UNITED NATIONS DEVELOPMENT PROGRAM,
GLOBAL RESEARCH FOR THE IMPROVEMENT OF SORGHUM & MILLET

Report for tho period August 1973 to December 1974

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A. SORGHUM IMPROVEMENT

Introduction

At the first meeting of the UNDP Policy Advisory Committee Meeting on August 29th, 1973, we reported that 2 hectares of sorghum breeding material were in the field at Patancheru. During the 1973 kharif and rabi seasons (K73 and R73) we were sorting and selecting material and building up staffing and capability. In the summer season (S74), we began some trials work, and with the addition of Dr. Peter Lawrence to our plant breeding team were able to mount a more adequate trials programme in the kharif and rabi seasons of 1974. Some of the early material is now growing for the fifth generation, and we expect by the end of the summer season to have completed two cycles of recurrent selection based on S_1 testing in the NP "fast lane" populations.

A summer generation is necessary for rapid progress, but should be located away from Patancheru, to provide a fallow period there to break the cycle of pest build-up. The major part of the sorghum work will be based on two generations a year, with the kharif season providing selection under purely rain-fed conditions. A period after the kharif harvest is essential to receive and digest results, so the appropriate recombinations cannot be made until the summer, ready for planting under selection in the following kharif. Similarly, the F_1 generations from crosses made in the rabi season are grown in the summer, permitting the segregating F_2 generation to be grown and selected in the kharif. The

Hyderabad kharif season coincides with the main rains in most of the Northern hemisphere, so the material for regional testing needs to be ready at that time also: the Southern hemisphere is 6 months out of phase, and for the present we shall accept this 6 months lag as there are few large and important sorghum areas south of the Equator.

Land development has kept up with our essential requirements, and now that some Manmool village houses have become available, we have sufficient working accommodation. We have a capable and keen group of Research Associates, and hope that we have now identified and trained a large enough group of support staff for immediate needs (Table 1). It will be good to have better seed storage, better computor facilities, a decent library on the site, and living accommodation for at least some of the staff in the Patancheru area. However, basically we are established and operational, and planning to commence co-operative activities in India, Africa, and elsewhere in the semi-arid tropics. We had hoped to put out a nursery in 1974, but just did not have quite the staffing or capability to do this: but we expect to have breeding populations, nurseries, and trials going out to everybody willing to grow them for the 1975 main rains.

The staffing pattern will need to be watched during this next stage: the nucleus of experienced scientists must be sufficient to allow frequent and extensive travel, meanwhile maintaining a comprehensive and excellent applied programme at Patancheru and training post-doctoral fellows for work in the ICRISAT co-operative centres. This will require one more international scientist and some increase in support staff.

...e laboratory services are now able to handle the protein and lysine estimations in sufficient numbers and with sufficient accuracy to permit of the required ranking and screening for the breeders' needs.

Breeding

The breeding programme has evolved into a series of projects: at the heart are composite population and trials, into which will be fed new accessions from germplasm identified as having valuable characteristics. There are co-operative projects for pest resistance (Entomologist), disease resistance (Pathologist), efficient plant design and function (Physiologist) and grain quality (Biochemist and Indian Nutrition Laboratories). Straight breeding projects include (1) short-term photoperiod insensitive plants with quality grains, resistant to grain mould, or protected from mould by an envelope of papery glumes. (2) Grain-grass sorghums, short, early, tillering and ratooning freely, on a plant type somewhat resembling that of wheat (3) Striga resistant sorghums of good agronomic type and grain quality. (4) Superior cultivars for high altitudes (5) Superior cultivars for W. African conditions. (6) Superior cultivars for E. African conditions.

Promising segregates from every project are fed back to the trials group for co-operative evaluation, and the best proven elite lines will go into the "Hybrids" project. There is also a small project on tetraploid grain sorghum, rather more "way out" than the others, but with a possible potential which deserves to be explored.

Composite populations:

Composite populations utilize a large number of chosen parents which are intercrossed in all combinations with the aid of genetic male-sterility. The best plants resulting from these crosses are selected and used to start the next series of crosses in a fresh population, the next cycle. In this way, the whole population is steadily improved, and the probabilities of finding superior plants and better recombitants in that population become steadily greater. The associated projects aim to develop the kinds of populations most likely to produce the kinds of plants we are seeking: to develop populations adapted to particular ecological areas: to develop very broadly adapted populations by selection and testing throughout the semi-arid tropics: and to learn in a very applied way how these populations may be most effectively and productively handled. All the other breeding projects have a populations component.

As recorded last year, 33 composite populations were received up to April 1974; a further twelve have been received since April, and as yet have only been grown for multiplication. (Table 2). These populations have been under selection for three generations, and several have been merged. Some of the populations had too much photoperiod sensitivity, with many tall and late plants. Mass selection was practised in these and also bulk crossing to NP or PP stocks, which are photoperiod insensitive, and contain plenty of short plants. The good grain population is of particular importance to the programme, and is being deliberately crossed to the high quality photoperiod insensitive AICSIP line 370. The Downes population and R composite showed a low frequency of steriles: R composite was merged into the Serere Elite population. Downes was subjected to individual plant selection (K73), identification of steriles in head rows (R73) and crossing of steriles with bulked pollen (K74). The steriles so crossed were then planted in R74. Populations requiring this type of handling are being treated as source populations, while those consisting largely of photoperiod insensitive plants of short to medium height with a reasonable frequency of grains of good quality are being handled as advanced populations and entered into recurrent selection systems with formal yield trials. Table 3 summarizes what has been done on the populations: a series of lines from many of these populations will go out into the 1975 regional trials to identify the areas where they perform best, with a view to developing populations for particular ecological zones (Table 3).

The populations from Nebraska (NP) were immediately ready for recurrent selection, and two "fast lane" sets were run, maintainer (NPB) and restorer (NPR) by merging the B & R populations appropriately. Selections were taken from bulks (K73), S_1 performance estimates by eye-judgement and row weights (R73), and some of the best put into appropriate recombination blocks (S73). 30 lines contributed to NPB, and 47 lines to NPR 326 B and 554R Half-sib rows from selected steriles were grown in K74, 200B & 278R selfed heads were taken from some 50 percent of the best rows, and put into S_1 trials (R74). The best 10 entries from each population trial will be recombined in the summer of 1975 and the third cycle will start in the kharif 1975.

The Purdue populations (PP), and the remainder of the NP's were merged into US type B and US type R populations. Grown as bulks in K73, 1621 sterile plants and 445 fertile plants were selected and grown as head rows in R73. From those were selected 640 steriles and 2338 fertiles which went in to appropriate yield trials in K74. The characteristics of the best 10 entries, and the trial mean yields, are given in Table 4. These trials were done with a single replication on each of 4 sites, black and red soils with and without fertilizer. The low fertility replications were very uneven and of limited use. We have to learn how to create reasonably uniform, low fertility fields. Two additional replications were also planted under severe shoot-fly infestation for resistance screening. The 160 best entries from these trials are being grown for recombination (R74), 80 lines to give US type B and 80 lines for US type R. There was much coarse grain quality in this material, and a higher proportion of entries of good grain quality were included in the recombination than yield considerations alone would have allowed. An S_2 testing system will now be followed:

K75	Half sib testing.	Patancheru and one or more sites in India if available
R75	S_1 testing.	Patancheru and several sites in India
K76	S_2 testing.	Through semi-arid tropics at all available sites. Sibbing at Patancheru
S77	Recombination.	Coimbatore or other summer season centre
K77	Half sib testing	

This is likely to be the pattern followed for the improvement of most of the advanced populations. Basically, it involves choosing random crosses on the appearance of the female parent, and carrying them through to the F_3, evaluating in each generation. For a mainly self pollinating crop with varieties as the main product, this seems a suitable procedure.

Other populations nearly ready for handling as advanced populations are Tropical conversion, RS/B, and RS/R, all of Serere origin. We have begun to develop cytoplasmic steriles from RS/B with the intention of trying a form of reciprocal recurrent selection, using a succession of sterile inbreds from RS/B in succeeding cycles as testers for the RS/R population, as this system has worked well in maize.

Two of the most attractive populations in the rabi season for plant and grain type are Bulk Y and WABC developed by D.J. Andrews in Nigeria, but both have a high level of photoperiod sensitivity, and pest susceptibility, especially to shoot-fly, so appropriate crosses have been made to 12 selected lines from the ALAD nursery and 8 lines chosen in Nigeria from Dr. Pickett's Purdue nurseries, and to shoot-fly resistant material.

One of the best sources of good material appears to be the three diallel crosses of 45 varieties from Rajendranagar, referred to in last August's germplasm report. These together include a balance of material chosen for yield, or for resistances to pests and diseases, or for grain quality. We had available three sources of male-sterility (al, ms_3, ms_7, see Table 1) but all the populations were in one of those three cytoplasms. We have therefore started to develop composite populations based on the Rajendranagar diallel crosses used as female parents and crossed with all three steriles. This will give a good balance of parents, a wide range of cytoplasms, and a choice of one or more steriles. 1046 crosses from 256 families were made in R73 (with ms_3, 360: ms_7, 309: al, 377), the F_1 generations were grown in K74, and the segregating F_2's are now growing in R74 for backcrossing to the best 640 selected lines out of these Rajendranagar diallels, together with 55 outstanding selections from the Entomologists' Rajendranagar nursery (see p8 below).

Elite materials & trials:

The carrying out of a large number of trials at Patancheru and through the semi-arid tropics is a vital part of the programme: there can be no consistent progress in selection without measurements and assessment at every stage. We have formed a team which is responsible for all variety trials work, so that we achieve the best possible level of efficiency in basic trial operations and data retrieval. However, each research associate remains responsible for his own material in the trials, and is personally involved with data collection, observations, and operations including harvest.

The greatest contribution which ICRISAT can make soon is to locate good material, screen it, and send the best out through the semi-arid tropics as potential material for other plant breeders. Any good plant in any of our programs is a potential choice for this screening process. The first available material for screening were the nursery and selections sent from ALAD: 1471 lines planted in K73 gave 439 selections in R73, and the best of these were planted in a 25 entry trial in S74 and K74, or went in to the main elite trials in K74. Yields are shown in Table 5. The best summer grain yields were over 5,000 kg/ha, those in the 25 entry K74 trial were 4,530.

A CIMMYT nursery from Dr. Elmer Johnson's high altitude program in Mexico of 2462 entries was grown in K73 and 700 selections planted in R73. The best of these went into 25 entry trials in S74 and K74. (Table 6). The best grain yields in both seasons were about 3,800 kg/ha. This material is evidently not going to be widely useful outside the high altitude areas:

and much of it still has the dark, bitter grain type of the Uganda parents which will be unacceptable in high altitude regions such as Ethiopia.

The Rajendranagar diallels were an excellent source of elite lines. 712 plots in K73 yielded 680 selections grown in R73, some on two sites in the red and black soils. From these, over 2,000 entries went in to the K74 trials.

