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Research Article

Multiple criteria selection of crosses for improvement of yield in Safflower, *Carthamus tinctorius L.*

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Abstract

The F_1 along with parents of a 4 x 6 line x tester crosses in safflower were studied and seven parameters, i.e., D^2_7 based on 7 characters and D^2_4 based on yield and its 3 direct componenets and mid parent value (MP-Y), F_1 mean (F_1-Y), relative heterosis (RH-Y), biparental average GCA (MPGCA-Y) and SCA effect (SCA-Y) for yield were estimated. Twenty four selected crosses were studied for segregation for yield in F_2. Thirteen combinations were as criteria for selection of crosses. The predictivity of a selection criteria was assessed by correlation and regression of F_2DS_7 on the DS of selection criteria. The usefulness of individual parental and F_1 parameters as selection criteria was also assessed. Among the single parameter criteria, D^2_4 based on yield and its direct components gave the highest R^2 of 39.71%, followed by MP-Y (39.46%) and F_1-Y (35.60%). Eight of the thirteen multiple criteria proved to be better predictor of F_2DS_7 than the best single parameter criterion MP-Y. The multiple criterion DS (2,4,6) based on D^2_4 and F_1 mean and biparental average GCA for yield was found to be the best criterion fro selection of crosses for yield improvement in safflower.

Key words: Safflower, line x tester, discriminant function

Introduction

The major approach in breeding for yield in allogamous crops is hybridization followed by selection in segregating generations. The basis of improvement by this method is transgressive segregation that results from recombination of desirable genes of the parental varieties. Choice of parents or crosses is a crucial factor determining success from recombination breeding for yield. In absence of any objective method, the breeder selects parents and makes crosses taking into consideration local adaptation, ecogeographic diversity, parental performance per se and yield component complementation. The process is subjective and it is a common experience that while some crosses produce superior progeny, others prove disappointing and much effort is expended before such differences become apparent. Though the problem is well recognized, an objective method for choice of parents or crosses is yet to be found. Some workers have assessed the usefulness of D^2, parental performance *per se*, F_1 performance, heterosis and GCA as criteria for choice of parents or crosses in different crops. The present study in safflower evaluates multiple selection criterion based on combinations of parental and F_1 parameters with a view to finding an objective method for choice of parents or crosses of better segregation potential.

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Materials and methods

The material consisted of a 10 parental (4 lines and 6 testers) line x tester cross of safflower. The parental varieties include Manjira, Sagarmuthyalu, TSF-1 and TSF-2 (lines) and GMU 1946, ASD-07-9, ASD-07-10, SSF 658, SSF 698 and SFS 9920 (testers). The $F_1$of the line x tester cross along with the parental varieties were grown in randomized block design with 4 replications during rabi, 2008. Each entry was represented by one row of 5 m length. Sowing was done with 45 cm x 20 cm spacing and normal agronomic practices were followed. Observations were taken on days to 50% flowering and maturity on plot basis and on plant

height, number of capitula per plant, number of seeds per capitulum, 100-seed weight and seed yield from 10 random plants.

Analysis of variance and covariance was carried out on the 100 parental varieties and genetic divergence among the varieties estimated by D^2 (Rao, 1952). Two sets of D^2 were estimated, one based on all the 7 characters studied (D^2_7) and another based on yield and its direct components, capitula per plant, seeds per capitulum and 100-seed weight. Combining ability analysis was done and GCA and SCA effects estimated following Griffing (1956).

The parental and F1 parameters evaluated as criteria for choice of parents and crosses were D^2_7, D^2_4, mid-parent value for yield (MP-Y), F_1 performance for yield (F_1-Y), relative heterosis for yield (RH-Y), biparental average GCA for yield (MPGCA-Y) and SCA effect for yield (SCA-Y). These parameters were estimated for the 24 crosses which covered the whole range of each of the seven parameters. This limited number of crosses to be handled in F2 enabled large samples of plants to be studied for assessing segregation potential and also the crosses involved all the 10 parental varieties.

