MR. L.J. HARAVU

# RESOURCE MANAGEMENT PROGRAM

Program of In-House Review

September 21-25, 1987

BOOK 1

## RESOURCES AND CONSTRAINTS

ICRISAT

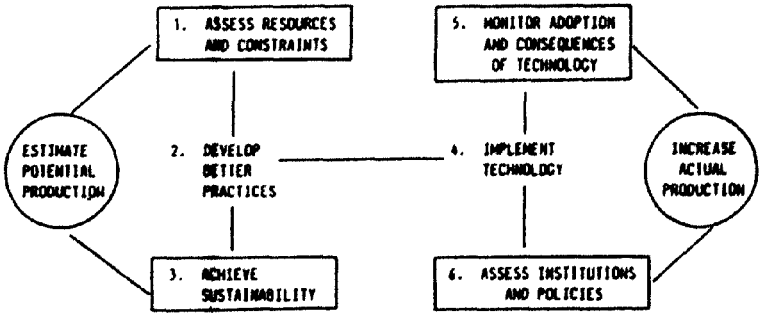
International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

**RESOURCE MANAGEMENT PROGRAM**

**In-house Review, September 21-25, 1987**

## RESOURCES AND CONSTRAINTS

ORGANOGRAM OF RMP RESEARCH THRUSTS



# ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number: RM-104(84)IC

2. Project Title: Characterisation of the moisture environment of SAT.

3. Project Scientist(s): S.M. Virmani
A.K.S. Huda
Piara Singh
M.V.K. Sivakumar

4. Period covered by report (Month/Year): Feb. 86 - Sept. 87

5. Summary of Progress Report:

Sub-project 1. Variability of rainfall and its impact on crop production in the SAT.

Last year we studied rainfall variability of groundnut growing areas of West Africa. This work has been extended to other SAT areas in Eastern and Southern Africa, and India.

Brief results:

The average coefficient of variation of annual rainfall in the SAT is between 20 and 30%. Our recent work shows that there are two types of variations in rainfall. These are: (a) a declining trend in annual rainfall subsequently resulting in lower average rainfall values. For example in the Sahel the annual rainfall isohytes have shifted by about 100 km to the south. In parts of Ethiopia (Debre-Marcos area), the annual rainfall has decreased from a mean of about 1600 mm in the fifties to about 1200 mm in the last few years. In Southern India our cooperative work with Krishnan has shown that the rainfall variability has increased during the recent past. b) In Southern Africa (Botswana) an oscillatory trend in annual rainfall has been found. A series of 7 - 10 low rainfall years are followed by a series of relatively high rainfall years.

Conclusions:

1. Decreasing average rainfall generally means shorter and more variable growing season. As a strategy the work on intercropping and watershed based soil and water management will have to be emphasized in areas where a decreasing trend in rainfall has been recorded. Sivakumar has worked out a package of tactical decisions for the choice of crops suitable for the Sahel in relation to the date of onset of rainy season.

2. In SAT areas having oscillatory variability of rainfall

cropping systems" work emphasizing the propotionate cropping [e.g., maize and sorghum] in relation to the wet or dry year series is indicated.

3. The water balance work has shown that the impact of decreasing rainfall or oscillatory variability of rainfall on crop yield is much less in soils with (100 - 150 mm) holding capacities compared to soils with lower holding capacities. An integration of precipitation and soil maps is necessary for defining food security of different SAT areas

Sub-project 2. Water availability periods and the length of crop growing season of selected locations of India.

This work was taken up in 1984-85. Water availability periods and the length of crop growing season of over 220 locations of India have been computed. An analysis of the locations selected by the Oilseed Technology Mission of the Government of India to identify climatic and soil related constraints is in progress. An example of results is attached.

6. Publications:

Virmani, S.M. 1987. Climate and food security. Strategies for coping with climatic fluctuations and change - cropping systems. Paper presented at the International Symposium on Climate Variability and Food Security, organized by INSA, AAAS, ICAR, IRRI, 6-9 Feb 1987 at New Delhi, India. [Proceedings under preparation].

Virmani, S.M. 1987. Agroclimatology of Vertisol areas of Africa. Paper presented at the Conference on Livestock and the Improved Management of Dark Clay Soils in Africa held at ILCA headquarters at Addis Ababa, 31 Aug - 4 Sep 1987. [Proceedings under publication].

Huda, A.K.S., Seetharama, N., and Virmani, S.M. 1986. Management of agricultural drought with special reference to soil water availability and water requirements of dryland crops in India. Jal Vigyan Sameeksha 1:153-170. (ICRISAT JA No.666).

Huda, A.K.S., Sekaran, J.G., and Virmani, S.M. 1987. Applications of computers for using agroclimatic data in agricultural planning. Pages in Proceedings of All India Seminar on "Computer as a Tool for Improving Agricultural Productivity", 5-7 Nov 1986, organized by the Dept. of Agriculture, Govt. of Andhra Pradesh, Hyderabad, India. Oxford IBH Publishing Co., (In press). (ICRISAT CP No.337).

Huda, A.K.S., and Virmani, S.M. 1987. Effects of variations in climate and soil water on agricultural productivity. Pages 36-55 in 'The Effects of Climatic Variations on Agriculture in Dry Tropical Regions of India', Vol. 2. Assessments in Semi-Arid Regions. Reidel, Dordrecht, The Netherlands. (ICRISAT JA No.673).

7. Work plan for the next year:

Assessment of climatic variability for eastern African countries, and SADCC countries will be carried out. The application of climatic indexing work to relate it to economic parameters of dryland technology will be finalised.

AGROCLIMATIC ANALYSIS OF SOME SELECTED DISTRICTS ADOPTED BY THE NATIONAL OILSEEDS DEVELOPMENT PROJECT FOR THE INTENSIFICATION OF RAINY SEASON GROUNDNUT PRODUCTION IN INDIA

Total number of districts selected by National Oilseed Development Project

185

Districts selected for rainy season groundnut production

46

Districts for which agrometeorological data are available at ICRISAT.

21

Districts where only limited irrigations required (130 growing season secured in 8 out of 10 years).

11

Ranchi (Bihar)
Bhavnagar (Gujarat)
Bolgaum, Gulbarga (Karnataka)
Chindwara (Madhya Pradesh)
Jolgaon, Osmanabad (Maharashtra)
Puri, Cuttack (Orissa)
Tiruchirapalli, Salem (T.Nadu)

Main problems:

Water-logging
Nutrients
Diseases

Districts where high yields are possible with irrigated agriculture (130 growing season secured in 5 out of 10 years).

10

Anantapur, Kurnool, Cuddapah, Mahbubnagar (Andhra Pradesh)
Rajkot, Jamnagar (Gujarat)
Chitradurga, Bijapur, Raichur (Karnataka)
Coimbatore (Tamil Nadu)

Main problems:

Crop establishment
Mid-season drought
End season drought
Harvesting
Nutrients
Plant protection
Diseases

## TRAINING PROJECT PROPOSAL

1. Project No: TR-RM-XXX(87) Linked Project Nos: RM-102(84)IC
   RM-104(84)IC

2. Project Title(s): (1) Microclimatic environment of groundnut crop;

   (2) Identification of efficient agroclimatic zones for groundnut in Gujarat state.

3. Project Location: ICRISAT Center, Patancheru

4. Project Scientist(s): In-Service Post-Doctorate Fellow [Dr. A.M. Shekh]

   S.M. Virmani
   A.K.S. Huda
   Piara Singh

5. Cooperating Scientist(s): R.C.N. Rao
   J.L. Monteith

6. Date to Start: October, 1987

7. Date of Completion: September, 1988

8. Objectives and Scope: (1) To quantify the effect of microclimate on growth and yield of groundnut genotypes. (2) To test and validate PNUTGRO model. (3) To analyse meteorological data of Gujarat state for determining agroecological potential for groundnut production in parts of the state.

9. Expected contribution of this project to ongoing approved research: (1) Dr. Shekh is one of the cooperators for modeling of groundnut crop. His working closely with us will help in collection of reliable data sets. (2) Microclimatological data collection of groundnut crop will be speeded up.

10. Anticipated Supervisor(s): A.K.S. Huda
    Piara Singh

## ICRISAT RESEARCH PROJECT OUTLINE

1. Project Number: RM-145(87)IC

2. Old Project Number:

3. Program: Farming Systems

4. Discipline(s)/Subprogram(s):

5. Project Title: Characterization and grouping of the different sets of sorghum growing environments in Eastern Africa based on agro-climatic data.

6. Project Locations:

   India Patancheru Kenya Ethiopia Uganda Rwanda Burundi Somalia Sudan Yemen AR PDR Tanzania

7. Scientific Staff Names:

   (a) Discipline/Subprogram Leader Names:

   | | |
   |---|---|
   | S.M. Virmani | (SMV) |
   | V. Guiragossian | (VG) |

   (b) Project Scientist Names:

   | | | Scientist-Years |
   |---|---|---|
   | S.M. Virmani | (SMV) | |
   | V. Guiragossian | (VG) | 0.10 |

   (c) Cooperating Scientist Names:

   | | |
   |---|---|
   | J. Rutto | (JR) |
   | Y. Kebede | (YK) |
   | M. Zake | (MZ) |
   | A. Alio | (AA) |
   | M.A. Mahmoud | (MAM) |

   (d) Supporting Staff:

   Research Associate(s)
   Field Assistant(s)
   Field Attendant(s)

8. (a) Date of Start: 1987

   (b) Years Revised:

   (c) Year of Completion: 1989

9. **Objectives and Scope:**

Identify and group sorghum growing environments with similar zones of adaptation in different agro-ecological zones in Eastern Africa.

10. **Keywords:**

Agro-climatic data
Eastern Africa
Adaptation zones
Agro-ecological zones
Environment

11. **Technique in brief (Methodology):**

1. Collection of agro-climatic data elevation, latitude, longitude, minimum and maximum monthly temperatures during the growing seasons and rainfall distribution, duration and amount, for each station found within different ecological zones of each country in the region. Agroclimatic data available at ICRISAT Center. Analysis of the data by ICRISAT scientists at the Center (Dr. S.M. Virmani). Grouping of similar zones of adaptation. 2. Cluster techniques and computer based pattern, analysis techniques will be used for grouping the stations with 'similar' climate. Water balance method will be utilized to determine the length and characteristics of the growing season. This would allow integration of climatic and soil characteristics in a crop relevant index.

12. **Source of Funds:**

13. **Cost Estimates: (Direct)** 1987 1988 1989

Operational (recurring)

(a) Labor

(b) Travel

(c) POL

(d) Supplies

TOTAL

Capital (non-recurring)

Indirect Costs

14. Land Requirements (ha)

Location

15. Review of past background and present status:

Almost all the major sorghum ecological zones found worldwide are present in eastern Africa. Currently classification is based on elevations above sea level - high elevation (above 1800 m); intermediate elevation (between 1500 m - 1800 m); low elevation (below 1500 m). a) Very dry lowland, b) Humid erratic lowland. Movement of sorghum germplasm within the region using this classification has not been very effective. As a result, the Advisory Committee of EARSAM network felt the need to group similar sorghum growing environments in eastern Africa based on agro-climatic data. References: 1. Brown, C.H. and J. Cocheme. 1969. Agroclimatology of the highlands of Eastern Africa. WMO Technical Bulletin. 125. 2. FAO, 1984. Agroclimatological data. Volume I and II Africa. Food and Agriculture Organization of the United Nations. Rome.

16. Existing linkage with other centers or research projects:

Linkages in this project is mainly among national programs of Eastern Africa and ICRISAT Center.

17. Likely future course of development:

Future promising varieties will be tested in similar adaptation zones.

18. Availability of training facility:

Training in agroclimatic analysis in relation to ICRISAT mandate crops will be given to the national scientists of the eastern and southern African region. Facilities for this purpose exist.

## ICRISAT Research Project Outline

(NEW)

1. **Project Number:** RIM - [ ] [ ] [ ] (87) [ ]

2. **Old Project Number:** [ ]

3. **Program:**

4. **Discipline(s)/Subprogram(s):** Agr / [ ] / [ ] / [ ] / [ ]

5. **Project Title:** Characterization of agroclimatic environments for growing sorghum with particular emphasis in SADCC region

6. **Project Locations:**

| | | | | |
|---|---|---|---|---|
| IC | India | ICRISAT/SADCC | Matopos | Zimbabwe |
| | | | | |
| | | | | |

7. **Scientific Staff Names:**

(a) **Discipline/Sub-Program Leader Names:**

| | | |
|---|---|---|
| S.M. | Virmani | (SMV) |
| L.R. | House | (LRH) |
| C. | Renard | (CR) |
| | | ( ) |
| | | ( ) |

(b) **Project Scientist Names:**

| | | | Scientist-Years |
|---|---|---|---|
| A.K.S. | Huda | (AKSH) | 0.4 |
| M. | Osmanzai | (MO) | 0.1 |
| S.M. | Virmani | (SMV) | 0.1 |
| M.V.K. | Sivakumar | (MVKS) | 0.1 |
| | | ( ) | |

(c) **Cooperating Scientist Names:**

| | | |
|---|---|---|
| C.K. | Ong | (CKO) |
| P. | Singh | (PS) |
| J.L. | Monteith | (JLM) |
| N. | Seetharama | (NS) |
| A.B. | Obilana | (ABO) |

(d) **Supporting Staff:**

| | |
|---|---|
| Research Associate(s) | 0.3 |
| Field Assistant(s) | 0.2 |
| Field Attendant(s) | 0.2 |

8. (a) **Date of Start (mo/yr):** 09/1987

(b) **Years Revised :** [ ] [ ] [ ] [ ] [ ]

(c) **Date of completion (mo/yr):** 08/1992

**Objectives and Scope: (10 lines maximum)**

Overall:

i) To define environments in terms of production potential of sorghum.
ii) To identify sorghum adaptation zones.
iii) To hypothesize alternate agronomic practices.

