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ANNUAL REPORT 1974-75

Introduction

The objective of the ICRISAT pearl millet improvement programme is to create genetically superior and widely adaptable germplasm for use directly, or indirectly via national breeding programmes to produce varieties or hybrids which can give better and more stable yields in the Semi-Arid Tropics.

The improvement programme involves the integration of several disciplines - the breeders to continually create new and better variability and to see that it is efficiently selected in appropriate environments; pathologists and entomologists to investigate yield reducing diseases and pests and to develop techniques to identify and intensify levels of plant resistance; physiologists to investigate the physiological bases of yield and to assist in breeding more efficient plants; agronomists to discover the best and most stable ways of cropping new genotypes; analytical facilities to enable more nutritious grain to be identified and finally economists to determine what consequences new varieties could have in future production systems.

Breeding

During the period reported the 1974 summer crop (S74) was harvested in May, the main kharif crop (K74) planted in June and harvested September/

October, the rabi crop (R74) planted late October, harvested in February and the 1975 summer crop (S75) planted 21-24 March. In these seasons the respective areas planted to breeding material were 7, 15, 12 and 7.5 ha.

The breeding programme has been divided into eight inter-related projects namely:

M-brd-1 Advanced Composites I - Intrapopulation Improvement
-2 Advanced Composites II Interpopulation Improvement
-3 Source Composites
-4 Variety crosses and synthetics
-5 Hybrids
-6 Working collection etc.
-7 Yield testing
-8 International Cooperation

The physical list of breeding material in these projects is shown in Appendix I. Breeding staff also collaborated in entomology, pathology, germplasm, physiology, and grain quality projects.

The project titles largely reflect the goals of the breeding programme. Both recurrent selection within composites, and more conventional methods of controlled crossing and progeny evaluation are being used to produce higher yielding populations, synthetics and hybrids. For the last, attention is being directed to producing a new and wider range of superior parents. Diseases at present are the main hazard and threat to the adaptability and

stability of new pearl millet genotypes. Downy mildew (Sclerospora graminicola)is the most widespread disease but ergot (Claviceps microcephala) is dangerous, as can be rust (Puccinia penniseti)and smut (Tolyposporium penicillariae). Ergot and rust either appear in sufficient intensity, or can be artificially induced at Hyderabad to enable the detection of resistant or tolerant genotypes. This is not the case with downy mildew or smut. Much breeding material has now been generated which, before it advances further, must be adequately tested against disease.

In March 1975 The Pearl Millet breeding programme - ICRISAT, by D.J. Andrews and J.V. Majmudar was published, which was largely devoted to the rationale and approach needed in millet breeding for the Semi-Arid Tropics.

Applied Breeding Programme

Advanced Composites: M-brd-1 and 2

Development continued on the major composites (constructed or acquired) intended for either intrapopulation or interpopulation improvement.

550 parent lines for the four main ICRISAT composites chosen from the K 73 germplasm represented a deliberate selection of diverse types. The dwarf (less than 1.80 m) lines of all maturities (86) were grouped together to constitute a dwarf composite. The five hundred and fifty lines were grouped into three categories based on days to 50% bloom.

Early Maturity Composite - less than 45 days -- 194 entries

Medium Maturity Composite - 45 to 55 days -- 197 entries

Late Maturity Composite - 55 + days -- 46 entries

The Irish method of random mating was used wherein inbred and bulk (prepared by mixing all the entries of a composite, weighting those entries which are particularly desirable) are planted in alternate rows. After completing three random mating generations by K 74, 1000 half-sibs were grown from each of the Early and Dwarf Composites and 545 and 519 S_1's taken from the selected half-sibs of the respective Composites in R 74. Two replications of these have been planted in S 75, from which S_2's will be taken for kharif testing at two or three locations in India. In the other two composites (Medium and Late), 500 full sibs were produced in R 74 and full sib progenies will be tested in K 75 in replicated yield trials at four locations, (West Africa and 3 in India).

Nigerian Composites:

Four composites, World Composite, Nigerian Composite-3, N x W (Nigerian x World) Composite-2 and Ex Bornu (S) C_1 were introduced from Nigeria in K 73, grown and S_1's made. Maiwa New Strain and Gero New Strain segregating populations were also received from Nigeria and progenies were selfed to F_3 and then tested for their specific combining ability with MS 5071A in project M-brd-5. S_1's from all the four composites were used for the improvement of the composites per se. The details are given below:

