# FIRST ANNUAL REPORT OF THE ICRISAT RESEARCH PROGRAM

27

## MAY 1972 - MARCH 1973

BY

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APRIL 1973

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

ICRISAT

# C O N T E N T S

# FOREWORD

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) takes pride in presenting herein a report on its first year of field research. With a very small advance guard and most of these on part-time or short term loan from other organizations initially, the first field experimental plantings were made simultaneously with the promulgation of its constitution and the organization of its Governing Board. The very creditable record of results and the extremely valuable guides of this first year's observations are already making contributions toward finding ways for improving dependability of food production in the semi-arid rainfed tropics. They will also contribute toward providing a sound base for planning the future studies of the Institute. This is due to the dedication, hard work, determination, competence and diligent and thorough attention of this small group. They had to exercise a great deal of ingenuity in the initial stages with very limited facilities but were able to enlist cooperation from many sources and made very substantial progress.

From this modest beginning, the ICRISAT is determined, as its staff and facilities are expanded, to fulfil the dreams and aspirations of its sponsors to become truly a world center of excellence which will be able to support and backstop a whole network of national and regional efforts which cooperatively will truly bring about a revolution in improved levels and dependability of production of major food crops of the semi-arid, seasonally dry, rainfed tropical regions of the world, and make a real and substantial contribution to the improvement of opportunities of the people of these regions.

Ralph W. Cummings
Director

# F I R S T  A N N U A L  R E P O R T
of the
# I C R I S A T  R E S E A R C H  P R O G R A M
May 1972 - March 1973

by
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## S U M M A R Y

At the request of Dr. R. W. Cummings, then Chairman of the ICRISAT Organizing Committee, B.A. Krantz commuted from Delhi to start a field research program during the monsoon (kharif) season. During the first season at ICRISAT, the area experienced the "worst drought on record" with a late and weak monsoon. The May-March rainfall was 46% of normal. During the monsoon (kharif) and post monsoon (rabi) seasons, a total of 26 experiments were conducted on both the red and black soils involving comparison of dates of planting, fertilization, varieties and intercropping patterns with sorghum, pearl millet, pigeon peas, soybeans, chick peas, sunflower and safflower (tables 6 - 35). The following summary statements are based on the results of these experiments.

1. In the Date of Planting Trials, the yields of all sorghum varieties were distinctly better in the earlier dates of planting. The relative grain yields for dates 1, 2, 3 and 4 were 100, 96, 72 and 24. The high incidence of shootfly was the major factor causing the yield reduction in dates 3 and 4. In contrast, the pearl millet and pigeon pea yields were only slightly reduced at the later dates of planting.

2. The number of days from planting to heading was greatly reduced with the later dates of plantings in both sorghum and millets. The number of days to 75% heading for sorghum for dates 1, 2, 3 and 4 was 65, 60, 54 and 52, respectively. The number of days to heading for millets was 56, 52, 46

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and 38, respectively. These results indicate that the sorghum and pearl millet varieties used in this trial were photo sensitive.

3. There was a response to phosphorus application in all crops grown, particularly on the red soil. During the rabi season (October 15 planting), fertilization trials were conducted on five crops on adjacent areas in the red soil. This gave an opportunity to study the comparative fertilizer responsiveness of these crops. There was a marked visual and early seedling response on all five crops. The magnitude of the yield response was greatest in case of sorghum where the yield of $P_0$ and $P_{30}$ was 2.2 and 30.0 q/ha, respectively. The ranking of the magnitude of phosphorus yield response on the other 4 crops is as follows : pearl millet, sunflower, safflower and chick peas. Pigeon Peas grown in an adjacent experiment showed no response to phosphorus.

4. In the red soil, phosphorus differentials were included in trials 2, 3, 9 & 1 which were planted over a 3.5 month period. The respective planting dates of these four trials were June 29, July 17, August 30 and October 14th. The magnitude of phosphorus response was far greater in the later part of the season than in the June 29 plantings. The increase due to phosphorus in trial 2 (June 29) and trial 11 (October 14) was 7.7 and 27.8 q/ha, respectively The trials planted in July and August were intermediate in magnitude of response to phosphorus. The differential magnitude of response to phosphorus in pearl millet was similar to that of sorghum.

5. Trials involving nitrogen and potassium differentials were conducted on sorghum, pearl millet, pigeon peas, sunflower and safflower. In almost all cases there was a response to the first 40 kg/ha increment of nitrogen and no appreciable response above the 40 kg N rate. There was no significant yield response to potassium in any crop on either soil.

6. Sorghum hybrid, CSH-1 generally gave the highest yield in both red and black soils. The superiority of CSH-1 was more marked in the red soil during the kharif season when there was a moderately severe soil moisture stress.

7. The highest average sorghum yield recorded in any experiment on the blac soil was 51 q/ha (average of CSH-1 and CSH-3 - table 6).

8. Carbofuran gave excellent control of flea beetles as well as shootfly in the late August sowings.

9. Most of the shootfly tolerant selections exhibited some tolerance to fle beetle attack as well as to shootfly attack.

10. Since commercial varieties with shootfly resistance cannot be expected soon and no low cost chemical method is available, methods involving avoidanc of shootfly should be further investigated. Plantings made at the onset of the monsoon were free from shootfly damage due to low survival of the shootfl during the preceeding hot summer. In the black cotton soils planting is commonly delayed until late in the monsoon period because of the difficulty of soil manipulation before and during the monsoon. In the Farming Systems Research program, much emphasis is being directed toward development of soil and water management techniques which would make it feasible to plant in the black cotton soils at the onset of the monsoon.

11. In the pearl millets there was relatively little grain yield difference between the 4 hybrids HB1, HB3, HB4 and HB5. During the kharif season the yields of all four hybrids was markedly above that of the Vijay (local). However, during the rabi season the grain yield of Vijay was equal to or better than that of the four hybrids and K 559. The reason for this appears to be related to the comparatively better seed set of Vijay during the cool rabi season.

12. The possibility of ratooning pearl millet for multiple harvest appears promising. During the kharif in a fodder-grain harvest system, HB-4 produced 233 q/ha of high quality green fodder (98 q/ha air dry) followed by a ratooned grain crop of 13 q/ha.

13. The ratoonability of the pearl millet makes it a very flexible and useful plant in the Farming Systems Program. When pearl millet was harvested at flowering stage there was always a profusion of tillers which produced a good ratoon crop in 3 to 4 weeks. However, when the first crop was allowed to grow to maturity for grain harvest most of the small tillers died and regrowth was slow and ratoon yield was meager. The greatest total production of pearl millet was produced in the harvest procedure involving two fodder crops followed by a grain crop. In this system the first crop was harvested at 52 days, the ratoon fodder crop at 71 days and the final ratoon grain crops at 129 days.

14. The vegetative growth of pigeon peas appeared to be good but the grain yield level was relatively low in all experiments. The reason for the low yield is not known, but the severe attack of the red and black blister beetles on the flower buds is believed to be an important factor.

15. The growth and yield of pigeon pea was relatively insensitive to fertilization, added inoculum or the dates of planting used in these experiments. Likewise, there was relatively little difference between the varieties used. It is obvious that much intensive research on pigeon peas is needed to develop varieties and production techniques which will provide greater yield potentials.

16. The general yield level of chick peas was relatively low. This may be due in part to the wider than normal row spacing used (45 cms.). The early flowering varieties (40 - 50 days) tended to have better seed set and higher yield than the late flowering varieties (65 - 75 days). This may be due to the higher temperatures and the greater soil moisture stress which occured late in the growing season. There was no significant difference between the three inoculums used, and nitrogen application had no beneficial effect on either soil.

17. Sunflower variety EC 6974 gave the highest yield and Sunrise variety the lowest yield on the red soil. There was no significant difference between the other three varieties. The highest sunflower yield was 17.3 q/ha in the black soil which was 50% above the yield of the red soil.

18. There was no significant difference between the six safflower varieties on either the black or red soil, but C-440 tended to give the highest yield and C-437 the lowest yield on both soils. The top yield of safflower on black soil was 21.2 q/ha which was almost double that of the red soil.

19. In the pigeon pea - pearl millet intercropping experiment there were large yield differences due to planting patterns. In the alternate row treatment, pearl millet was able to capitalize on the space left vacant during the first six to eight weeks while the slow growing pigeon peas were becoming established. The yields of pearl millet fodder or grain in the alternate row plots were 50 to 60% higher than those of the solid plantings on an area basis. Apparently, the harvest of the pearl millet was early enough so that the yields of the companion pigeon pea crop in alternate rows was reduced by only 0.9 q/ha below that of the solid planting of pigeon peas, on an area basis. Thus the total production of the alternate rows system was over 50% greater than that of the system involving solid planting of each of the two crops.

20. In the pigeon peas - soybeans intercropping trial, soybeans showed only a slight tendency to capitalize on the vacant space in the alternate row treatments. The Bragg variety which was used produced a very small vegetative growth due to extremely early flowering (31 days) of this determinant growth variety. With this small growth, the soybeans might have produced more if the soybeans rows had been spaced closer together.

21. The Swastik grain drill was modified by mounting two seed boxes behind and above the regular seed box. By this modification two crops can be planted simultaneously, each at its own proper rate of sowing.

22. During this abnormally dry season, ICRISAT experienced a 46-day drought (July 4 to August 20). During early August, a minimal amount of water (about 5 cms.) was applied by sprinkler to "break" the drought. This amount of water was sufficient to save the crop until a 55 mm rain came on August 20 to 24th. Since no water application variables were possible in these experiments,

we cannot measure the exact yield contribution of the 5 cm of water applied. However, with the severe wilting observed just before applying the irrigation, it is believed that much of the sorghum crop and millet crop would have been a near failure without this minimal supplemental irrigation. The marked effect of minimal irrigation gives us great encouragement for the development of improved water harvesting, storage and utilization techniques in the Watershed-Based Farming Systems.

23. In January 1973 work was started to develop five natural watersheds for complete monitoring of the water balance and intensive data collection on cropping systems of variable composition which will be applied to these catchments. The areas selected for study are located along the western boundary of the experimental farm on the black (cotton) soils: The watersheds vary in size from 3.6 to 19.1 ha, the total area of the five watershed being about 48 ha. Two of the experimental watersheds will be maintained in their present state and layout. Two variations of presently applied cropping patterns in the Hyderabad region will be simulated on these. In the remaining three catchments, efforts will be made to facilitate an optimum use of the monsoon precipitation during kharif. Grassed waterways are being constructed to carry off excess rainfall. In the largest watershed a surface storage pond approximately 4 m deep with a capacity of about 0.2 ha m is presently being built for collection and re-utilization of surface run-off water. As new information is being generated, improved systems of farming will be super-imposed on the watersheds with the ultimate aim of developing "models of approach" to the development of farming systems which make the best use of given soil, water and human resources.

# I N T R O D U C T I O N

At the request of Dr. R. W. Cummings, then Chairman of the ICRISAT Organizing Committee, a field research program was started during the monsoon (kharif) season of 1972.

## General Objectives

1. To conduct a wide spectrum of field investigations to get useful leads for future Farming Systems Research Program.

   a. To accomplish this goal, agronomic experiments were conducted involving comparisons of fertilization, dates of planting, varieties, inoculatants and intercropping patterns of the best available varieties of sorghum, pearl millets, pigeon peas and soybeans during the kharif season.

   b. During the rabi season, similar studies were conducted on sorghum, pearl millet, pigeon peas, chick peas, kabuli chick peas, garden peas, sunflower and safflower.

2. To observe and measure yields, growth responses, insect infestations and rooting patterns of the various crops.

3. To observe soil erosion problems and responses of black and red soils to tillage and management techniques.

## Picture Record of Early Developments

A. Pictures were taken of key places of the Institute's property to record the initial situation before starting any field or construction operations.

B. Pictures were taken of key events, construction starts, Field operations and crop responses in Experimental plots including the following :

1. Handling over of the title of the property.

2. The starting of the brush clearing by bulldozers on May 2.

3. Starting of the planting operation on June 24.

4. Boundary road construction.

5. Boundary fence installation.

6. Drain construction, culverts installations.

7. Construction of temporary farm service building.

8. Experimental plots depicting nutrient, varietal and intercropping responses and various cultural operations.

9. Soil profiles and typical surface landscape features of both the red and black soils.

All pictures were taken both in color and black and white. All of these pictures are being cataloged, labelled and will become part of the ICRISAT permanent file. It is hoped that these pictures will, in the years to come, have historical significance as well as showing early research and land development programs.

Soils of the 1972 experimental area

Two experimental sites of about eight hectares each were chosen, one representing red soil and the other representing black soil. The same experiments were planted on both the black and the red soil sites.

A temporary fence was constructed around both sites to protect the experiments from cattle, sheep and goats. In both soils the kharif experiments were planted in a 72 x 400 meter strip across the north side of the site and the rabi crops were planted along the south side of the site. The soil samples were taken before planting from both sites (table 1).

Table 1. ICRISAT Soil Analysis Samples taken and analyzed in May 1972*

| Location | pH | E.C. | Avail. $P_2O_5$ (ppm) | K (ppm) Ex-K | K (ppm) non-ex K | Avail. zinc (ppm) | Organic Carbon (%) | Mechanical Separates % Sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| Black soil (West) | 8.6 | 0.12 | 9.0 | 206 | 663 | 1.10 | 0.42 | 33 | 14 | 53 |
| Black soil (East) | 8.7 | 0.20 | 14.5 | 197 | 719 | 0.80 | 0.41 | 35 | 13 | 51 |
| Red Soil (Brush area) | 6.2 | 0.60 | 4.5 | 91 | 494 | 1.10 | 0.44 | 78 | | 17 |
| Red Soil (S. cropped) | 6.1 | 0.08 | 7.0 | 104 | 438 | 0.85 | 0.38 | 76 | | 20 |
| Red Soil (N. cropped) | 7.3 | 0.09 | 11.0 | 65 | 363 | 1.25 | 0.32 | 81 | | 15 |

*Samples from the black and red soil experimental areas were taken by B.A.Krantz and analyses were made by Dr. C. Krishnamurthy (E.C. moles/cm of 1:2.5 soil - water ratio.

## Land Preparation and Planting Operations

Red Soil - After the removal of brush and old boundary bunds, the area was chiselled in two directions as deep as possible with available ripper. The depth attained varied from 30-45 cms, depending on the hardness of the subsoil. The chiselling operation was done for two reasons: i) to break up the compacted clay subsoil in the cropped area and ii) to loosen brush roots in the uncropped area so they could be removed before the planting operations. The area was then disced and floated (wooden float) to fill the micro-depressions, before spraying with aldrex @ 2 kg/ha of active ingredient to control termites. (This area was heavily infested with termites, which occurred in the brush clumps or in the sorghum stubble). The field was disced immediately to incorporate the aldrex. The area to be planted with 75 cm rows (Trials 1-5, & 8) was ridged, ring rolled and planted, using the belt-type planter. The intercropping area (trial 6 & 7) which was planted in 45 cm rows with the Swastik grain drill was not pre-ridged, but small furrows were made with 3 ridging shovels mounted on the drill.

Black soil - After the brush and bund removal, the only land preparation required on the black soil was one discing. No aldrex spray was given because no termites were observed in the black soil site. The ridging and planting operations were the same as for the red soil.

The assembling of the necessary seed, fertilizer and experimental equipment; the borrowing of land preparation equipment; the borrowing, buying and adapting planting equipment; and training field men and laborers in the short time available presented a real challenge. The delay in the onset of the monsoon (about two weeks) gave us extra preparation time and we were able to start the kharif planting on June 24th - 5 days after the gradual onset of the monsoon rains. In the black soil, there was considerably variation in plant growth where bunds had been levelled or where soil was bulldozed into a depression.

In the former bund areas, the crop emergence and plant growth were poorer than in the normal soil. This emphasizes the advisibility of planting a general crop for one season to help overcome gross soil variation before starting an experiment. It also emphasizes the need for avoiding deep cuts when grading land for experimental work.

The first rabi plantings were at the end of August (trials 9 & 10). The balance of the rabi planting (trials 11-18) were made in mid October.

## Weather conditions

### Kharif season

During the first crop season at ICRISAT, the Hyderabad area experienced the "worst drought on record". Table 2 shows the normal rainfall for Hyderabad and Sangareddy area, the rainfall at ICRISAT and the percentage departure from normal each month.

Table 2 - Monthly rainfall in 1972-73 at ICRISAT and per cent of average normal rainfall in the area.

| | ICRISAT | Percent of normal* | Normal Rainfall (mm) | | |
|---|---|---|---|---|---|
| | | | Hyderabad | Sangareddy | mean of Hyd. & Sangaredd. |
| | mm | % | mm | mm | mm |
| May | 8* | 30 | 30 | 23 | 26 |
| June | 107* | 92 | 107 | 125 | 116 |
| July | 83* | 49 | 165 | 178 | 171 |
| August | 60 | 38 | 147 | 165 | 156 |
| September | 63 | 35 | 163 | 199 | 181 |
| October | 26 | 39 | 71 | 63 | 67 |
| November | 7 | 29 | 25 | 22 | 24 |
| December | 0 | - | 6 | 6 | 6 |
| January | 0 | - | 2 | 9 | 6 |
| February | 0 | - | 11 | 11 | 11 |
| March | 0 | - | 13 | 12 | 13 |
| Totals | 354 | 46 | 740 | 813 | 777 |

*Data from Hyderabad, no rain gauge at ICRISAT until August. Average normals at Hyderabad and Sangareddy used to calculate "Percent of Normal" for 1972 rainfall at ICRISAT.