Priority:

i) Characterization of drought pattern and intensity for a few selected locations as suggested by ICRISAT/SADCC Program.

**). Keywords: (Maximum 7)**

Agroecological zoning
Sorghum model
Agronomy
Crop adaptation

**). Technique in brief (Methodology): (15 lines maximum)**

1) Data: Collect and computerize relevant data on climate (rainfall, temperature, radiation, pan evaporation), soils (water holding capacity, depth, texture, classification) and crop performance (yields of specified cultivars) and agronomic (time of sowing, plant density) management (irrigated/rainfed, plant protection, nutrient).
2) Data source: Some of these data are available with the respective national/regional/international institutes. Data from breeding and agronomy regional and international trials will be useful.
3) Analysis: a) Simple agroclimatic analysis (rainfall distribution, dry period occurrence, length of growing season, extreme temperatures).
b) Use of crop models of different orders depending on the data availability to relate environments to crop production potential and to suggest alternate agronomic practices.
c) Analysis of multilocation trial data in order to verify suitability of genotypes in a region.

h. Source of Funds: | | | | | | | | | |

i. Cost estimates: (Direct) 19 19 19

Operational (recurring)

| | | | |
|---|---|---|---|
| (a) Labor | | | |
| (b) Travel | | | |
| (c) POL | | | |
| (d) Supplies | | | |
| TOTAL | | | |
| Capital (non-recurring) | | | |
| Indirect Costs | | | |

j. Land requirements (ha)

Location

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

k. Review of past background and present status: (20 lines max.)

This is a new project proposed to use our experiences mainly from the Indian region to characterise agroclimatic environments in SADCC countries. Sorghum and millets are important cereals in that region and the SADCC/ICRISAT program has been working on the improvement aspects of these two cereals. The growing season there is usually from October/November to March/April. There has been large variation in climate and soils. Data on climate and soils are available with the national programs of these countries. Few reports on agroclimatological work have been published by FAO and by the national programs e.g., in Zimbabwe, Botswana, and Mozambique. We have climatic data from several locations in Botswana and Malawi. Climatic data of Botswana have been analysed by us. For carrying out specific analyses, we have to approach the concerned institutions in the respective countries.

xisting linkage with other centers or research
rojects: (8 lines maximum)

his is an inter center project (ICRISAT/Patancheru, ICRISAT/Sahelian
enter, and ICRISAT/SADCC). We need to strengthen the links between
CRISAT and the respective national/regional institutes.

ikely future course of development: (8 lines maximum)

he project will be subject to periodic reviews and modified in the
light of findings, progress and interactions. We plan to conduct
cooperative interdisciplinary experiments at a few well defined
environments to collect minimum data on crops, soils, weather, and
management for agroecological zoning and crop adaptation work.

vailability of training facility: (4 lines maximum)

Training facilities will be available. In-service trainees from the
SADCC countries may be encouraged. We are expecting a scientist from
Malawi by the end of 1987 to carry out climatic data analysis
cooperatively.

Project Scientist  Group Leader  Program Director

APPROVED

Date: _____  Director of Research

## ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. **Project Number** : RM 502(86) IS

2. **Project Title** : Characterisation of drought frequencies and drought probabilities in West Africa

3. **Project Scientist(s)** : M. V. K. Sivakumar (MVKS)

4. **Period covered by the report (Month/Year)** :

   From: May 1984 To: August 1987

5. **Summary of Progress Report** :

**Computation of the average dates of beginning and ending of rains, the length of the growing season and the associated variability for different locations in West Africa.**

We defined the date of onset of rains (X) as that date after 1 May when rainfall accumulated over 3 consecutive days is atleast 20 mm and when no dry spell within the next 30 days exceeds 7 days. The date of ending of rains (Y) is taken as that after 1 September following which no rain occurs over a period of 20 days. Length of growing season (Z) is taken as the difference (Y-X).

A program to compute the average dates of beginning and ending of rains, the length of the growing season and the associated standard deviations has been developed for use on the microcomputer as well as the main frame. We have used daily rainfall data updated till 1984-86 for locations with a minimum of 30 years data in Niger, Mali and Burkina Faso. For several stations in Niger and Burkina Faso the beginning of rains at the drier Sahelian locations is delayed by 20-30 days as compared to the higher rainfall locations in the Sudanian climatic zone. Standard deviation of beginning of rains is also higher at the drier locations. Ending of rains is less variable as reflected by lower standard deviations. These differences in the beginning and ending of rains result in large differences in the length of the growing season. Standard deviations of the length of growing season show that in dry years the length of the growing season could be very short, specially in the Sahelian zone.

We have observed a strong association between the date of onset of rains and the length of growing season. Early onset of rains, relative to the computed mean date of onset for a given location, resulted in a longer growing season. For the computed series of X, Y and Z for a given location we have used the Kolmogorov-Smirnov test for goodness of fit of a specified distribution. For all the locations tested, the parameters X, Y and Z followed a normal distribution.

We computed probabilities of growing season lengths for early, normal and delayed onset of rains. Results for selected locations (Table 1) show that an early onset of rains offers a longer growing season while delayed onset results in considerably shorter growing season.

The implications of the above analysis are that crop management tactics in the Sahelian zone may have to be altered depending upon the onset of rains. We developed a methodology termed "Weather-responsive Crop Management Tactics" that combines the knowledge from the analysis of historical rainfall data with current weather to make changes in the management tactics depending on the onset of rains. The first field test of this methodology was carried out during the 1986 rainy season at ISC and we continued this test during the 1987 rainy season. Results from the 1986 season (Table 2) as well as the preliminary results from the 1987 season suggest that in years with early onset of rains, it is possible to harvest two rainfed crops in a relay crop of millet-cowpea thereby ensuring an effective exploitation of the long growing season. During years with delayed onset of rains, short duration cultivars should be sown.

**Characterization of the length of wet (or dry) spells and their probabilities during the crop growing season to evaluate the drought risks to millet and sorghum in West Africa.**

Procedures for computation of dry spells available in the literature are often based on a monthly calendar. Results of these analyses have only limited value for specific applications to sorghum and millet in West Africa since sowing dates of these crops and crop phenology change with rainfall distribution each year. To overcome this problem, we used the specific definition of onset of rains in each year as the sowing date and computed the length of dry spells (or days until next day with rainfall greater than a threshold value) at different probability levels.

Dry spell lengths at 90% probability level for Niamey, Niger (mean annual rainfall 560 mm), Kaolack, Senegal (800 mm), Ouagadougou, Burkina Faso (830 mm) and Sikasso, Mali (1300 mm) are shown in Figure 1. These data show that dry spells in the emergence to panicle initiation phase (upto 20 DAS) are more probable than those during panicle initiation to flowering phase (20-60 DAS). At Niamey, the length of dry spells increases with time after 90 DAS. Kaolack and Ouagadougou with nearly similar mean annual rainfall show important differences in the length of dry spells. The length of dry spells becomes progressively longer after 100 DAS at Kaolack and after 120 DAS at Ouagadougou.

Since the dry spell analysis shown in Figure 1 is based on the computed date of sowing for each year of rainfall records available, these data could be used as a guide for

the various maturity durations of varieties to breed in different locations. At Niamey, breeding strategies should be oriented towards maturity in 80-90 days, for Kaolack 100 days, for Ouagadougou 110-120 days and for Sikasso 140 days.

6. Publications

(i) Sivakumar, M.V.K. 1986. Agroclimatological considerations in sorghum improvement research in West Africa. Paper presented at the Regional Workshop on Sorghum Improvement, 21-24 October 1985, Bamako, Mali.

(ii) Peacock, J.M. and M.V.K. Sivakumar. 1986. Screening for drought resistance in sorghum (Sorghum bicolor (L.) Moench) with particular reference to Sub-Saharan Africa: Role of environmental physiology. Paper presented at the International drought symposium on food grain production in the semi-arid regions of sub-saharan Africa, Nairobi, Kenya, OAU/SAFGRAD.

(iii) Sivakumar, M.V.K. 1986. Analyse des probabilites de secheresse - Application en amelioration et a la production du sorgho et du mil en Afrique au sud du Sahara. Pages 116-128 an Seminaire sur "l'Assistance de la Climatologie et l'Agrometeorologie a l'Agriculture", 16-17 octobre 1986, Bouake, Cote d'Ivoire.

(iv) Sivakumar, M.V.K. 1987. Predicting rainy season potential from the onset of rains in the Sahelian and Sudanian Climatic zones of West Africa. Agricultural and Forest Meteorology 28 (in press).

7. Work plan for the next year

(i) In collaboration with the scientists at the USDA Cropping Systems Research Laboratory at Lubbock, Texas, we propose to develop methodologies to consider the influence of temperature in the calculation of drought spells.

(ii) After accomplishing work plan (i), we propose to submit the results of this project for publication as an Information Bulletin.

(iii) In view of items (i) and (ii), we propose to extend this project with its present title till 1989, at which time a new project on exploiting the potential of the rainy season will be submitted.

Table 1. Probabilities of growing season length exceeding specified durations for variable onset of rains for selected locations in the Bokoliga zone.

| Location | Mean annual rainfall (mm) | Average growing season (days) | Date of beginning of rains: 20 days early — Length of growing season exceeding 75 | 85 | 115 | 135 | 10 days early — 75 | 85 | 115 | 135 | Average — 75 | 85 | 115 | 135 | 10 days late — 75 | 85 | 115 | 135 | 20 days late — 75 | 85 | 115 | 135 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bosso | 810 | 89 | 100 | 88 | 52 | 2 | 100 | 88 | 14 | 0 | 88 | 48 | 2 | 0 | 88 | 14 | 0 | 0 | 87 | 0 | 0 | 0 |
| Niamey | 866 | 84 | 100 | 88 | 49 | 1 | 98 | 81 | 7 | 0 | 88 | 89 | 0 | 0 | 81 | 7 | 0 | 0 | 81 | 2 | 0 | 0 |
| Tahoua | 388 | 78 | 100 | 85 | 21 | 0 | 100 | 82 | 1 | 0 | 84 | 17 | 0 | 0 | 82 | 1 | 0 | 0 | 38 | 0 | 0 | 0 |
| Zinder | 482 | 88 | 100 | 87 | 27 | 0 | 100 | 88 | 3 | 0 | 86 | 23 | 2 | 0 | 89 | 3 | 0 | 0 | 46 | 0 | 0 | 0 |

Table 2. Grain and hay yields (kg $ha^{-1}$), water use (mm) and water use efficiency (kg $ha^{-1}$ $mm^{-1}$) of millet-cowpea sequential cropping system, ISC, Niger, 1986 rainy season.

| Treatment | Millet | | | | | Cowpea | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grain yield | Straw yield | Water use | Water use efficiency | | Grain yield | Hay yield | Water use | Water use efficiency | |
| | | | | Grain | Straw | | | | Grain | Hay |
| Irrigated | 1730 | 4100 | 398 | 4.4 | 10.3 | 50 | 680 | 237 | 0.2 | 2.9 |
| Rainfed | 1210 | 3650 | 374 | 3.2 | 9.8 | 5 | 420 | 223 | -- | 1.9 |
| SE | ±100 | ±410 | ±7 | ±0.31 | ±1.2 | ±10 | ±10 | ±4 | | ±0.05 |
| CV (%) | 10 | 15 | 3 | 12 | 17 | 50 | 3 | 3 | | 3 |

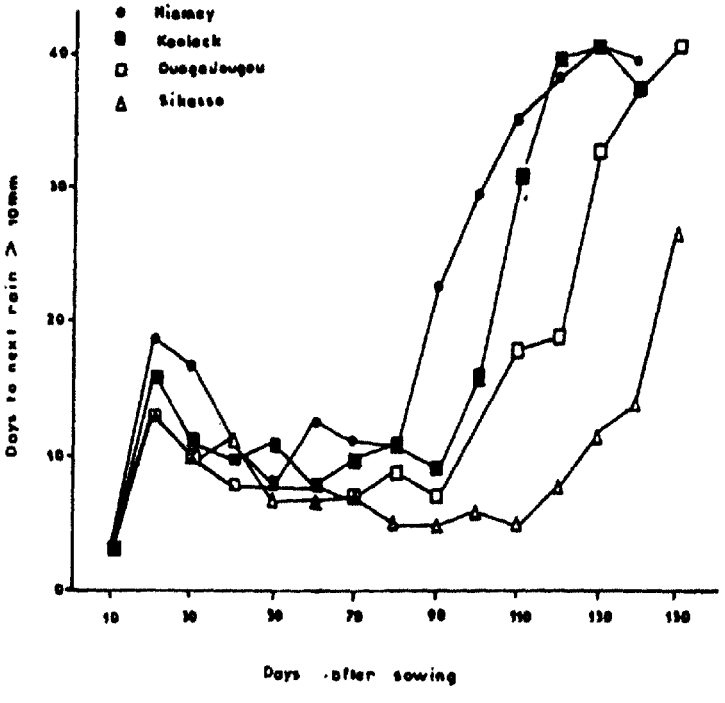



Figure 1. Number of days until the next rainfall greater than 10mm (at 90% probability level) at selected locations in West Africa.

## ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number : RM 504(86) IS

2. Project Title : Multilocation Water Balance Studies in Niger

3. Project Scientist(s) : M. V. K. Sivakumar (MVKS)

4. Period covered by the report (Month/Year) :

   From: May 1984 To: August 1987

5. Summary of Progress Report :

**Effect of fertilizer and location on the water use, growth and yield of millet**

Millet was grown at Sadore (mean annual rainfall 560 mm), Dosso (640 mm) and Bengou (840 mm). We applied N, P and K at 45, 20 and 25 kg/ha or no fertilizer; bare soil was an additional treatment. At the three sites selected neutron access tubes have been installed and soil water balance, growth and yield data were collected during 1984, 1985 and 1986.

There were significant differences in the rainfall distribution at the three locations over the three years. At all the three locations, drymatter accumulation patterns were different and fertilizer treatment significantly increased the dry matter production. For example, during 1985 total drymatter production and its accumulation in different plant components increased from Sadore to Bengou (Fig. 1) and was significantly influenced by the fertilizer treatment. An important consequence of the use of fertilizers is increased water use efficiency (WUE). Early vigorous growth builds up a larger canopy that shades the ground early in the season, when a significant proportion of the water is lost through soil evaporation, and helps in effective and efficient use of the scant rainfall. At three locations substantial increases in WUE were observed with the use of fertilizer (Table 1). Significant enough, the order of magnitude of increase in the WUE with fertilizer use was greatest at Sadore where the seasonal rainfall was the lowest of the three locations. Increases in water use efficiency due to fertilizer were 334% at Sadore, 208% at Dosso and 152% at Bengou.

**Evaluation of water use, growth and yield of millet, sorghum, groundnut, millet/groundnut, and millet/cowpea at Bengou in Southern Niger**

At Bengou where the mean annual rainfall is 840 mm and soils have a higher clay content, since 1986 we have been studying the water use, growth and yield of five different cropping systems-- millet, sorghum, groundnut,

millet/groundnut and millet/cowpea. During 1986, rainfall at Bengou was 866 mm and there were periods with substantial amounts of drainage from the soil. In the absence of tensiometric data, it is difficult to calculate the drainage beyond the root zone. During the 1987 rainy season, studies on the relationship between volumetric water content and tension for the two soil types at Bengou are under way and these data will be used to compute drainage in the water balance equation. Hence water use data for the results from the 1986 season are not presented here.

Grain and fodder yields for different cropping systems with and without fertilizer at Bengou for the 1986 rainy season are presented in Table 2. In absolute terms, of the different component crops, sorghum gave the highest grain and fodder yields, both with and without fertilizer. However as a cropping system, millet/cowpeagave the best returns.

6. Publications

NIl

7. Work plan for next year

I) Rainy season 1987 is the final season of field trials in this project. During 1987-88, we will evaluate the available soil water balance models for effective simulation of water balance in the sahel region using the soil-crop-climatic data. After this phase this project will be terminated.

II) Using the data collected in this project, we will develop predictive equations relating the response of millet to rainfall and other climatic factors.

**Table 1. Water use (WU), grain yield (Y) and water use efficiency (WUE) for pearl millet grown at 3 sites in Niger during rainy season 1985.**

| Site | Rainfall (mm) | Treatment | WU (mm) | Y (kg $ha^{-1}$) | WUE (kg $ha^{-1}$ $mm^{-1}$) |
|---|---|---|---|---|---|
| Sadore | 543 | Fertilizer | 382 | 1570 | 4.14 |
| | | No fertilizer | 373 | 460 | 1.24 |
| Dosso | 583 | Fertilizer | 400 | 1700 | 4.25 |
| | | No fertilizer | 381 | 780 | 2.04 |
| Bengou | 711 | Fertilizer | 476 | 2230 | 4.68 |
| | | No fertilizer | 467 | 1440 | 3.08 |

**Table 2. Grain and fodder yields (kg $ha^{-1}$) of different cropping systems with and without fertilizer, Bengou, rainy season 1986.**

| Treatment | Grain yield | | Fodder yield | |
|---|---|---|---|---|
| | + Fert | - Fert | + Fert | - Fert |
| Sole sorghum | 2980 | 1430 | 7130 | 4680 |
| Sole millet | 1720 | 1090 | 5610 | 3690 |
| Sole groundnut | 1580 | 1480 | 170 | 170 |
| Millet/groundnut | | | | |
| Millet | 1630 | 1370 | 6070 | 4070 |
| Groundnut | 250 | 240 | 90 | 80 |
| Millet/cowpea | | | | |
| Millet | 1580 | 1100 | 5230 | 3080 |
| Cowpea | 1430 | 750 | 1710 | 1390 |
| SE (±) | 94 | | 280 | |
| CV (%) | 18 | | 22 | |

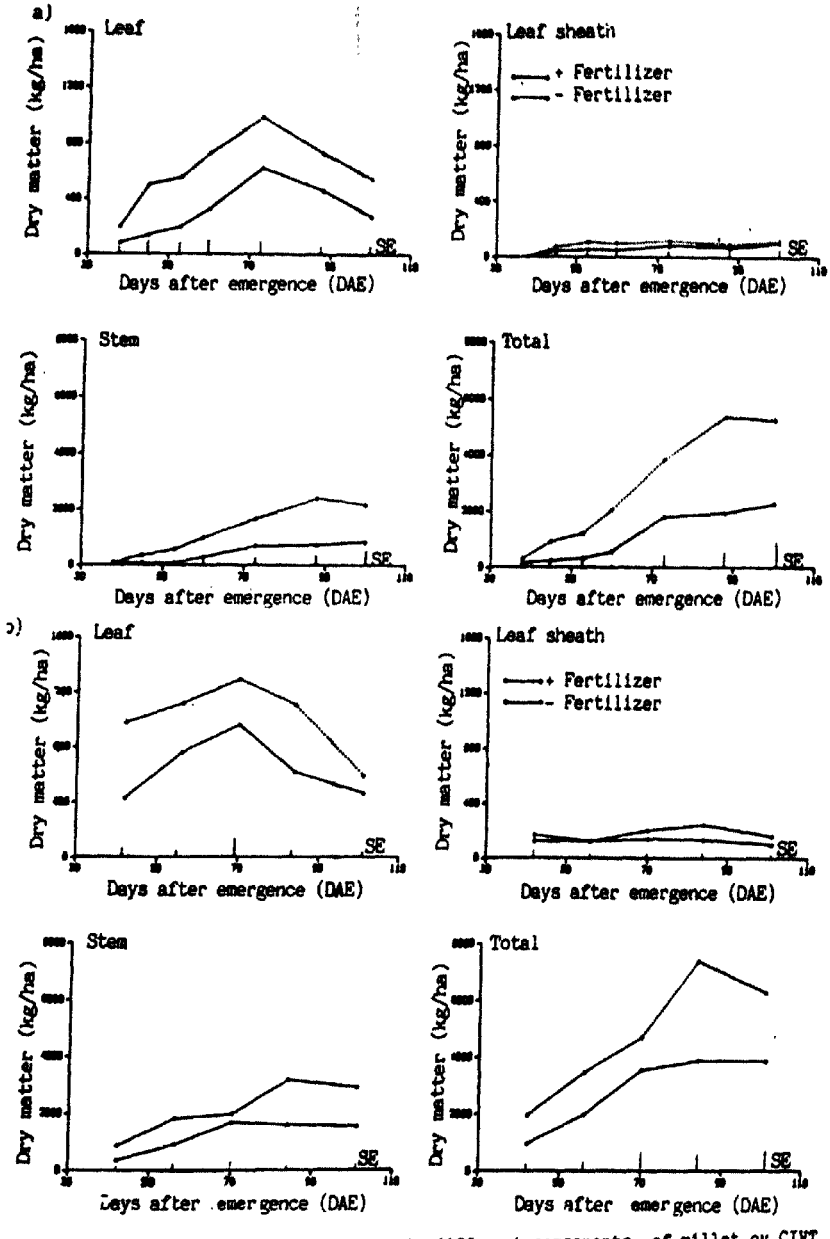
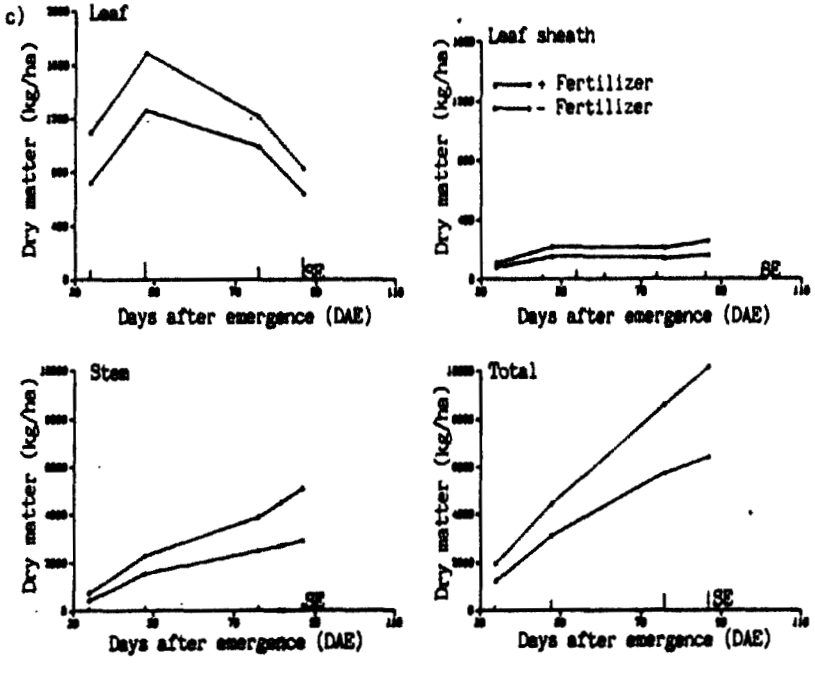



Figure 1. Dry matter distribution in different components of millet cv CIVT at (a) Sadoré, (b) Dosso and (c) Bengou, all in Niger, rainy season 1985.

Figure 1. Contd.



## ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number : RM 506(86) IS

2. Project Title : Measurement and prediction of actual evaporation from sparse dryland millet crop

3. Project Scientist(s) : J. S. Wallace (JSW)
Institute of Hydrology
M. V. K. Sivakumar (MVKS)

4. Period covered by the report (Month/Year) :

From: Sep 1985 To: August 1987

5. Summary of Progress Report :

**Testing new instrumentation (the 'HYDRA') for the direct measurement of actual evaporation.**

We made direct measurement of actual evaporation over the millet crop using the new instrument the "Hydra" which employs the eddy correlation technique. The new version of the Hydra was designed to minimize the effects of temperature induced drifts in the humidity and vertical wind speed signals and also reduce the high frequency flux losses. A comparison of the cumulative flux of available energy (Rn-G) with the cumulative sum of sensible and latent heat fluxes (H + E) before (25 September 1985) and after (6 October 1985) the harvest of millet, showed that evaporative flux recorded by the Hydra before harvest amounted to 93% of (Rn-G), while after harvest the Hydra continued to record fluxes equivalent to nearly all the available energy. The flux recovery ratio, (H+E)/ (Rn-G) was consistently close to unity (Fig. 1b) with a mean value of 0.98(±10%).

During the comparatively wet 1986 rainy season, evaporation from the millet crop was quite variable. Actual evaporation ranged from around 90% of the PE on days following substantial rains to about 50 percent of PE in drier soil.

**Estimation of the transpiration component of the total crop evaporation and direct measurement of the soil component of total evaporation using soil lysimeters.**

We estimated the transpiration component of the total crop evaporation using the Penman-Monteith equation from porometry measurements of stomatal conductance, aerodynamic resistance, leaf area index, and weather data. Continuous measurements of hourly average weather data were made using two automatic weather stations. Data stores were transferred to floppy discs on a microcomputer, which was programmed to

produce an hourly summary of weather data and a daily total value of potential evaporation. Direct measurement of the soil component of total evaporation was made using soil lysimeters located within the crop. We measured comparatively high stomatal conductances, despite the extremely high atmospheric demand. On a day when the soil was wet (19 September 1985), and potential evaporation was very high (8.3 mm), transpiration increased steadily during the day reaching a maximum in the afternoon. Immediately following the rain, soil evaporation was high, between 2 and 2.5 mm/day, while one week later, it was less than 0.5 mm/day. Cumulative soil evaporation was linearly related to the square root of time elapsed since the last rain storm (Fig. 1).

Comparison of the total evaporation measured by the Hydra and that calculated from porometry and lysimetry on two clear days, one with wet and the other with dry soil, showed that when the soil was wet the agreement between the two methods was very good while in the drier soil, Hydra gave higher rates of evaporation.