The F_2s of these crosses along with the parental varieties were grown in randomized block design with 3 replications during rabi, 2008. Each entry was represented by 10 rows of 5m each in each replication. Agronomic practices were same as in F_1. Single plant observation was taken on seed yield from 100 plants per cross and 40 random plants / parent variety in each replication. Eight parameters of segregation potential for yield were estimated in F_2. An F_2 plant giving higher yield than the highest yielding plant of the better parent was considered to be a positive transgressive segregant (PTS) and the frequency of such plants was PTSF. PTSM was the average of PTS. MXT was the difference in yield of the highest yielding PTS and the highest yielding plant of the better parent. AVT was estimated as the difference of the PTSM and the highest yielding plant of the better parent. All the parameters were estimated replication wise and then averaged. Weighted average was used in case of PTSM and AVT. The interrelationship of the parental and F_1 parameters, ie., D^2_7, D^2_4, MP-Y, F_1-Y, RH-Y, MPGCA-Y and SCA-Y and the F_2 segregation parameters, ie., mean, s^2, T10%M, S10%, PTSF, PTSM, MXT and AVT was analyzed by simple correlations.

Discriminant analysis by Fisher's linear discriminant function (Mardia *et al*., 1979) was employed as the method for simultaneous use of multiple parental and F_1 parameters for selection of crosses. The discriminant function, which gives a discriminant score as a linear combination of the variables for each object, is of the following form.

$$y= a1x1+a2x2+a3x3+\ldots\ldots\ldots\ldots\ldots\ldots..+anxn \quad (1)$$

where a1, a2,……an are the weighing coefficients, x1, x2,……..xn are the mean values of the variables of an object and *y* is the discriminate score. The a's are to be so chosen as to maximize the ratio of between-groups SS to within groups SS of *y*. In matrix form, the ratio of between groups SS to within groups SS of y is a 'Ba/a' Wa, where B is between groups SS and SP matrix of the original variables x,s and a is the vector of unknown (a's). The vector 'a' of the Fisher's discriminant function is the eigen vector of (W-1B) corresponding to the largest eigen value. This method was followed in the present study. Once the weighing coefficients, a's were estimated, discriminate scores of the crosses were estimated using the function as at (1). It may be noted that the vector a can be re-scaled without affecting the ratio a'Ba/a'Wa. For the purpose of the present study, the discriminant score having the highest numerical value should be positive. Therefore, wherever necessary, the vector 'a' was re-scaled by multiplying it by -1.

Discriminant analysis of the crosses was carried out with various combinations of parental and F_1 parameters and the discriminate scores (DS) valuated as selection criteria. Discriminant analysis was also carried out on the F_2s in order to have a single multivariate measure of segregation potential (F_2DS_7) based on all the seven segregation parameters estimated for yield in F_2. All variables, both of F_1 and F2 were standardized as they were in very different units. The predictive value of the selection criteria, ie., DS based on parental and F_1 parameters, was assessed by simple correlations and regression of F_2DS_7 on DS of selection criterion.

Results and discussion

The present study, which aimed at finding an effective criterion for choice of crosses for yield improvement, envisaged multiple criteria selection is based on a combination of parental and/or F_1 parametres like D^2 and parental performance *per se*, F_1 performance, heterosis (RH), biparental average GCA and SCA fro yield. These parameters

were estimated from study of the parents and F_1 of a line x tester cross among ten varieties of diverse origin. There were significant differences among parental varietal and among the F_1 hybrids for all the seven characters studied. D^2_7 estimates among the parental varieties ranged from 12.56 to 47.31 and D^2_4 ranged from 10.84 to 38.67. With D^2_7 that the ten varieties grouped into 3 clusters and with D^2_4 they grouped into 4 clusters. The D^2 values and number of clusters to which the varieties grouped indicated substantial genetic diversity among the varieties for productivity traits.

Parental and F_1 parameters

The seven parental and F_1 parameters evaluated as selection criteria i.e., D^2_7 and D^2_4 and MP-Y, F_1-Y, RH-Y, MPGCA-Y and SCA-Y for yield were estimated for all the 24 crosses for study of segregation for yield in F_2. Range of variation of the parameters among the 24 crosses fro study of segregation for yield in F_2. Range of variation of the parameters among the 24 crosses was 14.93 to 27.69 for D^2_7, 19.04 to 49.79 for D^2_4, 8.51 to 11.76 g/pl for MP-Y, 7.83 to 16.27 g/pl for F_1-Y, -3.92 to 103.01% for RH-Y, -1.46 to 10.18 g/pl for MPGCA-Y and -2.41 to 3.58 g/pl for SCA-Y (Table 1).