Every month had below normal rainfall and the total May - March rainfall was only 46% of normal at ICRISAT. The longest drought period during the kharif was from July 4 to August 20. During that period, minimal supplemental irrigations were given to all experiments, drawing water from the nearby dug wells. The amount of water applied during kharif was 3-4 cm in the black soil and 4.5 cms in the red soil experiments (table 3)

Rabi Season

At the August 28 and 30 plantings (trial 9 & 10) the soil moisture was sufficient for good germination and stand establishment. However, at the mid-October plantings (trials 11-18) the surface soil was so dry that 2 to 3 cms of sprinkler irrigation water was applied after planting to germinate the seed. Since the rabi plantings were made on fallow land there was some subsoil moistu especially in the black soil. The only rainfall after planting was small showers during October 29-31 and November 26 (see table 3). The total of these showers was only 2.2 cm. Therefore, minimum irrigation was necessitated to prevent crop failure and achieve the stated objectives of the experiments. The total amounts of water applied by experiments for the red and black soil are given in Table 3.

Table 3 - The date and amount of supplemental irrigation water applied during Kharif and Rabi seasons.

| Kharif | | | | | Amount |
|---|---|---|---|---|---|
| Red Soil | - 1st sprinkling, Aug. 2-4 | | | | 2.5 cm |
| | 2nd " " 18 | | | | 2.0 cm |
| Black Soil | - Trials 1, 3, 4, 6 & 7 | 1st sprinkling | July | 30 | 2 cms |
| | | 2nd " | Aug | 17 | 2 cms |
| | Trial 2, 5 & 8 only | one sprinkling | Aug | 14 | 3 cms. |

Rabi

Red & Black soil - Uniform sprinkler application on all trials after planting for stand establishment 4-5 cms

On the red soil there was no further water application on trials 17, trial 11 - safflower and trial 11 - sunflower. All other rabi trials received about 3 to 4 cms of additional water by sprinkler.

On the black soil there was no further water application on trials 11 - safflowe trial 15, trial 16, and trial 17. All other trials received an additional 5-7 cm of water by furrow method.

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The total rainfall from planting to maturity during the two seasons are as follows :

Kharif (June 24 to Oct. 15) 31.7 cm

Rabi (Oct. 15 to March 31) 2.2 cms.

## DISCUSSION OF RESULTS

### General

For the convenience of discussion, the results are grouped by crops for both the black and red soils. In the case of sorghum and millets both the kharif and rabi experiments are discussed together in order to make comparisons of the responsiveness of various fertilizer nutrient and differential variety reactions. The one exception to the grouping by crops is the intercropping experiments (trials 6 and 7) where the companion crops are discussed together.

In tabulating the results of trial 1, trial 3, trial 9R and the sorghum in trial 2, only the main effects of main plots and split plots are given in the tables 6, 7, 9 & 10. In most cases the interaction between main plots and split plots was not significant and in the few cases where the interaction was significant, the magnitude of interaction was too small to be of practical importance. Thus two-way tables giving interactions were omitted from the report.

All stalk and green fodder weights were taken as fresh weights immediately after harvest. Due to a lack of drying facilities it was not possible to take dry weights on each individual plot. Dry weights were obtained by compositing an aliquot sample from each of the 4 replicates of each treatment. The dry weight means were obtained by multiplying the means of the green (fresh weight) by the dry weight percentage of the composite samples. Thus no statistical analysis was possible for the air dry weights of any stalks or fodder yields.

For the purposes of this report, reference to "stalks" indicates the harvest of the stalk and leaves which remain after the grain heads have been removed. The term "fodder" refers to a harvest where the whole plant is harvest at flowering stage. All grain, stalk and fodder yields given in table 6 - 35 are recorded in q/ha. The values given are averages of four or more replications.

Seedling samples were taken in trials 2, 3, 9 and 11 on selected treatments to determine the effects of fertilizer and other treatments upon seedling weight. In all cases, 10 plants were selected at random from the guard rows from each plot of the 4 replications. The average fresh weight and oven dry weight of 4 replications are given in grams for each treatment. The seedling samples in trials 2, 3 & 9 (tables 7, 9 and 10) were taken at 3 to 4 weeks after planting. In trial 11 (tables 33 and 35) the samples were taken at about 8 weeks after planting.

The dates of planting, emergence, harvesting and other cultural operations for the kharif and rabi season are given in tables 4 & 5.

SORGHUM EXPERIMENTS

During the kharif and rabi seasons nine sorghum experiments were conducted on both red and black soils involving dates of planting, fertilization and variety comparisons. The results of these trials are given in tables 6 - 14.

Planting Dates X Variety Experiment - Trial 1

The comparative yields of the 4 sorghum cultivars at 4 planting dates are given in table 6. The first planting was made at the onset of the monsoon and the 3 subsequent plantings were made at 10 days interval thereafter. The actual date of first planting was June 24 on the black soil and June 29 on the red soil.

Delayed planting caused a drastic reduction in yield of all sorghum cultivars The average relative grain yields of both soils for Dates 1, 2, 3 and 4 were 100, 96, 72 and 24, respectively (table 6). The 4th plantings made about August 1st and all varieties were severely attacked by shootfly (83% of the plants damaged) which accounts for the severe grain yield reduction.

There was no shootfly damage in the first and second dates of planting. However, there was a reversal in yield in the black and red soil. In the case of the black soil the first planting date yield was clearly the highest while in the red soil the second planting was highest. The reason for this reversal is

not known, but it is believed to be related to the severe moisture stress on the red soil during the first 20 days of August. Henderson and Smeltzer[1] have shown that the sorghum plant is very sensitive to moisture stress during the pre-boot stage when the inflorescence is about 5 cm long.

In the red soil, the first planting appeared to be at this sensitive stage during the severe moisture stress period. While in the second planting the inflorescence was probably delayed until after the rains came on August 20. In the black soil, where the soil moisture stress was less severe, the first date of planting was clearly the best. The black soil data are in line with data from the All-India Coordinated Sorghum Improvement Program (AICSIP)[2]. It is fortunate the plantings at onset of monsoon are the best, particularly in the black soil, because these soils with their high (55%) montmorillinitic clay content can best be planted at onset of the monsoon. Shortly after the onset of the monsoon these soils becomes saturated and are extremely sticky and difficult to till or plant.

The number of days to 75% heading for dates 1, 2, 3 and 4 were 65, 60, 54 and 52, respectively, thus showing a progressive decrease in the time required for maturity with the later dates of planting. The results indicate that these 4 varieties are moderately sensitive to photoperiod.

The average relative yields for both soils for experimental Hybrid-2219A X CS354, CSH-1, 302 and 604 are 100, 94, 75 and 53 (table 6). Again it is interesting to note the differential response of varieties under the black and red soil conditions. In the black soil where the degree of moisture stress was relatively low, the experimental hybrid was clearly the best and 604 was only slightly below the other two cultivars. However, under the high moisture stress conditions of the red soil, the experimental hybrid was inferior to CSH-1 and 604 was only 40% of that of CSH-1. These preliminary data would indicate that both 604 and the experimental hybrid are more sensitive to moisture stress than CSH-1. Other workers[2] have shown that CSH-1 has been

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[1] Henderson, D. W. & Smeltzer D.G. (1962) Irrigation & Drainage Letter No. 18 University of California.

[1] Singh, M., B.A. Krantz and G.B. Baird, Agronomic Production Techniques in Sorghum. International Sorghum Symposium at Hyderabad, October, 1971.

able to stand drought stress conditions better than most of the other sorghum cultivars. The average grain yield on the red soil was about 84% of that of the black soil.

The effect of planting date upon stalk yields was similar to that upon the grain yields, however, the amount of reduction in stalk yield due to late plantings was less. The relative stalk yield in both soils for dates 1, 2, 3, 4 was 100, 97, 74 and 42, respectively. The stalk yield in the red soil was about 77% of that of the black soil.

The variability in this experiment was higher than normal because of the problems involved in germination due to the relatively dry conditions which prevailed during the 2nd, 3rd and 4th planting. To remedy this situation in part, sprinkler irrigation, involving 2 cm of water, was applied immediately after the 4th date of planting. This assured the emergence of the 4th date of planting and also resulted in emergence of ungerminated seed in dry spots in 2nd and 3rd date of planting.

## Fertilization Experiments

### Trial 2 - Kharif

There was a marked early growth response to phosphorus application in both the red and black soils. This is shown quantitatively in the green and oven dry weight of 10 seedlings taken 3 weeks after planting. In the red soil trial the plants with phosphorus weighed twice as much of those without phosphorus (table 7). This early seedling response also carried through to significant yield responses to phosphorus application to the end of the season. The growth and yield response to phosphorus in the black soil was less than that of the red soil but there was still a significant response to phosphorus application. There was a significant response to the first 40 lbs increment of nitrogen applied on both soils and there was no significant response above the 40 lb. nitrogen rate in either soil. The yield trends for the green and dry weight of stalks were similar to that of the grain yield.

In the red soil the average grain yield in CSH-1 was 43% above that of CSH-3. In the black soil, however, there was no significant difference between the two varieties. These results again indicate that the superiority of CSH-1 is most apparent under the greater moisture stress conditions found in the red soil.

The general yield level in the black soil was consistently above that of the red soil. On the black soil, the average grain yield of 4 adequately fertilized treatments of both varieties (treatments 2 - 5) was 43.4 q/ha. The average yield in the same 4 treatments in the red soil was on 26.1 q/ha or 60% of that of the black soil. The percentage for CSH-1 was 73% and for CSH-3 it was only 47%.

Trial 11 - Rabi

This experiment was similar to trial 2 which was conducted during the kharif season. The main difference in observed responses was the much greater magnitude of the yield response to phosphorus application. This was observed visually and is reflected in both the seedling weights and final grain yields.

In the red soil, the oven-dry seedling weight at 58 days in Trial 11 for the -N, -P, & NP treatments was 136, 31 & 203 grams respectively. The respective seedling weight for these treatments in the black soil was 156, 196 and 101. In the red soil, the magnitude of P response is twice as large as that of trial 2 (table 7).

It appears that the magnitude of the phosphorus deficiency increased with the later dates of planting in the red soil area. The table below gives the grain yields of the minus P & NP treatments in four adjacent experiments planted over a 3.5 month period.

| Trial No. | Date Planted | Grain yield (q/ha) -P | NP | Increase due to P | |
|---|---|---|---|---|---|
| Trial 2 | June 29 | 18.7 | 26.4 | 7.7 | (Table 7) |
| " 3 | July 17 | 7.7 | 26.8 | 19.1 | ( " 9) |
| " 9 | Aug. 30 | 11.8 | 26.2 | 14.4 | ( " 10) |
| " 11 | Oct. 14 | 2.2 | 30.0 | 27.8 | ( " 8) |

The reason for the greater P deficiency and response with the later planting is not known but could be related to climatic conditions and lower soil temperature late in the season. This observation should be studied further in future experiments.

There was a marked response to the first 40N increment and no significant response above 40 kgs/ha of N on either soil (table 8). The magnitude of the nitrogen responses appeared to be similar for trials 2, 3,9 & 11 in the red soil (tables 7, 9, 10 and 8). This is in contrast to the magnitude of phosphorus response mentioned above.

There was no visual response to K and no significant yield response to K in any experiment on either soil (table 7 & 8).

Likewise there was no visual evidence of deficiences of zinc or any other mieronutrients. Since the soil analyses indicated that the K and Zn levels in the red soil were moderately low (table 1) continued vigilance is needed to watch for possible deficiencies of K and Zn in the future. With continued intensive cropping with adequate N & P, it is expected the deficiencies of K & Zn may appear within the next few years in the shallower red soil area of ICRISAT.

## Fertilizer Placement for seedling stimulation & carbofuran for protection from shootfly

### Trial 3 - late kharif

This trial involved various placements of N & P fertilizers (18-46-0) at planting of 2 varieties (CSH-1 and CSH-3) with and without carbofuran granules with the seed at planting. The plantings were made on July 15 at the time when shootfly infestation would have been expected. However, due to abnormally delayed monsoon this year, there was no appreciable shootfly infestation at this date. Thus, we were unable to study the effect of treatments upon shootfly damage. There was no difference due to carbofuran treatment at either location (table 9). In the red soil the yield of CSH-1 was significantly higher than that of CSH-3, while on the black soil there was no significant difference between the two varieties. (This is the same as the trend observed in trial 2 - table 7).

In treatment 5 (NP broadcast) the seedling growth was relatively poor. Although the plants recovered later, the yield was still significantly below that of the NP banded treatment (table 9).

The placement of fertilizer with the seed (treatment 6 & 7) caused considerable stand reduction due to germination injury. However, the surviving plants appeared to tiller heavily and thus overcome some of the effect of the stand reduction. However, there was still significant reduction in grain yield at harvest time due to the placement of fertilizer with the seed (treatment 6 Vs 4 table 9).

In treatments where phosphorus was used, there was also a significant yield increase due to nitrogen application at planting time. This was true even though ample nitrogen was applied to all treatments at topdressing time to eliminate nitrogen as a limiting factor after the seedling stage (treatments 3 Vs 4 in table 9)

The yield trends in the black soil were similar to that of the red soil; however, the differences were not significant. Again the general yield level of the black soil was consistently higher than that of the red soil (table 9). The grain yield of the NP banded treatment of the red soil was 26.8 q/ha or 65% of the 41.1 q/ha produced in the black soil.

Since the major objective of this experiment was to study the effect of fertilizer placement, variety and carbofuran upon shootfly incidence, the experiment did not achieve the objectives because of the low incidence of shootfly at this date of planting. This experiment was repeated in the early part of the rabi season and the results are given below in trial 9.

Trial 9 - Early rabi season

This trial was planted at the end of August when the shootfly attack was severe. In the black soil there was also a severe attack of nocturnal flea beetles on the emerging sorghum seedlings. Plots with no carbofuran treatment were severely damaged by the flea beetle (over 50% of the plants

killed). Plots with carbofuran showed no injury and dead flea beetles were found on the treated plants. Thus carbofuran gave excellent flea beetle control as well as the expected shootfly control.

There was a highly significant grain and stalk yield response to carbofuran on both soils (table 10). There was almost complete shootfly control by carbofuran in both soils. The magnitude of the shootfly damage in the no-carbofuran treatments was much greater in the black soil (85% of plants damaged) than in the red soil (32%). Likewise the magnitude of the yield response to carbofuran was also greater in the black soil than in the red soil (table 10).

There was a marked yield response to phosphorus on the red soil (11.8 Vs 26.2 q/ha). There was also a 17 day delay in heading where P was omitted, (table 10). As in trial 3, the NP broadcast application (treatment 5) was significantly below NP banded (treatment 4). In the black soil there was no significant effect of fertilization upon yield or heading date.

As in trial 3, the placement of NP fertilizer with the seed (treatment 6 & 7) caused severe delay in emergence and reduced plant stand due to the fertilizer salt injury upon germination. Since this so-called "pop-up" treatment had no apparent beneficial effect upon the plants that did emerge and also caused reduction in plant stand, the placement of fertilizer with sorghum seed has no advantages and has a serious disadvantage. In all cases NP banded to the side of the seed appears to be by far the best placement of fertilizer for sorghum in the Semi-Arid conditions.

## Shootfly tolerance Variety experiment

### Trial 4 - kharif

Eight shootfly tolerant selections obtained from Dr. N.G.P. Rao were compared with CSH-1, CSH-3, CSH-4 and PJ8K (local). This experiment, like that of trial 3, was planted in mid July with the expectation of severe shootfly infestation. However, due to the late monsoon no appreciable shootfly build up had occurred and thus there was no opportunity to study the shootfly tolerance of these varieties.

Trial 10 - rabi

This trial was similar to trial 4, but planted at the end of August when the shcotfly incidence was very high.

In addition to shootfly damage there was severe damage by flea beetles to emerging seedlings in the black soil. Visual observations indicated that the shootfly tolerant selections also showed some flea beetle tolerance. Visual scoring on a 1-10 scale (1 no injury and 10 extreme injury) made on September 19 were as follows :

| Variety No. | Score |
|---|---|
| 1 - 6 | 4 - 5 |
| 7, 8, 9 & 12 | 6 - 8 |
| 10 & 11 | 0 - 10 |

Thus it appears that Varieties 1 - 6 which showed some shootfly tolerance also possessed considerable flea beetle tolerance (table 12). Likewise, the 3 hybrids which showed the greatest shootfly damage also showed the greatest flea beetle damage. The possible linking of shootfly tolerance and flea beetle tolerance should be further checked by breeders and entomologists.

Significant yield differences were found in both soils but yields are of little or no importance in this trial (table 12).

The 8 shootfly tolerant entries were crossed in all possible combinations in both trial 4 & 10. Plantings were also made on December 10 & 20 in the red soil and crossed in all possible combinations. All of the progenies of these crosses will be turned over to Dr. Doggett and the ICRISAT entomologist for testing and further crossing.

