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HIGHLIGHTS OF RESEARCH RESULTS OF VARIOUS PROGRAMS FOR 1975 - 76

AND

LIST OF RESEARCH PROJECTS

APRIL 1976

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
HYDERABAD

INTRODUCTION

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was set up in July 1972 with the following four objectives :

i. To serve as a world center to improve the genetic potential for grain yield and nutritional quality of sorghum, pearl millet, pigeonpea and chickpea. Groundnuts will be added as a fifth crop next year.

ii. To develop farming systems which will help to increase and stabilize agricultural production through better use of natural and human resources in the seasonally dry semi-arid tropics.

iii. To identify socio-economic and other constraints to agricultural development in the semi-arid tropics and to evaluate alternative means of alleviating them through technological and institutional changes.

iv. To assist national and regional research programs through cooperation and support and contributing further by sponsoring conferences, operating international training programs and assisting extension activities.

The research activities of ICRISAT can be conveniently grouped into Crop Improvement Researches, which are seed centred researches, Farming Systems Researches, which are resource centred researches and Economic Researches which deal with socio-economic and other constraints to agricultural development in the SAT. The Economic researches are also related to farming systems and crop production technology.

Though ICRISAT was set up in July 1972 it started its major research activity from kharif 1973. In 1972 only a beginning was made with some preliminary agronomic experiments related to farming systems. In 1973 the watershed management research and cereal improvement research was initiated as soon as the senior staff members in those programs joined. Towards the end of 1973, the research work on chickpeas was also started as the Associate Scientist-Chickpea joined. In the the year 1974, the research activity got an impetus as more scientists joined. During 1974-75 the research programs started taking shape as the scientific teams for inter-disciplinary work were developing rapidly. It was considered an opportunate hour to introduce the concept of projects and clearly define the objectives, approaches and mechanism for operation of the research activity and identify the research workers responsible for every research project.

The whole research effort was divided into Programs - Sub-Programs - Projects and Sub-Projects. The major programs are Sorghum, Pearl Millet, Pigeonpea, Chickpea and Groundnut (not yet formalized), Farming Systems and Economics. The sub-programs of the various crop improvement programs are Germplasm, Breeding, Genetics, Physiology, Pathology, Entomology, Microbiology, Agronomy, Biochemistry and Quality. In the Farming Systems the sub-programs are Climatology, Agronomy, Soil Chemistry, Soil Physics, Land & Water,Hydrology and Agricultural Machinery. The Economics Program is sub-divided into Production Economics and Marketing.

In March 1975, an In-House Review was held wherein all the research scientists participated and critically reviewed the proposed projects. This resulted in modification and sharp definition of the objectives of the projects and establishing interdisciplinary team work. The second In-house Review was organised in March 1976 and in the first week of April. It aimed at critical evaluation of the results achieved, review of the objectives and techniques in the light of one year's experience and to suggest necessary modifications.

This document gives the highlights of the results achieved in various programs and summary of the projects, titles, their objectives and names of the scientists responsible for implementing them together with the time schedule. It gives a bird-eye-view of the research activity of the institute and provides a useful reference material.

New projects on Microbiology and Groundnut will also be added shortly.As more scientists join, new projects will be added. Further changes in research activities will be made as a result of recommendations of the Governing Board and the Program Advisory Committee of the Board.

Thus the research activity of ICRISAT is highly dynamic and responsive to the needs and suggestions from competent bodies. It represents continued effort by the scientific faculty of ICRISAT to achieve the goals and to serve the people in the semi-arid tropics of the world.

CEREALS IMPROVEMENT
(SORGHUM)

Highlights of 1975-76 results

SORGHUM BREEDING

Two trials were sent to 14 locations each, and a third, of tropical material, to 9 locations within 10^{o} of the equator. Material showing up well in our trials included Kafinam x Simila, K x SB 65, K x Lulu dwarf, Dobbs, and some 5DX, 9DX and 2KX lines from the Serere (East Africa) programme: and CSV 1, 4, 5, SPV 9, 13, 35, CSH 1, 6 and SPH 6, 10, 24 from the All India programme. Pioneer hybrid 22E did well in Senegal.

Populations made good progress, and several lines derived from the Fast Lane populations out-yielded the local checks at both low and high fertility levels. S_1 testing was done on 1946 lines in all populations.

The grain-grass sorghum crosses segregated a wide range of very promising material some with good grain type, synchronous tillers, and grass like plant form. Others showed the non-senescent character and should therefore ratoon well.

The technique for screening for Striga resistance (low production of stimulant) at the seedling stage has been adopted, and screening of sorghum varieties is being started. Anatomical studies were made of types showing mechanical resistance.

The entomologist has supplied 89 shoot-fly resistant lines, 83 midge resistant lines, and 40 stem borer resistant lines. Some of these have reasonably good agronomic characters and were crossed to a range of parents, both for pedigree breeding and to develop population.

In the earliness and grain mould resistance project, 30 early germplasm lines were crossed to 28 lines having some mould resistance and to 26 high yielding lines from disease sources. 1721 single crosses and 341 double crosses were made. Three IS lines identified by the pathologists as probably resistant (unconfirmed) were crossed to many early and adapted parents and also to male-sterile sources and to 6 advanced populations. 286 single crosses, 26 double crosses, were made with 35 large glume types.

A new population for evident grain qualit was begun, using a wide range of segregates from our own material. Selection in the high lysine segregates from crosses with the Ethiopian hl gene showed promise. We believe we have obtained some 50 lines with plump seeds, high lysine, and acceptable agronomic characters.

Selection and intercrossing in the tetraploid material is resulting in yield improvement and much better grain quality. Successful crosses were made with S. halepense.

A departmental newsletter was issued for cereal workers

in the SAT, in order to improve our contacts, and co-operation.

GERMPLASM

11,114 sorghum lines were maintained and evaluated for important morphological characters. Some ten percent of the entries did not match their published descriptions. The germplasm collection was therefore obtained from Purdue, and grown in parallel with the collection here. This will enable some entries to be corrected, and will also supply some of those missing. We expect the number to be about 12,000 by the end of the 1976 season. Some 5,000 remain to be obtained from Puerto Rico or Fort Collins.

Some data on 300 lines were processed in Colorado, and data sheets for 10,050 classified lines are being prepared for documentation in the TAXIR system by Colorado Taximetric Laboratory.

9,777 seed samples were distributed to breeders and scientists in ICRISAT, in India, and overseas.

A collection of rabi sorghums was made in the Khammam, Kurnool, Nellore, and Prakasham districts of Andhra Pradesh.

PLANT PATHOLOGY

Fifteen organisms were isolated from mouldy sorghum grains and identified at species level. Moulds seriously reduced germination percentage, and this effect could not be diminished by using seed

dressings. Curvularia and Fusarium appeared to be the most damaging of the pathogens. A technique for inoculating sorghum heads was developed: the pathogens were multiplied on autoclaved sorghum grain, and after 7 days the cultures were suspended in water. The resultant inoculum was sprayed on sorghum heads 4-7 days after emergence from the boot. Four thousand germplasm lines with white or yellow grains were screened using this technique. Three were classed as very resistant, 99 as resistant. (Scores 1 and 3 on a 1-3-5-7-9 scale).

We have not yet succeeded in obtaining consistent high levels of sorghum downy mildew disease at Patancheru.

34 entries showing reduced susceptibility to leaf blight were identified.

Macrophomina phascoli and a Fusarium sp. were isolated from sorghum stalk rots.

PLANT PHYSIOLOGY

The range of variability available in the germplasm for important physiological characters was investigated. In growth stage 1 (GS1), mean leaf number varied from 8.3 to 10.2, and rate of leaf production from 3.0 to 4.6 days per leaf.

Duration of GS2 varied from 31 to 64 days, leaves produced from 2.2 to 10.8, and rate of leaf production from 4.6 to 14.3 days per leaf. The position of the largest leaf from the top varied from

2.0 to 5.8, and the node bearing the largest leaf was, on average, 2.6 nodes above the node which had a fully expanded leaf at the time of floral initiation. GS3 varied from 31 to 56 days, and grain filling rate from 24.0 to 54.6 g per 1,000 seeds. Seed number per head varied from 469 to 2,161, and seed size from 24.0 to 54.6 g per 1,000 seeds.

Nitrogen

Total nitrogen uptake per plant varied from 0.22 g to 1.14 g. NTE varied from 57.8% to 86.6%, and was strongly positively correlated with harvest index. Grain yield was strongly positively correlated with total plant nitrogen (r=51 ***), grain nitrogen content (r=58 ***) and nitrogen transfer efficiency (NTE) (r=0.33 *).

Large differences were found in root development, using brick chambers. In the comparison of the hybrids 22E and CSH-1, adventitious roots produced per plant upto 60 days were 37 and 27, but at 75 days were 41 and 72. Total length of main adventitious roots at 60 days were 794 and 545, but at 75 days were 1420 and 1934. Root/shoot ratio at all stages was greater in 22E.

Large differences were obtained in seedling vigour, and these appear to be heritable. Drought endurance trials using 73 genotypes are in progress.

SORGHUM ENTOMOLOGY

Most of the work in cereals entomology was focussed on pests of sorghum, as for a further year pest levels at Patancheru on millet were low.

Seventy five insects were identified as attacking the sorghum crop. Most of the identities of these have been checked with taxonomists and a working reference collection built up. The most important source of crop loss locally is Atherigona soccata, sorghum shoot-fly.

Detailed studies on this species were carried out. It was confirmed that some cultivars are non preferred for oviposition, that delay of sowing resulted in increased egg laying, and that usually one or two eggs were laid per plant. Experimentation showed that oviposition was heavier at higher plant densities, i.e. more eggs were laid per unit area. Percentage plants bearing eggs was highest at 20 cm between plant spacing within the row. These facts are of assistance in our screening programme. Studies of carry of shoot-fly indicated that 13 different grasses carried shoot-fly. Some 700 flies have been reared from alternative hosts, and most of them were A. soccata. The main grass species from which flies were collected was Digitaria ascendens.

Considerable progress was made on screening of sorghum germplasm shoot-fly resistance. Stark's technique was used and found satisfactory. Work on the attractant effect of fishmeal was initiated and valuable

information continues to be obtained. Attractant techniques will enable us to monitor fly populations throughout the dry season. Tolerance to shoot-fly was confirmed in several lines including IS 1054, 2269, 2312, 4664, 5604, 95656. Some crosses with West African selections were also tolerant. Breeders material was rated for shoot-fly levels.

Another important pest is Chilo. Work on the carryover of this pest as a torpid larva continued. It was observed that many larvae (11%) collected from stubble and cut stalks after harvesting of the head did not pupate in the period December/June. A high proportion of the larvae reared in the laboratory were parasitised (21-29%). Tachnids were the main parasites recorded.

Collaborative work with TPI on use of phermone for the trapping Chilo gave interesting preliminary results and is being continued Little success was achieved in a study of viruses in Chilo conducted on conjunction with BTI.

Preliminary proposals for collaborative work with ICIPE, COPR, CIBC and local institutions have been formulated.

Information is being gathered on the sorghum and millet pest complexes in areas of cooperation, particularly in Africa.

SORGHUM MICROBIOLOGY

Large differences (ten fold) in nitrogen fixation associated with different sorghum varieties were observed. CSH-1 S. almum, and

S. verticilliflorium were among the most active of the lines so far examined.

SORGHUM BIOCHEMISTRY

The technology for rapid screening of small quantities of sorghum grains for protein and lysine content has been perfected. We use a "technicon" auto analyser for protein and UDY for lysine (Total basic amino-acids). Over 4,100 samples were screened, and the high lysine entries identified.

HD:nr
April 14, 1976

CEREALS IMPROVEMENT
PEARL MILLET

Highlights of 1975 results

Since the last In-House Review there has been a considerable expansion in activity in the pearl millet improvement program and a consequent return in terms of information and genetic advance. This activity and results to date were presented in brief in the project reports* at the In-House Review on March 30, 1976. A few salient points are indicated below:

Pathology: Dr. R.J. Williams joined during the year and begun a vigorous attack on pearl millet diseases. An additional research associate was appointed who will work on the floral diseases - ergot and smut. A problem requiring early resolution since it affects seed movement is whether downy mildew can be internally seed transmitted. Very critical studies at ICRISAT have been unable to produce downy mildew in seedlings from properly surface sterlized seed. Joint tests are now in progress with Indian scientists to resolve the problem.

Experiments to develop reliable field screening methods for downy mildew have come up with what looks to be a successful solution based on infector rows planted 3 weeks beforehand. This will permit breeding material to be screened in large amounts in ordinary fields prior to multilocation

testing and so we will no longer be subject to the confines of a sick plot. A field technique is also being developed to give uniform smut infection, but more basic studies will be necessary before the same can be realised for ergot.

