A COMPARATIVE STUDY ON DIALLEL AND PARTIAL DIALLEL ANALYSES

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Many workers have studied the efficiency of partial diallel in comparison with full diallel in self- and cross-pollinated crops (Murty, Arunachalam and Anand, 1967; Harinarayana and Murty, 1970; and Dhillon, 1973). The inferences regarding optimum number of crosses per parent which provides estimates of different components of genetic variation, the yield potential and general combining abilities of the lines tested, varied from study to study. However, in general, it was concluded that precision of estimates was observed to be influenced by nature and magnitude of genetic variability present in addition to number of crosses. Most of the earlier studies provide information regarding the comparison of designs in diallel without reciprocals, assuming that no reciprocal differences exhist. However, it is to be seen whether reciprocal differences due to maternal effects, if present, create any disturbance in the precision of the estimates of genetic parameters in the partial diallel as compared to full diallel. Also very little information is available with regard to the efficiency of partial diallel in case of often-cross-pollinated crop like Sorghum. In the present study, attempts are being made to obtain such informations in certain agronomic (grain yield, days to flower and 100-grain weight) and quality traits (protein and lysine contents).

Materials and Methods

Eight varieties representing diverse grain quality and head types were chosen for inclusion in a full diallel mating design. All possible reciprocal crosses were also made. The pedigree, origin and salient features of these varieties have been reported elsewhere (Govil and Murty, 1973). All possible 56 crosses among these varieties, alongwith parents were grown at Delhi (29°N) and Coimbatore (11°N) during the year 1968–69. A randomized complete block design with two replications was used at both the locations. All the entries were planted in single row plots of 240 cm. length. Observations were recorded on the five randomly selected plants from each experimental row for the characters namely, protein content in flour expressed as percent of the dry weight, lysine percent of protein, grain yield per plant (gm), 100-grain weight (gm) and days to 50 percent flowering.

Combining ability analysis in diallel was based on Model I, Method I of Griffing (1956). Following the procedures outlined by Kempthorne and Curnow (1961), partial diallel sets corresponding to $s=5$ and 3 were derived from the full diallel sets. Combining ability analysis in partial diallel was computed accordingly (Kempthorne and Curnow). The method used for the analysis of protein content and lysine were based on "Association of Official Agricultural Chemicals" (1970). Crude protein was estimated by Micro-Kjeldahl method. Biological assay of lysine was done using *Leuconostoc mesenteroides* (p-60) for the assay.

Results

The analysis of variance of the cases $s=7$, 5 and 3 for all the five characters at both the locations, Delhi and Coimbatore are presented in Table 1.

TABLE 1

Diallel and fractional diallel analysis of combining ability in F_1 of 8×8 diallel for five characters in sorghum at Delhi and Coimbatore

Character	Source	s= d.f.	Mean squares 7 Delhi	7 Coimbatore	5 Delhi	5 Coimbatore	3 Delhi	3 Coimbatore
Protein content	*gca*	7	13·69**	2·41**	5·74**	1·84**	11·79**	1·18
	sca	28–4	11·17**	1·79**	21·31**	3·53**	42·20**	4·64**
	R. E.	28–12	1·18**	1·06**	14·86**	2·76**	21·90**	2·26**
	Error	63–22	0·56	0·35	1·29	0·70	1·16	0·67
Lysine content	*gca*	7	0·10**	0·10**	0·08	0·05	0·06	0·06**
	sca	28–4	0·04**	0·05**	0·14**	0·13**	0·18**	0·25**
	R. E.	28–12	0·04**	0·03*	0·12**	0·12**	0·10**	0·15**
	Error	63–22	0·02	0·02	0·04	0·04	0·04	0·01
100-grain weight	*gca*	7	6·86**	1·89**	2·66**	0·40**	1·96*	0·27**
	sca	28–4	0·84**	0·21**	2·45**	0·75**	5·41**	1·02**
	R. E.	28–12	0·38	0·32**	2·40**	0·63**	3·35**	0·54**
	Error	63–22	0·27	0·03	0·70	0·04	0·54	0·05
Grain yield	*gca*	7	1516·30**	291·55**	909·02	141·00	1326·44**	102·92
	sca	28–4	777·21**	261·46**	1332·02**	395·54**	4620·98**	692·90**
	R. E.	28–12	216·73	91·19**	1134·53**	306·55**	1582·53**	299·06**
	Error	63–22	148·58	41·49	411·39	82·19	264·85	48·48
Days to flower	*gca*	7	1842·12**	279·99**	583·81**	80·92	387·34**	61·46
	sca	28–4	85·96*	72·25	592·42**	170·95*	833·17**	192·52*
	R. E.	28–12	42·74	33·96	577·16**	138·32*	515·01**	129·81
	Error	63–12	28·90	44·88	30·30	64·80	30·92	71·88