**Measurement of hourly soil heat flux using heat flux plates and hourly soil temperature profiles**

We made hourly measurements of soil heat flux and soil temperature profiles. Soil heat flux increased rapidly in the morning, reaching very high values of 150 $w/m^2$ by midday. Soil temperature increased by 23[ C at 0.5 cm soil depth, but both the amplitude and the phase of the temperature wave decreased with depth in the soil. Soil heat flux is a large component of the energy balance of the sparse millet crop and therefore cannot be ignored or assumed to be a specific fraction of net radiation.

After rain, evaporative fluxes were twice the sensible heat fluxes while on days when the soil surface was dry, almost equal amounts of energy were apportioned to evaporative, sensible and soil heat fluxes.

**Measurements of photosynthesis and plant water status**

We measured photosynthesis and plant water status in the leaves and seed head using a portable IRGA, a pressure chamber and an osmometer respectively. Stomatal conductance was highest in the flag leaf and other upper leaves and was maintained for a substantial part of the day. Leaf photosynthesis also followed a very similar pattern with the highest rates usually occurring in the flag leaf. Gas exchange measurements on the panicles showed high respiration rates particularly at the early seed filling stage. Water vapor loss from the panicles was greatest in the newly emerged panicles and decreased as the panicles aged. Plant water potential measurements showed a clear gradient of water potential up the plants with the most negative values occurring in the panicles and flag leaf. These results

suggest that the upper leaves maintain stomata open and photosynthesis proceeds although under greater water stress than leaves lower down on the plant. These leaves would then be the major source of photosynthate used for grain filling.

6. Publications

(1) Wallace, J.S., Gash, J.H.C., McNeil, D.D., and Sivakumar, M.V.K. 1986. Measurment and prediction of actual evaporation from sparse dryland crops. Scientific Report No. OD149/3, Institute of Hydrology, Wallingford, U.K.

7. Work plan for next year

This project will continue till the 1987 crop season. After data analysis and report writing, this project will be terminated by December 1988.

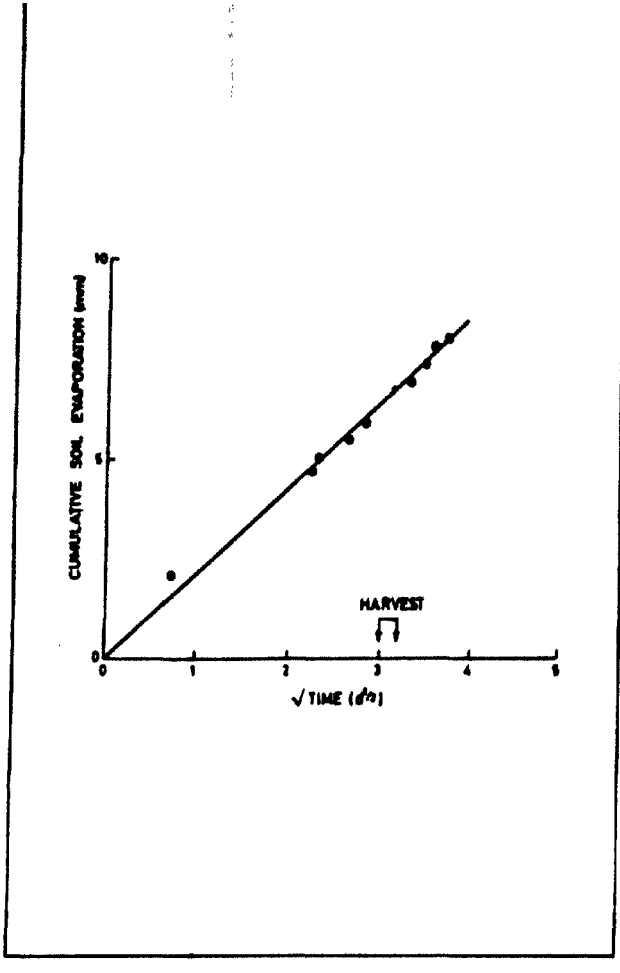



Figure 4. The relationship between cumulative soil evaporation and the square root of time since the last rain storm.

New Project under consideration

## ICRISAT Research Project Outline

1. **Project Number:**

2. **Old Project Number:**

3. **Program:** Resource Management

4. **Discipline(s)/Subprogram(s):** Engineering

5. **Project Title:** Studies on crusting and sealing on Alfisols under simulated and natural rainfall.

6. **Project Locations:** ICRISAT Centre,

7. **Scientific Staff Names:**

   a) Discipline/Sub-Program Leader Names:

| | | |
|---|---|---|
| Laryea | K.B. | KBL |

   b) Project Scientist Names:

| | | | Scientist-Years |
|---|---|---|---|
| Sachan | R.C. | RCS | 0.30 |
| Pathak | P. | PP | 0.15 |
| Laryea | K.B. | KBL | 0.10 |

   c) Cooperating Scientist Names:

| | | |
|---|---|---|
| Singh | Sardar | SS |
| Srivastava | K.L. | KLS |

   d) Supporting Staff:

| | |
|---|---|
| Research Associate(s) | 0.5 |
| Field Assistant(s) | 1.0 |
| Field Attendant(s) | 0.5 |

8. a) Date of Start (mo/yr) 6/1987

   b) Years Revised
   c) Date of completion (mo/yr) 6/1990

9. **Objectives and Scope:**

   1) Study soil texture effects on crusting and sealing and its implications for hydrologic process on Alfisols

   2) Evaluate ameliorative practices (tillage, crop covers, mulches, sand admixtures) for use on crusting and sealing soils.

3) Develop quantitative relationships between soil constituent properties, rainfall characteristics, crop and soil managment practices and surface structural stability in terms of infiltration, runoff and surface roughness.

10. Keywords: (Maximum 7)

Alfisols
Crusting
Sealing
Texture
Tillage
Physical properties
Hydrologic process

11. Technique in brief (Methodology):

The main experiment will consist of a factorial combination of three sandy soil textures (75%, 85% and 95% sand), and three rain intensities in combination with (a) crust breaking tillage (b) crop cover (c) mulch, and (d) other ameliorants such as inorganic and organic amendments. Assessemtns will be made under simulated rain using the rotating disc simulator. Limited studies under natural rain will allow correlation between the effects of each rain type and cover types with crop cover. Soil properties and processes to be measured include infiltration, runoff rate and soil erosion in relation to rainfall intensities. Soil crusting and hard setting (bulk density, strength and water content relationships), sorptivity and conductivity of the crusted layer. Curst composition will be studied using wet sieving and microscopic examiniation of this sections.

12. Source of Funds: ICRISAT Core

13. Cost estimates: (Direct)

| | 1987 | 1988 | 1989 |
|---|---|---|---|
| Operational (recurring) | | | |
| a) Labor | 2,000 | 2,000 | 1,000 |
| b) Travel | | | |
| c) POL | 1,000 | 1,000 | 1,000 |
| d) Supplies | 3,000 | 3,000 | 1,000 |
| TOTAL | 6,000 | 6,000 | 3,000 |
| Capital (non-recurring) | 1,000 | 500 | - |
| Indirect Costs | | | |

14. Land requirements (ha)

Location: RP 19B 0.5 Ha

15. Review of past background and present status:

Extensive areas in semi-arid region have soils of low structural stability and are known for their tendency to form seals and crusts at the surface. Crusts impede seedling emergence reduce water infiltration, and air movement. since rainfall is very erractic and unpredictable in SAT, a rainfall simulator has been used in ISRAEL on loessial soils and in Mali on aggregated Alfisols and some semi-arid temperature countries. Quantitative studies on crust related to nonaggregated Indian soils are lacking. Therefore it is not possible to expalin the results or to transfer the result of another soil or climate. There is need to evaluate to evaluate the crust behaviour and its effects on hydrologic processes and to test alternative means for crust management. The responses to various means can be used to develop a quantitative approach to processes involved in crust behaviour and its management to other environment.

16. Existing linkage with other centers or research Projects:

No direct linkage have been established yet but they shall be established in due course particularly with mentor organisation, working on closely related soils and environments.

Efforts will be made to establish linkages with other ICRISAT Center Projects on Alfisols and with CRIDA projects studying crust management.

17. Likely future course of development:

The project will be subject to periodic reviews and modifications. At the end of 3 years, findings could be used for another project or to extend the approach to evaluate the management alternatives on field scale plots and for other soils and environments.

18. Availability of training facility:

In service training on crust and characterisation and hydrologic process will be available. Management alternatives would be useful for extension. A Research Scholar will be sought for studying crust genesis and hydrologic process modelling.

Project Scientist Sub-Program Leader Program Leader

APPROVED

Date:

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Director of Research

## Collaborative Projects

**Project No. TR-RM-5(87) (Linked to Project No. RM-130(85)IC**

**Project Title:** Physical and hydraulic properties relevant to in-situ soil-water management of Vertic Inceptisols and Alfisols

**Name of the Scientist responsible for the project:** K.B. Laryea

**Duration:** 1 year

Date of Start: 1987
Date complection:

**Objective and scope:**

The Vertic Inceptisols cover about 27.8 million hectares and constitute 37% of the total land area occupied by the black soils in India. The profile is very gravelly. The standard techniques for quantifying physical and hydraulic properties are for homogenous soils. A review of the literature indicates that nobody has as yet attempted to examine the suitability of these techniques for the gravelly soils like Vertic Inceptisols or Alfisols. We need to examine a variety of these methods and modify them to measure accurately the physical and hydraulic properties of these gravelly soils. The objectives of this project therefore are to:

i. Compare known methods and select those suitable for measuring the bulk density (and hence volumetric water content), soil moisture potential, hydraulic conductivity-water content relationship, soil water diffusivity, sorptivity, and infiltration rate in the field.

ii. Use the various infiltration equations for homogenous soils already published in literature (e.g., Philip 1969 equation, Talsma-Parlange 1972 equation, etc) and determine if the sorptivity and saturated hydraulic conductivity measurements can predict the infiltration characteristics of the gravelly soils.

**Source of funds:** ICRISAT

**Progress so far:**

**Remarks:** Arrived on August 9, 1987. The project has just been started.

## ICRISAT Research Project Progress Report

1. **Project Number:** RM-132(84)IC

2. **Project Title:** Quantifying inherent site characteristics for predicting and controlling soil erosion by water in the SAT.

3. **Project Scientist(s):** S. Singh
P. Pathak

4. **Period covered by report (Month/year):** March 1986 to May 1987

5. **Summary of Progress report:**

The progress of work for 1984 and 1985 was presented in the last In-house Review in May 1986. The present report is the extension of that and covers the period of last year rainy season.

The data on total runoff and sediment concentration for each storm was collected from the bare fallow plots in both Alfisols and Vertisols.

The individual rainfall storms were characterized for total rain, intensity and duration, kinetic energy, erosivity indices and peak intensities.

The rainfall during 1986 was below normal. Only 506 mm and 487 mm rain were received in BW3 and RW3 respectively. The majority of storms came in <20mm/hr intensity and only few storms produced runoff.

Rainfall intensities at ICRISAT Center are low; lower than in the SAT West Africa with a comparable climate like Mali or Niger.

The highest storm intensity recorded for 15 minute period was 88 mm/hr on February 13, 1986 in Bw3 and 80 mm/hr on August 11, 1986 in RW3.

The annual total kinetic energy calculated by Hudson's method was 78.6 MJ/ha/mm in BW3 and 75.3 MJ/ha/mm in RW3.

The erosivity indices calculated for 15,30,45 and 60 minutes period were less than 25, indicating that the period under review was not very erosive year. This had an effect on runoff and soil loss.

In general, the soil loss from the bare fallow plots were related to the steepness. Soil losses increased with plot length.

Mild slopes (0.4,0.8,1.6,3%) on our plots did not appreciably influence runoff losses. Runoff per unit area decreased with increase in plot length.

6. Publications: Nil

7. Work plan for the next year:

The work as planned will continue. New multislot structures will be installed in half of the plots in the two soils to collect and sample runoff and sediments. The data collected from the two types of structures will be compared. Mathematical model based on rainfall events will be tested using the data from previous years.

1. Project Number : RN 510 (86) IS

2. project Title : Sources and Management of nitrogen fertilizers

3. Project Scientist : Andre Bationo

4. Period covered by report : From May 1982
On-going

5. Objectives

a) To assess the performance of different sources of nitrogen fertilizers under appropriate management systems

b) To assess the values of point placed as compared with banding and broadcasting

c) To construct 15N balances in order to determine the fertilizer N uptake and losses that occur with different N sources under different management systems

d) To determine the effect of various soil and agroclimatic factors on the performance of N fertilizers.

6 Summary of progress report.

In the traditional farming system, with shifting cultivation, farmers were able to maintain stable productivity but population pressures and desertification have forced farmers away from this traditional shifting cultivation and fertility declines becomes more severe.

Although it is recognized that phosphorus is the most limiting nutrient in the semi arid West Africa a significant response to N is often obtained (Fig. 1). The strength of the response to N can vary greatly depending on the N source used, the method and timing of its application, and the rainfall.

