Pak. J. Bot. 6 (2): 101—107, 1974.

A DIALLEL ANALYSIS OF YIELD ITS COMPONENTS IN GRAIN SORGHUM, *SORGHUM VULGARE* PERS. I. MANIFESTATIONS OF HYBRID VIGOUR.[1]

MOHAMMAD SARFARAZ KHAN

Punjab Agricultural Research Institute, Lyallpur,

AND

MOHMMAD ASLAM

Department of Plant Breeding and Genetics Agriculture University Lyallpur, Pakistan.

Abstract

A complete 6 —6 diallel cross was studied during 1967 and 1968 to measure heterosis for seven agronomic characters *viz.*, yield, number of seeds per head, number of heads per plot, plant height, days to 50% bloom and threshing percentage. Heterosis was found to be highly significant for all the seven characters, although the effect for grain yield was highly pronounced. Heterosis was striking in cases of crosses involving distinctly related parents. The increase in grain production due to heterosis came largely from more number of seeds per head, whereas 1000-seed weight and number of heads per plot showed little effect on yield.

Introduction

Although some reports on the use of diallel analysis to study the inheritance of quantitiative characters on grain sorghum have appeared in the literature, there seems to be little work done in this regard in Pakistan. Heterosis estimates computed by means of diallel crosses have been reported in sorghum by Niehaus & Pickett (1966) and Chiang & Smith (1967). Niehaus & Pickett (1966) compared the performance of F1 and F2 populations obtained from diallel crosses of eight parents. They found that heterosis was striking only if at least one of the parents was an introduction. While Chiang & Smith (1967) observed heterosis through a 7X7 complete diallel cross experiment that heterosis was highly significant for all the characters. The heterotic effect ranged from —5.09% for number of tillers bearing heads to 41.42% for head weight. Those characteristics which showed highest heterosis also had high inbreeding depression.

The present studies were planned to study the inheritance of yield and its components using diallel analysis in grain sorghum. This experiment was conducted to accomplish the following objectives for various characteristics studied:

(I) Manifestations of hybrid vigour; (II) the estimation of general and specific combining ability and the evaluation of their variance; (III) the association between yield and various components in terms of combining ability; (IV) the estimation of genotypic and phenotypic correlations between characteristics and (V) the determination of the presence or absence of maternal effects. The present paper deals with the first of these objectives only.

Materials and Methods

The genetic material comprised of six inbred lines of sorghum viz; J263, IS1041, IS 1080, IS1134, AUS13, and AUS16. The varieites J263, AUS13 and AUS16 were indigenous selections while IS1041, IS1080 and IS1134 were received from USA and have been maintained at Lyallpur since 1962. These lines were not closely related in their origin and thus provided a good deal of genetic diversity. A brief description of the varieties is given in Table 1.

1. Part of dissertation submitted by the senior author in partial requirements for the Ph. D. degree at the Agriculture University, Lyallpur, 1970.

Table 1. Two years means of six inbred lines for yield and various components of yield.

Inbred lines	Grain yield lbs./plot	1000 seed Weight(g)	Seeds per head	Heads per plot	Plant height (cm)	Days to 50% bloom	Threshing %
IS 1041	5.15	22.84	2599	40.75	182.96	73.80	70.13
IS 1080	4.85	29.44	1968	43.88	173.05	71.81	69.59
J 263	4.19	21.05	2383	43.88	162.78	66.07	67.96
IS 1134	3.98	24.44	1998	44.25	183.19	72.17	73.04
AUS 16	3.60	19.45	2161	63.00	78.41	62.90	71.20
AUS 13	3.40	19.98	1970	61.88	75.46	62.05	70.85
S. E.	0.05	0.23	30.35	0.61	1.21	0.27	0.49

*Inbred lines tabulated in the descending order of their merit in yield.