**Significant at 1% *Significant at 5% R. E.=Reciprocal effects.

It can be seen that variances due to reciprocal effects were found to be consistently significant for protein and lysine content at both the locations in the diallel as well as in the partial diallel cases. For the characters, 100-grain weight and grain yield, the reciprocal effects became more pronounced and significant at both the locations in the partial diallel cases only whereas for days to flower, no definite trend could be noticed. Considering the general and specific combining abilities variances, it could be seen that, in general, for most of the traits the estimates of variances appeared to be inflated in the partial diallel cases at both the locations. It is interesting to note that there was an increasing trend in the magnitude of specific combining ability variances from $s=7$ to $s=3$, whereas the estimates of general combining ability did not show any such pattern in the change in magnitude.

The magnitude of general combining ability variance was found to be higher for all the five characters in the diallel analysis at both the locations. For most of the characters, the specific combining ability variances exceeded the corresponding general combining ability variances in the partial diallel analysis of different sizes at both the locations. The estimates of variance due to reciprocal effects also showed an increasing trend in magnitude from the diallel to the partial diallel cases.

Table 2 presents the estimates of general combining ability effects of the parents and the average standard error of the differences between any two general combining ability effects for all the characters for the cases $s=7$, 5 and 3 at both the locations separately. A perusal of the table indicated that, in general, the nature of the general combining ability effects of the parents were reflected similarly in both $s=5$ and 3 cases. There was, however, differences in the magnitude of general combining ability effects for all the characters except days to flower at Delhi. The general combining ability effects of the parents were of higher magnitude in the $s=5$ and $s=3$ (in that order). For days to flower, however, no definite trend could be noticed with regard to nature and magnitude of general combining ability effects.

Based on the general combining ability effects, the top four varieties were selected at both the locations separately for $s=7$, 5 and 3 cases. It was interesting to note that irrespective of the size of partial diallel, both, diallel as well as partial diallel analyses contributed at least three out of the four top parental selections for most of the characters at both locations (Table 3). The location differences were apparent in the ordering of the parents as well as in the magnitudes of the effects.

The average standard error of the differences between any two general combining ability effects of the parents showed an increase in the magnitude from $s=7$ to $s=3$ for most of the characters.

Discussion

The advantage of partial diallel analysis in comparison to diallel analysis lies in the fact that a larger number of parents can be studied without making all

TABLE 2

General combining ability effects estimated for 8 × 8 F_1 diallel and corresponding partial diallels in sorghum for five characters at Delhi and Coimbatore