Urea and Calcium ammonium nitrate (CAN) are among the most common sources offered for sale in Niger. In an experiment designed to compare the efficiency of banded N applied as urea (URSP Bd) or CAN (CANSP Bd) against urea applied using deep-point placement near the plant (USPG) little difference was found between treatments even though the response to N was strong (Fig.1).

Because of the low amounts of moisture available to the crop, wide spacing ( 1 x 1 m) is employed in the planting of millet it was therefore postulated that urea may not be efficiently used by the plant if not placet near it. Attempts to improve N uptake by deep point placing urea near the plant reulted in poor efficiency due to severe volatization lossess. In the nitrogen balance using 15N, it was found that losses of N were very high and in the case of point placed urea, exceeded 50%

of the nitrogen applied. An average of 24.6% of the applied N was taken up by the plant as a whole of this 10.3% of the fertilizer N was found in the grain. Thus the efficiencies of the fertilizers used in term of uptake by millet were very low (Table 1).

Table 1. Recovery of 15 N in the Millet Plant and Soil at Harvest, Sadori, 1983.

| Treatment | 15 N Recovery (%) | | | |
|---|---|---|---|---|
| | Grain | Plant | Soil | Loss |
| Check | - | | | |
| CAN split band | 13.0 | 28.8 | 34.2 | 37.0 |
| Urea split band | 9.8 | 22.8 | 39.2 | 38.0 |
| Urea point placed | 8.0 | 22.0 | 25.3 | 52.5 |
| | 10.3 | 24.6 | 32.8 | 37.4 |
| LSD (.01) | 1.6 | 3.2 | 3.4 | 2.2 |

a. Total recovery in grain and stover fraction.

Note. 15 N fertilizer applied at 30 kg N/ha.

At harvest, the distribution of fertilizerN in the soil was determined and most of the N left in the soil was found to be in the surface 0-15 cm horizon. The abscence of N at depth further indicates only limited N leaching.

In an attempt to improve spatial availability of the N without promoting N volatization CAN and Ammonium sulfate (AS) (which does not readily volatize) were used in deep-point placement (CANG and ASG). This was compared to urea deep-point placement (USG) urea surface point placement (US) (a farmer's method dof N appli-cation), and broadcast application of all three N sources (ASBi, URBI and CAN BU). A strong response to N was found (Fig. 2). The three broadcast treatments yields similar rsponse curves and were not different from the urea deep point placed. Little response was found to N applied using the farmer's method of surface point placement indicating that most of the N applied in this manner was probably due to volatilization. Point placement of AS (ASG) and CAN (CANG) resulted in significantly improved yields probably because the soil environment around the plant was rich in a fertilizer N, some which was not succeptible to volatization.

In the Sudanian zone of Niger where annual rainfall is about 800 mm, sorghum becomes an important crop. An experiment was started since 1985 to compare thee effectiveness of urea supergranule hill placed (UG) and CAN hill placed (CANG) compared to urea broadcast (UBI) and urea banded (UBd). The 15 N data are still not ready but little difference was found between N source

and methods of application.

7. Publications

Christianson, B. A. Bationo, and P.L.G. Vlek, 1985. Fate and Efficiency of nitrogen fertilizers in sub-sahara Africa. Agronomy abstracts Chicago Illinois

Fussell, L.K., P.G. Serafini, A. Bationo and M.C. Klaij 1986. Management practices to increase yield and yield stability of peral millet in Africa. Paper presented at the International Pearl Millet workshop held at ICRISAT Patancheru, Andhra Pradesh, India. In Press.

Mughogho, S.K., A. Bationo, B. Christianson and P.L.G. Vlek, 1986. "Management of nitrogen fertilizers for tropical African soils" In Mokwunye, A.U. and Vlek, P.L.G. (eds) Management of nitrogen and phosphorus fertilizers in sub-sahara Africa. Martinus Nijhoff Dordrecht, the Netherlands.

Bationo, A., Christianson, C.B. and Mokwunye, A.U. 1987. Soil fertility Management of the millet producing sandy soils of sahelian West Africa: the Niger experience paper presented at the workshop on soil and crop Management systems for rainfed agriculture in Soudano-Sahelian zone. Niamey, Niger January 11-16, 1987 In Press.

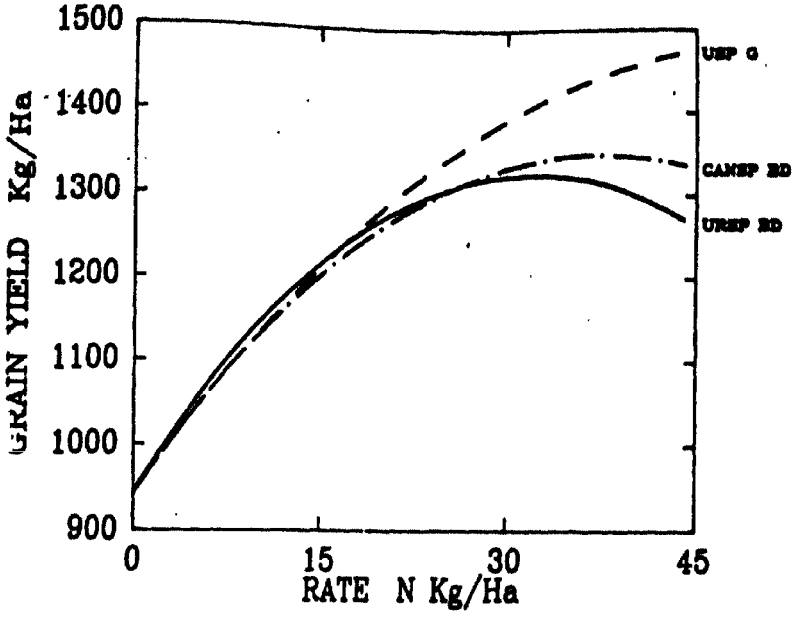
Christianson, B., A. Bationo and J. Henao 1987. Nitrogen fertilizer efficiency in millet growing areas in Niger Agronomy abstracts. New orleans Louisiana.

8. Workplan for next years.

a) Work on N loss mechanism and means to alleviate them

b) Modeling millet response to N

c) Contribution of legume (Cowpea or groundnut) in N cycle for rotation with millet.

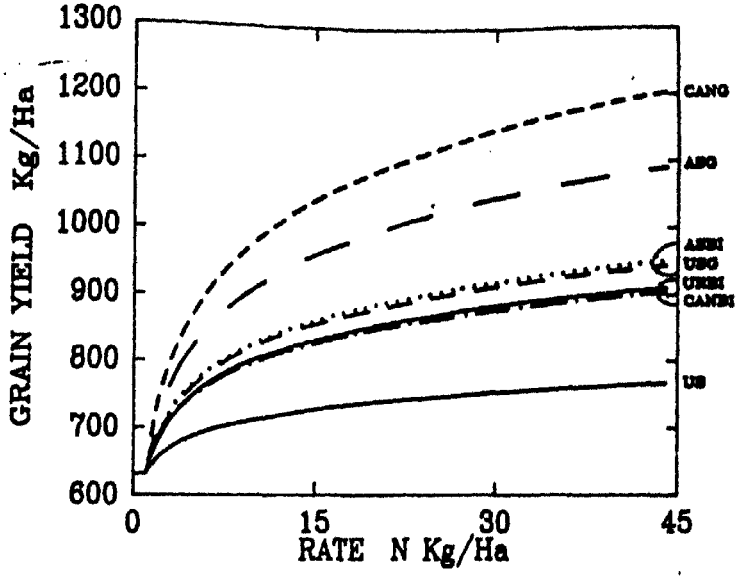



$$\hat{Y} = 942 + 23.95\ USPBd - .37\ USPBd^2 + 21.22\ USPG - .21\ USPG^2$$

$$+ 21.81\ CANSPBd - .29\ CANSPBd^2$$

$$R^2 = .27 \qquad S.E. = 101$$

Figure 1 Effect of Different Sources, Rates, and Methods of Application of Nitrogen on Millet Grain Yield (Sadore 1985).




$$\hat{Y} = 631 + 73.74 \ln UBI + 82.97 \ln UG + 72.02 \ln CANBI + 151.25 \ln CANG$$

$$+ 84.76 \ln ASBI + 121.69 \ln ASG + 35.92 \ln UB$$

$R^2 = .27$ S.E. = 133

Figure 2. Effect of Different Sources, Rates, and Methods of Nitrogen Application on Millet Grain Yield (Gobery 1985).

1. Project Number : RM 511 (86) 1S

2. Project Title : Sources and management of phosphorus fertilizers

3. Project Scientist : Andre Bationo

4. Period covered by report: From May 1982
On-going

5. Objectives

a) To provide basic data on the amounts of nativephosphorus in the soils and to quantify the transformations invoving native and applied phosphorus

b) To carry out agronomic research with the aim of providing information on the external and internal phosphorus requirements of major crops under prevailing farming systems

c) To develop management practices for a more efficient utilization of phosphorus fertilizers.

d) To characterize develop and improve indigenous phosphate resources where available as substitutes for expensive imported fertilizers.

6. Summary of progress report

For over 50 years investigators have observed that lack of phosphorus constitutes a major constraint to crop growth in semi arid West Africa.

The sandy soils of semi arid West Africa are very low in available nutrients and in the millet-growing region of Niger available P as measured by Bray 1 extraction hardly exceeds 3 mg/kg soil. These sandy soils have a low capacity to absorb phosphates and results-ecological zones have shown that as little as 20 kg $P_2O_5$/ha can more than double the yield of millet as compared with yields from unfertilized land.

One of the objectives was to assess the potential of indigenous phosphate rock (PR) to satisfy the phosphorus needs of crops. Niger has two deposits of phosphate rock (PR) one is Tahoua (T) and a second is the Parc-W (W). Direct application of indigenous ground phosphate rock can be an economic alternative to imported commercial phosphorus fertilizers. PRT and PRW were compared to commercial single superphosphate (SSP). The less reactive PRW was 48 % as effective agronomically as SSP while the more reactive to PRT was 76% as effective as SSP. (Fig. 1).

Agronomic effectiveness of PR is governed by the rock's physical, chemical and mineralogical characteristics. One means sto utilize unreactive rocks is to increase the plant-available

phosphorus by chemical conversion to a partially acidulated phosphate rock (PAPR) product. The term PAPR refers to a phosphate rock that has been treated with only a portion of the acid (sulfuric or phosphoric) required to fully convert the insoluble tricalcium phosphate to water-soluble form-monocalcium phosphate monohydrate (MCP). Thus, the term PAPR50 indicates that 50% of the acid required to produce a fully acidulated superphosphate is use to make the product. PAPR products may be attractive to produces because less acid is used, resulting in significant saving in foreign exchange. For example, the factory-gate cost of $P_2O_5$ obtained from sulfuric based PAPR is estimated at about 80% of that obtained with SSP.

Sulfuric acid-based PAPR products using parc-W PR have been tested in several field trials. Results show that Parc-W PAPR50 is almost as effective agronomically as commercial superphosphate (Fig. 2). Present results strongly indicate that this less expensive product can adequately meet the phosphorus needs of the crops with the potential of savings the nation substantial sums in foreign exchange. An advantage of the low phosphorus retention capacity of these sandy soils is the high residual effects of phosphorus fertilizers even when applied at low rates.

In 1986 trials managed entirely by the farmers were initiated at Gobery to test a promising package of fertilizer input and its interaction with farm management practices in order to optimize millet production.

Twenty farmers were selected to participate, each farmer, being a replicate. The following treatments were used.

a) Control
b) 30 kg $P_2O_5$/ha as SSP broadcast and incorporated
c) 30 kg $P_2O_5$/ha as SSP and 30 kg N/ha as urea, both broadcast and incorporated
d) 30 kg $P_2O_5$/ha as SSP hill placed and 30 kg N/ha as urea hill placed
e) 30 kg $P_2O_5$/ha as PAPR 50 and 30 kg N/ha as urea both broadcast and incorporated

Table 1 shows that millet yield can be increase up to 270% under farmers' management. PARP50 performed as good as single super phosphate. The method of application of nitrogen and phosphorus did not have a significant effect on grain yield. Also, application of fertilizers improved both plant establishment and tillering very significantly.

## 7. Publications

Bationo, A. Ugo A. Mokwunye and C.A. Baanante. 1985. "Agronomic and Economic evaluation of alternative phosphate fertilizer sources in Niger" in Appropriate Technologies for farmers in

Semi-Arid West Africa Herbert Ohm and Joseph G. Nagy eds. International Program in Agriculture Purdue University.

Fussell L.K., P.G. Serafini, A. Bationo, and M.C. Klaij 1986. Management practices to increase yield and yield stability of pearl millet in Africa. Paper presented at the International Pearl Millet workshop held at ICRISAT, Patancheru, Andhra Pradesh, India. In Press.

Bationo, A., S.K. Mughogho and Mokwuney, A.U. 1986. Agronomic Evaluation of phosphate Fertilizers in Tropical Africa" in A.U. Mokwunye and Vlek, P.L.G. (eds) Management of nitrogen and phosphorus fertilizers in sub saharan Africa, Martinus Nijhoff, Dordrecht, the Netherlands.

Bationo, A. Chien, S.H. and Mokwunye, A.U. 1986. Chemical characteristics and Agronomic values of some phosphate rocks in West Africa. Paper presented at the International Symposium on Drought in sub saharan Africa. Nairobi, Kenya, May 19-23, 1986. In Press.

