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SORGHUM IMPROVEMENT
REVIEW OF WORK AND PROGRAMMES

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SORGHUM IMPROVEMENT

PERSONNEL - MARCH 31, 1976

BREEDING

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SORGHUM IMPROVEMENT

SUMMARY

BREEDING

COMPOSITE POPULATIONS

Good progress has been made with sorghum improvement through recurrent selection in random-mating composite populations. The best lines from the Fast Lane population yielded around 55-60 q/ha at high fertility levels, and 25-30 q/ha at low fertility levels, comparing very favourably with the control hybrid and variety. Seven populations were tested at five sites in India, one in Thailand and one in Uganda. Several showed good stability across environments, a major objective of the programme. Individual lines produced encouraging yields, averaging 38-45 q/ha across all seven environments.

PEST RESISTANCE

In the pedigree programme, 26 good, adapted varieties from several countries were crossed with shoot-fly resistant lines (470 crosses), stem borer resistant lines (93 crosses) and midge resistant lines (466 crosses). Recurrent selection seems to be the best long-term approach for combining pest resistance with yield and grain quality. Selected lines carrying good grain quality, high yield, and either ms_3 or ms_7, were crossed to resistant sources of shoot-fly (375 crosses) stem borer (115 crosses) and midge (285 crosses) to create such a population. Crosses of the few best resistant lines were made to five advanced populations to develop "side-cars" for feeding resistances in to these populations. Genetic tests indicate that our field screening technique for shoot-fly resistance can be used effectively in S_1 and S_2 lines, but not in half-sib rows.

STRIGA

Striga is a major cause of yield loss in many places. The identification of the low stimulant production type of resistance, using seedlings in the laboratory, has now been standardised, with the help of WRO, Oxford. We have started field testing of cultivars reported as resistant, and of lines withdrawn from a Nigerian composite population of types resistant to *S. hermonthica*. We are able to test at Akola as well as Patancheru through co-operation with Punjabrao Krishi Vidyapeeth. A synthetic "strigol" analogue from Sussex University used at 5 ppm. again reduced the striga population in red soil to 15 percent of that in the control: but was completely ineffective in black soil.

INTERNATIONAL TESTING

Four trials were sent to various locations in India, Africa, S.E. Asia and S. America. Data have been returned from only some sites. On the ICRISAT site itself, we tested at both high fertility (111N: 105 P_2O_5) and low fertility (20N: 20P_2O_5).

Some of the All India Co-ordinated Sorghum Improvement Project lines did well at several centres including W. Africa. Material of Serere, Uganda origin also did well, especially within 10^0 of the equator. These multilocation tests are very important in breeding for stability of yield.

EARLINESS WITH MOULD RESISTANCE

The pedigree programme to produce types with non-weathering, lustrous grains resistant to grain moulds in short-term sorghums involved intercrossing 30 early types (40-50 days to flower) 23 mould tolerant types, and 23 high yielding cultivars adapted to various parts of Africa and to India. A total of 2250 single, 341 double, and 175 three-way crosses were made in the kharif, but sixty percent were rejected after the rabi planting when more information on the mould resistance of the parents became available. The F_3 progenies from 2,500 selections will be screened for mould resistance in the 1976 planting. All the single and double crosses were crossed to good early steriles (ms_3 or ms_7), for composite population development, 454 good grain, short-term selections were taken from random-mating populations, and the mould resistance Nigerian Composite was random-mated and 426 steriles were selected.

Early, adapted lines were crossed to 35 parents with large glumes, to transfer the grain protection afforded by large glumes. Some 286 single, 26 double, and 25 F_2 hybrids were grown in the kharif, and the value of the large glumes will be field tested in 1976. The creation of a random mating population was also begun, deliberate sibbing being used as natural outcrossing with large glume types is probably low.

GRAIN QUALITY

The new "good grain" population for evident grain quality was still under development: types with very large grains, and also a range of "local" cultivars highly esteemed for quality were crossed with the population to create "side cars" for these characters. Segregates from RY 49 were backcrossed to RY 49, and we now have photoinsensitive derivatives which carry the wheatlike flavour of this parent type. Quality samples were sent to CFTRI for study. Progress with high lysine crosses was puzzling: inbred selections with high lysine levels for three previous generations failed to show high lysine this year: yet in every case, the protein levels were unusually high, and sometimes double the values for earlier generations. P721 was stable for these characters, but showed some pollen sterility. Populations involving both groups are being created.