Since no shootfly tolerant commercial varieties can be expected soon and control by carbofuran is rather expensive, other methods such as avoidance of periods of high build-up of shootfly should be further explored.

All late sorghum plantings (late July through December) experienced varying degree of shootfly infestations. However, the plantings at onset of monsoon were free from shootfly problem due to the low shootfly survival during the preceding hot summer season and the time required for the population to build up. It therefore seems logical to attempt to work out cropping systems in which almost all sorghum could be planted at the onset of the monsoon. This is fairly common practice for red soils, but in the black soil, planting is usually delayed until near the end of the monsoon because of well known difficulties of soil manipulation just before and during the monsoon.

Further research should be directed to the soil and water management problems involved and develop soil, water and crop management that will make it feasible to plant sorghum at the onset of the monsoon in all soils including the black cotton soils. The Farming System Research program at ICRISAT has this as one of its major objectives from the standpoint of water and soil management as well as evasion of the shootfly problem.

## Sorghum Variety Experiments

### Trial 8 - Kharif season

In the red soil, 5 sorghum cultivars were compared (table 13). The grain yield of CSH-1 was 36.7 q/ha, which was significantly above any of the other cultivars. In the black soil CSH-1 gave the highest grain yield (40.6 q/ha), but there was no significant difference between the 4 cultivars. The weight of green stalks of CSH-3 was significantly higher than that of any of the other cultivars on both the black and red soils.

To study the ratoonability of various cultivars one half of these plots were harvested for green fodder at the flowering stage and then allowed to ratoon. CSH-3 gave the highest yield at the first harvest, but the lowest ratoon fodder yield (table 13). The ratoon fodder yields of all sorghum cultivars were considerably poorer than those of the pearl millet cultivars which will be discussed later.

Trial 13 - rabi season

The grain and stalk yields of 3 hybrids (CSH-1, 3 & 4), Swarna and PJ8K for black and red soils are given in table 14. In the red soils all three hybrids gave significantly higher yields than Swarna and PJ8K. The yield trend in the black soil was similar to that of the red soil. In the black soil the yields of CSH-4 and CSH-1 were 40.9 and 39.3 q/ha respectively. The average yield level in the red soil was only 68% of that of the black soil.

The relative number of days to heading of CSH-1 and CSH-3 reversed positions in moving from the kharif to the rabi season. During kharif the average number of days to 75% heading for CSH-1 & CSH-3 was 64 and 73, respectively (table 7). In the rabi the respective number of days for CSH-1 and CSH-3 was 58 and 51 (table 14). These data indicate the extreme photo sensitivity of CSH-3.

CSH-1 produced the highest average grain yield of the 5 cultivars during both the kharif and rabi seasons. The average yield during kharif and rabi reasons was 39.2 and 34.6 q/ha, respectively (table 13 & 14). The respective yield for the black and red soils was 40.0 and 33.5 q/ha (table 13 & 14).

Table 4 Dates of Planting, cultural operations*, and measurements during kharif 1972

| Trial No. | Planting Date | Emergence | Thinning | Cultivation | | Insect spray | | Shoot fly counts | Harvest Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Red Soil | | PM S PP | | | | | | | PM | S | PP |
| 1-D1 | 29-6-72 | 3- 4- 5 | 20-7-72 | 11/7 | 8/8 | - | | 14-8 | 16/9 | 4/10 | 27/10 |
| 1-D2 | 7-7-72 | 11-12-13 | 24-7-72 | " | " | - | | 14-8 | 16/9 | 4/10 | 21/11 |
| 1-D3 | 21-7-72 | 25-26-27 | 8-8 | | 8/8 | - | | 14-8 | 4/10 | 18/10 | 21/11 |
| 1-D4 | 3-8-72 | 7-8-10 | 20-8 | | " | - | | 14-8 | 4/10 | 27/10 | 21/12 |
| 2 | 29-6-72 | 3-4-5 | 20-7 | 11/7 | 8/8 | 8/8 | 25/8 | - | 19/9 | 29/9 16/10 | 27/10 |
| 3 | 17-7-72 | 22-7-72 | 8/8 | 6/8 | | 5/8 | | 17/8 | 18/10 | &2/11 | |
| 4 | 17-7-72 | 22-7-72 | 8/8 | 6/8 | | - | | 17/8 | 18/10 | &2/11 | |
| 5 | 29-6-72 | 5-7-72 | 24-7 | 8/8 | | - | | - | 28/10 | | |
| 6 | 30-6-72 | 5-7-72 | 6/8 | 2 Handweed 2 Push Cultivator | | | | - | Soya 28/9 | P.P 29/10 | |
| 7 | 1-7-72 | 5-7-72 | 18/7 | " | | - | | - | 12/9 | 30/10 | |
| 8 | 29-6-72 | 3 to 8 | 20-7 | 11/7 | 8/8 | 8/8 | 25/8 | | 15/9 | | 27/10 |
| Black Soil | | | | | | | | | | | |
| 1-D1 | 24-6-72 | 28-29-30 | | 14/7 | 22/7 | | | 4-8-72 | 21/9 | 3/10 | 1/11 |
| 1-D2 | 10-7-72 | 14-15-16 | | 22/7 | 7/8 | | | " | 21/9 | 19/10 | 22/11 |
| 1-D3 | 21-7-72 | 25-26-27 | | 28/7 | 7/8 | | | " | 3/10 | 19/10 | 22/11 |
| 1-D4 | 30-7-72 | 3- 4- 4 | | 7/8 | | | | " | 3/10 | 25/10 | 14/12 |
| 2 | 24-6-72 | 28-29-30 | | 14/7 | 7/8 | 9/8 | 23/8 | | 11/9 | 3/10 19/10 | 24/10 |
| 3 | 15-7-72 | 20-7-72 | | 6/8 | | 8/8 | | 16/8 | 19/10 | & 2/11 | |
| 4 | 15-7-72 | 20-7-72 | | 6/8 | | | | 16/8 | | 3/11 | |
| 5 | 24-6-72 | 30-6-72 | 20-8 | 14/7 | 22/7 | | | - | SB | 14/12 | |
| 6 | 10-7-72 | 16-7-72 | 20-8 | | | 5/8 | | - | 5/10 | 10/11 | |
| 7 | 10-7-72 | 16-7-72 | 20-8 | | | | | - | 18/9 | 2/11 | |
| 8 | 24-6-72 | 29/7 | | 14/7 | 7/8 | 9/8 | 23/8 | - | | | |

*Rainfall data & dates of supplemental irrigation are given in section on "weather conditions".

Table 5 Dates of Planting, cultural operations and measurements for Rabi 72-73

| Trial No. | Planting Date | Emergence | Thinning | Cultivation | | Insect Spray | Date of first flower | Harvest Date |
|---|---|---|---|---|---|---|---|---|
| Red Soil | | | | | | | | |
| 9 | 30-8 | 5-9 | 17-9 | | 18-11 | - | - | 4-1 |
| 10 | 30-8 | " | " | | " | - | - | " |
| 11 Sorg. | 14-10 | 20-10 | 6-11 | 31-10, | 13-11 | - | - | 25-1 |
| 11 P.M. | " | 19-10 | " | " | " | - | - | 12-12 |
| 11 Sunf. | " | 22-10 | " | " | " | - | 2-12 | 9-2 |
| 11 Saff. | " | 24-10 | " | " | " | - | 14-12 | 16-2 |
| 12 | 13-10 | 21-10 | - | 31-10, | 15-11 | 17-12 | 23-11 | 9-2 |
| 13 Sorg. | 14-10 | 20-10 | 5-11 | 27-10, | 12-11 | - | - | 23-1 |
| 13 P.M. | " | 17-10 | " | " | " | - | - | 20-1 |
| 14 | 13-10 | - | 27-11 | 31-10, | 12-11 | - | 10-12 | 1-3 |
| 15 | 13-10 | 24-10 | - | 31-10, | 15-11 | | 7-12 | 16-2 |
| 16 | 14-10 | 19-10 | - | 31-10, | 16-11 | 17-12 | 4-12 | 1-3 |
| 17 | 14-10 | 20-10 | - | 31-10, | 14-11 | 17-12 | - | 16-2 |
| 18 | 14-10 | 19-10 | - | 31-10, | 14-11 | 17-12 | 29/11to5/12 | 18-1 |
| Black Soil | | | | | | | | |
| 9 | 28-8 | 4-9 | 17-9 | - | - | - | | 10-1 |
| 10 | " | " | " | - | - | - | | 10-1 |
| 11 Sorg. | 15-10 | 21-10 | 9-11 | 1-11, | 15-11 | - | | 24-1 |
| 11 P.M. | " | 20-10 | " | " | " | - | | 12-12 |
| 11 Sunf. | " | 24-10 | " | " | " | - | 4-12 | 2-2 |
| 11 Saff. | " | 26-10 | " | " | " | - | 15-12 | 16-2 |
| 12 | 15-10 | 24-10 | | 1-11, | 15-11 | - | 24-11 | 9-2 |
| 13 Sorg. | " | 22-10 | 9-11 | 1-11, | 14-11 | - | - | 23-1 |
| 13 P.M. | " | 21-10 | " | " | " | - | - | 18-1 |
| 14 | 15-10 | | 13-11 | 30-10, | | - | 6-12 | 2-2 |
| 15 | 15-10 | 23-12 | | 1-11, | 14-11 | - | 16-12 | 16-2 |
| 16 | 16-10 | 20-10 | - | 1-11 | 7-12 | - | 1/12to5/12 | - |
| 17 | 16-10 | 20-10 | | 1-11 | 15-11 | - | - | 16-2 |
| 18 | 16-10 | 21-10 | - | 1-11 | 15-11 | - | 27/11to3/12 | 18-1 |

*Rainfall data and dates of supplemental irrigation are given in sections on "weather conditions".

Table 6 Effect of 4 planting dates upon grain yield, green and air dry stalk yields and days to 75% heading of 4 sorghum cultivars on red & black soils (Trial 1 - 1972 kharif - all yields in q/ha)

| Treatments* | Grain yield | Stalks | | Days to 75% heading | Shoot fly % damaged |
|---|---|---|---|---|---|
| | | Green | air dry | | |
| Red Soil | | | | | |
| Dates of Planting (M.P.) | | | | | |
| 1. June 29 | 30.2 | 85.0 | 42.5 | 64 | 0 |
| 2. July 7 | 34.4 | 85.7 | 38.1 | 58 | 0 |
| 3. July 21 | 20.6 | 57.9 | 34.4 | 54 | 60 |
| 4. Aug. 3 | 6.6 | 42.1 | 24.9 | 51 | 80 |
| F Value | 27.0** | 20.6** | | | |
| LSD (05) | 7.6 | 15.1 | | | 4th date only |
| a. CSH-1 | 30.6 | 60.4 | 32.8 | 56 | 82 |
| b. 302 | 21.7 | 77.1 | 37.0 | 58 | 83 |
| c. 604 | 12.2 | 72.3 | 40.0 | 56 | 74 |
| d. 2219AXCS354 | 27.2 | 60.8 | 35.2 | 56 | 80 |
| F Value | 8.7** | 4.7* | | | |
| LSD (05) | 5.9 | 12.4 | | | |
| Black Soil | | | | | |
| Dates of Planting (M.P.) | | | | | |
| 1. June 24 | 38.5 | 115.5 | 49.0 | 66 | 0 |
| 2. July 10 | 31.2 | 107.6 | 53.0 | 62 | 0 |
| 3. July 21 | 29.5 | 91.7 | 46.7 | 54 | 35 |
| 4. July 30 | 10.6 | 39.8 | 19.6 | 53 | 86 |
| F Value | 6.2* | 20.4** | | | |
| LSD (05) | 15.3 | 24.1 | | | 4th date only |
| a. CSH-1 | 27.6 | 64.1 | 31.8 | 57 | 84 |
| b. 302 | 24.5 | 99.3 | 49.5 | 60 | 91 |
| c. 604 | 21.6 | 97.5 | 48.8 | 58 | 80 |
| d. 2219AXCS354 | 36.1 | 93.8 | 39.7 | 58 | 88 |
| F Value | 2.9 | 2.8 | | | |
| LSD (05) | N.S. | N.S. | | | |

*Fertilization uniform and adequate.

Table 7 The effect of fertilization upon the average grain yields, green and air dry stalk yields, seedling weight and days to 75% heading of two sorghum hybrids on Red & Black soils (Trial 2 - 1972 Kharif - all yields in q/ha)

| Treatments* | Grain Yield | Stalks Green | Stalks air dry | Days to 75% heading | Seedling (gms) green | Seedling (gms) oven dry |
|---|---|---|---|---|---|---|
| Red Soil | | | | | | |
| 1. 0 - 26 - 0 | 13.4 | 43.9 | 18.4 | 69 | 18.8 | 2.64 |
| 2. 40 - 26 - 0 | 25.2 | 84.3 | 38.8 | 67 | 39.8 | 4.35 |
| 3. 80 - 26 - 0 | 27.9 | 94.0 | 45.1 | 63 | - | - |
| 4.120 - 26 - 0 | 25.1 | 95.4 | 55.5 | 63 | - | - |
| 5.160 - 26 - 0 | 26.2 | 106.8 | 57.7 | 63 | - | - |
| 6.160 - 0 - 0 | 18.7 | 87.4 | 38.5 | 66 | 14.3 | 1.93 |
| 7.160 - 52 - 0 | 21.5 | 97.9 | 46.0 | 64 | 40.3 | 4.42 |
| 8.160 - 26 - 50 | 25.8 | 103.4 | 43.4 | 64 | - | - |
| F Value | 4.94** | 6.77** | - | - | - | - |
| L.S.D.(05) | 6.4 | 21.57 | - | - | - | - |
| a. CSH-1 | 27.0 | 79.0 | 37.9 | 60 | 28.3 | 2.92 |
| b. CSH-3 | 18.8 | 98.5 | 50.2 | 70 | 28.2 | 3.75 |
| F Value | 18.2* | 5.4 | - | - | | |
| LSD (05) | 6.2 | N.S. | - | - | | |
| Black Soil | | | | | | |
| 1. 0 - 26 - 0 | 29.2 | 108.4 | 41.2 | 78 | 12.0 | 1.68 |
| 2. 40 - 26 - 0 | 41.7 | 120.9 | 43.5 | 69 | 26.0 | 3.19 |
| 3. 80 - 26 - 0 | 46.9 | 134.8 | 45.5 | 73 | - | - |
| 4.120 - 26 - 0 | 43.5 | 145.9 | 66.4 | 77 | - | - |
| 5.160 - 26 - 0 | 41.5 | 131.8 | 63.9 | 67 | - | - |
| 6.160 - 0 - 0 | 32.4 | 113.4 | 54.4 | 71 | 14.0 | 2.03 |
| 7.160 - 52 - 0 | 46.1 | 124.1 | 58.9 | 71 | 35.0 | 4.33 |
| 8.160 - 26 - 50 | 51.0 | 125.9 | 62.3 | 70 | - | - |
| F Value | 5.38** | 1.44 | - | - | - | - |
| LSD (05) | 9.3 | N.S. | - | - | - | - |
| a. CSH-1 | 41.0 | 108.7 | 40.2 | 68 | 21.5 | 2.79 |
| b. CSH-3 | 41.8 | 141.5 | 76.4 | 76 | 22.0 | 2.84 |
| F Value | 0.05 | 15.1* | - | - | | |
| L.S.D. (05) | N.S. | 27.0 | - | - | | |

*Fertilizer treatment main Plots & Hybrid-split plots 160-26-50 refers to total amount of N,P & K applied in Kgs/ha. To convert P to $P_2O_5$ multiply by 2.3. To convert K to $K_2O$ multiply by 1.2. All P & K and 24 kgs/ha of N was applied at planting in a band 5 cms to one side. The balance of the nitrogen was topdressed. Since the interaction was not significant, only main plot & split means are given.

Table 8 The effect of fertilization upon grain & stalk yield of CSH-3 sorghum on red and black soils. (Trial 11 - 1972 - 73 rabi - all yields in q/ha)

| | Fertilization* | | | Grain yield | | | Stalks (green wt.) | | | Stalks (air dry) | | | Days to 75% Heading |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Red | Black | Means | Red | Black | Means | Red | Black | Means | Means |
| 1. | 0 | 30 | 0 | 14.6 | 19.2 | 16.9 | 60.4 | 76.6 | 68.5 | 31.4 | 41.4 | 36.4 | 63 |
| 2. | 40 | 30 | 0 | 26.5 | 32.6 | 29.5 | 83.3 | 100.1 | 91.7 | 41.6 | 54.1 | 47.9 | 60 |
| 3. | 80 | 30 | 0 | 29.6 | 28.8 | 29.2 | 83.1 | 95.6 | 89.3 | 44.9 | 52.6 | 48.8 | 60 |
| 4. | 120 | 30 | 0 | 30.3 | 31.8 | 31.0 | 86.2 | 98.5 | 92.3 | 46.5 | 55.2 | 50.9 | 60 |
| 5. | 120 | 0 | 0 | 2.2 | 17.3 | 9.7 | 62.9 | 70.0 | 66.4 | 32.7 | 39.2 | 36.0 | 72 |
| 6. | 120 | 30 | 50 | 23.1 | 32.7 | 27.9 | 75.2 | 106.2 | 90.7 | 40.6 | 59.5 | 50.1 | 60 |
| | F Value | | | 42.3** | 7.74** | | 2.13 | 6.8** | | | | | |
| | LSD (05) | | | 5.0 | 7.6 | | N.S. | 16.7 | | | | | |

*Refers to total amount of N, P, & K applied. 27 kg/ha of N and all P was applied in a band at planting as 150 kg/ha of 18-46-0. The K and the balance of the N was topdressed about 20 days after planting. (to convert P to $P_2O_5$ multiply by 2.29; K to $K_2O$ multiply by 1.2).

