposes, who make up over half of those who have migrated, since we are unable to judge the size of the attrition bias for these individuals due to the nature of migration; the new data will fill this lacuna. In addition, much can be said for the impact of migration, in particular temporary or seasonal migration, at a village level. For example, it would be interesting to study whether the decision to migrate has an impact on child nutrition (Hildebrandt 2005) or child enrolment in educational institutions. McKenzie and Rappaport (2002) study the impact of migration on educational attainment in Mexico; they find that the low-skilled migration flows to the US have a negative impact on the number of years of schooling attained in given areas. Another pertinent research question is the impact of migration on technology adoption – do migrants act as an information flow, bringing knowledge and new technology home with them? In ICRISAT, much has been done to ensure that the VLS dataset continues to expand in a methodologically sound manner. Ensuring that all further split-offs are included in the village level surveys will allow the VLS dataset to incorporate the dynamic elements of household formation, as well as ensuring that attrition bias is reduced to a minimum. The tracking of migrants that is currently in taking the concept of reducing attrition bias one step further, by providing a truly comprehensive data set.

Title	: The effects of major crop commodities on iron intake in rural India (1972 – 2002)
Name	: Christina Nyhus Dhillon
Institute	: Cornell University
Supervisors	: MCS Bantilan, Global Theme Leader
Period	: 2005

Abstract:

This research proposes to understand how the Green Revolution (GR), the agricultural programs which tripled rice and wheat yields, affected iron intakes in India from 1983 until 2002. The specific aims of the project are to (1) describe trends in dietary intake of iron in the rural Indian diet over the past 20 years and (2) investigate the effects of prices as well as individual and household-level characteristics on iron intakes in rural India from 1983 to 2002. Using secondary data of the National Nutrition Monitoring Board (NNMB) and the ICRISAT District Level Database, trends in dietary intakes for iron as well as major agricultural commodities in the Indian population over the last twenty years will be analyzed.

Title	: Collective action and property rights for poverty reduction in watersheds
Name	: Srigiri Srinivas Reddy
Institute	: Humboldt University
Supervisors	: B Shiferaw, Principal Scientist and MCS Bantilan, Global Theme Leader
Period	: 2005

Abstract:

Collective action (CA) lowers the transaction costs for the farmers in the rural areas. It enables them to make investments to improve both the private and common property resources, which is otherwise a costly affair. But, the property rights to both privately and commonly held resources need to be well defined and respected. While some communities/societies engage in CA successfully and benefit from such activities, others fail. This study makes an attempt to (a) conceptualize and measure CA for watershed management in India, and (b) identify the determinants of successful CA.

Methodology: Eighty-seven watersheds were randomly selected from six districts [representing two from each of the low (less than 700 mm), medium (700 mm to 900 mm) and high (more than 900 mm) rainfall zones of the state of Andhra Pradesh in India]. All the sample watersheds were implemented following the 1994 guidelines for watershed development. Data were collected at the community level from leaders, user groups and key informants on a range of issues that characterized the village and the watershed groups. The main hypothesis of this study is that, the level to which communities can act collectively varies. The primary data of the proxies was collected. Different variables representing CA were aggregated. The scoring coefficient was obtained through the principal component factor analysis.

Conclusions: A huge variation of the capacities to engage in CA exists among the sample watersheds. The following are a few factors, which explain the variation:

- High levels of CA exist among the experienced groups. The finding supports the hypothesis that individuals of the group develop trust and are more forthcoming to participate in CA irrespective of the kind of goal pursued.
- Presence of conflict resolution mechanisms improves the CA.
- Distance to input and output markets are positively and significantly associated with the LCA. Selling the produce and buying the inputs significantly minimizes the costs

Title	: A bioeconomic modeling approach: methodology to analyze impact of technological and policy interventions for micro-watershed in Semi-Arid India
Name	: Nedumaran
Institute	: TNAU
Supervisors	: B Shiferaw, Principal Scientist; SP Wani, Principal Scientist and TK Sreedevi, Senior Scientist
Period	: 2005

Abstract:

The overall objective of the study is to develop a methodology to analyze the possible impacts of technology change and policy incentives on household welfare and the sustainability of the natural resource base in the SAT regions. The previous impact studies of watershed development in India have hardly ever integrated the biophysical factors with economic factors to assess the complementarities and the tradeoffs within the framework of farm household economic behaviour. So it is important to apply a holistic and integrated approach like bio-economic modeling to simultaneously assess and evaluate impact of watershed development on the welfare of the poor and the natural resource conditions at a micro level and also to identify effective policy instruments and institutional needs for enhancing the effectiveness of the watershed approach. The benchmark watershed in Kothapally village, Ranga Reddy district, Andhra Pradesh is selected as the study region because of the unique availability of both biophysical and socioeconomic data covering a period of 5-6 years. The data provides an opportunity to integrate both biophysical and socioeconomic data to develop a bioeconomic model to study simultaneously the impact of the technological and policy interventions on household welfare and quality of the natural resource base in the watershed.

The baseline model serves as a starting point for policy experiments to assess the likely impact of alternative policy intervention. The bioeconomic model used in the study analyses the combined effects of land degradation, population growth and market imperfections on household production, welfare and food security.

Title	: Development of a dynamic non-linear bioeconomic model with crop livestock integration
Name	: Nedumaran
Institute	: TNAU
Supervisors	: B Shiferaw, Principal Scientist; SP Wani, Principal Scientist and TK Sreedevi, Senior Scientist
Period	: 2005

Abstract:

Bioeconomic models are useful tools in policy analysis because they can reflect the biophysical as well as socioeconomic conditions essential for decision making with in specific “bioeconomy”. They may be used to explore the linkages between ecology and the economy and the dynamic effects of these linkages over time. In this study a watershed level dynamic non-linear bioeconomic model with crop-livestock integration is developed for the Kothapally watershed. This model maximizes the income of the whole watershed, which include three types of households based on land endowment (small, medium, large), who are spatially disaggregated into six different segment in the watershed landscape [three types of soils based on soil depth (shallow, medium and deep) and two types of land (dry land and irrigated land)]. The model maximizes the aggregate net present value of income of the watershed over a 10 year planning horizon. The income of the household groups is defined as the present value of future income earned from different livelihood sources (like crop, livestock, non-farm, etc) subject to constraints on level, quality and distribution of key production factors (e.g., land, labour, capital, bullock power, soil depth), animal feed requirement and minimum subsistence food requirements for the consumers in each household group.

The crop production in the model is affected by change in soil depth, which is reducing due to soil erosion. The erosion level in the watershed is estimated for predicted land use pattern and through transition equation soil erosion reduces the initial soil depth of the land. By using econometric method the yield-soil depth response is estimated and used in the production function in the bioeconomic model. The nutrient balance in the watershed is estimated by using nutrient balance equation in the model. This equation estimates the nutrient balances for simulation period based on inflow (fertilizer and manure application, biological fixation and atmospheric deposition) and outflow (crop grains and residual yield, erosion and leaching) of nutrients in the watershed. The baseline model serves as a starting point for policy experiments to assess the likely impact of alternative policy intervention. The bioeconomic model used in the study analyses the combined effects of land degradation, population growth and market imperfections on household production, welfare and food security.

The study, which is a Ph.D dissertation, concludes that increase in price of dry land crops and increasing the yield of the dry land crops by introduction some high yielding drought tolerance varieties can be effective technological and policy instruments for slowing down the process of land degradation and improve the welfare of the farmers in the watershed. The results from the

Kothapally watershed study should be useful to policymakers and others seeking to reduce poverty and improve land management in SAT regions of India. This model can also be used as a decision support tool to develop an optimum farm plan for different households in the watershed with available resource without affecting the natural resource base. Beyond this, the bioeconomic modeling approach used in this study can be usefully adapted and applied in many other settings.

Title	: Aurepalle Village: A Case Study on Investments in Water and the Implications of Increased Groundwater Extraction
Name	: Aditi Nigam
Institute	: University in USA
Supervisors	: MCS Bantilan, Global Theme Leader and KPC Rao, Principal Scientist
Period	: 2005

Abstract:

This paper looks at Aurepalle Village in the Mahabubnagar District of Andhra Pradesh. It portrays the issue of groundwater extraction through many facets: from the conditions of the drought prone SAT to the shift in cropping patterns and increases in investments made on wells with particular focus on the years 1975 to 2004. It then looks at the much larger implications of groundwater depletion for the rural poor of the SAT.

The report has looked at the problem of water scarcity beginning with the decrease in rainfall and ending with the problem of groundwater depletion that faces not only the village of Aurepalle, but all villages in the drought prone areas of the SAT. It is the rural poor who suffer from this burden of water scarcity and if they suffer now, then what next? Groundwater depletion is a problem that exists. It is foolish to avoid it. The real question refers to the actions that must be taken against it. We cannot stop the depletion of our natural resource unless we ourselves take measures to prevent, recharge, or decrease its rate of occurrence. The area of concern is the future and the implications of this groundwater extraction. Due to the low water retention of the Mahabubnagar red soils among other reasons, the rate of groundwater extraction is greater than that of recharge.

The rural poor have done all that they can to fight against the urgency of water unavailability by digging in-well bores (a risky investment), migrating, and even shifting their cropping patterns. The question to be asked for the farmer is whether such coping strategies are sustainable in the future? Farmers will always have to grow something. They are only concerned with higher returns. But if the current cropping system is unsustainable, it may have implications for sustainability and even migration.

The answer to this question like all those before depends upon the availability of water in the long run.

Although Aurepalle is one village in India, it represents a larger community: that of villages affected by similar SAT conditions. It demonstrates how those living in unfavorable conditions are already facing our tomorrow if we do not take the initiative to conserve our groundwater.

To make tomorrow a reality, we must act today. Water management practices and policies should be implemented either through government policies, taxes, or a review of water rights. To make changes in groundwater extraction, we must work at all levels of society from the farmer to the rich bureaucrat. Water is a necessity and in the rural SAT, it is most definitely not a luxury. The conservation of our natural resource holds many implications but also many lives. It is water alone that connects all people, livelihoods, and in the case of the rural SAT, the future.

Title	: Collective marketing to increase market access and farmer household income: the case of pigeonpea commercialization in Eastern Kenya
Name	: Margaret Loeffen
Institute	: Wageningen University
Supervisors	: Bekele Shiferaw, Principal Scientist
Period	: 2005

Abstract:

Collective action is needed to link smallholders to the most rewarding marketing channels, such as supermarkets and export markets. Smallholders in Mbeere and Makueni district, in the semi-arid areas of Eastern Kenya have been organised into a number of Producer Marketing Groups (PMGs) in 2003. The PMGs are member organisations, aimed at increasing the incomes from the commercialisation of cashcrops, of which pigeonpea is an important one. Day to day management is in the hands of committees of elected member farmers.

Market participation in absolute amounts as well as percentage of pigeonpea commercialised depends in the first place on the amount produced. This stresses the need for the promotion of varieties which are high yielding under semi-arid conditions and other inputs. The fact that input and output markets are closely linked through production level makes it important for the PMGs to increase the access of member smallholders to both types of markets.

High prices for pigeonpea farmers are positively related to selling at a larger distance from farm-gate and to selling to urban traders. Selling to rural traders, shopkeepers and brokers is related to lower prices. Because price differences seem large enough, PMGs are likely to make more profits when hiring transport and delivering produce directly to urban traders. Seasonality is also expected to be important, with high prices obtained when selling before the main harvest in August. This makes early maturing varieties economically attractive.

Although the exclusion of the poorest and risky farmers was mentioned as one of the limitations of PMGs as vehicles for poverty reduction, those farmers were not excluded in the PMGs in Mbeere and Makueni. Both men and women were also equally represented.

The PMGs are limited by a lack of cash / credit, which does not enable them to pay cash on delivery. The urgent need for cash of most smallholders, in combination with the lack of cash payment on delivery at the PMG, still forces to sell in low-price channels. As a result, the volumes in which the PMGs deal have remained low and economies of scale have not been created. In addition, a lack of bookkeeping and marketing skills of the farmers making up the PMG-committees results in poor management. Lastly, the weak legal standing of the PMGs forms an obstacle to both obtaining credit and growing as an organisation.

In order to make the PMGs a success, the problems of lack of credit, lack of bookkeeping and management skills of committee members and weak legal standing of the institution itself have to be solved. Solutions to these problems are respectively the provision of credit, training and better institutional design, which required changes in the legal framework. The private sector, development agencies and the government are all needed to realise this.

Year 2003

Title	: A Comparative Analysis of Rice and Sorghum Yields Across India: “ Does Irrigation Have an Impact?”
Name	: Sukitha Abeysekera
Institute	: University of Manitoba, Canada
Supervisors	: MCS Bantilan, Global Theme Leader
Period	: 2003

Abstract:

As the world approaches the 21st century population is on the verge of increase which has led to many problems such as: food insecurity, malnutrition, poverty etc. This has led stakeholders of poverty alleviation programs to explore ways to increase productivity from existing resources/crops.

Many regions in India are classified in to many agro-ecological zones (AEZ). Is there a significant impact of yield trends between these AEZ's? This paper will include an in-depth analysis to this question across India using two crops namely that are rice and sorghum. Taking another approach on this line recently, many stakeholders have proposed increased investment towards irrigation on the premise that irrigation increases crop yields. However with increased funding towards irrigation, does it really have an impact on yields? An in depth analysis for this issue will also be carried out within this paper.

Title	: Pattern of labour employment and earnings
Name	: Satish Tangirala
Institute	: Hyderabad Central University
Supervisors	: KPC Rao, Principal Scientist; and MCS Bantilan, Global Theme Leader
Period	: 2003

Abstract:

International Crops Research Institute for the Semi Arid Tropics (ICRISAT)'s program Village level studies (VLS) tries to study rural life in SAT India. Microeconomic studies to understand labour relations, labour market functioning on demand and supply concepts, contractual labour and migration has drawn considerable attention from many of the social scientists in recent times. Questions like why labour is migrating? Is it because of better wages? What are average earnings per day in the villages of India? How many people are actually participating in labour market? These are some of the interesting questions, finding answers to which has made me do this work. This work tries to answer those questions and many more.