Bationo, A., Christianson, C.B. and Mokwunye, A.U. 1987. Soil fertility Management of the millet producing sandy soils of sahelian West Africa: the Niger experience paper presented at the workshop on soil and crop Management systems for rainfed agriculture in Soudano-Sahelian zone. Niamey, Niger January 11-16, 1987 In Press.

Christianson, B., A. Bationo, and J Henao 1987. Nitrogen fertilizer efficiency in millet growing areas in Niger Agronomy abstracts. New Orleans Louisiana.

Bationo, A. Mokwunye, A.U. Henao, J. and D.T. Hellums. 1987. The use of phosphate rock to build up phosphorus fertility in a West African entisol. Agronomy abstracts New-Orleans Louisiana.

Table 1. Effect of different sources and method of fertilizers application on millet grain yield, density and tillering (Gobery 1986).

| Treatment | Grain yield (kg/ha/) | Density (pockets/ha) | Tillering (tillers/pocket) |
|---|---|---|---|
| Control | 320 | 3390 | 3.8 |
| SSP30 Bl N30 Bl | 860 | 4580 | 5.9 |
| PARP30 Bl N30 Bl | 860 | 5850 | 4.6 |
| SSP30 hp N30 hp | 760 | 5090 | 5.2 |
| SSP 30 Bl | 730 | 4650 | 5.1 |
| SE | ±41 | ±193 | ±0.3 |
| CV (%) | 27 | 18 | 25 |

+ SSP 30 Bl N30 Bl = 30 kg P205/ha as single super phosphate broadcast and incorporated and 30 kg N/ha as urea broadcast and incorporated.

PARP 30 Bl N30 Bl = 30 kg P205/ha as Parc-W partially acidulated phosphate rock at 50% broadcast and incorporated.

SSP 30 hp N30 hp = 30 kg P205/ha as single super phosphate hill placed and 30 kg N/ha as urea hill placed.

SSP 30 Bl = 30 kg P205/ha as single super phosphate broadcast and incorporated.

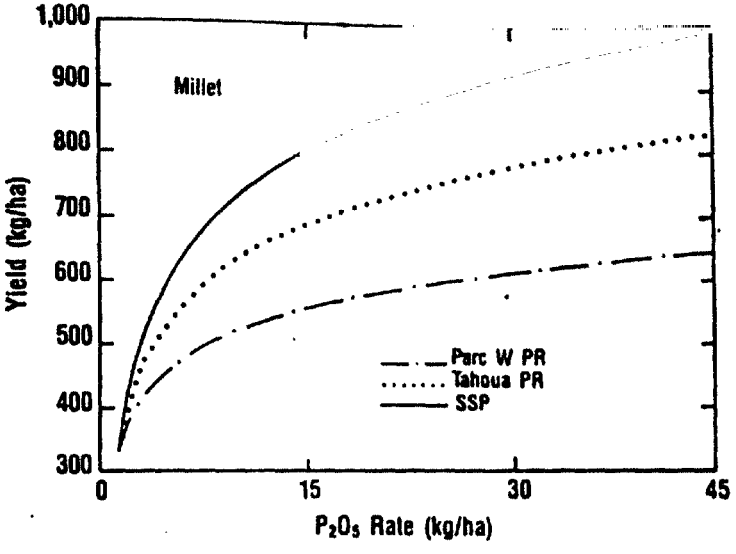
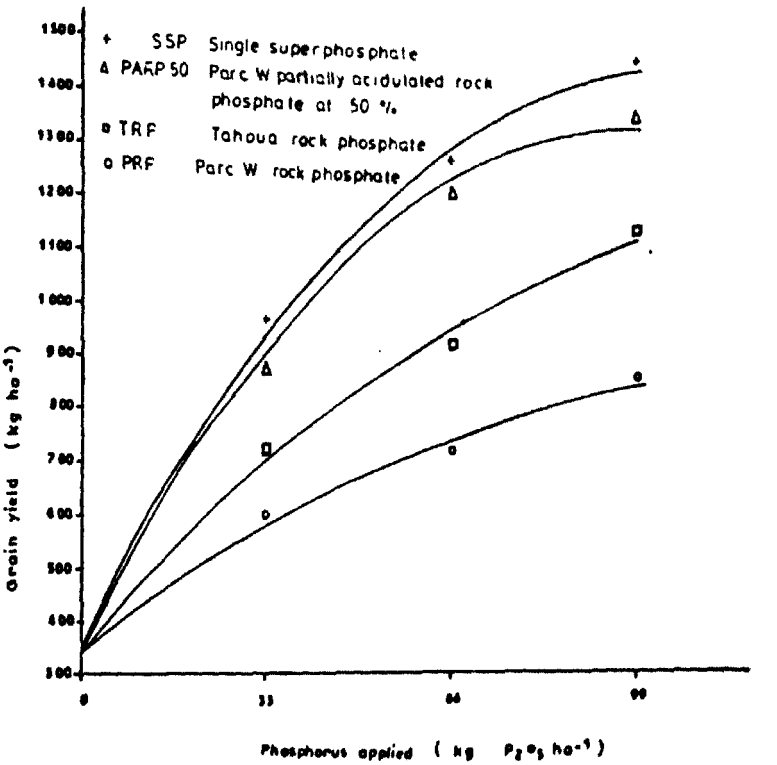



Figure 1. Millet Grain Yield Obtained With Two Phosphate Rocks (PR) and Single Superphosphate (SSP) at Gobery in Niger. Adapted from Bationo et al (1985).




+ $Y = 347 + 11.80\,SSP - .0450\,SSP^2$ R = .88 rse = 193

Δ $Y = 339 + 8.10\,PARP50 - .0269\,PARP50^2$ R = .81 rse = 162

□ $Y = 366 + 20.56\,TRP - .1094\,TRP^2$ R = .84 rse = 277

○ $Y = 347 + 21.11\,PRP - .1008\,PRP^2$ R = .88 rse = 277

**Figure 2.** Effect of phosphorus sources and rates of application on pearl millet grain yield ( kg $ha^{-1}$ ) Gobery, Niger, rainy season 1986.

ICRISAT RESEARCH PROJECT PROGRESS REPORT

Project Number: RM-123(84)IC

Project Title: Characterization of chemical and biological properties of selected Vertisols and Alfisols.

Project Scientist(s): K.L. Sahrawat

Period covered by report (Month/Year): May 1986-September 1987

Summary of Progress Report:

1. Phosphorus

i. Measurements of the sorption of isotopically exchangeable and non-exchangeable phosphate in surface samples from an ICRISAT Alfisol and Vertisol were done in colloboration with G.P. Warren and P.H. LeMare, at the University of Reading (U.K.). Adsorption isotherms were determined for total adsorbed and isotopically exchangeable phosphate (P-32). The Vertisol had a much greater adsorption capacity for phosphate than the Alfisol. However, all the added P was isotopically exchangeable with P-32 in both soils. Although Vertisol took up P more strongly and had a higher capacity for P adsorption, all this P remained in the forms that were exchangeable with P-32 indicating that all the added P remained potentially available and was not adsorbed in unavailable form.

ii. The above results support the field and laboratory results obtained at ICRISAT Center, which indicated that Vertisols have a low sorption capacity for phosphorus.

iii. The above results led to the initiation of field experiments at ICRISAT Center to compare the residual effects of phosphorus on an Alfisol and a Vertisol.

2. Nitrogen

Urea hydrolysis rates were studied in the laboratory to provide a basis for predictions of rates in the field. Rates of hydrolysis increase with urea concentration up to 2000 mg urea/kg soil, at field capacity. Studies to determine the hydrolysis rates in the field are being made under a training project (TR-RM-03).

6. Publications:

JA 307 Rao, J.K., Sahrawat, K.L., and Burford, J.R. 1987.

Diagnosis of iron deficiency in groundnut, Arachis hypogaea L. Plant and Soil 97(3):353-359.

Sahrawat, K.L. 1986. Recent developments in urease and nitrification inhibitors. Pages 85-97 in Soil Biology: proceedings of the National Symposium on Current Trends in Soil Biology, 25-27 Feb 1985, Hisar, Haryana, India. Hisar, Haryana, India: Haryana Agricultural University (CP 219).

Sahrawat, K.L., Rao, J.K. and Burford, J.R. 1987. Elemental composition of groundnut leaves as affected by age and iron chlorosis. J. Plant Nutrition 10 (in press) (CP 304).

7. Work plan for next year.

Sorption studies will be made on other Vertisols to assess variations in their P-sorption capacity.

## COLLABORATIVE PROJECTS

**Project No.** TR-RM-03 **Linked Projects Nos.** RM123(84)IC

**Project title:** Rates of nitrogen transformations associated with the hydrolysis of urea in Alfisols and Vertisols.

**Collaborating institute:** APAU

**Scientists**

a) Collaborating Institute: G.W.L. Jayakumar
(M.V. Shantaram)
A. Shivaraj

b) ICRISAT: K.L. Sahrawat
J.R. Burford

**Duration**

a) Date of start: 1985
b) Date of completion: 1988

**Objectives:**

To determine the rates of hydrolysis of urea, and accumulation of ammonium and nitrate, in Vertisols and Alfisols in the field.

**Source of funds:** ICRISAT

**Progress so far:**

The field experiments conducted so far on the Alfisol and Vertisol have shown that urea hydrolysis rates measured in the field are very low (< 1mg/kg soil/hr) and are much lower than the rates commonly recorded in laboratory incubations (5-20 mg/kg soil/hr). Current experimentation is examining the causes.

**Remarks.**

Initial progress was hindered by equipment breakdown.

# ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number: RM-140(85)IC

2. Project Title: Assessment of atmospheric pollutants at ICRISAT Center and their implications for crop growth

3. Project Scientist(s): K.L. Sahrawat, J.A. Wightman, C.K. Ong, J.R. Burford, Piara Singh

4. Period covered by report: May 86 - Sept. 87

5. Summary of Progress Report:

   1. The report by a consultant, Mr. N.J. Colls of Nottingham University (February-March, 1986) confirmed the desirability of assessing the importance of atmospheric pollution at ICRISAT Center.

   2. The main identified source of pollution is the 'Pratap' steel-recycling plant, located to the north-east of ICRISAT Center. Importance given to known pollutants is: high--particulate emissions; moderate--sulphur dioxide; (probably) low--nitrogen oxides (NOx); probably not important--carbon dioxide.

   3. The selection and means of aquisition of the appropriate specialized equipment is underway.

   4. Measurements of the composition of rainwater at ICRISAT Center over the current reporting period are in agreement with measurements made in earlier years. The annual deposition is about 8-9 kg sulphate-S/ha and 6-8 kg inorganic-N/ha. N.J. Colls' preliminary opinion was that these depositious were of a regional nature, and were not related to localized pollution sources.

6. Publications: Nil (one in preparation, by the consultant)

7. Work plan for next year:

   Extension of project is sought to allow time for acquisition of equipment.

## ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number: RM-141(84)IC

2. Project Title: Behaviour of phosphorus in soils

3. Project Scientist(s): K.L. Sahrawat

4. Period covered by report (Month/Year): May 86 - Sept. 87

5. Summary of Progress Report:

   Medium-term (3-year) field experiments have been commenced on an Alfisol and a Vertisol to assess the residual effects of fertilizer (water-soluble) phosphorus . These will be assessed by the conventional means of crop yields and uptake of phosphorus for 1-2 years after application of P at different rates; additionally, however, the residual effects will be also assessed by measuring the responses of a test crop to current application of phosphorus. The latter experimental approach has been rarely used in agriculture research.

6. Publications: Nil

7. Work plan for next year:

   The above two experiments will be continued for another two years, that is, until the end of the 1989 season. A subsequent 'uniformity' crop may be desirable in 1990, depending upon the experimental results obtained.

ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number : RM-110(85)IC Merger of RM-109(85)IC
RM-122(84)IC
RM-110(85)IC

2. Project Title : Tree-crop interaction in agroforestry systems.

3. Project Scientist(s) : Ong, C.K.
Walker, T.S.
Rego, T.J.
Sahrawat, K.L.
Pathak, P.
Sardar Singh

4. Period covered by report (Month/year) : Jul. 86 - Jul. 87

5. Summary of Progress Report:

1. Systematic designs [RM-110(84)IC]. Data for three years have been analysed for effects of row orientation and spacing experiments (2-way design). Row orientation appeared to have some effect during the first month of the kharif season but towards the end of the season there was no significant differeces between treatments. Sunflower was consistently more effected by leucaena than sorghum. Spacing experiment clearly indicates that competition is extremely severe at spacings closer than 5 m. Both experiments will be discontinued by 1988.

2. Soil conservation [RM-109(85)IC] and RM-122(84)IC]. Extensive soil sampling was carried at the begining of the experiment and a final sampling will be done in 1987, the fourth year of tree growth. Erosion studies and yield measurements were also made but the plot size was too small and major edge effect from trees of adjacent treatment may confound the findings. An alternative experiment may be needed for future work.

6. Publications:

Huda, A.K.S. and Ong, C.K. 1987. Crop simulation model and some implications for agroforestry systems. ICRAF/WMO/UNEP workshop on the Application of Meteorology to Agroforestry Systems Planning and Management, Nairobi, Kenya, 9-13 Feb. 1987.