The Physiologists have now acquired reference data on the genetic variability in growth attributes in 50 genotypes; have determined types of drought reaction and made detailed panicle and root development studies on two contrasting genotypes. Physiologists and breeders have together selected 82 breeding lines for crossing which complement each other for yield attributes. The potential of upper nodal tillers which ripen simultaneously in contributing to yield in favourable or post-stress conditions will be further investigated. Information gained in Summer 1975 has enabled 1700 breeding lines to be currently put to test under drought stress on red soil (where severe stress can be quickly induced).

The germplasm was utilized early in the program in variety crosses and in the formation of composites. The IP collection upto No. 2117 was found to be incomplete and to contain some impurities. However what was there has been regrown and seed renewed. From this and newer introductions a Working Collection of 340 entries from mostly Africa + India has been assembled. This is being catalogued in different environments and will represent a good range of source material for breeders. Breeding staff participated in a germplasm collection expedition in West Africa. A research associate for millet germplasm will soon be appointed.

On the nutrition side a further 1380 grain samples were analysed for protein content and some for lysine (UDY value). Effectiveness of selection for these traits depends in part on their environmental stability where we are evaluating the considerable variation apparent. However three groups of material have been identified where the range of protein content between individual lines is large, these being the Working Collection (6.0 - 14.50%) the Senegal Dwarf Synthetic (8.1 - 15.2%) and the 'World' Composite (7.5 - 15.0%). The progeny of last the population have shown good visual grain and head characteristics, and have also given good yield and disease performances in 1975 tests.

There are fortunately less entomology problems current in pearl millet. Marsalia, an ear head larva is serious in some years and some parts of West Africa and it is clear that the ICRISAT entomologist there will have to work on this pest. Shoot-fly and midge have caused localised damage. Essentially entomology activities at present are those of surveillance to detect any ntoward change in the millet pest picture

Agronomy and Farming Systems: Existing Indian hybrids and synthetics have been tested in rotation and intercrop patterns. The potentialities of intercropping early maturing pearl millet with slow establishing medium and late duration pigeon peas (180 days) appear to be excellent. The combined rupee value of cropping these in alternate rows ranged from 40 to 83% more than the "shared" crop system where each species was planted to half of the area as a pure crop. However, the Indian hybrids

used had limitations (at Hyderabad) in terms of ergot susceptibility and poor resistance to head moulds which created harvest difficulties. Suitable types have now been identified from the 1975 tests on ICRISAT material to enable observations on the intercropping potential of different millet genotypes to commence in 1976.

Breeding: Drs.S.O. Okiror and B.W. Hare joined the breeding team prior to going to West African locations. Results of the International Observation Nursery so far to hand (10 out of a possible 16 sites) indicate that in India several ICRISAT experimental hybrids, PHB-14 from AICMIP, and two populations have given comparable yields at 4 locations, where they were equal or better than the local check. Only at Bambey in Africa did hybrids give better yields than the local populations.

During 1975 the breeders put much effort into conducting extensive breeding nurseries at two contrasting centres apart from Hyderabad. These were at Hissar (29°N) and Coimbatore (11°N) in co-operation with Agricultural Universities. A limited range of breeding material was sent to the ICRISAT breeder at Saria in Upper Volta. The reason for this activity was to comprehensively select in much of the material generated earlier in the program for wider adaptation, and for field resistance to diseases not found at ICRISAT. A large part of the material was population progeny, totalling (including replications) some 19,600 plots. As expected, downy mildew incidence was good at both Hissar and Coimbatore, very high at Saria but low at Hyderabad where both low and high fertility conditions were used.

Smut was moderate at Hissar and severe at Saria; rust was absent at all sites except Coimbatore where it was severe, and leaf blast was moderate at Saria. Head moulds were moderate at Hyderabad where ergot was severe on late planted hybrids. Therefore in addition to genotype reaction to environmental differences between locations such as day length, day and night temperatures, moisture and soil differences, it was possible also to integrate selection for field reaction to a number of diseases. The outcome of these activities in terms of the more advanced material has been the assembly of the following groups which we think have good promise. These are available for distribution and will be multi-locationally tested in 1976:

50 inbred lines of diverse parentage

12 pollen parents which have given the best hybrids

3 new A/B line pairs (seed parents)

3 hybrid combinations (one an inbred x population cross)

1 Synthetic

8 groups of 'experimental varieties' generated from the composite progeny tests

1 Working Collection catalog of 340 entries (data being processed)

* Project reports containing results summaries presented at the Millet In-House Review, March 30, 1976

i) PM-12 Pearl Millet Breeding and Nutrition Project Reports 1974-75

ii) Cereal Improvement Programs - Pathology, Revised Research Projects

iii) Sorghum and Millet Physiology Project Report 1974-75.

iv) Project No. M-ENT-1 Pearl Millet Entomology

v) Agronomy Program with pearl millet

New Projects proposed:

M-brd-9 Comparison of Population breeding methods

M-micro-1 Nitrogen Fixation associated with Millet

DJA:nr
April 9,76

Germplasm accessions in excess of 4,400 were classified for days to flowering, flower color, pod color, seed color, seed size, plant height, plant width, days to maturity, and yield per row in plantings consisting of single rows of germplasm collection with frequent repetition of a check variety. Screening has revealed some lines resistant to sterility mosaic virus. Screening for wilt resistance and insect reaction has been initiated. The breeding section has initiated evaluation of germplasm groups, selected germplasm lines, and has in process a top crossing test which will further evaluate the genetic diversity in the germplasm collection. New collections were made in U.P., Karnataka, Orissa, and Bihar. Two Atylosia spp. from S. India were added to the collection.

Pigeonpea is a photosensitive crop and reacts differently at different latitudes. Monthly plantings have illustrated that at Hyderabad early and medium maturity types will mature before June if they are planted in November or December. Planting in February gives a typical photoperiodic response with the later maturing varieties, which when planted in February/March or April, will not flower until September. Preliminary studies on the inheritance of photoperiod indicate a single major gene effect, although it has not been determined if this is actually inheritance of photoperiod response or the inheritance of maturity differences.

Growth studies have shown that there is a very large proportion of the biological growth going into stems. The initial growth phase has the highest relative growth rate while the grand period of growth has a lower relative growth rate because of the large base. Observations on waterlogging and reaction to high soil pH indicate distinct

genetic differences within the germplasm material. Highly specific iron toxicity symptoms have been found in a very few cultivars when grown on high pH.

Flower and pod drop is high in pigeonpeas in general. Observations indicate that the source is adequate and the plants could support a larger number of pods than actually produced. Defoliation experiments indicated that 50% defoliation at the time of flowering slightly decreases seed yield, while 100% defoliation reduces yield about 80%. On the other hand, calculations indicate that all of the flowes produced could not possibly mature seed, because the seed yield in that case would be greater than the total biological production. Flower drop is also related to insect damage and studies on black and red soils have shown a differential response on the two soils. Insect damage was generally higher on the black soils and the dropped pods showed a higher percentage of insect damage.

Outcrossing in pigeonpea has lead to a study of the pollen vectors. Bee experts from Rothamsted made observations at ICRISAT during the past season, and the results of their studies are to be published. Selfing studies have indicated that muslin cloth permits enough light penetration for pod setting, and a general practice of selfing individual branches has been adopted in order that the rest of plant can develop under a natural environment. Studies simulating insect activities on flowers have indicated that a higher percentage pod set is obtained when the flowers are manipulated than when they are permitted to develop without disturbances.

Male sterility was found in the germplasm material, and reduced pod set was found to be due to several causes. One empty-anther type is of most interest and is being transferred to other genotypes. Meanwhile an investigation of the heterostyles is in progress. There was some indication that incompatability might be a factor in low pod set in some lines but no investigation of this has been initiated. Effective distance of insect cross pollination is being studied in blocks separated by varying distances where the central block has a dominant genetic marker.

Response of different plant types to spacing is being investigated in fan plantings. Spreading plant type compensates for additional space provided, while an extreme non-spreading type with limited branching, HY-3C, does not compensate for additional space and could be planted at a higher plant population. Investigation of pigeonpeas as a rabi crop is in progress, and indications are that a late maturing variety is more satisfactory for November planting.

Observations on the growth response of pigeonpeas grown on a medium black soil the second year has lead to the conclusion that there may be some toxic effect of the crop. This is being investigated further.

Intercropping with pigeonpeas as the base crop and different cereals and legumes as the intercrop indicate that full yields of pigeonpeas can be obtained when grown with mung beans or setaria millet. With sorghum as an intercrop the yield of pigeonpeas is reduced to some extent. Different pigeonpea plant types were tested in combination with sorghum and the results of this experiment are being summarized. Observations of insect damage in intercrops indicates that there is a definite

vations of insect damage in intercrops indicates that there is a definite influence of the intercrop, although conclusive data are yet to be obtained. With a soybean intercrop the incidence of fusarial wilt in pigeonpeas was considerably higher.

Disease surveys in Andhra Pradesh and Maharashtra have shown that wilt is the most important disease, and that there are regional differences in the severity of attack. Incidence of sterility mosaic virus was generally low but districts differed in the percentage damage. An efficient and simple "leaf-stapling technique" has been developed to screen for resistance to sterility mosaic. Over 2,300 accessions were screened using this technique and 6 immune lines have been identified. Laboratory screening techniques for wilt are being developed and it has been found possible to induce wilt in young seedlings. In addition the wilt sick plot is being developed for confirmation of laboratory results in the field. Wilt incidence has been increased by defoliation of plants at flowering stage.

Insect surveys were made in conjunction with the disease surveys. Total damage to pods varied from 17.6 to 61.3% in different districts. The main pod borer was Heliothis armigera. More pod damage was found in determinate cultivars.

In a limited number of cultivars studied, yield components were found to compensate, for example, large seeded HY-3C with a much lower pod number and much larger seed size produced yields comparable to ICRISAT-1. Breeding progress to date has resulted primarily in the

development of bulk populations, pedigree selected material, and some backcross and triple and double-cross material. Within the past year 46 F_2's, 230 F_1's, 375 F_3 lines were furnished to a total of 18 breeders in India, and 8 F_2's and 1 F_1 were furnished to four breeders outside of India. Selections were made in approximately 32 F_2's during the past season and evaluations of 378 cultivar F_1's and 45 group F_1's were completed. New crosses consisted of 429 top crosses for further evaluation of parent material.

The need for study of storage factors was emphasized. Preliminary data with vegetable oil treatment of seed indicates that this old method does have an effect on Bruchids. Factors influencing price in the market are being investigated. Within a limited number of markets seed color and seed size were found to be factors that influence price.

Investigations of quality have indicated a range of 13 to 28% protein in the germplasm, and limited investigations on methionine and cystine indicate that there are significant cultivar differences for these two amino acids. There is a negative correlation between protein content and methionine and cystine, but methionine and cystine contents are not correlated with each other. Some high protein lines have been found in the intergeneric material.

Laboratory investigations are going forward on the non-protein nitrogen content of pigeonpeas, measurements of methionine and cystine, carbohydrate measurements, and determination of protein fractions.

Microbiological investigations, recently begun, will include the examination of the populations of Rhizobium nodulating pigeonpea in different soils and under different cropping sequences as an aid to predicting where seed inoculation will be of benefit. A world collection of Rhizobium strains isolating pigeonpea will be held at ICRISAT. Strains, and cultivars x strain interactions in nodulation and nitrogen fixation will be tested. Development of Rhizobium inoculants and training in techniques of production will be undertaken.

CHICKPEA IMPROVEMENT PROGRAMME

Highlights of 1975-76 Chickpea season:

'In the 1975 Programme Review Committee the Committee were requested to consider the establishment of a second site for chickpea improvement in Northern India to cater for the main chickpea belt of the Indian sub-continent where chickpeas mature from 160-170 days, in comparison to Hyderabads approx. 110 day maturity period. The Committee agreed to this and a cooperative chickpea programme was established at the Haryana Agricultural University, Hissar. Most of the disciplines working on chickpea improvement took advantage of this extra location and while harvesting of this years crop is only just beginning it already appears that the establishment of this site was justified. For instance most F4 lines rated as good in Hyderabad appear to be poor in Hissar and vice versa, though it is possible that we may detect cultivars adapted to both environments. The growth of the crop is particularly lush at Hissar and the results from the physiologists population x genotype studies may be different from those obtained in Hyderabad.

Probably the most important advances of the year were made in the pathology section, with the identification of the pathogens of the Wilt Complex and the development of techniques for screening. The development of a laboratory technique for screening Ascochyta blight is a major advance, for the disease does not occur in the field at Hyderabad. The breeding section this year tested F4 progeny lines

from the first crosses made in 1973 and some lines were producing up to 42% more yield than the standard southern cultivar JG 62, but replicated trials are called for in 1976-77 to verify these apparent advances. It nevertheless appears that we are at a stage where we can start a worthwhile inter-disciplinary breeding pathology project for the ddvelopment of high yielding, disease resistant cultivars.