Over all, in Mahbubnagar villages Aurepalle and Dokur female labour has participation days of 148 (with a wage of RS 27) and 120 days (with a wage of RS 39 per day) respectively. The male participation in these Aurepalle and Dokur villages is 180 days (with a wage of RS 65) and 172 days (with a wage of RS 68 per day) respectively. In Sholapur villages Kalman and Shirapur female labour has labour participation days of 139 (with a wage of RS 32) and 136 days (with a wage of RS 26 per day) respectively. The male participation in these Kalman and Shirapur villages is 137 days (with a wage of RS 66) and 173 days (with a wage of RS 97 per day) respectively. Lastly in Akola villages Kinkheda and Kanzara female labour has labour participation days of 127 (with a wage of RS 24) and 126 days (with a wage of RS 23 per day) respectively. The male participation in these Kinkheda and Kanzara villages is 172 days (with a wage of RS 64) and 160 days (with a wage of RS 46 per day) respectively. At the end it can be said that a female labour has around 120 to 140 days of work in all the six villages and earns a wage ranging from RS 25 to RS 35 while male labour finds work for 160 to 180 days getting a wage between RS 65 to RS 90 per day.

Title	: Economics of crop enterprises in the semi arid regions of Andhra Pradesh and Maharashtra
Name	: Ragini Sharma
Institute	: Hyderabad Central University
Supervisors	: KPC Rao, Principal Scientist; and MCS Bantilan, Global Theme Leader
Period	: 2003

Abstract:

SAT regions are often characterized by erratic rainfall, low soil fertility and extreme poverty. While India was well endowed with survey information and secondary data, much of it was concentrated on non-SAT regions. Because of this reason, longitudinal village studies were initiated in India's SAT tropics in mid 1970s.

This paper attempts to analyze the data for villages in Andhra Pradesh and Maharashtra in terms of different crops productivity for the year 2002-03. Being a drought year, the productivity levels of crops were lower in 2002-03 when compared to those in 2001-02. In AP villages, the yields of crops including paddy are quite low. But the yield of castor in Dokur is higher in 2002-03 than in 2001-02. The yields of rabi sorghum, sugarcane and onion were higher in Shirapur, while those of maize and sugarcane were higher in Kalman when compared with those in 2001-02. The yields of wheat in both Kanzara and Kinkheda were better in 2002-03 than those in 2001-02. But for these exceptions, the yields of all the crops in the six VLS villages during 2002-03 were lower than those in 2001-02.

Title	: Food Security, Rural Women and Social Capital: A Case Study of Umra and Ashta
Name	: Neetu Choudhury
Institute	: Indian Institute of Technology-Bombay
Supervisors	: MCS Bantilan, Global Theme Leader and R. Padmaja, Sr. Scientific Officer
Period	: 2003

Abstract:

An important dimension of Social sciences has been to look at the gendered nature of social world. However, analysis of food security from a gendered approach is relatively recent trend. Operationalisation of food security entails a multi pronged strategy. Understanding gender

roles in this regard and making a gendered intervention in this area is one way to raise food security status at household level. Role of women though recognised late, is crucial in this context. In fact, a separate positive focus on women's status and work participation is highly desired today to enhance the food security for women herself as well as for the family as a whole. This paper deals with this gendered dimension to operationalise household food security and tries to bring out various ways in which women contribute towards the same.

It is an irony of development paradigm that in this era of spectacular technological advancement, food security still remains a distant dream for a large fraction of world populace. After years of big claims and announcements, food insecurity remains and with a greater impulse, on the development agenda of national and international organizations. Food security however, is not a development issue. It is an issue to be identified with the existence of human life itself. The fact that millions of human lives are under threat because of food insecurity compels us to revisit and rethink not only the requisite policy prescription but also the whole understanding of food security itself. An achievement in this direction is the recognition of women's role towards food security in general and household food security in particular.

A number of recent studies show that women especially in rural areas form the key to household food security. The present study has been undertaken with the view to look deeply into these claims. As expected, the findings explicitly support this observation made by social scientists across the world. In the study based on two villages viz. Ashta and Umra in the Nanded district of Maharashtra, it has been found that women contribute around 70-75% of household food security requirement. Their contribution to household food security comes from their daily paid and unpaid work. Besides being a breadwinner in poor families primarily, women from all farm households and landless households, contribute immensely towards family's well being. This latter part of women's role comes from, her unpaid work on family farm and her never-ending domestic work liabilities. On the family farm, a large part of labour intensive work like weeding, cleaning etc is performed by family women with or without the support of hired labour depending upon the status of farm households. Women's domestic responsibilities include works as homely as cooking and cleaning to as exhaustive as collecting firewoods and fetching water. There is third way in which women in very poor families contribute to food security for the children and male counterparts. This is done by compromising on women's own consumption in terms of quantity and quality as derived from women's traditionally subordinate position in the society. This phenomenon however is found to be negligible in the two village studied here. This may be due to the fact that, overall food security status of these villages is not quite pathetic and families are not at the verge of starvation. Also, in both Umra and Ashta women from all household categories contribute to household food security in equally significant manner on annual basis. Women in all big farm households do not go to field but in cases where they go to farms, they work more than men counterparts and equal to women from other farm categories. Even though, these women work with labour's help, the large size of their family farms equates their farm work to that of women from small and medium farm households. Besides, farm activities in all large farm households and most medium farm households go on through out the year because of better access to agricultural infrastructure. Due to this on annual basis women from these households undertake more farm activities as compared to women from small farm households, which grow crop only in the rainy season. The women from big farm household families however are usually saved from the hardship of fetching water and browsing fire and fuel wood. Women from small farm and landless families are found to contribute to food security primarily through direct wage earning and domestic activities.

Farm activities on family farm are little or not significant for these women. An under valuation of these women's work comes from relatively low female wage rate prevalent in all the villages.

Annual contribution to household food security is highest for women from medium farm households. These women rely less on labour for farm and domestic activities and work throughout the year. Even though, women from small farm families and landless households work more, because of low female wage rate their contribution to household food security in monetary terms is relatively low. This is the dysfunctionality associated with the attempt to quantify an aspect of social life as qualitative as women's role in household food security. However, quantification enables us in concretizing women's contribution, which is much blurred actually. This is especially important given the poor status of women in terms of decision-making power and resource ownership in the villages. In both the villages, the indicators of women's status especially in income generating arena is rather miserable. Such contradictory position of women given the huge contribution to food security she makes has striking policy implication.

The understanding of women's role in food security implies that women can play an instrumental role in improving food security and nutritional status of not only women themselves but of the family as a whole. Any policy intervention needs to be in conciliation with this role of women, which is diffused across different economic and non-economic activities. The fact that women are key to food security despite the being engulfed with severe resource constraints and lack of independence, reveals that with greater access and control over resources she can contribute in a better and more efficient way. The policy implication for this is that efforts should be directed towards transfer of basic economic rights like and rights to women, which will also enhance their socio-economic status and so their capacity to contribute to the well being of family and society. At the same time, since it is realized that women are under tremendous work burden, which is almost double of their men counterpart in rural areas, infrastructure to the convenience of women should be developed. In other words, since facilities like better water supply, provision of cooking gas etc. reduce hardship for women, emphasis should be on such women-friendly overheads. Dissemination of knowledge among on issues of nutrition can be further helpful in eliminating malnutrition problems of the children and women themselves to the extent they are caused by unhealthy food intake due to ignorance. Role of social capital is crucial here. Self help groups and voluntary organisations of women created an encouraged for this purpose specifically will be highly helpful in this direction. To sum up, the external policy interventions aiming at raising food security status should be women-centric and suitable to the socio-economic milieu in which it has to be employed. Women are the means as well as end beneficiaries in the whole process of improving food security status. This needs to be incorporated in the policies designed in this direction.

Title	: Social Capital and migration: A study on the pathway of development in Dokur village
Name	: B.V.J. Gandhi
Institute	: Madras Christian College, Chennai
Supervisors	: MCS Bantilan, Global Theme Leader and R. Padmaja, Sr. Scientific Officer
Period	: 2003

Abstract:

This paper attempts to study the role of social capital in enabling labor migration, a coping mechanism (against drought, persistent poverty and HIV/AIDS), in the SAT village of Dokur in the Devarkadra Mandal of Mehabub Nagar District. The pathway of development from absence of livelihood to choosing an alternative livelihood for survival is studied.

The SAT regions are characterized by scanty and uncertain rainfall, on which agricultural production largely depends, infertile soils, poor infrastructure, extreme poverty, rapid population growth and high risks (Ryan & Spencer 1990). The SAT was not documented well in the development literature this led to the longitudinal VLS, which provided the microeconomic data of villages in the SAT regions. One such village is Dokur where people used to in-migrate in times of harvest because it was plenty. The last decade has been one of severe drought leading to absence of livelihood options within the village. This has led to mass migration especially by the people BC and SC communities within the village. The social networks present within and without the village initiate this process of migration. Migration does bring a livelihood to the people of Dokur, however it brings along other vulnerabilities that are faced by migrant workers. One important such feature is the HIV/AIDS risk. The paper focuses on the out migration of the people of Dokur village and their path towards sustainability.

Title	: Adoption and Impact of Improved Chickpea Cultivars in Eastern Maharashtra
Name	: Shwetha Kabra
Institute	: Gokhale Institute of Politics and Economics, Pune
Supervisors	: KPC Rao, Principal Scientist; MCS Bantilan, Global Theme Leader and VK Chopde, Senior Scientist
Period	: 2003

Abstract:

This adoption and impact study was taken up with the following objectives:

- To estimate the growth in the area, production, and yield of chickpea in selected districts of Maharashtra.
- To know the extent of adoption of improved chickpea cultivars in general, and ICRISAT in particular in eastern Maharashtra.
- To identify the factors influencing the adoption of improved cultivars of chickpea.
- To assess the impact of these cultivars on yield of chickpea and production cost.

This study was taken up in five districts of Eastern Maharashtra, Akola, Amravati and Buldhana districts were from Vidarbha region and Aurangabad and Nanded were from Marathwada region. ICRISAT cultivars showed increasing trend from 1996 to 2000. The decreasing trend during later periods may be because of non-availability of seeds of these cultivars. Percentage

adoption of non-ICRISAT cultivars increased from 15% in 1996 to 44% in 2001. Non-ICRISAT cultivars give higher return per hectare compared to ICRISAT and Chafa varieties. Higher grain yield, short duration, drought and disease resistance are the major traits liked by farmers in the new cultivars. Lack of awareness, lack of irrigation and non-availability of seeds in time are the major constraints faced by chickpea growers in adopting new cultivars.

Ongoing

Title	: The sociological analysis of social networks
Name	: Pramila Krishnan
Institute	: Cambridge University
Supervisors	: MCS Bantilan, Global Theme Leader
Period	: Ongoing

Abstract:

There is a considerable body of literature on social capital and social networks, which has been published over a relatively short period of time. Each of these have some interesting findings to offer. This concept is found to be useful in understanding how cooperation, collective/group action can help people combat poverty. The focus is on how social networks and relationships can empower people personally and in revitalizing their communities and thus impact on their everyday lives. A social network can be viewed as a set of concrete interpersonal relations linking the individual to other individuals who are members of diverse systems of groups and categories. A network, even when viewed from the standpoint of a single individual, has a dynamic character. New relations are forged, and old ones are discarded or modified. This is particularly true of rapidly changing societies in which individual choice plays an important role. For an indepth understanding of this concept, it is necessary not only to chart the concrete networks of different individuals, but to relate these different networks to one another, to draw up, a master chart, in a coherent and systematic manner. Social network analysis will help to more systematically describe different kinds of social relationships that exist and develop within the context of rural communities. Social network analysis is focused on uncovering the patterning of people's interaction. This analysis is based on the premise that these patterns are important features of the lives of the individuals who display them. Social network analysis in general studies the behaviour of the individual at the micro level, the pattern of relationships (network structure) at the macro level, and the interactions between the two. The analysis of the interaction structures that is involved in social network analysis is an important element in the analysis of the micro±macro link, the way in which individual behavior and social phenomena are connected with one another.

Though there is plenty of literature on social networks and their role in influencing decisions, more methodological and conceptual work is needed to understand the network conditions that best help to nurture and support the many aspects of rural communities. The focus of this study is on the SAT poor engaged in agriculture, the marginalized groups especially women. Appealing to the concept of social capital as networks and relationships, this research will analyze the types of social networks that men and women farmers associate with, the networks

that powerful groups have access to, and assess the relationship between all of these. Mapping the network architecture (including networks developed either through formal organizations, kinship groups, neighborhoods networks, work groups, self-help groups, or informal interactions), will allow us to investigate the flow of information and the functioning of power relations in the village, and envisage how to improve the impact of particular development programs on rural households, in terms of risk-insurance and poverty-reduction. The research will also use a social lens on the dynamics of shocks and how social networks can help in coping with shocks.

The architecture of social networks in the study villages is mapped. This mapping will help us understand how the pattern of ties in a network provides significant opportunities and constraints because it affects the access of people and institutions to such resources as information, wealth, and power. The research will also help in developing a knowledge base on social networks at various levels that will facilitate informed R & D, policy making, and interventions. This will help in particular to identify local networks already in place that will facilitate layering new innovation intervention; and groups or households that are not socially connected, and thinking about how their needs can be included. The findings may assist in designing strategies, policy formulation and institutional arrangements for effective intervention. Benefits to the community include increased incomes through enhanced linkages, greater access to resources through altered property rights regimes, and new governance mechanisms based on participation and inclusion of community members.

This project will provide an understanding of the linkage existing between different institutional spheres and between different systems of groups and categories. This understanding can be used for policy formulation to help the rural community help themselves come out of poverty. This might include:

- Training agricultural professionals to work with existing systems of learning and experimenting.
- Identifying local innovation networks already in place before introducing ideas and technology from outside of a community.
- Considering particular groups or households that are not socially connected, and thinking about how their needs can be included.
- Existing programmes to promote rural development in remote areas will continue to be important. They can become more effective, however, if they build on existing local networks, and make use of the ability of rural communities to develop new processes themselves. Developing effective connections between formal processes and informal local networks is a major challenge. Making linkages that work successfully will be a
- vital feature of policy support for sustainable rural livelihoods in many areas.

