Madras Agric. J., 83(4): 230-236 April 1996
https://doi.org/10.29321/MAJ.10.A01011

DIALLEL, TRIALLEL AND QUADRIALLEL ANALYSES FOR GRAIN YIELD IN MAIZE

S. GIRIDHARAN , M.N.PRASAD AND S.R.SREE RANGASWAMY

Tamil Nadu Rice Research Institute
Tamil Nadu Agricultural University
Aduthurai 612 101

ABSTRACT

Diallel, triallel and quadriallel analyses were studied for grain yield in six maize inbreds. The mean phenotypic expression and range of variation for grain yields wassuperior in single cross hybrids than thethree way cross hybrids, parents and double cross hybrids, in the sequence mentioned. The general combining ability effect of the inbreds was pronounced in diallel only. The parent order was very clearly elcuidated in triallel and quadriallel. Though both additive and non additive gene action was observed in diallel, further partitioning the genetic components of variances in triallel and quadriallel analyses indicated predominance of non- allelic interactions involving dominance, suggesting that grain yield could be improved by heterosis breeding. Related inbreds could also be developed by selfing the superior crosses. The single cross hybrid 88/261 out yielded the three way or double corss hybrids. More number of economic hybrids for grain yield was observ ed in the three way crosses.

KEY WORDS : Maize, yield, Diallel, Triallel, Quadriallel Analysis

Maize (*Zea mays L.*) has seen a number of break through in production through the evolution of single, three way and double corss hybrids, composites and synthetics. The present study was carried out for the better understanding of six maize inbreds with reference to their combining ability effects, gene action and parent order for the character grain yield by applying to diellel, triallel and quadriallel analyses.

MATERIALS AND METHODS

Six maize inbreds *via.*, UMI 62, UMI65, UMI 88, UMI180, UMI 261 and UMI 53 (herein after referred by their numbr) were used as parents. During 1982, a set of 15 direct crosses was effected in diallel fashion. In the second season, 60 three way and 45 double crosses were made. Simultaneously, the 15 direct crosses resynthesised and the parents selfed.

The seeds of six inbred parents, 15 single, 60 threeway and 45 double cross hybrids were sown during 1983 in randomised block design with three replications in plots of 4.5 x 0.6 m size by adopting 60x30 cm spacing. Data were recorded for 10 plants per entry at random for grain yield per plant. The analysis was done in IBM 600 computer in FORTRAN language at IASRI, New Delhi. Combining ability analysis was carried out by following Model I method II of Griffing (1956) for triallel study. The statistical model assigned by Rawling and Cockerham (1962) and as persented by Singh and Chaudhary (1977) was followed for quadriallel study (Tables 1-5).

RESULTS AND DISCUSSION

The mean squares for the inbreds for yield per plant was highly significant, indicating adequate variability. The *gca and sca* variances for this character was significant in diallel; general line effect of the first kind and two line specific effect of the first kind were significant in triallel and none of the combining ability effects was significant in quadriallel, evidencing the occurrence of limited specific/interaction effects in three way and double cross hybrids.

Evaluvation of different types of hybrids

The mean phenotypic expression for grain y ield per plant was higher in single cross hybriods (108.70g) than the three way cross hybrids (101.74g), inbreds (101.74g) and double cross hybrids (94.66g). The variation between the extreme values also followed the same trend with values of 61.18, 46.50, 39.28 and 32.68g respectively. The economic hybrids in three way crosses were 28.3 per cent as compared to 20 per cent for single and double cross hybrids.

Among the different kinds of hybrids

Table 1. Mean values of six parents, their 15 single, 60 three way and 45 double cross hybrids for yield per plant

Details	Yield per plant (g)
Parents	
62	80.71
65	91.55
88	98.47
180	119.99*
261	110.77*
53	108.95
Mean	101.74
CD (5%)	7.26
Single cross hybrids	
62/65	92.59
62/88	86.36
62/180	111.75*
62/261	105.84
62/53	93.31
65/88	89.16
65/180	105.12
65/261	108.09
65/53	101.43
88/180	106.41
88/261	147.54*
88/53	98.36
180/261	98.69
180/53	117.12*
261/53	93.74
Mean	103.70
CD (5%)	7.26
Three way cross hybrids	
62/65//88	110.98*
62/65//180	91.64
62/65//261	100.92
62/65//53	106.69
62/88/65	97.57
62/88/180	98.88
62/88//261	114.42*
62/88//53	111.48*
62/180//65	90.83
62/180//88	106.63
62/180//261	109.43*
62/180//53	98.54
62/261//65	94.76
62/261//88	118.08*
62/261//180	105.03
62/261//53	112.07*
62/53//65	82.96
62/52//88	110.50*
[illegible]	94.57