7. Work plan for the next year:

1. Because of the severe competition between leucaena and crops the emphasis has changed to methods of reducing tree-crop interaction. A new experiment using perennial

pigeopea as a multipurpose tree has been initiated on Vertisols to compare the operational and economic advantage of two spatial arrangements which give minimal or maximal tree-crop interaction.

2. Soil conservation work should consider other tree species such as indigenious species as leucaena is not the best for soil fertility or physical amelioration. Species like Dalbergia sisso and Cassia siamia grow as well as leucaena and may be more appropriate for long term studies on soil conservation.

## ICRISAT Research Project Outline

1. **Project Number:** RIM - [ ] ([817]) [NC] **NEW PROJECT**

2. **Old Project Number:** [ ]

3. **Program:** Resource Management

4. **Discipline(s)/Subprogram(s):** [CS] / [ ] / [ ] / [ ] / [ ]

5. **Project Title:** Characterisation of resource utilisation by agroforestry systems and the management of tree canopy

6. **Project Locations:**

| | | | | |
|---|---|---|---|---|
| CRIDA | | GONAGAL | | |
| | | | | |
| | | | | |

7. **Scientific Staff Names:**

(a) **Discipline/Sub-Program Leader Names:**

| | | |
|---|---|---|
| C.K. | Ong | (CKO) |
| | | ( ) |
| | | ( ) |
| | | ( ) |
| | | ( ) |

(b) **Project Scientist Names:** **Scientist-Years**

| | | | |
|---|---|---|---|
| C.K. | Ong | (CKO) | 0.2 |
| M.S. | Reddy | (MSR) | 0.2 |
| R.P. | Singh (CRIDA) | (RPS) | 0.2 |
| | | ( ) | |
| | | ( ) | |

(c) **Cooperating Scientist Names:**

| | | |
|---|---|---|
| Md. | Osman | (MO) |
| Neelam | Saharan | (NS) |
| | | ( ) |
| | | ( ) |
| | | ( ) |

(d) **Supporting Staff:**

| | |
|---|---|
| Research Associate(s) | 0.2 |
| Field Assistant(s) | 0.4 |
| Field Attendant(s) | 0.2 |

8. (a) **Date of Start (mo/yr):** 05/1987

(b) **Years Revised :** 1989 | | | | |

(c) **Date of completion (mo/yr):** 05/1989

Objectives and Scope: (10 lines maximum)

To determine the causes of the severe competiti[illegible] and crops on the shallow Alfisols of Gunagal.

To manage three canopies to reduce competiti[illegible] to maximise tree products viz. poles or fodder.

Keywords: (Maximum 7)

Agroforestry
Competition
Seasonal water use
Leucaena

Technique in brief (Methodology): (15 lines maximum)

Above ground competition or environmental modification will be monitored with appropriate sensors and data l[illegible] based on experience at IC with alley cr[illegible]. Below ground competition will b[illegible] by [illegible] trees root barrier and use o[illegible]. Seasonal water use by trees will be monitored b[illegible] pulse apparatus which is non-destructive.

5. Source of Funds: ICRISAT | 50 | CRIDA | 50 | | |

6. Cost estimates: (Direct)

| | 1987 | 1988 | 1989 |
|---|---|---|---|
| Operational (recurring) | | | |
| (a) Labor | | | |
| (b) Travel | | | |
| (c) POL | | | |
| (d) Supplies | | | |
| TOTAL | | | |
| Capital (non-recurring) | | | |
| Indirect Costs | | | |

Land requirements (ha)

| Location | | | |
|---|---|---|---|
| Gunagal | 0.5 ha | 0.5 ha | 0.5 ha |
| | | | |
| | | | |
| | | | |
| | | | |

Review of past background and present status: (20 lines max.)

Seedling establishment and growth of [illegible] affected when grown in close [illegible] rowing trees like Leucaena. Observations over the last two years show that such competition is more severe at Gunagal farm than at IC although total rainfall in both sites are similar. Experiments [illegible] moisture competition is responsible for yield reduction of millet in alley cropping. At Gunagal heavy shading of crops [illegible] also be responsible for the reduction in crop yield [illegible] these root barrier is a very effective method for separatin the below ground and above ground competition in our experiments at IC.

Existing linkage with other centers or research projects: (8 lines maximum)

This project will [illegible] with CRIDA on agroforestry. Also we could both benefit by working together rather than starting similar experiments on our own.

Likely future course of development: (8 lines maximum)

Progress in this area of research will complement and assist the work of the All India Coordinated Research Agroforestry (AICRPA). Such techniques could be used in the research [illegible] research.

Availability of training facility: (4 lines maximum)

Limited at present because of logistics.

Project Scientist  Sub-Program Leader  Program Leader

APPROVED

Date: _____  Director of Research

# COLLABORATIVE PROJECT PROPOSAL

1. Project No. TR-RM-01 Linked Project No. RM-112(85)IC

2. Project Title: Root competition between crops and Leucaena in alley croping.

3. Name of the Collaborative Institute: University of Nottingham

4. Name of scientists responsible for the project:

   (a) Collaborative Institute: Res. Scholar J.E. Corlett (U.K)
   C.R. Black
   University of Nottingham

   (b) ICRISAT : C.K. Ong and J.L. Monteith

5. Duration:

   (a) Date of start : 14 April 1986

   (b) Date of completion : 31 March 1988

6. Objectives: Ph.D. thesis research

7. Source of funds: Self

8. Progress so far:

   Agroforestry combination of millet/leucaena:

   Results for 1986 confirmed that alley cropping improves the temperature, humidity and windspeed for crop growth but the extent of amelioration was marginal compared to the moisture competition between the two species. Prevention of root competition by polythene root barrier resulted in 40% increase in yield of intercropped millet.

9. Remarks: Nil

## COLLABORATIVE PROJECT PROPOSAL

1. Project No. TR-RM-14 (New) Linked Project Nos. RM-109(85)IC
   RM-122(85)IC

2. Project Title: Response of trees and crops to canopy management and environmental modification.

3. Name of the Collaborative Institute:

4. Name of scientists responsible for the project:

   (a) PDF : J. Daniels (Sri Lanka)

   (b) ICRISAT : C.K. Ong and K.K. Lee

5. Duration:

   (a) Date of start : 1 Sept. 1987

   (b) Date of completion : 1 Sept. 1989

6. Objectives:

   1. To investigate the effect of severe defoliation or pruning on the root activity and nitrogen fixing ability of leucaena.

   2. To relate the biological activity of soils to the changes in the microenvironment in agroforestry systems e.g. soil temperature and moisture.

   3. To develop canopy management practice which increases the productivity of crops, trees, and soils.

7. Source of funds: ICRISAT

8. Progress so far: Nil

9. Remarks: Yet to arrive.

# COLLABORATIVE PROJECT PROPOSAL

1. Project No. TR-RM-12

2. Project Title: Cropping systems x genotype interaction using fertilizer or management factors.

3. Name of the Collaborative Institute: APAU

4. Name of scientists responsible for the project:

   (a) M.Sc. : M.J. Freire (Mozambique)

   (b) ICRISAT : C.K. Ong

5. Duration:

   (a) Date of start : 15 August 1985

   (b) Date of completion : 15 August 1987

6. Objectives: M.Sc. thesis research

7. Source of funds: IDRC

8. Progress so far:

   Work was carried out on a maize/groundnut system at different sowing dates and pattern of intercropping. First draft of thesis is ready for examination in August.

9. Remarks: Nil

## ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number : RM-1I2(85)IC

2. Project Title : Microclimatology of plant communities

3. Project Scientist(s) : Ong, C.K.
Reddy, M.S.
Singh, S.D.
Subramanyam, P.

4. Period covered by report (Month/year) : Jun. 86 - Jul. 87

5. Summary of Progress Report:

1. Microclimate of millet/groundnut intercrop:

This is a multidisciplinery experiment involving scientists from groundnut pathology and physiology with the main emphasis on leaf spots of groundut. In 1985 and 1986 the incidence of leaf spots was among the lowest ever recorded in IC because of the drought. Conditions were excellent for spore germination but dry spells prevented development of leaf spots. Instead data were excellent on drought interaction with microclimate. In 1985, LER was 1.6 in contrast to 0.8 for 1986 and 1.3 in a normal rainfall season.

2. Agroforestry combination of millet/leucaena:

Results for 1986 confirmed that alley cropping improves the temperature, humidity and windspeed for crop growth but the extent of amelioration was marginal compared to the moisture competition between the two species. Prevention of root competition by polythene root barrier resulted in 40% increase in yield of intercropped millet.

6. Publications:

Ong, C.K. 1987. Characterisation of the microenvironment: Measurement Techniques, in "Soil, Water, and Crop Livestock Management Systems for Rainfed Agriculture in the Sudano - Sahelian Zone", Niamey, 11-17 January 1987.

Corlett, J.E., Ong, C.K., and Black, C.R. 1987. Modification of microclimate in alley-cropping and intercropping in WMO/ICRAF Symposium on "Agrometeorology of agroforestry", February 1987, Nairobi.

7. Work plan for the next year:

1. Millet/groundnut intercrop is being repeated this year in anticipation of a better rainfall for normal disease

infestation. Postdoc with groundnut entomology will also participate in September 1987 to monitor leaf-miner population and damage. If good disease is recorded in 1987 the experiment will be terminated.

2. Agroforestry. Millet/leucaena is being repeated this year and depending on the results obtained we may concentrate on a groundnut/leucaena system where modification of microenvironment may be more pronounced.

ICRISAT RESEARCH PROJECT PROGRESS REPORT

1. Project Number : RM-117(85)IC Merger of RM-118(85)IC

2. Project Title : Agroforestry ex-ante analysis and field research.

3. Project Scientists : Van Den Beldt, R.J.
Walker, T.S.
Ong, C.K.
Remanandan, P
Gilliver, G

4. Period cover by report (Month/year) : Jul. 86 to Jul. 87

5. Summary of progress report:

a. Ex-ante analysis. The economic prospects of agroforestry interventions in India's SAT were evaluated with regard to (1) the importance of existing agroforestry systems, (2) the scope for synergistic tree-crop interactions, (3) the potential of perennial/annual intercropping land use systems, and (4) alternative end uses.

Across agroforestry systems and/or interventions in India's SAT, present economic importance and the scope for tree-crop interactions are inversely related. Systems that are now important have a low potential for tree-crop interaction; systems with potential for such interactions are not now sown extensively by farmers. Emerging experimental evidence indicated that narrowly spaced alley cropping systems will not compete economically with conventional field cropping systems in India's SAT. The demand for fodder is increasing, and fodder is the end use that meshes best with ICRISAT's present mandate.

The economic prospects for agroforestry interventions are not sufficiently bright to warrant the core funding of a separate program unit to conduct and integrate agroforestry research. Several of the more promising agroforestry themes that are also more in tune with ICRISAT's crop and area mandates can be accommodated within the existing or proposed research units within the Resource Management Program. Priority areas for economic investigation included interdisciplinary research on the estimation of production possibility curves for tree and crop species combinations, an evaluation into the consequences of the rapid diffusion of farm forestry systems, an enquiry into why tree fodder markets have been so slow to develop, and an assessment of the demand for leucaena.

Field work. Evaluation of different perennial pigeonpea for agroforestry uses was carried out on both Alfisols and Vertisols and preliminary analysis indicates that it is more

productive than leucaena at IC. Fuel wood production of about 20 t ha could be obtained after a period of 18 months on Vertisols. The same production could be obtained in Alfisols but with irrigation. It is clear that perennial pigeonpea should be tested in agroforestry system and more genotypes should be evaluated. Work on multistorey millet/leucaena experiment has been discontinued because the research scholar from Holland has decided not to come this year.

6. *Publications:*

Singh, R.P. , Van Den Beldt, R.J., Hocking, D., and Korwar, G.R. 1986. Alley cropping in the semi-arid regions of India. Presented at the workshop on Alley Cropping, March 10-14, 1986, International Institute of Tropical Agricultural (IITA), Ibaden, Nigeria.

Van Den Beldt, R.J. 1986. ICRISAT's agroforestry research program: methods, strategy, and future emphasis. Presented at the conference on Agroforestry collaboration between IARCs and ICRAF, September, 1986, International Council for Research on Agroforestry (ICRAF), Nairobi, Kenya. (Limited distribution.)

Van Den Beldt, R.J. 1987. Agroforestry research in the farming systems of the Semi-Arid Tropics. Agronomy Group, Resource Management Program, Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Walker, T.S., 1987. Economics prospects for agroforestry interventions in India's SAT: implications for research resource allocation at ICRISAT. Economics Group Progress Report No-79, Resource Management Program, Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Work plan for the next year :

This project has been terminated. The results of the ex-ante analysis were presented to the Program Committee of the Governing Board in March 1987.