352 entries of an "Entomologists" nursery from Rajendranagar were grown in R73, 50 of the best were planted in S74 and 190 good selections taken, which were included in the K74 yield trials. Other entries in these trials came from Dr. N.G.P. Rao's AICSIP program, from Dr. Pattanayak's Pioneer Seed Co. hybrid program, and from various external sources. Altogether there were some 2,900 potential elite lines tested by the trials group in K74, as well as the 5,338 entries from the populations, on 4 sites, with 2 extra replications screened for shoot-fly resistance. Out of some 5000 entries, the best 50 are being multiplied in R74 for trials throughout the semi-arid tropics in K75: and another 450 will be retained for further study. Extracts from the elite trials results are shown in Table 7.

The generation of new material for extracting elite lines must be a continuous process: some will come from the populations directly: but many crosses of (good male-sterile in population) x (good variety or line) have been made. The F_1 generations of 620 such crosses were grown in S74, and the F_2 generations planted in K74. The F_1 generations of a further 770 such crosses were planted in R74. This material will be handled in a conventional manner: selections will be taken from the best F_2's and grown on a pedigree system, to be fed into the elite trials as and when appropriate.

Short-term, photoperiod insensitive types with good grain, resistant to grain mould, or protected from moulds by enveloping glumes:

In order to make best use of the available rainfall, and to achieve the most consistent yields, it is often desirable to use a sorghum variety of shorter duration than the rains. A consistent length of maturity is important, so insensitivity to photoperiod is essential. A short-term variety is liable to mature during wet weather in many parts of the semi-arid tropics: so grain moulds are a major problem, and the grain must be either resistant to these, or protected from them. A high quality grain is an essential requirement.

Crosses between 8 parents with large, papery glumes and good grain, short term agronomically desirable parents were commenced in R73 and backcrossed to photoperiod insensitive good grain parents in K74. In R74, 35 varieties representing a wide range of glume length and breadth were identified from the world germplasm collection, and 8 of these were crossed in all possible combinations and also to 3-5 short, photoperiod insensitive good grain parents.

Some 2,000 early maturing selections were taken from all available material in K74, and planted in R74. Further early material was identified in the world collection in R74, and seed of 5 very short term types from Turkana, Kenya, was received from the EAAFRO programme.

The late rains in October of K73 gave the opportunity to select 50 apparently mould resistant types, which were grown in R73 and in K74, when there was again late rain. This permitted selection for mould resistance, in a much wider range of material. However, with the advent of Dr. Nene, plant pathologist, it became possible to get the screening for mould resistance established on a proper footing. Suitable infection techniques have been worked out, and much of the material in this project is being properly screened in R74. Dr. Nene reports that 7 grain mould genera have been identified, namely, Currularia, Colletotrichum, Fusarium, Penicillium. Helminthosporium, Phoma, and Olpitrichum.

Grain-grass sorghums:

The grain-grass sorghums were developed by Dr. R.E. Karper in Texas some 20 years ago. They have a plant type more like wheat than sorghum, with relatively thin culms and numerous tillers. The grain-grass sorghums could be valuable in irregular rainfall areas where they could be grazed or cut back in a difficult part of the season, but would then ratoon and produce grain rapidly when rain came. Resistance to both shoot-fly and midge will be essential. The potential of these grain-grass sorghums has not yet been explored, although Dr. N.G.P. Rao informs me that they yielded well in India when tried some years ago.

Three of the 4 grain-grass sorghums in the Rajendranagar world collection proved to be totally different material, and the fourth did not germinate. However, one of the original types was identified as a B line in the cytoplasmic steriles section, and 3 shallu-grass sorghums were available. These were crossed in R74 to a range of parents involving the characteristics of earliness, high yield, excellent grain quality, resistance to shoot-fly, to midge, to stem-borer, and to Striga. Seed of the original grain-grass sorghums has now been obtained from the U.S.A.

Striga resistance:

Striga is a serious source of crop loss in India and Africa. There are several species and strains, and it is not yet known whether resistance to one species may also confer resistance to others. Breeding work will have to be done at several centres, as Striga seed must not be moved from one country to another.

F_2 rows from 261 crosses between parents lines identified by Dr. Stan King (Project 26, Nigeria) as resistant to Striga, and used to pollinate an ms_7 source, were grown in K73, steriles were identified, and sibbing done where possible. The material was mostly photoperiod sensitive, very tall, and continued growth well in to the Rabi season. The harvest was therefore not planted again until R74, by which time a composite population of backcrosses to the Striga resistant parents had been received from Nigeria. This has also been planted, and it is likely that the first crosses will not be required. This material was selected for resistance to Striga hermonthica, and we do not yet know how it will react to S. asiatica which is prevalent at Patancheru. There are some areas at Patancheru which are heavily infested with this parasite, and there will be no difficulty in developing a suitable "sick plot" for screening.

Dr. Gerald Roseberry from the University of Sussex tested out a number of synthetic stimulants for Striga seed germination in boxes of infested soil. One compound showed promise, and the results are shown in Table 8. Such stimulants cause the Striga seed to germinate, and in the absence of a host plant, the Striga seedling dies, so reducing the amount of Striga seed in the soil.

Cultivars for high altitudes:

There are extensive high altitude sorghum areas in Eastern Africa, and many of the famine areas of Ethiopia grow mainly highland sorghums.

Reference has already been made to the CIMMYT material. In R73, 8 of the best lines were crossed to good steriles in the Nebraska populations (NP_1 & NP_3) to combine the cold tolerance and earliness of the high altitude lines with the good characteristics of the Nebraska populations. 128 F_1 rows were grown out in S74, and the corresponding F_2 populations were screened for earliness and white grain type in K74. 150 crosses were made between cultivars from Ethiopia and steriles in the Purdue or Nebraska populations, and the F_1 rows grown in R74. A high altitude site will be needed to continue with this work, and we hope that somewhere suitable will be found in the Nilgiri hills. We hope to co-operate in this work with CIMMYT in Mexico, EAAFRO at Kitale, and the College of Agriculture at Alemaya, Ethiopia.

West African cultivars:

Mention has already been made of the improvement of the WABC and Bulk Y populations, and the numerous crosses with elite lines made with WABC or Bulk Y as one parent. Both these populations and the derived lines from the crosses should be particularly suitable for selection and testing under West African conditions.

East African cultivars:

East African material which had performed well near the equator proved to be photoperiod sensitive in Hyderabad. 150 elite lines from Serere were grown and selected in K73, and 774 selections grown in R73, when the best were crossed to short, photoperiod insensitive NP and PP steriles. 420 such crosses were grown in R74, and 529 selections from the R73 elite lines were grown in K74 and selected for photoperiod insensitivity, and for use as possible parents for shoot-fly resistance. 860 selections from crosses between Serere elite lines and good grain quality parents from the world collection (2K x crosses) were received as F_2 or F_3 seed and grown and selected in R73, when they were bulk-crossed with MP steriles to introduce photoperiod insensitivity. The F_1 of the bulk crosses was grown out in R74. In K74, 350 of these 2Kx crosses were grown and selected for photoperiod insensitivity. A further 716 selections from the 2Kx crosses were grown in R74.

Pest resistance:

Shoot-fly is a serious pest of later planted sorghums in India and Africa. Midge builds up on early flowering varieties, causing serious damage on later flowering types. Short-term sorghums introduced into districts where the bulk of the crop is later flowering can cause severe crop loss from this cause, and must be midge resistant. Stem-borers do damage in all areas, being most severe when growing conditions for the plant are harsh.

Preliminary screening against shoot-fly was attempted in R73, by treating one half of each row with carbofuran, and leaving the other half unprotected. Shoot-fly incidence was negligible, and no progress could be made until K74, when Dr. Davies had joined ICRISAT as entomologist. A large screening operation was developed in the South West corner of the site, well away from any pesticide spraying operations. Unfortunately, no fertilizer was used, because low fertility tends to accentuate susceptibility to shoot-fly as the plants grow more slowly and thus the vulnerable stage lasts longer. We had not appreciated quite how uneven and poor the land would be as a result of levelling: and recovery resistance was impossible to estimate, because growth was too poor. However, levels of shoot-fly infestation built up to over 90 percent using the system of interlards and fishmeal spreader developed at Serere, and it was possible to screen for primary shoot-fly resistance.

In addition to the 5,000 entries in two replications of the trials material, a large volume of other material was screened. This included Serere material (879 entries), Rajendranagar entomologists' nursery material (614 entries), crosses between West African material and shoort-fly resistant sources (190 entries) miscellaneous shoot-fly resistance crosses from Rajendranagar (109 entries), crosses for primary resistance from Nigeria (25 entries), recovery resistance lines from Serere via Nigeria, (60 entries of which 5 had also been screened for Chile resistance), together with populations 110 & 111 developed for recovery resistance at Serere and then at Samaru, and three other Serere composite populations which might contain resistance. Some 200 lines were chosen as having a useful degree of primary resistance, and some of these were crossed on to populations 110 and 111, as a step towards broadening the base of these shoot-fly resistance populations, which in any case have an undesirable level of photoperiod sensitivity. It will be essential to re-evaluate much of this material for recovery resistance, and a further screening is now being done in R74.

We received and multiplied seed of 51 midge resistant lines, but have not yet screened these for resistance. Some of the EE lines of Serere origin were subjected to very heavy midge attack on the shoot-fly screening site, and their level of resistance looks good: the combination of shoot-fly resistance and midge resistance would be very useful.

Plant Physiology:

As yet little is known about the physiology of the sorghum plant. In addition to obvious possibilities such as selection for drought resistance, and for efficient use of minerals, plant breeding may be able to contribute to the development of a more efficient plant under semi-arid conditions. Three possibilities are being investigated: (i) Differences in seedling vigour, as good establishment and good stands are essential for good yield (ii) Shortening of the duration of the growth stage from floral initiation to flowering (GS2). (iii) Deriving as much yield as possible from the initial seed set.

The variety Naga White has outstanding seedling vigour, and was crossed to the NP and West African Populations in K73. The F_1 generations was grown in S74, and the F_2's grown and selected in K74. A further F_2 planting of the Bulk Y and WABC crosses with Naga White was made in R74, because of the photoperiod sensitivity of the female parents.

A range of 148 entries from the World Collection, representing large, medium and small seeds with hard or soft endosperm types was chosen, and coloured v. white grain was an additional classification. These were planted in R73, and observations were then taken on the duration of the grain filling period, and an estimate was also obtained of the rate of grain filling, from grain numbers and weights. These are evidently important components of yield. There should be scope for selection for (duration x rate of filling) as there was some good variability in the material under study (Table 9).

Measurements were also made of the leaves, during the growing season, with the possibility in mind that the position of the largest leaf may be correlated with time of floral initiation. There were substantial differences between varieties, the largest leaf ranging from a mean position of 2.3 to 9.6, counting the flag (top) leaf as No.1. Subsequent studies in R74 by Dr. Amir Kassam cereals physiologist, have confirmed the existence of much intervarietal variability in the number of leaves expanded between floral initiation and flowering. GS2 is a critical stage for drought stress, and plant breeding may have a useful contribution to make here.

These 148 entries were crossed to PP steriles, both as male and female parents, and the F_1 generations were planted in R74. Meanwhile, Dr. Kassam is making more thorough studies of 49 of the 148 varieties, and appropriate backcrosses will be made to those identified by him as having the best potential for development. If he is able to identify the stage of floral initiation from appropriate leaf measurements, selection for different numbers of leaves in GS2 will be straightforward. All plant physiological studies are now in Dr. Kassam's hands, and we shall be working co-operatively on the breeding of more efficient plant types.