Table 1. Contd.,

Details	Yield per plant (g)
62/53//261	112.97*
65/88//62	91.77
65/88//180	98.12
65/88//261	126.92*
65/88//53	109.49*
65/180//62	95.33
65/180//88	82.46
65/180//53	105.38
65/180//261	122.97*
65/261//62	102.91
65/261//88	115.58*
65/261//180	92.44
65/261//53	114.17*
65/53//62	96.26
65/53//88	103.53
65/53//180	104.57
65/53//261	103.26
88/180//62	102.87
88/180//65	88.73
88/180//261	128.79*
88/180//53	105.78
88/261//62	79.04
88/261//65	104.21
88/261//180	90.56
88/261//53	102.65
88/53//62	91.80
88/53//65	74.36
88/53//180	99.67
88/53//261	108.87*
180/261//62	97.34
180/261//65	92.16
180/261//88	91.17
180/261//53	101.57
180/53//62	106.75
180/53//65	82.29
180/53//88	105.08
180/53//261	106.94
261/53//62	109.44*
261/53//65	87.20
261/53//88	113.92*
261/53//180	100.19
Mean	101.74
CD (5%)	6.84
Double cross hybrids	
62/65//88/180	99.35
62/65//88/261	84.72
62/65//88/53	91.99
62/65//180//261	99.76
[illegible]	107.52*

Table 1. Contd.,

Details	Yield per plant (g)
62/65//261/53	101.77*
62/88//65/180	87.94
62/88//65/261	96.63
62/88//65/53	80.57
62/88//180/261	89.40
62/88//180/53	107.99*
62/88//261/53	92.42
62/180//65/88	98.30
62/180//65/261	86.49
62/180//65/53	81.55
62/180//88/261	88.33
62/180//88/53	88.27
62/180//261/53	91.02
62/261//65/88	97.40
62/261//65/180	99.77
62/261//65/53	89.98
62/261//88/180	108.31*
62/261//88/53	95.37
62/261//180/53	93.63
62/53//65/88	104.53*
62/53//65/180	92.41
62/53//65/261	95.01
62/53//88/180	95.74
62/53//88/261	94.51
62/53//180/261	95.09
65/88//180/53	79.12
65/88//180/261	106.97*
65/88//261/53	112.02*
65/180//88/261	101.56*
65/180//88/53	79.34
65/180//261/53	90.38
65/261//88/180	99.63
65/261//88/53	84.83
65/261//180/53	90.77
65/53//88/180	85.09
65/53//88/261	87.36
65/53//180/261	111.74*
88/180//261/53	96.62
88/261/180/53	91.43
88/53//180/261	94.93
Mean	94.66
CD (5%)	6.86

* Significant at 5 per cent level; Figures underlined indicate highest mean value

was registered by the single cross hybrid 88/261 (147.54g) followed by the three way cross hybrid 88/180//261 (128.79g.) Weatherspoon (1970) accounted superiority of single crossesas a result of epistatic effects. Stangland and Russel (1981) highlighted the uniformity of the related single cross hybrids.

Per se and *gca* of inbreds

In diallel set, the *gca* effect was significant for the inbreds 180 and 261 with high *per se* performance as well. In triallel, none of the inbreds was significant for the general line effect of the first kind (h_i) while that of the second kind (g_i) was significant in 88, 261 and 53, indicating their use as a third parent in the make up of the three way cross hybrids. In quadriallel, one line general effect (g_i) was not significant in any of the inbreds. Thus, as the order of analyses proceeded, the general combining ability effect was restricted. Arunachalam *et al.* (1985) pointed out that *gca* of a parent is variable, determined by the nature of other parent and by the level of cross as two way, three way and so on. Simmonds (1979) brought out that *gca* values were relative and depend upon the mean of the chosen material and stressed the importance of *sca* effect in selecting crosses for selection.