GRAIN-GRASS SORGHUMS

The large number of crosses made between grain-grass types and cultivated sorghums with yield, resistance, or quality characters enabled much selection to be done, and some of the material is now in the F_5. As a group, they showed good cold tolerance in the rabi season, with little change of maturity length, and the physiologists found excellent drought endurance. Non-senescent types which ratoon easily were also identified. There is a real potential for this new plant type, which will be grown at higher plant populations than normal sorghum.

TETRAPLOID GRAIN SORGHUM

Progress was made in developing photoperiod insensitive types with better grain quality, and crosses and backcrosses were made to *halepense* types to move the excellent adaptive characteristics into the cultivated crop.

GERMPLASM

A total of 14240 accessions is now available in the ICRISAT germplasm bank. Part of the World Collection was received from Purdue, and grown alongside the corresponding cultivars here to identify mistakes and contaminations. In the rabi season, 147 new farmers types were collected in Andhra Pradesh, and 211 new accessions were received. The whole collection, other than new accessions, was evaluated for principal morphological characters, and the data are being sent to the Colorado University Taximetric laboratory to supplement the pilot catalogue. Screening for disease, pest, striga, or drought resistance was done by the appropriate scientists on 5877 entries.

ENTOMOLOGY

More than 95 percent of the flies bred from sorghum plants during the year were *Atherigona soccata*. Other species obtained, though rarely, included A. *orientalis*, A. *approximata* and A. *eriochloae*. A. *soccata* was also obtained from maize, pearl millet, and the wild grasses *Echinochloa colonum*, *Eriocholoa procum*, *Cymbopogon sp.*, and *Paspalum scrobiculatum*. Many other species were reared from wild grasses during the year.

Experiments with shoot-fly attractants showed that fish meal is strongly attractive, especially 4-8 days after mixing with water, but its "pull" can be doubled by supplementing with Ammonium sulphide plus Brewers yeast. Oviposition studies showed that maximum egg numbers are laid at close plant spacings, but the greatest percentage of plants attacked was obtained at 10-20 cm. spacing. Some 10 ha. of germplasm and breeders lines was screened for resistance. Indian sorghums identified as resistant in AICSIP programmes also showed up well in our screening trials, and we are confident we now have a reproducible field screening methodology suitable for handling large numbers. Some Indian x W. Africa derivatives showed marked non-preference. Preliminary plant morphology studies indicate that trichomes may be associated with non-preference, and behavioural studies indicate that chemoreception may be involved in selection of oviposition sites.

Detailed studies of carry-over in stalks of various cultivars for the stem-borer *Chilo partellus* showed high levels of parasitism, and five parasites were identified. On the ICRISAT site, a significant population of stalks carry *Chilo* at the start of the kharif season, but in farmers' fields, none could be found during the period March-May. A "close season" on the site is thus important. Synthetic *Chilo* pheromones were studied in field traps in co-operation with TPI London. Progress was made in developing suitable media for rearing *Chilo* in the large numbers required for screening in the resistance breeding programme, and the possibilities of utilizing natural attack were also looked at.

Midge attack at Patancheru was low, and parasitism high, three parasites being identified. We shall need to screen for midge resistance elsewhere.

PATHOLOGY

A total of 4036 germplasm and breeding lines were screened for resistance to grain moulds, using innoculums of *Fusarium* and *Curvularia*, supplemented by natural mould infection during the prolonged rains. Three lines showed very good resistance and 90 good resistance, but these results must be reconfirmed. The screening technology was tried in the rabi season, and in spite of reduced seed set under the bags on the heads, grading for levels of mould was again possible. Microfloral and seed treatment studies showed that grain mould infection may reduce germination to around five percent in evidently mouldy grain, but even apparently clean grain from mouldy heads may show only twenty percent germination. Seed treatments gave some improvement for the latter material, but virtually none for the evidently mouldy grain. Benlate was most effective in reducing fungal infection.

Preliminary tests indicate that it should be possible to screen material for resistance to downy mildew and several leaf diseases in the kharif season (but not in the rabi) by using spreader rows (infector lines).