Inbred lines were grown in field during the year 1966 and crossed *inter se* to obtain seed of 30 F1 hybrids (including reciprocals). Emasculation was done by a slight modification of the method described by Stephens & Quinby (1933); by dipping the heads in hot water for 7-12 minutes before first blooming, when the temperature was maintained between 115-121°F. After emasculation , the head was bagged as soon as it was dry and the first pollination was done 1-2 days after emasulation. Second and third pollinations were made every other day thereafter. In the year 1967, six parents and 30 F1 hybrids (including reciprocals) were planted in a randomized complete block design with four replications. Within each block, tne inbred lines and crosses were grouped into separate sub-blocks bordered by appropriate non-experimental lines to eliminate uneven competition. Simultaneously, in a separate crossing block the selfing and crossing operations were repeated and the seed obtained was used for a second run of the trial during the year 1968 using exactly the same field plan as of 1967.

Each plot consisted of two 457.2 cm rows, 91.44 cm. apart, with 22.86 cm, spacing between the hills. Planting was made at the rate of two seeds per hill and when the seedlings were about 30.48cm tall, they were thinned to a stand of one plant per hill. The missing hills, if any, were filled by a second planting made after 10 days. During both years, the crop which had a mild attack of maize and sorghum borer (*Chilo zonellus* Swin) was sprayed thrice at a 10-day interval with endrin of 280 g/hs active materual. Normal cultural practices were followed throughout the season. A total of 100 kg/ha of nitrogen in the form of ammonium sulphate was applied in two split doses.

Random sample of twenty plants was harvested from each plot and data were recorded for seven characters viz; grain yield per plot, 1000-seed weight, seeds per head, heads per plot, plant height, days to 50% bloom and threshing percentage. Whole plot was takel into consideration for number of heads per plot and grain yield per plot. Heteros s was calculated after Matzinger *et al* (1962) and "t" test was used to evaluate the difference of F1 means according to Rawling's formula cited by Wynne *et al* (1970).

TABLE 2: Analysis of variance of two years data of all possible crosses including reciprocals, among six inbred lines, for yield and the components of yield.

Sources of variation	Degrees of freedom	MEAN SQUARES						
		Grain yield per plot	1000-seed weight	Seeds per head	Heads per plot	Plant height	Days to 50% bloom	Threshing %
Years	1	0.45*	4.65*	74906.67*	11.70	402.05xx	8.07	48.22**
Blocks within years	6	0.05	4.14*	55236.61**	9.69	16.68	0.98	8.30**
Crosses	29	13.80**	35.63**	2210527.41**	535.56**	8565.45**	160.96**	32.36**
Crosses X years	29	0.29**	3.31**	71846.01	9.78**	49.20**	3.74**	9.66**
Error	174	0.09	1.07	11672.01	4.87	11.64	2.13	2.75

*Significant at 5% level.

**Significant at 1% level.

TABLE 3. Mean pooled comparison for grain yield and its components for all possible crosses among six parents.