Germplasm:

The collection of the cultivated Cicer arietinum now consists of 10381 lines and serves as a constant source of variability for the breeding programme. 2724 exotic lines were grown at Hissar with Indian checks. Sample data on 300 lines were processed in Colorado as a start to the future issue of a germplasm catalogue.

Thirteen of the Wild Cicer species have now been collected and attempts at interspecific crossing are being made. This work could be of particular value for the breeding programme as recent Israeli work suggests that Cicer reticulatum is the progenitor of the cultivated Cicer arietinum and that crosses between C. reticulatum a and desi cultivars of C. arietinum are fertile. C. reticulatum could be a source of disease or pest resistance and possibly yield increase.

Pathology:

Extensive studies of chickpea wilting (drying) have been carried out at ICRISAT sites and throughout India. Three diseases seem

to predominate. These are chickpea stunt (now re-named phloem necrosis), probably caused by a virus, wilt caused by Fusarium oxysporum f. sp. ciceri, and root rot caused by Rhizoctonia bataticola. Sufficient knowledge has been obtained to diagnose stunt, wilt and root rot and it is intended to publish a broohure with coloured pictures of the different diseases. A laboratory technique(" water culture") for screening germplasm against Fusarium oxysporum and F. solani have been standardized and current work using Isolation Plant Propagator is almost perfected for screening Ascochyta rabiei.

Two "sick plots" are being developed at Patancheru; one for screening breeding populations for Fusarium oxysporum only and the other for screening several pathogens. This will be a joint pathology/breeding project.

Entomology:

Helicopvera (Heliothis) armigera is the major pest of chickpea and at Patancheru the percentage of pods lost on unsprayed chickpeas could be as high as 37%. Surveys carried out within Andhra Pradesh indicated that in 1974 damage ranged from 3% to 24% and in 1975 from 1 to 20%. Spraying trials indicated that the pod number and yields were significantly reduced on unsprayed plots and loss in yield amounted to the equivelent of 433 kgs/ha for the cultivar C 235.

Various cultivars, selected on the basis of growth habit, flower colour, seed size and seed colour were screened for resistance to Helicopvera. There appeared to be little effect of plant habit on resistance. In general, the Kabuli types (white flowered and large seeded) were far more heavily attacked at the pod stage; levels ranged from 15 to 33% in these types with an average of 21%. In the local Desi cultivars (red flowered, small seeded) the attack ranged from 2 to 14% with an average of 8%. These differences are important for the breeders, and the actual cause of susceptibility and resistance will be further investigated.

Physiology:

In the 1974-75 season a great deal of effort was put into the analysis of growth and yield, using five cultivars for study. The results provided a sound basis for future physiological studies of the crop. The effects of different geometries of planting and plant population on growth and yield were investigated at Patancheru. The highest yields were obtained with the highest populations used (100 plants/m^2). There was no advantage of the square method of planting over rectangular planting at high populations and a significant disadvantage at lower populations. These results suggest that competition for water and nutrients is more important than competition for light. The population studies have been extended to Hissar in the 1975-76 season and it will be interesting to see if there are

differential responses between our northern and southern sites.

In the 1975-76 season detailed studies on source-sink relationships were initiated. These studies should provide a deeper understanding of genotype x environment effects on the growth, development and yield of chickpeas and could lead to the identification of morphological characteristics which can be used as selection indices by the Plant Breeders. The advantages, if any, of the double-podded character have been investigated by converting double-podded to single podded cultivars by clipping off the second flower produced at each node. An upright-pod mutant is available and possible advantages of this character for photosynthesis in the pod are being investigated by shifting the pods on a normal cultivar to an exposed position above the leaves.

Biochemistry:

The biochemistry section have continued their analysis of the germplasm collection and the cultivars used in the breeding programme. This work is important for the breeders if they are to produce cultivars with higher protein content and good amino-acid profiles per unit area per day.

The protein percentage of desi cultivars ranged from 14.5 to 25.2 with a mean of 18.5. The protein % of Kabuli cultivars ranged from 13.9 to 26.2 with a mean of 18.2. Further investigations are to be undertaken to investigate genotype x environment interaction on % protein.

Microbiology:

This is a new discipline and future investigations will be as follows:

1) Study of Rhizobium populations in soil
2) Response to innoculation andplant N. supply.
3) Rhizobium strain selection and inoculant production
4) Screening germplasm & crosses for nodulation characters
5) Nutritional effects on nodulation and N_2 - fixation

Agronomy:

Marked seedling growth response and significant yield response to phosphorous application was obtained in red soils but in the black soils there was no significant yield response.

Date of planting studies on an early, a medium and late cultivars showed that yields of the medium and late cultivars were greatly reduced at later plantings. While no significant yield reduction was obtained by late planting the early cultivar.

Extensive studies are now being undertaken on weed research and herbicide treatments which could be of great value as weeds are a great problem early in the chickpea growing season.

More than 6000 crosses have been made to date and during

the 1975-76 season to Patancheru and Hissar F1, F2 and F3 populations and F3 and F4 progeny rows from various types of crosses were growing. The early crosses were largely desi x desi but the main emphasis is now being placed on various desi x kabuli cross combinations in which transgressive segregation is greater.

It is difficult to estimate the genetic gain being made during the early generations of a breeding programme and the F4 progeny rows grown this year at Patancheru and Hissar are the first indications of progress. Many of the F4 progeny lines (grown on black precision fields and the Manmool basin) appear to be out yielding the standard cultivars. The F4 line 7341-12-1 from the cross H-208 x No. 59 (both Indian desi cultivars) gave the highest yield recorded so far among these progenies in the 1975-76 season: 2677 kg/ha, representing a 42% increase over the 1884 kg/ha yield of the standard southern cultivar JG-62. The northern cultivar G-130 yielded 1229 kg/ha in Hyderabad. We feel that these results are most encouraging considering that the F4 progenies came from crosses made in 1973 when there was limited germplasm available. We know from the earlier generation material grown this year (F2's and F3's) that future yield advances can be expected to be of greater magnitude.

An off-season (for India) crop was grown in the Lebanon during the 1975 summer. Thisprovided some evidence (and we are now accumulating more) that desi types adapted to East Asia can only be

selected within populations grown in East Asia and that Kabuli types adapted to Western Asia can only be selected from populations grown in West Asia. Further more, co-adaptation appears to be important in chickpeas and results indicate that a (Kabuli x Desi) x Desi backcross will produce superior cultivars for East Asia and the reciprocal (Kabuli x Desi) x Kabuli backcross produce superior cultivars for West Asia. This has important implications for breeding strategy and the Programme Review Committee are asked to consider the necessity for a breeding site in Western Asia to cater for the production of Kabuli cultivars adapted to Summer plantings. An ICRISAT/ICARDA cooperative project is suggested.

International Cooperation:

During the 1975-76 winter season we made available the following materials for chickpea breeders:

1) An International Chickpea Cooperative Trial (49 cultivars, mostly desi)
2) 200 Elite germplasm lines
3) 10 F3 segregating bulk populations

These were sent to various cooperators in India, Pakistan, Thailand, Chile, Ethiopia, Sudan, Burma, Mexico, Bangladesh, Phillipines Yemen Arab Republic and Nepal. The results of these are just coming in. Reports from Ethiopia and Sudan indicate that 3 of our F3 populations are producing plants higher yielding than hitherto recorded in these countries.

During March 1976 we made available:

1) One International Chickpea Cultivar Trial (36 kabuli cultivars)

2) One International Chickpea Cultivar Trial (25 desi cultivars)

3) 100 Elite germplasm lines

4) 15 F3 segregating bulk populations of Kabuli x desi crosses

These have been sent to cooperators in Iran, Iraq, Afghanistan, Jordon, Algeria, Tunisia, Liberia, Tanzania, Lebanon, Spain, Greece and Turkey. An International Disease Nursery was also sent by the pathologists to sites in Iran, Lebanon, Spain, Greece and Turkey. It is very difficult to get seed from Hyderabad to these summer planting areas on time, as our Hyderabad harvest overlaps the optimum planting dates for most countries of western Asia. These difficulties would not arise if we had a breeding programme based in Western Asia.

PROJECT HIGHLIGHTS OF ECONOMICS PROGRAM

1975-76

PRODUCTION ECONOMICS

1. Studies of Traditional Cultivation Practices and Resource Availabilities in SAT India

Investigators have been living in each of six villages of Andhra Pradesh and Maharashtra since May, 1975. They have been collecting biological, physical, climatic and socio-economic data and making observations. To date approximately 12 rounds of data have been collected and tabulated for computer analysis for the 240 households. An interim report is under preparation.

2. Implications of Human Nutritional Status in the SAT for Research Strategies and Government Policies

An analysis of the gre n revolution in wheat in the six major wheatgrowing states of Punjab, Haryana, U.P., M.P., Rajasthan and Bihar was completed. Aim was to determine if the overall effect of the reduction in pulse production results in deterioration in per caput availability of proteins, calories, lysine, methionine, cystine, tryptophan, leucine and isoleucine. Preliminary results suggest per capita availability of all nutrients increased substantially after the green revolution compared with what they would have been had pre-green revolution trends continued.

3. Risk and Uncertainty in SAT agriculture

The major emphasis in this project was on a review of the literature on the effect of risk on farmers' adoption of modern techniques and on methods to reduce riskiness of farming. This review has resulted in the formulation of various sub-projects in this area which will address the following questions: (i) How is adaptability of varieties across locations correlated with stability over time in a given location ? (ii) How is soil moisture variability translated into yield variability ? (iii) How is income risk related to yield and price risks and are there strongly offsetting negative covariances between yields of different crops, between prices of different crops and between yield and prices ?

4. Economic Comparison of Human, Animal and Mechanical Power Sources in the SAT

A review of the Indian literature of mechanization in agriculture and the role of the agricultural machinery industry and publicly funded research institutes as suppliers of mechanical innovation was undertaken. The design work of Agricultural Engineering Department in Universities and Research Institutes does not seem to have contributed much to the mechanization process in India (nor anywhere in the world). This suggests that lack of design has not been the primary constraint to the use of improved implements in the SAT. It

further suggests substantial emphasis in our own efforts in this area needs to be given to obtaining a clear understanding of the nature of constraints to the adoption of improved implements.

5. Economics of Prospective Technologies in the SAT

Benefit-cost analyses of various treatments on catchment experiments at ICRISAT, Patancheru, were completed for 1973-74 and 1974-75. The 1975-76 data are being analysed and will be completed by end of May.

Regression equations with runoff as dependent variables and rainfall, rainfall intensity, vegetative cover, slope, land condition and soil moisture as explanatory variables have been fitted using ICRISAT and Ludhiana data. Data from Sholapur is being analysed. Results suggest that it may be possible to derive runoff prediction equations which will allow us to generate runoff probability estimates with some degree of accuracy relying primarily on daily rainfall as the explanatory variable. Accuracy may improve when one has data on the other explanatory variables but often the latter data are not available in time series. In these cases we may be able to utilize daily rainfall and arrive at reasonably good runoff predictions.

6. History and Economics of Existing Tank Irrigation in India

A survey of the history of tank irrigation systems revealed that some of the tank irrigation systems still in use are several hundred, and sometimes more than one thousand years old. Historically tanks have been located predominantly in red soil areas. Tank irrigation systems existed primarily under feudal land tenure systems controlled primarily by rulers of the Princely States who built and maintained tanks and controlled water allocation.

To study the economics of existing tanks under present conditions, 33 tanks were selected in six different districts in Andhra Pradesh and Maharashtra. For each tank, data were collected on size of the tank bund, water levels, inundated area, rainfall from the nearest weather station and area irrigated over the last 10 years. In addition, eight randomly selected farmers per tank were interviewed. Data analysis is in progress.

7. Approaches to Group Action and Organisation for Improved Land and Water Resource Utilization in the SAT.

This has only recently commenced and a research proposal was prepared, circulated and discussed with Farming Systems research staff.

MARKETING ECONOMICS

1. Evaluation of Relevant Economic Characteristics of Legumes and Cereals in the SAT.

First results for pigeonpeas indicated that for five different markets in Andhra Pradesh 100-seed-weight and colour mix consistently explained up to 70 per cent of the variation in prices.

For chickpeas results from two Andhra Pradesh markets show that 100 seed-weight consistently explained price variations; however, colour preferences differ significantly between the two markets indicating, as expected, regional differences in consumer preferences. The study continues on all crops and in markets of other regions in India.