PHYSIOLOGY

A variability study on 49 genotypes of various characteristics in growth stages 1 to 3 (GS1, GS2, GS3) was done. The duration of GS1 (vegetative phase) varied from 30 to 41 days: that of GS2 (head development phase) from 31-64 days, and that of GS3 (grain filling phase) from 31 to 56 days. There were substantial differences between genotypes in leaf number, rate of leaf production, position of the largest leaf, grain yield, seed number, seed size, grain filling rate, and number of nodes per head, in addition to differences in other characters. Grain yield per season varied from 20.6 to 72.9 kg/ha per day, and yield per day for GS3 only varied from 58.6 to 273.4 kg/ha. We can now begin to use the variation identified in a breeding programme to develop more efficient plants.

Forty entries from elite selections were studied to define the range in variability in nitrogen uptake and distribution, and possible influences on yield. Nitrogen uptake per plant varied from 0.22 g to 1.14 g, and nitrogen transfer efficiency (NTE) from 57.8% to 86.6%, at a given total nitrogen uptake there were genotypes with an efficiency of over 77%. The expected weak negative correlation between grain yield and grain nitrogen concentration was found ($r = -0.36^{*}$). Grain nitrogen was highly correlated with total biomass ($r = 0.77^{***}$), so large plants tend to have more nitrogen. NTE and Harvest index were strongly correlated ($r = 0.83^{***}$) so high harvest index requires high NTE: grain yield was positively correlated with total plant nitrogen (r = 0.51***), grain nitrogen content (r = 0.58***) and NTE (r = 0.33*). Set against the rather weak negative correlation with grain nitrogen concentration (r = -0.36*) this suggests that high yielding genotypes with a high nitrogen concentration can be obtained which would need selection of types with above average nitrogen uptake and maximum transfer of nitrogen from plant to grain.

Seventy eight genotypes were studied in petri dish, pot and field for seedling, root and panicle development. Results showed that the absolute weight of seed reserves mobilised for new growth during germination increases with seed size, but from 15 to 30 days, the association between seedling size and seed size is not very strong, so not all big seeds produce big seedlings, which relates to the photosynthetic area and efficiency of the seedling.

Brick chambers were used for root studies, and showed that the average day weight of roots per plant at all stages was greater for the Pioneer hybrid 22 E than for CSH-1. Field studies of panicle development in these hybrids, and their parents, showed that 22 E deviated considerably from its parental developmental time table, but CSH-1 did not.

Seventy four genotypes were evaluated in the field for drought resistance under a stress period of 30 days beginning at the panicle initiation stage. An evaluation procedure based on the effect of stress on growth cycle length, absolute yield under stress, and yield decrease compared to no stress has been developed. Resistant types with an avoidant response (growth cycle changed by less than 7 days) and resistant types with a tolerant response (growth cycle extended by 7 to 30 days) were identified, together with intermediate types. We consider that a resistant type should be capable of yielding 20 q/ha under artificial stress, with no more than 30% yield reduction relative to "no stress" conditions.

MICROBIOLOGY

During the rabi season 115 sorghum entries, known to perform well under both low and high fertility conditions, were grown under low (20N: 20P_2O_5) fertility conditions. Acetylene assay of the nitrogenase activity of the washed root systems showed up to forty fold differences in activity, with a maximum of 1.2 Umol/q dry weight of root/h. There was substantial variation between plants within lines as well as between line means. High nitrogenase activity was associated with 10 entries, including CSH-1, CSH-5 and *S. halepense*, and was greater after flowering than previously in these irrigated plants. We are concentrating on developing a suitable assay system to identify reliably lines which stimulate much nitrogen fixation.

BIOCHEMISTRY & NUTRITION

Some 7000 sorghum samples were screened for protein content and total basic amino-acids (which includes lysine). The biuret method for protein estimation was discarded in favour of the microKjeldahl and the Technicon systems. The UDY test was used throughout to estimate total b.a.a. and therefore lysine. Twenty three samples sent to the TPI, London, for starch and fibre analysis showed a negative correlation of starch with protein (-0.68**) and with fibre (-0.70**). Protein was positively correlated with fibre (0.77**), and 100 grain weight was not correlated with protein, fibre or starch.

PROGRESS IN BREEDING FOR IMPROVED LYSINE

CONTENT OF SORGHUM GRAINS, 1973-75

A) MATERIAL

The following material was received from Purdue in time for planting in Rabi 1973.

