Comparison of diallel and its modifications

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Introduction

The choice of any of the several alternative breeding procedures to be adopted for amelioration of a crop, primarily depends upon the nature and magnitude of gene actions involved in the expression of different characters and mating flexibilities. A number of sophisticated biometrical tools for estimation of genetic parameters have been developed in recent years. The different procedures when applied to same crop variety often give a different picture of genetic make up. Such discrepancy can primarily be assigned to the method of computation applied in estimating these parameters and the extent to which the assumptions involved in each method are fulfilled. Therefore, a study of the comparative efficiency of some of the biometrical procedures can be of great value in assessing the true picture of the genetic make up of a particular crop.

Comparative studies on diallel and its modifications with other methods in common use are scanty. MATZINGER, SPRAGUE and COCKLRHAM (1959) were the first to compare diallel with COMSTOCK and ROBINSON (1948) experiment I and II. Besides above designs, GARDNER (1963) included experiment III of ROBINSON *et al.* (1949) in his comparison. In 1961, KEMPTHORNE and CURNOW theoretically compared all the three diallel and showed that partial diallel was better than design I and II, whereas design III was better than partial or complete diallel. GARDNER and EBERHART (1966) compared their model with that of the HAYMAN (1954) and GHIPFING (1956) approaches. They further established the advantages of their model in which heterotic effects were further partitioned and both the general and specific combining ability effects and components of gene action were obtained.

KEARSEY (1965), was the first to compare five designs, i.e., full diallel, half diallel, partial diallel, North Carolina (NC) I and NC-II, in the light of the merits of each of these designs. He concluded that half diallel was the best. MURTY and ANAND (1966) compared diallel with partial diallel methods and showed that the partial diallel was better than full diallel particularly when more than or equal to half of the parents were sampled from each parental line in case of partial diallel experiments.

The present investigation was, therefore, undertaken to compare and assess the relative efficiency of diallel and its modified techniques in estimation of genetic parameters, such as additive, dominance, epistasis and general and specific combining ability effects using barley as the working crop.

Materials and Methods

Materials

Six exotic (AB-1259; EB-1556; PTS-57; A-59; Numer and EC-24882) and six indigenous (BG-1; K-572110; IB-226; C-164; RD-42 and BP-3) varieties of barley were selected keeping in view the diversity among them. Diallel crosses among eight of these varieties were attempted including reciprocals. Next year fresh F_1s, partial diallel and three-way crosses were attempted. The following experiments were conducted at the experimental fields of Genetics Department, Haryana Agricultural University, Hissar.

i) Fifty six F, hybrids and thirty partial diallel crosses with twelve parents were sown in a randomized block design with four replications,

ii) Sixty three-way crosses with six parents were sown in a randomized block design with four replications.

Five competitive plants were taken at random from each line in each replication for recording data on: plant height; total and effective tillers; ear length; grain yield; 100-seed weight; grain weight per ear and number of grains per ear.

Statistical analysis: For the statistical analysis the following four approaches were followed, i.e.

a) Combining ability analysis (GRIFFING, 1956),
b) Partial diallel analysis (KEMPTHORNE and CURNOW. 1961)
c) Triallel analysis (PONNUSWAMY, 1971) and
d) Diallel analysis (numerical approach of HAYMAN, 1954).

All these methods were compared using average degree of dominance ($\bar{a}$) as a base. Average degree of dominance was computed by dividing the dominance component with the additive component of genetic variance in all the methods adopted in the present invastigation. This was done with a view of finding out an overall picture of gene action revealed by the different kinds of analysis.

In an alternative approach for comparing the efficiency of the each of the analytical approaches, the following criterion was used. The parents were ranked on the basis of their average array performance under full diallel and the pooled ranks over all the characters were compared with the pooled ranking of the individual lines on the basis of gca effects, sca effects and the average degree of dominance obtained under various methods. Finally the rank correlations were calculated (SNEDECOR, 1946).

Results and Discussion

SPEARMAN'S rank correlations between average array performance and gca effects (*Table* 1) showed indentical ranking pattern (rs = 1.00) in full diallel followed by a rank correlation of 0.95 and 0.93 for half and quarter diallel, respectively. It clearly indicated that all the three methods of dallel are equally efficient. On the contrary these correlations for PD-I, II, III and IV were 0.26, 0.19, 0.54 and 0.36, respectively. All these values were non-significant with highest value in PD-111, where gca estimates were, to a certain extent, close to the full diallel. Considering the value of ($\frac{s}{n}$ X 100) being 12%, 25%, 63% and 38% for PD I, II, III and IV respectively, the above correlation values are well justified. High correlation, though non-significant, in case of PD-I11 is due to its largest proportion of sampled crosses. Clearly the efficiency of a partial diallel will depend on the size of the sampled crosses and just any random number of cross taken for a partial diallel will not give the reliable estimates. MURTY and ANAND (1966) have rightly suggested that the biasness in the estimates is more

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Table 1. — Rank Correlations.