1. Project Number : RP-315(85)IC

2. Project Title : Studies of household economics.

3. Project Scientist(s) : K.C. Sharma
T.S. Walker

4. Period covered by report (month/year) : May 1986-January 1987

5. Summary of Progress Report:

Household price and expenditure elasticities were estimated for disaggregated commodity demand systems in one study village, Kanzara. Output supply and factor demand functions were also estimated. Work on simultaneous estimation of household consumption and production was initiated. Initial results suggest that the farm profit effect of output price is not as strong for diversified cultivator households in India's SAT as for more specialized farm households producing paddy in the humid tropics. Thus viewing the farm household as a separate production and consumption entity appears to be a more reasonable assumption in India's SAT than in more humid regions where monoculture is common.

6. Publications: None.

7. Work plan for next year:

Household models will be estimated for two more villages, Aurepalle and Shirapur. The simultaneous equations approach will also be used to estimate consumption and production parameters in those two villages. A Ph.D. thesis will be submitted to the University of New England in 1988.

## COLLABORATIVE PROJECT PROPOSAL

1. Project Number : TR-RM-6(87); Linked Project No.:RM-315(85)IC

2. Project Title : Marketed surplus, household inventories, and price expectations in SAT India.

3. Name of collaborative Institute : Department of Economics and Business North Carolina State University

4. Name of scientist(s) responsible for the project:

   (a) Research Scholar : M. Renkow, J. Carlson (advisor)

   (b) ICRISAT : T.S. Walker
   R.A.E. Mueller

5. Duration:

   (a) Date of start : April 1987

   (b) Date of completion : April 1988

6. Objectives:

(a) Investigate the impact of on-farm storage capacity and intra-seasonal price movements on the timing of consumption and market sales of major food staples;

(b) Econometrically evaluate the relative importance of arbitrage and food security (risk) motives with regard to inventory demand by different classes of farmers;

(c) Identify binding constraints on inventory-holding in different areas of SAT India.

7. Source of Funds : ICRISAT

8. Progress so far:

A dynamic model of semi-subsistence farm households was developed. The model incorporates household storage opportunities for staple foods as well as other means of smoothing consumption over time (e.g. borrowing). Quarterly inventory and consumption schedules for major staples have been constructed from the VLS data for one village (Shirapur) and are underway for two others. Interviews with VLS respondents have

been carried out in all three villages to determine the nature and extent of storage losses, liquidity constraints, and other factors affecting market behavior and inventory demand.

9. Remarks:

By the end of October, quarterly inventory and consumption series will have been constructed for Kansara and Aurepalle. Estimation and hypothesis testing will take place when researcher returns to North Carolina in November. A Ph.D thesis will be submitted to N.C. State University by the end of April 1988.

COLLABORATIVE PROJECT PROPOSAL

1. Project No.: TR-RM-10(86); Linked Project No.: RM-315(85)IC

2. Project Title : Women's participation in agricultural production: A cross-cultural, comparative evaluation between India's and West Africa's SAT.

3. Name of the Collaborative Institute : Iowa State University.

4. Name of scientists responsible for the project:

   (a) Collaborative Institute : Research Scholar A.g. Mengesha, J.L. Tate, Iowa State University

   (b) ICRISAT : T.S. Walker

5. Duration:

   (a) Date of start : June 1986

   (b) Date of completion : June 1988

6. Objectives:

(a) To study the role of women in agricultural production in the Semi-Arid Tropics;

(b) To understand the social and environmental constraints that affect women's role in household decision-making; and

(c) To compare cross-cultural factors that promote or hinder women's participation in agricultural production in rural society between India and Cameroons.

7. Source of funds : ICRISAT; World Food Conference.

8. Progress so far:

Data on daily and seasonal time allocation and on household decision-making were collected from 80 respondents in each of two ICRISAT study villages in India. Those data have been processed, and tabular analysis started in August 1986.

9. Remarks:

Similar data will be collected on rural households in Cameroons in late 1987 or early 1988. A Ph.D. thesis will be submitted to Iowa State University in 1989.

New project under consideration

## ICRISAT Research Project Outline

1. **Project Number:**

3. **Program:** Resource Management

4. **Discipline(s)/Subprogram(s):** Economics

5. **Project Title:** Evolution of component management practices in farming systems in the SAT.

6. **Project Locations:** ICRISAT Center, village sites in the SAT.

7. Scientific Staff:

(a) Discipline/Sub-Program Leader(s):

(b) Project Scientist(s) :

| | Scientist-Years |
|---|---|
| Walker, T.S. | 0.50 |
| Singh, R.P. | 0.33 |

(c) Cooperating Scientist(s):

Mueller R.A.E. :
Matlon P.J. :
RMP scientists
National program scientists

(d) Supporting Staff:

| | | |
|---|---|---|
| Research Associate(s) | : | 1.0 |
| Field Assistant(s) | : | 1.0 |
| Field Attendant(s) | : | |

(a) Date of Start (mo/yr): 03/1989

(b) Years Revised: 1992, 1996

(c) date of completion (mo/yr): 12/2000

9. Objectives and Scope: (10 lines maximum)

a) To identify and test the historical regularity in the adoption of component management practices;

b) To classify management interventions by agroclimatic zone and farming intensity to direct agricultural research and technology transfer to those areas where prospects are brightest;

c) To forge closer linkages with economists and other scientists in national programs; and

d) To generate information on regional researchable problems which fall within ICRISAT's mandate and which could be solved with collaborative research between national programs and ICRISAT scientists.

10. Keywords: (Maximum 7)

SAT
Farming systems
Agricultural intensification
Evolution
Management practices
Rapid rural appraisal

11. Technique in brief (Methodology): (15 lines maximum)

Sites representing broad benchmark crop, soil, and climatic environments and locations where population density is changing rapidly will be chosen. In total about 100-150 sites in peninsular India, Northeast Thailand, West Africa, southern and eastern Africa, Northeast Brazil, and Mexico and Central America will be surveyed with rapid rural appraisal techniques. Data will be collected in field visits lasting a few days to one week at each location. Participation by RMP scientists, depending on area of interest and field of specialization, would be encouraged. The surveys will be updated every 3-4 years during the 12-year project period.

12. Source of Funds: ICRISAT Core and donor funded

13. Cost estimates: (Direct)

| | 1989 | 1990 | 1991 |
|---|---|---|---|
| Capital (non-recurring) | | | |
| Indirect Costs | 20,000 | 20,000 | 20,000 |

14. Land requirements (ha)

Location

15. Review of past background and present status: (20 lines max.)

This project is in the spirit of research by Hans Ruthenberg on farming systems in the tropics and by Ester Boserup on agricultural intensification induced by increasing population density. More recently, researchers at the World Bank have carried out similar work on the evolution of agricultural mechanization and land tenure systems in Sub-Saharan Africa. Presently, World Bank and ILCA researchers are using rapid rural appraisal techniques in multiple village sites to study the transition from crop-livestock interaction to crop-livestock integration in Sub-Saharan Africa. Although the proposed project relies heavily on this earlier research for concepts and methods, the substantive focus on the evolution of management practices within farming systems in the SAT is new.

16. Existing linkage with other centers or research projects: (8 lines maximum)

Linkages could be developed with other IARCs particularly with the ILCA-World Bank collaborative projects on crop-livestock systems. This project could also became a part of a larger donor funded project involving several centers. For example, similar research by IITA or IRRI in the humid and subhumid tropics and by ICARDA in the arid tropics would add perspective to the proposed study in the SAT.

17. Likely future course of development: (8 lines maximum)

The project will be discussed and modified accordingly before it is scheduled to commence in 1989. Before the project is launched, a hypothesis paper will be written on the management practices to be examined and their potential adoptability with regard to population density, transport infrastructure, external markets, off-farm employment, and other economic and cultural considerations, and agroclimatic and edaphic characteristics.

18. Availability of training facility: (4 lines maximum)

This project should provide a vehicle to follow-up on our short-term training program on problem identification and technology assessment for economists working in NARS. Participant involvement in this project would be encouraged.

Project Scientist Sub-Program Leader Program Leader

New project under consideration

## ICRISAT Research Project Outline

1. Project Number:

3. Program: Resource Management

4. Discipline(s)/Subprogram(s): Economics

5. Project Title: Dynamics of supply and demand for mandate crops.

6. Project Locations: ICRISAT Center

7. Scientific Staff:

   (a) Discipline/Sub-Program Leader(s):

   (b) Project Scientist(s) : Scientist-Years

   | | |
   |---|---|
   | Walker, T.S. | 0.25 |
   | Mueller, R.A.E. | 0.25 |

   (c) Cooperating Scientist(s):

   | | |
   |---|---|
   | Production agronomists | |
   | Crop improvement scientists | |
   | Economists (CGPRT) | |

   (d) Supporting Staff:

   | | |
   |---|---|
   | Research Associate(s) | 2.0 |
   | Field Assistant(s) | 2.0 |
   | Field Attendant(s) | |

8. (a) Date of Start (mo/yr): 6/1988

   (b) Years Revised: 1990

   (c) date of completion (mo/yr): 12/1992

9. Objectives and Scope: (10 lines maximum)

(a) To assess the determinants of recent trends in the regional demand for and supply of ICRISAT mandate crops and their competitors within India's SAT and AGLN countries.

(b) To assess the demand for leucaena and to analyse the development of fodder markets in India's SAT;

(c) To evaluate how agricultural research can better accommodate prospective supply and demand trends towards regional specialization.

10. Keywords: (Maximum 7)

| | |
|---|---|
| Market trends | Mandate crops |
| Regional specialization | Leucaena |
| Fodder | South Asia |
| | Southeast Asia |

11. Technique in brief (Methodology): (15 lines maximum)

Conventional economic techniques will be employed to address the various interrelated issues covered in this umbrella project. They range from the estimation of integrated demand systems to rapid rural appraisal surveys of the early acceptance of new crops such as leucaena. Analysis of secondary data will be complemented by field visits to producing regions experiencing rapid shifts in area.

12. Source of Funds: ICRISAT core and donor funding (if available).

13. Cost estimates: (Direct) 1986 1987 19

Capital (non-recurring)

Indirect Costs

14. Land requirements (ha)

Location

15. Review of past background and present status: (20 lines max.)

Examining recent trends in cereal area in India suggests that regional specialization is increasing. Wheat has pushed out chickpea in much of north particularly northwestern India, sorghum is increasingly being

produced in Maharashtra and is declining in importance in other major producing regions, and Maize is rapidly expanding into Karnataka, eastern Rajasthan, and western Madhya Pradesh. Pearl millet is declining in area in southern India and Gujarat. Rice is moving north and is expanding in areas in eastern Maharashtra and Madhya Pradesh. With regard to end uses, the fodder grain price ratio is increasing in some SAT regions. We don't know much about regional demand patterns, fodder markets, or the potential of alternative fodder sources such as leucaena to substitute for ceral straw in dairy production. We do know that the potential of mandate grain legumes is likely to be constrained by demand in AGLN countries in Southeast Asia.

16. Existing linkage with other centers or research projects: (8 lines maximum)

Staff from the CGPRT in Bogor will be involved in demand studies on ICRISAT grain legumes in selected AGLN countries. K.N. Murty from the Central University at Hyderabad will collaborate as a consultant in the estimation of regional demand parameters. Potential linkages on the fodder market and demand for leucaena study includes the F/FRDP network in Thailand. Collaboration with ACIAR in Thailand has been initiated on the demand for pigeonpea.

17. Likely future course of development: (8 lines maximum)

Several of the subprojects will start as soon as visiting scientists, research scholars, and/or postdoctoral fellows are recruited.

18. Availability of training facility: (4 lines maximum)

Opportunities are ample for research scholars and postdoctoral fellows to be involved. We envisage such involvement in the subprojects on alternative uses of sorghum and on regional specialization and diversification in India.

Project Scientist Sub-Program Leader Program Leader

APPROVED

1. Project Number RM-3?1(85)IC

2. Project Title Compendium containing quantitative characterization and interpretation of farming systems in major agro-climatic zones of SAT India.

3. Project Scientist(s) : R.A.E. Mueller
R.P. Singh

4. Period covered by report (month/year) : May 1986-July 1987

5. Summary of Progress Report:

We have developed a detailed list of contents. We have produced most of the tables and graphs describing the natural, economic, an infrastructural environment of the VLS-villages. Tables and graphs describing cropping activities in the villages are complete. We have developed a method of graphically representing the averages and distribution of starting dates of cropping operations and applied it to major cropping operations in three villages. We have produced crop budgets for major cropping activities in three villages.

6. Publications None.

7. Work plan for the next year:

A draft of the compendium will be circulated for comments and suggestions towards the end of 1987. In this draft only the representative farms of one village will be described. We will then proceed to process data for the representative farms of other VLS-villages. A final draft of the compendium is expected to be ready towards the end of the 2nd quarter of 1988.

1. Project Number : RM-324(87)IC

2. Project Title : Identification of quality characteristics of foodgrains and oilseeds suitable for market grading.

3. Project Scientist(s) : G.R. Bhatia (DMI)
R.A.E. Mueller
R. Jambunathan

4. Period covered by reort (month/year) : January 1987-July 1987

5. Summary of Progress Report:

DMI is supposed to have collected samples of groundnut and sorghum from primary assembly markets and to have analysed the bulk of the samples in DMI laboratories. DMI has not yet sent samples for cross-analysis in ICRISAT's laboratories. We have accompanied DMI staff on a sample collection tour to Mancherial market.

6. Publications : None.

7. Work plan for the next year:

Laboratory and data analyses will begin as soon as DMI sends samples and data.