The framework for the study is developed with a focus on women as a distinct group. Caste and class may also act as barriers to development in Indian situations. Along with gender, caste and class considerations will also be looked into. Methodological and design aspects of the project include participatory and inter-disciplinary research involving qualitative and quantitative methods, social network analysis, gender-based social analysis, and needs assessment. It will include mapping of the network architecture for enabling market linkages and social inclusion, improving access to and management of agricultural innovations and livelihood diversification and coping with shocks. The research will also address how and why social networks are fragmented within communities? Which collective benefits could emerge from creation of new links? To date, empirical research on the factors that affect rural people's ability to engage in various forms of collective action, and on the effectiveness of collective action to improve

people's life, is mostly of a qualitative nature. This research proposes to combine quantitative and qualitative analysis in two selected villages - Aurepalle in Andhra Pradesh and Kanzara in Maharashtra, where ICRISAT has been conducting a village-level surveys (VLS) for about thirty years.

Preliminary findings: Analysis of sociological research undertaken during the VLS 1 period. The focus during this period was on social organization and group size. Identification and understanding of anthropological conditions for group action have been a major research focus in ICRISAT's economics program since the latter part of 1976. This included a study of literature regarding cooperation for agricultural production, examination of particular cases from India, and study of relevant anthropological work on group size and function (Doherty and Jodha 1979, Doherty 1980) and on agricultural production, social status and intra-compound relationships (Helga Vierich; Koho, Burkina Faso). Some important findings include:

- how much cooperation is to be expected from different sizes of groups of farmers under different conditions
- whether group ownership and control can be considered in a particular case or whether individual ownership and control is necessary
- close links between the village institutions that organized economic activities and agricultural performance
- rate and impact of the adoption of new technology was found to vary by ethnic group
- adoption of new technology – increased productivity and privileges accorded to social status brought access to labor resources

Analysis of VLS 2 data on social networks and linkages

The variables considered for the analysis include: membership in organization by type of organization, degree of participation, benefits from the groups; information networks and services. These are compared across caste and gender. Results from two villages - Aurepalle and Kanzara - are compared in this analysis. In Kanzara it was found that there are two dominant groups existing in the village – the credit society group (dominated by male members of the community) and the women self help groups. In Aurepalle, a contrasting picture was seen – there are many networks/groups operating in the village and it was observed that people belonged to multiple groups/networks. Women belonged to the self-help groups as well as the credit society, men were members of the credit society, and they were members of the education committee and so on. This result raises some questions- what are the reasons for people of Aurepalle to form diverse networks and be a part of them? Are there cultural, social, economic or political reasons as to why people of Kanzara are not coming together to form new networks? These can be addressed through the social network analysis.

The analysis of the intersection of gender and caste in the network formation in Kanzara reveals that men from the forward caste belong to the credit society while the women from the backward and scheduled castes are coming together to form the self-help groups. The issue then is to understand what the factors that inhibit men and women from different social groups to become members of different groups and networks are. On participation in groups the preliminary analysis revealed no active participation by men and women in both the villages. Is this so because of the power structure that exists in the village? A social networks analysis may help us to identify these and such reasons. Both men and women farmers perceived access to credit as the main benefit from group membership. Probing on the important groups approached for access to services, the Kanzara data revealed that the gram panchayat was the most sought after group by both men and women, and more for issues related to water and its availability.

Information of this kind will help in understanding the emergence of connections/ties and also help in catalyzing the tie formation. For example, knowing where the connections are, and are not, allows a researcher/development planner to influence local interactions. This is particularly important in introducing interventions – health, agricultural, market or policy - as knowledge of the key nodes plays an important role in understanding what flows throughout the network. Will influencing a small number of well-connected ties like the women self-help groups or accessing the top persons (eg, sarpanch) result in better outcomes? If so, social network analysis will help find answers to why, when and how this will occur.

Title	: The potential contribution of agricultural technologies to reducing vulnerability to HIV among women smallholder farmers in Malawi
Name	: Janneke Verheijen
Institute	: University of Amsterdam
Supervisors	: MCS Bantilan, Global Theme Leader
Period	: Ongoing

Abstract:

Conventional AIDS interventions aimed at raising awareness remain barely effective in sub-Saharan Africa, arguably because structural underlying causes of the pandemic inhibit people, especially poor women, to live up to the propagated behavior changes. A different approach is urgently needed, one that does address those underlying causes. While much scientific attention goes to identifying and mitigating the devastating impacts of AIDS, little attention is directed at understanding and addressing the drivers of the pandemic. This research project aims to increase understanding of the facilitators of the pandemic, especially food insecurity and gender inequality, and to identify ways of addressing these through appropriate agricultural interventions.

To increase understanding on the impact of livelihood insecurity of rural women in Malawi on their susceptibility to HIV, current ineffectiveness of interventions aiming to change agricultural and sexual behavior, and opportunities to increase the impact of such interventions in order to mitigate the spread of HIV.

Key results and implications for future: In a practical sense, this research project aims to formulate recommendations to policy makers and project planners, agricultural research institutions and extension services on how to realize the potential contribution of agricultural development to reducing vulnerability to HIV infection among women smallholder farmers in Malawi. Through improved understanding of the needs, constraints, priorities and information flow pathways of differently situated women smallholder farmers, recommendations will be made on how to increase the relevance of innovations and effectiveness of extension methods for these various types of women. By using such a livelihood perspective, the research aims to broaden the scope of HIV prevention efforts and so increase their effectiveness. By using a qualitative lens to look at issues that are generally assessed with quantitative research tools, it is aimed for that recommendations can also be made to increase the effectiveness of future quantitative research instruments.

On a more academic level, this research project aims to increase theoretic understanding of the practice of development intervening through the transfer of modern information; increase understanding of the factors that contribute to HIV vulnerability; and increase theoretical understanding of how anthropological research can contribute to solving practical problems.

Methodology used: Extensive literature review accomplished. Since October 2007 (until end 2008) data collection through participant observation, formal and informal interviews (later also quantitative surveys).

Major findings: Findings result only from literature review, as empirical data collection has only just begun: Women are disproportionately infected, already constituting 59% of all infected in SSA. Furthermore, while infection rates are still highest in the urban areas, rates increase fastest in the rural areas, where the total number of infected now outnumbers the total urban infected. Within the field of agriculture and AIDS, by far most attention is directed at identifying and mitigating the devastating impacts of AIDS on food security. Far less attention has been directed at the reverse relationship: how food insecurity fuels the pandemic. This fueling is both through weakened, malnourished and thus more susceptible bodies, as well as pushing the hungry to survival strategies such as male migration and female transactional sex that increase risk of HIV spreading. More understanding is urgently needed of the mechanisms that put (especially rural) women at risk of infection, and ways through which the resistance of poor women farmers can be increased.

Zimbabwe and Niger

**Abstracts of Students' Research Projects
2003-2008**

Zimbabwe:

2003:

Title	: A first step in assessing possibilities and constraints for use of grain legumes for soil fertility improvement on smallholder farms in the semi arid areas of Zimbabwe
Name	: Martine vaan Wolfswinkel
University	: Wageningen Agricultural University
Degree	: MSc

Abstract:

Growth and development of four grain legumes (*Cajanus cajan*, *Vigna unguiculata*, *Arachis hypogaea* and *Vigna subterranea*), under irrigated and dry conditions, on a clay soil, was analysed in the 2002/2003 season on an experimental field of the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) in Bulawayo (Matopos), Zimbabwe. The collected data were compared to predictions of the Agricultural Production Systems Simulator (APSIM). APSIM was able to predict growth and development of the grain legumes reasonably well. Above ground biomass and yield were well predicted, except for indeterminate cultivars of pigeonpea and cowpea. Biomass N content was less well predicted. Before APSIM can be used to explore scenarios of use of grain legumes in smallholder farming systems in semi-arid Zimbabwe to improve soil fertility, model parameters should be changed to improve prediction of biomass of indeterminate pigeonpea and cowpea cultivars and nitrogen content of biomass. Furthermore, it should be tested with an independent data set, on a sandy soil, under dry conditions, as most smallholder farmers have sandy soil and no access to irrigation.

2004

Title	: A hydrological Assessment of Land Use Changes and Human's Effects on Water Resources in Semi-Arid Zimbabwe: The case of the Insiza Sub-Catchment
Name	: Jean-Marie Kileshye Onema
University	: Univ. of Zimbabwe
Degree	: Msc

Abstract:

The main objective of this study was to assess and identify over time flow characteristics changes and their interactions with land use changes and human's activity in semi-arid Zimbabwe. The focus of this thesis is surface water, ground water characteristics are not analysed. Hydrological time series (35years) of four gauging stations of the catchment were analysed. The methodology was a combined analysis of flow characteristics such as Flow duration curves, Maximum flows, Number of days with zero flows, Runoff coefficients and satellite images to track lands use changes.

Human's influences over water resources were assessed through the effect of hydrological infrastructure mainly dams. The study area, named Insiza Sub-catchment is part of the Umzingwane Catchment, draining southwards into the Limpopo River. It covers an area of 3401km² and is divided into two main hydrological zones, the Upper Insiza and the Lower Insiza. Mean Annual Runoff of the two hydrological zones is 50mm and 38mm respectively. This Sub catchment falls under the province of Matebeleland South and the District of Insiza in Zimbabwe. The analyses indicate a decrease in flows when comparing the sixties to eighties and the nineties. Runoff generation increase at a smaller scale was not felt at the sub-catchment level. Dam's management affected the flow regime of the river by increasing the flow occurrences. Land use change over the period considered shows a conversion of mixed impacted lands into fields, as well as a decrease in good natural vegetation. Further research should be carried out at the plot scale as well as at the bigger scale for a better understanding of changes in runoff generation. The need of a larger picture in time of land use changes will provide a deeper interaction between land use changes and water resources.

2004

Title	: An on-farm evaluation of the effects of low cost drip irrigation on water and crop productivity, compared to conventional surface irrigation system
Name	: Norman Maisiri
University	: Univ. of Zim
Degree	: MSc

Abstract:

The dominant agricultural philosophy that views land as a scarce resource and aims to maximise crop yields per unit land through better varieties while removing nutrients and water as constraints needs to be replaced by a philosophy that views land, water, nutrients and genetic sources as an integrated scarce resources that need to be managed by stakeholders. This on farm research study was carried out at Zhulube irrigation scheme in a semi arid agro tropical climate of Zimbabwe to determine how low cost irrigation technologies compare with conventional surface irrigation systems in terms of water and crop productivity.

A total of nine farmers who were practising surface irrigation were chosen to participate in the study. English giant rape (Brassica napus) was grown under the two irrigation systems with

three fertiliser treatments in each system. These trials were replicated three times in a randomized block design. Biometric parameters of leaf area index (LAI) and fresh weight of the produce, water use efficiency (WUE) were used to compare the performance of the two irrigation systems. A water balance was performed for analysis of WUE. The economic profitability and the operation, maintenance and management requirements of the different systems were also evaluated.

There was no significant difference in yield between drip and surface irrigation systems, 8.5 ton/ha for drip compared to 7.8 ton/ha for surface irrigation. There were significant increases in yield due to use of fertilizers. The leaf area indices were comparable in both systems with the same fertilizer treatment ranging between 0.05 for surface irrigation without fertilizer to 6.8 for drip irrigation with fertigation.

Drip irrigation used about 35% of the water used by surface irrigation systems, thus giving much higher water use efficiencies. However, current irrigation water pricing policy, which is based on area irrigated rather than water abstracted, does not encourage water savings.

Low cost drip irrigation systems did not show any labour savings compared to surface irrigation, especially when farmers have to manually lift the water into the drum supplying the drip system. The gross margin level for surface irrigation was lower than for drip irrigation, but the gross margin to total variable cost ratio was higher in surface irrigation systems. The implication is that surface irrigation systems give higher returns per variable costs incurred.

It is concluded that low cost drip irrigation systems achieved overall water saving over 50% as compared to surface irrigation systems.

It was not the type of irrigation but the type of fertilizer that significantly influenced vegetable yield. Accordingly, low cost technologies should be used in conjunction with good water and nutrient management if higher water and crop productivities are to be realised.

2004

Title	: Water Productivity and yield gap analysis of water harvesting systems in semi-arid Mzingwane Catchment, Zimbabwe
Name	: Jean-Marc Mwenge Kahinda
University	: Univ. of Zimbabwe
Degree	: MSc

Abstract:

Water for food is now a global major challenge. In southern Africa semi arid tropics, rain fed agriculture accounts for more than 95% of the land used for food. However, high population growth, decline in productivity, scarcity of arable land, irrigation expansion limitations, erratic rainfall and frequent dry spells are causing food scarcity in the region. For this reason, interests are directed at increasing rainfed agriculture crop yields in the semi-arid regions through the use systems such water harvesting systems (WHS).

A survey of existing WHS was carried out in the southeast regions of Zimbabwe in the districts of Insiza,

2004:

Title	: Access to Water for Improved Livelihoods: An Investigation of the Perspectives, Experiences and Strategies of Orphans and Other Vulnerable Children: A Case Study of Insiza District Mzingwane Catchment
Name	: Rosemary Murata
University	: Univ.of Zimbabwe
Degree	: MSc

Abstract:

Poverty stricken rural and water-scarce semi-arid tropics such as in the Limpopo basin are global hot spot area in terms of water for food and improved livelihoods. The study area is situated in Zimbabwe, a country characterised by a number of challenges such as HIV/AIDS, a deteriorating economy and hyper-inflation. The impact of HIV/AIDS and generally deepening poverty has undermined the capacity of families to provide care and support for children. Particularly vulnerable groups are orphans and those infected and affected by HIV/AIDS, street children and other working children and the disabled. As more children are becoming heads of households because of the HIV/AIDS pandemic, it is vital to consider their voices when looking at stakeholders in natural resource management, including water.

The study aimed at hearing the perspectives, experiences and strategies employed by orphans and vulnerable children in their quest to secure water. Data was collected through questionnaire interviews, structured in-depth interviews, focus group discussions and observations. The lives of the children, their coping mechanisms and suggestions on how they feel their plight can be alleviated were discussed in the focus group discussions. Observations were also undertaken to reinforce data gathered on the water sources in the area, methods of abstracting water and the distances to the water sources.