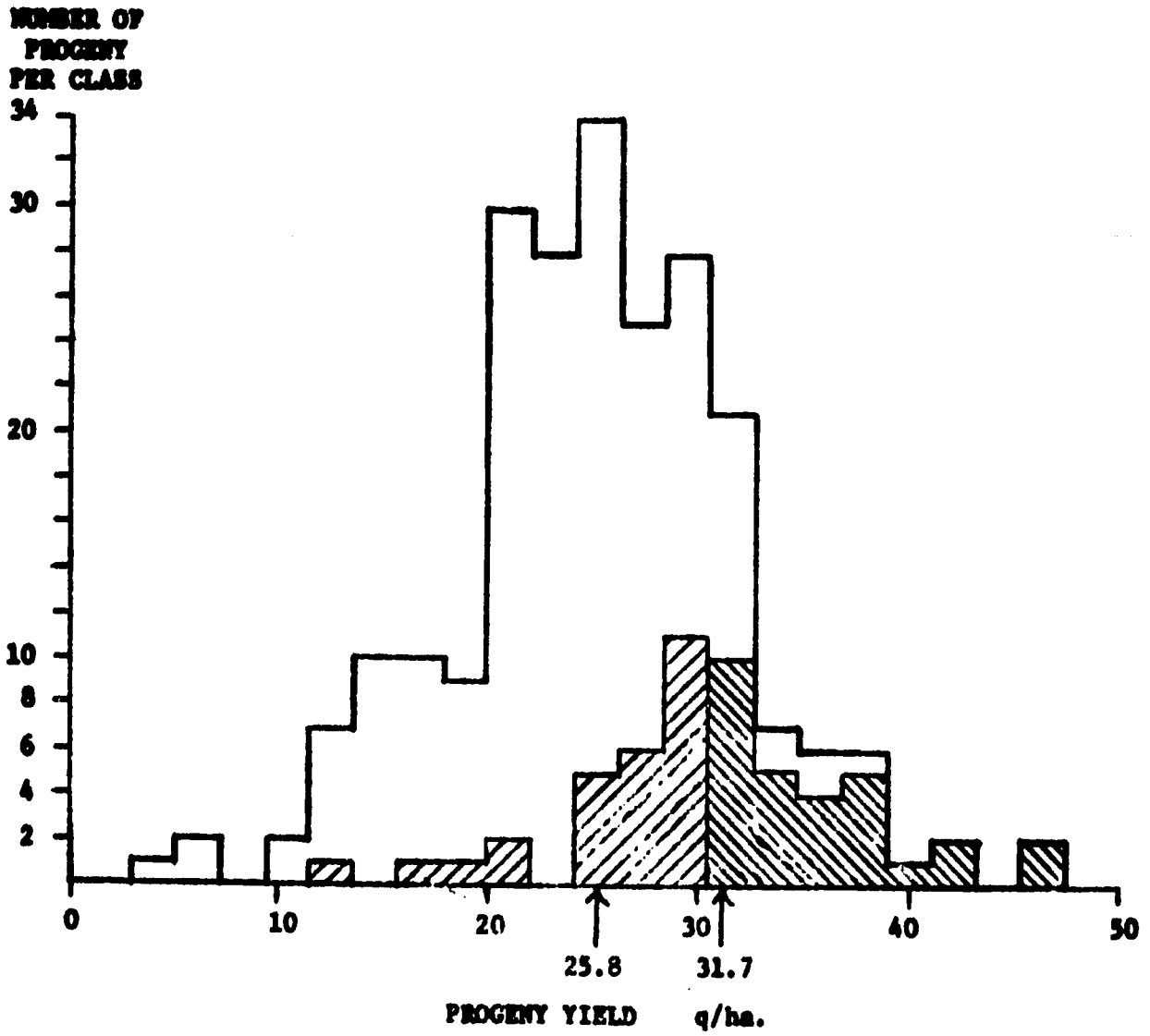
Composite testing: S_1 lines from Nigerian Composite-3 (157), N x W Composite-2 (120), World Composite (114) and Ex Bornu (S) C_1 (127) were grown in K 74 in 2 replications. Selection was practised within and among S_1 lines in each of the above four composites. The S_2's were harvested and tested in R 74. Ex Bornu (S) C_1 was not found particularly high yielding and not very variable and was therefore consigned to M-brd-3. The stand in World Composite and N x W Composite - 2 was poor, and hence only mild selection pressure was applied. The number of S_2 lines tested and selected for recombination is as follows:

	S_2 lines tested	Selected for recombination
Nigerian Composite - 3	230	56
N x W Composite - 2	231	101
World Composite	205	109

Nigerian Composite - 3 was superior to the other three composites. The mean yield of S_2 lines was 25.78 q/ha and varied from 3.73 to 47.96 q/ha. (Diagram 1). The magnitude of genotypic variance for grain yield was 2.19 times larger than the error variance. The heritability in broad sense was 68.6 per cent. The mean yield was relatively good (for the rabi season) and the amount of genetic variability suggests this composite has promise for continued improvement. It is classed in the mid Late maturity group and (from its origin) should contain good downy mildew resistance.

Diagram 1 **Pearl Millet - Nigerian Composite**

Grain yields (q/ha) and distribution of S_2 progenies tested at Hyderabad, Rabi 1974/75



Mean yield of entire population (230 progeny) 25.8 q/ha.

Mean yield of selected progenies (24.3%) 31.7 q/ha comprising:-

= progenies selected primarily for yield (12.6%), mean 36.4 q/ha.

= progenies selected primarily for other agronomic traits (11.7%) eg short stature, precocity, non-lodging, head and grain characteristics, mean 26.7 q./ha.

Pedigree selections: A number of phenotypically good looking selfed plants from the former three populations and F_3 progenies of Maiwa New Strain and Gero New Strain were harvested in R 73:

1. Nigerian Composite - 3	..	- 23 plants
2. N x W Composite - 2	..	- 22 "
3. World Composite	..	- 25 "
4. Maiwa New Strain	..	- 24 "
5. Gero New Strain	..	- 20 "

These entries were planted in S 74 and the best plants were both selfed and crossed to MS 5071A. The number of crosses made in each case is as follows:

World Composite	..	- 248 crosses
Nigerian Composite - 3	..	- 154 "
N x W Composite - 2	..	- 32 "
Maiwa New Strain	..	- 103 "
Gero New Strain	..	- 33 "

The F_1 hybrids were tested in K 74 and 96 hybrids were retained. The advanced selfed lines and hybrids (remade) were passed on to the hybrid programme for further testing.