2. Study of Market Channels for SAT Crops

A case study of the rural market system in Mahbubnagar District is underway, where Dr.F. Pesneaud, Visiting Scientist from the University of Strasbourg, during a first visit of three months, has initiated data collection on villagewise cropping patterns, market arrivals, origin of arrivals, and market prices. Preliminary data analysis shows that regional specialization within the district is considerable and that market catchments and market arrivals differ among markets.

Literature reviews of existing studies on the efficiency of rural markets in India have shown that they differ considerably in efficiency of pricing and of operations. Also, marketed surplus of foodgrains varies considerably among crops and regions. In order to explain these variations and to derive policy implications to improve marketing systems, a study of three markets in Andhra Pradesh is underway, where market prices and costs of marketing are studied in relation to amount, origin and flows of commodities; number and size distribution of traders; organization of the market committee and services supplied to farmers and traders.

3. Estimation of Elasticities of Supply and Demand of ICRISAT Crops

Presently available estimates of the elasticities of supply and demand are contradictory and inconsistent. A model for regional supply analysis has been developed, which is based on the duality between profit, cost and production functions. Collection of district-wise data on area, yield, production, rainfall and input supplies has been started for Andhra Pradesh.

4. Market Efficiency, Inter-regional Trade, Specialization and Aggregate Productivity in SAT agriculture

Preliminary investigations clearly show that regional specialization and shifts in production patterns among regions are underway in India; but it is not known to which extent these shifts follow and make full use of the principle of comparative advantage.

HIGHLIGHTS OF RESULTS OF ICRISAT'S FARMING SYSTEMS RESEARCH PROGRAM*

Agroclimatology:

On the basis of probability analyses of rainfall and water balance studies, the lengths of growing periods in three types of soil situations have been estimated, at different levels of probability, using 70 years of Hyderabad data for a sample calculation. The results show that the mean agricultural growing period in a shallow red soil is 17 weeks, in a deep red or medium black soil 21 weeks and in a deep black soil 25 weeks.

The inter-seasonal drought probabilities are relatively high through out the growing season in shallow red soil, while in medium black or deep red soils the water availability to crops is likely to be deficient only towards the end of the growing season; this conclusion has implications for research on the use of supplemental water. The deep black soils offer an excellent crop-water environment throughout the growing season in 7 or 8 out of 10 years. This quantitative information and knowledge of the durati and moisture requirements of crops, make it feasible to fit single crops or combinations of intercropping and double cropping to make the best use of the environment for each of the simulated climate-soil conditions; such models also provide guidelines to the Crop Improvement Program.

Preliminary estimates on climatologically excess water (excluding rainfall intensity considerations) which is expected as runoff or deep percolation have likewise been made. In soils with low water storage capacity (50 mm) the calculated excess water quantity varied from 24 to

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* Prepared by B.A. Krantz, J. Kampen & Associates as requested by J.S.Kanwar for distribution to the Program Committee of Governing Board April 1976.

257 mm. Probabilities of having three consecutive working days for harvesting crops in the late monsoon period under red and black soil conditions were likewise developed; these indicate serious problems for short duration crops.

With the present simulation models, it would be feasible to quickly analyse climatic and soils data from any given area and then to use this information in determining the range of most promising crops and cropping systems given the quantified moisture environment. It is recognised that this approach will only give first approximations, it will, however, reduce the amount of experimentation required to develop economically viable cropping systems and crop varieties.

Hydrology:

Catchment-based studies on the hydrology and crop production potentials of presently applied land and water management practices have indicated low rainfall use efficiencies (about 30%) as well as associated drainage and erosion problems. In testing alternative soil conservation and land and water management techniques it has been found that, on black soils, ridged cultivation systems at a range of slopes (.4 - .8%) result in increased infiltration and reduced runoff and soil erosion. Preliminary data for red soils indicate the effectiveness of raised beds for soil and water conservation. The hydrologic data seem to support the contention that rainfall use efficiencies can be raised substantially (e.g. to 60 - 75%) by improved land and water management practices and more suitable and productive cropping systems.

Catchment-based research on systems of runoff collection and use indicates that particularly on light red soils, but probably also on shallow and medium deep black soils, a very substantial stabilising effect can be contributed by runoff utilization. A dramatic response to one small supplemental watering (5 cm) was obtained during a 30-day drought in 1974 on red soils with maize, sorghum and pearl millet, while small water applications on tomato during the post-monsoon season of 1975 also resulted in large yield increases, in monetary terms amounting to Rs.2835/ha (with 2.5 cm supplemental water) and Rs.5984/ha (with 2 times 2.5 cm). Substantial responses to supplemental water were also obtained on sorghum in the post-monsoon season.

Soil Physics:

Studies on bulk density on ICRISAT soils showed values of 1.25 to 1.63 g/cm^3. Red soils seem to be characterised by relatively high bulk densities, while intermediate and relatively low values were found for shallow and medium depth black soils and deep black soils respectively. Bulk density was found to generally increase in "murram" layers. The available moisture in a 150 cm profile on a deep red soils was found to be about 220 mm and on deep black soils about 290 mm. (assuming ideal rooting patterns extracting all available moisture in this depth).

Infiltration studies on black soils showed final rates of 5, 2 and 1.5 mm/hr under cropped ridged, cropped flat and monsoon-fallow conditions, respectively. On red soils final infiltration rates of 15, 18 and 20 mm/hr were measured under flat, ridged and raised bed conditions respectively.

Preliminary indications from studies on rooting patterns and rooting depths with sorghum and pigeonpea show distinct differences between different varieties of crops; there is also some evidence of correlations between rooting patterns and cultivation practices.

Soil Fertility and Chemistry:

Fertilisation trials, conducted during the past 4 years, indicate a marked response to phosphorus application, particularly on red soils. Since the experiments on various crops were conducted in close proximity to each other it was possible to compare the magnitude of response of several ICRISAT crops. These data indicate that sorghum is the most responsive, followed closely by pearl millet. Sunflower and safflower were moderately responsive and chick pea and pigeon pea were the least responsive to phosphorus application. This information will be helpful in planning sound soil fertility management programs for a given cropping system.

Zinc deficiencies were observed on both red and black soils in areas where soil had been removed either by severe erosion or soil movement during the land levelling process. No potassium deficiencies have been observed and no growth or yield response to potassium application has been found on any crop during any season at ICRISAT. Preliminary studies with slow-release sulphur coated urea on "N-serve" (a nitrification inhibitor) showed no positive response over that of ordinary urea under either red or black soil conditions. Preliminary studies were initiated to study seasonal variations in the nutrient status of soils under different management systems.

Farm Equipment and Tools:

The main emphasis has been on adaptation and minor modifications of existing animal-drawn implements. The objective is to identify or develop low-cost implements which have the potential of achieving adequate precision and efficiency, so that the farmers of the Semi-Arid Tropics can benefit from the application of scientific agriculture using their available power sources.

Equipment modified and used includes the following: Seed-cum-fertiliser drill, versatool, ridger, plow, cultivator and land scraper.

Land and Water Management:

Studies of alternative land and water management techniques on replicated trials involving medium scale fields of .3 to .4 ha (because the studied phenomena, runoff, erosion and drainage are not expressed on small plots) are establishing the superiority of ridged or bedded systems of cultivation in terms of controlling water from the place where it occurs as rainfall, the feasibility of early land preparation, the application of small quantities of supplemental water, weed management etc. In 1975, several instances of "atmospheric drought" were observed; although the available moisture status was still relatively favorable, extremely high evapotranspiration intensities resulted in wilting.

A 15 ha catchment (watershed), BC7 was developed by the exclusive use of animal power and human labor. The average land development cost was Rs.575/ha. Since this catchment contained many gulleys and large field bunds, it may be presumed that this is a realistic cost estimate. Four small inter-connected tanks were constructed in this catchment by

use of animals and human labor. The major cost component in the tank construction consisted of charges for labor, animals and equipment which, at ICRISAT rates, resulted in a cost of about Rs.2/cu.m. of storage capacity. Substantial progress has been made in arriving at tank designs with larger (2-3) excavation to storage ratios; this has resulted in considerably lower costs per unit of storage.

Preliminary seepage studies on small pits have indicated that clay sediments from red soil tanks combined with sodium carbonate proved to be effective for seepage reduction. Seepage has been found to be one of the most serious problems associated with small deep tanks.

High density polyethylene pipes (4" in diameter) are being tested for feasibility and economic viability in a closed system for water conveyance. These pipes are low-cost (Rs.12 per meter), flexible, lightweight, rodent-proof, almost dent-proof, and have a low flow resistance. However, the presently available coupling is too costly. A prototype of a low-cost, leak-proof coupling has been fabricated at ICRISAT; this coupling requires a marginally larger labor input. The developed system will result in an overall cost reduction of about 50% compared to similar available conveyance system. These findings provide encouragements to the development of low-cost, closed systems for water conveyance which is desirable for the efficient use of small quantities of scarce supplemental water to back stop rainfed agriculture.

Intercropping and Relay Cropping Investigations:

Intercropping investigations have been conducted during the past 4 years involving various crop geometries. In all cases the alternate-row intercropping system has been superior to the "shared cropping" system in which each crop is planted as a pure crop on 50% of the area. The most favorable intercrop combination has been a spreading type medium to late duration (about 180 days) pigeon pea with cereal crops such as setaria. In a study of the effect of light and moisture competition between pigeonpea and various intercrops, pigeonpea and setaria were found to be only slightly competitive with each other on black soils. Setaria grown as an intercrop in pigeon pea produced over 35 q/ha, either as an intercrop or as a pure crop. Likewise, pigeon pea produced 25 q/ha, either as a pure crop or as an intercrop with setaria. In red soils the general yield was lower and the setaria intercrop decreased the yield of pigeon pea slightly, but not significantly. Other crops such as pearl millet, soybean and sorghum were more competitive but still resulted in a positive effect from intercropping over that of the shared cropping system.

The effect of different levels of light and moisture competition upon the performance of relay crops was studied in an experiment involving monsoon-fallow (no shade) Vs kharif maize in which 3 treatments were allowed to mature to grain (full shade). In 3 additional treatments, every second maize plant was removed at the green cob stage (24 days before grain harvest) thus providing partial shade. In each of the 3 monsoon-crop conditions, 3 dates of planting relay crops were carried out at 24, 12 and 0 days before maize grain harvest. An excellent crop of maize was grown, producing an average of 74 q/ha of grain. However, the greatest economic value was

produced when half of the plants were removed at green cob stage and the remaining plants allowed to produce grain.

Sorghum, sunflower and safflower all produced well as relay crops with the second planting date generally being the optimum date. The monsoon-fallow, rabi crops produced only slightly more than the rabi crop following maize. The potential for double cropping appears to be very high compared to that of rabi cropping only, which is commonly practised in many of the deep black soils in India. The highest gross value attained under the double crop system was Rs.9,703 compared to the highest value of only 2,655 in the monsoon-fallowed, rabi cropping system. Additional basic studies are planned to more fully exploit the apparent potential of intercropping and relay cropping systems.

Weed Research:

ICRISAT's weed research project was started in 1975 with the appointment of a Research Associate in Weed Science. In recognition of the fact that the farmers have low capital resources, emphasis is being placed on developing low-cost, weed management systems for the major crops and cropping systems of the SAT. It was found that the uncontrolled weed growth reduced yields as much as 70% in sorghum, pearl millet and groundnut. It was also found that maximum crop yields were obtained when these crops were kept "weed free" for 3 to 6 weeks after sowing. A herbicide screening trial was conducted in both the kharif and rabi season to determine the effect of a wide range of herbicides on a range of SAT crops and associated weeds. Several herbicides were found to be promising and will be studied further. Weed monitoring investigations were initiated

in different soil and crop management systems in the catchment areas. This study will be continued to determine any shifts in the composition of the weed population or in the amount of weeds. Similar studies are being initiated on insects and diseases by the Pathology and Entomology units of ICRISAT.

Steps in Technology:

Experiments were conducted on red soils to study the effect of stepwise additions of various facets of improved technology upon sorghum yields. In this experiment an attempt was made to simulate local soil and crop management systems from the standpoint of timing of tillage, implements used for seeding and fertilization and row and plant spacing. Local fertilisation consisted of 50 cart loads of manure/ha.

With local fertilisation and local soil and crop management practices there was no difference between the local varieties and the improved (CSH5) variety. With improved fertilisation the yields of both varieties improved significantly. However, by far the greatest improvement occurred when improved fertilisation and improved management practices were combined with the improved (CSH5) variety. In comparing local technology with improved technology, the grain yield of the local variety was increased by 85%, while the grain yield of the improved variety was increased by 245%. These preliminary data indicate the ability of high yielding varieties to manifest their superiority over local varieties when a full system of improved technology is adapted.