Grain quality:

Quality has both obvious and concealed attributes: the obvious characteristics of good quality in sorghum grain are (i) free threshing (ii) absence of pigment (iii) a very hard corneous layer in at least the outer endosperm (iv) clean, plump, well-filled grain (v) lustrous appearance (due to a very thin pericarp which allows the lustre of the outer corneous endosperm layer to show through). It would be difficult to rank these characteristics in order of importance, but most consumers would rate completeness of threshing, absence of pigment, and hardness of corneous endosperm as being of primary concern. More needs to be learnt about milling behaviour and differences in suitability for food preparation methods, but such meagre evidence as there is suggests that similar sorghum grain types have broadly similar milling and food preparation characteristics and that seems to be the opinion of the sorghum growers. Pending more study of these attributes, the prime quality objective in the program is to select for grains with the five attributes listed above: and the good grain population was developed on this basis.

In previous programmes and reports, this list of obvious quality characteristics in sorghum was perhaps too readily assumed to be common knowledge among those dealing with these crops, and does need to be spelled out.

As so often with grain crops, the best quality is generally not associated with the highest yields, although some of the new releases from the AICSIP program at Rajendranagar achieve good combinations of grain quality and yield. The hard, corneous endosperm is of particular importance because of its slower rate of damage by storage pests, and as most small farmers in the semi-arid tropics will be storing their own grain for many years to come, the basic food varieties must have the hard corneous grain characteristic.

High tannin grains have to be grown in certain areas of Africa where quelea birds do devastating damage: and there, pigment has to be accepted. It is hard to believe that such grain types have a very long-term future, and the extent to which the Hyderabad program ought to be involved with improving such types remains to be determined. One of the co-operating centres in Africa should probably be the main centre for such work.

The concealed attributes of quality include nutritional value and digestibility. The second major product of sorghum yield, next to starch, is protein. Much work has been done on high lysine types, particularly at Purdue. Sorghum protein has a fairly good amino-acid balance, apart from the low level of lysine. Sorghum and finger millet share the bottom place for lysine content among the world's important cereals, with levels of around 2 percent and often less. The "high lysine" types discovered by Dr. Rameshwar Singh and Dr. John Axtell in Ethiopian material have lysine levels of around 3 percent, which is of the same order as that in wheat. It seems evident that, with the developing world relying on cereals for 50 percent of its protein requirements by 1985, the amino-acid balance of sorghum protein should be improved if this can be done easily. We have therefore followed the policy set out on p.12 of the Annual report to the Director of ICRISAT of April 1974. "The objectives of the protein work are clear: we are combating protein/calory malnutrition so the grain protein content must be no higher than is compatible with maximum grain yields under prevailing conditions. This probably means accepting levels of around 10 percent. As much as possible of the protein produced must be of high biological value."

Laboratory methods were worked out, and it looks as though decortication with NaOH, followed by a biuret estimate of protein level, then a UDY value on the protein, gives a rapid screening technique in which less than 10 percent of the entries are wrongly ranked. By plant breeding standards, this is good. Very pigmented grains or types with high tannins cannot be screened in this way, but it is doubtful whether they should be involved in high lysine work at all. Dr. Jambunathan, biochemist, joined us in November, and we can expect the development of more satisfactory methodology soon.

The two high lysine Ethiopian lines IS 11167 & 11758 proved to be tall, late, and photoperiod sensitive. Further, their grains when ripe are shrivelled, with a low endosperm content. 95 crosses were made in R73 to some of our populations, and the F_1 generations were grown out in S74. Segregating generations were planted in R74: but only the most promising will be screened for lysine content.

Dr. Axtell kindly supplied seed of 1651 selections from crosses and backcrosses between the NP & PP populations, and the high lysine IS 11167 and 11758 parents.

These were grown in R73, and sibbed, as they carried the ms_3 gene. The shrunken seeds segregated on the heads in the rows, and many of the heads with white or shiny red grains segregating in this way were screened on the light box. The shrunken seeds were not all opaque, but there was insufficient material for chemical tests, and it is not known whether all were high lysine. A small proportion (less than 2 percent of the heads contained a few plump grains which were opaque.

One thousand of the heads with white grain were analysed in the laboratory and those with the best UDY values are shown in Table 10. It can be seen from the table that some 6 percent of these had high UDY values above 30.0 compared with the mean of 24.9, though often with low protein levels. As these had all been translucent on the light box (all plump opaque seeds were taken separately) there may well be some useful endosperm types among them, and the best 102 were planted in R74 to develop a population and for further study and analysis. These data suggest that there is little point in using the light box any further, since it is the non-opaque endosperm types which are needed by the consumer, and the chemical analyses seem to be picking up high lysine entries in these sufficiently well for breeding purposes. The program will therefore be slanted much more strongly towards the development of high quality grain types with high lysine values by chemical screening only.

The K74 plantings from the Purdue high lysine crosses consisted of (i) Plump, opaque seeds from 300 heads. Many did not germinate, but protein and lysine analyses on those which did will be available for the meeting. (ii) 850 sibs in 2 replications. (iii) 2573 head rows from selected plants. Much of the material was tall and late, and only 300 selections were taken for screening and planting in R74. All the high lysine selections from the plump opaque seed plot were also grown on.

Seed was received from Purdue of crosses between three of our populations, (Tropical conversion, Good grain, and Hybrid R_s) and (PP x Ethiopian high lysine) parents, and 746 selections were planted in R74. Plant types and head sizes look promising, and these will be grown as F_2 populations in the summer, and F_3 lines with white grains will be screened in 75 K for photoperiod insensitivity and lysine value.

Twelve high lysine and one high methionine line from the world collection, as identified from the Purdue publication of the analyses of 832 entries, were planted in R74 and crossed on to photoperiod insensitive

Dr. Axtell supplied seed of 15 selections from Dr. D.P. Mohan's mutation programme which are said to have high lysine, and these were grown in K74.

Tetraploid sorghum:

Tetraploid wild sorghums are highly successful (e.g. Johnson grass) and the genomes are similar to those of the cultivated crop. Tetraploid grain sorghums have been developed at Serere, and one variety was developed by Dr. W.M. Ross in Nebraska. Tetraploids would seem to have a potential for larger grains, better yields, and some fixation of "hybrid vigour" in varieties. The current project is concerned with the development of grain types, which will be followed by testing, and probably also by the development of rhizomatous grain-grass types for difficult areas.

27 bulks of heterogeneous tetraploids from Serere and one of Ross 4n from Nebraska were planted in K73. The Serere types were photoperiod sensitive, so tall and late, and quite a lot of contamination with diploids had occurred. 1198 head rows were planted in R73, and screened as far as possible against diploids, by making test crosses on to CK60A male-sterile. Ross 4n was also grown, and used as a parent to introduce shortness and photoperiod insensitivity, 210 such crosses being made. 356 crosses were also made among other tetraploid lines, especially those segregating for male sterility. 48 percent of the Ross 4n crosses and 25 percent of the intercrosses were successful, and were grown in K74 together with 1171 head rows. These were screened with the aid of the microscope, and selected for shortness and earliness. In R74, 672 rows from the crosses and 535 selections from the bulks were grown. These

included 150 from Ross 4n, which has developed much more variation than was evident in the original introduction. Cytological studies indicate that selection for fertility has greatly improved meiotic behaviour, there being very few univalents or trivalents. Some of this stability comes from S. almum, which was used as a parent to introduce high fertility into many of the Serere tetraploids.

B. Pearl Millet

Introduction

The pearl millet programme commenced with the collection and sorting of germplasm. Inbreds and hybrids received most attention in the first two seasons, then emphasis moved more strongly towards composite populations. The millet work is always overshadowed by disease problems; news of downy mildew spreading on the hybrids, and the presence of ergot and rust in our own material, were constant reminders of where the challenge lies. It has proved easy to obtain three seasons a year at Patancheru, so the planting in the current rabi season is the fifth since the programme began in July 1973. Photosensitive varieties flower too late when grown in the kharif, so these are used as parents in crosses during the rabi season, the F_1 generations are grown in the summer, and the segregating F_2 generations in the kharif season. Again, the experience of small farmers in India and Africa has been proved true here: pearl millet does best on the light land. Many millet lines grow badly on the heavy black soil in the rains, and even under irrigation in the dry season growth is better on the red soil.

The millet group share the former crop improvement building with only cereals germplasm and the cytology laboratory, so there is now sufficient working space. J.V. Majmudar joined the programme from the beginning, and has made a sterling contribution. D.J. Andrews shared both millet and sorghum work from August 1973 until April 1974, when he contracted infectious hepatitis. He returned in August 1974, to assume leadership of the millet programme, but still required time to convalesce. A small group of hard working, able Research Associates has been established, with a core of good field help (Table 1). However, here again another senior scientist and some increase in support staff will be needed if we are to ensure a good programme at Patancheru with adequate support for the co-operating centres. There will be post-doctoral fellows and graduates to train, and a small core of experienced scientists is essential to achieve this.

The millet programme is also ready for work to begin outside Patancheru: it will be essential to screen material at a very early stage against downy mildew in the rabi and summer seasons, and we hope to find sites at which to do this in South India. Also, we are ready to put out inbreds, hybrids, and composites for regional testing and selection in 1975.

Breeding

A. Composites:

Pearl millet is a cross-pollinating crop, so the plant breeding product is a synthetic, a broader based composite, or a hybrid. Recurrent selection in composite populations is therefore the obvious basic breeding procedure, and we may expect many similarities with maize, although there is rather more selfing in the millet crop (circa 30 percent). S_1 testing is simple and should be useful: with 3 generations to a cycle, a fresh cycle can be started each year. However, this is rather a scramble, and does not allow much time to digest results. Further, seed dormancy is an important advantage on millets which ripen before the end of the rainy season: and this character could be rapidly eliminated if sowing is done too soon after harvest, which must be the case to get 3 generations in a year. Full sib recurrent selection fits very well to two seasons a year, as does S_2 testing. For the latter, we need to know whether there is any real advantage in carrying inbreeding to the F_3 in a cross-pollinating crop. Most of the progeny from an individual millet plant in the population.

A breeding system which uses test crosses may have some advantages. Half-sib methods using an inbred tester or a top cross to the population are possibilities, but some form of reciprocal recurrent selection would seem to be the obvious choice. Hybrids have been successful in millet: and there is no need to think only of single cross hybrids. These merely represent an extreme situation, and broader based varietal hybrids can be made from crosses between the two populations involved in the recurrent selection system or between groups of lines of any desired size drawn from these populations. Similarly, synthetics can be extracted from both sides of the recurrent selection system. There are at least three cytoplasmic sterility systems available in pearl millet, so the tools for reciprocal recurrent selection systems are there, and it may even be possible to use the system without a sterility mechanism: a little accidental selfing would do no harm, and D.J. Andrews has pointed out in the programme section (still in manuscript) that thick planting of naturally crossed seed can result in stands containing over 80 percent of hybrid plants. Reciprocal recurrent selection improves the composites, and improves the hybrid vigour expressed in crosses between the composites: and it has worked well with maize. Initially, our program is based on full sib, S_1 testing and S_2 testing procedures, but we are moving towards the use of reciprocal recurrent selection in some of our material.