Senegal Dwarf Synthetic (M) C_2: This population was introduced from Senegal via Kano (Nigeria) and where it had undergone 2 cycles of mass selection against downy mildew. We have produced 270 S_1's in

R 74 and these will be tested in K 75. The object is to improve this population for downy mildew resistance and seed set besides other characters through S_2 testing. Though this population is dwarf with a total plant height of about 1.20 m, head lengths may exceed 60 cm.

Serere Composites: Six morphologically similar composites were received from Uganda and about 200 S_1's were produced from each of these composites in R 74 to be tested in K 75. The best S_1's will probably be pooled into one composite. Serere material though tall is early and has shown good combining ability for yield with both Indian and West African strains.

R and B Composites: A large number of test crosses on $23D_2A$ grown in K 74 (details in hybrid programme) identified a diverse group of good restorers (171 entries) which were used to form an R-Composite (1 R) and a diverse group of maintainers (111 entries) for a complementary B-Composite (1 B). Both the populations have undergone a first random mating in R 74. We hope to also develop different R and B composites in respect of the other cytoplasmic male sterile systems (A_2 and A_3). These B and R composites would be improved through reciprocal full-sib system.

Maiwa A and B bulks: These were received from Nigeria and grown in R 74 and were the result of 1 backcross of Maiwa by 23B. Maiwa is a photosensitive Nigerian land race possessing particularly good

downy mildew resistance. In the bulks wide variation for both days to 50% bloom and height was observed. Plant to plant crosses were made in R 74 to obtain pure lines. For transferring the downy mildew resistance and good grain qualities, crosses were made between Maiwa B and 6 other cytoplasmic maintainer lines (5071B, $18D_2B$, L 66B, L 67B, L 111B and $239D_2B$). Maiwa B was also crossed on to other male sterile lines, to determine the maintainer/restorer relationship.

Top cross testing: A number of crosses between populations using individual S_2 plants in one population, and mass pollen from the other were made in R 74 for ascertaining the combining abilities of some populations. The details are given below:

World Composite (S_2)	x Cassady dwarf population (Mass pollen)	= 48
" "	x Senegal dwarf synthetic (Mass pollen)	= 48
" "	x Sauna D_2 (Mass pollen)	= 48
N x W Comp. (S_2)	x Cassady Dwarf population (Mass pollen)	= 38
" " "	x Sauna D_2 (Mass pollen)	= 38

Source Composites: M-brd-3

We have initiated a project on "Source Composites" in R 74 with two objectives:

a) to form composites with sources possessing valuable characteristics which may not be in adapted backgrounds and

b) to maintain, or merge composites often of exotic origin, where only mass selection can be practised.

ICRISAT has introduced eleven populations (Cassady's dwarf population from USA; Mokwa-Maiwa, Maiwa, Early millet dwarf populations from Nigeria; Ex Bornu (S_1) C_2 and six populations from Serere, Uganda) into its millet programme. These populations by themselves do not have the merit to get into recurrent selection programmes, but with some mass selection they can contribute some useful variability. S_1's were obtained in Rabi 74 from all these populations and planted in Summer 75 for evaluation. Shortly we hope to form source composites for rust resistance, dwarfness (D_2 lines only), downy mildew resistance and drought tolerance.

Variety Crosses and Synthetics: M-brd-4

The objective of the variety crossing project is to produce new variation for selection by crossing inbreds or varieties which complement each other. Single plant selection is made in the F_2 generation as well as delaying this till the F_3. Desirable selections will be intercrossed at the earliest stage possible. The products from these crosses will be good inbreds as such, new hybrid parents (both pollen and seed) parents for synthetics or entries for composites for recurrent selection.

It has been observed that over the wide range of millet inbred lines from Indian sources (contributed to ICRISAT by numerous Indian breeders), there were some general morphological differences between these and millets of East and West African origin (principally the Serere, Nigerian and

Senegal material). The developed Indian germplasm lines tend to be dwarf and early with thin stems, numerous tillers with rather small heads which ripen simultaneously, medium to small grains with little dormancy, and not very high levels of resistance to downy mildew, ergot or rust. The African lines, especially those from West Africa tend to be tall, late with fewer but larger heads, large mould resistant and dormant grains and a considerable degree of resistance to downy mildew, smut and rust. Previous work conducted on the World Collection indicated that good combining ability existed between Indian and African millets, and that the Nigerian millets contained much useful diversity. From our crossing work we have generally observed that crosses between any of the three groups (East or West African and Indian) have been productive of good hybrids and inbreds up to F_3, which is as far as we have yet advanced to date.

In S 74, 166 variety cross F_1's were planted in observation plots of 2 rows 2.5 m long. Most of these crosses were between a few known Indian elite inbreds and Nigerian and Ugandan material. Grain yield was recorded on all the entries. An observation of interest was that some notable F_1 hybrids performed very well and out yielded the best hybrids made with cytoplasmic male sterile lines growing in the same field, by a margin of more than 25 per cent. The best five variety hybrids were:

Variety cross	Yield/ha (Kgs.)
J 1249 x 700544	6668
J 934-5 x World Composite	6294
J 1623 x 700797	5547
J 1644 x 700594	4912
J 1798 x Gero New Strain	4907

(J = Jammagar inbreds, others of Nigerian origin)

F_2 populations of 148 crosses was grown in K 74. Each population was represented by 750 to 1000 plants, spaced at 20 cm within rows and 75 cm between rows. Ergot and rust infection was heavy in this season and 565 early, dwarf to semi-dwarf, ergotless, rust resistant vigorous plants were selected. Selection could not be made for downy mildew resistance since this disease did not appear in sufficient intensity. The following intervarietal crosses gave a high proportion of desirable segregants:

25-1 (N. Delhi) x 700515

J 104 x 700544

J 1188 x 700780

J 934-6 x Ex Bornu (Nigeria)

565 F_3 progenies were grown in R 74 in plots of two 5m rows each. This material was interesting and many number of families looked promising and the uniformity in some was surprising considering they were only F_3's. They combined the desirable characters of both the Indian and African parents. Seven hundred and eight single plant selections were made from 119 F_3 families and in 50 of these families preliminary test crosses were made to ms lines. Ninety five progenies were observed as particularly promising and uniform. The cooler weather affected seed set under bags and while sufficient seed was obtained for limited distribution, open pollinated bulk seed was also harvested from these 95 entries to supply to other millet breeders to augment their germplasm base. Some of the most promising families were:

25-1 x 700515	J 1188 x 700780
J 104 x 700349	J 1188 x 700780
J 104 x 700441	J 1476-2 x 700797
J 104 x 700441	J 1644 x 700515
J 104 x 700623	J 1644 x 700537
T 166-2 x 700594	J 1644 x 700569
T 166-2 x 700594	J 1798 x Serere 34
J 1188 x 700441	

(T = Dr. Thakre, Serere = Uganda)

In S 74, 599 new variety crosses were made and sown in K 74. These crosses involved a wide range of Indian and exotic material. 79 phenotypically desirable F_1 hybrids were selected for continuation in R 74 and at the same time the F_2 seed was used to develop an intervarietal synthetic (IVS). The F_1's had an impressive plant and head type (shape, length and girth) and appeared relatively resistant to rust and downy mildew though again the general incidence of the latter was low.

Intervarietal Synthetic (IVS) This was grown in the rabi season for first random mating. 15 hybrids were rejected at this stage because of their poor performance. From the remainder, 1000 open pollinated plants were harvested. S_1 lines produced from these will be reviewed for the formation of one or several synthetics. The whole population, depending on the variability seen between S_1's, could be considered as a composite suitable for improvement by recurrent selection.

The seventynine F_2 populations were planted in R 74 and three hundred and fortynine single plants were selected. In addition to single plants 25 of the better F_2 populations were identified as of possible use to other breeders of the SAT, who could select desired plants from them for their own areas to strengthen their local programmes. With this view open pollinated bulk seed was harvested for distribution from within each of these populations.

Thirteen inbreds and two populations were selected in S 74 from their performance in variety crosses and hybrid combination. A full diallel (excluding reciprocals) of 105 variety crosses plus 15 parents were grown in a replicated experiment in K 74 to study the combining ability of the selected parents. The germination and stand of the experiment was not satisfactory and the experiment will be repeated in K 75. Selfing was done in all the 105 crosses and F_2 seed was obtained, which has been planted to study the F_2 populations. The parents used in 15 diallel were as follows:

Entry	Origin	Entry	Origin
J-25-1	India (Jamnagar)	K 560	India (Kanpur)
70-1	" (N. Delhi)	700490	Nigeria
A 836	" (Dr. Z. Ahmed)	700594	"
J 934-7	" (Jamnagar)	700544	"
J 1623	" "	700760	"
J 1644	" "	700797	"
J 1798	" "	World Composite	"
		Gero New Strain	"

RF Synthetic: Selfed seed of 190 "good" single cross fertile hybrids (23A, $23D_2A$, $18D_2A$) were planted in RF synthetic for first and second random mating in K and R 74, respectively. This synthetic has a high tillering ability but is poor in seed set. Its future will be reviewed, particularly in relation to ergot infection level, on its K 75 performance.

The summary of the material which we generated during the year under report by variety cross programme is as follows:

Generation	S 74	K 74	R 74	R 74 (selections)
Fresh crosses	599	105		
F_1	166	600	105	
F_2		148	79	105
F_3 progenies			565	349 + 25 F_2 bulks
F_4 inbreds				780 + 95 F_3 bulks

The hybrid program M-brd-5

The project is designed to identify elite high yielding hybrid combinations tolerant of disease and drought. Other breeding projects at ICRISAT continually produce new inbred material which contains either potential pollen parents or potential seed parents. Some varieties may also be useful as male parents. In M-brd-2 populations are identified as B (Seed) or R (pollen) for complementary (reciprocal) improvement for better hybrids. However, since the majority of variety crosses generate either R lines or

imperfect restorers, crosses between existing B lines (as females) of all systems have been made, and also with dwarf and downy mildew resistant African material.

In Summer 1974, 904 new hybrids were harvested from observation plots each two rows 2.5 m long. The seed parents used were ms 23A, $18D_2A$ and $23D_2A$. The male parents used represented a wide range of geographic origins and genetic diversity and the numbers of hybrids made on the three ms lines used were:

Hybrids with 23A	..	156
$23D_2A$	..	423
$18D_2A$	..	325

The best five fertile hybrids were:

	Yield Kgs./ha.	Geographic origin of male parents
$23D_2A$ x A 836	5041	India
" 700760	4801	Nigeria
" x 70-1	4667	India
" 700726	4561	Nigeria
" 700250	4534	Nigeria