1. Correlation between array means and the gca effect of:		
	Full diallel	= 1.000*
	Half diallel	= 0.952*
	Quarter diallel	= 0.928*
	PD-I	= 0.262
	PD-II	= 0.187
	PD-III	= 0.542
	PD-IV	= 0.363
	Pooled partial diallel	= —0.429
	Triallel	= —0.600
2. Correlation between *per se* performance and the sca effects in		
	Full diallel	= 0.890*
	Half diallel	= 0.910*
	Quarter diallel	= 0.866*
	Triallel	= 0.146
3. Correlation with respect to degree of dominance between full diallel and		
	Half diallel	= 0.952*
	Quarter diallel	= 0.903*
	PD-I	= —0.556
	PD-II	= —0.333
	PD-III	= 0.230
	PD-IV	= 0.188
	HAYMAN	= 0.667
	Triallel	= —0.111

* Significant at 5%.

common when 's' is lesser than n/2. Out of the four partial diallels studied in the present investigation, this situation was met only in PD-III. In triallel, ranking pattern of the parents was not similar to ranking pattern of full diallel. The value (rs = —0.60) was high, non-significant and negative.

Rank correlations (rs) between sca effects and the *per se* performance in case of full, half and qurter diallel were 0.89, 0.91 and 0.87 respectively indicating a high association between these two parameters. It showed that the pattern of sca effects in all the three analysis of diallel was closely related to the pattern based on *per se* performance of these crosses.

Rank correlations were also calculated for comparing these methods with respect to the degree of dominance. Full diallel was taken as control for comparing the various methods as in full diallel maximum entries are included. Rank correlations (rs) values indicated the HAYMAN approach to be the best one. In other methods, this value was eihter too high or too low. In some cases even negative values were recorded. Keeping all these factors in view the HAYMAN approach appeared to be comparatively better than the other methods.

The data on average degree of dominance *(Table 2)* showed a clear situation of over dominance for all the characters under different methods with a few exceptions. However, the values were variable for each of the characters under various methods. Estimates of average degree of dominance through various methods were, therefore, compared with respect to a particular character for a better understanding of the picture. Accordingly, all the methods were divided into four groups for each of the characters *(Table 3)*. Methods showing lowest degree of dominance were placed in Group 1 (partial dominance to complete dominance). Group 2 comprised of methods in which the degree of dominance was in the range of complete dominance to over dominance. Group 3 was comprised of methods which clearly indicated over dominance and had considerably high magnitudes. The last group contained the methods which indicated 'strikingly' high values for the degree of dominance. This classification was arbitrary and strictly characterwise.

Table 2. — Component of degree of dominance by various methods.

Characters	Griff. I	Griff. II	Griff. IV	P.D. I	II	III	IV	Triallel	HAYMAN
Plant height	5.141	5.935	2.000	6.223	0.788	0.584	1.249	30.402	1.742
Total tiller	8.682	8.808	3.906	5.164	30.708	49.308	1.040	—	2.996
Ear length	22.661	216.000	146.667	1.984	0.931	11.484	1.987	1.019	4.212
Effective tillers	7.747	7.796	3.673	3.741	17.507	23.832	1.085	1.058	3.196
Grain yield	15.601	12.083	5.572	1.615	1.260	52.860	0.520	176.124	3.083
100-seed weight	3.227	2.409	2.139	7.111	7.955	19.250	0.310	32.171	2.015
Grain weight/ear	8.750	90.000	7.000	42.000	2.500	5.500	4.300	302.958	2.911
Grains per ear	4.875	5.073	2.898	9.971	2.564	8.301	2.469	20.379	2.232

Table 3. — Characterwise classification of various methods based on the degree of dominance.