Material developed:

Four basic composites (Early, less than 45 days to flower) Mid-late (45-55) Late (55 +), and Dwarf (less than 1.80m) were designed using sources available in the first kharif. These composites had 194, 197, 46 and 85 entries respectively. (Table 11). Some of the more favourable entries were weighted, and an approximate 50/50 balance thereby obtained between the contribution from Indian and other, mostly African, sources to reach population. After 3 random mating generations 1000 half sibs have been chosen from each of the Early and Dwarf composites which will be advanced to S_2's for testing in K75. Adequate C_o bulk seed has been kept of each for future comparisons. It is estimated that the remaining two composites will be sufficiently random mated during this rabi season, and so it will be possible to test S_1's from these next kharif, via summer half sibs. Sufficient seed will be produced to allow 2 replications at each of 5 locations, for each composite.

Four composites from Nigeria (Nigerian; World; Nigerian x World and ex Bornu (a blend of local landraces), and 11 composites from Uganda (Serere) were initially received. Many of the latter are phenotypically similar (though classified B, R or BR on A_1 (23A) and are being maintained by mass selection (mass sibbing). Yields of some of these composites from a trial in K73 are shown in Table 12.

In the Nigerian composites 230, 231, 204, and 202 S_1's respectively have been extracted for testing this rabi, and while the unreplicated S_1 progeny rows of each composite showed good variability, Nigerian x World appeared to be best. Seed protein estimations of the 204 N x W S_1's ranged from 9 to 19% and there was no strong correlation with seed size.

The Early and Mid-late composites (after the second random mating generation) were included in a yield trial in K74. Results are shown in Table 13. The two composites with mean yields of 3,020 and 2990 kg/ha did not differ from the best source of HB3, which gave 3,290 kg/ha. HB4 was attacked by rust.

Six new populations have been recently received from Nigeria:

1. The Senegal Dwarf synthetic $(M_1)C_2$ selected for 2 generations at Kano for downy mildew resistance

2. Cassady dwarf population $(M)C_1$

3. Sauna D_2 x Ex-Bornu

4. Maiwa composite - base population

5. Early millet Dwarf (base) population

6. Mokwa maiwa (M) $(?C_4)$

also later cycles of two composites already received - the Nigerian composite $(S_4)C_1$, and Ex Bornu $(S_1)C_2$

B and R Composites:

During the course of evaluating crosses of numerous entries on to cytoplasmic steriles it was noted that a good restorer on one A-line (eg.$23D_2A$) did not necessarily restore male fertility well on other sterile lines reputedly of the same cytosterile system $(A)_1$; and similarly for the maintaining ability of B lines. Therefore, choosing only $23D_2A$ as a test source, we have identified a diverse group of good restorers (171 entries) to form an R population (74R), and a diverse group of maintainers (111 entries) for a complementary B population (74B), the intention being to conduct reciprocal recurrent selection between the two, after compositing.

Maiwa A and B composites have recently been received from Nigeria. The male sterility and dwarfness in these was derived from 23A. The B composite should be a valuable breeding source for disease resistance and grain characteristics useful in developing non-photosensitive A and B lines.

Synthetics:

RF synthetic - Seed harvested from all good single cross hybrids (fertile) using 23A, $23D_2A$ and $18D_2A$ (190 entries) based on performance in the yield trials has been random mated once in the K74. The value of this synthetic will depend on the effect of the incidence of male steriles on possible ergot infection and spread.

VX 74. Seventy-nine promising variety crosses were selected in K74 for synthetic formation in the next season.

Diallel 15

105 F_1's were made from all possible crosses between 15 inbreds chosen because of their previous good performance in several crosses.

B. Conventional hybrids:

Emphasis on conventional hybrids is still strong, because in all respects other than disease susceptibility they have been highly successful, especially under difficult conditions. Downy mildew has been the most damaging disease, and ergot has also been of major importance, because some of this in the crop makes the whole harvest from that field unfit for human consumption. Rust incidence is often high, but the effects of rust on yield are believed not to be serious in most millet types. Diseases are discussed below. The cytoplasmic sterile female parent of 23A, used for most commercial hybrids, has proved to be very susceptible to downy mildew,, and the line 5071A was developed by AICMIP through irradiation of 23. This appears to have a better level of downy mildew resistance, and is being used as a hybrid parent.

904 experimental hybrids were evaluated in the second season at ICRISAT. 269 were good fertiles while only 13 potential B lines were isolated of which 2 were subsequently dropped, 6 backcrossed once and 5 twice. Seed of 38 of the best hybrids was remade in the summer and used in a preliminary yield trial (4 reps) in K74 and though yields were moderate (HB 3 check gave 1980 kg/ha), the best hybrid (700250 x $23D_2A$) gave 38% more (Table 14). In K74 a further 166 new hybrids were tested with 5071A' (irradiated downy mildew resistant derivative of 23A), 741 with $23D_2A$ and 660 with $18D_2A$. Out of these 44 were selected for preliminary yield trial and 69 for nursery testing where selection was still required within the male parents. Additionally composites or populations have been contributing to the hybrid program: 248 S_1's of World Composite, 154 S_1's of Nigerian World Composite-2 32 S_1's of Nigerian Composites were crossed on to 5071A in S74. These hybrids were evaluated in K74. 78 hybrids were chosen and will be remade using reselections from the male parents in R74.

103 F_4's of Maiwa New Strain and 33 F_4's of Gero New strain were crossed to 5071A in S74. These hybrids were evaluated in K74 and 18 were selected to remade in R74.

Variety, variety/inbred ms_c crosses:

A limited number of hybrids have been made using mass pollen on an ordinary A line. In two cases, $23D_2A$ x Serere 2A, and $23D_2$ A x (Nigerian x World Composite), successful hybrids were obtained which both averaged 25% more yield than HB3 in replicated tests (tables 14 and 15).

The phenotypic variability among the hybrid plants was not as large as expected and both were agronomically acceptable. The possibilities of such hybrids will be further investigated.

Maintenance of AB and R lines:

Eleven ms_c lines along with their maintainers are available with us (below). They were maintained in R73, S74 and K74 and increased in each season.

Type of sterile cytoplasm	Designation of line
A_1 source	23A, 5071A, $23D_2A$, $18D_2A$, 101A, 111A, Serere 10LA
A_2 source	239 D_2A, 66A
A_3 source	67A, 431A

The 5071A and B material grown in S74 was still segregating, so 100 plant to plant crosses were made between the A and B plots, and 48 pairs have been retained from the kharif planting. These will shortly be retested, especially for disease resistance.

Production of hybrids:

The first hybrid seed multiplication plot will be planted in R74 to produce the hybrid $23D_2A$ x 700250. This will go out for regional testing.

C. Variety crosses:

Generation of new variation:

170 variety crosses were made in R73 and 148 taken through to the F_2 from which 574 single plants have been chosen.

A further 600 crosses were made in S74 and are being taken through to F_2 in R74. Some of these variety hybrids, though rather late maturing, have been extremely vigorous and high yielding.

Some segregating material was obtained from other programmes, including inbreds lines (70 series), Maiwa dwarf bulk lines, and Maiwa and Gero new strain crosses all from Nigeria. Selfing and selection within these has identified promising pollen parents, and other useful inbreds.

Interspecific crosses:

15 wild species and wild interspecific crosses were brought from Punjab Agricultural University, Ludhiana and IARI, New Delhi and are been increased by vegetative propogation. The seed of 12 species/crosses was harvested. The original stock will be allowed to grow vegetatively by continuous care and irrigation.

D. Disease resistance:

Observations taken on the germplasm and breeding material in K73 and R73 showed that rust (Puccinia pennisietiZimm.) was severe in both seasons. One line from Nigeria, 700841, was completely free from rust, and individual rust free plants were found in various Nigerian and Serere lines, and also in the Serere composites.

Downy mildew (Sclerospora graminicola (Sacc.)Schroct.) showed a low natural incidence in K73 and R73, although 23A and $23D_2A$ both showed a rather high incidence. Material was collected to establish a sick plot, and augmented by diseased material from Dr. Sundaram. 2150 lines were planted in this sick plot in K74. These included 71 downy mildew resistant lines from Dr. Safeeula, Mysore. Incidence of the disease was rather light. The major problem with this disease is the fact that, being an obligate parasite, different strains of the pathogen may arise, so that any program based on single cross hybrids could develop the dog-chase-rabbit situation which has occurred with the rusts of wheat. It is therefore important to look at the broader based synthetic, composite and varietal hybrid approach to resistance, at least until we know a lot more about the disease. In traditional land races of millet in both Africa and India this disease was always present, but with a frequency of perhaps 5 percent of infected plants. There seem no grounds for pessimism, we should be able to achieve at least this low level of incidence, and probably do rather better.

Ergot (Claviceps microcephala (Walter)Tul.). Serere infection was noted in K73 and R73, especially in the border rows of HB3. 26 of Dr. Safeeulla's 71 lines were also found to be susceptible, although resistant under Mysore conditions. This disease was also troublesome in the K74 breeding fields, but came into the "sick plot" screening rather late. True resistance to this disease must evidently be found and used, but delayed pollination, often marked when male-steriles flower under poor pollen shedding conditions, is undoubtedly a factor contributing to disease build-up. Prompt and plentiful pollination must be a major consideration in developing millets which can live with this disease unscathed.

Dr. Y.L. Nene, plant pathologist, joined us in September 1974. Although the pulse pathologist, he now has a major program on these millet diseases, which involves close cooperation with the plant breeders. His report follows.

E. Entomology: Heliothis armigera Hb., and some ear-head bugs were troublesome at times, but pest levels do not yet warrant special emphasis in the breeding program.

F. Plant Physiology Dr. Kassam began millet growth and development studies and millet genotype evaluation studies in R74.

G. Grain quality Millet eaters like plump, bright, clean grains of a bluish-grey colour. We know little of the reason why. Protein levels and lysine levels in millet are quite good: and we do not expect to have to place much emphasis on this in the breeding program, although evidently good basic levels of both must be maintained, requiring regular monitoring.

Seed analysis:

We have found that the Udy-binding capacity method can be used successfully to screen large populations for total protein (on a fixed flour sample) and lysine (on a fixed protein basis). The Neotec is also giving good results, but needs a larger sample size. Till now a systematic screening for total protein has been done on 264 samples of fertile hybrids (range: 9.58 - 18.54%, mean 13.05%) and 124 samples from line x tester hybrids (range: 9.41 - 18.00%, mean: 13.18%). Much variation in 1000 grain weights also exists. For example, 129 samples derived from hybrid yield trials in K74, had a range of 1000 grain weights from 5.80 to 12.30 gms. In future, we shall quote the 1000 grain weight and date of harvest for all the samples analysed for protein and lysine. We shall shortly be screening a part of our germplasm collection for total protein and lysine.

We shall be screening for oil content, since one of the problems with many millet types is the poor keeping quality of the flour, which goes varied quickly. Starch content will also be studied, and with the new Neotec protein, oil and starch can all be read off the same sample in a matter of seconds.

Digestibility differences need investigating also, but are less straightforward to assess.

C. Cereals Germplasm

An international scientist has not yet been appointed for the cereals germplasm work. The millet germplasm has been maintained, largely as selfed lines, in the course of the normal breeding work, with the exception of some IP numbers from the Rajendranagar store, planted in R74.