LIST OF RESEARCH PROJECTS APPROVED FOR 1976-77

Project Title	Objectives in brief	Project Leader & others	Date of start	Date of completion
3	4	5	6	7
SORGHUM				
Sorghum Breeding				
International testing of breeding material	Evaluation of breeding material at all stages of development over wide environments	P.Lawrence H.Doggett Associates	1974	Annual Review
Introgression of exotic germplasm and development of source populations	1. To utilise new germplasm by introgressing into adapted breeding material 2. To develop random mating populations from progeny derived from introgression crosses 3. To maintain and improve populations by simple recurrent selection.	P.Lawrence K.E.Prasada Rao	1974	Annual Review
Advanced population improvement.	1. To develop and improve advanced populations for different agroclimatic regions 2. To extract elite lines from populations.	Bhola Nath P. Lawrence K.V.Seshureddy K.N.Rao	1974	Annual Review
Development of hybrids	1. To test the best elite lines for their suitability as parents for hybrids 2. To develop new cytoplasmic male sterile lines	Bhola Nath H. Doggett	Kept in abeyance till new elite material is available.	

1.	2.	3	4	5	6	7
5.	S-brd-5	Exploitation of grain grass sorghums	To develop short, early grain grass sorghums with a plant resembling wheat or Eleusine millet with ratoon-ability character-istics.	K.V. Ramaiah H.Doggett	1974	Annual Review
6.	S-brd-6	Development of tetra-ploid grain sorghums	To develop tetra-ploid grain sorghums and with better grain size and quality. To use polyhaploids from tetraploids to introgress germ-plasm from the highly successful grass S.halepense into the cultivated crop.	K.V.Ramaiah H. Doggett	1974	Annual Review
	S-brd-7) S-brd-8)	Merged together in S-brd-11				
7.	S-brd-9	Development of Striga resistant cultivars	To develop striga resistant cultivars with good yield and quality	K.V.Ramaiah H.Doggett	1975	Annual Review
8.	S-brd-10	Development of cultivars for high altitude conditions	To develop sorghums adapted to high alti-tude locations which combine high yield and photoperiod insensitivity with good grain quality.	D.S.Murthy H. Doggett	Will start after suitable site is selected.	

1	2	3	4	5	6	7
9.	S-brd-11 (NEW)	Development of source and back-up populations.	1. To develop random mating source populations from accessions derived from the germplasm collections, or from progeny derived from the introgression crosses; 2. To maintain and slowly improve these populations by simple recurrent selection procedures, so that this wide genetic variation is in a useful form for breeders in the national programs, or for the advanced and back-up populations; 3. To maintain populations similar to the advanced populations, but only improve them slowly so as not to lose any useful genetic variability.	B.Balaramireddy Peter Lawrence	1974	Annual Review
10.	S-brd-phy-1	Development of sorghum ideotypes for SAT	1. To develop cultivars which establish well, grow quickly and have a long duration of grain filling. 2. Drought resistant cultivars 3. Cultivars for making optimum use of available nutrients.	N. Seetharama H. Doggett A. H. Kassam	1976	Annual Review
1.	S-brd-ent-1	Breeding for resistance to pests	1. Resistance to shootfly 2. Resistance to stem borer 3. Resistance to midge 4. Resistance to storage pests	P.Lawrence Seshu Reddy	1975	Annual Review

1	2	3	4	5	6	7
12.	S-brd-info-1	International dissemination of information on sorghum improvement	To disseminate scientific information on various aspects of sorghum improvement to scientists throughout the SAT.	P.Lawrence J.W.Spaven	1975	Annual Review
13.	S-brd-micro-1 (NEW)	Nitrogen Fixation Associated with Sorghum	1. To evaluate nitrogen fixation in sorghum by making measurement of nitrogenase activities 2. To determine the heritability of nitrogenase activity associated with the roots 3. To determine the amount of nitrogen fixed and transferred to sorghum plants and the effect of agronomic factors.	P.J.Dart H. Doggett Associates	1976	Annual Review
4.	S-brd-q&n-1	Breeding and evaluation of high quality, nutritious sorghum grain types	1. To select sorghums with white, plump, well-filled grains, hard flinty endosperm starch and pericarp with low fibre content. 2. To select sorghums with low prolamine, high lysine and low leucine, compatible with optimum protein and yield and protein matrix giving easily digestible endosperm starch 3. To select sorghum with good cooking quality.	H. Doggett Umaid Singh R.Jambunathan	1974	Annual Review

1	2	3	4	5	6	7
5.	S-brd-mch-1	Development of short-term sorghums with quality grains resistant to grain mould or protected from it	To develop short-term sorghums with good quality and mould resistance grains	D.S. Murthy K.N.Rao	1974	Annual Review
Sub-Program : Sorghum Physiology						
6.	S-phy-1	Identification of superior carbohydrate source-sink relationships	1. To define the carbohydrate source-sink relationships in space and time in GS1, GS2 and GS3 for production of high yield, (i.e. high seed number per unit area and grain filling rate) within a given number of days to maturity. 2. To develop techniques and indices to evaluate and screen genotypes with either superior source (Carbohydrate production) characters and/or superior sink (panicle) characters.	N.Seetharama A.H.Kassam G.Alagarswamy R.K.Maiti	1974	1977
7.	S-phy-2	Identification of superior nitrogen uptake and distribution	1. To define nitrogen uptake and distribution pattern in the plant required for production of high yield within a given number of days tomaturity. 2. To develop techniques and indices to evaluate and screen genotypes for superior uptake and distribution attributes.	N.Seetharama A.H.Kassam G.Alagarswamy R.K.Maiti	1975	1977

2	3	4	5	6	7
S-Phy-3	Identification of genotypes with superior drought endurance and contributing plant characters	1. To identify genotypes including breeding material with superior ability to endure drought stress in the field, and to develop an effective evaluation procedure. 2. To identify plant characters such as root system, tissue water potential characterstics, leaf diffusive resistance, and heat and desiccation tolerance, associated with drought endurance.	A.H.Kassam N.Seetharama R.K.Maiti	1975	1977
S-Phy-4	Identification of superior attributes related to seedling, root and panicle development	1. To study the relationships between seed characters and seedling development in a range of genotypes, and to develop technique for evaluating genotypes for seedling vigour. 2. To develop a method of studying root development and to collect basic information on the favourable variability in root development in different genotypes. 3. To study the developmental changes to obtain basic information in order to identify superior developmental relationship between panicle characters	R.K.Maiti A.H.Kassam N.Seetharama G.Alagarswamy	1975	1977
b-Program: Sorghum Pathology:					
S-Path-1.1	Basic investigations on Sorghum grain moulds	To determine the etiology of sorghum grain moulds and their effect on grain quality and	K.N. Rao R.J.Williams	1975	1977

1	2	3	4	5	6	7
.	S-Path-1.2 (NEW)	Identification and utilization of sorghum grain mould resistance	To develop elite sorghum lines resistant to grain moulds	K.N.Rao R.J.Williams	1975	Annual Review
.	S-Path-1.3 (NEW)	Evaluation of potential resistance conferred by such factors as large papery glumes, deep coloured grains, etc.	To evaluate the effects of various physical/ chemical parameters on the susceptibility to grain moulds in sorghum	K.N. Rao R.J.Williams	1975	1978
.	S-Path-2.0 (NEW)	Identification and utilization of sources of resistance to sorghum downy mildew	To develop elite lines with high degree of stable effective SDM resistance	K.N. Rao R.J.Williams	1975	Annual Review
.	S-Path-3.0 (NEW)	Identification of sources of resistance to sorghum leaf diseases	To develop methods to promote leaf diseases and to find out resistance sources for various leaf diseases	K.N.Rao R.J.Williams	1976	Annual Review
.	S-Path-4.1 (NEW)	Investigations on sorghum stalk rot diseases	To determine the causal agents of sorghum stalk rots and to develop suitable efficient screening techniques	K.N. Rao R.J.Williams	1976	Annual Review
.	S-Path-4.2 (NEW)	Identification and utilization of sources of resistance to sorghum stalk rots.	To develop elite lines with high degree of stable effective resistance to stalk rots.	K.N.Rao R.J.Williams	1976	Annual Review

2	3	4	5	6	7
Sub-Programme : Sorghum Entomology					
S-Ent-1	Pest incidence on hybrid and local varieties of sorghum and millets	To identify the pests and the dmage to the crops of sorghum and millets	K.V.Seshureddy J.C.Davies	1974	1976
S-Ent-2	Pest Carry-over studies	To study the mechanism of carryover of shootfly and shoot borer in sorghum	K.V.Seshureddy J.C.Davies	1974	1977
S-Ent-3	Screening of sorghum varieties for pest resistance	To screen lines produced by breeders for pest resistance	K.V.Seshureddy J.C.Davies P.K.Lawrence	1974	Annual Review
S-Ent-4	Testing of granular insecticides for shootfly and stem borer control.	To find out most economical dose and method of use of granular insecticide.	K.V.Seshureddy J.C.Davies	1975	1977
S-Ent-5	Shootfly attractant studies	To develop suitable trapping procedures for shootfly sampling. To ascertain, if possible, which chemical is the active principle in attracting shootfly.	J.D.Skinner J.C.Davies	1975	1977
S-Ent-6	Chilo phermone studies	To test the use of phermones as attactant and sampling roots.	J.D.Skinner J.C.Davies	1975	1977

1	2	3	4	5	6	7
Sub-Program : Sorghum Germplasm						
33.	S-gp-1	Germplasm evaluation and maintenance	To maintain, evaluate and document and distribute germplasm	K.E.Prasadarao LJG van der Maesen	1974	Annual Review
34.	S-gp-2 (NEW)	Collection of Sorghum germplasm and taxonomic clasification	1. To fill the gaps in the collection 2. To obtain new genetic resources in wild sorghum spp. 3. To document and publish collections 4. To test the suitability of various classification systems	K.E.Prasadarao van der Maesen	1975	Annual Review
Sub-Program : Sorghum Quality & Nutrition						
35.	S-Q&N-1	To improve the protein quality of sorghum	To select for low prolamine, high lysine sorghum with optimum protein content	Research Associate R. Jambunathan H. Doggett	1974	Annual Review
36.	S-Q&N-2	To study some of the factors affecting the nutritional quality of sorghum	To assay the variation in digestability of sorghum, fractionate proteins and amino-acids and determine the starch content of selected sorghum samples.	R.Jambunathan H. Doggett	1975	Annual Review

Project No.	Project Title	Objectives in brief	Project Leader & others	Date of start	Date of Completion
2	3	4	5	6	7
PROGRAM : MILLET					
Program : Millet Breeding					
M-brd-1	Advanced Composites I-Int -population improvement.	To breed widely adopted high yielding populations of several maturities with good seed quality.	S.C.Gupta	1973	Annual Review
M-brd-2	Advanced composites II-Inter-population improvement.	To breed widely adapted ponulations of several maturities with good seed quality which, between pairs of populations, produce good variety or single cross hybrids.	S.C.Gupta Vacant	1974	Annual Review
M-brd-3	Source composites	1. To form composites where sources with valuable characteristics may not be in generally adapted backgrounds 2. To maintain composites, usually of exotic origin which may require mild selection and time for recombination.	K.Anandkumar D.J.Andrews R.J.Williams R.Jambunathan	1973	Annual Review
M-brd-4	Variety crosses and synthetics	1. To create variability by crossing specific parents, and to select progeny under several environments. 2. To identify suitable parents for creating synthetic populations 3. To provide cooperators with segregating material.	R.P.Jain D.J.Andrews J.V.Majmudar R.J.Williams A.H.Kassam R.Jambunathan	1974	Annual Review

1	2	3	4	5	6	7
5	M-brd-5	Hybrids	To breed high yielding stable hybrids, which may be single cross, variety top cross or variety cross hybrids	J.V. Majmudar R.P.Jain D.J.Andrews R.J.Williams A.H.Kassam R.Jambunathan	1973	Annual Review
.	M-brd-6	Merged with M-brd-3				
6.	M-brd-7	Yield Testing	To conduct trials on materials emerging from the breeding program both at Hyderabad and cooperating centres to determine performance and stability and adaptability.	K.Anandkumar D.J.Andrews J.V.Majmudar R.J.Williams	1971	Annual Review
7.	M-brd-8 (NEW)	International cooperation	1. To channel seed and information in both directions between ICRISAT and breeders in the SAT. 2. To conduct coordinated trials in the SAT countries.	D.J.Andrews J.V.Majmudar K.Anandkumar	1974	Annual Review
8.	M-brd-9 (NEW)	Comparison of population breeding methods	To compare the efficiency of different methods (Gridded Mass Selection, Recurrent restricted parental selection, full sib selection and S_2 selection) of population improvement in pearl millet.	R.A. S.C.Gupta D.J.Andrews H.Doggett	1976	Annual Review
9.	M-brd-Micro-1 (NEW)	Nitrogen fixation associated with millets	1. To evaluate nitrogen fixation in millets by making measurement of nitrogenase activities 2. To determine the heritability of the nitrogenase activity association 3. To determine the amount of nitrogen fixed and transferred to millet plants and the effect of agronomic factors.	P.J. Dart D.J. Andrews	1976	Annual Review