Table 9 The effect of fertilization and carbofuran upon the grain yield, green & dry stalks yield, seedling weight, shootfly damage and days to 75% heading of CSH1 & CSH3 on Red & Black soils (Trial 3 kharif 1972 - all yields in q/ha)

| Treatments Fertilizer at Planting* | | | Grain yield | Stalks green | Stalks air Dry | Days to 75% heading | Shootfly % damage | Seedling (gm) Green | Seedling (gm) Oven dry |
|---|---|---|---|---|---|---|---|---|---|
| **Red Soil** | | | | | | | | | |
| 1. 0 | 0 | | 8.3 | 8 | 28.5 | 82 | 12 | 16 | 2.2 |
| 2. 24 | 0 | Banded | 7.7 | 50.3 | 26.2 | 80 | 10 | 21 | 2.6 |
| 3. 0 | 26 | " | 16.2 | 77.5 | 38.7 | 68 | 13 | 108 | 11.3 |
| 4. 24 | 26 | " | 26.8 | 93.1 | 46.5 | 64 | 7 | 188 | 17.3 |
| 5. 24 | 26 | B'dcast | 20.0 | 85.9 | 41.2 | 67 | 9 | 49 | 5.3 |
| 6. 24 | 26 | with seed | 20.2 | 70.7 | 32.5 | 65 | 8 | - | - |
| 7. 12 | 13 | " | 23.0 | 71.6 | 35.8 | 66 | 11 | 157 | 16.7 |
| F Value | | | 17.1** | 15.5** | | | | | |
| LSD (05) | | | 5.3 | 11.8 | | | | | |
| CSH-1 | | | 20.1 | 48.6 | 24.3 | 64 | 7 | 86 | 8.9 |
| CSH-3 | | | 15.7 | 95.8 | 46.9 | 76 | 5 | 93 | 9.5 |
| F Value | | | 8.0** | 422** | | | | | |
| LSD (05) | | | 4.83 | 7.3 | | | | | |
| 0 Carbofuran | | | 18.0 | 67.6 | 33.8 | 70 | 8 | 94 | 10.2 |
| 40 kg/ha | " | | 17.9 | 76.8 | 38.4 | 71 | 3 | 86 | 8.3 |
| F Value | | | .01 | 16.1** | | | | | |
| LSD (05) | | | N.S. | 7.3 | | | | | |
| **Black Soil** | | | | | | | | | |
| 1. 0 | 0 | | 30.5 | 90 | 50.4 | 70 | 8 | 139 | 15.3 |
| 2. 24 | 0 | Banded | 31.6 | 97.1 | 54.4 | 67 | 5 | 166 | 18.9 |
| 3. 0 | 26 | " | 32. | 100.8 | 59.5 | 66 | 6 | 139 | 16.2 |
| 4. 24 | 26 | " | 41. | 123.3 | 69.1 | 65 | 4 | 223 | 23.1 |
| 5. 24 | 26 | B'dcast | 40.6 | 117.7 | 73.0 | 66 | 8 | 180 | 20.2 |
| 6. 24 | 26 | with seed | 39. | 117.7 | 70.6 | 64 | 5 | 298 | 31.6 |
| 7. 12 - 13 | " | " | 35. | 108.7 | 63.1 | 66 | 4 | 265 | 28.2 |
| F Value | | | 1.92 | 2.62 | | | | | |
| LSD (05) | | | N.S. | N.S. | | | | | |
| CSH-1 | | | 36.93 | 75.95 | 46.32 | 59 | 13 | 184 | 21.2 |
| CSH-3 | | | 35.09 | 140.51 | 77.28 | 74 | 8 | 219 | 22.7 |
| F Value | | | 0.5 | 72.7** | | | | | |
| LSD (05) | | | N.S. | 24.1 | | | | | |
| 0 Carbofuran | | | 36.0 | 100.7 | 59.4 | 65 | 15 | 189 | 19.8 |
| 40 kg/ha | " | | 36.0 | 115.8 | 66.0 | 68 | 3 | 214 | 24.1 |
| F Value | | | 0 | 4.0 | | | | | |
| LSD | | | N.S. | N.S. | | | | | |

*24 - 26 refers to N + P applied at planting as 131 kg/ha of 18-46-0 all plots were topdressed sufficient N to bring total N application to 120 N. Carbofuran was applied with seed where indicated.

Table 10 The effect of fertilization and carbofuran upon the grain yield, green and dry fodder yield, seedling weight, shoot fly damage and days to 75% heading of CSH-1 and CSH-3 on Red and Black soils (Trial 9 Rabi 1972 - all yields in q/ha)

| Treatments Fertilizer at Planting* N - P | Grain yield | Fodder | Fodder Dry | Days to 75% heading | Shoot Fly % damaged Plants 14/9 | 21/9 | 29/9 | Seedling Wt. (gms) Fr. | Dry |
|---|---|---|---|---|---|---|---|---|---|
| **Red Soil** | | | | | | | | | |
| 1. 0 - 0 | 15.0 | 59.9 | 30.6 | 69 | 15 | 20 | 21 | 35 | 5 |
| 2. 24 - 0 Banded | 11.8 | 56.7 | 30.1 | 70 | 18 | 22 | 23 | 41 | 6 |
| 3. 0 - 26 " | 23.0 | 74.2 | 39.3 | 64 | 21 | 21 | 35 | 71 | 24 |
| 4. 24 - 26 " | 26.2 | 79.5 | 42.1 | 53 | 26 | 38 | 43 | 285 | 30 |
| 5. 24 - 26 B'dcast | 21.0 | 64.1 | 34.0 | 64 | 21 | 31 | 32 | 197 | 22 |
| 6. 24 - 26 with seed | 23.0 | 57.2 | 30.3 | 56 | 14 | 25 | 29 | 133 | 20 |
| 7. 12 - 13 " " | 24.7 | 68.3 | 36.2 | 62 | 18 | 19 | 40 | 247 | 26 |
| F Value | 14.65** | 6.39** | | | | | | | |
| LSD (05) | 3.9 | 10.3 | | | | | | | |
| CSH-1 | 20.2 | 62.8 | | 64 | 17 | 25 | 32 | 135 | 16 |
| CSH-3 | 21.2 | 68.5 | | 62 | 20 | 23 | 32 | 186 | 26 |
| F Value | 0.40 | 2.0 | | | | | | | |
| LSD (05) | N.S. | N.S. | | | | | | | |
| 0 Carbofuran | 18.0 | 57.0 | | 64 | 37 | 31 | 32 | 101 | 17 |
| 40 kg/ha " | 23.3 | 73.2 | | 62 | 0.7 | 1 | 1 | 220 | 25 |
| F Value | 11.2** | 18.8** | | | | | | | |
| LSD (05) | 5.1 | 12.7 | | | | | | | |
| | | | | | 0 Carbofuran only | | | Carbofuran Plots only | |
| **Black Soil** | | | | | 20/9 | 27/9 | 4/10 | | |
| 1. 0 - 0 | 20.6 | 70.0 | 35.7 | 69 | 45 | 53 | 90 | 256 | 30 |
| 2. 24 - 0 Banded | 21.7 | 73.6 | 39.0 | 68 | 49 | 60 | 92 | 264 | 29 |
| 3. 0 - 26 " | 17.4 | 67.9 | 36.0 | 66 | 42 | 60 | 87 | 264 | 28 |
| 4. 24 - 26 " | 23.3 | 77.9 | 41.3 | 66 | 38 | 46 | 86 | 369 | 41 |
| 5. 24 - 26 B'dcast | 21.6 | 78.7 | 41.7 | 70 | 38 | 52 | 70 | 229 | 27 |
| 6. 24 - 26 with seed | 22.8 | 69.5 | 37.0 | 67 | 37 | 56 | 85 | 286 | 31 |
| 7. 12 - 13 " " | 22.0 | 83.6 | 44.3 | 65 | 26 | 46 | 84 | 340 | 36 |
| F Value | 1.2 | 1.0 | | | | | | | |
| LSD (05) | N.S. | N.S. | | | | | | | |
| 0 Carbofuran | 12.9 | 44.2 | | 73 | 39 | 53 | 85 | | |
| 40 kg/ha " | 29.7 | 104.5 | | 62 | 0 | 3 | 11 | | |
| F Value | 17.2** | 74.74 | | | | | | | |
| LSD | 10.8 | 22.2 | | | | | | | |

* 24 - 26 refers to N + P applied at planting as 131 kg/ha of 18-46-0
All plots were topdressed with sufficient N to bring total N application to 120 N. Carbofuran was applied with seed.

Table 11 The comparative grain yield, stalk yield and days to 75% heading of 8 shoot fly tolerant cultivars & 4 standard cultivars of sorghum on red & black soils. (Trial 4 - 1972 kharif Planting date = July 15 - all yields q/ha)

| Varieties* | Grain | Stalks | | Days to 75% heading | Shoot fly count % |
|---|---|---|---|---|---|
| | | Green | air dry | | |
| Red Soil | | | | | |
| 1. I.S.1053 | 14.1 | 147.2 | 88.3 | 70 | 2.2 |
| 2. " 1082 | 14.5 | 164.5 | 98.7 | 69 | 1.4 |
| 3. " 2123 | 5.5 | 139.2 | 83.5 | 83 | 0 |
| 4. " 3962 | 1.8 | 225.8 | 135.5 | 86 | 0 |
| 5. " 4646 | 1.5 | 160.5 | 96.3 | 84 | 0 |
| 6. " 5459 | 5.0 | 172.2 | 103.3 | 73 | 1.5 |
| 7. " 5642 | 2.4 | 178.2 | 106.9 | 77 | 6.2 |
| 8. " 5702 | 4.5 | 201.5 | 120.9 | 75 | 0 |
| 9. CSH-1 | 29.4 | 49.0 | 29.4 | 52 | 6.6 |
| 10. " 3 | 20.6 | 108.2 | 64.9 | 70 | 7.4 |
| 11. " 4 | 31.2 | 76.9 | 46.1 | 55 | 2.9 |
| 12. PJ8K(Local) | 20.1 | 109.9 | 65.9 | 67 | 6.9 |
| F Value | 65.5** | 15.78** | - | - | - |
| LSD(05) | 4.1 | 37.1 | - | - | - |
| Black soil | | | | | |
| 1. I.S. 1053 | 28.6 | 160.0 | 96.0 | 64 | 10.0 |
| 2. " 1082 | 35.0 | 178.2 | 106.9 | 65 | 2.8 |
| 3. " 2123 | 15.7 | 179.8 | 107.8 | 65 | 0 |
| 4. " 3962 | 18.8 | 234.3 | 140.6 | 82 | 24.8 |
| 5. " 4646 | 19.4 | 190.8 | 114.5 | 82 | 0 |
| 6. " 5459 | 24.5 | 144.2 | 86.5 | 69 | 0 |
| 7. " 5642 | 28.5 | 182.2 | 109.3 | 80 | 3.2 |
| 8. " 5702 | 33.2 | 262.7 | 157.6 | 77 | 6.4 |
| 9. CSH-1 | 28.2 | 59.9 | 35.9 | 58 | 25.7 |
| 10. " 3 | 29.2 | 115.9 | 69.5 | 68 | 25.3 |
| 11. " 4 | 44.2 | 89.2 | 53.5 | 58 | 6.7 |
| 12. PJ8K(Local) | 38.9 | 136.2 | 81.7 | 63 | 13.7 |
| F Value | 5.6** | 7.4** | - | - | - |
| LSD(05) | 1.0 | 4.6 | - | - | - |

Seeds furnished by Dr. NGP Rao, Coordinator, AISIP, Rajengranagar.

Table I2 The comparative grain yields, stalk yields, % of plant with shoot fly damage and day to 75% heading of 8 shoot fly tolerant cultivars 4 standard cultivars of sorghum on red & black soil. (Trial 10 - 1972 rabi Planting date = Aug. 28-30 - all yield in q/ha)

| Varieties* | Grain Yield | Stalks Green | Stalks air dry | Days to 75% heading | Shoot fly count 14-9-72 | 21-9-72 | 28-9-72 |
|---|---|---|---|---|---|---|---|
| Red Soil | | | | | | | |
| 1. I.S. 1053 | 16.9 | 82.3 | 48.56 | 70 | 9 | 23 | 27 |
| 2. " 1082 | 13.1 | 81.6 | 49.78 | 72 | 8 | 19 | 23 |
| 3. " 2123 | 6.9 | 87.6 | 52.56 | 79 | 5 | 18 | 23 |
| 4. " 3962 | 12.3 | 123.2 | 73.92 | 77 | 4 | 10 | 14 |
| 5. " 4646 | 11.3 | 85.9 | 48.96 | 72 | 3 | 12 | 17 |
| 6. " 5459 | 11.7 | 105.2 | 59.96 | 73 | 3 | 16 | 25 |
| 7. " 5642 | 10.0 | 94.6 | 54.87 | 78 | 8 | 23 | 25 |
| 8. " 5702 | 11.7 | 120.2 | 73.32 | 78 | 7 | 19 | 27 |
| 9. CSH-1 | 14.1 | 50.9 | 32.07 | 63 | 20 | 39 | 47 |
| 10. " 3 | 15.9 | 39.6 | 23.76 | 64 | 43 | 55 | 64 |
| 11. " 4 | 18.5 | 54.9 | 31.84 | 64 | 23 | 38 | 50 |
| 12.PJ8K(Local) | 10.1 | 62.9 | 36.22 | 67 | 17 | 28 | 40 |
| F Value | 5.7** | -10.0** | | | | | |
| LSD(05) | 3.6 | 24.1 | | | | | |
| Black soil | | | | | 21-9-72 | 27-9-72 | 4-10-72 |
| 1. I.S. 1053 | 10.0 | 99.6 | 58.76 | 72 | 26 | 31 | 56 |
| 2. " 1082 | 12.3 | 114.9 | 70.09 | 73 | 27 | 43 | 55 |
| 3. " 2123 | 8.7 | 115.2 | 69.12 | 76 | 19 | 28 | 42 |
| 4. " 3962 | 21.5 | 162.5 | 97.50 | 77 | 19 | 27 | 39 |
| 5. " 4646 | 13.8 | 97.2 | 55.40 | 75 | 20 | 28 | 48 |
| 6. " 5459 | 8.9 | 122.9 | 70.05 | 76 | 15 | 27 | 52 |
| 7. " 5642 | 11.2 | 136.9 | 79.40 | 76 | 28 | 37 | 52 |
| 8. " 5702 | 14.1 | 153.8 | 93.82 | 76 | 19 | 35 | 53 |
| 9. CSH-1 | 11.8 | 50.3 | 31.69 | 70 | 44 | 59 | 90 |
| 10. " 3 | 12.5 | 48.6 | 29.16 | 69 | 43 | 66 | 92 |
| 11. " 4 | 22.7 | 63.3 | 36.71 | 73 | 49 | 58 | 90 |
| 12.PJ8K(Local) | 10.2 | 66.6 | 37.30 | 74 | 38 | 59 | 87 |
| F Value | 3.2** | -9.12** | | | | | |
| LSD (05) | 7.3 | 37.3 | | | | | |

* Seeds furnished by Dr. N.G.P.Rao, Coordinator AICSIP, Rajendranagar.

Table 13 Comparison of 5 Varieties of Sorghum in a Grain & stalks plus Ratooned green fodder system Vs a green Fodder plus ratooned green fodder harvest system on red and black soils. (Trial 8 - 1972 kharif - all yields in q/ha)

| Varieties* | Grain harvest system | | | Fodder plus Ratoon Fodder system | | | |
|---|---|---|---|---|---|---|---|
| | Grain | Stalks | | Fodder | | Ratoon Fodder | |
| Red Soil | | Green | air dry | green | air dry | Green | air dry |
| 1. CSH-1 | 36.7 | 159.5 | 86.1 | 71.8 | 38.8 | 28.4 | 15.3 |
| 2. " 3 | 15.8 | 244.4 | 176.0 | 108.7 | 78.3 | 7.6 | 5.5 |
| 3. " 4 | 28.2 | 140.8 | 98.6 | 79.6 | 55.7 | 25.0 | 17.5 |
| 4. Swarna | 20.4 | 134.9 | 80.9 | 77.6 | 46.6 | 31.4 | 18.9 |
| 5. PJ8K (Local) | 19.9 | 184.0 | 92.0 | 92.1 | 46.1 | 28.0 | 14.0 |
| F Value | 37.0** | 15.5** | - | 3.72* | - | 57.8** | - |
| LSD (05) | 4.1 | 34.6 | - | 22.1 | - | 3.6 | - |
| Black soil | | | | | | | |
| 1. CSH-1 | 40.6 | 133.5 | 70.7 | 214.9 | 118.2 | 12.3 | 6.6 |
| 2. " 3 | 37.5 | 151.0 | 107.2 | 295.2 | 197.8 | 15.2 | 10.6 |
| 3. Swarna | 33.9 | 133.9 | 92.4 | 203.6 | 142,5 | 15.0 | 9.0 |
| 4. PJ8K (Local) | 37.7 | 128.9 | 65.3 | 242.5 | 131.0 | 20.4 | 10.61 |
| F Value | 0.82 | 17.2** | - | 4.19* | - | 1.01 | - |
| LSD (05) | N.S. | 7.8 | - | 65.0 | - | N.S. | - |

Fertilization adequate and uniform.