Character	I	II	III	IV
Plant height	PD-II and III	Griff.-IV, PD-IV and HAYMAN	Griff.-I and II	Triallel
Number of total tillers	PD-IV & Triallel	Griff.-IV, PD-I and HAYMAN	Griff.-I and II	PD-II and III
Ear length	PD-I, II and IV and Triallel	HAYMAN	Griff.-I and PD-III	Griff.-II and IV.
Number of effective tillers	PD-IV and Triallel	Griff.-IV, PD-I and HAYMAN	Griff.-I and II	PD-II and III
Grain yield	PD-I, II and IV	Griff.-IV and HAYMAN	Griff.-I and II	PD-III and Triallel
100 seed weight	PD-IV	Griff.-I, II and IV and HAYMAN	PD-I and II	PD-III and Triallel
Grain weight per ear	PD-II and HAYMAN	PD-III and IV	Griff.-I and IV	PD-I, Griff.-II and Triallel
Number of grains per ear	Griff.-IV, PD-II and IV and HAYMAN	Griff.-I and II	PD-I and III	Triallel

A review of the literature, clearly indicated the degree of dominance ranging from partial to over dominance with the highest degree of dominance being 3.64. Present grouping demonstrated that group 1 and 2 were in agreement with the previous findings, whereas group 3 and 4 were the consequence of some abnormality. GARDNER (1963) indicated that in early generations, the values tended to be over-estimated because of the upward bias due to the repulsion phase of linkage. In later generations, the linkage was broken due to recombinations and a low degree of dominance was obtained. Keeping this factor and also the sampling errors in view, group 1 indicated partial dominance and group 2 over dominance. Groups 3 and 4 gave higher values. Now considering methodwise it can be clearly explained that HAYMAN (1954) was the only method which was lying in group 1 or 2. Hence the HAYMAN numerical approach was considered to be the best method.

Summary

The present investigation was planned to compare the relative efficiency of diallel and its modifications. Using six exotic and six indigenous varieties of barley the following experiments were conducted (a) Full diallel involving eight parents, (b) Partial diallel of twelve parents and (c) Triallel of six parents. The data were analysed following (a) GRIFFING, 1956 (b) KEMPTHORNE and CURNOW, 1961 (c) PONNUSWAMY, 1971 and (d) HAYMAN, 1954 approaches. For estimation of gca effects, it was found that half diallel and quarter diallel were as efficient as full diallel. The efficiency of partial diallel I (n = 12, s = 5), II (n = 12, s = 3), III (n = 8, s = 5) and IV (n = 8, s = 3) was far below those of full, half and quarter diallel. From among the partial diallels, however, PD III was the most efficient. In triallel analysis the ranking pattern of the parents on the basis of gca effects was not similar to that of full diallel. For estimation of sca effects also half and quarter diallels were similar to the full diallel. Considering average degree of dominance as a criterion of comparison, HAYMAN's approach was found the best followed by quarter diallel and partial diallel for grain yield. The situation was, however, different for different characters. The estimates of genetic parameters were discussed in view of their significance in barley breeding.

Key words: Half diallel, partial diallel, quarter diallel, triallel, degree of dominance, rank correlations.

Zusammenfassung

Zum Vergleich der relativen Effizienz des Diallels und seiner Modifikationen wurden ein Voll-Diallel mit 8 Sorten, partielle Diallele mit 12 Sorten und ein Triallel mit 6 Sorten erstellt, wobei die Modelle von Griffing, Kempthorne und Curnow, Ponnuswamy und Hayman verwendet wurden. Es hat sich dabei herausgestellt, daß ein Viertel- und ein Halb-Diallel genau so effizient sein können wie ein Voll-Diallel. Dagegen ergaben partielle Diallele weniger gute Schätzungen. Zur Schätzung des Dominanzgrades des Ertrages war das Modell von Hayman den anderen überlegen.

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Genotype x Environment Interaction and Genotypic Stability in Loblolly pine*

III. Heterosis and heterosis × environment interaction

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Introduction

Because forest trees must withstand the vagaries of changing environments for many years, tree breeders have been deterred from exploiting chance heterotic combinations among genotypes which may otherwise have very restricted genetic bases. However, heterosis has been exploited or is of great potential utility at some phases of a tree improvement program. The most obvious is when inter-specific and inter-racial crosses prove far superior to intra-population selections. As examples, hybrids of European larch × Japanese larch (ROHMEDER, 1963) and of *Pinus taeda* × *P. rigida* (HYUN, 1969) are superior to either pair of parent species and are being commercially produced. The superiority of inter-racial crosses between Swedish and central European races of Norway Spruce (NILSSON and ANDERSON 1970, NILSSON 1974) is also well documented. Some heterosis upon inter-racial crossing in Douglas fir has been reported by ORR-EWING (1969) and, to a lesser degree, in loblolly pine (WOESSNER 1972).

Loblolly pine has a wide natural range and the results of Southwide seed source study (WELLS and WAKELY 1966) in-

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