CROSSES	% increase (+) or decrease (—) of mean of F1 over mid parent and better parent values						
	Grain yield /plot	1000- seed weight	Seeds/head	Heads/plot	Plant height	Days to 5% bloom	Threshing %age
J263 × IS1041	63.81** 48.54**	11.16** 6.83**	47.84** 41.70**	5.32 *ns* 1.57 *ns*	24.49** 14.98**	1.56 *ns* —3.75**	6.67** 4.89**
J263 × IS1080	76.55** 64.54**	9.66** —5.94**	60.34** 46.38**	—3.85 *ns* —3.85 *ns*	25.49** 21.77**	9.88** 5.49**	9.38** 8.10**
J263 × IS1134	31.05** 27.92**	19.30** 11.05**	10.48** 1.56 *ns*	4.81 *ns* 4.38 *ns*	21.63** 14.86**	2.75* —1.59 *ns*	4.54** 0.92 *ns*
J263 × AUS13	79.21** 62.53**	19.30** 16.29**	43.32** 30.90**	9.34** —6.56**	67.25** 22.48**	12.83** 9.40**	6.48** 4.32**
J263 × AUS16	55.13** 44.39**	26.86** 22.04**	20.59** 14.98**	12.76** —4.35*	56.71** 16.10**	10.93** 8.28**	2.59 *ns* 00.25 *ns*
IS1041 × IS1080	58.20** 53.59**	9.03** —3.19*	47.00** 29.16ɪɪ	5.01 *ns* 1.28 *ns*	27.82** 24.36**	4.70** 3.29**	8.16** 7.61**
IS1041 × IS1134	10.07* — 2.33 *ns*	5.33* 1.88 *ns*	5.65** — 6.57**	7.51* 3.25 *ns*	9.89** 1.47**	17.43** 16.14**	—3.13* — 4.93*
IS1041 × AUS13	65.19** 37.28**	12.28** 5.25**	42.18** 24.97**	— 3.66 *ns* —20.10**	62.57** 14.89**	11.48** 2.62**	2.61 *ns* 2.22**
IS1041 × AUS16	77.85** 51.26**	15.08** 6.57**	48.46** 35.95**	— 4.59 *ns* —21.43**	46.22** 4.44**	8.13** 0.15 *ns*	1.79 *ns* 1.17*
IS1080 × IS1134	10.41* 0.62 *ns*	7.05** — 2.04 *ns*	— 3.36 *ns* — 4.08 *ns*	10.07** 9.63**	19.95** 16.63**	6.15** 5.89**	6.87** 4.35**

IS1080 × AUS13	93.46** 64.74**	11.25** — 6.62**	70.30** 70.21**	9.10** — 6.77**	47.28** 5.83**	8.46** 1.07 *ns*	8.91** 7.95**
IS1080 × AUS16	98.82** 73.40**	11.41** — 7.47**	61.28** 54.08**	20.70** 2.38 *ns*	72.02** 20.01**	7.14** 0.50 *ns*	7.10** 5.90 *
IS1134 × AUS13	81.84** 68.59**	13.82** 3.44 *ns*	56.57** 55.47**	9.29** — 6.27 *ns*	56.52** 10.58**	5.05** — 2.31**	3.07** 1.53 *ns*
IS1134 × AUS16	70.98** 62.81**	7.47** — 3.48 *ns*	48.36** 42.76**	11.24** — 4.35 *ns*	40.99** 0.67 *ns*	10.19** 3.12**	1.12 *ns* — 0.15 *ns*
AUS13 × AUS16	18.29** 15.00**	6.39* 5.01*	6.29* 1.60 *ns*	14.41** 13.40**	9.44** 7.51**	3.01* 2.32*	1.53 *ns* 1.29 *ns*
Overall heterotic effect.	59.39 44.86	12.36 3.31	37.69 29.27	7.16 — 2.52	39.22 13.11	7.98 3.37	4.51 3.03

2 readings in each cell show mid-parent and better-parent values, respectively.

*Significant at 1 % level.
**Significant at 5 % level.
n.s. Non-significant.

Results and Discussion

The F1 data for reciprocal crosses were pooled within families for the comparison of heterosis. This was justified, as reciprocal differences were in significant for all the characters studied. Analysis of variance, presented in Table-2, reveals that variation due to years for grain yield per plot, 1000-seed weight, number of seeds per head, plant height and threshing percentage was significant. but not for heads per plot and days to 50% bloom. However, th crosses X years interactions were found to be significant for all the characters studied, which indicates that yield and its various compnents were influenced by yearly enivronmental fluctuations.