1.	2	3	4	5	6	7
10.	M-brd-Agr-1	Agronomy	To determine the range and optimum cultivation requirements and inter-cropping characteristics for new millet genotypes	D.J.Andrews M.R.Rao B.A.Krantz	1975	Annual Review
	M-brd-Ent-1	Breeding for pest resistance	To select and breed resistance for millet shoot fly, stem borer and midge	NOT STARTED		
11.	M-brd-Path-1	Breeding for disease resistance	The identification and incorporation of resistance to Downy Mildew, Ergot and Grain smut is fundamental to all parts of the breeding program	R.P. Jain S.C. Gupta R.J. Williams	1974	Annual Review
12.	M-brd-Phy-1	Physiology	Identifying and utilizing genotypes with desirable physiological traits such as high yield composites, efficiency of nutrient utilization and ability to endure water stress.	A.H.Kassam Anand Kumar S.C.Gupta R.P.Jain	1974	Annual Review
13.	M-brd-Q&N-1	Grain Quality	1. To select grain with good visual appearance. 2. To select for nutritional quality 3. Preparation, cooking and taste	K.Anandkumar R.Jambunathan Umaid Singh	1974	Annual Review
Sub-Program : Millet Physiology						
14.	M-Phy-1	Identification of superior carbohydrate source-sink relationships.	1. To define the carbohydrate source-sink relationships in space and time in GS1, GS2 and GS3 for production of high yield (i.e.,high seed number per unit area and grain filling rate) within a given number of days to maturity.	G.Alagarswamy A.H.Kassam N.Seetharama R.K.Maiti	1974	1977

1.	2	3	4	5	6	7
14	(contd)		2. To develop techniques and indices to evaluate and screen genotypes with either superior source (carbohydrate production) characters and/or superior sink (panicle) characters.			
15.	M-Phy-2	Identification of superior nitrogen uptake and distribution.	1. To define nitrogen uptake and distribution pattern in the plant required for production of high yield within a given number of days to maturity. 2. To develop techniques and indices to evaluate and screen genotypes for superior uptake and distribution attributes.	G.Alagarswamy A.H.Kassam N.Seetharama R.K.Maiti	1975	1977
16.	M-Phy-3	Identification of genotypes with superior drought endurance and contributing plant characters	1. To identify genotypes including breeding material with superior ability to endure drought stress in the field, and to develop an effective evaluation procedure. 2. To identify plant characters such as root system, tissue water potential characters, leaf diffusive resistance, and heat and desiccation tolerance, associated with drought endurance.	A.H.Kassam G.Alagarswamy R.K.Maiti	1975	1977

1.

17	M-Phy-4	Identification of superior attributes related to seedling, root and panicle development.	1. To study the relationships between seed characters and seedling development in a range of genotypes, and to develop techniques for evaluating genotypes for seedling vigour. To develop a method of studying root development and to collect basic information on the favourable variability in root development in different genotypes. To study the development changes in the panicle in selected genotypes to obtain basic information in order to identify superior developmental relationship between panicle characters.	R.K. Maiti A.H. Kassam G.Alagarswamy N. Scetharama	1975	1977
Sub-Program: Pathology:						
18.	M-Path-1.1	Studies on the biology and epidemiology of pearl millet downy mildew	To determine basic knowledge of the biology and epidemiology of pearl millet downy mildew to enable the development of logical effective control measures.	S.D.Singh R.J.Williams	1975	1977
19.	M-Path-1.2 (NEW)	Studies on the promotion of Bajra downy mildew	To find out an effective inoculation technique	S.D.Singh R.J.Williams	1975	Annual Review
20.	M-Path-1.3 (NEW)	Studies on seed transmission	To determine whether the pathogen is internally seedborne, and if so under what circumstances; and to determine if the disease is internally seed transmitted and if so what treatments can be used to	S.D.Singh R.J.Williams	1975	1976

21.	M-Path-1.4 (NEW)	Studies on the viability and pathogenicity of Sclerospora graminicola oospores.	To determine the efficiency of oospores in infection and to determine the effects of various physical and chemical treatments on the viability and pathogenicity of oospores.	S.D.Singh R.J.Williams	1975	1977
22.	M-Path-1.5	Identification and utilization of sources of resistance to downy mildew	To identify sources of stable resistance to downy mildew, and incorporate the resistance into elite high yielding materials.	S.D. Singh R.J.Williams D.J.Andrews Associates	1975	Annual Review
23.	M-Path-2.1	Studies on the biology and epidomiology of ergot.	1. To determine the relationship between physiological stages of flowering and susceptibility to ergot. 2. To understand whether fertilization and/or age of stigmas prevent(s) infection by the ergot pathogen. 3. To study the role of differentpropagules-macroconidia, microconidia, sclerotia and ascospores in epidemiology as source(s) of inoculum, and 4. To study the host-range of the pathogen, collateral and alternate hosts and their role in epidemiology.	R.P.Thakur R.J.Williams	1975	Annual Review
24.	M-Path-2.2	Studies on different inoculation methods for screening lines against ergot and smut.	1. To determine the best inoculation method for efficiently screening large number of lines for ergot and smut resistance 2. To determine the usefulness of infector (donor) lines in the screening program.	R.P.Thakur R.J.Williams	1975	Annual Review

25.	M-Path 2.3	Identification and utilisation of sources of resistance to ergot and smut.	1. To identify sources of resistance, tolerance or escape to ergot and smut. 2. To utilize the resistance in the breeding program to produce elite high yielding resistant lines.	R.P.Thakur R.J.Williams D.J.Andrews Associates	1975	Annual Review
26.	M-Path-3.0	Identification of sources of rust resistance.	To identify effective and stable sources of rust resistance.	-dO-	1975	Annual Review

Sub-Program : Millet Entomology

27.	M-Ent-1 (NEW)	Pest incidence on HB-3	1. To determine the range of pests found on pearl millet. 2. To obtain valid indetifications of the species involved 3. To characterise the damage caused and to obtain an idea of their relative importance. 4. To compare the species present with those of other areas in SAT. 5. To accumulate information on the seasonal abundance, behaviour patterns and plant preferences to the various pests. 5. To accumulate information on the seasonal abundance, behaviour patterns and plant preferences to the various pests.	K.V.Seshureddy J.C.Davies	1974	Annual Review

Sub-Program : Millet Germplasm

28.	M-gp-1	Germplasm Evaluation and maintenance	To maintain, evaluate, document and distribute germplasm	van der Maesen	1973	Annual Review

Sub-Program : Millet Quality & Nutrition

29.	M-Q&N-1	To improve the nutritional quality of pearl millet	1. To select for high lysine 2. To study protein fractions 3. To study variation in starch in some selected millet samples.	R.Jambunathan K.Anandkumar D.J.Andrews J.V.Majmudar	1975	Annual Review

Sl No	Project No.	Project title	Objectives in brief	Project Leader and others 5	Date of start 6	Date of Completion 7
PROGRAM: PIGEONPEA:						
Sub-Program: Pigeonpea Breeding:						
1.	PP-brd-1	Development of early maturing cultivars	To develop early maturing high yielding cultivars for pure stands and mixed cropping	D. Sharma J.M.GREEN JC Davies Y.L.Nene AR Sheldrake L.J.Reddy K.B.Saxena BVS Reddy R.Jambunathan	1974	1978
2.	PP-brd-2	Development of intermediate to late maturing cultivars	To develop high yielding cultivars with acceptable grain and suited for companion cropping	J.M.Green D.Sharma and Associates	1975	1978
3.	PP-brd-3	Germplasm Utilisation technique	To improve breeding techniques in pigeonpea by using material in projects 1 & 2 on studies of methodology of hybridization selection and population improvement.	J.M. Green D. Sharma and Associates	1975	1978
4.	PP-brd-4	International cooperation	To develop international programs to strengthen and assist existing programs in SAT.	J.M. Green D. Sharma	1975	1978
5.	PP-brd-5	Intergeneric hybridization	To increase genetic variability in Cajanus from wild species of Atylosia and to explore the possibilities of finding cytoplasmic sterility and derived aneuploids	LJ Reddy LJG van der Maesen JM Green D.Sharma	1975	1978
6.	PP-brd-6	Study of Pollination of pigeonpea	To determine the extent and factors affecting cross pollination and to determine the best means of artificial self pollination and to determine the nature of self sterility in non-podding plants	JM Green D. Sharma J.C.Davies and Associates	1975	1977

ul-Program: Pigeonpea Physiology:

.	PP-phy-1	Comparison of pigeonpea genotypes	Comparative study of desirable and undesirable characteristics	A.Narayanan J.M. Green D. Sharma	1975	1977
.	PP-phy-2	Responses of pigeonpea to environment and cultural practices	1. To study the effect of day length and temperature (locations) 2. Spacing and planting geometry effect 3. Intercropping relations 4. NP nutrition and root nodule and mycorrhizal activity 5. Seed grading and seed size effect 6. Water relations in red and black soils	A.Narayanan J.M.Green D. Sharma	1975	1977
).	PP-Phy-3	Source-sink relationships in pigeonpea	Study of photosynthetic production of assimilates	A.Narayanan A.R.Sholdrake	1975	1977

Sub-Program: Pigeonpea Pathology:

10.	PP-Path-1	Studies on pigeonpea wilt	1. Development of technique to screen varieties for wilt resistance 2. Detecting and characterising physiologic races of wilt pathogen 3. Factors influencing wilt	Y.L.Nene J.Kannaiyan M.V.Reddy	1975	1977
11.	PP-Path-2	Studies on sterility mosaic of pigeonpea	1. Study of the nature of casual agent, survival of mite vector and its relationship to casual agent 2. Development of tech.forscreening	Y.L.Nene M.V.Reddy J.M.Green J.C.Davies	1975	1977
12.	PP-Path-3	Screening for resistance to pigeonpea wilt and sterility mosaic	Screening of germplasm and early generations of breeding material	Y.L.Nene M.V.Reddy J.Kanniyan	1975	1977
13.	PP-Path-4	Survey of pigeonpea diseases	To determine relative incidence of various diseases in pigeonpea growing areas	Y.L.Nene J.Kannaiyan M.V.Reddy	1975	1977

14.	PP-Path-5	Studies on the microflora associated with pigeonpea seed	To study the nature and extent of microflora associated with pigeonpea seed	Y.L.Nene J.Kannaiyan	1975	1977
Sub-Program: Pigeonpea Entomology:						
15.	PP-Ent-5 CP-Ent-5	Pest assessment on standard varieties of legumes grown at ICRISAT (initially pigeonpea and chickpea)	To determine the range of pests found on the legume crops, to obtain an idea of their relative importance, to characterise the damage caused by individual species, to obtain valid identification of insects involved and to obtain observations on behaviour of pest species and their seasonal population fluctuations	S.S.Lateef JC Davies	1974	Annual Review
16.	PP-Ent-6	Biology of legume Pests Pigeonpea	Study of biological important pests of pigeonpea for developing of suitable pest management technique	S.S.Lateef JC Davies	1974	1976
17.	PP-Ent-7 CP-Ent-7	Development of screening techniques for assessing resistance of pigeonpea and chickpea	To develop screen house technique for chickpea and a means of ensuring high pest attack on pigeonpea	S.S.Lateef JC Davies	1975	1977
18.	PP-Ent-8	Insecticide Trials on Legumes	To assess desirability of applying insecticides in solid stands	S.S.Lateef J.C.Davies	1975	1977
Sub-Program: Pigeonpea-Germplasm						
19.	PP-gp-1(72)	Maintenance and evaluation of pigeonpea germplasm	To maintain, evaluate, document, publish and distribute genetic material	LJG van der Maesen JM Green D.Sharma YL Nene JC Davies AR Sheldrake	1972	Annual Review

9	PP-gp-2(74)	Collection of Cajanus and Atyl germplasm and preparation of taxonomical revision	To collect new genetic resources in Cajanus and Atylosia and document and publish the collection	LJG van der Maesen JM Green D. Sharma	1975	19

Sl-Program: Pigeonpea Quality & Nutrition:

1	PP-Q&N-1	Screening of germplasm and breeding material for protein and limiting amino-acids	To screen the germplasm and breeding material for their protein content and limiting amino-acids such as Methionine, Cystine etc.	R. Jambunathan	1975	1976
2	PP-Q&N-2	To study some of the factors affecting nutritional quality of pigeonpea	To test by assay variation in pigeonpea digestibility; Fractionation of proteins of mature and immature pigeonpea; Screening for protease inhibitors	R. Jambunathan	1975	1976

Program : Chickpea Breeding

	Project No.	Project Title	Objectives in brief	Project Leader & others	Date of start	Date of completion
	CP-brd-1	Breeding 'desi' type with high yield and stability of performance	Breeding for high yield and stability of performance and good consumer acceptance	K.B.Singh A.K.Auckland OnkarSingh S.C.Sethi	1973	Annual Review
2.	CP-brd-2	Breeding 'kabuli' type with high yield and stability of performance	-do-	A.K.Auckland K.B.Singh K.C.Jain G.C.L.Gowda	1973	Annual Review
3.	CP-brd-3	Breeding for disease resistance	Breeding for resistance to wilt and Ascochyta blight consistent with high yield and stability of performance	A.K.Auckland Y.L.Nene Associates	1975	Annual Review
4.	CP-brd-4	Breeding for insect resistance	Resistance to Heliothis sp.	A.K.Auckland J.C.Davies Associates	1975	Annual Review
5.	CP-brd-5	Breeding varieties responsive to high levels of phosphate application	1. To identify existing strains for responsiveness to phosphate application 2. To use them for development of high yielding varieties	K.B.Singh A.K.Auckland S.C.Sethi A.R.Sheldrake P.J.Dart	1974	Annual Review
6.	CP-brd-6	Breeding for higher protein content and good amino acid profiles per unit area per day.	Development of varieties high in protein quantity and quality without reduction in yield and stability.	K.B.Singh A.K.Auckland R.Jambunathan	1976	Annual Review

7.	CP-brd-7	'I' otype' Breeding	To study plant characteristics in various segregating populations for ideal ideotype.	A.K.Auckland K.B.Singh A.P.Sheldrake S.C.Sethi K.C.Jain Onkar Singh GCL Gowda	1974/75	Annual Review
8.	CP-brd-8	Recurrent selection breeding	1. Production of new high yielding varieties 2. Creation of 'diverse gene pools'.	A.K.Auckland K.B.Singh GCL Gowda	1974/75	Annual Review
9.	CP-brd-9	Breeding Methodology	To develop techniques for chickpea breeding	A.K.Auckland K.B.Singh K.C.Jain S.C.Sethi Onkar Singh GCL Gowda	1975	1980
10.	CP-brd-10	Plot Technique Investigation	Investigation of most efficient plot sizes for new genotype testing.	K.B.Singh A.K.Auckland and Associates	1975	1980
11.	CP-brd-11	International Cooperation	1. To introduce varieties to other countries 2. To supply segregating populations 3. To identify genotypes with wide range adaptability 4. To release varieties with special characters	A.K.Auckland K.B.Singh Y.L.Nene	1975	Annual Review
12.	CP-brd-12	Genetic studies of qualitative and quantitative characters	To study the modes of inheritance of various plant characteristics. Results of value to all plant breeders.	K.B.Singh A.K.Auckland Y.L.Nene Associates	1974	Annual Review

Sub Program : Chickpea Physiology

13.	CP-phy-1	Comparison of chickpea genotypes	Comparison of genotypes for desirable and undesirable characteristics	N.P.Saxena A.R.Sheldrake	1975	1977
14.	CP-phy-2	Responses of chickpeas to environment and cultural practices	Study of interactions of chickpea and agronomic environments	N.P.Saxena A.R.Sheldrake	1975	1977
15.	CP-phy-3	Source-sink relationships in chickpeas	Study of photosynthetic assimilates, their formation and distribution in chickpea	N.P. Saxena A.R. Sheldrake	1975	1977
16.	PP-CP-phy-1	Anatomical studies on Chickpea and Pigeon pea.	Anatomy of organs and tissues of the shoot and root systems in different varieties.	A.R.Sheldrake N.P.Saxena A.Narayanan	1975	1977
17.	PP-CP-phy-2	Root nodule development and physiology	Initiation, development, structure and functions of root nodules in pigeonpea and chickpea	A.R.Sheldrake P.J.Dart	1975	1977

Sub-Program : Chickpea Pathology

18.	CP-Path-1	Investigation on chickpea diseases of unknown etiologies	To investigate chickpea wilt, virus, mycoplasma and their causes and remedies.	Y.L.Nene M.P. Haware M.V. Reddy	1975	1977
19.	CP-Path-2	Disease resistance in chickpea	1. To develop remedies efficient techniques for resistance to Fusarium, Rhizoctonia, Sclerotium and other diseases 2. To screen germplasm and breeding material for resistance to different pathogens.	Y.L. Nene M.P. Haware	1975	1977

20.	CP-Path-3	Studies on Microflora associated with chick-pea seed.	To identify the microflora associated with chickpea seed and to develop techniques for their eradication.	Y.L.Nene M.P.Rawore K.M.Ahmed	1975	1977

Sub-Program : Chickpea Entomology

21.	CP-Ent-5	Pest Assessment	1. To determine the range of pests found on chick-pea 2. To obtain an idea of their relative importance 3. To characterise the damage caused 4. To obtain valid identifications of the species involved 5. To accumulate information on the seasonal abundance, behaviour patterns and plant preferences of the various pests.	S.S.Lateef J.C.Davies	1974	Annual Review
22.	CP-Ent-7	Development of screening techniques and screening of chickpea cultivars for pest resistance	To develop suitable methods for screening chickpea cultivars for pest resistance and to determine pest tolerance of chickpea cultivars included in the National program (AICPIP) under pesticide free conditions. To observe pest levels on a range of cultivars.	S.S.Lateef J.C.Davies	1975	1977

1.	2.	3.	4.	5.	6.	7.
Sub-Program : Chickpea Germplasm						
23	CP-gp-1 (72)	Maintenance and evaluation of chickpea germplasm	Maintain, evaluate, document and distribute chickpea germplasm	LJG van der Maesen	1972	Annual Review
24	CP-gp-2 (74)	Collection of Cicer germplasm and updating Cicer taxonomy	To collect, document and classify the new germplasm	LJG van der Maesen	1975	1978
Sub-Program : Chickpea Quality & Nutrition						
25	CP-Q&N-1	To improve the protein quality of chickpea	1. To select for chickpea having higher concentration of methionine, cystine and tryptophane without reducing protein. 2. To study the genetic inheritance of the material.	Umaid Singh R. Jambunathan.	1974	1978
26	CP-Q&N-2	To study factors affecting nutritional quality of chickpea	1. To assay digestibility of chickpea. 2. Fractionation of proteins of chickpea 3. Screen for protease which may be resistant to various proteolytic enzymes.	Umaid Singh R. Jambunathan.	1975	1978

Sl. No.	Project No.	Project Title	Objectives in brief	Project leader & Others	Date of start	Date of comple-tion
1.	2.	3.	4.	5.	6.	7.
PROGRAM : ECONOMICS						
Sub-Program : Marketing Economics						
1.	EC-Mark-1 (74)	Evaluation of relevant economic characteri-stics of legumes and cereals in the SAT.	Determination of economically relevant consumer preference characteristics of sorghum, millet, pigeonpea, chickpea and groundnuts.	M.von Oppen V.T.Raju C.Picha-iah	1974	1976
2.	EC-Mark-2 (75)a	Study of Market Channels of SAT crops	Determination of res-trittions to agri. development imposed by agri. markets	M. von Oppen V.T.Raju	1975	1977
3.	EC-Mark-2 (75)b	Study of market channels of SAT crops - A case study of the Rural Marketing System in Mahbubnagar District.	To explain the spatial differentiation and efficiencies of marke-ting services in rural areas; to determine the relationship between small, medium, and large farmers' market participation and their adoption of new techno-logies; to evaluate the possibilities of commercial cropping and specialisation and the limitations set by home consumption requirements, agronomic constraints and risk.	F. Pesneaud Visiting Scientist M. Von Oppen	1975	1976

1.	2.	3.	4.	5.	6.	7.
4	EC-Mark-3 (75)	Estimation of Elasticities of Supply and Demand of ICRISAT crops	To estimate regional and aggregate price responses of production, area of supply, on-farm consumption and market sunplies and demands for crops grown in the SAT with particular emphasis on sorghum, pearl-millet, pigeonpeas, chickpeas and groundnuts.	M. von Oppen	1975	1977
5.	EC-Mark-4 (76)	Agricultural Marketing, Regional specialisation and aggregate productivity.	To separate the effect of improvements in agricultural marketing on agricultural development from other development - determining factors such as new technologies, application of fertilisers and extension services, to determine the potential contribution that increased efficiency of marketing channels could have on commercialisation regional specialisation and aggregate productivity.	M. von Oppen S.L. Bapna V.T. Raju F. Pesneaud	1976	3 years
Sub-Program : Production Economics						
6.	EC-Prod-1 (74)	Studies of traditional cultivation practices and resource availabilities in SAT.	To understand the causes responsible for present farming practices and identify the physical, biological and economic constraints in SAT farming systems, to develop approaches for influencing policies for removing constraints.	J.G. Ryan N.S. Jodha H.P.Binswanger	1974	1977

1.	2.	3.	4.	5.	6.	7.
7.	EC-Prod-2 (74)	Implications of Human Nutritional Status in the SAT for Research Strategies and Govt. Policies.	1. To determine existing availability of nutrients in the diet of people living in SAT by utilising primary and secondary data. 2. To study the effect of nutritional status of farmers on labour utilisation and farming systems. 3. To compare the nutritional status of subsistence farmers with non-farmers.	J.G. Ryan Umaid Singh A.R.Sheldrake R.Jambunathan	1974	1977
8.	EC-Prod-3 (74)	Effect of Risk and Uncertainty on Farmers' Behaviour in the SAT.	1. To understand the relationship between adapatability of varieties across regions and stability over time; 2. To understand how soil moisture variability translates into yield variability at an aggregate level. 3. To characterise the extent of farm income variability in different regions of the SAT, and break it down into yield and price components. 4. To analyse the joint influence of risk and opportunity cost of credit on farmers' crop mix and input level decisions. 5. To understand farmers' adaption behaviour to risk.	H.P. Binswanger B.C. Barah	1975	1977

1.	2.	3.	4.	5.	6.	7.
	EC-Prod-4 (74)	Economic comparison of human, animal and mechanical power sources	1. Assessment of economic studies in mechanization in SAT 2. Historical study of efforts at introducing improved bullock drawn equipment. 3. Assessment of major constraints to mechanization in SAT.	H.P.Binswanger B.C. Barah	1975	1977
10.	EC-Prod-5 (74)	Economics of Prospective Technologies for SAT	To conduct economic analysis of experiments conducted at ICRISAT with a view to identify promising technologies.	J.G. Ryan K.V.Subrahmanyam	1974	1977
11.	EC-Prod-5.2(75)	Assessing the potential for water harvesting and supplementing irrigation using empirical models.	To formulate the empirical model from the results of agronomic and hydrologic experiments and crop yield data in SAT, India.	J.G. Ryan K.V.Subrahmanyam S.M. Virmani	1975	1977
12.	EC-Prod-6 (74)	History and economics of existing tank irrigation in India.	Economic Evaluation of tank irrigation systems and determination of potential for improvement.	M. Von Oppen	1974	Concluded Report is being prepared.
13.	EC-Prod-7 (75)	Approaches to Group Action and Organisation for improved land and water resource utilization in the SAT.	Examine the feasibility and means of implementation of group action and organization for improved catchment-based farm technology in SAT areas, with special reference to India. To identify those components of prospective catchment-based system which require group action and those which do not. To identify the elements for incorporation in the prospective technology which can induce group action. To identify technological and institutional alternatives to voluntary group action if the latter's transactions costs prove to be excessive.	N.S. Jodha J.G. Ryan H.P.Binswanger	1975	1977

Sl. No.	Project No.	Project Title	Objectives in brief	Project Leader & Others	Date of start	Date of completion
1.	2.	3.	4.	5.	6.	7.
PROGRAM : FARMING SYSTEMS						
Sub-Program : Agroclimatology						
1.	FS-Cl-1	Collection and interpretation of climatic data	The collection, analysis and interpretation of climatic data to classify the agroclimatic zones of the SAT.	Agroclimatologist (S.M. Virmani) J.Hari Krishna J. Kampen	1975	4 years
2.	FS-Cl-2	The moisture environment for crop grown	Determination of the moisture environment for crop growth in major regions of the SATs from climatic and soils data	Climatologist & Associates	1976	Annual Review
3.	FS-CL-3	Microclimatic elements influencing production potentials	To investigatevarious microclimatic elements which significantly influence production potentiality of various crops.	Climatologist & Associates	1976	Annual Review
Sub-Program : Hydrology						
4.	FS-hyd-1	Runoff probabilities and erosion hazards in various agroclimatic zones	To quantify the runoff probabilities and erosion hazards in the various agroclimatic zones of the SAT.	J. Kampen M. von Oppen	1976	Annual Review (1980)
5.	FS-hyd-2	Hydrologic behaviour of catchments under different management treatments.	To compare the runoff infiltration, deep percolation and soil loss characteristics of widely varying land management systems on both red and black soils.	J.Hari Krishna J. Kampen B.A.Krantz H.P.Binswanger	1975	3 years

Sub-Program : Hydrology (contd.)