Thirty eight hybrids yielded more than 3,000 kgs/ha. and were selected to go forward for testing in a replicated yield trial. Out of these 38 restorers, 17 originated from India, 3 from the U.S.A., 16 from Nigeria and 2 from Uganda. Remnant seed of 23 of these was used to plant two small

trials in K 74, and all 38 were tested from remade seed in R 74. The best hybrids were all with $23D_2A$ (detailed results in M-brd-7 table 2, page 22) and the best pollinators were 700250, 700651, N x W composite, Ghana, Serere Composite 1, and Old Jamnagar which are all of African origin. 22 combinations were retained for multilocation testing in K 75. New material was available for crossing in summer 1974 with the three male sterile lines above, but replacing 23A with 5071A developed at IARI, Delhi by backcrossing an irradiation mutant found to be resistant to downy mildew, into 23A. 1567 new hybrids were made using pollinators from new Nigerian material, more inbreds from Jamnagar and downy mildew resistant inbreds from Dr. N.V. Sundaram. These crosses were planted in kharif 1974 and since rainfall was erratic an irrigation was given for satisfactory germination. In the final evaluation of these crosses 44 were selected for direct entry into replicated field tests while 69 were retained for another nursery test, usually because the hybrid, although good was not uniform indicating the need for further selection within the male parent. Among the 44 elite restorers 21 were of Indian origin, 3 from U.S.A., 2 from Bangkok, 5 from Uganda and 13 from Nigeria. In Kharif 1974 only a few crosses were made (123) since in this season rain and humidity makes the production of seed under bags difficult because of damage caused by rain to the selfing bags and covered heads. The main crossing programme is therefore made in the rabi and summer seasons.

Up to this stage we had used 4 ms lines belonging to the A_1 system in the crossing programme, and it was now necessary to include test lines available from the A_2 and A_3 systems. Accordingly eight ms lines were used

in the R 74 crossing programme. On the male side mostly inbreds had so far been used, so we also widened our choice by using varieties or populations to make variety top cross hybrids. In R 74 about 2500 crosses were made which included 133 variety top crosses with Ugandan and Nigerian populations. About 1,500 of these crosses were ripe early enough to be planted in S 75, the remainder being held over till K 75.

In Summer 1974 a line x tester study was conducted to compare the combining ability of 3 female parents (23A, $23D_2A$ and $18D_2A$) and 81 pollinator parents of which 46 were of Indian origin 22 from the U.S.A., 11 West Africa and 2 East Africa. 243 crosses were planted in 3 replications and data recorded for plant height, ear girth, ear length and grain yield. The hybrids did not differ significantly for ear girth but good general and specific combiners were identified for the other 3 characters. Among the seed parents $23D_2A$ was the best combiner followed by 23A, with $18D_2A$ poorest. In the general crossing programme ms $23D_2A$ also has been outstanding as a good combiner. However, since it is susceptible to downy mildew, crosses with $23D_2B$ have been made to resistant sources. A good D_2 seed parent would widen the range of hybrids possible since at present many good dwarf pollinators are available would be difficult to use commercially as they are shorter statured than the seed parent.

New B-lines: While evaluating the test crosses the first consideration for a good pollinator is that it should adequately restore fertility. The opposite is true for a B-line, so the test cross programme also affords the

opportunity to identify potential new seed parents among those that appear to maintain the male sterility. This observation is also checked routinely by bagging a few heads in the test hybrid plot and inspecting for seed set. In S 74, 13 lines were found, which apart from maintaining male sterility on the A_1 system seemed agronomically suitable as seed parents. 5 were backcrossed in the same season and again in the next season when the other 6 were also backcrossed (2 being discarded), and further backcrosses made in R 74. Dwarf line J 1352 seems to be the best of the 11 potential B lines which now have to be rigorously tested for disease reaction. Lines known to be good A_1 restorers have been used on the backcrossed A lines to initiate combining ability studies in K 75.

In S 74 seed of 5071 A and B (a downy mildew resistant mutant resembling 23A) was received from the Project Co-ordinator, Millets, New Delhi for multiplication. At flowering some rogueing was necessary as segregation was noted in both parents. Additionally 100 plant to plant crosses were made and after growing these pairs twice we have retained 21 of which 3 rather early lines seem of particular interest. They will now be tested for combining ability and disease reaction in the same way as for other potential A-B lines.

Working Collections M-brd-6

To maintain a large germplasm collection in a cross pollinated crop like pearl millet is nearly as impossible task. To overcome this problem,

from the germplasm nursery planted in Kharif 1974 (see section on Millet Germplasm), 340 lines were selected to identify and classify lines and populations with special characteristics to constitute a Working Collection. We maintain well established inbred lines by continued selfing. In that season we have, by and large, maintained these lines by selfing. Since selfing in millet generates infinite number of lines in Rabi 1974 within these 340 lines enough heads were sibbed to preserve the variability within each line and also to meet the seed requests. These 340 lines have their origin from Chad (65), India (120), Mali (1), Mauritania (1), Niger (34), Senegal (11), Uganda (38), Upper Volta (27) and a collection from ALAD (43). In this initial assembly enough variability exists for maturity disease reaction (downy mildew and rust), plant height, tillering, ear length girth and hardness (grains/cm^2), seed shape, size and colour, plant pigmentation and protein content. We have identified one line from Kano (ICRISAT K-74 5358) as "immune" to rust, an extremely early line flowering in 28 days and mature in about 60 days (ICRISAT K-74 7133) and another with yellow endosperm (ICRISAT K-74 7048), both from Chad.

Apart from this, in the working collection are included the 9 wild species:

Pennisetum orientale (both 2n and 4n)	P. polystachyon
P. villosum	P. purpureum
P. massaicum (both 2n and 4n)	P. squamulatum
P. ruppellii	P. oleopcurus
	P. setosum

We will be identifying and preserving potentially useful traits from our germplasm nursery, exotic introductions and breeders nurseries. The types of variability we are mainly interested in are disease resistance, dwarfness, cytoplasmic sterility, new restorers, earliness, drought tolerance and nutritional quality characteristics. A strong need is felt to collect and catalogue primitive cultivars or land races before they are permanently eroded.