The loss of both parents by the children came out as the most devastating aspect of the HIV/AIDS pandemic with 96% of those interviewed having lost their fathers and 90.2% having lost their mothers. 57% of the children were staying in households headed by grandparents who themselves were often too old to handle the household chores, such as looking after the children, sourcing water, undertaking economic activities and bringing food to the table.

Results reveal that 41% of the children get their water from unprotected wells, with 46% saying the source was less than 500m from their household. 70% of the children got the water they needed themselves for uses such as cooking, drinking and hygiene purposes. Most children responded that their water sources do not have water throughout the year and that they resort to unprotected sources such as dams. Awareness on government and NGO projects that use water to improve rural livelihoods was minimal and of those who responded, 54% were not

involved in the projects and, of those involved, 53% did not get an income. This clearly shows a loss of an economic opportunity for water

2004:

Title	: Impact and Sustainability of Drip Irrigation Kits, in the Semi-Arid Lower Mzingwane Catchment, Limpopo Basin, Zimbabwe
Name	: Richard Moyo
University	: Univ. of Zimbabwe
Degree	: MSc

Abstract:

Smallholder farmers in the Mzingwane Catchment are confronted with low food productivity due to erratic rainfall and limitations to appropriate technologies. Several drip kit distribution programs were carried out in Zimbabwe as part of a global initiative aimed at 2 million poor households a year to take major step on the path out of poverty. Stakeholders have raised concerns of limitations to conditions necessary for sustainable usage of drip kits, such as continuing availability of minimum water requirement. Accordingly, a study was carried out to assess the impacts and sustainability of the drip kit program in relation to water availability, access to water and the targeting of beneficiaries.

Representatives of the NGOs, local government, traditional leadership and agricultural extension officers were interviewed. Drip kit beneficiaries took part in focus group discussions that were organised on a village basis. A survey was then undertaken over 114 households in two districts, using a questionnaire developed from output of the participatory work. Data were analysed using SPSS.

The results from the study show us that only poor members of the community (defined for the purpose of the study as those not owning cattle), accounting for 54% of the beneficiaries. This could have been a result of the condition set by some implementing NGOs that beneficiaries must have an assured water source – which is less common for poorer households. Only 2% of the beneficiaries had used the kit to produce the expected 5 harvests over 2 years, owing to problems related to the water and garden problems. 51% had produced at least 3 harvests and 86% 2 harvests. Due to water shortages 61% cropping using the drip kit was done during wet season, meaning that the drip kit was mostly used for supplementary irrigation. Conflicts between beneficiaries and water point committees, or other water users developed in some areas, especially during the dry season.

Low cost drip kit programs can only be a sustainable intervention if implemented as development (not relief), where all stakeholders are involved and the implementing agents ensure that the benefits reach the intended beneficiaries. Issues of water access and availability, which confront the poor in the water scarce regions such as Mzingwane, catchment have to be adequately investigated and addressed, prior to distribution of drip kits.

2004:

Title	: Involvement of stakeholders in the water quality monitoring and surveillance system: The case of Mzingwane Catchment
Name	: Lerato Nare
University	: Univ.of Zim
Degree	: MSc

Abstract:

The world has witnessed a paradigm shift in strategies for managing water resources in recent years. There has been a shift from supply based strategies to demand management. The focus is now on managing as much as possible the available resource. Stakeholder participation is viewed as critical in the current water sector reforms taking place in the region including Zimbabwe. Zimbabwean policies and legislation encourage stakeholder participation and this study aimed at finding out whether indeed on the operational level, there was stakeholder participation in water quality monitoring and surveillance and also assess indigenous knowledge and practices in water quality monitoring and surveillance and also assess indigenous knowledge and practices in water quality monitoring communities, extension workers, farmers and NGOs were interviewed.

There is very limited stakeholder participation although there is adequate institutional frame, structures and organisations to support this. For the Zimbabwe National Water Authority (ZINWA), stakeholders are the permit holders, who they give feedback after analysis of samples, since these pay for them. The Ministry of Health and Child Welfare generally only releases information to rural communities when it is deemed necessary for their welfare. There are no guidelines on how a dissatisfied member of the public can raise a complaint – although some stakeholders carry such complaints to Catchment Council Meetings.

There are many useful indigenous knowledge and practices used by the communities of the area. Physical parameters such as smell, taste, colour and odour are used to assess the quality of water. Residents are generally more concerned about the physical parameters than the bacteriological quality of water. They are aware of what causes water pollution and the effects of pollution on human health, crops, animals and aquatic ecology. They are aware of ways of preventing pollution and when a source of water is polluted, they prefer to boil the water if it is meant either for human consumption or laundry and bathing. For productive water, they felt that the source had to be abandoned and alternative source found. Many of these knowledge systems could be integrated into the formal water quality monitoring systems, in order to complement the official monitoring networks.

There are partners such as NGOs and Rural District Councils who are willing to fund a more encompassing water quality system.

2004:

Title	: Role of Arbuscular Mycorrhizal Fungi in Subsistence Agroecosystems in the semi-arid tropics of Zimbabwe
Name	: Ylva Besmer
University	: The Pennsylvania State University
Degree	: PhD

Abstract:

Low soil fertility limits crop production in Zimbabwe. Legumes have the potential to increase the availability of nitrogen (N) to maize and thereby increase production of this staple. However, N accumulation in legumes could be limited by the low phosphorus (P) availability in these old, highly weathered soils. In fact, available soil P explained 98% of the variation in nodules number of greenhouse-grown groundnut (*Arachis hypogaeae*) in 9 different Zimbabwean soils. By adding P to one soil, nodule numbers increased fourfold, resulting in a significantly higher N content in the shoot tissue. Field experiments in two subsistence farmer's fields located on a sandy soil and black clay showed that legumes differed in the amount of N they accumulate in the shoot tissue followed by pigeonpea (*Cajanus cajan*) and groundnut. Furthermore, nodule mass and shoot N content both increased significantly with P fertilizers, indicating that optimal N accumulation of legumes in these two soils was limited by low availability of soil P. Subsistence farmers do not have access to inorganic fertilizers, however, so other methods need to be pursued to increase yields. Arbuscular mycorrhizal fungi (AMF) are present in most soils and can increase plant P uptake by providing an increased surface uptake area. In fact, a meta-analysis of agricultural studies showed that shoot P concentration increased 27% on average as a result of increased mycorrhizal colonization. The sandy soil and black clay in Zimbabwe differed in their response to an increase in AMF inoculum potential. In the sandy soil, increasing the AMF inoculum potential through an inoculation significantly increased nodule numbers and shoot N accumulation in greenhouse-grown groundnut and lablab. This indicates that plant P uptake was limited by low mycorrhizal inoculum potential and that AMF could, to a limited extent, substitute for P fertilizers. However, the increased colonization level did not result in increased shoot growth. Based on this, the additional P taken up by the fungi in the inoculated treatment was likely to be enough to promote nodule number and nodule weight but not to combat shoot P deficiencies. Nodule weight and N accumulation did not increase significantly in the black clay, indicating that in this soil P uptake was not limited by low AMF abundance. The differences in results between the two soils seemed to be due to higher AMF inoculum potential in the black clay as determined by a bioassay. We also detected large differences in AMF species compositions between the two soils, but this difference did not affect the AMF efficiency (i.e. plant performance at a given level of colonizations).

The meta-analysis also showed that management practices affect mycorrhizal inoculum potentials differently. Inoculation was most effective in increasing mycorrhizal colonization followed by crop rotations with mycorrhizal plants (as opposed to non-mycorrhizal plants), shorter fallow and reduced disturbance. In our field trials, crop rotation affected the mycorrhizal inoculum potential, whereas tillage and fallow period had no effect. The lack of fallow and tillage effects in our experiments contradicts earlier findings in mesic temperate regions and

could be due to climatic differences. A greenhouse study showed that fungal viability of two AMF species declined under moist warm conditions but remained high in dry soils or when the moist soil was frozen, regardless of whether the isolates were from tropical or temperate climates. Thus minimal fallow periods may be necessary to maintain a high mycorrhizal inoculum potential only in certain regions where the soil is moist and above freezing.

In summary, our results showed that while legumes are limited by P, P uptake is not necessarily limited by low AMF inoculum potential. Where it is, increasing the AMF abundance with native fungi mimics the effects of modest P additions but due to generally high inoculum potential and low availability of soil P, the effect of an increased AMF inoculum potential is likely to be small. If benefits of an increase AMF inoculum potential are suspected, inoculum potential could be enhanced prior to the onset of the drought by growing vigorous mycorrhizal crops because fungal viability remains high during the fallow in the dry soils.

2005:

Title	: Cultivating livelihoods: An assessment of water allocation and management practices in small-holder scale irrigation schemes- Cases studies in Mzingwane Catchment
Name	: Muchaneta Munamati
University	: Univ.of Zimbabwe
Degree	: MSc

Abstract:

Good management of irrigation schemes is becoming increasingly recognized as an essential means to achieve successful irrigated agriculture the world over. It is recognized that poor performance is not only a consequence of technical performance in the design and operation of irrigation systems (although it is sometimes an important factor), but many of the problems are based on weaknesses in the organization and management of the scheme. This paper seeks to examine and evaluate the socio-cultural, institutional and political aspects of water allocation and management in small-scale irrigation schemes in the Mzingwane Catchment. The methodology used includes documentary review, case study approach and comparative analysis. The methods used to collect the necessary data are key-informant interviews, semi-structured interviews, group discussions as well as administering a questionnaire to the farmers. Content analysis was used to analyse and quantify the results of the interviews. For quantitative data, excel was used to generate frequency tables. The findings show that the institutional arrangement in the schemes determines the way water is allocated and they also affect water use and management. The results also show that the irrigators do not have the same access to water and do not speak with one voice as to how water should be managed as social status, gender, power, institutional dynamics and group interests appear to determine one's accessibility to water and its management. These findings lead me to conclude that for smallholder irrigation to achieve equity and efficiency in water allocation and management there should be integration of the technical, institutional dynamics, social and political factors from planning to implementation of projects

2005:

Title	: Estimating the influence of on-farm Conservation Practices on the Water Balance, Case of the Mzinyathini Catchment in Zimbabwe
Name	: Lennart Woltering
University	: UNESCO-IHE/TU Delt
Degree	: MSc

Abstract:

The Sub-Saharan region can be characterised by erratic rainfall and high population growth. Nevertheless, 95% (FAO,2004) of the cultivated land is solely dependant on rainfall. Food security can only be reached when more crops per drop is achieved instead of increasing the stress on the available Blue water resources.

Given the limiting soil and climatic conditions, there exists a yield gap between what is (0.5-1t/ha) and when (1.5-2) be produced on a farm. This gap be minimized when farmers alter their management practices and realise that their socio-economic conditions are amenable to changes. Conservation farming groups water, soil and crop management practices, which focus on sustainable farming. Conservation farming contributes to yield stability and dry spell mitigation in drought prone regions. Tillage is an important aspect of conservation farming, because it changes the surface conditions such as pore space and roughness, affecting the potential for infiltration and runoff. However, the key to successful conservation farming is the integration of tillage within the total package within the total production system. This means that besides applying, for example, zero tillage, mulching or ridging, it is also important to focus on measures that increase the water uptake capacity of the plants, such as, pests management, crop rotations, weeding etc. Research from several countries show significant improvements in crop yields and reduced soil erosion after the introduction of alternative tillage practices for conventional mouldboard ploughing. Thus, the risk of crop failure as a result of water stress can be decreased significantly; moreover the willingness to invest more in their crops in terms of fertilization eventually leads to even higher yields. However, with equipment and know-how available adoption of conservation practices is still very low due to lack of adequate labour, insecure land tenure systems, limited access to credit markets, and failing technology transfer. Proper socio-economic conditions and land management increase the resilience against calamities, so that for example, droughts not always lead to social disaster.

The catchment water balance consists of physically based equations for interception, transpiration and surface runoff, the base flow component is calculated using a statistical multiple linear regression model. The rainfall partitioning on farm scale is linked to the input variables from the multiple linear regression model. The input variables can be adjusted to represent the effects of different farm management implementations on rainfall partitioning. This way farm management innovations that work on a farm scale can be used for the water balance on a catchment scale. There is considerable more Green than Blue water available in the catchment, so there is a lot of potential optimising rainfed agriculture. The goal of the farm management practices is to maximize the transpiration. It appeared to be effective to increase

the plant available soil moisture, but this reduces the river recharge through base flow. Tied ridgig stop surface runoff from the plots, when applied on a larger scale this has similar effects on the river recharge. Decreasing the interception losses through minimum tillage or mulching provides more water for transpiration and runoff. The water is transformed from interception loss usable water for plants, besides that, the effects fro river water users downstream are minimized.

2006:

Title	: On farm evaluation of the influence of different conservation agriculture practices on infiltration in rainfed agriculture, compared to conventional farming
Name	: Clever Dhliwayo
University	: Univ of Zimbabwe
Degree	: MSc

Abstract:

The negative impacts of mid season dry spells on the productivity of rain fed cropping in the smallholder sector of southern Africa is well documented. One way of mitigating these impacts is the promotion of conservation agriculture to enhance infiltration and soil water retention. This on farm study was carried out in ward 1 of Insiza District, Zimbabwe. A short season maize (*Zea Mays L.*) variety SC403 was grown under three tillage practices (farmer practice, planting basins and clean basins and clean ripping), on tow soil types: sandy silt loam soil (Soil A) and clay loam soil (Soil B). Cumulative infiltration and the soil moisture retention and grain yield were determined for each treatment under the same climatic conditions.

Seasonal rainfall during the season was 490mm in Field A and 513mm in Field B. For both soil types, cumulative infiltration was highest in planting pits and lowest in clean ripping. Soil A had the highest cumulative infiltration compared to Soil B, yet soil B retained the most moisture. Planting pits showed the highest moisture retention capacity in both soil types. However, clean ripping retained more moisture than farmer practice in soil A and less for soil B. Statistically, there was no significant difference in either the cumulative infiltration and the soil moisture retention in the three tillage practices for the same soil type.