F_2 segregation parameters

Twenty four crosses were studied for segregation for yield in F_2. Eight parameters ie., mean, s^2, T10%M, S10%, PTSF, PTSM, MXT and AVT for yield were estimated from large samples of 100 plants per F_2. Analysis of variance revealed significant differences among the crosses for all the eight parameters. Means of crosses (F_2s) for yield ranged from 6.34 to 12.41 g/pl with a general mean of 9.65 g/pl., compared to 5.28 to 9.56 g/pl of the parental varieties with a general mean of 7.38 g/pl (Table 2). Range of variation of other parameters of segregation for yield among the 24 F_2s was 2.53 to 6.24 g/pl for variance s^2, 8.64 to 16.44 g/pl for T10% M, 3.47 to 7.51 g/pl for S10%, 2 to 19 per 100 (0.01 to 0.19%) for PTSF, 10.14 to 19.48 g/pl for PTSM, 0.32 to .06 g/pl for MXT and 0.14 to 2.45 g/pl for AVT.

Correlation among F_2 segregation parameters

All the 28 correlations among the 8 F_2 segregation parameters were positive and 22 of them significant at 1% level (Table 3). Five of the 6 non-significant were those of mean with other parameters. The parameters s^2, T10% M, S10%, PTSF, PTSM, MXT and AVT showed high positive correlation among them. The segregation parameters estimated in F_2 covered all possible factors determining the segregation and selection potential of a cross. The nature of relationship among the F_2 segregation parameters showed that the parameters are reinforcing rather than counteracting factors and that their use in linear combination for a single measure of the relative segregation and selection potential of the cross would be straight forward.

Correlation between parental / F_1 and F_2parameters

Six of the eight F_2 segregation parameters showed significant positive correlation with both D^2_7 and $D^2$4 (Table 4), but the correlations with D^2_7 were higher than those with D^2_4. Dikshit and Swain (2001) found no relationship between D^2 based on 14 characters and F2 segregation parameters like variance, top 10% mean, PTS frequency, PTS mean and average transgression for yield and positive relation of F_2 variance with F_1 mean, relative heterosis and bi-parental average GCA. Mishra *et al*., (2008) reported positive significant correlation of F_2 segregation parameters with F_1-Y and MPGCA-Y. In this study, none of the F_2 segregation parameters showed significant negative correlation with any parental / F_1 parameter. The present results showed that D^2_4, F_1 mean and biparental average GCA were good indicators and RH and SCA were poor indicators of segregation potential.

Parental and F_1 parameters as selection criteria

Fisher's linear discriminant function (Mardia *et al*., 1979) was used to obtain a single measure of segregation potential of a cross, based on all the aforesaid F_2 parameters. The discriminant score F_2DS_7 based on the 8 segregation parameters was taken as the measure of segregation potential of a cross and the predictivity of individual parental and F_1 parameters for predicting F_2DS_7 was assessed by correlation and regression analysis. F_2DS_7 showed high positive correlation with MP-Y ($r>0.6$) and moderate correlation ($0.5<r<0.6$) with MPGCA-Y and low correlation ($r<0.5$) with D^2_7 and F_1-Y (Table 5). The b-coefficient of the regression of F_2DS_7 on D^2_7, D^2_4, MP-Y and F_1-Y were highly significant, while those of RH-Y, MPGCA-Y and SCA-Y were non-significant. The results showed that $D^2$4, $D^2$7, MP-Y and F_1-Y have a predictive relationship with F2DS7. Between D^2_7 and $D^2$4, the later would be a better indicator of segregation potential for yield. D24 gave the highest R^2 of 39.71% followed by MP-Y (39.46%), F_1-Y (35.60%), RH-Y (32.09%) and $D^2$7 (28.04%). The

coefficient of determination (R^2) being generally low in these cases, no single parental/ F_1 parameter could be considered to be an adequate criterion for selection of crosses. However, when information is available only on the parental varieties D^2_4 giving a moderate R^2, can be used as a criterion for choice of parental combinations, to some advantage. Similar results on selection criteria were also reported by Mishra *et al*., (2008).