Yield Trials M-brd-7

Kharif (monsoon) season is the main testing season for our experimental hybrids and populations. Trials in this season are normally conducted without any irrigation. However, if the point is reached where further drought would render the trial useless, for certain trials a life saving irrigation may then be given. Observations are recorded on days to 50% bloom, plant height, ear length and girth, head count/plot, lodging percentage, head weight/plot, yield, seed size and protein content.

Kharif 1974: Two yield trials were conducted to evaluate 23 new experimental hybrids. The results are shown in Table 1 together with the rabi trials where the same entries were also tested (see below). The following were best among those tested in the kharif:

Hybrid	% increase over HB-3*
$23D_2A$ x 700250	38.0
$23D_2A$ x Serere 2A	24.3
$23D_2A$ x Nigerian World Composite	25.6

*(23A x J-104) of the Indian Millet Programme currently grown in India on large areas is used as the standard check

We have also conducted a yield trial to assess the performance of our composite bulks in relation to the released hybrids of the Indian Millet Programme. The results (Table 2) indicated no significant differences between the currently grown Indian hybrids and the unselected bulks of ICRISAT's Early Composite and Mid-late Composite. In fact, in these two composites the incidence of rust and downy mildew was relatively low, though the low yield of HB-4 was due to rust.

Apart from these trials, in this season, we cooperated with the All India Co-ordinated Millet Improvement Project (AICMIP) in conducting five trials: These were for:

(a) arid conditions: 20 entries
(b) limited moisture conditions: 23 entries
(c) adequate moisture conditions: 21 entries
(d) preliminary evaluation trial I: 32 entries, and
(e) preliminary evaluation trial II: 13 entries

The best three hybrids in each of the five trials are summarized in Table 3.

Table 3 Parentage and Yield kg/ha

Trial No.	Best hybrids ranked (1)	(2)	(3)	Check (HB-3)
I	23A x J 108 2453	$23D_2A$ x J 41 2273	23 Ax J 87 2093	1740
II	$126D_2A$ x J 1270 2040	5071A x D 111 1966	HB - 3 1853	1853
III	$126D_2A$ x J 1270 2313	PHB - 12 2260	5071A x D 95 2026	1920
IV	$126D_2A$ x J 1986 2044	$126D_2A$ x J 1925 2022	$23D_2A$ x D 32 1844	1288
V	$126D_2A$ x J 1270 1646	$126D_2A$ x J 1270 1580	$126D_2A$ x J 1399 1366	1206

In all the seven trials conducted in this season, a severe attack of ergot and the late rains received during the second week of September enabled us to evaulate the entries for ergot resistance and lodging percentage.

Rabi 1974: Three yield trials were conducted in this season. Two of these were laid out to evaluate our new experimental hybrids and the third to assess the performance of ICRISAT's Early Composite and Dwarf Composite in relation to the released hybrids of the Indian Programme. Results of the first two trials are summarized in Table 2. Six hybrids $23D_2A$ x Ghana, $23D_2A$ x Serere Composite 1(S)4, $23D_2A$ x J 128-3, $23D_2A$ x 700250, $23D_2A$ x 700651 and $23D_2A$ x Old Jamnagar yielded from 64.5 to 20.6 percent over the check, HB-3. In yield trial III no significant differences were found between the eight entries HB-4, HB-3 (Anna Farm), HB-5, Dwarf Composite, $23D_2A$ x 700250, and Early Composite where the yields were 13.01, 12.74, 12.30, 10.36, 8.96 and 8.67 quintals/ha., respectively.

Table 2 Millet Experimental Hybrids Yield Trials ICRISAT Kharif and Rabi 1974

Grain yields in quintals/ha.

	Rabi 1974	Kharif 74	
	Trial I	Trial I	Trial II
$23D_2A$ x 700651	25.89	19.66	-
" x Old Jamnagar	23.68	-	-
" x 700620	20.76	-	16.82
" x 700760	20.68	18.91	-
" x 700764	19.98	-	16.02

Table 2 continued:

	Rabi 1974 Trial I	Kharif 74 Trial I	Kharif 74 Trial II
$23D_2A$ x World Composite	19.91	18.55	-
HB-3 Check	19.63	-	-
$23D_2A$ x 700452	19.21	-	15.72
" x 70-1	18.91	-	-
" x R 2591	18.19	-	-
" x 700626	18.15	-	-
" x N x W Comp.	17.89	-	19.58
" x Nigerian Comp.	17.84	20.58	-
" x Serere 2A	17.73	24.66	-
$18D_2A$ x 700318	16.69	-	-
" x KG-70	15.95	20.10	-
$23D_2A$ x 700770	15.33	-	-
" x 700429	15.09	-	-
" x 700743	9.55	-	18.41
$18D_2A$ x J 1720	8.77	-	-
CD at 0.05%	5.12	-*	-*
CV = 20.42		-*	-*
	Rabi Trial II		
$23D_2A$ x Ghana	18.54	18.28	-
" x Serere Comp. 1	16/48	18.70	-
" x J 128-3	16.03	-	-
" x 700250	15.37	27.37	-
" x J 2155-3	14.53	-	-
$18D_2A$ x J 166-1	13.98	9.19	-

Table 2 continued:

	Rabi 1974 Trial I	Kharif 74 Trial I	Kharif 74 Trial II
$23D_2A$ x A 836	13.87	-	-
$18D_2A$ x J 260-2	13.78	10.81	-
5071A x J 1188	12.88	-	-
$23D_2A$ x J 2155-1	12.87	-	-
$18D_2A$ x Cassady Comp.	12.84	14.39	-
$23D_2A$ x J 2155	12.67	-	-
$18D_2A$ x 1244-2	12.63	13.45	-
$23D_2A$ x 1996	11.77	-	-
5071A x 118	11.49	-	12.59
HB-3 Check	11.27	19.83	15.58
$23D_2A$ x J 1720	11.15	-	16.75
" x KG-10	9.83	15.55	-
5071A x J 1740	8.83	-	10.95
$23D_2A$ x J 1407	8.35	14.09	-
CD at 0.05%	4.42	4.41*	3.85*
CV = 24.1%	- 18.2*	- 17.32*	-

Experimental details:

Planting: Kharif 13-15 July; Rabi November 1
Harvesting " 16-29 October Rabi February 28
Gross plot size Four .75 m rows each 5m long = 15.0 m^2
Net plot size Two .75 m rows each 5 m long = 7.5 m^2
Design, RDB, 4 replications
Fertilizer level 100N: 60 P_2O_5 kg/ha

Table 3

Grain Yields (Kg/plot) of trial with released Hybrids and unselected composite bulks ICRISAT K 74

Entry	Replication I	II	III	IV	Mean Yield (q/ha.)
HB-3 (Anna Farm)	17.98	26.87	20.13	14.05	32.92
HB-3	17.73	17.37	25.54	12.62	30.52
Mid-late Composite	18.78	22.32	11.05	20.23	30.16
Early Composite	18.76	18.81	18.52	15.63	29.89
HB-3 (J-41)	16.09	20.77	12.17	19.74	28.65
HB-5	16.92	15.29	17.40	17.40	27.94
HB-4	10.23	8.93	10.07	9.23	16.04

CD at 0.05 level = 9.57

CV = 22.9%

Experimental details:

Season: Kharif 1974
Fertilizer dose: 100N: 40 P_2O_5 kg/ha

Date sown: July 9, 1974
Date harvested: October 14, 1974
Gross plot size: 5 x 13.5m = 67.5 m^2
Net size: 5 x 12.0 m = 60.0 m^2

International Cooperation M-brd-8:

Through this project will be channelled seed and information in both directions between ICRISAT and breeders and agriculturalists concerned with pearl millet. During the year new seed was received from Senegal, Niger, ALAD, U.S.A. and India. 1646 seedlots were distributed from ICRISAT to 16 countries.

Material derived from the breeding programme at ICRISAT was assembled for distribution in 1975. This consisted of 3 classes (1) 60 experimental hybrids (2) An observation nursery of 13 entries + local check (3) Breeders material consisting of intervariety F_1's, F_2 and F_3 bulks, some F_4 seed and a 25 entry group from the working collection. The experimental hybrid trial will be planted at 3 locations in India and in Senegal, while 20 sets were made of in the other classes where about 15 locations have been identified (Page 5, Appendix I).

An extensive range of breeding material appropriate to West Africa was assembled for planting in a location in Upper Volta where ICRISAT has a cooperative project. Results from this material will also assist with the core breeding programme.

Looking forward in Pearl Millet Breeding:

There are numerous areas in which future work is needed to breed better millet, but a few may be singled out for special or continued attention, namely, increased disease and drought resistance, stability of

yield, the utilization of new superior genotypes in crosses and production of better seed parents.

A large amount of new segregating material has been generated both in the composite and the variety cross projects. Parents with downy mildew resistance have been widely used. There is now an urgent need to expose the segregating material to severe downy mildew attack from 1975 onwards. A 2 ha. sick plot is under development at ICRISAT which should be fully functional in 1976. Since the natural disease level is low at Hyderabad, sites have been chosen elsewhere where the natural incidence is sufficiently high to give 90 to 100% infection to susceptible varieties. Hissar and Coimbatore have these conditions, as does Saria in Upper Volta. 2 to 5 ha. of segregating and early generation material will be grown at each of these locations. Other diseases also important are ergot, rust, and smut. Adequate levels of plant resistance exist for downy mildew, rust and smut, but this is less certain for ergot. The pathologists have worked out a simple technique for spraying emerging heads with a standard concentration of conidia, so that large numbers of genotypes may be effectively screened. Similarly, preliminary work on drought stresses applied by the physiologists to a range of genotypes in the field has shown large differences in response, and this method can be used next dry season to screen breeding material for drought resistance.

Stability of yield is influenced by disease and drought, but also by differences between environments in terms of temperature and day length. The multilocation testing mentioned above as immediately necessary for

identifying downy mildew resistance may perhaps be more important in future in terms of identifying widely adaptable and stable genotypes. Initial selection in the breeding nursery for these attributes can be made by comparing the progeny or line performance in kharif or rabi seasons, where temperatures are cooler and daylength decreasing, with performance in the radically different environment of the summer season where both day and night temperatures are higher and differ less, and daylength is increasing. Genotypes which yield well and mature at relatively the same time in both seasons should have better adaptability.

Periodic recombination between increasingly superior genotypes is central feature in composite breeding. The same principle has to be applied to variety cross progeny. When reviewing the range of breeding material available to ICRISAT in the beginning of the programme, crosses between Indian and exotic genotypes were thought to be essential to create new useful variability and this has been the case. However, some of these crosses are rather wide, involving tall late African varieties, so the frequencies of desirable progenies in these crosses has been quite low (similar experiences have occurred in several sorghum programmes where African and combine varieties have been crossed). These crosses may be called first round crosses. The second round of crosses is between the better progeny of the first round, and is likely to be productive of a much higher frequency of agronomically desirable material. We have started some second round crosses, but have to await the identification of disease resistant lines to avoid working in too many wasteful crosses.