In the sand silt loams, yields of 1648kg ha⁻¹, 1815 kg ha⁻¹, 700 kg ha⁻¹ for farmer practice, planting pits and clean ripping respectively, were observed. For clay loam the yield was 663 kg ha⁻¹, 798 kg ha⁻¹, 525 kg ha⁻¹ for farmer practice, planting pits and clean ripping, respectively. There was no significant difference in the yields obtained in the three tillage practices for the same soil type but there was a significant difference in yield between the two soils types. Crops in sandy silt loams had higher yields

It was concluded that, planting pits enhance infiltration and produce the highest yields in both soil types and that the lack of statistical differences could be attributed to the above normal rainfall received and that only one season was observed. It was recommended that farmers adopt planting pits as a conservation agriculture technique and that additional weeding

operations be carried out in the clean ripping practice in the first year as weeds outgrow the maize crop.

2006:

Title	: An assessment of the soil water management practices for increased seasonal rain water productivity to mitigate against climatic risks
Name	: Liberty G Moyo
University	: Univ of Zim
Degree	: MSc

Abstract:

Soil and water management is viewed as key to improving water productivity in rain fed agriculture in the semi arid climates. Water is viewed as major limiting factor in agricultural production. As a result, technologies to manage soil water to survive against agricultural droughts are being promoted by agricultural research institutions and non-governmental organisations. A major challenge is to seek if these advanced technologies really result in the perceived benefits in smallholder agriculture, particularly in semi arid regions that are most hardly hit by the effects of drought. The paper reports on work done to evaluate if there are any significant yield benefits and water productivity improvements derived from *in situ* rainwater harvesting techniques to increase soil water in rain fed agriculture in semi arid areas of Gwanda, Zimbabwe. Field experiments on soil water management techniques are analysed. In situ techniques include double spring ploughing, basin tillage, ripper tillage and conventional tillage and off-field techniques in practice include dead level contour ridges. The results show that the double spring ploughing results in higher yields (but no significant difference) from the other soil and water management techniques and what the farmers are currently practicing. Maize yields varied from 950 kg ha⁻¹ to 1400 kg ha⁻¹ in the experimental plots with different soil and water management techniques giving an insignificant yield difference ($p>0.05$). Field results are suggesting an increase in rain water use efficiency giving an average of 6.5kg ha⁻¹ mm⁻¹ with micro dosing with ammonium nitrate at a rate of 10kg ha⁻¹ and an average of 6.1 kg ha⁻¹ mm⁻¹ without micro dosing during the assessment period in rain fed agriculture. The concept of micro dosing results in insignificant yield benefits in a good rainy season in the semi arid environments. It is concluded that deep winter ploughing and basin tillage can bridge short mid season dry spells though they are labour intensive. Labour requirements to implement the soil and water management techniques evaluated do not match the yield benefits in rain fed agricultural production.

2006:

Title	: Effect of Soil degradation from grazing pressure on rangeland soil hydrology
Name	: Thobekile Ngwenya
University	: Univ of Zimbabwe
Degree	: MSc

Abstract:

Overgrazing by livestock has caused changes in the productivity and composition of rangeland vegetation in Africa. The problem stems from the low carrying capacity of rangelands - a result of low vegetation cover. It is decreasing with range degradation. In Insiza, the present livestock density of 3.4 ha/LU exceeds the recommended carrying capacity of 8 ha/LU; which is contributing to overgrazing of rangelands. This has an impact on land degradation, which affects soil hydrology. A study was carried out to determine the physio-hydrological responses of soil to different intensities of livestock grazing and land management by comparing the effect of uncontrolled grazed land, fenced off (ungrazed) land and stone lined grazed treatments. The study was carried out over the 2005-2006 rainy season. Two range sites were chosen: one with clay soil and one with clay loam soil. Each site had three different treatments: (i) fenced off to prevent grazing, (ii) stone lined grazed, using a low-tech stone line built manually and (iii) uncontrolled grazed treatments. Infiltration was measured with the use of tension infiltrometer and soil moisture was measured with the use of Time Domain Reflectometer (TDR) soil moisture meter. Plant biomass was measured at the end of the season.

The results show that there is a significant different in infiltration rate and soil moisture among the two sites and among the three treatments. The first day of sampling, the results shows that the effect was due to soil type, only the second sampling, which was after one month, reflected the effect of treatments. The effect of treatments on soil moisture was proportional to the effect of vegetation, as well as the effect of soil type on soil moisture, thus vegetation production depends on soil moisture. Both stone lining and fencing off the land (excluding livestock) improved soil moisture levels and biomass production. The low-tech stone line is thus a possible appropriate technology for improving rangelands. Rotating grazing areas during the rainy season could also be beneficial.

2006:

Title	: Tillage and manure interactions under dryland cropping in semi-arid Zimbabwe
Name	: Patricia Masikati
University	: Univ of Zim
Degree	: MSc

Abstract:

Rain fed crop production systems in the semi-arid areas of Zimbabwe are characterised by low productivity due to low inherent fertility and low, erratic and poorly distributed rainfall. The purpose of this study was to assess the interactions between different tillage practices and manure management techniques in relation to N and P uptake, crop yield and soil physical and chemical properties. Three tillage systems namely No-till (NT), Summer plough (SP) and Winter followed by Summer Plough (WPSP) and three manure management systems heap uncovered and pit covered and heap covered were used. Cattle manure used was applied at a rate of 4 t ha⁻¹ and had total N content ranging from 0.60 to 0.83%. The three tillage and cattle

manure management systems had no significant ($p < 0.05$) effects on N and P uptake, sorghum yield, bulk density and soil moisture content over two seasons. Although there were no significant differences in the second season biomass yield at vegetative stage, grain and stover yield were in the order WPSP>SP>NT. . Manure chemical characteristics were affected by different curing methods heap covered, heap uncovered and pit covered. Heap and pit covered cattle manure was of better quality after curing for three months. Covering manure reduced nitrogen losses. Nitrogen and OC losses ranged between 2 to 5 kg t⁻¹ and 31 to 51 kg t⁻¹ respectively. Effects of soil type and manure type on N and P uptake and crop yield were evaluated in a pot experiment. Three soil types sand, clay loam and black clay soils and two manure types goat and cattle were used. The manure was of high quality N>2.25% and had C:N ratio of 16 and 12 for goat and cattle respectively. Sorghum biomass yield was in the order clay>sand>clay loam. Total mineralized N and P were high on clay followed by clay loam and sand had the least. Nitrogen and phosphorus uptake was in the order sand>clay>clay loam. Calculated values of N and P uptake by sorghum ranged between 22 to 60% and 8 to 30% respectively of total mineralised N and P. Goat manure amended pots had higher biomass yields than those with cattle manure.

2007:

Title	: Understanding Cropping Systems in the Semi-Arid Environments of Zimbabwe- Options for Soil Fertility Management
Name	: Bongani Ncube
University	: Wageningen Agricultural University
Degree	: PhD

Abstract:

African smallholder farmers face perennial food shortages due to low crop yields. The diversity of sites and soils between African farming systems is great, therefore strategies to solve soil fertility problems should suit the opportunities and problems encountered in the different climatic regions. This thesis characterizes the semi-arid regions of south-western Zimbabwe and explores some of the strategies that can be used to provide farmers with more options for soil fertility improvement.

Resource flow maps were used to study the characteristics of the semi-arid farming system of Tsholotsho (Mkhubazi) in south-western Zimbabwe. The results revealed that farmers in the regions face perennial cereal grain shortages, but the poorly-resourced farmers are the most affected. Nutrient management is limited to the use of limited amounts of manure by the better-resourced and medium-resourced farmers. Poorly-resourced farmers did not apply any nutrients to their crops.

The use of low rates of manure and fertilizer is one option that farmers in the semi-arid regions can adopt. Farmers who had access to small amounts of manure and fertilizer were able to increase cereal yields through farmer participatory research experiments. Previously the farmers did not apply manure to crops. In 2003-2004, with good rainfall maize yields due to manure applications at 3 and 6 t ha⁻¹ were 1.96 and 3.44 t ha⁻¹ compared to 1.2 and 2.7 t ha⁻¹ from plots without. Top dressing with 8.5kg N ha⁻¹ increased yields to 2.5 t ha⁻¹ of manure,

and to 4.28 t ha⁻¹ with 6 t ha⁻¹ of manure. In dry years manure in combination with N fertilizer increased grain yield by about 0.14 and 0.18 t ha⁻¹.

The research results also showed that it is possible to successfully grow grain legumes under the semi-arid conditions and derive substantial residual yield benefits to sorghum grown after the legumes. New varieties of grain legumes seemed to be well adapted to dry environments. Sorghum grain yields after legumes reached 1.62 t ha⁻¹ in 2003/04, more than double yields in the sorghum rotation and the yields were also higher in 2004/05.

The Agricultural Production SIMulator (APSIM) was used to model the legume-sorghum rotation to test its capability in simulating cropping systems in the semi-arid southern Africa. The model output of N and water stress factors on plant growth assisted in better understanding the water, N and plant growth interactions within a cropping season, as well as the residual benefits of legumes interacting with variable seasonal conditions. The model showed that the residual benefits of the legumes were driven by nitrogen availability more than water even under the semi-arid conditions.

Further research will focus on the simulation of long-term effects of the manure/fertilizer experiments and the legume-cereal rotations. The use of farming systems models is required in order to get a better understanding of the functioning of smallholder farming systems in semi-arid regions and identify possible development pathways of the systems.

2007:

Title	: Environmental Impact Assessment of Small Scale Resource Exploitation: A case of Zhulube Catchment, Limpopo Basin, Zimbabwe.
Name	: Nevin Tunhuma
University	: UNESCO-IHE
Degree	: MSc

Abstract:

In sub-Saharan Africa most of the population is poverty stricken and living in the rural areas. These people support their livelihoods by exploiting the natural resources in their vicinity. Some of the natural resource exploitation does not promote sustainable development and environmental protection. This study assesses the impacts of such small-scale natural resource exploitation, their implications on water resources and rural livelihoods, with the aim of establishing ways to protect the environment while generating livelihoods as well as coming up with trade-offs which promote sustainable development.

This study focuses on small scale resource exploitation in the Zhulube catchment in the Limpopo basin, Zimbabwe. Environmental impacts assessment of small-scale resource exploitation was done using the Pressure-State-Impact-Response Approach. The state of the environment in the area was evaluated based on the researcher observation; water quantity was estimated using rainfall and sediment yield was estimated using two weirs in the catchment together with suspended solids in river water. Water quality evaluation was based on chemical water analyses of samples collected from the rivers in the catchment. A survey and informal

interviews where carried out to assess the response. The research was also supported by extensive literature reviews.

The results show that the forms of small scale resources exploitation active in Zhulube catchment have negative impacts on the environment in general and water resources in particular. The most important form of resource exploitation is gold panning, followed by agriculture. These activities cause land clearance, sedimentation and introduction of pollutants among other environmental impacts. The most significant driver of environmental degradation, gold panning, was observed to cause an increase in sediment, an elevation of sulphates entering water bodies resulting in the permanent hardness and an introduction of the toxic metal mercury. The results also showed that there is sufficient legislation on environmental protection at national level but limited enforcement and compliance at local level.

Apart from limited enforcement and compliance of national law, other factors are also responsible for the generation of these impacts. These include poor resource use practises, a lack of sense of ownership as well as the need to generate livelihoods among users. It is therefore recommended that illegal forms of small scale resource exploitation such as gold panning, be formalised. Formalisation would bring accountability from the resource exploiters as well as facilitate the use of cleaner technologies that would reduce environmental damage. Local communities should also be involved in policy making and environmental protection. Furthermore a continuous and systematic environmental monitoring system should be set up. This system would then act as the basis of decision making in areas of small scale resource exploitation.

2007:

Title	: Microdosing: A case study on the use of small amounts of nitrogen fertilizer on cereals in semi-arid Zimbabwe
Name	: Martin Moyo
University	: Univ of Reading
Degree	: MSc

Abstract:

Many soils of sub-Saharan Africa are low in fertility, with the soils of Zimbabwe, especially the fragile semi-arid areas being no exception. Crop yields in the fragile semi-arid areas of Zimbabwe have been declining steadily over the years, with the soil fertility decline arising from a number of factors that include monocropping on the smallholdings, and the situation is exacerbated by high human population pressure, forcing the farmers to cultivate marginal lands, leading to further land degradation. Some other challenges that are faced by farmers in the semi-arid environments include the lack of draft animal power, inadequate soil moisture, lack of soil fertility amendments, with manure being of scarce and if available, being of poor quality and poor pest and disease management. With increasing land pressure, the decline in fallows, limited rotations and scarce manure and other nutrient sources such as compost, leaf litter and termitaria, there is a need to find other ways to improve crop productivity in the semi arid areas. Previous studies have revealed that fertiliser use is limited in the semi-arid environments (less than 5% of the farmers use fertilisers) of Zimbabwe, though greater and more efficient use of

chemical fertilisers can significantly improve crop yields in Zimbabwe's drought prone, semi-arid areas (Natural Region IV and V). The objectives of this study were to (1) evaluate how the use of small doses of Nitrogen fertiliser could affect cereal yields (maize, sorghum and pearl millet yields) and (2) assess how the following factors influenced yield under the microdosing technology;

- ❖ Rainfall
- ❖ Time to fertiliser application
- ❖ Time to weeding
- ❖ Initial soil fertility status
- ❖ Gender

Some on-farm experiential trials were established, with farmers taking a lead role through farmer learning groups (participatory learning approach) in 7 districts of Southern Zimbabwe, lying in the semi-arid environments. A total of 746 farmers established the experiential learning trials on microdosing, with a paired plot design, with the plants on 0.1ha of the plot being amended with 5kg of N fertiliser and the other 0.1ha having no N fertiliser applied (being treated as the control or the normal farmer practice plot).