Combinations of parental and F_1 parameters as selection criteria

The study envisaged multiple criteria of selection based on combinations of parental and F_1 parameters. Thirteen combinations of six parental and F_1 parameters, leaving out D^2_7 were tried. These included combinations of parental parameters such as $D^2$4 and MP-Y and F_1 parameters like F_1-Y, RH-Y, MPGCA-Y and SCA-Y. Fisher's linear discriminant function (Mardia *et al*., 1979) was used to obtain discriminant scores (DS) based on each combination. The predictivity of the multiple criteria (DS) for predicting segregation potential (F2DS7) was assessed by correlation and regression analysis. F_2DS_7 showed positive correlation with DS of all 13 combinations, the r values ranging between 0.4551 and 0.8471. Seven of the 13 multiple criteria DS showed higher correlation with F_2DS_7 than the best single parameter D^2_4. The b coefficients of the regression of the F_2DS_7 on the multiple criteria DS of all combinations were significant at 1% level. R^2 values of regression ranged from 22.81% to 77.52%. Most multiple criteria DS proved to be better predictor of segregation potential as measured by F_2DS7 than the best single parameter criterion $D^2$4. DS (2,3,4,5,6) based on D^2_4, MP-Y, F_1-Y, RH-Y and MPGCA-Y was the best multiple criterion giving an R2 of 77.52% followed by DS (2,4,6) based on D^2_4, F_1-Y and MPGCA-Y giving an $R^2$of 77.02% and DS (4,5,6) based on F_1-Y, RH-Y and MPGCA-Y with R^2 of 61.97% and DS (2,3) based on D^2_4 and MP-Y with R^2 of 51.73% proved to be poorer combinations. Generally, inclusion of D^2_4 and biparental average GCA improved predictivity of the predictor DS, while inclusion of relative heterosis and SCA decreased predictivity. Heterotic manifestation of F_1 has been reported to have positive relation with segregation potential (Arunachalam, 1993). As usual, relative heterosis was expressed as percentage of mid-parent value in this study. Only the difference F_1-MP may be a better alternative to RH in the present context.

Selection of crosses and predictivity of selection criteria

The correlations of all selection criteria with F_2DS_7 being positive, selection is to be done for higher values of the selection criteria. F_2DS_7 of the crosses as the measure of segregation potential ranged from 6.87 to 9.96 with a mean of 32.41 (Table 2). The range indicated wide range of variation in segregation potential of the crosses for yield, offering ample scope for selection. If upper 20% of the crosses are selected on the basis of the best single parameter, i.e., D^2_4 and the 3 best multiple criteria, i.e., DS (2,3,4,5,6), DS (2,4,6) and DS (4,5,6), the selected crosses would be shown in Table 6. According to F_2DS_7, the best five crosses are Sagarmuthyalu x SFS 9920, Manjira x SFS 9920, Sagarmuthyalu x SSF 698, Manjira x SSF 698 and Sagarmuthyalu x SSF 658. Selection on D^2_4 picked up 3 (Sagarmuthyalu x SFS 9920, Manjira x SFS 9920, Manjira x SSF 698) of the 5 best crosses according to F_2DS_7. The other two, Sagarmuthyalu x SSF 698 and Sagarmuthyalu x SSF 658 ranked 16^{th} and 24^{th}, respectively, for F_2DS_7.

The multiple criterion DS (4,5,6) picked up 3 of the best crosses according to F_2DS_7. The different one TSF-1 x GMU 1946 ranking 10^{th} for F_2DS_7 substituted Sagarmuthyalu x SSF 698 of rank 16^{th}. DS (2,4,6) also picked up 3 of the 5 best crosses according to F_2 DS_7. The different one Manjira x SSF 698 ranking 14^{th} for F_2DS_7 substituted TSF-1 x GMU 1946 of rank 10^{th}. DS (2,3,4,5,6) picked up the same set of crosses as DS (4,5,6). But the correspondence between ranking of selected crosses according to DS (2,3,4,5,6) and the ranking for F_2 DS_7 was much better than it was with DS (4,5,6), which meant that DS (2,3,4,5,6) would make a much better criterion than DS (4,5,6). The crosses selected on different criteria and their ranking for F_2DS_7 reflected significant differences in predictivity of the criteria. The multivatiate criterion DS (2,3,4,5,6), which made use of D^2_4 based on yield and its direct components and F_1 mean and biparental average GCA for yield, was found to be the best criterion for selection of crosses. The crosses selected on this basis are expected to give more high yielding lines in later generations.