Parents	S=	Protein			Lysine			100-grain weight			Grain yield			Days to flower		
		7	5	3	7	5	3	7	5	3	7	5	3	7	5	3
I.S. 3922	I	0·99	0·74	1·93	–0·04	0·04	0·20	0·04	–0·10	–0·39	–1·74	–7·42	–31·28	–7·13	–2·85	–5·83
	II	0·02	–0·21	–0·22	0·12	0·07	–0·23	–0·09	–0·21	–0·26	–3·05	–4·73	–9·70	–2·81	–1·61	–2·53
I.S. 8353	I	–0·52	–0·78	–3·38	0·01	–0·03	–0·05	0·06	–0·15	–1·05	8·02	6·84	1·02	–8·18	–4·02	–11·70
	II	–0·29	–0·53	–0·17	–0·11	–0·16	0·06	0·06	0·08	0·02	–2·03	–9·12	–6·90	–2·24	0·95	–4·28
I.S. 3817	I	–1·88	–1·21	–2·70	–0·10	–0·16	–0·19	–1·15	–1·28	–2·19	–15·36	–19·65	–33·65	17·15	16·07	11·14
	II	0·08	0·10	–0·21	–0·03	–0·04	–0·15	–0·55	–0·49	–0·59	2·17	1·44	0·44	6·26	4·13	7·46
I.S. 3688	I	0·44	0·37	2·05	0·13	0·71	0·13	0·01	0·36	0·41	3·11	6·31	24·88	–12·23	–15·64	–14·30
	II	–0·27	0·07	–0·11	0·07	0·10	0·10	–0·22	–0·11	0·00	–5·01	–1·64	6·54	–5·56	–5·45	–0·53
I.S. 3126	I	0·73	0·83	3·72	–0·06	–0·13	–0·14	–0·53	–0·22	0·16	3·33	2·98	14·15	–2·08	–2·08	1·80
	II	0·68	0·65	0·14	–0·08	–0·02	–0·18	–0·27	–0·15	0·01	–1·20	1·07	–1·87	2·62	1·38	3·47
I.S. 675	I	0·37	0·72	3·51	–0·04	–0·82	–0·83	0·99	1·05	1·56	0·36	3·90	7·89	5·08	1·64	8·42
	II	0·45	1·05	1·21	–0·05	–0·09	–0·20	0·31	0·21	0·17	–2·82	–1·00	1·69	1·82	1·80	3·97
I.S. 10,202	I	0·34	–0·53	–1·23	0·02	0·05	0·92	0·63	0·78	1·88	14·12	22·24	30·93	–5·98	–9·05	–3·23
	II	–0·28	–0·13	–0·30	0·03	0·06	0·17	0·40	0·29	0·21	7·30	8·71	15·00	–3·88	–4·11	–6·28
I.S. 968	I	–0·47	–1·77	–3·88	0·09	0·25	0·13	–0·14	–0·44	–0·20	–11·84	–15·71	–5·42	13·37	15·94	13·76
	II	–0·39	–1·00	–0·52	0·03	0·08	0·28	0·36	0·37	0·15	4·64	5·27	5·64	–3·79	4·80	–1·28
S.E. (g_i)	I	0·17			0·03			0·12			2·85			1·26		
	II	0·14			0·03			0·04			1·51			1·57		
S.E. (g_i-g_j)	I	0·26	2·33	5·46	0·05	0·18	0·34	0·18	0·78	1·95	4·31	18·52	49·66	1·90	11·69	24·38
	II	0·25	0·98	1·78	0·05	0·18	0·39	0·12	0·43	0·81	4·55	9·97	22·15	2·37	6·64	11·62
$\log_e \sigma^2_s/\sigma^2_e$	I		2·15	2·87		0·18	0·77		0·24	1·47		0·11	1·82		2·14	2·57
	II		0·65	1·15		0·14	2·12		2·14	1·98		0·57	1·87		–0·06	0·32

I=Delhi, II=Coimbatore.

TABLE 3

List of the top four general combiners (I. S. No.) for 8 × 8 F_1 diallel and corresponding partial diallels in sorghum for five characters at Delhi and Coimbatore

Character		$s=7$	$s=5$	$s=3$
Protein content	I	3922, 3126, 3688, 675	3126, 3922, 675, 3688	3126, 675, 3688, 3922
	II	3126, 675, 3817, 3922	675, 3126, 3817, 3688	675, 3126, 3688, 8353
Lysine content	I	3688, 968, 10202, 8353	3688, 968, 10202, 3922	10202, 3922, 3688, 968
	II	3922, 3688, 10202, 968	3688, 968, 3922, 10202	968, 10202, 8353, 3688
100-grain weight	I	675, 10202, 8353, 3922	675, 10202, 3688, 3922	10202, 675, 3688, 3126
	II	10202, 968, 675, 3922	968, 10202, 675, 8353	10202, 675, 968, 8353
Grain yield	I	10202,8353,3126, 3688	10202, 8353, 3688, 675	10202, 3688, 3126, 675
	II	10202, 968, 3817, 3126	10202, 968, 3817, 3126	10202, 3688, 968, 675
Days to flower	I	3688, 8353,3922, 10202	3688,10202,8353,3922	3688, 8353,3922,10202
	II	3688, 10202, 968, 3922	3688,10202,3922,8353	10202, 8353, 3922, 968