Table 14 Yield comparisons of 5 sorghum cultivars on red & black Soils
(Trial 13 rabi 1972-73 - all yields in q/ha)

| Varieties | Grain yield | | | Days to 75% heading Means R & B | Stalks (Green wt.) | | | Stalks (air dry wt.) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Red Soil | Black Soil | Means R & B | | Red Soil | Black Soil | Means R & B | Red Soil | Black Soil | Means R & B |
| 1. CSH-1 | 30.3 | 39.3 | 34.6 | 58 | 63.0 | 106.4 | 84.7 | 31.5 | 55.3 | 43.4 |
| 2. " 3 | 27.9 | 35.6 | 31.5 | 51 | 54.5 | 85.6 | 70.0 | 28.3 | 44.5 | 36.4 |
| 3. " 4 | 27.8 | 40.9 | 33.9 | 59 | 66.4 | 127.4 | 96.9 | 34.50 | 68.8 | 103.3 |
| 4. Swarna | 18.2 | 27.4 | 22.6 | 65 | 70.5 | 132.6 | 101.6 | 35.3 | 69.0 | 52.1 |
| 5. PJ8K(Local) | 13.1 | 30.2 | 21.6 | 64 | 70.5 | 134.1 | 102.3 | 40.9 | 80.5 | 60.7 |
| F Value | 45.0 | 3.23 | | | 0.46 | 8.95** | | | | |
| L.SD(05) | 3.4 | N.S. | | | N.S. | 21.6 | | | | |

## PEARL MILLET

Experiments involving dates of planting, fertilization and variety comparisons were made on pearl millet during the kharif and rabi seasons. The results of these experiments are reported in tables 15 - 20.

### Date of Planting X Variety - Trial 1

The effects of planting date upon grain yield, stalk yield and days to 75% heading of 4 pearl millet cultivars are given in table 15. The first planting was made at the onset of the monsoon and the next three plantings were made at approximately 10 days intervals. In the red soil, dates 1 and 2 were significantly higher than date 4. Date 3 was intermediate but not significantly different from either the earlier or later dates. The average grain yields for dates 1, 2, 3 and 4 were 31.9, 33.0, 29.2 & 26.2 q/ha, respectively (table 15). The number of days from planting to 75% heading for dates 1, 2, 3 and 4 were 56, 52, 46 and 38 respectively. These results indicate much earlier heading in the later plantings and a high degree of photoperiod sensitivity.

In the black soils the yield trends were similar to the red soil with the exception of the low grain yield in date 1. This is believed to be due to the extremely heavy bird damage since this trial provided the first available bird food in the area. Due to the high degree of variability there was, however, no significant difference in grain yield between the 4 planting dates.

The grain yield and heading dates of the 4 pearl millet cultivars were not significantly different on either the black or the red soil (table 15). The stalk yields of HB-5 and K559 were significantly higher than that of HB 1 & 3.

On the red soil, there was a heavy infestation of large blister beetles which "forage" on the pollen. The average number of beetles per 5 m of row for HB-1, HB-3, HB-5 & K-559 was 32, 24, 35, & 37, respectively.

## Fertilization

### Trial 2 - Kharif

There was a marked seedling response to phosphorus applications which carried through to significant grain yield increases on both soils (table 16). In the red soil there was also a marked response to nitrogen application up to the 40 kg/ha nitrogen rate. On the black soil, trends were similar but the magnitude of the response was much less.

The stalk yield response to phosphorus was less than that of the grain. However, the yield response to nitrogen was greater in the stalk than in the grain (table 16).

The grain yield level of pearl millet in the black soil was only slightly higher than that of the red soil in both trials 1 & 2. This is in contrast to the comparative sorghum experiments where the yield level in the red soil was only about 65% of that of the black soil. The reason for this difference is not known, but one possible explanation is the fact that because of the earlier maturity the pearl millet did not suffer as much from the late season moisture stress of the red soil as did the sorghum.

### Trial 11 - rabi

As in the case of sorghum, the major differenee between trial 11 and trial 2 is the magnitude of the response to phosphorus application in the red soil area (table 16 & 17). This is reflected visually in pictures, and in the seedling weights and final yields. In the red soil, the seedling oven-dry weights taken at 8 weeks for the -N, -P & NP treatments are 84, 20 & 111 gms, respectively. Thus in the red soil, phosphorus application increased seedling growth over five-fold in trial 11 and less than two-fold in trial 2. Likewise, in harvested yield, phosphorus increased first crop fodder yield more than four-fold in trial 11 while the yield increase due to phosphorus was only 32% in trial 2. Since the sites of trial 11 and trial 2 are only about 80 meters apart this amount of difference would not be expected. Thus the reasons for this magnitude of differential response to phosphorus deserve further study.

Since the seed set of rabi planted pearl millet is normally not good due tu cool weather, this experiment was harvested for fodder at flowering stage. The first fodder harvest was at 57 days after planting, the first ratoon harvest was 86 days after planting and the second ratoon harvest on February 14, 121 days after planting.

The amount of fodder yield and the magnitude of the response to P & N was greatest in first crop and fairly good in the first ratoon. By the time of the 2nd ratoon crop soil moisture was the overriding limiting factor. Since there had been only 2.2 cm of rain since planting and the last minimal irrigation occurred on December 12 in black soil and December 31 on red soil, soil moisture was the overriding limiting factor during the growth of the second ratoon crop. In the red soil the average total fresh fodder yield of the adequately fertilized treatments (No. 2, 3, 4 & 6) was about 220 q/ha or (80 q/ha air dry). The yields in black soil were only slightly less than those of the red soil. Further studies are needed to assess the nutritional and economic value of this high quality fodder compared to the low quality leafless stalks which are normally marketed in this area.

## Variety Experiments

### Trial 8 - Kharif

In the red soil, 5 pearl millet cultivars were compared under three systems of harvest (table 18). It is interesting to note that when the first harvest was made for green fodder at the flowering stage most of the varieties produced good ratoon yields either for fodder or grain. However, when the harvest was delayed until the matured grain stage the ratooned growth was greatly reduced. Hybrid HB-4 gave highest yield both when harvested for green fodder at flowering stage or for grain at maturity. The grain yield of the Vijay (local was consistently below that of the 4 hybrids in both the first crop and the ratoon crop. In HB-4 after a large harvest of high quality green fodder 233 q/ha the ratooned crop produced from 13 q/ha of grain which was only slightly less than the yield produced from the grain crop at first harvest (table 18). The possibility of ratooning pearl millet for multiple harvest looks encouraging and further studies are planned on the ratoonability of various pearl millet varieties.

The yields of 4 pearl millet cultivars under two systems of harvest on the black soil are given in table 19. When the first harvest was made for grain, HB-5 produced the highest yield (31.3 q/ha). HB-5 also produced the highest yield of stalks and green fodder. This is in contrast to the red soil where HB-4 produced the highest yields.

Trial 13 - Rabi

Because of cool weather at flowering time the seed set of pearl millet is generally poorer during rabi than during kharif. In spite of this, good grain yields (21 - 24 q/ha) were obtained, especially on the black soil (table 20). One of the reasons for conducting this experiment was to observe comparative seed set under the cool rabi conditions. Seed set scoring indicate that Vijay was the best. There was relatively little difference between the 4 hybrid, although HB-1, 3 & 5 tended to have slightly poorer seed set, especially on the red soil.

The big difference between the two seasons was in the yield of Vijay (local). During the kharif (tables 18 & 19) the hybrids yielded two to three times that of Vijay, while in the rabi (table 20) the yield of Vijay was equal to that of the hybrids.

Table 15 The effect of 4 planting dates upon grain yield, green and air dry stalk yield and days to 75% heading of 4 Pearl millet cultivars on red & black soils (Trial 1 - 1972 kharif).

| Treatments | Grain yield | Stalk yield | | Days to 75% Heading |
|---|---|---|---|---|
| | | Green | air dry | |
| Red Soil | | | | |
| Dates of Planting (M.P.) | | | | |
| 1. June 27 | 31.9 | 103.1 | 39.2 | 56 |
| 2. July 7 | 33.0 | 122.7 | 41.7 | 52 |
| 3. July 21 | 29.2 | 89.8 | 32.3 | 46 |
| 4. Aug 3 | 26.2 | 102.4 | 35.8 | 38 |
| F Value | 4.47* | 20.9** | - | - |
| LSD (05) | 4.6 | 9.6 | - | - |
| a. HB-1 | 28.6 | 92.5 | 33.3 | 49 |
| b. HB-3 | 32.0 | 101.8 | 36.7 | 48 |
| c. HB-5 | 31.3 | 112.8 | 41.7 | 48 |
| d. K-559 | 28.3 | 110.8 | 41.0 | 48 |
| F Value | 0.84 | 11.1** | - | - |
| LSD (05) | N.S. | 8.9 | - | - |
| Black soil | | | | |
| Dates of Planting (M.P.) | | | | |
| 1. June 24 | 16.7 | 132.7 | 37.2 | 53 |
| 2. July 10 | 29.8 | 111.6 | 42.4 | 54 |
| 3. July 21 | 31.6 | 115.4 | 32.1 | 45 |
| 4. July 30 | 27.1 | 109.6 | 30.7 | 44 |
| F Value | 3.09 | 2.2 | - | - |
| LSD (05) | N.S. | N.S. | - | - |
| a. HB-1 | 25.5 | 106.3 | 36.1 | 49 |
| b. HB-3 | 25.0 | 113.3 | 31.7 | 46 |
| c. HB-5 | 27.4 | 125.8 | 45.3 | 49 |
| d. K-559 | 27.4 | 123.8 | 39.6 | 47 |
| F value | 0.30 | 2.0 | - | - |
| LSD 05 | N.S. | N.S. | - | - |

Table 16 The effect of fertilization upon the average grain yield, green stalk weight, dry stalk weight and days to 75% heading of Pearl millet hybrid HB3 on Red and Black soils (Trial 2 - 1972 kharif - all yields in q/ha)

| Treatments* | Grain | Stalks | | Days to | Seedling Wt. (gms) | |
|---|---|---|---|---|---|---|
| Red Soil | yield | Green | air dry | 75 % heading | Green | oven dry |
| 1. 0 - 26 - 0 | 12.8 | 48.0 | 15.4 | 47 | 21.5 | 2.26 |
| 2. 40 - 26 - 0 | 22.4 | 78.1 | 28.0 | 46 | 44.5 | 5.03 |
| 3. 80 - 26 - 0 | 26.3 | 86.9 | 26.1 | 45 | | |
| 4.120 - 26 - 0 | 24.5 | 87.7 | 24.6 | 44 | | |
| 5.160 - 26 - 0 | 28.4 | 95.4 | 26.7 | 45 | | |
| 6.160 - 0 - 0 | 21.5 | 94.4 | 26.4 | 47 | 34.1 | 3.33 |
| 7.160 - 52 - 0 | 27.3 | 88.7 | 23.1 | 45 | 68.6 | 6.85 |
| 8.160 - 26 - 50 | 26.2 | 100.4 | 28.1 | 45 | | |
| F Value | 6.85** | 5.84** | - | - | | |
| L.SD 05 | 5.6 | 20.0 | - | - | | |
| Black Soil area | | | | | | |
| 1. 0 - 26 - 0 | 20.6 | 51.6 | 15.5 | 52 | 13.7 | 1.44 |
| 2. 40 - 26 - 0 | 23.4 | 63.3 | 22.1 | 56 | 24.5 | 2.66 |
| 3. 80 - 26 - 0 | 22.4 | 73.7 | 30.6 | 55 | | |
| 4.120 - 26 - 0 | 26.0 | 86.4 | 27.7 | 53 | | |
| 5.160 - 26 - 0 | 28.6 | 92.1 | 31.3 | 51 | | |
| 6.160 - 0 - 0 | 14.8 | 77.1 | 32.5 | 53 | 18.7 | 1.80 |
| 7.160 - 52 - 0 | 32.5 | 83.7 | 39.5 | 52 | 36.0 | 2.61 |
| 8.160 - 26 - 50 | 29.1 | 101.3 | 39.4 | 52 | | |
| F Value | 6.0** | 5.85** | - | - | | |
| LSD | 6.7 | 19.2 | - | - | | |

*Fertilizer treatment main Plots & Hybrid - split plots. 160 - 26 - 50 refers to total amount of N, P & K applied in kgs/ha. 24 N and the P & K was applied in a band 5 cms to one side of seed at Planting. The balance of N was topdressed. (To convert P to $P_2O_5$ multiply by 2.29 and K to $K_2O$ multiply by 1.2)

Table 17 The effect of fertilization upon grain yield of HB-3 Pearl Millet on red and black soils. (Trial 11 - 1972-73 Rabi - all yields in q/ha).

| Red Soil Fertilization | | | Green Fodder Yield | | | | | Dry Fodder Yield | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd | Total | Means of totals of Red & Black | 1st | 2nd | 3rd | Total | Means of totals of Red & Black |
| N | P | K | | | | | | | | | | |
| 1. 0 | 30 | 0 | 79.5 | 49.3 | 20.8 | 149.6 | | 35.0 | 12.8 | 5.2 | 53.0 | |
| 2. 40 | 30 | 0 | 113.1 | 84.7 | 18.5 | 216.3 | | 49.8 | 23.7 | 4.8 | 78.3 | |
| 3. 80 | 30 | 0 | 98.9 | 88.5 | 21.0 | 208.4 | | 45.5 | 24.8 | 5.5 | 75.8 | |
| 4.120 | 30 | 0 | 101.4 | 89.3 | 24.2 | 214.8 | | 44.6 | 25.0 | 6.3 | 75.9 | |
| 5.120 | 0 | 0 | 22.9 | 45.6 | 25.8 | 94.3 | | 10.1 | 13.7 | 10.7 | 34.5 | |
| 6.120 | 30 | 50 | 116.0 | 103.1 | 24.8 | 243.9 | | 53.4 | 33.9 | 6.4 | 93.7 | |
| F Value | | | 12.73 | 4.93 | 0.995 | 28.0** | | | | | | |
| LSD (05) | | | 29.3 | 25.2 | N.S. | 31.4 | | | | | | |
| Black Soil | | | | | | | | | | | | |
| N | P | K | | | | | | | | | | |
| 1. 0 | 30 | 0 | 88.7 | 32.7 | 9.2 | 130.6 | 140.1 | 39.9 | 11.1 | 2.6 | 53.6 | 53.3 |
| 2. 40 | 30 | 0 | 101.2 | 37.9 | 9.2 | 148.3 | 182.3 | 44.5 | 12.1 | 2.6 | 59.2 | 68.8 |
| 3. 80 | 30 | 0 | 103.9 | 48.5 | 11.2 | 163.61 | 186.0 | 47.8 | 16.5 | 3.4 | 67.7 | 71.8 |
| 4.120 | 30 | 0 | 119.1 | 57.3 | 12.1 | 188.5 | 191.7 | 47.6 | 20.6 | 3.6 | 71.8 | 73.9 |
| 5.120 | 0 | 0 | 81.2 | 53.1 | 13.1 | 147.4 | 120.9 | 37.4 | 19.1 | 3.9 | 60.4 | 47.5 |
| 6.120 | 30 | 50 | 105.8 | 57.1 | 10.6 | 173.5 | 208.7 | 48.7 | 20.6 | 3.2 | 72.5 | 83.1 |
| F Value | | | 6.45 | 6.045 | 2.117 | 6.49** | | | | | | |
| LSD (05) | | | 5.11 | 8.96 | N.S. | 22.7 | | | | | | |

*Refers to total amount of N,P & K applied. 27 kg/ha of N and all was applied in band at planting as 150 kg/ha of 18-46-0 the K and the balance of the N was top-dressed about 20 days after planting (to convert P to $P_2O_5$ multiply by 2.29 and K to $K_2O$ multiply by 1.2)