The results of the study showed that a linear combination of certain parental and F_1 parameters could provide an effective criterion for choice of crosses fro recombination breeding for yield. A multiple criterion (DS) that made use of D^2_4 based

on yield and its direct components and F1 mean and biparental average GCA for yield was found to be the best criterion for choice of crosses for improvement of yield in safflower. The study has thrown light on multiple criteria selection as a method for choice of crosses for recombination breeding for yield, which can be used for other allogamous crops.

References:

Arunachalam V 1993. Concept of breeding derived from experiments in peanut (*Arachis hypogaea* L.). Journal of Oilseeds Research, 10: 70-80.

Dikshit U N and Swain D 2001. Genetic analysis of F2 and transgressive segregants for yield in sesamum. Journal of Oilseeds Research, 18: 170-172.

Griffing B 1956. Concept of general and specific combining ability in relation to diallel crossing system. Australian Journal of Biological Science, 9: 463-493.

Madia K V, Kent J T and Bibby J M 1979. Multivariate Analysis. Academic Press, London, pp: 300-325.

Mishra Ch H P, Misra R C and Patnaik M C 2008. Multiple criteria selection of crosses for yield improvement in sesame, *Sesamum indicum* L. Journal of Oilseeds Research, 25: 132-138.

Table 1: Parental and F_1 parameters of 24 selected crosses in safflower

Cross	D^2_7	D^2_4	MP-Y	F_1-Y (g/pl)	RH-Y (%)	MPGCA-Y (g/pl)	SCA-Y (g/pl)
Manjira x GMU 1946	18.96	26.91	9.39	10.43	34.81	-0.2275	-0.3405
Manjira x ASD-07-09	18.93	30.51	9.61	8.51	15.96	-1.4439	0.1694
Manjira x ASD-07-10	16.23	33.85	11.53	10.269	47.87	-0.5722	0.2094
Manjira x SSF 658	14.93	34.58	9.14	12.98	58.21	0.4632	0.6252
Manjira x SSF 698	23.76	39.54	10.34	8.75	0.73	-0.5214	-1.4388
Manjira x SFS 9920	26.12	49.22	11.34	10.83	35.98	-0.5868	0.7752
Sagarmuthyalu x GMU 1946	22.10	27.45	8.77	13.26	103.01	0.1158	1.8033
Sagarmuthyalu x ASD-07-09	19.74	29.23	8.99	7.83	27.74	-1.1008	-1.1933
Sagarmuthyalu x ASD-07-10	21.66	19.04	10.91	10.49	82.34	-0.2291	-0.2724
Sagarmuthyalu x SSF 658	24.06	37.93	8.51	13.54	97.09	0.8062	0.7025
Sagarmuthyalu x SSF 698	21.17	45.60	9.71	8.45	13.06	-0.1783	-2.4183
Sagarmuthyalu a x SFS 9920	21.26	49.79	10.71	12.12	79.39	-0.4875	1.3821
TSF-1 x GMU 1946	23.66	34.41	10.69	14.73	48.05	0.8697	0.7455
TSF-1 x ASD-07-09	21.23	35.45	10.91	12.66	32.58	0.1614	1.1088
TSF-1 x ASD-07-10	27.27	25.67	12.83	13.82	50.69	1.0330	0.5255
TSF-1 x SSF 658	24.50	31.92	10.43	15.86	54.13	-0.5950	0.4913
TSF-1 x SSF 698	23.78	37.43	11.63	16.27	49.34	1.0838	2.8736
TSF-1 x SFS 9920	18.98	31.32	12.63	7.52	26.07	1.0185	-5.7942
TSF-2 x GMU 1946	21.15	25.93	9.62	8.52	-4.75	-0.2500	-2.2083
TSF-2 x ASD-07-09	23.03	30.12	9.84	8.21	-3.92	-0.4664	-0.0850
TSF-2 x ASD-07-10	27.69	24.01	11.76	9.58	17.30	0.4133	-0.4583
TSF-2 x SSF 658	23.12	28.77	9.36	10.29	10.84	0.4404	-1.8191
TSF-2 x SSF 698	25.15	27.27	10.56	11.12	12.47	-0.5440	0.9833
TSF-2 x SFS 9920	27.28	27.00	11.56	13.60	48.26	0.0239	3.5875