(1) 39712011 328 to 39713098 999 (397328 - 397999). 648 entries. These consisted of F_2 seed, from selfed plants of crosses between Purdue populations (PP1R, PP2B, PP3R), Nebraska populations (NP3R), a source identified as ms_3 (presumably Coes) Redlan, IS 5614, and IS 5623, used as female parents, and pollinated by the Ethiopian high lysine cultivars, either IS 11167 or IS 11758. 397721 - 730 consisted of crosses between IS 11758 as female and IS 0855 as pollinator. 397731 - 754 were inter-crosses between IS 11167 and IS 11758. 397787 - 821 consisted of crosses between IS 4668, or IS 5376, as females, and IS 11758 or 11167 as males.

(2) 39631064 001 to 39642016 752. (396001 - 396752) 651 entries. These were essentially backcrosses in relation to the hl gene. The "recurrent parent" was 73 PP2B, a high protein yield, non-restorer selection: 73 PP1R, a high protein yield, restorer selection: 73 PP6B, a high yield non-restorer selection, or 73 PP5R, a high yield restorer selection. The donor parents were crosses of the 397 series type, but confined to PP1R, PP2B, or PP3R, with a very occasional Redlan or ms_3 crossed with IS 11167 or IS 11758. Pollen for the 396 series of crosses was taken from the F_1, and no attempt was made to stick with the "B" and "R" separations. Both IS 11167 and IS 11758 were classed as non-restorers (B lines).

(3) 39353071 310 to 39357102 566 (393310 to 393566) 266 entries. These had similar pollen parents to the 396 series, but the female parents

were plants from Bruce Maunder's yellow endosperm population. Pollen was collected from the F_1 generation of the (PP x hl) cross.

(4) 39022004 061 to 39025052 338 (390061 to 390338) 84 Entries. These are much the most complex of the crosses to describe concisely. NP2 and NP3 were crossed to IS 11167 or 11758: all dented seed segregating in the F_2 of these crosses was pooled and labelled "73 PP9". This is the main parent through this series, used as the male except for 390201 to 390239. Groups of parents shown below were crossed to either NP2B or NP3R, and F_2 plants segregating from these crosses were pollinated with 73 PP9:

(i) 350 series: Having high sulphur contents: which included IS 1295, IS 3290, IS 4328, IS 6065, IS 6774, and IS 6908: in addition, there were 78473 and 78515 of unknown origin, but almost certainly IS lines.

(ii) 351 series: IS 0003, IS 0005, IS 0079 and IS 0157.

(iii) 352 series: High oil selections, IS 1259 and IS 2944.

(iv) 353 series: Yellow endosperm selections: including IS 2840, IS 3915, IS 3932, IS 4736, IS 7886, IS 8305, IS 10304, IS 10472, and IS 10723. Also the presumed but unidentified IS row 79406.

(v) 354 series: High Protein lines: IS 0035, IS 0211, IS 0501, IS 0657, IS 1486, IS 2283, IS 2341, IS 2401, IS 2874, IS 2881, IS 3138, IS 3979, IS 4923, IS 5568, IS 6027, IS 6203, IS 6992, IS 7118, IS 7243, IS 7886, IS 8160.

(vi) 355 series: White seed selections: IS 0174, IS 0222, IS 0803, IS 1059, IS 3496, IS 3681, IS 3792, IS 3950, IS 4004, IS 4736, IS 4886, IS 5275, IS 8335, IS 8666, IS 8752, IS 8760, IS 1149, IS 10244, IS 10248, IS 10250, IS 10252, IS 10254, IS 10261, IS 10264, IS 10489, IS 10491, IS 10493, IS 10497, IS 10505, IS 10508, IS 10560, IS 10567, IS 10572, IS 10580, IS 10594, IS 10601, IS 10648, IS 10917, IS 10943 and IS 10648.

(vii) 356 series: Large seed selections: IS 10932 and a partially converted line from Texas, 954062.

(viii) 357 series: High yield selections: IS 0057, IS 4225, partially converted line 954206, and the Purdue lines 956032 and 932296.

(ix) 367 series: Straight crosses of some of the above IS numbers to 73 PP9.

(x) 316 series: Straight crosses of IS numbers, partially converted lines, or Purdue lines, to 73 PP9, except for six entries which were 73 PP9 x (NP3R x 11167).