Table 18 Comparison of 5 varieties of Pearl millet in 2 harvest system on red soils. (Trial 8 - 1972 Kharif - all yields in q/ha)

| Varieties* | Fodder | | Ratooned Fodder | | Ratoon | Ratooned Stalks | |
|---|---|---|---|---|---|---|---|
| | Green | air dry | Green | air dry | Grain | Green | air dry |
| | Green Fodder plus ratooned green fodder system | | | | | | |
| 1. HB - 1 | 157.5 | 66.2 | 38.3 | 14.6 | - | - | - |
| 2. HB - 3 | 148.3 | 56.4 | 56.7 | 24.9 | - | - | - |
| 3. HB - 4 | 233.3 | 98.0 | 80.0 | 28.8 | - | - | - |
| 4. HB - 5 | 196.7 | 74.7 | 56.7 | 24.9 | - | - | - |
| 5. Local (Vijay) | 200.0 | 88.0 | 60.0 | 24.0 | - | - | - |
| F value | 8.5** | - | 7.2** | - | | | |
| L.S.D. (05) | 25.6 | - | 16.8 | - | | | |
| | Green Fodder plus ratooned Grain & stalks | | | | | | |
| 1. HB - 1 | 157.5 | 66.2 | - | - | 9.5 | 10.8 | 5.4 |
| 2. HB - 3 | 148.3 | 56.4 | - | - | 9.6 | 10.8 | 5.0 |
| 3. HB - 4 | 233.3 | 98.0 | - | - | 13.0 | 16.7 | 7.7 |
| 4. HB - 5 | 196.7 | 74.7 | - | - | 12.3 | 13.3 | 5.6 |
| 5. Local (Vijay) | 200.0 | 88.0 | - | - | 5.3 | 13.3 | 6.1 |
| F Value | 8.5** | - | | | 4.4* | 2.0 | - |
| LSD (05) | 25.6 | | | | 4.5 | N.S. | - |

| | Grain & stalks plus Ratooned green Fodder | | | | |
|---|---|---|---|---|---|
| | Grain | Stalks | | Ratoon fodder | |
| | | Green | air dry | Green | air dry |
| 1. HB - 1 | 11.9 | 96.7 | 29.0 | 6.3 | 3.2 |
| 2. HB - 3 | 18.1 | 118.3 | 30.7 | 11.5 | 5.3 |
| 3. HB - 4 | 22.8 | 159.2 | 47.8 | 9.6 | 4.4 |
| 4. HB - 5 | 17.2 | 132.5 | 37.1 | 9.5 | 4.0 |
| 5. Local (Vijay) | 6.8 | 148.3 | 50.4 | 12.7 | 5.8 |
| F Value | 9.69** | 5.9** | - | 3.86* | - |
| LSD (05) | 6.1 | 30.8 | - | 4.0 | - |

*Fertilization adequate and uniform

Table 19 Comparison of 4 varieties of Pearl millet in a Grain and stalks plus Ratooned green fodder system Vs a green Fodder plus ratooned green fodder harvest system on black soils. (Trial 8 - 1972 kharif - all yields in q/ha)

| Varieties | Grain & stalk plus Ratoon Fodder Sy. | | | | | Fodder plus Ratoon Fodder system | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Grain | Stalks green | Stalks air dry | Ratooned Fodder green | Ratooned Fodder air dry | Fodder green | Fodder air dry | Ratooned Fodder green | Ratooned Fodder air dry |
| 1. HB-1 | 20.6 | 147.2 | 48.7 | 32.5 | 13.7 | 204.7 | 81.9 | 48.7 | 19.5 |
| 2. HB-4 | 25.2 | 153.0 | 52.0 | 36.7 | 16.2 | 228.6 | 86.9 | 62.1 | 26.1 |
| 3. HB-5 | 31.3 | 182.0 | 56.4 | 40.0 | 20.0 | 244.4 | 102.7 | 62.9 | 26.4 |
| 4. Vijay (local) | 14.8 | 180.5 | 61.4 | 50.8 | 24.4 | 208.6 | 83.5 | 38.3 | 16.9 |
| F Value | 4.43 | 11.41 | - | 1.29 | | 2.61 | | 1.24 | |
| LSD (05) | 10.66 | 17.18 | - | N.S. | | N.S. | | N.S. | |

Table 20 Yield comparison of 6 pearl millet cultivars on red and black soils. Trial 13, 1972 - 73 rabi. (Means of 4 replications - all values given in q/ha).

| Varieties* | Grain yield | | | Days to 75% Heading | Stalks - Green wt. | | | Stalks - air dry | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Red Soil | Black Soil | Means R & B | R & B | Red Soil | Black Soil | Means R & B | Red Soil | Black Soil | Means R & B |
| 1. HB-1 | 9.0 | 22.6 | 15.8 | 51 | 64.6 | 121.0 | 92.8 | 27.1 | 58.1 | 46.2 |
| 2. " 3 | 10.6 | 21.8 | 16.2 | 49 | 70.2 | 96.2 | 83.2 | 28.1 | 26.2 | 37.2 |
| 3. " 4 | 13.7 | 21.0 | 17.4 | 48 | 61.8 | 87.4 | 74.6 | 24.7 | 49.0 | 33.3 |
| 4. " 5 | 10.8 | 23.7 | 17.3 | 50 | 80.8 | 125.5 | 103.2 | 35.6 | 65.3 | 50.5 |
| 5. K 559 | 12.0 | 19.9 | 16.0 | 54 | 76.4 | 107.9 | 92.2 | 35.6 | 58.3 | 46.0 |
| 6. Vijay (local) | 14.6 | 20.5 | 17.6 | 61 | 84.8 | 145.1 | 115.0 | 39.0 | 81.3 | 60.2 |
| F Value | 3.14* | 0.44 | - | - | 19.08** | 10.84** | - | - | - | - |
| LSD (05) | 3.5 | N.S. | - | - | 6.3 | 41.4 | - | - | - | - |

*Uniform and adequate fertilization provided.

PIGEON PEAS

During the kharif season experiments involving dates of planting, fertilization, inoculation and variety comparisons were conducted on pigeon peas. The results of these experiments are given in tables 21 - 23.

Although the vegetative growth was good, the general grain yield levels of pigeon peas were low throughout all the experiments. The reason for this is not fully understood, but it is believed to be due mainly to the very heavy infestation of the large (2.5 cm) red and black blister beetles. These beetles forage only on flower buds and have a voracious appetite. Attempts at control by application of insecticides were only slightly effective. The attack came in two periods and since the damage was quite general it is difficult to assess the degree of damage. We hope to find better methods of dealing with this beetle before the next season.

Dates of planting X Varieties - Trial 1

In the red soil there was a significant reduction in yield with the later plantings (table 21). The trend was similar in the black soil but not significant. The average yield for the two soils at first planting was 11.1 q/ha and there was a progressive yield reduction to 7.5 for the 4th planting date.

In the variety comparisons there was no significant difference in red soil. In the black soil S-3 was significantly better than Pusa Ageti (table 21).

Fertilization - Trial 2

There was no appreciable visual response to any fertilizer treatment during the growing season. Likewise there was no significant yield response to fertilization on either the red or the black soil (table 22).

Since there were marked responses to both phosphorus and nitrogen in the adjacent pearl millet and sorghum experiments, it is obvious that pigeon peas are much less responsive to fertilization.

Pigeon Pea Variety and Inoculation - Trial 5

A comparison of 6 varieties is given in table 23. Three varieties from Brazil which were furnished by Dr. A Downie of USAID were extremely late and appeared to be of little value as such in this area. These plants were still blooming at the end of March but a harvest was made of the few pods which had formed. These seeds will be kept for the pigeon pea breeder to use in crossing work.

The balance of experiments involved 3 varieties - Pusa Ageti, Type 21 and ST-1 local with and without inoculum. During the growing season there was never any visual difference between the inoculated and uninoculated plants. Examinations of the roots indicated that the plants to which additional inoculum had been added still had a large number of nodules scattered over the root system. Apparently these were sufficient to take care of the nitrogen needs of the plant. Pusa Ageti tended to have slightly higher yield than the other two varieties but the differences were not significant.

In a large scale variety trial, the yields of ST-1 (local) and T-21 were 8.6 and 7.6 q/ha respectively and there was no significant difference between the two varieties.

It is obvious that much intensive research is needed to develop varieties and production techniques which will provide greater yield potential.

Table 21 The effect of 4 planting dates upon grain yield of 4 Pigeon Pea Varieties on Red and Black soils.(Trial 1 - 1972 kharif - all yields in q/ha).

| Treatments* Dates of Planting (M.P.) | Grain yields Red | Black | Means |
|---|---|---|---|
| 1. June 29 | 11.6 | 10.6 | 11.1 |
| 2. July 7 | 10.0 | 10.2 | 10.1 |
| 3. July 21 | 9.8 | 8.3 | 9.0 |
| 4. Aug 3 | 7.3 | 7.7 | 7.5 |
| F Value | 16.1** | 1.62 | - |
| LSD (05) | 1.4 | N.S. | - |
| Varieties (Split plots) | | | |
| a. Pusa Ageti | 10.5 | 8.4 | 9.4 |
| b. Sharda | 9.4 | 9.0 | 9.2 |
| c. Mukta | 9.2 | 9.2 | 9.2 |
| d. S-3 | 9.5 | 10.3 | 9.9 |
| F Value | 2.4 | 7.7** | - |
| LSD (05) | N.S. | 1.5 | - |

Fertilization uniform and adequate.

Table 22 The effect of fertilization upon the average grain yield weight and days to 50% heading of the pigeon pea on Red and Black soils (Trial 2 - 1972 Kharif - all yields in q/ha)

| | Treatments | | | Grain yields | | | Days to 50% Flowering | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Red | Black | Means | Red | Black | Means |
| 1. | 0 | 26 | 0 | 10.2 | 11.5 | 10.9 | 55 | 56 | 56 |
| 2. | 24 | 26 | 0 | 11.1 | 10.9 | 11.0 | 54 | 54 | 54 |
| 3. | 48 | 26 | 0 | 11.7 | 10.1 | 10.9 | 52 | 52 | 52 |
| 4. | 48 | 13 | 0 | 10.0 | 10.8 | 10.4 | 52 | 52 | 52 |
| 5. | 48 | 39 | 0 | 9.9 | 9.4 | 9.7 | 52 | 52 | 52 |
| 6. | 48 | 0 | 0 | 11.3 | 11.1 | 11.2 | 57 | 59 | 58 |
| 7. | 48 | 52 | 0 | 11.2 | 10.4 | 10.8 | 52 | 53 | 53 |
| 8. | 48 | 26 | 50 | 8.9 | 10.8 | 9.9 | 52 | 52 | 52 |
| | F Value | | | 1.46 | 2.04 | - | | | |
| | LSD (05) | | | N.S. | N.S. | | | | |

*48-26-50 refers to total amount of N, P & K applied in kgs/ha. All P & K and 24 kg/ha of the N. applied at planting. The balance of the N applied as top-dressing about one month after planting. To convert P to $P_2O_5$ multiply by 2.3 K to $K_2O$ multiply by 1.2.

Table 23 Pigeon pea variety and inoculation experiment on red and black soils. (Trial 5 kharif 1972 - all yields in q/ha)

| | Variety | Grain yields | | |
|---|---|---|---|---|
| | | Red | Black | Means |
| 1. | Brazil 465 + Inoculum* | 1.0 | 0.4 | 0.7 |
| 2. | " 466 + " | 1.7 | 0.7 | 1.2 |
| 3. | " 467 + " | 2.1 | 1.9 | 2.0 |
| 4. | Pusa Ageti + " | 12.5 | 14.3 | 13.4 |
| 5. | Type 21 + " | 12.2 | 9.5 | 10.7 |
| 6. | ST-1 + " | 11.7 | 9.3 | 10.5 |
| 7. | Pusa Ageti No Inoculum | 10.6 | 14.8 | 12.7 |
| 8. | Type 21 " " | 12.3 | 10.9 | 11.6 |
| 9. | ST-1 " " | 11.9 | 10.2 | 11.1 |
| | F Value | 0.44 | 1.31 | - |
| | LSD (05) | N.S. | N.S. | - |

*Inoculum furnished by Dr. R. B. Rewari, IARI, New Delhi.
Varieties 1, 2 & 3 omitted from analysis of Variance because of heterogeneity of Variance.

## INTERCROPPING EXPERIMENTS

The main objective of this study was to determine whether or not greater total crop production and profit could be produced by intercropping of two crops compared to solid cropping of each crop. This approach appears to be particularly important when dealing with a plant like pigeon peas in which seedling growth is very slow. This first year study involved intercropping of pigeon peas with a legume (soybeans) in trial 6 and with a fast growing cereal (pearl millet) in trial 7.

### Modifications of Swastik seven row Planter

In order to plant intercropping experiments with varying patterns of intercropping such as alternate row and alternate double row plantings, it was necessary to modify the Swastik planter. This modification involved the mounting of 2 seed boxes behind and above the regular seed box so that the seed tubes could be shifting in either direction for various row patterns. By this modification soybeans or pearl millets could be placed in the standard seed box and pigeon pea in the extra boxes, so that each could be sown simultaneously at proper rates. The fertilizer adjustment plate was also re-designed with narrow triangular shaped slots in order to give better accuracy at lower rates of application than is possible with the standard fertilizer plate. With these modifications the Swastik drill worked satisfactorily for seeding the intercropping experiments. An additional modification is being made for next season. It involves the removal of the pack wheel tool bar and replacing it with a hollow 2" square tool bar for placing furrow shovels.

### Soybeans - Pigeon Pea intercropping - Trial 6

Grain yields from three methods of intercropping of Pigeon Peas and Soybeans compared with solid plantings of each crop are given in table 24. There was no significant difference due to different methods of intercropping on either crop on the black or the red soil. Observations during the growing season indicated that growth was slightly better in alternate row plantings

(treatment 2) than in solid plantings (treatment 1). The final yields show similar trends but these trends are not statistically significant. The yield comparisons are given both on a row basis and on an area basis. In the case of the first three treatments, the area basis is calculated by merely dividing the row-based value by 2, since each crop occupied half of the space. In case of treatment 4 the calculations are made on the basis of 25:75 ratio for pigeon pea and soybeans, respectively.

The Bragg variety of soybeans which was used in this experiment has an indeterminate growth pattern and started flowering at 31 days when the vegetative growth was very small, particularly in the case of the red soil. It is apparent that the soybeans were not able to capitalise on the extra space early in the season, as was true in the case of pearl millet in Trial 7. It is possible that with this small growth greater soybean yields could have been obtained by closer row spacing of soybeans.

Although it was not possible to make direct comparisons between soybeans and other crops, visual observations indicated that soybeans were more sensitive to drought than the companion pigeon pea. The soybeans likewise appeared to be more sensitive to drought than the pearl millet in adjacent trial 7. This was especially noticeable in the red soil where the soil moisture stress was severe.

This year soybean stubble was removed and several rabi crops planted in its place. The removal of soybean stubble and preparation of a seed bed in dry soil at the end of the kharif season was difficult. Even more difficult was the successful establishment of crops like chick peas, sunflower, safflower and castor beans in between fullgrown pigeon pea plants. On the basis of this year's experience, this experiment will be re-designed to delete any seeding of rabi crops in fullgrown pigeon peas. However, the concept of intercropping during kharif season with a quick growing plant such as soybeans, cowpeas, mung beans and short season varieties of millets and sorghums warrants further investigation.

The main insect problem encountered was the invasion of the hairy caterpillar in the red soil site. The caterpillar hatched out in the surrounding shrubs and weeds and invaded enmass from July 10 to 25th. The hairy caterpillar has a voracious appetite and will eat most crops and weeds; however it showed a strong preference for soybean seedlings. A trench covered with BHC powder helped greatly in halting the invasion. This method was supplemented by a "biological control" procedure - six ladies with sticks.

Pearl Millet - Pigeon Pea Intercropping - Trial 7

The yield potential of intercropping pearl millet with pigeon peas looks very promising. In alternate row plantings, the pearl millet was able to capitalize on the space left vacant during the early period while the pigeon peas were being established. In the red soil the pearl millet yields of alternate row planting were about 50% higher than solid row planting, (table 25) In the black soil the pearl millet yields in alternate rows were about 60% higher than in the solid plantings (table 26). In spite of the greatly increased growth and yield of the pearl millet in the alternate rows, the pigeon pea yield in the alternate rows was only slightly reduced compared to solid planted pigeon peas. The comparative pigeon pea yields for solid (treatment 1) vs alternate rows (treatment 2)were 9.9 Vs 8.1 q/ha on the row basis and 4.95 Vs 4.05 q/ha on an area basis. Likewise, the different methods of pearl millet harvest had no significant effect upon the yield of the companion pigeon pea crop.

In the pearl millet the following four harvest systems were used on the red soil (tables 25 & 26).

a. Fodder (52)* ratooned grain (113)
b. Fodder (52) ratooned fodder (71) ratooned grain (129)
c. Grain (72) ratooned fodder (129)
d. Grain (72) ratooned grain (144).

*The number in parenthesis indicates the number of days after planting at which each of the multiple harvests were made. In the black soil the "c" harvest system was omitted.