As is apparent from the data presented in Table-3, all the seven characters included in the present study exhibited a considerable overall heterosis both over mid and better parent comparisons except for heads per plot which showed negative value (-2.52) over better parent estimates. In case of grain yield per plot, the increase of F1 over mid-parents ranged from 10.07 to 98.82 and over better parents from -2.33 to 73.40. The F1 hybrids IS1041 × IS1134 (-2.33%) IS1080 × IS1134 (0.62%) were non-significant against better parent comparisons. While the cross IS1080 × AUS16 which had shown the highest heterosis both over mid and better parent values in case of grain yield per plot exhibited 11.41 and -7.47 percent heterosis over mid-parent and better-parent values for 1000-seed weight, respectively, indicating comparatively less contribution of seed weight to grain yield. Similarly heads per plot also did not show considerable heterosis and the mean performance of lines IS1041, J263, IS1134 and IS1080 was relatively poor as compared to AUS13 and AUS16. Number of seeds per head showed a positive contribution to grain yield, as the crosses exhibiting significant heterotic effects also had narked heterosis for this character. In case of number of days to 50% bloom (Table-3) late blooming seems to be contributed by lines IS1041, IS1134 and IS1080 as crosses involving these lines took long time to 50% blooming. For threshing percentage, heterosis was not very high both in mid-parent and better-parent comparisons. Maximum heterosis was observed in the cross J263 × IS1080 followed by IS1080 × AUS13 with values of 9.38 and 8.91 over mid-parent and 8.10 and 7.95 over better-parent estimates. Mean performance of line J263 seems to be much better as compared to other lines.

Although the data on grain yield and 1000-seed weight, heads per plot, and days to 50% bloom revealed no consistant relationship in different crosses investigated, yet there was sufficient evidence to speculate that heterotic behaviour of the F1's for seeds per head, plant height and threshing percentage may influence hybrid yield. Of all the components of yield, 1000-seed weight and heads per plot did not show marked effect on yield. This is corroborated by Beil & Atkins (1967) and Kirby & Atkins (1968) who re ported a negative correlation between grain yield and heads per plant and showed that a single large head on each plant was more productive than several small heads. The results, however, do not agree with those reported by Kambal & Webster (1965) and Niehaus & Pickett (1966) who obtained a positive association between grain yield and yield and heads per plot. This discrepency may be attributed to the differences in the level of tillering of various inbred lines used in the two studies. In the present studies, inbred lines AUS13 and AUS16 produced larger number of heads per plot and the nybrids involving thse lines also had a higher number of heads per plot. All other lines produced fewer heads per plot due primarily to their low tillering capacity.

Marked heterosis for yield and several other traits noticed in some crosses could be attributed to genetic diversity, because the crosses involving distinctly diverse plants produced high yielding hybrids. These observations are supported by Niehaus & Pickett (1966) who showed that heterosis was outstanding when one of the parents was an introduction. Although heterosis was striking in the dwarf than the tall F1's yet such data must be used with caution and any observations made in this study apply only to these six lines and may not have general application.

References

Beil, G. M. and R.F. Atkins. 1967. Estimates of general and specific combining ability in F1 hybrids for grain yield and its components in grain sorghum, *Sorghum vulgare* Pers. Corp Sci., 7: 225-228.

Chiang, M.S and J.D. Smith. 1967. Diallel analysis of the inheritance of quantitative characters in grain sorghum 1. Heterosis and inbreeding depression. Can. J. Genet. Cytol., 9: 44-51.

Kambal, A.E and O.J. Webster. 1965. Estimates of general and specific conbining ability in grain sorghum, *Sorghum vulgare* Pers. Crop Sci., 5: 521-523.

Kirby, J.S and R.F. Atkins. 1968. Heterotic response for vegetative and mature plant characters in grain sorghum, *Sorghum bicolor* (L.) Moench. Crop Sci., 8: 335-339.

Matzinger, D.F; T.J. Mann and C.C. Cockerham. 1962. Diallel crosses in *Nicotiana tabacum*. Corp Sci., 2: 383-386.

Niehaus, M.H and R.C. Pickett. 1965. Heterosis and combining ability in a diallel cross in *Sorghum vulgare* Pers. Crop Sci., 6: 33-36.

Stephens, J.C and J.R. Quinby. 1933. Bulk emasculation of sorghum flowers. J. Hered, 25: 233-234.

Wynne, J.C, D.A. Emery, and P.W. Rice. 1970. Combining ability estimates in *Arachis hypogeae* L. II. Field performance of F1 hybrids. Crop Sci., 10: 713-715.