I = Delhi, II = Coimbatore.

possible F_1 combinations among them particularly in crops in which crossing is difficult. The partial diallel without causing disturbance in the estimates of genetic parameters especially general combining ability effects of the parents would tend to reduce the work load of the plant breeder. It is, however, to be found out how small the size of partial diallel can safely be made without affecting selection of parents. Earlier investigations of Murty *et al.* (1967), in linseed and Somayajulu (1970) in wheat belonging to self-pollinating system indicated that $s=n/2$ (where n is the number of parents) was a reasonable proportion of partial diallel size which did not create disturbance in the estimates of genetic parameters. Harinarayana and Ram (1968) and Harinarayana and Murty (1970) reported similar findings in a cross-pollinated crop like *Pennisetum typhoides*. There is no information available on this aspect in the often-cross-pollinated crop like sorghum. The results of the present findings appears to substantiate the findings of Murty *et al.* (1967) and Dhillon (1973). The nature of estimates of general combining ability effects and subsequent selection of top four parents made on the basis of reduced size of partial diallel ($s=3$) appear to be similar to those obtained in $s>n/2$ ($s=5$) and full diallel ($s=7$), even though there was slight changes in the order of selection and the magnitude of general combining ability effects. It is also evident that the presence of significant reciprocal effects do not produce any disturbance in the efficiency of general combining ability estimates and subsequent selection of parents.

Regarding the manitude of specific combining ability variances there was undoubtedly an upward bias in the estimates when s was reduced gradually from 7 to 3, whereas the general combining ability variance appeared to be generally unaffected.

The diallel analyses indicated that magnitude of general combining ability variances far exceeded the specific combining ability variances for most of the characters at both the locations. In other words, the relative magnitude of additive component was much higher than non-additive component. It can, therefore, be concluded that inspite of over-estimation in the specific combining ability variances in $s > n/2$ ($s=5$) and $s < n/2$ ($s=3$) of partial diallel sizes, the estimates of general combining ability effects remained unaffected leading to successful selection of top four parents out of eight parents in as low a size as $s=3$ of partial diallel. It, therefore, follows that under such situations where the trait in question is predominantly under the control of additive effects, it is possible to choose even a smaller number of crosses per parent ($s < n/2$) reaching as low as $s=3$ without adversely affecting the efficiency of selection. These conclusions remain valid even with large genotype environment interactions attributed to increasing environmental variances and standard error of differences of any two general combining ability effects of parents at two locations.

Summary

An effort is made to compare the diallel and partial diallel analyses for the quality component, fitness and grain yield in some varieties of Sorghum, differing in grain quality and panicle shape. The presence of significant reciprocal effects did not produce any disturbance in the efficiency of general combining ability effects and subsequent selection of parents in partial diallels. There was an increasing trend in the magnitude of specific combining ability variances from full diallel ($s=7$) to reduced size of partial diallel ($s=3$), whereas the estimates of general combining ability effects did not show any such pattern in the change in magnitude. Additive component was much higher than non-additive component in diallel. The estimates of general combining ability effects remained unaffected leading to successful selection of top four parents in as low a size as $s=3$ of partial diallel. Hence for characters wherein the heritability was high and degree of dominance was low even the smallest number of crosses per parent ($s=3$) gave reliable estimates without adversely affecting the efficiency of selection. These conclusions remained valid at both locations, Delhi and Coimbatore even when the differences in the performance of varieties at two locations were brought out.

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