The final need which may be mentioned is that of new seed parents. These are particularly required to assist the Indian breeder's efforts in this direction. We have intercrossed various B lines and made crosses with other good lines to quickly generate new B lines. $23D_2A$ is an outstanding seed parent with very good combining ability, but it is not downy mildew resistant. This seems to be one case where backcrossing to incorporate disease resistance would appear to be justified.

DJA:ns
June 22, 1975

APPENDIX I

PEARL MILLET

BREEDING MATERIAL LIST (by project)

M-brd-1 Advanced Composites I - Intrapopulaion Improvement.

Material	K.74(Nov)*	R.74(Mar)*	Harvest from S.75(June)	Harvest from K.75(Oct.)
Early Composite	1000 HS	545 S_1	(500)S_2's	S_2 results
Mid late "	RM	600 FS	-	FS results
Late "	RM	600 FS	-	FS results
Dwarf "	1000 HS	519 S_1	(500)S_2's	S_2 results
Senegal Dwarf Synthetic	-	270 S_1	-	S_1 results
Nigerian Composite	230 S_2	56 S_2	-	RM
World "	205 S_2	700 FS	-	FS results
6 Composites from) Serere)	)	$\pm$ 250 S_1 from each)	S_1 results from 5	RM best S_1's from all composites.

* Planting delayed both seasons. Respective harvests normally expected October and February. In future Rabi harvested material will not be planted in following summer. Summer planting will be in February only.

K = kharif; R = rabi; S = summer; RM = random mate.

M-brd-2 Advanced Composites II - Interpopulation Improvement.

	Harvest from K.74	R.74	S.75	K.75
1 R (re $23D_2A$)	Test cross	(171) RM	RM	RM
1 B (re $23D_2A$)	" "	(111) RM	RM	RM
Nigerian x World Comp	231 S_2	100 S_3	_	RM

	Harvest from			
	K.74	R.74	S.75	K.75
Serere Composite 1 (S_4)	-	177 S_1	S_1 results & Inbred Test x	Test cross results
2R) (re 239D_2A))))	-	550 Test crosses	275 Test cross results	550 Test cross results
2B) (re 239D_2A)	-	-	" "	
3R) (re L67A x))))	-	294	237 Test cross results	294 Test cross results
3B) (re L67A) x	-	-	"	

M-brd-3 Source Composites

(i) Exotic populations being maintained:

Ex Bornu, Dwarf, Maiwa and Mokwa-maiwa Composites from Nigeria, Cassady's Dwarf population (USA), some Serere bulks (Uganda).

(ii)Possible future back up composites:

Earliness)
) ?
Drought - tolerant)

Dwarf (D_2 only)

Disease resistant (DM; ergot; rust)

Good grain - visual)
) ?
Nutritional quality)

M-brd-4 Variety crosses and Synthetics

		Harvest		
Crosses	K.74	R.74	S.75	K.75
1973	565 F_3	780 F_4 lines (= 120 F_3 families)	151 progeny of 14 best F_4 families	Progeny from 120 families
		95 F_4 bulks	-	-
1974	79 F_2	248 F_3 lines plus 25 F_3 OP bulks	248 F_3 planted	F_4 inbreds
		105 F_2s	105 F_2 planted	F_3 progeny
Synthetics				
(1) 15 x 15 Diallel		Diallel results 1st planting	-	Diallel results 2nd planting
(2) RF synthetic	RM	RM	-	RM
(3) Intervarietal synthetic	79 F_2s	1003 H.S.	S_1 and FS from non filial progeny	FS testing

M-brd-5 Hybrids

		Testing			
Cytosterile system	S.74	K.74	R.74	S.75	K.75
A_1 Test cross	904	2178	123	1516	2774+
Prelim.Yield T		24	38		
Main Yield T					57
A_2	-	-	-	275	550+
A_3	-	-	-	237	294+

M-brd-6 Working Collections

World Collection	..	1673 obtained from original total of 2356 (1333 K.73, 340 R.74)	
Working collection (R. 74)	..	Senegal via Beirut	11
		Chad " "	65
		U. Volta " "	27
		Niger " "	34
		Mali " "	1
		Maurutania "	1
		Uganda-breeders lines	38
		India " "	120
		ALAD	43
			340
Wild species	..	..	9

M-brd-7 Yield Testing

	73 K	K.74	74 R	75 K
Entries in Hybrid trials:				
Preliminary yield trial	-	24	38	
Main yield trial	-	-	-	57
AICMIP Trials 1.	21	20		
" " 2.		23		
" " 3.		21		
" " 4.		32		
" " 5.		13		

M-brd-8 International Cooperation

	Material	Proposed Locations 1975
Experimental Hybrids trial	60 ICRISAT experimental hybrids	Hissar Coimbatore Hyderabad *Bambey
Observation Nursery	13 Promising varieties or hybrids from international sources (USA Nigeria Senegal India - AICMIP " - ICRISAT)	*Nigeria *Bambey *Tanzania *Upper Volta *ALAD *Pakistan *Kenya *Niger *Sudan *Thailand Pantnagar Jamnagar New Delhi Anna Farm Coimbatore
Breeders material	3 intervarietal F_1's 24 F_2 bulks 55 F_3 bulks 25 entry selection from working collection	*Bambey *Upper Volta *Niger *Nigeria *ALAD Hissar New Delhi Ludhiana Pantnagar Jaipur Jamnagar Parbhani Rahuri Akola Coimbatore Vijayanagaram