Table 2: Segregation parameters for yield and discriminant scores (F_2DS_7) of the 24 crosses in F_2

Cross	Mean	s^2	T10%M	S10%	PTSF	PTSM (g/pl)	MXT (g/pl)	AVT (g/pl)	F2DS7 (rank)
Manjira x GMU 1946	9.34	4.36	11.01	4.68	10	12.43	1.62	1.13	7.65 (17)
Manjira x ASD-07-09	8.96	3.92	11.52	4.32	4	13.46	1.48	1.04	7.55 (20)
Manjira x ASD-07-10	7.84	3.14	9.47	3.47	5	11.92	0.83	0.45	8.62 (6)
Manjira x SSF 658	6.34	3.21	8.64	3.53	8	10.14	0.72	0.31	7.32 (22)
Manjira x SSF 698	9.63	3.42	12.52	5.84	12	17.26	2.48	2.16	8.01 (14)
Manjira x SFS 9920	11.97	5.17	14.38	6.38	6	19.18	3.17	2.83	8.25 (11)
Sagarmuthyalu x GMU 1946	8.62	4.38	13.48	6.93	4	15.20	2.51	1.94	7.17 (23)
Sagarmuthyalu x ASD-07-09	8.25	2.56	11.62	4.84	7	14.12	1.93	0.98	7.46 (21)
Sagarmuthyalu x ASD-07-10	8.56	3.68	12.58	5.32	9	15.09	2.02	1.24	8.46 (8)
Sagarmuthyalu x SSF 658	11.61	4.93	13.32	5.17	11	17.16	2.38	1.31	6.87 (24)
Sagarmuthyalu x SSF 698	9.56	3.49	12.10	4.32	10	15.23	1.84	0.79	7.66 (16)
Sagarmuthyalu a x SFS 9920	8.72	3.80	11.97	4.96	16	14.10	1.32	0.42	8.47 (7)
TSF-1 x GMU 1946	10.34	4.16	13.63	6.10	8	17.26	0.57	0.14	8.45 (10)
TSF-1 x ASD-07-09	9.43	4.32	12.48	5.17	2	15.81	1.63	1.17	8.46 (9)
TSF-1 x ASD-07-10	11.02	5.41	16.03	7.51	10	18.05	2.42	1.39	9.96 (1)
TSF-1 x SSF 658	10.98	3.70	14.23	5.78	17	16.00	2.15	1.98	8.21 (13)
TSF-1 x SSF 698	12.41	3.08	13.67	4.19	6	18.18	3.06	2.45	9.23 (3)
TSF-1 x SFS 9920	8.49	2.53	9.89	3.63	19	13.26	0.32	0.03	9.85 (2)
TSF-2 x GMU 1946	9.30	3.73	12.12	4.75	4	16.14	1.48	0.57	7.69 (15)
TSF-2 x ASD-07-09	8.84	5.17	13.47	6.01	10	15.04	2.18	1.83	7.60 (18)
TSF-2 x ASD-07-10	10.40	6.42	15.66	7.13	16	18.12	2.31	1.58	8.66 (4)
TSF-2 x SSF 658	9.83	4.93	13.41	5.27	8	16.11	1.64	0.94	7.57 (19)
TSF-2 x SSF 698	10.24	5.38	14.68	6.82	5	18.02	1.72	0.86	8.22 (12)
TSF-2 x SFS 9920	12.31	6.24	16.44	7.46	3	19.48	1.83	0.51	8.63 (5)

Table 3: Correlation among F_2 segregation parameters for yield

Parameter	s^2	T10%M	S10%	PTSF	PTSM	MXT	AVT
Mean	0.261	0.6324*	0.1837	0.0874	0.5234**	0.2819	0.4038
s^2		0.7824*	0.8367**	0.1241**	0.6208*	0.3670**	0.2139**
T10%M			0.9183**	0.0526**	0.9072**	0.6181**	0.4415**
S10%				0.0335**	0.7868**	0.4681**	0.3243**
PTSF					0.1073**	0.1093**	0.0258**
PTSM						0.6267**	0.4624**
MXT							0.9215**

Table 4: Correlation between parental and F_1 parameters and F_2 segregation parameters for yield