The application of the small doses of nitrogen fertiliser, rainfall amounts, the time of application of the nitrogen fertiliser, the initial soil fertility status, and the days to weeding all had a significant effect on the cereal yields ($P < 0.05$). Sorghum had the highest response to microdosing in the semi-arid areas, with a 53% grain yield increase, compared to maize (51% grain increase) and pearl millet, which had the lowest grain yield increase of 18% across the 7 districts. The results indicate that microdosing as a technology could be suitable for different regions, with different climatic conditions, soil types and different farmers with different resource levels and management capabilities. The results from this study indicate that microdosing is a promising technology that could be encouraged for farmers to take up fertilisers, especially to those farmers who do not have any experience with using chemical fertilizers in fragile environments such as semi-arid environments. The study revealed that nutrient use efficiency could be increased by improving the timing and availability of nutrients and good agronomic management practices are necessary for farmers to realize substantial yield gains with the use of key inputs such as fertilizers. Participatory research, which makes technology testing more realistic and helps farmers accept results and recommendations more easily, was used and is likely to be key to promotion of small doses of fertilizer.

2007:

Title	: Effect of rainfall viability and options for adaptation on household food security under semi-arid conditions at sub-catchment level
Name	: Brenda Chibulu
University	: Univ of Zim
Degree	: MSc

Abstract:

Poverty, hunger and malnutrition amongst rural people in semi-arid areas where small scale farming is dominant are widely recognized as major problems. The fact that rural communities of southern Africa reside in marginalized areas which are characterized by low and highly variable rainfall that is poorly distributed exacerbates these problems. Most of their attempts at farming activities result in yields that are way below the expectation of farmers. Sometimes these dryland farmers experience complete crop failure leaving them with nothing to live on, or let alone sell and earn the much needed income. So how then, can a growing community whose main means of survival is at the mercy of nature feed itself? The challenge at hand is to determine how crop productivity can be improved in semi arid areas in the wake of erratic and low rainfall. This research is in line with both the Millennium Development Goal (MDG) number 1, which is to eradicate extreme poverty and hunger and the Poverty Reduction Strategy (PRS) which aim to increase national food security. Also the fight against the negative impacts of HIV/Aids cannot be won without the necessary basic nutrition.

This investigation tried to investigate the effect of rainfall variability on crop yield under semi-arid conditions at sub-catchment level.

Ten portable raingauges were installed at ten locations within Zhulube meso-catchment based on direction of prevailing wind and soil type. In addition to this, seven 10m*10m experimental maize plots were cultivated and a household survey was carried out to assess the farming practices that prevail in the area in order to understand their possible impacts on crop yield.

Results have revealed that while there was temporal variability of rainfall in the study area, it was significant in the long-term and insignificant in the short-term. Spatial variation of rainfall was significant in Zhulube meso-catchment in the short-term. It was however not significant enough to cause significant differences in yield. Results from the household survey indicated that despite the villages cultivating common crops with maize being the most common, they exhibited variation in most of the critical farming practices.

NIGER

2003:

Title	: Etude de la distribution spatiale et du mode de gestion des haies dans le sud ouest du Niger: cas du terroir de Tiguo Tegui.
Name	: Amina Tidjani Allou
University	: Université Abdou Moumouni, Niamey, Niger
Degree	: MSc

Abstract:

Cette étude est une contribution à une meilleure connaissance des systèmes de production culture-élevage dans le sud-ouest du Niger. Elle s'insère dans les études de caractérisation des systèmes de production mixte culture élevage entreprise depuis 1994 par l'ILRI et l'ICRISAT. Elle a pour objectif de permettre une meilleure connaissance de la gestion et l'exploitation des haies dans le terroir de Tigo Tegui par l'utilisation combinée de la télédétection et de l'enquête socio-économique. Ainsi, grâce aux potentialités du système d'information géographique dans la caractérisation du terroir, les haies vives ont été cartographiées à partir d'une image satellitale de type IKONOS couvrant une superficie de 121 km² afin d'étudier leurs répartitions spatiales et de déterminer les facteurs physiques qui influencent la gestion et l'exploitation des haies vives. Une enquête complémentaire de type socio-économique a permis d'identifier les caractéristiques des haies dans le terroir de Tigo Tegui et d'étudier les relations existantes entre les exploitants agricoles et cette ressource.

Mots clés : Haies vives, Télédétection, Enquête socio-économique

2003:

Title	: Diversification des systèmes de culture: cas du sésame (<i>Sesamum Indicum</i> (L.) et du Guar (<i>Cyamopsis tetragonoloba</i> (L.) Taubert) et estimation des rendements par le méthode de télédétection basse-altitude
Name	: Rirabé DJIDINGAR
University	: Université Abdou Moumouni, Niamey, Niger
Degree	: MSc

Abstract:

In Sahel, taken into account the agrarian agricultural environment caused by the climatic peroration and the decreased of the soil fertility, crops diversification appear as a main solution

to ensure the farmers' food and financial security. These trials have been conducted; in a split plot design of 1.8 ha. Each main plot comprise eighteen main plots in which different levels of fertility (30 U DAP2 +5 T ha⁻¹ manure, 2 g DAP per hill et 5 T ha⁻¹ manure) sowing density: 0.25 m x 0.25 m and 0.5 m x 0.5 m for the sesame and 0.25 m x 0.25 m, 0.5 m x 0.5 m and 1 m x 1 m for cluster bean are randomized. In fact, three fertilization levels, two density levels were use for the sesame and three density levels were used for the cluster bean test. To estimate the yields (straw and grain) a low aerial photography has been used. The assessment of green normalized on aerial photography explains the grains yields at 75% and straws ones at 83% during the harvesting .The different fertility and sowing density levels have no significant effect on sesame's grain and straw yields. The variety effect is highly significant, then sowing a great morphological and agronomic diversity between the varieties. The yields levels vary between 615 to 652 kg ha⁻¹ and straw ones between 1636 kg ha⁻¹ to 1727 kg ha⁻¹ and both have been obtained though performant varieties such as the local variety of Aguie, 18TCD 94 ISE 003 and Zermou Attari one. Regarding to cluster bean, the interaction density x fertility and density have a significant effect on straw yield. Concerning the grain yield only the density has a significant effect. The grain yield varies about between 51.1 to 70 kg ha⁻¹ about the variety such as RGC 187 and M 83 and straws yields ones between 69.2 to 75.6 kg ha⁻¹ for M 83 and GG-1. The low aerial photography gives the new perceptive which can approached the most important factor in agriculture yields determination. Son adoption will be a substantiates contribution in yields determination in Sahel. There's a variability in tern of sesame grains composition: (46-54.30%) oil, (23.19-27.56%) protein, (3.33-6.53%) mineral matters, (0.511-1.022%) calcium, (3.680-4.410%) nitrogen, (0.653-0.837%) phosphor, (0.851-1.033%) potassium, (0.419-0.492%) magnesium, (595.3-646.7 mg-Na kg⁻¹) sodium, (70.1-117.8 mg-Mn kg⁻¹) manganese, (68.0-100.6 mg-Zn kg⁻¹) zinc and much trace of iron.

2005:

Title	: Les propriétés chimiques des sols de parcelles cultivées dans la Fakara (Niger)
Name	: Olivier Ska
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

Le projet PAD (Projet d'Aide à la Décision), financé par la DGCD a pour objectif l'amélioration des conditions de vie des populations rurales sahéliennes. L'objectif spécifique est d'améliorer les revenus et de réduire la dépendance de ces populations, en tenant compte des fluctuations du climat et du marché en fournissant une information appropriée et intégrée pour la prise de décision au niveau des ménages.

Ce mémoire s'insère dans le cadre d'une partie du projet PAD, l'évaluation de l'impact de techniques d'intensification sur la production de mil à l'échelle du terroir.

Deux objectifs ont été fixés pour ce mémoire : la caractérisation de la variabilité spatiale des propriétés chimiques à l'échelle du terroir du Fakara, et l'analyse de sensibilité du logiciel APSIM aux paramètres internes du cycle de l'azote dans le sol.

L'étude de la variabilité spatiale des propriétés chimiques, réalisée à l'aide d'échantillons prélevés sur toute la superficie du terroir et de l'analyse des propriétés chimiques de ces échantillons, a posé les premiers jalons de la réalisation d'une hypothétique carte de la fertilité chimique du Fakara. Cependant, le fait que la variabilité spatiale inter-parcellaire soit inférieure à la variabilité spatiale intra-parcellaire, de même que la prédominance de la matière organique comme facteur explicatif de la fertilité chimique ainsi que le peu de différences rencontrées entre types de sols différents sur base des propriétés chimiques rendent l'intérêt de la réalisation de cette carte discutable.

L'analyse de sensibilité du logiciel APSIM à ses paramètres internes du cycle de l'azote dans le sol est également un pré requis à l'utilisation de ce logiciel pour la réalisation de cartes. APSIM est un simulateur de systèmes de production agricole, modèle numérique à structure modulaire modélisant entre autres la croissance et le développement du mil. Ce travail constitue une première étape dans le calage des paramètres internes avec les conditions locales. L'analyse de l'effet de ces paramètres internes sur le rendement en grain et en biomasse nous a livré quelques observations importantes telles que le peu d'influence du pH et du rapport C/N, ainsi que la grande importance des paramètres liés à la matière organique et les teneurs en azote initiales.

2005:

Title	: Caractérisation des propriétés hydrodynamiques et étude de la possibilité d'agrégation de trois types de sols au Fakara, Niger
Name	: Mélanie Weynants
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

Le calcul du bilan hydrique à l'échelle d'un terroir implique, a priori, la prise en compte des propriétés hydrodynamiques spécifiques à chaque type de sol. Cette démarche est relativement fastidieuse. Dès lors, l'étude de la possibilité d'agréger certains types de sols cultivés, sur base d'une comparaison de leur bilan hydrique simulé, permettrait d'éviter une surcharge de travail lors de l'estimation du bilan hydrique à l'échelle de ce terroir. Ainsi, les propriétés hydrodynamiques des trois principaux sols cultivés au Fakara, Niger, ont été déterminées par plusieurs méthodes. Deux méthodes exploitent des mesures d'infiltration sous tension: la solution quasi analytique de Wooding et la modélisation inverse des paramètres de van Genuchten (1980), grâce à HYDRUS 2D (Šimunek et al., 1996). Des données de granulométrie sont utilisées pour estimer ces mêmes paramètres grâce aux fonctions de pédotransfert Rosetta (Schaap, 1999). Des essais de Multi Step Outflow ont été entrepris mais ils n'ont pas abouti. Les résultats obtenus pour chacune de ces méthodes ont été comparés à ceux publiés par différents auteurs ayant travaillé sur des sols semblables. Les valeurs des paramètres estimés pour les trois sols par chaque méthode ont été comparées, à deux profondeurs d'échantillonnage. Le drainage saisonnier, composante du bilan hydrique, a été simulé par APSIM 4.1 (2005). Les valeurs résultantes ont également été comparées pour les trois types de sols. Les tests d'égalité des moyennes réalisés permettent d'aboutir à l'agrégation de deux des trois types de sols.

2005:

Title	: Optimization of Farming Systems in the Fakara (Sahel) with Regard to Soil Fertility Using a Dynamic Modelling Approach
Name	: Josua Leistner
University	: University of Hohenheim, Germany
Degree	: MSc

Abstract:

A simple dynamic model, based on the works of Bontkes (1999, 2005), was built to assess the impact of different management practises on important variables of soil fertility on field scale.

Five farm types, grouped by their production factor endowment (Hiernaux and Turner 2002), were compared regarding sustainability of cropping systems. The dataset used in this work was collected by different organisations in the Fakara region (SW-Niger) over the last decade. It was found that only the high endowment group is able to achieve the objective of sustainable land use. Suggestions for improvement were made and tested using the mentioned model. The importance of mineral fertiliser use to increase yields and crop residues to maintain soil fertility was again affirmed. Additionally two different climatic change scenarios were used in a simple CGM to estimate temperature and precipitation development in the objective area for the next three decades. Results from these simulations give occasion to the hope that the West African Sahel is one of the few areas in the world actually benefiting from climatic change.

2005:

Title	: Analyse des activités des ménages agricoles du Fakara au Niger : cas de trois villages.
Name	: Nouhou Amidou
University	: CNEARC, France
Degree	: MSc

Abstract:

La zone du Fakara située dans le sud-ouest de la région de Tillabéri, est une zone aride aux sols pauvres. Sa population est composée de deux principales communautés qui cohabitent depuis longtemps et vivent d'activités agricoles et non agricoles. L'objet de la présente étude est i) d'étudier les activités par acteurs au sein de chaque groupe domestique et l'analyse des liens existant entre les différentes pratiquées par groupe domestique, ii) d'étudier les contraintes techniques (évolution de la fertilité des sols, calendrier surchargé), économiques (disponibilité en capital) et sociales (position dans la famille, âge et réputation) dans la réalisation de ces activités, iii) de représenter la part de chaque activité dans le revenu total du groupe domestique et iv) de définir les activités les plus intéressantes à favoriser par les projets dans la zone d'étude. Cette étude montre que des populations du Fakara sont organisées à plusieurs niveaux d'échelle : les unités de résidence et ménages. Nous avons répertorié plusieurs types de ménages qui constituent le premier niveau d'échelle d'organisation et se différencient par le nombre de groupes domestiques qu'elles renferment. Ces différents ménages composant ces unités de résidence sont indépendants les uns des autres et constituent le deuxième niveau d'organisation des populations. Il existe plusieurs types de ménages selon le nombre d'acteurs qui le composent et les activités qui y sont pratiquées. Deux groupes d'activités permettent aux différents ménages de mener leur vie. Ce sont les activités principales structurantes (la céréaliculture et l'élevage de bovin) et d'autres activités agricoles et non agricoles (activités secondaires) qui viennent en appui aux principales activités. Parmi ces activités secondaires, certaines sont pratiquées de façon permanente, tandis que d'autres sont exercées par certains groupes domestiques en cas de mauvaise année. L'étude des revenus révèle que la contribution des différentes activités au revenu global sont variables d'un ménage à un autre. La part des activités principales est plus importante que les autres activités. Cependant, la pratique de certaines de ces activités secondaires constituent une source de financement aux activités principales structurantes. L'analyse de ces revenus montre qu'il y a des activités intéressantes qui peuvent permettre aux ménages d'assurer leur sécurité alimentaire et même réduire leur

état de pauvreté. Nous souhaitons à ce que les projets et ONG s'intéressent à ces activités pour permettre aux populations de mieux les rentabiliser. Fakara dispose de potentialité humaine pour bien rentabiliser ces différentes activités mais, il leur manque de moyen matériel et financier pour bien développer certaines. Un appui de l'Etat et de ces partenaires au développement peut aider les populations à développer parmi ces activités celles qui génèrent de revenus important. Cependant, tout appui à ces populations doit d'abord sécuriser les productions agricoles qui conditionnent beaucoup la pratique d'autres activités.