Sections of the sorghum world collection were grown in R73, mainly to rescue seed or to meet seed requests. We were not always successful: Ethiopian "Introductions" material received proved to be non-viable, but we were able to grow the Cameroons collection. The Ethiopian material is still available from Alemaya, a set is packed ready for us there awaiting collection.

Once the germplasm scientist joins us, a policy on collections, how, where, and what should be maintained needs to be worked out. The present collections are a mixture of cultivars and land races developed by the small farmers of the semi-arid tropics, lines and selections made by plant breeders and wild relatives of the crops. These evidently need to be separated out. The question of how best to maintain millet accessions needs to be reviewed, selfing is clearly inappropriate and merely generates an infinite number of lines, so that many have to be rejected and discarded.

Mr. K.E. Prasada Rao, research associate, began the germplasm work in R74, and his report follows:

Germplasm (K.E. Prasada Rao):

The work on germplasm was initiated in R74 mainly with the object of increasing the seed of the world sorghum collection (I.S. numbers) which is losing viability in the Rajendranagar stores.

The other important material planted along with it, are the Ethiopian Sorghum collections viz. ESGPC and B.G. numbers. Local collections from North Ghana, collections from Dr. Axtell, World Collections from Senegal, New Introductions, and Cameroon Collections were also sown in order to maintain and increase the seed for meeting the seed requests from Sorghum Breeders of various nations. The following is the consolidated list of material sown as germplasm in the current Rabi season.

World Collection I.S. lines	..	8961
Ethiopian collections	..	1555
Local collections from N. Ghana	..	52
Axtell lines	..	128
New Introductions	..	96
World Collections for Senegal	..	603
Cameroon collections	..	728

All the collections are being maintained by selfing 3-5 representative heads in each line. In addition, 184 cytoplasmic male sterile lines of sorghum are being maintained by hand pollinating with their counterpart 'B' lines.

Under Millet germplasm 281 I.P. lines (World collections) are being grown, and maintained by sibbing 3 to 5 heads per line.

Apart from the above the following improved sorghum lines were sown for multiplication of selfed seed mainly with the object of meeting seed requests, and for utilization in the breeding programs.

1. Swarna
2. 370
3. 302
4. 604
5. 329
6. 148
7. R-16
8. CS 3541
9. NJ 1944
10. H 112
11. H 109
12. CS 3687
13. IS 3691
14. 296
15. 269
16. 168
17. B.P. 53
18. 555
19. IS 84
20. ODC-19-Sel-92793
21. SGIRL MR-1
22. E. 302
23. E. 303
24. 555
25. IS 11167
26. IS 11758
27. RY 49
28. SB 65
29. Lulu dwarf
30. Simila
31. IS 4474
32. IS 15075

Millet:

The following information has been supplied from the millet group:

We have with us five sets of Indian Pennisetum (I.P.) collections. These were received from five different sources, namely Rajendranagar, Jamnagar, Bangkok Ludhiana and Lebanon. The first four sets were sown and harvested in K73.

In K74, a germplasm nursery was sown, which included:

Jamnagar inbreds	..	1911 entries
I.P. series (from Bangkok)	..	395 "
Breeding lines from Kano ('70 series)	..	187 "
MPP (Mycology & Plant Pathology)	..	179 "
I.P. lines (from Lebanon)	..	1492 "
Plant selections received from regional selection nurseries, Lebanon (NEP accessions)	..	79 "
Lines from Niger	..	16 "

All the material in the germplasm nursery was sibbed and selfed as appropriate. The new I.P. series from Lebanon, NEP accessions and the lines received from Niger were evaluated to identify lines of agronomic interest for future use in our breeding programs. About 100 such lines have been planted in R74 and will form our initial 'working' germplasm collection. We also expect to bulk 'similar' duplicate entries of the I.P. collections.

Information on germplasm received is summarized in tables 16 & 17.

REVIEW OF THE SORGHUM/MILLET ENTOMOLOGICAL WORK 1974

J.C. DAVIES & SHESHU REDDY

In 1974, a start was made in establishing the cereal entomology programme at ICRISAT. Dr. J.C. Davies joined the staff in mid November, 1974 but had previously served on a 3 1/2 month secondment from the Centre for Overseas Pest Research, London, and established basic laboratory facilities. Dr. Sheshu Reddy who had already served at ICRISAT as general entomologist assumed the position of Research Associate.

Facilities:

The old school building at Manmool village was converted into Laboratory and Office space for the entomology unit. Preliminary orders were placed for essential equipment. Light traps were fabricated and brought into operation in order to assess the range of species present at the site.

Programme: - Screening:

Fourteen hectates of land were sown in the kharif season in a newly opened block of land at the perimeter of the farm. This area was to be kept free of chemicals, in particular insecticides, and was to be used for testing cereal material under high or "normal" pest challenge. All breeders material including the Diallel lines, PP restorer population, grain mould selections and NP steriles was subjected to high pest incidence by deliberated sowing interlards of susceptible sorghum some three weeks before sowing the test material. Selected lines which had already been partially screened for resistance to shoot-fly or stem borer earlier, in India or elsewhere, were subjected to intense pest, mainly shoot-fly attack by encouraging high populations by interlard sowing, and spreading fish meal between rows of both interlard and material under test. The material was also sown late. Extremely high levels of pest attack as assessed by egg laying were achieved. In all 2470 lines were screened in replicated trial and a further 340 received preliminary assessment. Counts were made on egg laying by shoot-fly, dead hearts produced and level of stem borer attack and on the basis of these 354 lines were selected for further detailed testing in 1974/75 'rabi' season.

This material together with other selections has now been sown.

Pest incidence at Patancheru:

A crop of the variety 302 and hybrid CSH_1 was sown prior to the break of the monsoon and regular destructive sampling carried out to assess pest incidence in a normal crop and the sequence of attack. Unfortunately poor growing conditions foiled the attempt to relate pest incidence to yield.

General observations were that in the difficult growing conditions experienced, 302 failed almost completely, while CSH_1, survived. The slow growth led to an early attack by grasshoppers which was more damaging than normally expected. Information was obtained on shoot-fly oviposition and biology and useful preliminary data on Chilo incidence accrued.

Atherigona soccata - shoot-fly:

After the germination of the crop on 1/7/74, egg laying increased rapidly by the 6 week stage 6[illegible]% of plants had shoot-fly eggs laid on them, while a maximum of 54% had dead hearts by the same date. Preliminary studies were made on methods of sampling the initial low and out of season populations using seedlings in trays, yellow bowls and ammonium sulphide attractants.

These were not entirely satisfactory - the former proving to be best. It was clear that the number of shoot-fly present in the 'summer' season was low, larvae or pupae were not found in samples taken from local grasses and the origin of the initial low shoot-fly populations is a subject of conjecture. It is a problem which must be solved since control of these initial low populations might be practical. Samples of Flies were sent to the British Museum. The most important species at the site is confirmed as A. soccata.

Chito zonellus - spotted stem borer:

This pest was found in the crop surprisingly early at the site. Sampling indicated that this was at least in part due to carry over of larvae in off season sowings. (Currently 3 crops of sorghum are grown in sequence at the site). Eight weeks from sowing 22% of the plants showed signs of damage by the pest and 10% of the plants contained larvae in stems sampled. Damage levels remained high until harvesting - between 12 and 13% of stalks had larvae. Sampling indicated that only one generation was produced in the crop - approximately 3% of the stalks had pupae 4 months from germination.

A large number of moths have been bred. Samples are being sent for identification since some slight differences in biology are apparent in oviposition behaviour and a range of characters appears to be present in the adults. Live material has been sent to the Centre for Overseas Pest Research, London to establish a colony for comparison with a colony already established from Botswana. It is hoped to develop a cooperative programme in an effort to establish reasons for apparent resistance to the pest in some sorghums. Seed of lines felt to be resistant will be sent to COPR/Kew for chemical analysis and feeding studies.

Contarina sorghicola - sorghum midge:

This appeared in the crop 3 months from emergence, 13 weeks from emergence over 13% of plants were infested. The attack was not devastating but certainly very considerable. It is unfortunate that it was not possible to assess the affect on yield of the various pests, including this one, at harvest.

All 3 principal pests of sorghum in the SAT are therefore present.

Other pests recorded included Mythimna separata and the head webbers including Eublemma siliculana and Celama analis (upto 13% of heads affected).

Attempts were made to guage the importance of the various hemiptera which are present. Calocoris angustetus is known to be a serious pest locally in India. By 8 weeks from emergence it was being recorded from 12% of the developing heads and built upto a maximum of 70% by the twelfth week. Shoot bugs were present on 10% of plants just before harvest. Aphids became common 6 weeks from emergence and 27% of the plants were affected at 8 weeks. The number declined to 2.5% affected at harvest.

The considerable collection of insects recorded will be sent for identification as soon as possible. Many are well known occasional visitors e.g. Nezara viridula, Dysdercus spp, Lytta spp, Zonabris pustulata. A working insect collection has been started for legume and cereal pests.

Non insect pests recorded included rats (severe), millipedes and mites late in the season.

Routine pest surveillance of the rabi sorghum and control of pests continues.

Light Trap Studies:

A light trap came into operation on August 1, 1974. Agriculturally important species are being sorted out and recorded each night. Among the important insects being recorded are Chilo, Agrotis, Heliothis and Tryporyza. It is particularly important to attempt to discover the seasonal pattern of incidence of such pests. In August for instance 25 Chilo were recorded, in September 8,915, in October 9,861, and November 8,107, including a peak catch of 1691 on the night of November 11, 1974. Such data will be important in making comparisons of pest fluctuation over the years.

Pest Control:

Routine counting was carried out on all breeding germplasm blocks to assess pest incidence. A spray schedule was devised which ensured low pest attack on these blocks so that germplasm material from very diverse sources was not eliminated by local pest species. Insecticides used included carbofuran, endosulfan, endrin in granular form and carberl. Pest levels were at a satisfactory low level on these blocks throughout the season.

A LIST OF INSECT SPECIES RECOVERED FROM SORGHUM AT HYDERABAD

The following list records species recovered from the growing crop in the kharif season. An attempt has been made to indicate which are considered to be major pests, minor pests and which species have been identified by specialists. A large amount of material has been submitted or is in the process of being submitted to insect taxonomists.