All yields in tables 25 and 26 are given on the row basis. The following table gives a comparison of pearl millet and pigeon pea yields of solid cropping Vs alternate row cropping on the "area" basis for the "a" and "b" systems of harvest (yields given are an average of red and black soil trials - All yields in q/ha).

| Treatments | Harvest Systems | Fodder Green | Ratoon Fodder Green | Ratoon Grain & Stalk Grain | Stalks Green | Pigeon Pea Grain |
|---|---|---|---|---|---|---|
| 1. Solid cropping | F-G | 105.2 | - | 6.3 | 23.9 | 4.95 |
| 2. Alternate row | F-G | 169.2 | - | 12.3 | 34.1 | 4.05 |
| 1. Solid cropping | F,F,G | 105.2 | 39.9 | 3.6 | 9.2 | 4.95 |
| 2. Alternate row | F,F,G | 169.2 | 56.5 | 5.3 | 10.2 | 4.05 |

F-G = Fodder-grain harvest system; F-F-G = Fodder, Fodder, Grain Harvest system.

The above data show that in either F-G or F-F-G harvest the total pearl millet yields in the alternate row cropping are over 50% above that of the solid cropping.

Since the pigeon pea yield in the alternate row planting was almost the same as solid planting, the total production of the two crops in the alternate row planting was 50% above that of the solid planting.

When pearl millet was harvested for fodder at flowering stage the small tillers quickly produced a ratoon crop. However, when the first crop was allowed to mature as grain, many of the small tillers died and regrowth of the ratoon crop was delayed and the yield was meager. In alternate row planting treatment, the ratooned grain yield after a fodder harvest (Fodder - Grain system) was 24.6 q/ha while after a grain harvest (Grain - Grain system) the ratoon grain yield was 4.4 q/ha on the row basis (tables 25 & 26). Even after two fodder harvests (Fodder - Fodder - Grain system) the average grain yield was 10.6 q/ha. This shows the superiority of ratoon crop yield after fodder harvest or even after multiple fodder harvests over that after grain harvest, during the conditions prevailing in 1972. The potentialities of multiple ratooning appear to be great and will be studied further.

Table 24 The effect of 3 methods of intercropping of pigeon peas and soybeans compared with solid planting of each crop on red and black soils. (Trial 6 Kharif 1972 - all yields in q/ha)

| Treatments* | Yield row basis | | Yield row basis | | |
|---|---|---|---|---|---|
| Red Soils | P.Peas | Soybeans | P.Peas | Soybeans | Tota |
| 1. Solid planting of each crop | 6.3 | 8.2 | 3.2 | 4.1 | 7.3 |
| 2. Alternate rows of each crop | 7.6 | 9.8 | 3.8 | 4.9 | 8.7 |
| 3. Alternate double rows of each crop | 6.5 | 9.8 | 3.3 | 4.9 | 8.2 |
| 4. 1 row P. peas 3 rows of soybeans | 7.6 | 7.9 | 1.9 | 5.9 | 7.8 |
| F Value | 3.86 | 3.28 | | | |
| LSD (05) | N.S. | N.S. | | | |
| Black soil | | | | | |
| 1. Solid planting of each crop | 10.1 | 17.1 | 5.1 | 8.6 | 13.7 |
| 2. Alternate rows of each crop | 12.9 | 19.3 | 6.5 | 9.7 | 16.2 |
| 3. Alternate double rows of each crop | 13.5 | 18.1 | 6.8 | 9.1 | 15.9 |
| 4. 1 row P. Peas 3 rows soybeans | 11.4 | 17.4 | 2.9 | 13.0 | 15.9 |
| F Value | 0.005 | 0.761 | | | |
| LSD (05) | N.S. | N.S. | | | |

* Fertilization uniform and adequate.

Table 25 The effect of 3 methods of intercropping of Pigeon Peas and Pearl Millet compared with solid planting of each crop at 4 different harvest systems of the pearl millet on Red soil. (Trial 7 kharif 1972 - all yields in q/ha).

| Treatments | Fodder | | Ratoon Fodder | | Ratooned | Ratooned stalks | |
|---|---|---|---|---|---|---|---|
| | Green | air dry | Green | air dry | Grain | Green | air dry |
| **Fodder & ratooned grain system (a)** | | | | | | | |
| 1. Solid Planting of each | 197.7 | 33.6 | | | 9.9 | 43.8 | 20.1 |
| 2. Alternate rows " " | 291.9 | 43.8 | | | 15.2 | 61.2 | 26.9 |
| 3. Alternate double rows " | 256.1 | 48.6 | | | 10.6 | 33.4 | 14.0 |
| 4. 1 row P. Peas 3 rows PM | 207.5 | 41.5 | | | 16.9 | 37.2 | 17.1 |
| F Value | 16.70** | | | | 3.42 | 13.04* | |
| LSD (05) | 34.4 | | | | NS | 10.9 | |
| **Fodder & ratooned fodder & ratooned grain system (b)** | | | | | | | |
| 1. Solid planting of each | 197.7 | 13.8 | 67.8 | 20.3 | 6.5 | 20.9 | 5.4 |
| 2. Alternate rows " " | 291.9 | 55.5 | 90.4 | 25.3 | 9.8 | 23.6 | 6.1 |
| 3. Alternate double rows " | 259.1 | 46.6 | 83.1 | 21.6 | 8.5 | 19.5 | 5.1 |
| 4. 1 row P. Peas 3 rows PM | 207.5 | 41.5 | 75.1 | 19.5 | 11.9 | 23.3 | 6.1 |
| F Value | 16.7** | | 1.44 | | 5.0** | 0.24 | |
| LSD (05) | 34.4 | | N.S. | | 3.14 | N.S. | |

| | Grain | Stalks | | Fodder | | Grain | Stalks | |
|---|---|---|---|---|---|---|---|---|
| | | green | air dry | Green | air dry | | Green | air dry |
| **Grain & ratooned fodder system (c)** | | | | | | | | |
| 1. Solid planting of each | 32.7 | 135.5 | 28.4 | 31.3 | 8.1 | | | |
| 2. Alternate rows of each | 48.7 | 198.4 | 36.2 | 32.3 | 7.1 | | | |
| 3. Alternate double rows " | 44.1 | 172.0 | 30.9 | 19.8 | 4.0 | | | |
| 4. 1 row P. Peas 3 rows PM | 29.8 | 124.8 | 21.2 | 26.4 | 5.8 | | | |
| F Value | 42.0** | 2.04 | | 3.04 | | | | |
| LSD (05) | 4.4 | NS | | NS | | | | |
| **Grain & ratooned grain system (d)** | | | | | | | | |
| 1. Solid planting of each | 32.7 | 135.5 | 28.4 | | | 3.6 | 18.1 | 4.7 |
| 2. Alternate rows of each | 48.7 | 198.4 | 35.7 | | | 1.9 | 7.3 | 1.9 |
| 3. Alternate double rows " | 44.1 | 172.0 | 30.9 | | | 2.2 | 7.3 | 1.9 |
| 4. 1 row P.Peas 3 rows PM | 29.8 | 124.8 | 21.2 | | | 4.0 | 11.1 | 8.8 |
| F Value | 42.0** | 2.04 | | | | 0.53 | 4.44* | |
| LSD (05) | 4.4 | NS | | | | NS | 7.9 | |

Table 26 The effect of 3 methods of interoropping of Pigeon Peas and Pearl Millet compared with solid planting of each crop at 4 different harvest systems of the pearl millet on Black soil. (Trial 7 kharif 1972 - all yields in q/ha).

| Treatments | Fodder | | Ratooned Fodder | | Ratoon | Ratooned Stalks | |
|---|---|---|---|---|---|---|---|
| | Green | air dry | Green | air dry | Grain | Green | air dry |
| **Fodder & ratooned grain system (a)** | | | | | | | |
| 1. Solid Plantings of each | 222.9 | 31.5 | | | 15.3 | 51.8 | 13.0 |
| 2. Alternate rows " " | 384.2 | 48.0 | | | 34.0 | 75.1 | 18.0 |
| 3. Alternate double rows " | 386.6 | 42.5 | | | 26.7 | 75.8 | 19.0 |
| 4. 1 row P.Peas 3 rows P.M. | 266.7 | 57.0 | | | 33.2 | 63.6 | 15.9 |
| F Value | 48.9** | | | | 7.75** | 2.94 | |
| LSD (05) | 35.1 | | | | 9.9 | NS | |
| **Fodder & ratooned fodder & ratooned grain system (b)** | | | | | | | |
| 1. Solid planting of each | 222.9 | 31.5 | 91.7 | 18.3 | 7.9 | 16.0 | 3.2 |
| 2. Alternate rows " " | 384.2 | 48.0 | 135.5 | 27.1 | 11.3 | 22.6 | 4.5 |
| 3. Alternate double rows " | 386.6 | 42.5 | 129.9 | 26.0 | 11.7 | 20.2 | 4.0 |
| 4. 1 row P. Peas 3 rows P.M. | 266.7 | 57.0 | 107.7 | 21.5 | 8.8 | 18.4 | 3.7 |
| F Value | 48.9** | | 6.70** | | 3.5 | 2.66 | |
| LSD (05) | 35.1 | | 24.7 | | N.S. | N.S. | |
| | Grain | | Stalks | | Grain | Stalks | |
| | | | Green | air dry | | Green | air dry |
| **Grain & ratooned grain (c & d)** | | | | | | | |
| 1. Solid planting of each | 36.7 | | 165.4 | 46.3 | 5.3 | 24.4 | 4.9 |
| 2. Alternate rows of each | 58.7 | | 254.0 | 99.0 | 6.8 | 29.1 | 5.8 |
| 3. Alternate double rows " | 64.2 | | 248.5 | 87.0 | 6.2 | 26.3 | 5.3 |
| 4. 1 row P. Peas 3 rows P.M. | 41.0 | | 168.2 | 83.9 | 7.7 | 24.5 | 4.9 |
| F Value | 40.9** | | 16.3** | | 5.8** | 2.2 | |
| LSD (05) | 6.7 | | 38.7 | | 1.5 | NS | |

Table 27 The effect of 3 methods of intercropping Pearl Millet and Pigeon Peas upon the yield of Pigeon Peas. (Trial 7 - Kharif 1972 - all yields in q/ha)

| Treatment* | Grain yield - row basis | | | Grain yield - area basis | | |
|---|---|---|---|---|---|---|
| | Red | Black | Means | Red | Black | Means |
| 1 Solid planting of each crop | 9.5 | 10.2 | 9.9 | 4.8 | 5.1 | 4.95 |
| 2 Alternate rows " " " | 8.2 | 7.9 | 8.1 | 4.1 | 4.0 | 4.05 |
| 3 " double rows " " | 7.3 | 6.9 | 7.1 | 3.7 | 3.5 | 3.60 |
| 4 1 row P. Peas 3 rows P.Millet | 6.2 | 7.1 | 6.7 | 3.1 | 3.6 | 3.35 |
| F Value | 41.5** | 5.5** | - | | | |
| LSD (05) | 0.7 | 1.9 | | | | |

*Fertilization adequate and uniform.

## CHICK PEA & GARDEN PEA EXPERIMENTS

### Fertilization & inoculation studies - Trial 12

The yields and flowering dates for red and black soils are given in table 28. The plant size was considerably larger in the black soil than in the red soil, but the grain yield was only slightly higher. The only consistent visual growth difference in either soil was that of the minus P treatment in the red soil. In the early seedling stage there was a marked growth response to phosphorus application. Although the magnitude of the P response diminished during the season, there was a significant yield response to P application on the red soil (6.3 Vs 9.6 q/ha).

There was no significant difference between the 3 inoculums S1, B4 and B7. Nitrogen application had no beneficial effect in any case and appeared to have a detrimental effect on yields when applied with no inoculum.

### Variety Comparison - Trial 17 & 16

The 24 varieties used in this trial represent a wide range of plant types and maturity dates. Early flowering varieties (varieties 4, 15, 18 and 10) tended toward higher yields than the late flowering varieties No. 5, 7, 9, 12, 14, 23 and 24). However, the yield differences were not significant (table 29).

The late flowering varieties appeared to have poorer seed set, possibly due to the high temperatures and moisture stress late in the season.

The Hima variety had the most vigorous vegetative growth, was the earliest flowering and produced significantly higher yield than any other kabuli chick pea variety (table 30). In the black soil trial 16 & 17 happened to be planted on a slightly saline area. Thus, the yields of these two trials on the black soil are not reported because of the variable stand.

The general yield of all chick pea varieties was relatively low in both trials 16 & 17. This may be in part due to the 45 cm row spacing, which is wider than normal. Since the early flowering varieties tended to be better than late flowering varieties, emphasis should be given to earlier planting in this region. It also suggests the importance of early maturity in variety development. It is recognized that the major chick pea growing areas are generally in areas with a longer cool season than exists in this area, so testing will need to be done in those areas as well.

Trial 18 (Garden peas)

There was no significant difference between the 9 varieties grown on either the black or red soil (table 31). The general yield level was similar to that of the chick peas in trials 16 & 17.

Table 28 Effect of fertilization and innoculation upon performance of Chick peas (Variety BEG 482) in red and black soils. (Trial 12, 1972 - 73 rabi - all yields in q/ha)

| | Treatments N | P | Inoculant* | Grain yield Red | Black | Means | Days to 75% flowering Red | Black | Means |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 0 | 30 | S1 | 9.5 | 10.4 | 10.0 | 60 | 53 | 56 |
| 2. | 0 | 30 | B4 | 10.5 | 9.9 | 10.2 | 61 | 53 | 57 |
| 3. | 0 | 30 | B7 | 9.6 | 9.9 | 9.8 | 59 | 54 | 56 |
| 4. | 0 | 30 | None | 8.4 | 11.6 | 10.0 | 59 | 52 | 55 |
| 5. | 40 | 30 | " | 6.9 | 9.4 | 8.2 | 61 | 54 | 57 |
| 6. | 80 | 30 | " | 7.2 | 10.2 | 8.7 | 60 | 52 | 56 |
| 7. | 40 | 30 | B7 | 9.5 | 10.7 | 10.1 | 60 | 53 | 56 |
| 8. | 80 | 30 | B7 | 9.3 | 10.0 | 9.6 | 60 | 53 | 56 |
| 9. | 0 | 0 | B7 | 6.3 | 7.9 | 7.1 | 60 | 54 | 57 |
| 10. | 0 | 30 | B7 (Furadan with seed) | 8.4 | 7.8 | 8.1 | 59 | 53 | 56 |
| 11. | 0 | 30 | B7 (Furadan granules in a separate band) | 9.8 | 8.7 | 9.2 | 59 | 53 | 56 |
| | F Value | | | 3.5** | 1.3 | - | - | - | - |
| | LSD (05) | | | 2.1 | N.S. | - | - | - | - |

*Inoculants furnished by Dr. R.B. Rewari Div. of Microbiology IARI, New Delhi.

Table 29 Comparison of 24 varieties of Chick Peas under Red soil conditions. (Trial No. 17 - 1972-73 Rabi - all yields in q/ha).

| | Varieties* | Plant type* | Grain Yield | Days to 75% Flowering |
|---|---|---|---|---|
| 1. | BG 1 | SE | 4.95 | 57 |
| 2. | BG 15 | S | 6.85 | 57 |
| 3. | H 208 | SE | 5.54 | 60 |
| 4. | H 214 | SE | 7.07 | 39 |
| 5. | H 355 | S | 3.87 | 71 |
| 6. | G 130 | SE | 5.81 | 68 |
| 7. | G 549 | SE | 2.97 | 74 |
| 8. | G-62-404 | SE | 4.41 | 52 |
| 9. | G-IET-T3 | SE | 3.84 | 72 |
| 10. | G-W.L.-2 | SE | 6.28 | 54 |
| 11. | J.G.S-4 | SE | 5.02 | 70 |
| 12. | F 229 | S | 1.89 | 71 |
| 13. | BEG 482 | SE | 4.41 | 63 |
| 14. | RLH 534 | SE | 3.02 | 74 |
| 15. | 10-2-3 | S | 7.72 | 49 |
| 16. | Radhey | S | 3.83 | 52 |
| 17. | T 3 | SE | 2.92 | 70 |
| 18. | Chaffa | S | 7.01 | 49 |
| 19. | IETK 468 | SE | 4.92 | 62 |
| 20. | Pant 102 | SE | 3.61 | 68 |
| 21. | Pusa Elg Bold IET | E | 4.07 | 66 |
| 22. | GVT 850-3+27 | E | 4.63 | 59 |
| 23. | SEL-5411 | SE | 2.73 | 72 |
| 24. | C - 235 | S | 4.81 | 73 |
| | F Value | | 0.826 | |
| | LSD (05) | | N.S. | |

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Seed furnished by Prof. S. Ramanujam Project Coordinator (Pulses) IARI, New Delhi. Seed inoculated with inoculant furnished by Dr. R. B. Rewari Director of Microbiology IARI - uniform fertilization - 150 kg/ha Diammonium Phosphate ($N_{27}P_{30}$) banded 4 cm to one side at seeding.