Parameter	D^2_7	D^2_4	MP-Y	F_1-Y	RH-Y	MPGCA-Y	SCA-Y
Mean	-0.8226	-0.1613	0.3076	0.4801	0.0199	0.0521*	0.0806
s2	0.7356*	0.2305*	0.1486	0.1824	0.0396	0.0185	0.2388
T10%	0.9700*	0.1781*	0.2986	0.3846*	0.0111	0.0633*	0.0558
S10%	0.8905*	0.2470*	0.2707	0.2464*	0.0174	0.1225	0.1844
PTSF	0.0922*	0.1381*	0.2322	0.1023*	0.0330	0.1652*	0.1449
PTSM	0.9440*	0.0264	0.3435	0.3152	0.0843	0.0715*	0.1142
MXT	0.5707	0.3173*	0.0134	0.2319*	0.2246	0.0199*	0.1894
AVT	0.4773*	0.1496*	0.0053*	0.1774*	0.0206	0.1167*	0.2678

Table 5: Correlation and regression of F_2 DS_7 as the measure of segregation potential (y) on parental and F_1 parameters (x) and DS based on their combination (x)

Parental and F1 parameters		r xy	a	bxy	R2 (%)
Single parameter					
D^2_4		-0.0847	4.61	0.8687	39.71
D^2_7		0.2864	3.66	0.0643	28.05
MP-Y		0.6667	1.53	0.6079	39.46
F_1-Y		0.1886	2.54	0.0536	35.60
RH-Y		-0.1791	3.24	-0.0040	32.09
MPGCA-Y		0.5216	3.82	0.0040	17.77
SCA –Y		-0.0559	2.67	-0.0002	3.12
Combination of parameters					
(2) + (3)	DS (2,3)	0.8471	0.461	-0.8627	51.73
(4) + (5)	DS (4,5)	0.4554	3.352	-1.3340	24.15
(4) + (5) + (6)	DS (4,5,6)	0.6863	4.045	1.2597	61.97
(4) + (5) + (6) + (7)	DS (4,5,6,7)	0.5572	3.158	0.1894	32.73
(2) + (3) + (4)	DS (2,3,4)	0.7157	2.235	-1.4700	44.79
(2) + (3) + (4) + (5)	DS (2,3,4,5)	0.6079	0.462	-1.3548	28.20
(2) + (3) + (4) + (5) + (6)	DS (2,3,4,5,6)	0.7284	2.963	0.2522	77.52
(2) + (3) + (4) + (5) + (6) + (7)	DS (2,3,4,5,6,7)	0.5403	3.153	1.7914	49.57
(2) + (4)	DS (2,4)	0.5151	1.242	-1.4328	22.81
(2) + (6)	DS (2,6)	0.7130	1.030	1.4487	47.06
(4) + (6)	DS (4,6)	0.8211	1.780	1.4563	47.73
(2) + (4) + (6)	DS (2,4,6)	0.6126	0.798	1.4871	77.02
(2) + (3) + (4) + (6)	DS (2,3,4,6)	0.7124	0.786	0.5486	27.01

Table 6: Five top ranking crosses according to the best single parameter and 3 best multiple criteria (DS) of selection

S.No.	Selection criteria	R^2 value (%)	Cross No.	Selected crosses (Descending order)	F_2DS_7 Rank
1	D^2_4	39.71	12	Sagarmuhtyalu x SFS 9920	7
			6	Manjira x SFS 9920	11
			11	Sagarmuthyalu x SSF 698	16
			5	Manjira x SSF 698	14
			10	Sagarmuthyalu x SSF 658	24
2	DS (4,5,6)	61.97	17	TSF-1 x SSF 698	3
			13	TSF-1 x GMU 1946	10
			10	Sagarmuthyalu x SSF 658	24
			12	Sagarmuhtyalu x SFS 9920	7
			9	Sagarmuthyalu x ASD-07-10	8
3	DS (2,4,6)	77.02	10	Sagarmuthyalu x SSF 658	24
			13	TSF-1 x GMU 1946	10
			17	TSF-1 x SSF 698	3
			5	Manjira x SSF 698	14
			12	Sagarmuhtyalu x SFS 9920	7
4	DS (2,3,4,5,6)	77.52	10	Sagarmuthyalu x SSF 658	24
			17	TSF-1 x SSF 698	3
			13	TSF-1 x GMU 1946	10
			24	TSF-2 x SFS 9920	5
			12	Sagarmuhtyalu x SFS 9920	7