MAJOR PESTS

Scientific name	Common name	Tentative status in SAT
Atherigona soccata	Sorghum shoot-fly	Common pest
Chilo zonellus	Spotted stem borer	Common pest
Contarina sorghicola	Sorghum midge	Common pest
Calocoris angustatus	Earhead bug	Local significance can by serious
Sitotroga cerealella	Angoumois gram moth	Common pest of stored grain
Sitophilus oryzae	Rice weevil	Common pest of stored grain

MINOR PESTS

Sesamia inferns	Pink borer	
Ansacta albisoiga	Hairy caterpillar	Can be locally important on other crops
Estigemene lactinea	Black hairy caterpillar	Common pest of agri. crops
Mythimna seperata	Army worm	Common, can be locally serious
Marasmia trapezalis	Sorghum leaf rotter	Common
Psalis securis	Yellow hairy caterpillar	Common on grasses & millets
Heliothis armigera	American bollworm	Common
Eublemnia silicularа	Earhead webber	Common
Cryptoblabes sp	Earhead webber	?
Panara mathias	Skipper	Common
Celema analis	Earhead webber	?
Rhopalosiphaum maidis	Sorghum aphid	Common, can be locally severe

Laonguinis sacchari	Aphid	Common
Peregrinus maidis	Shoot bug	Locally severe
Mycllocerus spp	Weevil	?
Triboleum Castaneum	Rust red flour beetle	Common, instored produce
Nezara viridula	Shield bug	Common
* Chrotogonus trachypterus	Grasshopper	Genus common
* Cyrtacanthacris tartarica	Grasshopper	Genus common
Colemania sphenerioides	Grasshopper	Genus common
* Aiolopus simulatrix	Grasshopper	Genus common
Pyrgomorpha new species		Sent to specialist
* Eyprepcnemis alacris alacris		?
* Catantops erubescens		Genus common
Locusts of various species		Periodic and severe

Other species found feeding:

Dolicoris indicus	Stink bug	Similar species common
Dysdercus spp	Cotton stainer	Common
Dichocrosis punctiferalis		Common
Zonabris pustulata	Blister beetles	Common
Lytta picta	Blister beetles	Common
Lytta tenuicollis	Blister beetles	Common
Gnatospastoides roui	Blister beetles	
Creontiadis spp		Common
Oxyectonia spp		
Various Lygaeids and Coreids		Common
* Euproctis subnotata	Earhead webber	?

*Already confirmed by specialists and incorporated in collection

CEREAL (SORGHUM AND PEARL MILLET) PATHOLOGY
(Review of the work done in 1974)

(Y.L. Nene, K.N. Rao, and S.D.Singh)

Dr. Nene joined as plant pathologist in September 1974, Mr. Singh joined as a research associate in August 1974, abd Dr. Rao, who was looking after the pathology problems in general during the previous year, continued as research associate.

From September 1974 onwards, we have been setting up laboratories and simultaneously carrying out some work. A laboratory has been set up at ICRISAT - III. Also house No.2 at Manmool village has been converted into a field laboratory. Equipment orders have been sent. A tentative program for research on cereal pathology was drawn up and was discussed informally with the Leader of the Cereal Improvement Program.

The work carried out during 1974 has been summarized below:

I. Diseases observed during 1974 at ICRISAT

Sorghum

Leaf diseases: Downy mildew, rust, leaf spots caused by species of *Helminthosporium* (tentatively identified as *H. turcicum*) *Colletotrichum*, *Gloeocercospora*, and some other fungi yet to be identified.

Inflorescence & Head diseases: Sugary disease, Head Smut and Grain Smut, Head moulds (species of *Curvularia*, *Colletotrichum*, and *Fusarium*, *Penicillium*, *Helminthosporium*, *Phoma*, *Olpitrichum*.

Pearl millet

Leaf diseases: Downy mildew, rust, leaf blast (*Pyricularia setariae*)

Inflorescence diseases: Ergot and Smut.

Out of these, downy mildew, rust, and head moulds in case of sorghum and downy mildew, ergot, and rust in case of pearl millet were more common in incidence.

II. Work on sorghum head moulds

Out of the species recorded on the sorghum heads, *Curvularia* sp. and *Fusarium* sp. were found to be highly destructive. Almost a total failure of germination was seen in case of seeds infected by these two fungi. Preliminary experiments have indicated that best time to inoculate heads with moulds might be post-fertilization to early milk stage. Also covering inoculated heads with brown paper bags or polythene bags is favourable for mould development. More than 2850 entries were evaluated for their reaction to head moulds under natural conditions. On a 5-point rating scale (1-5), 24 entries were given a rating of 1. These entries will be screened under artificial conditions against *Curvularia* and *Fusarium*.

III. Work on downy mildews of pearl millet and sorghum

A long-term study on the survival of oospores of these two downy mildews has been initiated. This study, hopefully, will provide answeres to the following questions:

1. How long oospores survive (i) under fallow and (ii) when these crops are grown in rotation with rabi crops like chickpea and safflower (These have been selected only for avoiding fallow)?
2. How do black and red soils influence oospore survival?

IV. Developing downy mildew sick plots

The debris from diseased plants was collected, dried and powdered. It was then incorporated in the soil in rows prior to seeding. This procedure will be followed repeatedly in the same plot to build up the inoculum.

Screening for pearl millet rust resistance under natural conditions

Since the natural rust incidence was severe in September 1974, the performance of breeding material against this disease was assessed. In all 5570 inbred lines and 2150 S_1 lines were compared and rated. Upto 60 percent rust severity (Modified Cobb's scale) was observed on susceptible lines. About 500 entries had less than 10 percent rust severity, but none was completely free. These 500 entries will be screened further.

Screening for pearl millet ergot resistance

In order to see the efficacy of inoculation technique using conidial suspension, 1350 lines in downy mildew nursery (downy mildew was negligible) were inoculated on young heads. Out of these 52 remained free from infection. These will need further testing.

I

REVIEW OF SORGHUM/MILLET PHYSIOLOGY WORK

August - December 1974

(Second meeting of UNDP Policy Advisory Committee)

Dr. A.H. Kassam joined the staff in August. Dr. N. Seetharama was transferred to cereal physiology in August from sorghum breeding where he had been evaluating genotypes for physiological characters (Dr Doggett has reviewed this work in his report). Mr. Bisen joined the physiology group in November as an anatomist to work on cereals and pulses on 50 -50 basis. Dr. Alagarswamy joined the staff in December.

Much of the time from August till December was spent in setting up the working facilities and basic equipment at Manmool Village, building up staff and working out a tentative physiology research programme.

Eight project areas have been defined but not yet finalised. The projects are:

1. Growth and developmental physiology
2. Nutrition physiology
3. Water relations and water stress physiology
4. Seeding vigour
5. Panicle development
6. Root studies
7. Rhizosphere fixation of nitrogen
8. Physiology of striga resistance

Projects 7 and 8 are considered as minor projects which may be developed subject to further discussions with the microbiologist and breeders.

Work was started in Project 1 and three trials are in progress.

A. Genotype screening and evaluation of growth developmental and yield characters.

49 genotypes of sorghum and 42 genotypes of millets are being evaluated for:

a) Seedling vigour

b) Lengths of GS1, GS2, and GS3

c) Plant morphology

d) Yield components

e) Relation between leaf stem and panicle development

f) Plasticity of grain size

g) Time and nature of formation and the abscission layer (selected genotypes)

The trial was sown in late September and will be completed in February 1975.

B. Growth, development and yield physiology of selected varieties and hybrids.

10 genotypes of sorghum and 8 genotypes of millet are being studied in detail. The trial was sown in late November and will be completed in March 1975.

C. Effect of sowing date on growth and development.

Sorghum and millet (one genotype each) are being sown at fortnightly interval to study the effects of environmental factors, particularly temperature and radiation, on growth, development and yield. This is a preliminary trials to identify the nature of physiological vulnerability to change in gross environmental factors. The trial was started in late October and will be completed in April 1975 in the case of sorghum and June in the case of millet.

A start has been made in Project 3. A trial has been sown to study effects of water stress and different growth stages on growth, development and yield of sorghum and millet (one genotype each). Vulnerability to water stress will be tested at panicle initiation stages, mid-GS2, flowering and mid-GS3. This is a preliminary trial which will be expanded into evaluation of genotypes for ability to endure water stress. The trial was sown in late November and will be completed in March 1975.

TABLE 1

Staff List, Cereals Improvement

International Staff

H. Doggett	Leader, cereals improvement, sorghum breeding
D.J. Andrews	Millet breeding
P. Lawrence	Sorghum breeding
J.C. Davies	Entomology
A.H. Kassam	Plant physiology
R. Jambunathan	Biochemistry
Y.L. Nene	Pulse Pathologist currently helping with the cereals pathology also

Research Associates

B.N. Verma	Sorghum breeding
D.S. Murthy	Sorghum breeding
K.V. Ramaiah	Sorghum breeding
S. Gowda	Sorghum breeding
R.P. Jain	Millet breeding
S.C. Gupta	Millet breeding
Anand Kumar	Millet breeding
K.E. Prasada Rao	Germplasm [illegible]
K.V. Seshu Reddy	Entomology
K.N. Rao	Sorghum pathology
S.D. Singh	Millet pathology
N. Seetharam	Plant physiology
S.P. Yadav	Biochemistry

Associate Scientist

J.V. Majumdar	Millet breeding

Laboratory Technician

Miss Santosh Gassi

Field and Laboratory Assistants

D.M. Pawar	Sorghum breeding
Upendra Ravi	Sorghum breeding
David Nicodemus	Sorghum breeding
N.R. Sharma	Millet breeding
K. Mallikarjuna Rao	Plant pathology
S. Suryaprakash	Biochemistry
P.V. Rao	Biochemistry
N.S. Rao	Biochemistry

Field and Laboratory Helpers

C.V. Abraham	Sorghum breeding
V. Gopal Reddy	Sorghum breeding
P. Venkateshwar Rao	Sorghum breeding
A. Narasimha	Entomology
K.A. Sasidharan	Biochemistry

Administration

Miss Nirmala Sharma	Secretary
(Mrs.) P. Sosamma Nair	Secretary
G.B. Deshmukh	Typist/Records Clerk

Driver/Field helpers

T.F. Anthony	Sorghum breeding
M.K. Khan	Millet breeding

Note : Short-term contract employees have not been included in this list. A number who have been working well with us will be offered probationery appointments in January 1975.

TABLE 2.

Composite Populations received in 1973-74

Donor	Country	Number	Designation	Materials incorporated	Sterile source
W.M. Ross	Kansas, U.S.A.	1	KP1 BR	USA Sorghums	Antherless, al.
"	Nebraska, U.S.A.	9	NP1-NP6, NP8, NP9 NP10	USA, African & Conversion Programme material, separated into maintainer & restorer populations	ms_3, with ms_c in NP1
		1	Ross 4n	Tetraploid grain type	none
J. Axtell	Purdue, U.S.A.	6	PP1-PP3, PP5 PP6, PP8	NP2B and NP3R crossed with 174 elite World Collection entries evaluated for protein, lysine, quality and agronomic characters	ms_3
D.J. Andrews	Nigeria	1 1 1	WABC Bulk Y B composite	Nigerian & exotic stocks of medium or short height with good grain quality	ms_7
J.Kern	EAAFRO Uganda E. Africa	2	RS/A & RS/R	Good lines developed at Serere, with good exotic stocks, maintainer & restorer	ms_3
		2	Collection Restorer Collection Non-restorer	Broad based World Collection entries, containing some 1200 entries in all	ms_3
		3	Ethiopian High altitude H.A. Maintainer	High altitude sorghums from Ethiopia, W.Uganda, & W.Kenya, with the basic components of RS/R	ms_3
		3	Good grain I Good grain II Red flinty	Lines with varied grain shapes, sizes & textures, but mostly white or yellow with corneous endosperm	ms_3
		1	RS5DX	Best Serere bred lines	ms_3

Donor	Country	Number	Designation	Materials incorporated	Sterile source
		1	RS5DXCSF	Shoot-fly resistant lines	ms_3
		1	RS1 x VGC	Elite collection entries x RS/R	ms_3
		1	Hybrid RS	Best hybrids of U.S. steriles x Collection entries at Serere	ms_c
		1	Puerto Rico	Second backcross of Conversion Program	ms_3
S.B. King	Nigeria	1	Striga composite	Striga resistant lines from World collection	ms_7
		1	Mould resistant composite	Grain Mould resistant grain types from World collection	ms_7
D. Barry	Nigeria	2	110 & 111	Shoot-fly resistant populations developed in Serere & Nigeria	ms_3
NGP Rao	AICSIP, India	1	R. Composite	Good lines in India program x RS/R	ms_3
R.W. Downes	Australia	1	Downes Composite	Sorghums drought tested in Australia	ms_3
O.J. Webster	Puerto Rico	4	PRIBR & 3 sub-samples	A broad range of temporate and tropical materials	ms_7

TOTAL 45 composite populations

TABLE 3.