sca, specific and interaction effects

The significant *gca* effect with high *per se* of the inbreds 180 and 261 combined to produce the highest significant *sca* effect in the single cross 180/261 but its hybrid mean was poor. Three crosses *viz.*, 180/261, 62/53 and 62/180 registered significantly positivie *sca* effect but significantly positive hybrid mean coincided only in 62/180. Likewise, significantly positive hybrid mean in crosses 88/261 and 180/53 had poor *sca* effect. Such situations of best F_1 performers not having significant *sca* effect and *vice versa* was reported by Sharma *et al.* (1984) in barley which may be due to the interaction leading to over dominance or transgressive segregation. Rao (1972) indicated the importance of genetic diversity of lines besides other estimatees.

The cross 62/53 neither had high *per se* performer nor with sinificant *gca* effect, but accounted significant *sca* effect. Baker (1978) attributed to this situation to the rare occurrence of additive gene action. The *sca* effect would increase with greater genetic divergence also (Inoue, 1984). In such situations, mean performance should be

Table 2. ANOVA for combining ability variances for grain yield per plant

Diallel

Details	Estimates
MSS for *gca* at 5 df	376.275**
MSS for *sca* at 20 df	150.677**
MSS for error at 40 df	31.805

Triallel

Source	df	Mean sum of squares
General-line effect of the first kind (h_i)	5	2201.320**
General-line effect of the second kind (g_i)	5	130.570
Two-line specific effect of the first kind (d_{ij})	9	5383195.300**
Two-line specific effect of the second kind (S_{ij})	19	285.613
Three line specific effect (t_{ijk})	21	138.714
Due to crosses	59	381.431**
Duto to h_i eliminating g_i effects	5	2155.792**
Due to d_{ij} eliminating s_{ij} effects	9	174.541
Error	118	104.926

Quadriallel

Source		df	Mean sum of squares
Hybrids		44	208.330
One-line general g_i		5	147.200
Two-line specific	S_{ij}	9	141.111
Three-line specific***	S_{ijk}	5	-8.400
Four-line specific***	S_{ijkl}	5	2.760
Two-line arrangement	$t_{ij}, t_{i,j}$	9	362.556
Three-line arrangement	$t_{ij.k}$	16	156.250
Four-line arrangement	$t_{ij.kl}$	5	285.036
Error		88	202.143

** Significant at 1 per cent level

In triallel, seven three line specific effect ($t_{ij.k}$) were significant but only two accounted significant three way cross hybrid mean. Similarly, out of 17 significant three way hybrids, only two had significant three line specific effect. The highest yield (128.79g) registering three way cross hybrid (88/180//261) also had non significant three line specific effect. This situation is due to one or combination of : F_1 interaction with the thrid parent, diverse inbreds superimposing one inbred's effect over the other, intercancellation of specific effects among inbreds, linkage of complete or over dominant genes in repulsion phase, in-interactions of inbreds leading to masking of phenotypic expressions. Inbreds 261, 88 and 53 occurred as a third parent in 7, 5 and 4 intances, clearly substatiating their general line effect of the second kind (gi). Inbred 261 as third parent occurred in the high yielding three hybrids. The two line specific effect of the first kind (dij) was significant only in 65/261. The two line specific effect of the second kind (Sij) and reciprocals (sji) were significant in three combinations each, wherein the former had 88 and 261 as immediate parents.

In quadriallel, one line general effect (g_i) was not significant for any of the inbreds but relatively high positive value was registered by the inbred 261. Variances due to three line (S^2t_3) and four line (S^2t_4) specific effects could not be estimated due to the use of 6 inbreds in this study as against the requirement of 8. The four line interaction effect due to a particular arrangement (tij.k1) was not significant in any of the double cross hybrids, but grain yield per plant was significant in nine double cross hybrids, 65/88//261/53 registered the highest grain yield of 112.02 g with a maximum non significat four line interaction effect of 5.792. Inconsistancy between interaction effects and hybrid means was earlier explained in diallel and triallel analyses. Rawlings and Cockerham (1962)