2005:

Title	: Effets de la fertilisation par micro dose sur la productivité du mil, les bilans des nutriments et de l'eau du sol au Niger
Name	: Bandoum Yambaye Patrick
University	: Université Abdou Moumouni, Niamey, Niger
Degree	: MSc

Abstract:

L'agriculture des pays d'Afrique Subsaharienne est caractérisée par une faible productivité due à des contraintes biophysiques. Les contraintes biophysiques majeures sont la faible pluviométrie et sa mauvaise distribution dans le temps et dans l'espace et la faible fertilité des sols (Pieri, 1989). La forte croissance démographique a entraîné une forte pression sur les ressources en terres cultivées avec pour conséquences la réduction de la durée des jachères et la dégradation des propriétés physico-chimiques des sols (Boubé, 2002).

Selon la Banque mondiale (2002), l'Afrique de l'ouest dont la population croit annuellement de 3%, doit nécessairement augmenter sa production alimentaire de 4% par an pour pouvoir assurer sa sécurité alimentaire. La concrétisation de ces prévisions ne peut se faire avec aisance, car les sols de ces régions sont généralement peu fertiles et leur bilan nutritif est négatif (Bationo, 1998).

C'est donc à juste titre que les questions liées à la gestion de la fertilité des sols occupent le centre des débats sur la durabilité des systèmes de production agricole en Afrique subsaharienne.

Ainsi, l'initiative « fertilité des sols » a été lancée à Rome en 1996 par la Banque Mondiale et ses partenaires lors du sommet mondial sur l'alimentation (Dioum, 1997 ; Salif, 2001).

L'objectif de cette initiative est de faciliter une meilleure compréhension des facteurs qui contribuent à la baisse de la fertilité des sols, des solutions potentielles et de catalyser les participations futures dans les projets et expérimentations de programme de gestion des sols. A cet effet, les producteurs et les chercheurs sont unanimes sur la nécessité de relever le faible niveau de fertilité des sols des zones tropicales semi-arides de l'Afrique afin d'accroître les rendements de cultures.

Cependant les problèmes qui se posent sont multiples :

L'indisponibilité ou l'inaccessibilité aux fumures organiques en quantité suffisante, permettant de couvrir les besoins des cultures en vue d'une augmentation de la productivité ;

La précarité des revenus des paysans ainsi que le coût exorbitant des engrais minéraux qui ne permet pas aux producteurs de s'en procurer à la dose recommandée (100 kg de NPK 15.15.15 par hectare, pour le mil par exemple); La méconnaissance des techniques appropriées et efficaces d'utilisation d'engrais par apport localisé.

Face à ces constats, les institutions de recherche telles que l' INRAN, ICRISAT, le TSBF-CIAT, et l' IFDC, et les projets de développement comme le Projet Intrants FAO et les ONGs au Niger ainsi que d'autres partenaires de la sous région ont développé et promu les technologies d'apport d'engrais par micro dose au poquet.

Cette technologie qui était initialement appliquée au mil et au sorgho, principales cultures destinées à l'alimentation dans la sous région, est actuellement en extension sur d'autres cultures, telle que le Niébé et l'arachide.

Vulgarisées dans quelques régions du Niger depuis 1999, du Burkina Faso et du Mali à partir de 2002, ces technologies de fertilisation par micro dose ont fait leur preuve. C'est ainsi qu'en 2004 les évaluations réalisées conjointement par le projet USAID/TARGET de l'ICRISAT (Institut International de Recherche sur les Cultures des Zones Tropicales Semi-arides), l'INRAN (Institut National de la Recherche Agronomique du Niger), le projet Intrants FAO et d'autres partenaires, font état d'une augmentation considérable de l'ordre de 44% à 120% des rendements en grains du mil et du sorgho dans les régions concernées.

Cependant il a été constaté suite à ces expériences qu'en dehors des effets des types et doses de fertilisants, les augmentations importantes des rendements du mil et du sorgho ont été influencées par le facteur variété et densité de cultures.

C'est dans l'optique de mieux cerner les effets des différents facteurs et de leurs interactions, et les effets à moyen terme de cette technologies de micro dose sur le bilan hydrique et des nutriments du sol que s'inscrit l'étude qui porte sur : effets de la fertilisation par micro dose sur la productivité du mil, les bilans des nutriments et de l'eau du sol au Niger.

2006:

Title	: On-Farm Yield And Water Use Response Of Pearl Millet To Different Management Practices In Niger
Name	: Comfort Manyame
University	: Texas A&M
Degree	: PhD

Abstract:

Pearl millet [*Pennisetum glaucum* (L.) R.Br.] production under subsistence farmer management on the sandy soils of southwestern Niger is faced with many challenges, including declining soil fertility, highly variable and scarce rainfall and poor resource base of the peasant farmers in the

region. This study was conducted to evaluate the potential of management to increase yield and water use efficiency of pearl millet grown on two farmers' fields in Niger during two growing seasons, 2003 and 2004. The management practices tested were: 1) Five manure treatments (no manure, transported manure, current corralling, a year after corralling, and two years after corralling); 2) The microdose technology (20 kg di-ammonium phosphate ha⁻¹, and 20 kg di-ammonium phosphate ha⁻¹ + 10 kg urea ha⁻¹); and lastly, 3) Three different pearl millet cultivars (Heini Kirei, Zatib, and ICMV IS 89305). In both growing seasons, manure had the greatest effect on the yield and water use of pearl millet at both sites. In 2003 grain yields were 389 kg ha⁻¹ in the NM treatment and 1495 kg ha⁻¹ in the C0 treatment at Banizoumbou whereas at Bagoua, the NM treatment had 423 kg ha⁻¹ vs. 995 kg ha⁻¹ in the C0 treatment. In 2004, the NM treatment at Banizoumbou had 123 kg ha⁻¹ grain yield and the C0 treatment had 957 kg ha⁻¹ whereas at Bagoua the NM treatment had 506 kg ha⁻¹ vs. 1152 kg ha⁻¹ in the C0 treatment. Residual effects of manure led to grain yields in the C1 and C2 treatments which were more than twice as high as in the NM treatment. The improved cultivars were generally superior for grain yields, whereas the local landrace was superior for straw yields at both sites. Root zone drainage was decreased by between 50 to 100 mm, and water use increased by the same amount in the current corrals at the two sites during the two growing seasons. Increased water use under corralling and presence of residual profile moisture at the end of each of the two seasons suggested that water did not limit pearl millet production at the two sites.

2006:

Title	: Caractérisation de la variabilité spatio-temporelle de la pluie au Fakara, Niger
Name	: Nathalie Van Vyve
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

Au Sud-Ouest du Niger, dans la partie du pays qui n'est pas aride, les agriculteurs sont entièrement tributaires de l'eau de pluie pour leurs cultures. En plus des besoins en eau des cultures, la réponse à l'engrais dépend également des précipitations. Une meilleure compréhension de la variabilité pluviométrique de la région permettrait une amélioration de la gestion des risques induits par cette variabilité. L'objectif de ce travail est de caractériser la variabilité spatiale de la pluie dans une zone du Fakara de 500 km² à l'Ouest du Niger. Un réseau d'une cinquantaine de pluviomètres implanté en 2000 a permis de récolter les données pluviométriques jusqu'en 2005. L'analyse exploratoire des données a démontré que sur cette zone et sur la période 2000 à 2005, il n'y a pas de corrélation entre le nombre d'événements pluvieux total sur la saison et le cumul pluviométrique annuel. L'analyse de la corrélation entre ce dernier et le nombre d'événements pluvieux du coeur de la saison n'a pas donné de meilleurs résultats. Les analyses de la structure spatiale des hauteurs de pluie et des champs de pluie ont été effectuées grâce à des variogrammes dont les classes de distances, d'intervalles de 1,5 km, vont de 1 à 22 km. Ces analyses ont été réalisées sur les données pluviométriques brutes et transformées en prenant la racine carrée des données brutes. Ces deux jeux de données ont été analysés sous forme normalisée ou non. Différentes échelles d'agrégation temporelle, de l'événement pluvieux à la saison, ont été analysées à travers ces

variogrammes. Aucune structure spatiale n'a pu être mise en évidence par les variogrammes représentant la structure spatiale des hauteurs de pluie à l'échelle événementielle si ce n'est une légère tendance linéaire croissante. Les hauteurs de pluie peuvent donc être considérées comme des variables indépendantes à cette échelle. La structure spatiale devient cependant plus significative quand le temps d'agrégation temporelle augmente. Pour les variogrammes des champs de pluie, la tendance linéaire croissante est plus marquée. Néanmoins, l'effet pépite est, dans tous les cas, très important et largement prépondérant sur toute structure spatiale proprement dite. La pluviométrie est, de ce fait, un phénomène essentiellement aléatoire au Fakara, puisqu'un effet de pépite pur représente une absence de corrélation entre les données. Certes, dans ces limites d'échelle spatiale (2 à 22 km), aucune structure n'apparaît, mais la tendance linéaire croissante peut être le reflet d'une corrélation spatiale qui serait mise en évidence grâce à des pluviomètres distants de plus de 20 km. Cette étude prouve encore une fois combien les champs de pluie au Fakara sont extrêmement variables et difficiles à prédire. Pour les producteurs sahéliens, la meilleure méthode de gestion des risques, qui découlent de la variabilité pluviométrique, pour les cultures est d'éparpiller les champs aux alentours du village.

2006:

Title	: Impact de pratiques de gestion de la fertilité sur les rendements en mil dans le Fakara (Niger)
Name	: Caroline Dandois Dutordoir
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

Le mil (*Pennisetum glaucum* (L.) R. Br.) est la plante alimentaire la plus cultivée dans la zone sahélienne du Niger. La pluviométrie et la faible fertilité des sols sont les principaux facteurs conditionnant le rendement de la culture du mil. Les sols cultivés sont sableux, contiennent peu de matière organique et de phosphore disponible et ont une faible capacité d'échange cationique. La culture permanente pratiquée sans restauration de la fertilité du sol provoque une diminution rapide de la teneur en éléments nutritifs et en matière organique ainsi qu'une acidification de la plupart des sols. Etant donné le manque de disponibilité de fumier, plusieurs études ont mis en évidence que l'utilisation d'engrais minéraux, couplée à l'application d'engrais organiques est la solution phare pour satisfaire la demande alimentaire croissante sans aggraver la dépendance du pays vis-à-vis de l'aide internationale. En vue de promouvoir l'utilisation par les agriculteurs de pratiques améliorées de gestion de la fertilité des sols, il est essentiel de pouvoir établir préalablement l'impact en conditions réelles de ces pratiques sur les rendements. C'est dans cet objectif qu'un essai en milieu paysan a été mis en place pour une durée de 3 ans dans 3 villages de la région du Fakara, au sud-ouest du pays. L'essai vise principalement la validation de la technique de placement d'engrais au poquet et la caractérisation de l'impact de pratiques indigènes de gestion de la fertilité. Il combine 3 variétés de mil (locale, ICMV IS 89305 et Zatib), 3 niveaux d'application d'engrais (témoin, DAP : phosphate diammonique et DAP + urée) et plusieurs pratiques de gestion des amendements organiques (transport de fumier et parcase) ainsi que leurs effets résiduels (un et deux ans après application). Les rendements des parcelles où un parcase a été effectué dans l'année ont augmenté de 168 % (en grain) et de 176 % (en paille), tandis que la technique du transport de

fumier a permis de doubler les rendements par rapport aux parcelles non fumées. L'effet du parage sur les rendements dépend fortement de la pluviométrie utile et est marqué pendant trois saisons de culture consécutives, l'effet résiduel du transport de fumier jusqu'à la deuxième saison de culture. L'application d'engrais a permis d'augmenter les rendements en grain de 15 à 19 % mais nous recommandons l'application de DAP seul par rapport à l'application de DAP + urée car les rendements ne diffèrent pas significativement entre les deux types de fertilisation. L'effet de DAP a été d'autant plus marqué que le parage et le transport de fumier étaient anciens. Les résultats indiquent que les agriculteurs gagneraient à appliquer DAP placé au poquet comme apport-relai en nutriments à partir de la 2^{ème}, voire de la 3^{ème} année après le parage. Les variétés testées ont révélé différents avantages et inconvénients. La variété locale, sélectionnée par les agriculteurs depuis de nombreuses années et adaptée à la région, fournit les meilleurs rendements en paille. La variété améliorée ICMV IS 89305 permet une augmentation du rendement en grain de 12 % et une diminution de 10 % par rapport au rendement de la variété locale. Dans la pratique, les quantités de fumier appliquées (estimées à 18 t ha⁻¹) sont hors de portée pour la plupart des agriculteurs sahéliens, généralement trop pauvres pour posséder suffisamment de bétail. D'autre part, les engrais importés sont chers et difficiles d'accès dans les campagnes. L'amélioration de l'accessibilité des intrants paraît essentielle pour parvenir à un accroissement durable des rendements en mil dans cette région.

2006:

Title	: Etude de la variabilité du climat et de la fertilité du sol sur la productivité du mil au Niger : Croissance et simulation
Name	: Adamou Abdou
University	: Université Abdou Moumouni, Niamey, Niger
Degree	: MSc

Abstract:

La faible fertilité des sols et la rareté des pluies sont les facteurs les plus limitatifs de la production agricole dans la zone soudano-Sahélienne en Afrique de l'Ouest. La région habite les populations les plus pauvres de la planète dont 90% vivent en milieu rural et tirent leur nourriture d'une agriculture de subsistance. Cependant, les rendements des céréales, en général, et du mil, en particulier qui constituent la nourriture de base sont très faibles (300-400 kg/ha). La recherche a développé des technologies de gestion intégrée de la fertilité des sols mais elles n'ont pas été adoptées par les paysans. DSSAT (Decision Support System for Agrotechnology Transfer) est un outil incorporant des modèles de 16 différents types de cultures avec un logiciel facilitant l'évaluation et l'application des modèles de cultures pour différentes utilisations. Mais son utilisation requiert un minimum de données sur le climat, les sols, les cultures et aussi les données expérimentales. Les simulations obtenues à partir de ces données permettront aux chercheurs de développer beaucoup de résultats prometteurs en milieu paysan. Cette étude montre les interactions entre la fertilité des sols et les rendements de mil dans trois sites (Banizoumbou, Bengou et Karabedji) au Niger sur une période de 5 ans (2001-2005) et une simulation de l'azote en utilisant DSSAT pour un des sites.