B. BREEDING

1973 RABI (SHORT DAYS)

Out of the total of 1649 entries received, 454 with sufficient seed were sown in 9 m. rows, and the remainder in 3 m. rows. ms_3 was segregating in a lot of the rows, and sibbing and selfing were done. All plants with white and red seeds (heads) were screened on the light box, and 300 with a very few plump, opaque seeds were identified. The following groups of selections were taken:

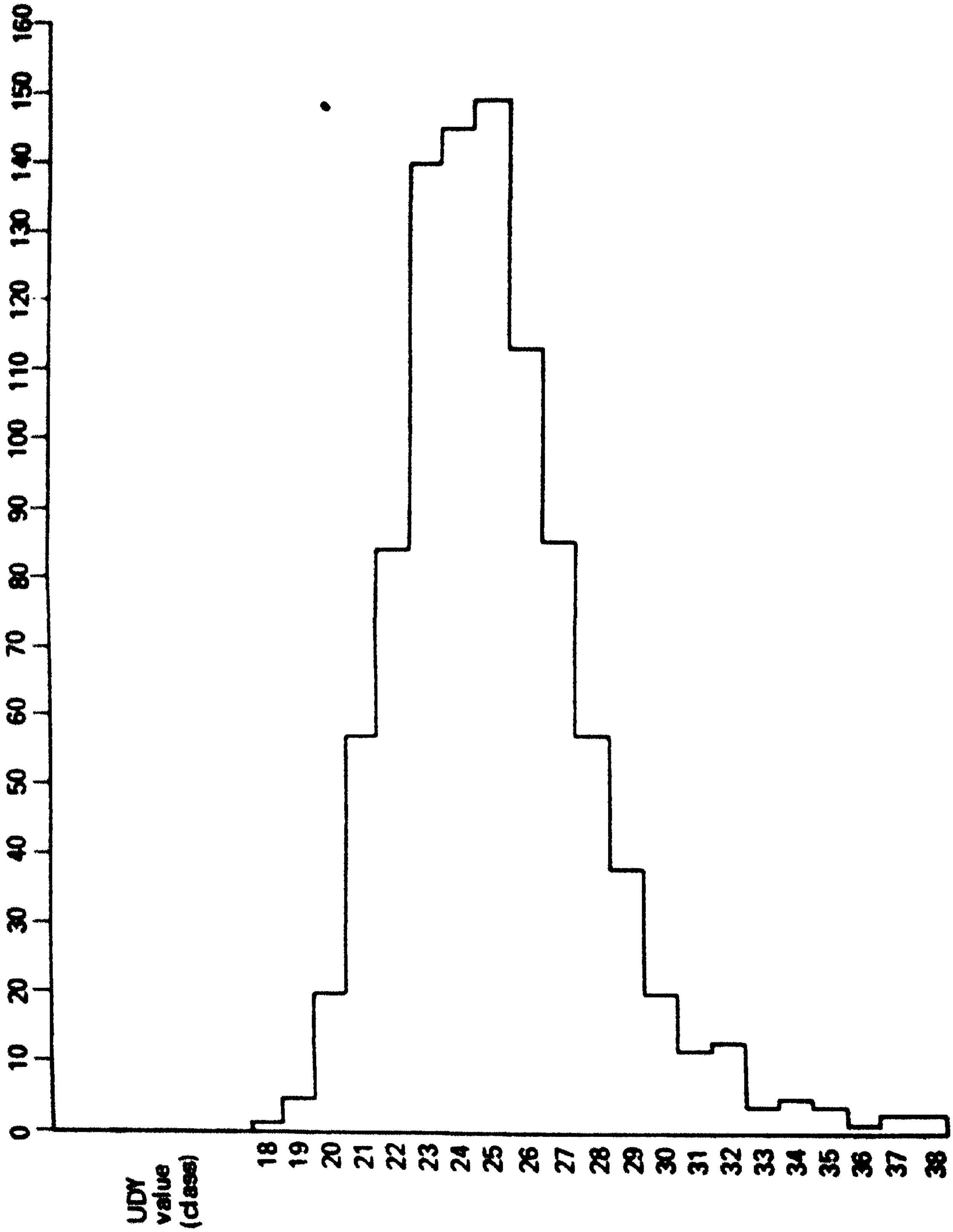
(A) Plants with plump, opaque seeds	300	selections
(B) White, plump non-opaque heads from rows which had segregated for plump opaque	900	"
(C) White, plump non-opaque heads from rows which had not segregated for plump opaque	275	"
(D) Red, plump seeds from heads segregating for hl	1,350	"
(E) Sibs from rows segregating for hl	750	"
(F) In the summer, 1,000 heads with white seeds, which had already been screened on the light box, were analysed chemically by biuret for protein content, and UDY, after removing the pericarp, as shown in Figure 1. The intention had been to analyze many more, but the heads got "lost", one of the results of working in makeshift conditions.	102	

1974 KHARIF (LONG DAYS)

Of the 300 selections in Group A, plants were obtained from only 240 seeds in 140 of the progeny rows. Intercrossing was done, as ms_3 was segregating, 105 plants being used as parents.