Composite populations (all populations were grown as bulks in K73 or when First received)

Present name	Components	Number of selections grown 1973 K	1973 R	1974 S	1974 K	1974 R	Lines for regional 1975 trials
NP/B	NP_2 NP_6	bulk	258	30	326	200	?
NP/R	NP_1 NP_3 NP_4 NP_5 NP_8	bulk	606	47	551	278	?
US/B	NP_2 NP_6 PP_2 PP_6	bulk	711	-	749	80	?
US/R	NP_1 NP_3 NP_4 NP_5 NP_8 PP_1 PP_3 PP_5	bulk	1355	-	1852	80	?
KP	KP1BR	bulk	158	-	355	30	?
Rs/R	Rs/R	bulk	191	-	393	98	30
Rs/B	Rs/A	bulk	258	-	456	91	37
High altitude	high altitude H.A. maintenance Ethiopian	bulk	653	-	525	84	17
Serere elite	Rs 5DX Rs 5DX x CSF Hybrid Rs Hybrid RsA/RsR RS1 x V6C	bulk	371	-	802	196	55
Tropical conversion	Puerto Rico conversion Puerto Ricon	bulk	213	-	612	143	40
WABC photo in sensitive	WABC		bulk	-	189	76	?
Bulk Y photo in sensitive	Bulk Y		bulk	-	415	155	?
Collection restorer	Collection restorer	bulk	166	-	263	154	?

Present name	Components	Number of selections grown					Lines for regional 1975 trials
		1973		1974			
		K	R	S	K	R	
Collection non-restorer	Collection non-restorer	bulk	280	-	504	239	?
Good grain	Good grain, Red Flinty	bulk	407	-	1007	407	?
Downes	Downes	bulk	140	-	-	-	/

Table 4. Characteristics of best entries in the population screening trials, Kharif 1974.

Entry	days to flower	height in cm.	shoot-fly rating	grain yield q/ha	100 grain weight	quality rating
A. Trial 2 - U S/R:						
1111	62	175	2.0	64.0	2.47	2
5002	52	130	3.0	63.5	2.67	1
1075	57	215	2.0	62.1	2.96	1
6030	50	140	2.5	61.9	3.03	1
2114	50	165	2.5	59.6	2.80	6
6060	50	180	3.0	59.5	2.99	
2116	48	175	2.5	59.2	2.31	
2068	50	160	3.0	57.7	2.78	
6019	48	145	2.3	56.0	3.78	
5009	50	150	2.5	54.3	2.83	
		Trial mean yield	=	41.50 q/ha		
B. Trial 12 - U S/B:						
3023	50	140	3.0	56.5	2.53	1
2121	59		2.3	56.0	2.95	6
3007	52	130	2.3	54.9	2.22	1
3081	54	110	3.0	54.4	2.09	1
1102	51	130	3.0	54.3	2.50	1
1050	59	120	2.0	53.6	2.31	1
1052	59	140	2.6	53.2	2.57	1
3094	52	120	3.0	52.0	2.36	1
4024	62	120	2.0	47.0	2.76	6
1055	62	150	2.6	46.9	2.71	6
		Trial mean yield		39.10 q/ha		

Scores: Shoot-fly and grain mould were rated on a 1 to 4 scale, 1 being good and 4 bad.

Qaulity was rated as follows: 1 red grain. 2. mixed. 3. white with sub-coat. 4. chalky white. 5. yellow. 6. pearly white.

TABLE 5

Data from entries in an elite lines trial, S74 and K74.

Entry No.	Pedigree	Grain yield, kg/ha S74	K74	Mean	Mean days to flower	Height cm.	100 g wt. g
17	IS-3659-1	4530	4530	4530	72	120	2.87
6	IS 858-2	5780	2980	4380	68	145	2.45
2	IS 517-1	4090	4420	4250	64	115	2.48
25	NES 3141-2	5300	2950	4120	60	95	2.53
4	EC 64830	4500	3650	4070	59	88	2.21
16	Picket-3	4920	3170	4040	65	135	2.98
19	NES-311-1	5360	2640	4000	62	105	2.56
13	EC 65066-1	4590	3010	3800	61	130	2.76
24	EC-65556	4180	3400	3790	62	118	2.44
22	IS 2927	4390	3120	3750	58	128	2.55
3	Picket-48	4330	3030	3680	73	148	2.91
20	Picket-13	2820	4380	3600	72	138	2.42
23	EC 64650-2	3970	2820	3390	63	125	2.54
8	Picket-1	2460	4200	3330	66	130	2.52
15	CSH-1	4710	1890	3300	72	150	3.01
11	EC 64735	2990	3320	3160	60	70	2.22
10	NES-2824-2	4530	1690	3110	71	120	2.77
9	IS 2223-1	3020	3170	3100	60	105	2.28
12	EC 65052	4240	1950	3100	64	110	2.66
21	IS 2215-2	3700	2340	3020	62	120	2.26
5	8993-Ex USA	2250	3060	2660	74	160	2.43
1	IS 3659	4150	1070	2610	60	120	2.34
14	EC 64376	2640	2470	2560	72	105	2.58
7	IS 8977	1420	3480	2450	71	135	3.43
18	S 302	3640	480	2060	75	175	1.84

LSD (P = 0.05) 820

Mean 3464

C of v 21 percent.

The genotype and season interaction was significant beyond P = 0.01.

TABLE 6

Data from Selections out of Dr. Elmer Johnsons' CIMMYT Nursery, S74 and K74

Entry No.	Grain yield, kg/ha S74	K74	Mean	Mean Days to flower	height cm	100 grain wt, gm.
7	3790	3880	3840	57	110	2.63
12	3820	3850	3840	59	110	2.27
9	3880	3280	3580	59	113	2.37
3	3730	3370	3550	60	120	2.16
21	3790	3040	3420	61	130	1.80
24	3530	3180	3350	57	138	2.27
20	3850	2830	3340	60	115	1.78
13	3350	3310	3330	60	95	2.40
25	3820	2690	3260	63	140	2.93
10	3530	2640	3080	60	133	2.06
11	3230	2670	2950	59	135	2.11
5	2670	3120	2890	62	120	2.12
23	3500	2280	2890	69	140	2.49
18	3560	2170	2860	60	140	2.10
16	3530	2130	2830	60	170	2.00
2	3410	2040	2720	62	150	1.75
6	3520	1750	2630	61	120	2.25
22	3230	1920	2580	61	140	2.03
17	3620	1180	2400	59	100	2.03
4	2340	2400	2370	62	130	1.72
8	2810	1750	2280	60	100	1.57
15	2520	1950	2240	60	120	2.16
1	2340	2040	2190	58	110	1.94
19	2310	2020	2170	57	153	2.78
14	1600	1640	1620	62	130	2.07
L.S.D. (P=0.05)			780			
Mean			2879			

C. of V. 24 percent

The genotype x season interaction was not significant.

Table 7. Characteristics of best entries from elite trials, Kharif 1974.

Entry	days to flower	height (cm)	shoot-fly rating	grain wt. q/ha	100 grain weight	quality rating	grain mould
57 - 538	52	170	2.6	68.0	2.80	1	3
72 - 004	61	120	2.3	65.3	3.01	2	3
72 - 018	59	130	2.5	62.3	2.46	2	3
67 - 171	63	240	2.6	60.3	3.01	1	1
52 - 053	54	190	2.6	60.0	2.55	2	3
52 - 710	61	160	2.5	59.8	2.47	6	4
72 - 96	59	120	2.0	59.8	2.52	2	3
57 - 204	61	150	3.3	58.8	2.86	6	3
62 - 357	57	160	2.6	57.5	3.00	6	3
57 - 197	61	160	2.6	56.9	2.36	4	4
67 - 245	59	150	1.6	56.8	2.74	5	2
62 - 512	63	160	2.0	56.8	2.13	6	3
52 - 196	54	180	2.3	56.2	2.48	1	2
62 - 280	52	160	2.3	55.7	2.69	6	3
52 - 240	59	150	2.3	54.8	2.88	6	3
57 - 620	57	120	3.0	54.8	2.80	6	3
52 - 188	54	150	2.6	54.4	2.68	4	4
62 - 541	61	210	2.0	52.2	-	5	3
52 - 529	63	140	2.5	52.2	2.63	6	3
47 -1014	60	170	2.0	50.4	2.90	6	2
42 -1048	51	110	2.5	50.1	2.97	6	-
57 - 709	63	180	2.0	49.8	3.09	6	3
62 - 417	57	110	2.0	49.8	2.30	1	3
42 -1149	61	130	3.0	46.8	2.47	6	-
52 - 598	59	170	2.3	45.6	2.32	4	3
42 -1075	61	170	2.0	44.3	2.37	4	-
57 - 516	63	230	3.0	44.3	2.38	6	2
42 -1108	63	150	3.0	42.7	2.49	5	-
42 -1053	61	165	2.5	42.6	2.16	5	-
42 -1011	62	120	2.5	42.3	2.39	4	-
57 - 181	57	180	2.3	40.4	2.88	6	2
42 -1049	57	135	2.5	40.4	2.25	4	-
42 -1117	66	125	3.0	37.4	2.48	6	-
67 - 246	55	150	2.0	34.8	2.23	4	3
42 -1019	61	125	2.3	30.0	2.01	4	-

Scores: Shoot-fly and grain mould were rated on a 1 to 4 scale, 1 being good and 4 bad.

Quality was rated as follows: 1 red grain. 2. mixed. 3. white with sub-coat. 4. chalky white. 5. yellow. 6. pearly white

HD:psn

TABLE 8.

Germination of Striga seed by a Strigol analogue
(Dr. Roseberry, University of Sussex)

Mean Number of Striga Plants

Strigol analogue, Concentration, p.p.m.	Red Soil	Black Soil
1	23.2	37.8
5	18.3	33.2
10	10.8	26.5
Control	45.0	90.0

Using the log transformation, all treatments are significantly better than control; on the red soil, differences between concentrations are all significant. There is no difference between concentrations on the black soil.

Method

Solutions of the compound were applied to boxes of soil containing *Striga asiatica* seed, and 2 months later, sorghum seed (CSH-1) was sown. Two months later, *Striga* plants appearing above ground were counted; the soil was then washed out and subterranean *Striga* counted, the figures in table being means of the sum of the above ground and subterranean *Striga* plants over 6 replications.