Table 3. General combining ability effect of the parents for grain yield

Parents	Diallel *gca* effect	Triallel-General line effect		Quadriallel one line general effect (g_i)
		First kind (h_i)	Second kind (g_i)	
62	-3.855	1.152	-3.936	0.020
65	-5.998*	-0.656	-12.496*	-3.392
88	-5.524*	0.483	4.147	-0.611
180	9.200*	-2.186	-5.048*	0.525
261	8.093*	2.559	12.835*	1.322
53	3.310	-1.353	4.498	-0.862
	(SE = 3.310)	SE (h_i) = 1.988	SE (g_i) = 2.515	SE (g_i) = 1.945

Table 4. Specific combining ability effect of the hybrids for grain yield per plant

Effect	cross combination and value		SE
Diallel			
sca effect	62/180 (11.508*)	180/261 (27.003*)	4.080
	62/53 (11.583*)	53/261 (-12.066*)	
Triallel			
Three line specific effect (t_{ijk})	62/53//261 (10.398*)		($t_{ij.k}$) 4.890
Two line specific effect of the first kind (d_{ij})	65/261 (4.562) Maximum		(d_{ij}) 3.507
Two line specific effect of the second kind (s_{ij})	62//88 (7.251*)	62//261 (-6.459*)	(s_{ij}) 3.078
Two line specific effect of the of second kind (s_{ji})	88/62 (-7.985)*	180//62 (6.176*)	(s_{ij}) 3.078
	53//62 (6.202*)	53//65 (-9.363*)	
	180//88 (-9.389*)		
Quadriallel			
Four line interaction effect of line ijkl due to a particular arrangement ($t_{ij.kl}$)	62/180//65/88 (5.792) Maximum	62/180//261/53 (5.792) Maximum	($t_{ij.kl}$) 42.371
	65/88//261/53 (5.792) Maximum		
Four line interaction effect of line ijkl due to irrespective of arrangement (s_{ijkl})		65/88//180/261 (2.379) Maximum	(s_{ijkl}) 18.680
Three line interaction effect of line i.j and k due to a particular arrangement (ij) (k-) i.e., ($t_{ij.k}$)		62/180//261 (4.972) Maximum	($t_{ij.k}$) 14.811
Three line inteaction of line i.j and k irrespective of arrangemnet (s_{ijk})		65/88//261 (0.879) Maximum	(s_{ijk}) 7.642
Two line interaction effect of line i and j due to a particular arrangement (ij) (--) i.e., (t_{ij})		65/88 (6.619) Maximum	$t_{(i.j)}$ 5.739
Two line interaction effect of line i and j due to a particular arrangement (i-) (j-) i.e. ($t_{i.j}$)		53//65 (2.159) Maximum	($t_{i.j}$) 5.228
Two line interaction effect of line i and j resspective of arrangement i.e., (s_{ij})		88//261 (0.840) Maximum	(s_{ij}) (3.568)

* Significant at 5 per cent level; Maximum values given in all effects were not significant

attributed that the effects arising due to arrangements of line are exclusively the results of dominance and interactions involving dominance showing high *sca* effect or high F_1 performer involving one good and one poor general combiner/performer could produce desireable

Table 5. Estimates of genetic components of variances for grain yield per plant

Components	Diallel	Triallel	Quadriallel
Additive	376.275	258.957	-271.747
Non-additive	150.677	-	-
Dominance	-	-1727.903	860.891
Additive x Additive	-	925.331	221.113
Additive x Dominance	-	2540.315	-2182.169
Dominance x Dominance	-	-817.075	350.549
Additive x Additive x Additive	-	-	1348.966

present in the good combiners/performers and the complementary spistatic effects in the F_1s acted in the same direction to maximise the desireable plant attributes.

None of the three line interaction effect of lines due to a particular arrangement ($t_{ij.k-}$) or irrespective of arrangement ($s_{ij.k-}$), two line interaction effect of lines due to a particular arrangement ($t_{ij.--}$) or irrespective of arrangement (s_{ij--}) or four line interaction effect of lines irrespective of arrangement of lines (s_{ijkl}) were significant. However, the three line interaction effect due to a particular arrangement ($t_{ij.k-}$) in respect of 62/180//261 was similarly expressed in four line interaction effect of lines due to a particular arrangement ($t_{ij.kl}$) in 62/180//261/53.