The Biuret and UDY screening method was looking very promising, and selection on the light box would only give opaque types

FIGURE 1: FREQUENCY DISTRIBUTION OF UDY VALUES FROM BIURET/UDY SCREENING OF 1000 SEGREGATES OF CROSSES & BACKCROSSES WITH IS 11167 & IS 11758



which had the wrong kind of endosperm. This was therefore discontinued, and emphasis was placed on chemical screening. This decision automatically put a ceiling on the numbers which could be handled. Removal of the pericarp was also discontinued, being very difficult to do successfully for some of the grains with very soft endosperm.

The rains were prolonged, with resultant grain mould, and chemical screening was judged to be misleading in the presence of mould. Selection was therefore based on agronomic characters, with white/yellow grains strongly favoured, since the red and brown pigments probably interfere with the UDY readings. Selection was biased against tall, late, photoperiod-sensitive types. Thus, in this generation, there was no selection for either protein or lysine contents, although in the case of group (F) the numbers of selections taken from each row was influenced by the UDY value of the parent head.

There was a strong preference for the shorter, more vigorous plants in the selections from groups B, C, D and E.

1974 RABI

The main chemical effort went in to screening the descendents of the 1,000 heads screened by biuret and UDY (Group F). There were 309 rows of these, and several heads were screened in each row. It had become clear that the biuret estimate of protein was unreliable, especially at the low protein end of the scale, so the most promising entries identified by this system were re-screened using microKjeldahl and UDY. (We were still not well enough organized to do large numbers of microKjeldahls). Results were expressed on a constant protein basis.

1092 plants from the 309 rows of group F were analysed, and 128 plants from 54 rows qualified for rescreening with MKJ and UDY. Finally, 20 selections from 12 rows were retained as having high UDY values at constant protein, with plump grains having a slight corneous-outer endosperm shell (Table 1). All of these entries showed MKJ protein values of 9.4 percent or less, so we were selecting low protein types, presumably with low prolamine.

The opaque group (Group A) together with their intercrosses, were also screened chemically. 8.6 heads from 425 progeny rows (themselves from selections out of the original 140 rows) together with some of the crosses, were screened similarly. 38 heads from 26 rows were finally selected, together with 8 of the intercrosses.

TABLE 1: HIGH UDY SELECTIONS TAKEN IN 1974 RABI DERIVED FROM THE BEST R73 SELECTIONS CHOSEN ON BIURET + UDY ANALYSES (80 mg. PROTEIN)

Row No.	Plant No.	1973 UDY Value	Biuret Protein	UDY Value	mkj pro-tein	UDY Value	Row No.	Plant No	1973 UDY Value	Biuret Protein	UDY Value	mkj pro-tein	UDY Value
79135	8	(37.5)	8.0	32.5	8.9	28.5	79335	6	(30.0)	6.3	36.5	7.6	29.5
79429	4	(34.0)	8.0	30.0	8.1	29.0	79337	2	(30.0)	6.3	35.5	7.2	30.0
79175	2	(30.5)	8.2	30.0	7.9	30.0	"	3	(30.0)	6.7	33.0	7.3	30.0
79233	7	(30.0)	8.7	30.0	9.4	28.0	"	4	(30.0)	6.3	34.0	7.2	31.5
"	8	(30.0)	8.0	31.0	9.0	28.5	79339	1	(30.0)	7.2	33.0	8.1	28.0
79235	5	(32.0)	9.0	30.5	9.4	28.0	"	2	(30.0)	7.3	32.0	7.8	29.0
79283	1	(32.0)	7.3	35.0	8.6	29.0	"	3	(30.0)	6.0	37.5	7.1	30.5
79287	1	(32.0)	6.3	38.5	8.1	28.5	"	8	(30.0)	7.2	31.5	7.8	29.0
79327	2	(30.0)	6.3	38.0	8.0	28.5	79449	1	(30.5)	6.0	32.0	7.0	28.0
79335	5	(30.0)	6.7	33.0	7.8	29.0	"	1	(30.5)	6.7	31.0	7.4	28.5

The remaining groups of rows from the original R6 kharif selections were then screened, as far as possible, preference being given to the best agronomic types with plump grains. 2250 were screened using biuret/UDY, and 78 were identified as high lysine, as we felt confident that a big enough discount for the weaknesses of the method had been made. In fact, when it finally proved possible to do the MKJ and UDY method, only three of these qualified. There seemed to be an encouraging association between Rabi 1973 values and progeny values two generations later (Table 2).