Conclusion

The compound used at 10 ppm has reduced the amount of viable *Striga* seed in the soil to some 25-30 percent of its initial level.

TABLE 9.

Grain filling period from flowering to black layer formation. Black soil, field B8, planted on 23.11.73

	Grain Size					
	Large		Medium		Small	
	Mean	Range	Mean	Range	Mean	Range
No. of entries	46		48		54	
1000 seed weight (gm)	40.5±3.3	35-58	31.1±1.4	28-34	23.7±2.6	12-28
1000 seed volume (cc)	33±3	35-50	26±2	25-30	19±2	10-25
Weight of seed per head (gm)	38.2±14.8	7.5-77.5	37.4±9.3	13.7-73.3	34.4±10.4	6.7-81.3
Seed no. per head	950±360	210-2060	1200±330	760-2550	1400±400	490-2650
Grain filling period (days)	39.2±2.7	32.3-44.6	38.1±2.6	30.2-44.1	36.5±2.1	30.5-41.0

TABLE 10

Estimates of protein percentage (Biuret method) and UDY values (total basic amino-acids) on 1000 plants from populations segregating for high lysine and protein content. (Crosses made at Purdue between NP or PP population and IS 11167 or IS 11758.)

Sample No.	Protein %	U I R	Sample No.	Protein %	U I R	Sample No.	Protein %	U I R
302	7.0	38.0	30	8.1	32.0	953	8.0	31.0
101	12.2	38.0	297	9.4	32.0	233	10.8	30.5
368	7.7	37.5	332	8.8	32.0	427	8.6	30.5
635	8.1	37.5	423	9.8	32.0	765	9.1	30.5
526	7.7	37.0	439	9.4	32.0	796	10.2	30.5
864	7.6	36.0	447	10.3	32.0	6	9.1	30.0
488	9.4	35.5	842	8.4	32.0	106	8.8	30.0
766	8.8	35.5	870	9.3	32.0	225	11.6	30.0
256	7.7	35.0	909	10.0	32.0	234	10.0	30.0
636	8.1	35.0	952	8.4	32.0	334	9.6	30.0
237	7.6	34.0	445	9.1	31.5	337	11.0	30.0
283	7.6	34.0	930	9.3	31.5	425	9.6	30.0
333	8.1	34.0	935	7.4	31.5	449	10.3	30.0
732	8.8	34.0	282	9.1	31.0	512	10.1	30.0
881	11.5	34.0	296	10.1	31.0	632	10.0	30.0
301	7.9	33.5	303	8.8	31.0	701	9.8	30.0
18	13.9	33.0	320	9.4	31.0	760	10.1	30.0
92	9.4	33.0	354	9.3	31.0	873	9.4	30.0
240	7.9	33.0	825	9.1	31.0	883	10.5	30.0
7	8.4	32.5	886	9.8	31.0	960	9.4	30.0
117	9.8	32.5	936	8.2	31.0	975	10.3	30.0
364	7.4	32.5						

UDY Values. Range, 18.0 - 38.0. Mean 24.9 Mode (Class) 25 N = 1000.

64 entries had a value of 30.0 or above.

TABLE 11.

(I) Early Maturing Composite (EC), entries less than 45 days to heading

Entries		Number	
Indian		153	
Good exotic		28	(entered twice)
Excellent exotic		13	(entered 3 times)
	Total	194	

(II) Mid-late Maturing Composite (MC) Entries heading in 45-55 days

Entries		Number	
Indian		144	
Good exotic		22	(entered twice)
Excellent exotic		33	(entered 4 times)
	Total	196	

(III) Late Maturing Composite (LC) Entries heading in 55 days or more

Indian		44	
Sauna D_2 (exotic)		1	(entered 5 times)
	Total	45	

(IV) Dwarf composite (DC) Entries of all maturity lengths

Indian		69	
Excellent exotic		17	(entered 4 times)
	Total	86	

TABLE 12.

Grain yields of African composites in kg/ha. Kharif season 1973 planted July 10, 1973 Black soil Plot B-8. Fertilized with 80N:40 P_2O_5

Entry	Yield	Entry	Yield
HB-3 (Hybrid)	2700	Nigerian	2000
Serere 2 M	2610	Serere 10 M	1790
Serere 3 M	2120	Serere 14 M	1760
Serere L	2000	Serere 13 M	750

L.S.D. (P = 0.05) = 800 Kg/ha

C. V. = 23.7%

TABLE 13

Grain yields of hybrid and composite millets, kharif 1974, in kg/ha.

Sown 9.7.74. Field RI, red soil. Fertilizer, 100 N : 40 P.

Harvested 14.10.74 4 Replications.

Composite or hybrid	Composition	Mean yield, kg/ha.
HB 3	23A x J104	3,050
HB 3 (Anna Farm)	5071A x J104	3,290
Mid-late composite	(after 2nd random	3,020
	(	
Early composite	(mating generation	2,990
HB 3 (J 41)	23A x J104-41	2,860
HB 5	23A x K 59-85	2,790
HB 4	23A x K560	1,600
L.S.D. (P = 0.05)		960
C. of V.		22.9%

TABLE 14

Grain yields of promising hybrids, Kharif 1974, in kg/ha.

Sown 2.7.74 Red soil. Fertilizer 100 N : 60 P

Harvested 7.10.74 4 Replications.

23D2A x 700250	2740	23D2A x World Comp	1860
23D2A x Serere 2A	2470	23D2A x Ghana	1830
K 230	2180	23D2A x KG10	1560
23D2A x Nig.Comp. (RM)	2060	18D2A x Casady Iwarf	1440
18D2A x KG70	2010	18D2A x J1407	1410
23A x J104 (HB-3)	1980	18D2A x J-1224-2	1340
23D2A x 700651-1	1970	18D2A x J2602	1080
23D2A x 700760	1890	18D2A x T-166-1	920
23D2A x Serere Comp. 1(S)4	1870		

L.S.D. (P = 0.05) 440 kg/ha.

C. of V. 18.2 %

TABLE 15

Grain yields of promising hybrids, Kharif 1974, in kg/ha

Sown 2.7.74 Red soil Fertilizer 100 N : 60 P.

Harvested 7.10.74 4 Replications.

23D2A x Nig. World Comp.	1960	23D2A x 700452	1570
23D2A x 700743	1840	HB - 3	1560
23D2A x J 710 P	1680	23D2A x 118	1260
23D2A x 700260	1680	23D2A x K560	1150
23D2A x 700764	1600	23A x J 1740	1100

LSD (P = 0.05) 380 kg/ha

C of V 17.3 %

TABLE 16

ELITE LINES, WORLD COLLECTIONS AND NEW ACCESSIONS OF SORGHUM RECEIVED 1973-74

Donor	Country	Number	Description
NGP Rao	AICSIP, India	991	Elite lines
		1172	World Collection entries
L.R. House	ALAD, Beirut	1471	Elite short straw entries, mostly of good grain quality
J. Marathee	CNRA, Senegal	8	Early lines with good grain quality
J. Kern	EAAFRO, Serere	150	Bulks of Elite EAAFRO lines
D.J. Andrews	Nigeria	16	Elite lines selected in Northern Nigeria
J. Axtell	Purdue	4	High lysine collections
		22	Elite lines
Brhane Gebrekidan	[illegible] Alemaya, Ethiopia	1309	Ethiopian sorghum varieties, including collections from fields containing high lysine types
W. Young	R.F. Thailand	23	Elite lines
R. Sundaram	India	50	Sorghum International Disease Resistant Nursery.
[illegible] Seed Corporation, JALNA	India	2	2077A and 2077B
Texas Agri. Exp. Station	U.S.A.	185	Converted alien lines from the World Sorghum Collection.
Safeeulla	India	12	Downy mildew resistant lines
Rameshwar Singh	India	3	Sugary mutants
Rameshwar Singh	India	6	Twin seeded lines.
Axtell	Purdue	625	High lysine cross progenies
Pioneer Seeds	India	4	Sorghum hybrids
Director, EAAFRO	Serere	7	3 varieties + 4 A&B lines
Maharashtra Seed Corporation, JALNA	India	2	Sorghum hybrids
Sorghum Entomologist APAU Rajendranagar	India	10	Shoot fly resistant lines

Director, EAAFRO	Serere	10	'V' numbers for insect resistance
Brought by Mr. DJA	Samaru, Nigeria	174	Entomologist experiments
Davies	Nigeria	51	Midge resistant lines
Brought by Dr. Doggett	Purdue	790	Cross progenies involving PP populations and 11758 & 11167
Brought by Dr. Doggett	Purdue	4	I.S. numbers having high protein and lysine
Brought by Dr. Doggett	N. Ghana	57	Local collections from North Ghana
Brought by Dr. Doggett	Bambey, Senegal	7	Cross progenies
Texas Agrl. Exp. Station	Texas	4	TAMBK Populations
N.G.P. Rao	India	8961	World Collections (I.S. numbers)
D.J. Andrews	Nigeria	49	Nigerian lines and A, B lines from Nigeria
Prahlad Karkikar	India	1	Wild Sorghum
University of Nebraska	Nebraska	75	V. numbers, W.MR. crosses
Brought by Dr. Doggett	Kenya	20	9 D X Crosses
Mazhani	Botswana	2	Segaolane and No. 81 bulks
Dallas L. Oswalt	Purdue	6	Grain grass sorghums I.S. numbers
Sorghum Entomologist A.P.A.U.	India	2	Midge resistant lines
Sorghum Breeder, A.P.A.U.	India	13	Sorghum improved lines
Total		16304	

TABLE 17

LIST OF PEARL MILLET ACCESSIONS RECEIVED, 1973-74

Country of Origin	Place	Number	Description
India	Jamnagar	767	Entries from the original All India Project World Collection (IP numbers)
India	Jamnagar	1004	Promising lines - inbreds
India	Jamnagar	3	Promising hybrids
India	Maharashtra	101	Promising lines
India	Mysore	71	Disease tolerant lines (from Dr. Safeeulla)
India	IARI, New Delhi	214	Disease free lines
India	IARI, New Delhi	1200	Promising lines from the All India Project co-ordinator
India	IARI, New Delhi	15	Promising hybrids
India	Ford Foundation, Delhi	689	I.P. entries, duplicates of (1)
Thailand	Bangkok	264	I.P. entries, duplicates from (1) originally, screened and multiplied in Thailand
E. Africa	Serere, Uganda	34	Varieties and lines from the program at Serere
E. Africa	Serere, Uganda	8	Composite populations developed in at Serere
W. Africa	Samaru & Kano, N. Nigeria	210	Promising lines
W. Africa	Samaru & Kano, N. Nigeria	3	Composites, developed in Nigeria
Lebanon	ALAD, Beirut	18	Varietal collection from ALAD area
Lebanon	ALAD, Beirut	2000	African collection and improved material from CNRA, Bambey, Senegal
U.S.A.	Tifton, Georgia	11	Newly developed Cytoplasmic male sterile lines from Dr. Burton
Lebanon	Beirut	1370	I.P. Collection entries increased in Kfardan, 1972
Lebanon	Beirut	80	Selections from Regional pearl millet and Pearl Millet selection nurseries planted in Terbol, 1973 (NEP accessions)
Lebanon	Beirut	141	I.P. accessions - Sahel region origin
Total		8203	