Table 30 Comparison of 6 Varieties of Kabuli chick peas on a red soil (Trial 16, 1972-73 rabi - all yields in q/ha)

| Varieties* | Grain Red | Days to 75% Flowering |
|---|---|---|
| 1. C-104 | 2.45 | 76 |
| 2. L-241 | 4.80 | 75 |
| 3. L-345 | 3.51 | 78 |
| 4. L-550 | 2.58 | 60 |
| 5. Hima | 6.23 | 54 |
| 6. J.C.12 | 1.24 | 71 |
| F Value | 15.4 | |
| LSD (05) | 1.4 | |

Table 31 Comparison of 9 Varieties of Garden peas under red and black soil conditions (Trial 18, 1972-73 rabi - all yields in q/ha)

| Varieties* | Plant* Type | Grain yield | | | Days to 75% Flowering | | |
|---|---|---|---|---|---|---|---|
| | | Red | Black | Means | Red | Black | Means |
| 1. T163 | E | 6.60 | 4.02 | 5.31 | 58 | 58 | 58 |
| 2. 6113 | E | 8.33 | 3.52 | 5.93 | 57 | 57 | 57 |
| 3. 450-B | E | 6.72 | 2.47 | 4.60 | 55 | 58 | 57 |
| 4. 172M | E | 5.05 | 3.08 | 4.07 | 54 | 57 | 56 |
| 5. 479B | E | 7.16 | 1.38 | 4.27 | 57 | 59 | 58 |
| 6. 6115 | E | 7.38 | 4.78 | 6.08 | 55 | 55 | 55 |
| 7. 353-2B | E | 6.77 | 2.80 | 4.79 | 56 | 56 | 56 |
| 8. 116 | SE | 8.05 | 5.10 | 6.58 | 56 | 53 | 55 |
| 9. P.S.391 | SE | 6.55 | 2.97 | 4.76 | 55 | 54 | 55 |
| F Value | | 0.82 | 3.66** | | | | |
| LSD (05) | | N.S. | 1.76 | | | | |

*Seed furnished by Prof. S. Ramanujam, Project Coordinator (Pulses), IARI, New Delhi. Seed inoculated with inoculant furnished by Dr. R.B. Rewari, Div. of Microbiology, IARI.

Uniform fertilization - 150 kg/ha Diammonium Phosphate ($N_{27}$ $P_{30}$) banded 4 cm to one side at seeding.

E = Erect type

SE = Semi-erect type

## SUNFLOWER & SAFFLOWER EXPERIMENTS

In an attempt to gain experience with other crops which might fit well as relay crops into the early rabi season, sunflower and safflower variety and fertilization trials were conducted (tables 32 - 35).

### Sunflower Varieties - Trial 14

In the red soil, sunflower variety EC 69c74 gave the highest yield and Sunrise the lowest. There was no significant difference between the three intermediate varieties (table 32). Likewise there was no yield difference between EC 68415 planted on November 1 compared to a planting made 15 days earlier (3 Vs 6). There was no significant difference between varieties on the black soil, but Sunrise again gave the lowest yield.

### Safflower Varieties - Trial 15

There was no significant difference between the yield of the six varieties in either the black or red soil. However, C-440 gave the highest yield and C-437 gave the lowest yield in both soils. The yield level in the black soil (19 to 21 q/ha) was almost double that of the red soil (table 34).

The relative yields of sunflower and safflower were about the same in the red soil, however, in the black soil the safflower yield was almost twice that of the red soil. Another important difference observed between the two crops was the greater sensitivity of sunflower to drought. Since the soil was dry at seeding, all rabi crops sown in mid-October received 5 cm of sprinkler irrigation water to germinate the seed and establish a stand. Even though only 2.2 cm of rain fell from planting to harvest and no further irrigation was given to the safflower, it showed only a slight moisture stress and produced a good yield, especially on the black soil. Conversely, sunflower showed considerable wilting and moisture stress in early December and further

irrigation was needed on both soils. These observations will need to be checked further in more critical experiments, but at present it appears that safflower will be better than sunflower as an early rabi crop in the farming system program especially on the black soil.

Fertilization - Trial 11

In the red soil there was a marked response to phosphorus application both in the sunflower and safflower. This was observed visually, in the seedling weight and final yield (table 33 and 35).

In both soils and both crops there was a significant response to the first 40 kg/ha increment of nitrogen but no response above the 40 N rate. This is similar to the responses observed with sorghum and millet.

As in the case of sorghum, millet and pigeon pea, there was no respons to potassium in sunflower or safflower on either soil.

Table 32 Comparison of six varieties of Sunflower grown upon red and black soils. (Trial 14 - 1972-73 rabi - all yields in q/ha)

| Varieties | Grain yield | | | Days to 75% heading | | |
|---|---|---|---|---|---|---|
| | Red | Black | Means | Red | Black | Means |
| 1. EC. 68413 | 11.2 | 10.4 | 10.8 | 70 | 83 | 77 |
| 2. EC. 68414 | 10.7 | 10.5 | 10.4 | 65 | 76 | 70 |
| 3. EC. 68415* | 11.8 | 11.5 | 11.6 | 62 | 61 | 62 |
| 4. EC. 69874 | 13.6 | 9.7 | 11.6 | 57 | 71 | 64 |
| 5. Sunrise | 9.0 | 9.4 | 9.2 | 58 | 72 | 65 |
| 6. EC. 68415 | 11.5 | 11.3 | 11.4 | 66 | 79 | 72 |
| F Value | 4.18* | 0.74 | - | - | - | - |
| LSD (05) | 2.2 | N.S. | - | - | - | - |

*Variety No. 3 was sown on 13/10 i.e. 15 days before treatment 1, 2, 4, 5 & 6.

Table 33 The effect of fertilization upon Sunflower yields of Variety EC 68415 on red and black soils. (Trial 11 - 1972 - 73 rabi - all yields in q/ha)

| Fertilization* | | | Grain yield | | | Days to 75% heading | | | Seedling Dry Wt. gms. | |
|---|---|---|---|---|---|---|---|---|---|---|
| N | P | K | Red | Black | Means | Red | Black | Means | Red | Black |
| 1. 0 | 30 | 0 | 7.3 | 13.7 | 10.5 | 69 | 60 | 64 | 48 | 174 |
| 2. 40 | 30 | 0 | 9.6 | 16.9 | 13.2 | 62 | 62 | 62 | | |
| 3. 80 | 30 | 0 | 10.9 | 17.3 | 14.1 | 64 | 64 | 64 | | |
| 4. 120 | 30 | 0 | 10.8 | 16.2 | 13.5 | 63 | 63 | 63 | 152 | 208 |
| 5. 120 | 0 | 0 | 3.3 | 12.0 | ~~14.4~~ 7.7 | 81 | 78 | 80 | 11 | 154 |
| 6. 120 | 30 | 50 | 9.3 | 13.9 | ~~18.8~~ 11.6 | 65 | 60 | 62 | | |
| F Value | | | 13.9** | 15.2** | - | - | - | - | | |
| LSD (05) | | | 2.3 | 1.6 | - | - | - | - | | |

*Refers to total amount of N, P & K applied. 27 kg/ha of N and all P was applied in a band at planting as 150 kg/ha of D18P-46-0. The K and the balance of the N was topdressed about 18 days after planting. (To convert P to $P_2O_5$ multiply by 2.29; K to $K_2O$ multiply by 1.2).

Table 34 Comparison of six varieties of Safflower grown upon red and black soils. (Trial 15, 1972-73 rabi - all yields in q/ha)

| Varieties* | Grain yield | | | Days to 75% heading | | |
|---|---|---|---|---|---|---|
| | Red | Black | Means | Red | Black | Means |
| 1. C-431 | 10.7 | 18.9 | 14.8 | 64 | 78 | 71 |
| 2. C-437 | 9.5 | 18.8 | 14.2 | 66 | 78 | 72 |
| 3. C-438 | 10.3 | 18.9 | 14.6 | 64 | 77 | 70 |
| 4. C-440 | 10.8 | 21.2 | 16.0 | 65 | 79 | 72 |
| 5. S-5 | 9.9 | 20.5 | 15.2 | 63 | 76 | 70 |
| 6. S-11 | 9.5 | 19.0 | 14.3 | 66 | 77 | 72 |
| F Value | 0.3 | 0.21 | - | | | |
| LSD (05) | N.S. | N.S. | - | | | |

*Seeds furnished by Mr. M.A. Khader APAU, Rajendranagar, Fertilization uniform and adequate.

Table 35 The effect of fertilization upon Safflower yields of variety S-11 on red and black soils (Trial 11 - 1972 - 73 Rabi - all yields in q/ha)

| Fertilization | | | Grain yield | | | Days to 75% heading | | | Seedling dry wt. gms. | |
|---|---|---|---|---|---|---|---|---|---|---|
| N | P | K | Red | Black | Means | Red | Black | Means | Red | Black |
| 1. 0 | 30 | 0 | 7.8 | 9.9 | 8.9 | 84 | 75 | 80 | 26 | 121 |
| 2. 40 | 30 | 0 | 8.9 | 12.3 | 10.6 | 85 | 75 | 80 | | |
| 3. 80 | 30 | 0 | 8.7 | 10.2 | 9.5 | 84 | 76 | 80 | | |
| 4. 120 | 30 | 0 | 9.2 | 10.9 | 10.1 | 80 | 75 | 77 | 47 | 113 |
| 5. 120 | 0 | 0 | 3.7 | 4.4 | 4.1 | 94 | 76 | 84 | 5 | 85 |
| 6. 120 | 30 | 50 | 9.9 | 8.4 | 9.2 | 81 | 77 | 79 | | |
| F Value | | | 28.4** | 2.1 | - | | | | | |
| LSD (05) | | | 1.2 | N.S. | - | | | | | |

* Refers to total amount of N,P & K applied 27 kg/ha of N and all P was applied in a band at planting as 150 kgs/ha of 18-46-0, the N and the balance of the N was topdressed about 18 days after planting (to convert P to $P_2O_5$ multiply by 2.29 K to $K_2O$ multiply by 1.2).

## WATERSHED-BASED FARMING SYSTEMS

### General

Water, either too little or too much, over entire crop seasons or during relatively short periods of a crop cycle, in damaging rainfall intensities or in the form of shallow phreatic levels, is one of the major constraints to profitable farming under conditions of natural rainfall in large regions of the semi-arid tropics. Shortfalls in production due to water related problems have an extremely high probability of occurrence. Thus, one essential component of programs to increase, stabilize and diversify agricultural production in rainfed areas will be the development of technically and economically sound methods providing for optimum utilization of precipitation and safe disposal of excess water. Hardly a beginning has been made to explore the potentials of this approach under tropical conditions. It is expected that substantial benefits can be gained from an integrated effort aimed at improved soil and water management in the semi-arid tropics.

Erratic rainfall patterns and undependability of water supply are major reasons why farmers in the semi-arid tropics generally have been unable to utilize the new high yielding varieties and capital intensive inputs such as fertilizers, agricultural chemicals and farm machinery. To achieve a break through in water control and management, much research is required in all facets of farming systems including not only improved water, soil and crop management but also with regard to more suitable varieties and appropriate power-equipment packages. Once technically optimum farming systems have been developed it is of course also necessary to test these with reference to their ultimate economic and social effects.

To study water as one of the basic factors it is necessary to have a closed system in which rainfall, runoff, infiltration, percolation, evaporation transpiration, groundwater movement, erosion and sedimentation can be continuously monitored and where the effect of presumably better systems of farming on these factors can be studied. At ICRISAT we are fortunate to have many

natural watersheds (catchments) which lend themselves ideally to investigations on watershed-based farming systems. We have defined watershed-based farming systems as follows : "the optimum utilization of the catchment precipitation through water, soil and crop management, either directly by the monsoon crop or as runoff which is collected and stored (above or underground) for improving and stabilizing production on the donor watershed". These watersheds as used in the farming systems program will also present an excellent opportunity to try out on a farm scale many of the recommended improvements resulting from small experimental plot work.

Initial activities:

In January 1973, work was started on the development of five natural watersheds for monitoring of the water balance and intensive data collection on various cropping systems. The areas selected for study during the next several seasons are located on black cotton soils along the Western boundary of the experimental farm as shown on the attached map (fig. 1). The five watersheds vary in size from 3.6 to approximately 25 ha involving a total area of about 50 ha. Until the 1972 monsoon season the land was used by farmers of the area; each catchment consists of several relatively small fields which are surrounded by bunds. In some places erosion has resulted in severe gully formation.

Two of the experimental watersheds will be maintained in their present state and will be used to simulate presently applied cropping patterns and soil management systems in the Hyderabad region. Kharif cropping will be practised on one of these two; rabi cropping on the other. The effect of these two farming systems on water utilization, erosion and crop production will be investigated.

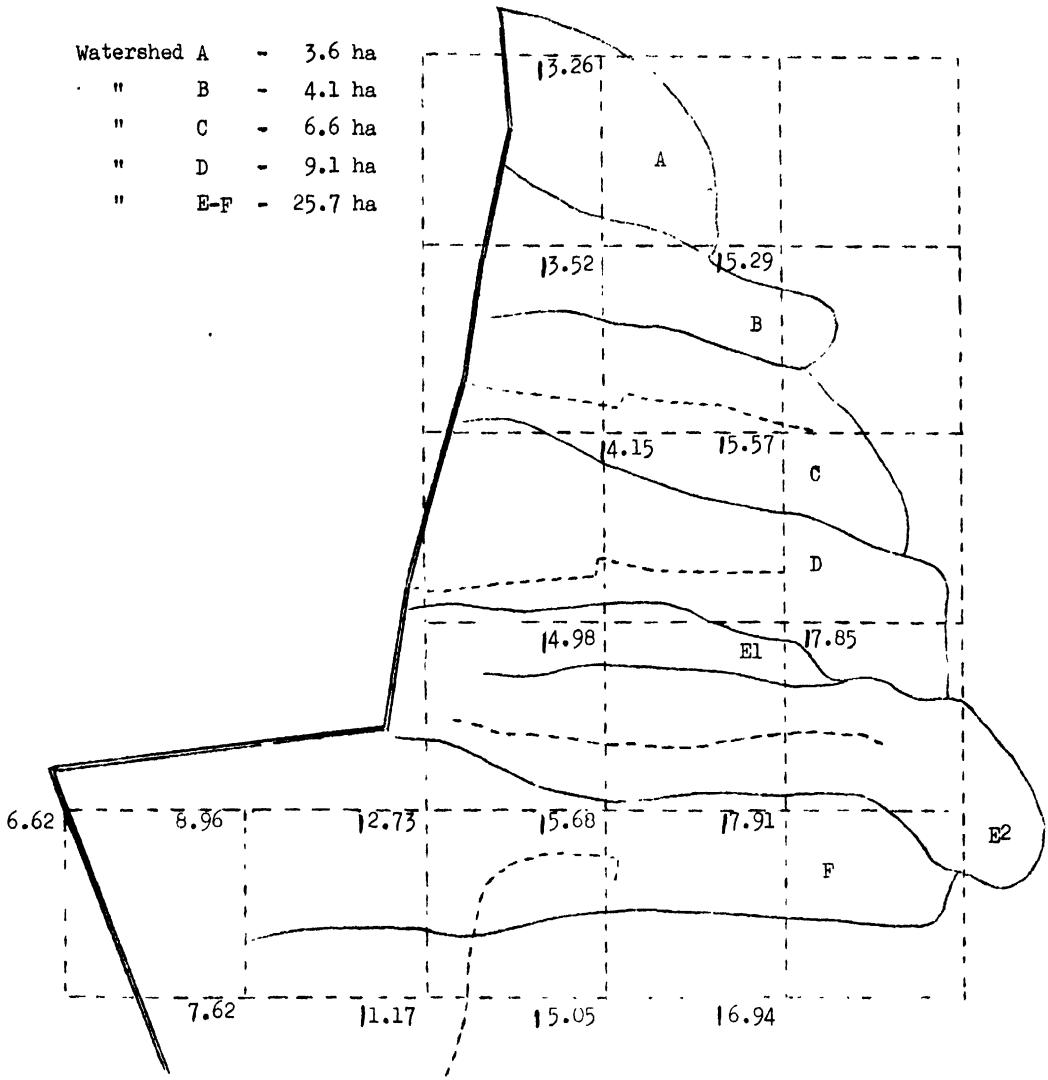
In the three remaining catchments the present gullies will be reclaimed and existing bunds removed. Grassed waterways will be constructed through all major depressions to carry off excess rainfall. Different grass varieties will be used to test whether or not the grassed waterways can contribute

substantially to forage production. In the largest watershed, a surface storage pond approximately 4 M deep with a capacity of about 0.25 ha M. is presently being built for collection of runoff water and the reutilization of this water during dry periods in the kharif or early rabi on the donor watershed. The pond is dug deep with a small surface area to reduce evaporation. Figure 2 shows a schematic drawing of a watershed with a grassed waterway and tank.

In each of the three developed watersheds various cropping patterns will be planted on ridges along predetermined grades on the existing or modified contours. The ridges and furrows will have different slopes on each watershed to study the effectiveness of slope with varying lengths and cropping systems on water infiltration, runoff and erosion.

As new information is being generated, other improved systems of farming will be imposed on the watersheds with the ultimate aim of developing "models of approach" towards the development of farming systems which make the best use of given soil, water and human resources.

LOCATION OF EXPERIMENTAL WATERSHEDS IN FARMING SYSTEMS PROGRAM - ICRISAT




Legend

Grids - 200 m x 200 m.

Numbers in corners give relative elevations in M.

Solid lines - Watershed (catchments) boundaries.

Broken lines - Old gullies & waterways.

Fig. 2.



SCHEMATIC DRAWING OF A SMALL WATERSHED