1974 RABI

TABLE 2: ASSOCIATION BETWEEN UDY VALUE (80 MG. PROTEIN) OF SELECTIONS RABI [illegible] AND PROGENIES TWO G[illegible] (BIURET + UDY SCREENING)

UDY value of 1973 rabi head selections (class)	No. of progeny rows two generations later		Percent of rows with high UDY	No. of heads		Percent of heads with high UDY
	UDY > 30	UDY < 30		UDY > 30	UDY < 30	
28-29	6	59	9.2	9	192	4.5
30-31	21	58	26.6	42	466	8.3
32-33	12	29	29.3	27	182	12.9
34-35	5	8	38.5	12	56	17.6
36-37	7	6	53.8	37	62	37.4

ADDITIONAL MATERIAL

Purdue University supplied seed of crosses between some of Doggett's Uganda populations, and F_1 plants of the 316 series. The Uganda populations were Puerto Rico Dwarf (DPRP) Good Grain (GGP), Hybrid Rs. (HRSP) and Red Flinty (RFP). The 316 series were PP_1, PP_2, or PP_3 (NP3 was used on two occasions) crossed with either IS 11167 or IS 11758.

403 rows of DPRP, 69 rows of GGP, 87 rows of DRF, and 186 rows of DHRS, were grown, no analyses were done, but selections were taken, choice being made on grain colour, head weight, height and vigour. These selections were planted at Bhavanisagar in the summer, and had

been chosen on agronomic characters only.

1975 KHARIF

All the material which successfully passed the screening test from the rabi and summer plantings 1974/75, was classified as follows: Group I, UDY of 30 or above: Group II, UDY of 29: and Group III, UDY of 28. In addition, there was the "good agronomic characters" group of 78 entries which had originally been thought to be high UDY, based on biuret protein estimates: and the Uganda bulks x 316 from the Coimbatore summer planting. There were two planting dates for some of the material. In addition, some head rows of P721 were grown, as well as some more Purdue material, involving the 411, 412, 414 and 417 series, consisting essentially of F_2 selections (F_3 in R6) from the series, involving Maunder Yellow, PP1, PP2, PP3 or PP4(?) crossed with (NP2 or NP3) x (11167 or 11758).

The Technicon apparatus for protein estimations had now become available, and it was possible to screen 2880 samples, several plants per entry being taken, more in the high groups than in the others. Table 3 shows the relationship between the plants identified from the Kharif 1975 harvest as having high UDY values, and the UDY values of the parent head with which the progeny row was planted.

TABLE 3: RELATIONSHIP BETWEEN UDY RATINGS FOR THE PARENT HEADS OF THE 1975 KHARIF PROGENY ROWS, AND THE RATINGS FOR THE SELECTIONS CHOSEN

Parent rows		UDY Group (constant protein) of kharif selections						
		I (30+)		II (29)		III (28)		IV (<28)
No. of entries	Description	No. of entries	No. of selections	No. of entries	No. of selections	No. of entries	No. of selections	No. of entries
17	UDY Group I	11	18	1	2	1	8	4
17	UDY Group II	1	1	1	1	3	3	12
25	UDY Group III	2	2	0	0	3	6	20
78	UDY Group IV	3	4	1	1	1	1	73
113	Opaque intercrosses	13	21	2	5	5	10	93
693	Uganda populations	9	9	2	2	6	7	676
22	P721 headrows	1	1	1	1	1	1	19

The trend is as expected: the proportion of selections with high UDY values is highest where the parent heads were highest. The numbers are not at all as expected: the frequency of the high UDY segregates is very low: and the protein levels of the progenies were much higher than those of the parent heads. At the time, this latter effect was thought to be seasonal: for the first time, we had data from a kharif harvest. Earlier data had all been from rabi or summer plantings.

RABI 1975 & SUMMER 1976

Three groups of the selections were chosen for combining into populations. Group A, with very high UDY values per 80 mg. of protein (30+) contained selections from seven lines: Group B, UDY value of 30-38.5, contained selections from 28 lines: and Group C, consisting of the model UDY values 28-29.5, contained selections from 25 lines. P721 selections were added to each of these groups, and within group inter-crossing, using the segregating male-steriles was begun at Bhavanisagar in the summer.