Mots clés : fertilité des sols, simulation, rendement, azote, sites.

Low soil fertility and erratic rainfall are the most limiting factors to crop production, in the Sudano-Sahelian zone of West Africa. The region is the home of the world poorest people, 90% of whom live in villages and derive their livelihood from subsistence agriculture. However, yields of cereals, in general, and millet in particular which constitute the staple food of the rural people are very low (300-400 kg/ha). Research has developed some technologies of integrated soil fertility management but resource poor farmers have not adopted them. DSSAT (Decision Support System for Agrotechnology Transfer) is a tool incorporating models of 16 different crops with a software that facilitates the evaluation and application of crop models for different purposes. But its use requires a minimum data set on weather, soil, crop management and experimental data. The simulations from these data can help scientists to develop considerable amount of promising results under farmer's conditions. This study shows the interactions between soil fertility and millet yields in 3 sites (Banizoumbou, Bengou et Karabedji) of Niger over 5 years (2001-2005) and nitrogen simulation in DSSAT.

Key words : soil fertility, simulation, yield, nitrogen, sites.

2007:

Title	: Du sac d'engrais à la ration : Adoption technologique et malnutrition infantile au Niger
Name	: Benedicte Pauly
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

En République du Niger, plus de 80 % de la population vit essentiellement de l'agriculture. Cependant, les sols nigériens sont généralement d'une composition peu favorable à l'exploitation agricole et subissent actuellement une forte chute de fertilité. De plus, les fluctuations interannuelles de la pluviométrie limitent régulièrement la production. Par conséquent, la sécurité alimentaire est loin d'être assurée. Des enquêtes menées en 2005 et 2007 sur trois sites différents ont ainsi tenté d'évaluer les stratégies de fertilisation menées par les agriculteurs. Elles indiquent une très faible utilisation des méthodes de parage, une stratégie majoritaire d'application de fumier organique ainsi qu'un intérêt moyen pour les engrais inorganiques. Les différences entre sites en terme de stratégie sont marquées et semblent dépendre particulièrement du stade d'intensification agricole, de l'accès aux marchés et aux informations. Les engrais minéraux pourraient constituer une solution parmi les moins coûteuses à l'augmentation des rendements, au maintien de la fertilité des sols et à la diminution de l'impact des sécheresses. Mais les engrais minéraux permettraient-ils réellement d'améliorer la nutrition infantile ? Cette question nécessite d'être abordée en deux étapes afin de contourner tout risque de biais d'endogénéité. L'adoption des engrais minéraux (75 observations) a donc tout d'abord été considérée à part. Cela s'est fait, premièrement sur une variable binaire d'adoption dans une régression probit ; ensuite, sur deux variables continues de quantités d'engrais évaluées en équivalents-azote et en équivalentsphosphore. La régression probit indique la contribution positive à l'adoption des engrais par les champs-école, la proximité de la boutique d'intrants si un système de crédit est disponible, l'exode et l'instruction. La

contrainte en crédit est quant à elle fortement négative. L'appartenance à une organisation paysanne en interaction avec la non-participation aux champs école permettrait d'identifier les personnes les moins intéressées par les engrais minéraux. Le supplément d'information apporté par la régression bitobit réside essentiellement dans le fait que les engrais azotés seraient favorisés par des variables de revenus tandis que les engrais phosphorés dépendraient davantage de variables d'informations et d'incitants. Ces effets sont attribués à la meilleure connaissance des engrais azotés par les agriculteurs, à la diminution des risques d'investissement induite par l'urée et au caractère nouveau des recommandations concernant le phosphore. La régression concernant la malnutrition infantile a été établie en utilisant comme variable dépendante continue les périmètres brachiaux d'enfants (6 mois à 5 ans, 106 observations) contrôlée par l'âge de l'enfant. Sont positives pour la nutrition de l'enfant : la taille du troupeau bovin et des variables de revenus telles que certaines activités du chef de ménage ou la vente de culture d'entre saison. Par contre, la contrainte en crédit, une mauvaise récolte précédente et le fait de ne cultiver ni niébé ni arachide ont une influence négative sur la malnutrition. La taille de ménage et l'âge moyen des mères du ménage sont également des facteurs d'importance. L'influence globale des engrais sur la nutrition infantile -évaluée par l'introduction des estimations des régressions probit et bitobit dans la régression de malnutrition- est quant à elle apparue négative. Le détail par éléments indique que ce serait les engrais phosphorés qui seraient responsables de cet impact négatif alors que les engrais azotés seraient, eux, positifs pour combattre la malnutrition infantile. Les choix actuels du type d'engrais et des pratiques d'application par les agriculteurs pourraient en effet induire une balance économique négative se répercutant sur la nutrition de l'enfant. La non-participation aux champs école serait actuellement négative pour l'alimentation des enfants en ce qui concerne le phosphore mais positive en ce qui concerne l'azote. Les champs école pourraient venir perturber les techniques traditionnelles adéquates pour les engrais azotés, dans la mesure où les agriculteurs appliqueraient les techniques apprises avec d'autres engrais que ceux utilisés lors de la formation. Enfin, il se peut que les qualités des grains et peut-être de la ration soient affectées suite à l'utilisation d'une fertilisation phosphorée. Cela pourrait induire une déficience en micro-nutriments négative pour la nutrition. Des études complémentaires avec davantage d'observations sont nécessaires afin de répondre plus précisément au lien entre engrais minéraux et malnutrition infantile.

2007:

Title	: Influence de la dispersion du parcellaire sur la gestion du risque climatique au Fakara, Niger
Name	: Julien Minet
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

Les systèmes agro-écologiques sahéliens se caractérisent par un important risque climatique, dû à la forte variabilité spatio-temporelle de la pluviométrie. Cette variabilité figure parmi les facteurs les plus limitants de l'agriculture sahélienne (Graef et Haigis, 2001).

A l'échelle du village, la dispersion des parcelles d'un ménage permettrait de gérer et de diminuer le risque climatique. L'objectif de ce travail est de vérifier l'influence de la dispersion du parcellaire villageois sur la distribution des rendements entre les ménages. L'hypothèse principale est que l'état dispersé des parcelles d'un ménage induirait des rendements moyens plus élevés et plus stables sur de nombreuses années. La région du Fakara, et plus particulièrement les terroirs de Banizoumbou et Kodey, ont été étudiés. Le travail de terrain au Fakara a montré que les paysans ont des pratiques de gestion spatiale du risque climatique. Ainsi, la dispersion de la jachère et le sarclage sélectif mènent à diminuer le risque d'un échec de culture, dans un système encore extensif. Méthodologiquement, il a fallu caractériser le régime pluviométrique à l'échelle d'un terroir. Une combinaison de réseaux très fins spatialement et de données journalières complètes sur 6 ans a pu mener à la simulation de la pluie à une résolution hectométrique sur un pas de temps journalier. Un modèle de croissance du mil, culture dominante au Fakara, a été spatialisé à partir des données pluviométriques simulées. Ce modèle, basé sur le logiciel APSIM, a permis également d'introduire d'autres facteurs tels que la fertilité en fonction de la distance au village (auréoles de fertilité) et certaines pratiques de gestion de la culture comme le sarclage. Les résultats spatiaux des simulations reproduisent assez bien la variabilité des rendements que l'on peut observer à l'échelle du terroir. Cette variabilité a une structure spatiale complexe, fruit de la répartition spatiale et temporelle de la pluviométrie. L'analyse du risque par rapport à la dispersion des parcelles montre que l'état dispersé des champs permettrait de stabiliser modérément les récoltes au cours des années, et également d'augmenter sensiblement les rendements moyens. La présence de champs dans la première auréole de fertilité a un impact certain qui pourrait surpasser celui de la répartition des pluies et devenir ainsi le principal facteur de décision spatiale. Enfin, d'un point de vue méthodologique, la spatialisation du modèle de croissance se révèle être un outil didactique et de recherche intéressant. Le couplage de l'information géographique au modèle gagnerait toutefois à être plus intégré.

2007:

Title	: Amélioration du suivi régional des cultures au Sahel par une meilleure estimation de la couverture végétale du mil à différentes échelles d'observations par télédétection spatiale
Name	: Catherine Lienard
University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: MSc

Abstract:

En perspective d'une amélioration des suivis agricoles au Sahel et en préalable à la détermination de la capacité de suivi à moyenne et basse résolution, notre objectif est d'étudier la détectabilité des différences de couverture végétale agricole à des niveaux d'échelles croissants et pour plusieurs types d'échantillonnages. La zone d'étude se situe au Niger et compte deux sites distincts. Le premier se situe à Sadoré dans un centre de recherche de l'ICRISAT et donc dans un milieu favorisé et sous contrôle. Le deuxième se situe au Fakara, région caractéristique du milieu paysan. Nous commençons par l'étude de photos prises au sol puis de photos aériennes et d'images satellite. Concernant les deux premiers types de photos, nous déterminons les pourcentages moyens de recouvrement du mil ainsi que les écarts-types

de ceux-ci. Au départ des images satellite, nous calculerons trois indice de végétation : le NDVI, le NDWI et le SAVI. L'analyse des photos prises au sol nous permet de déterminer l'hétérogénéité de croissance du mil dans les vingt deux champs suivis. Nous passons ensuite de l'échelle du transect à celle de la parcelle grâce, dans un premier temps, à l'analyse de photos aériennes PIXY et dans un deuxième temps à celle d'images SPOT. Notre objectif est de déterminer s'il existe ou non une corrélation entre les variations des pourcentages de recouvrement du mil en passant d'une échelle à l'autre. La meilleure corrélation est obtenue lors du passage des photos au sol aux photos PIXY. Par contre, les résultats obtenus grâce aux mesures de réflectances dans le rouge, le proche et le moyen infrarouge sont plus mitigés et illustrent la nécessité de choisir un indice de végétation adapté à la zone d'étude. Dans notre cas, la meilleure corrélation est observée entre le pourcentage de recouvrement du mil et le SAVI. En effet, celui-ci prend en compte les effets du sol qui sont importants au Niger. Afin d'améliorer le suivi agricole dans les pays du Sahel, le mieux serait donc, au vu des résultats, d'utiliser les photos aériennes sur l'ensemble des zones que nous désirons suivre. Cependant, cette méthode est coûteuse et nécessite un grand investissement sur terrain. L'utilisation des images satellite, bien que moins précise dans notre cas, semble donc être une meilleure opportunité. De plus, l'utilisation d'autres indices de végétation, plus adaptés aux pays du Sahel, pourraient donné de meilleures corrélations (TSAVI,...).

2008:

Title	: Millet response to water and soil fertility management in the Sahelian Niger: Experiments and modeling
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University	: Université catholique de Louvain, Louvain-la-Neuve, Belgium
Degree	: PhD

Abstract:

In the 400-600 mm annual rainfall zone of the Sahel, soil fertility is the main determinant of yield in rainfed millet cropping systems in all but the driest years. Numerous on-farm and on-station experiments have addressed the issue of improving soil fertility. Yet the widespread use of the experimental results is restricted by the highly sitespecific millet response to fertility management practices due to high spatially variable soil properties as well as high intra- and inter-annual rainfall variability. Mathematical soil-crop growth simulation models could therefore suitably complement experimental research to support decision making regarding soil fertility under variable rainwater supply conditions. The objective of this thesis was therefore to develop the biophysical basis for the use of crop-soil models in decision support regarding water and soil fertility management and risk mitigation strategies in rainfed millet-based systems of Sahelian Niger. Because farmers rely on multiple cultivars with variable length of growing cycle due to sensitivity to temperature and photoperiod as part of their risk management strategies we first characterized seven Sahelian millet genotypes and parameterized the Agricultural Production Systems Simulator (APSIM-millet model). The cultivars include three improved cultivars (CIVT, ICMV-IS-89305, ZATIB) and four landraces (Ankoutés, Hainikirey, Maewa and Zongo). Our research showed that only one of the cultivars, Maewa, was very photosensitive contrary to the six others. The majority of the agronomic state variables (leaf number, leaf area, biomass and

grain yield) were negatively affected by late sowing (associated with lower air temperatures). This characterization enabled to compute for the first time in the Sahel the principal eco-physiological or genetic millet parameters (thermal times of development phases, leaf area dynamics) of crop growth models (e.g. APSIM, DSSAT). To gain confidence in the use of the APSIM model for decision support in the Sahelian environment, it was successfully tested to reproduce the agronomic state variables under non-limiting water and nutrient supply conditions. Moreover the APSIM model satisfactorily reproduced the millet CIVT cultivar response to water x N interaction from the combined application of crop residue, cattle manure and mineral fertilizer during two years and for contrasted rainfall conditions. Using the model with site and cultivar specific parameterization, we implemented two applications for decision support. A 23-year, long term factorial numerical experiment showed that a moderate N application of 15 kg N ha⁻¹ is more appropriate for smallholder, subsistence farmers than the usual 30 kg N ha⁻¹ recommendation. Although it implies a lower long term average yield than at 30 kg N ha⁻¹, the application of 15 kg N ha⁻¹ guarantees both a higher minimum yield in extreme dry years and a lower inter-annual variability, thereby increasing food security and reducing farmers vulnerability. In the second model application, we integrated GIS information (land tenure, spatially distributed weather data, fertility management) and the APSIM model in a 12-year yield simulation to show that the spatial dispersion of fields of a household throughout the village territory (farmer risk management strategy) leads to more uniform yields across households and reduces the inter-annual yield variability in the Fakara region of Niger. Our research breaks the ground for several other applications of the use of crop-soil simulation models in millet-based systems in the Sahel, e.g. climate change impact and food crisis mitigation.