Parent order

In the present study, the parent order was clearly elucidated in both triallel and quadriallel analyses. Parent order in traillel and quadriallel analyses was earlier illustrated by Ponnuswamy *et al.* (1974) in maize. The three way cross hybrid 88/180/261 recorded the highest grain yield per plant (128.79*) with three line specific effect ($t_{ij.k}$) of 1.403; but the other forms of this triplet viz., 88/261//180 and 180/261//88 had lesser yield per plant (90.56 and 91.17g) with varying three line specific effect (0.424 and -2.321). The double cross hybrid 65/88//261/53 registered the highest yield of 112.02g with four line interaction effect due to a particular arrangement ($t_{ij.kl}$) of 5.792. The other two unrelated cross combinations 65/261//88/53 and 65/53//88/261 had very poor hybrid means (84.83 and 87.36g) and with varying negative four line interaction effect due to a particular arrangement ($t_{ij.kl}$) of -3.884 and -1.900. Thus, the parent order was very clearly brought out where in positi ing o n eds in the make u of three way or double crosses had pronounced effect not only on the specific effects but also in obtaining high hybrid means.

Gene action

In diallel set, the GCA and SCA variances were significant and was in the ratio of 2.5 : 1, indicating predominance of additive gene action. Sanghi *et al.* (1983) reported additive gene action while Nawar *et al.* (1980) and Haung *et al.* (1983) observed non-additive gene action for grain yield in maize.

Further partitioning the genetic components of variances for grain yield indicated 68:25:7 ratio for additive x dominance, additive x additive and additive in triallel analysis and 48:31:13:8 ratio for additive x additive x additive, dominance, dominance x dominance and additive x additive in quadriallel analysis. Thus in higher order analyses, the non-allelic interactions predominated and the additivity narrowed down very much. Kubecova and Vozda (1985) observed that grain yield was determined on the basis of dominance with additive x dominance, dominance x additive and additive x additive non-allelic interactions in the order mentioned, each making smaller contributions.

Inbred 261 was the best contributor for grain yield. High grain yield is obtainable at single cross level itself. Hybrids with high hybrid means or specific effects may be utilised in making related inbreds. Only proven inbred or pretested F_1s should be used as parents in three way and double cross hybrids in order to broaden the initial genetic base.

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(Received : December 1986 Revised : May 1995)

Madras Agric. J., 83(4): 236-239 April 1996

PRODUCTION POTENTIAL AND ECONOMICS OF CEREAL BASED CROPPING SYSTEM IN RED LATERITIC SOILS OF PUDUKKOTTAI DISTRICT

M.RAMASAMY, K.VAIRAVAN and K.SRINIVASAN

National Pulses Research Centre,
Tamil Nadu Agricultural University
Vamban 622 303

ABSTRACT

Field experiments were conducted in 1986 and 1987 *kharif* seasons to assess the production potential and economics of maize and *varagu* based intercropping system under rainfed conditions in red lateritic soils of Pudukkottai district of Tamil Nadu. Amog different intercrops tested, black gram is the best intercrop for maize based intercropping system and *varagu* based intercropping system. Further analysis showed that yield equivalent, land use efficiency and net profit were significantly increased by grain legumes intercrop and more than compensated the losses in main crops (maize and *varagu*). Maize and *varagu* normal sowing + one row of black gram (1:1) proved to be the best combination by recording maximum grain yield equivalent, LER and net profit.

KEY WORDS : Maize, *Varagu*, Intercropping, Production Potential, Economics

Cultivation of intercrops is a part of intensive agriculture to obtain possible means of better income under rainfed condition. Earlier experimental evidences go to show that intercropping increased maize yields upto 103 per cent, 16 to 82 per cent and 68 per cent with cowpea, mungbean and urdbean respectively (Gunasena *et al.*, 1979). Growing of green gram, black gram and cowpea has stimulating effect on maize growth and the dry matter acumulation in War and Kalra, 1981). On the other hand Searle *et al.* (1981) reported that maize had depressive effect on the dry matter yield of its intercrop. Enyi (1973) observed that grain and straw yields were reduced in maize when intercropped with cowpea, peas and pigeonpea. Mishra *et al.* (1994) observed that maize + pigeonpea at 1:1 ratio produced highest net return and LER. The present study was undertaken to assess the best legume intercrop for *varagu* and maize for augmenting the income of farmers.