Additionally, intercrosses were made between the best P721 lines and the high UDY derivatives from this hl crossing programme.

Only some of the laboratory results are at present available, but these are showing the same trend as that found in the kharif season-high protein levels, with reduced UDY values. Table 4 illustrates what has happened in the history of selection from two good Rabi 1974 lines, 80079 and 79337. High lysine selections have not disappeared completely. thus, in analysis of 31 plants out of four high lysine lines from Bhavanisagar, seven quality as high lysine (UDY of 28+) and one or more of these occurs in each line. Incidentally, in this season, UDY values were taken on 1 gm. of sample, and the 80 mg. equivalent was calculated on a proportional basis.

DISCUSSION

The puzzling aspect of the work so far has been our inability to produce true breeding high lysine lines with plump grains, or indeed, to raise the frequency of occurrence of such plants by very much. One first questions whether we have been dealing with high lysine plump grains at all, or whether we have been handling artifacts resulting from analytical errors. This year, a trial of ten entries in four replications was fed incognito into the analysis pipe-line, in among the breeders' samples, with the results shown in Table 5. On the whole, these are satisfactory for breeder's purposes. There is evidently one serious error of protein estimation in entry 7 (BP53) Rep. IV, and the

TABLE 4: BEHAVIOUR OF HIGH LYSINE SELECTIONS OVER GENERATIONS, UDY VALUES WITH PROTEIN VALUES IN BRACKETS, MEANS & RANGES

Selections from Rabi 74	Kharif 1975: Row means & ranges		Kharif 1975: Selections	Kharif 1975: Values	Rabi 1975: Selections	Rabi 1975: Values	Rabi 1975: Row means & ranges	n	Controls
80079-1 (7.5) 32.5	2011 (n = 30) (11.0) 24.7	(6.0 - 14.3) 21.5 - 44.5	2011-15 (8.7)	33.0	1669	(18.1) (17.5 - 18.8)	24.6, 23.4 - 25.8	2	CSH-1 (12.4) 23.2
			2011-16 (7.8)	31.5	1670	(15.7) (14.9 - 16.2)	23.8, 21.8 - 25.2	3	CSH-1 (12.6) 23.5
			2011-17 (6.0)	44.5	1671	(15.1) (13.4 - 17.0)	24.1, 22.7 - 25.4	10	P721 (15.5) 31.5
			2011-19 (7.2)	35.0	1672	(14.5) (14.0 - 18.3)	24.5, 22.6 - 25.8	6	P721 (15.9) 30.7
			2011-20 (8.3)	37.0	1673	(16.4) (13.4 - 17.9)	23.1, 18.3 - 25.4	9	148 (13.7) 22.8
79337-2 (7.2) 30.0	2002 (n = 7) (10.9) 23.6	(7.0 - 13.4) 21.0 - 32.0	2002- 6 (7.0)	32.0	1651	(13.8) (11.1 - 16.4)	23.9, 21.0 - 26.6	15	148 (13.6) 21.2
79337-3 (7.3) 30.0	2003 (n = 20) (10.5) 23.5	(7.9 - 12.7) 21.0 - 32.0	2003- 4 (7.9)	34.0	1652	(12.3) (9.4 - 15.5)	24.7, 22.0 - 28.5	21	CSH-1 (12.0) 24.0
			2003- 8 (8.7)	28.0	1653	(11.6) (10.4 - 13.8)	23.9, 21.0 - 27.0	30	CSH-1 (12.4) 23.8
79337-4 (7.2) 31.5	2004 (n = 25) (9.7) 24.5	(6.1 - 13.6) 20.0 - 32.0	2004- 1 (8.6)	32.0	1654	(15.2) (11.3 - 17.0)	24.4, 22.9 - 25.0	10	P721 (15.3) 31.6
			2004- 4 (8.3)	31.0	1655	(15.0) (12.1 - 17.1)	23.3, 22.5 - 28.2	17	P721 (16.1) 31.0
			2004-20 (7.2)	28.0	1656	(13.0) (11.3 - 15.8)	23.5, 22.2 - 25.9	18	148 (13.6) 24..
			2004-25 (6.1)	32.0	1657	(14.2) (11.8 16.6)	23.3, 20.0 - 25.1	14	148 (13.9) 23.0