6.	FS-hyd-3	Hydrologic models and simulation programs	To develop hydrologic models and simulation programs for the interpretation and extrapolation of research findings in the major agroclimatic zones of the SAT	J. Kampen J.G. Ryan	1975	Annu revie

Sub-Program: Soil Physics

	FS-SP-1	Compilation of physical characteristics data in red and black soils of ICRISAT & SAT	1.Determination of the physical properties such as mechanical composition bulk density, moisture retension characteristics etc. of surface and sub-surface soils of ICRISAT and major soil groups of SAT 2.Soil depth studies in relation to land and water management and crop production	Piara Singh B.A. Krantz J. Kampen Sardar Singh	1975	Annual review
8.	FS-SP-2	Water infiltration studies on red and black soils in various land and crop management practices	1.Determination of soil moisture characteristics of all the developed fields at ICRISAT and the major soil groups of SAT 2.To study the infiltration of water into the soil under different soil and crop management practices 3.To study the deep percolation losses in the watersheds during the rainy season	Sardar Singh J. Kampen Piara Singh	1975	Annual review
9.	FS-SP-3	Time and depth pattern of water use by important crops and cropping patterns of the SAT in both red and black soils	To determine the difference in the moisture extraction patterns of various crops & cropping patterns under optimum fertility and rainfed conditions. Also to identify the stages of greatest water requirement of crops	Piara Singh B.A. Krantz J. Kampen Sardar Singh Soil Physicist (Vacant)	1975	Annual

1	2	3	4	5	6	7
10.	FS-SP-4	Rooting patterns of important crops	1.A search would be made to find still a better method of sampling and analysis of roots particularly for lateral roots. 2.Root development of various crops would be studied in relation to other parameters such as temperature, moisture, and nutrient regimes. 3.Root interaction would be studied in different intercropping systems. 4.Root development studies would be carried out in different soil and water management treatments in red and black soil watersheds.	Sardar Singh B.A. Krantz A.H. Kassam A.R. Sheldrake	1975	Annual review
Sub-Program : Soil Chemistry & Plant Nutrition						
11.	FS-Soil-Ch.1	Chemical Properties of the major soil groups	Characterization of the chemical properties of the major soil groups of the various regions of the SAT grouping of the soils according to their fertility status based on soil analysis	T.J. Rego B.A. Krantz Sardar Singh	1975	1978
12.	FS-Soil-Ch-2	Investigations of seasonal changes in nutrient status	Monitoring of the seasonal nutrient status (with spl. reference to N), in relation to transformations, utilisation and recycling under different management practices of the watershed based research program and under varied conditions of the major regions in the SAT.	T.J. Rego B.A. Krantz P.J. Dart	1975	1978
13.	FS-Soil-Ch-3	Soil fertility management and fertilization	Answers would be sought to the following questions. 1.How best the crop residues and organic waste can reduce the need for chemical fertilizers in SAT? 2.How legumes help non-legumes when grown in association?	T.J. Rego B.A. Krantz P.J. Dart A.R. Sheldrake	1975	Annual review

13. (Contd.)		3.What are the ways to achieve maximum utilisation of soil N or P and obtain maximum efficiency of applied fertilizer N and P in SAT? 4.What is the optimum placement for efficient use of P fertilizers? 5.What improved land and water management practices help in improving the fertilizer use efficiency? 6.What are the differential nutrient requirements of new pre-release genotypes of the ICRISAT five target crops.			
14. FS-Soil-Ch-4	Nutrient losses from runoff, leaching and waterlogging	1.Investigations of nutrient losses due to runoff, leaching and water logging management regimes in watershed based research program 2.To utilize the information gathered for minimising the losses of nutrients by different cultural practices and use of chemicals	T.J. Rego J. Kampen B.A. Krantz J. Harikrishna	1976	Annual review
Sub-Program : Farm Machinery & Power					
15. FS-FM&P (fmp)-1	Available power and machinery resources; requirements for improved farming systems	Evaluation of the power and machinery resources available to traditional farmers and the power and implement requirements for improved systems of farming in the SAT.	INACTIVE	1976	Annual review
16. FS-fmp-2	Development of improved farm implements	The following projects have been taken up on priority basis: 1. Design and Development of a seed cum fertilizer drill suitable for ridge, flat and inter-row plantings. 2.Development of a tool carrier suited to watershed based technology 3.Development of a Mould Board plow for black and red soils.	Harbans Lal J. Kampen B.A. Krantz S.K. Sharma S.N. Kapoor H.P.Binswanger B.K. Sharma		

17. FS-fmp-3	Effective utilization of available power and generation of new sources of power	To improve efficiency of utilisation of available power and where necessary to generate new economically and sociologically viable power sources	INACTIVE	1976	Annual review
18. FS-fmp-4	Harvest and post-harvest technology	To develop harvesting techniques and to provide for optimum moisture utilization as well as generation of improved and viable post-harvest technology	INACTIVE	1976	Annual review
Sub-Program : Land & Water Management					
19. FS-LW-1	Resource utilization under present management practices	1.To establish the conditions under which traditional conservation measures have significant production effects and to determine these effects in a quantitative manner. 2.To evaluate the effects of traditional water storage facilities	P.N. Sharma J. Kampen	1975	Annual review
20. FS-LW-2	Improved soil conservation and land management technology	The infiltration, retention and runoff characteristics are different for red and black soils. Efforts will be made to identify the land management practices for each of these soils with the objective of creating the optimum soil and moisture conditions for plant growth	J. Harikrishna J. Kampen B.A. Krantz R.C. Sachan	1973	1978
21. FS-LW-3	Runoff collection and storage, ground water	1.To develop technically and economically superior designs for runoff collection and storage. 2.To study different types of materials and methods for controlling water losses from surface storage units. 3.To improve upon the use and development of the ground water resource on a watershed basis.	P.N. Sharma J. Kampen	1975	Annual review

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22. FS-LW-4	Techniques for conveyance and application of supplemental water	The development of technically and economically viable techniques for the withdrawal and conveyance of collected runoff water and available ground water supplies and the application of water to agricultural crops under conditions of limited water supplies	R.C. Sachan J. Kampen P.N. Sharma	1975	1978
23. FS-LW-5	Optimum use of supplemental water	1.The determination of yield-water response curves under conditions of limited water supplies. 2.The determination of single criteria for the optimum timing of life saving irrigations. 3.The determination of the quantities of water to be applied under conditions of limited supply and weather uncertainty	R.C. Sachan J. Kampen	1975	1978
24. FS-LW-6	Tillage and residue management	Determination of the effects of tillage and residue management systems upon the physical characteristics and moisture status of soil in relation to plant growth	J.Harikrishna J. Kampen Piara Singh Harbans Lal	1975	Annual review
25. FS-LW-7	Studies on evapotranspiration and leaching	1.To measure actual evapotranspiration for several rainfed crops: a.To determine evapotranspiration at different growth stages of crops as one factor in water-balance studies b.Studies to measure actual evapotranspiration and soil moisture status to derive reliable relationships between these two factors and the evaporative demand .To determine nutrient losses in the leached water	P.N. Sharma J. Kampen B.A. Krantz Sardar Singh Piara Singh	1975	1980

Sub-Program : Agronomy

26. FS-Agron-1	Cropping Systems Investigations	1. Determination of crop competition and shading upon inter-crop seedlings; 2. Determination of canopy density, rooting patterns, moisture competition, dry matter accumulation, nutrient uptake of crops at different physiological stages. 3. Investigations on geometry of planting and direction of rows. 4. Screening of potential post-monsoon relay crops for sensitivity to shading. 5. Investigations of the optimum soil management and tillage operations necessary to reduce weed population and stubble competition with the relay crop seeding. 6. Screening of sorghum and pearl millet germplasm for very high level of ratoon-ability for ratoon cropping and very low level of re-growth for sequential cropping. 7. Maintain occasional contact with breeders and/or coordinators of improvement programs of crops other than ICRISAT five for use in intercropping and relay cropping investigations.	M.R. Rao R.W. Wiley B.A. Krantz Sardar Singh V. Bhatnagar M.V. Reddy	1975	Annua Revie
27. FS-Agron-2	Steps in Technology	1. To study the effect of step-wise increments of various facets of improved technology upon crop yields in red and black soils. 2. To perform a complete economic analyses on the practices inputs and outputs involved in the implementation of various steps in technology in red and black soils.	S.K. Sharma B.A. Krantz J.G. Ryan Piara Singh T.J. Rego	1975	Annua revie

27. (Contd.)		3.To explore new production practices for possible inclusion in improved technology for the SAT.			
28. FS-Agron-3	Agronomy of new genotypes of pigeonpea, pearl millet, groundnut, chickpea and sorghum	1.To select in cooperation with the breeders and physiological pre-released cultivars for basic agronomic studies 2.To assist breeders, physiologists, entomologists and pathologists in evaluation of genotypes of the five ICRISAT target crops under intercropping and/or relay cropping conditions. 3.In cooperation with the Agroclimatologist assist ICRISAT breeders and physiologists in determining the most desirable crop duration, growth patterns, and plant morphology for the various agroclimatic regions of the SAT.	(Vacant) B.A. Krantz S.K. Sharma	1976 (acting)	Annu revi
29. FS-Agron-4	Development of Effective Weed Management Systems for the Semi-Arid Tropics	1.Developing effective alternate weed-management systems for the major SAT crops and cropping systems. 2.Studies on the nature, extent and critical period of crop-weed competition in ICRISAT's five major crops. 3.Investigations on weed ecology and management under different water, soil and crop management systems in red and black soil catchments 4.To study the possibilities of the use of herbicides in combination with other weed management systems 5.Survey of major weed flora of the semi-arid tropics 6.Studies on the biology of some noxious SAT weeds	S.V.R. Shetty B.A. Krantz J. Kampen A.R. Sheldrake S.N. Kapoor	1975	Annual review

30. FS-Agron-5	Weed competitiveness and Herbicide tolerance of different genotypes of ICRISAT's five target crops	1.To determine the competitiveness with weeds of the cultivars of sorghum, pearl millet, pigeonpeas, chickpeas and groundnuts 2.To identify the plant characteristics responsible for the competitiveness with weeds 3.To study the tolerance of these cultivars to commonly used herbicides in different soil types	S.V.R. Shetty B.A. Krantz D.J. Andrews A.K. Auckland H. Doggett R.W. Gibbons J.M. Green LJG van der Maesen K.E. Prasada Rao	1976	Annual review
31. FS-Agron-6	Evaluation of forage grasses and legumes, crop residues and trees	1.To screen a wide range of forage legumes and grasses for longevity, rapidity of regrowth, soil erosion control and production of palatable forage. 2.Screening of annual forages as catch crops following monsoon season crops on red soils and black soils during conditions or years of low moisture reserves 3.To determine the biological and economic feed value of crop residues from various crops genotypes under varying farming systems 4.To determine the place of fodder and fuel tree species on non-crop land in the Farming Systems.	Forage Agronomist B.A. Krantz J. Kampen P.J. Dart S.K. Sharma	1976	Annual review
Sub-Program : Farming Systems Entomology					
32. FS-Ent-9	Intercropping Entomology	To ascertain the pest numbers and damage caused to pigeonpeas under different intercropping and agronomic systems	V.S. Bhatnagar J.C. Davies	1975	1977
33. FS-Ent-10	Heliothis incidence and specific identity	To study the biology and obtain information on crop and alternative hosts of heliothis	V.S. Bhatnagar J.C. Davies	1974	1977

1.	2.	3.	4.	5.	6.	7.
34.	FS-Ent-11	Influence of special distribution and intercropping on insect pests, with special reference to Heliothis on pigeonpea.	To study the incidence of dynamics of pest species on pigeonpea	V.S.Bhatnagar J.C. Davies	1975	1977
35.	FS-Ent-12	Pest incidence in target crops in the SAT.	To ascribe some order of priority to the pests in different countries on these crops. To make up pest lists and reference lists on the various species.	J.C. Davies All Entomologists		

Sub program : Farming System Pathology : Projects form part of Pulses & Cereals

Sub-Program : Farming System Microbiology: Projects yet to be formulated.