recording 6.43 t/ha which was 52 per cent increase over control. Similar trend was observed also in *Samba* season. However, combined application of *Azospirillum* and *Azolla* with 50 and 75 kg N/ha levels increased the grain yield. At 100 kg/ha, the response due to biofertilizer was relatively low. This is in concurrence with the earlier findings (Gopalaswamy *et al.*, 1989)

With respect to straw yield, application of *Azospirillum* or *Azolla* with and without inorganic N augmented the biomass yield. Maximum increase in straw yield was noticed when *Azospirillum* and *Azolla* were applied with 75 kg N/ha alone. The study clearly indicated that the grain yield increased when judicious combination of N with combination of biofertilizers was followed. By applying biofertilizer individually or in combination, a reduction of only 25 kg N/ha over the recommended levels can be adopted without sacrificing the grain yield.

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COMPARISON OF SINGLE AND THREE-WAY CROSSES IN GROUNDNUT

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ABSTRACT

Comparison of parents, single crosses and three-way crosses in groundnut revealed that high level of heterotic effects were observed in single crosses for the traits : number of branches, number of mature pods and pod yield. The three-way crosses exhibited heterotic effects for shelling out turn, pod weight and kernel weight. Hence for the improvement of these traits three-way crosses may yield better results than single crosses. The range of mean values was narrow in three-way crosses for four of six traits studied, which suggests that the three-way crosses have more buffering capacity than single crosses.

KEY WORDS : Groundnut, single cross, three-way cross, heterosis

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop grown under diversified climatic conditions both under rainfed and irrigated situations. There is a need to broaden the initial genetic base to achieve stability in yield as the three-way and double crosses in maize were known to be stable and high yielding over environments (Weatherspoon, 1970).

In this process, three-way crosses are the next logical step to single crosses. However, multiple crosses are not common in groundnut. Hence, in the present study, an attempt was made to compare single and three-way crosses to find out their suitability.

MATERIALS AND METHODS

Six cultigens *viz.*, ICGS 44 (P1), Girnar 1 (P_2), ALR 2 (P_3), JL 24 (P_4), GG 2 (P_5) and Co 2 (P_6) (Table 1) were used in producing 15 single crosses, besides 20 three-way crosses were made ignoring the order of the parent at grand parent and parental level. For example, cross (1 x 2) x 3 was made ignoring crosses (1 x 3) x 2 and (2 x 3) x 1. Six parents, 15 F_1s and 20 three-way crosses were grown in a randomised complete block design replicated thrice during *Kharif*'93 season at the Regional Research Station, Vridhachalam. Each entry was grown in five rows of 5 m length with a spacing of 30 cm between rows and 15 cm between plants. All the package of practices was followed. Observations on six characters *viz.*, number of branches, number of mature pods, 20 pod weight (g), 20 kernel weight (g), pod yield (g) and shelling out turn (%) were recorded from 10 representative plants in each entry in each replication and means were computed.

Table 1. Particulars of six bunch groundnut varieties utilised as parents.

Parent	Source	Pedigree
ICGS 44	ICRISAT, Hyderabad	Selection from R 33-1.
Girnar 1	NRCG, Junagadh	X 14-4-B-19 B x NCAC 17090
ALR 2	Aliyarnagar	Selection from ICGV 86011
JL 24	Jalgaon	Selection from Ec 94943
GG 2	GAU, Junagadh	J11 x Ec 166659
Co 2	Coimbatore	EMS mutant from POL 1

For comparison of means of different groups, the corresponding standard errors (SE_s) and critical differences (CD_s) were calculated, as follows.

15 single crosses vs 20 three-way crosses

$$SE(d) = \sqrt{\left(\frac{1}{15} + \frac{1}{20}\right) X \frac{E.M.S.}{r}}$$

6 parents vs 15 single crosses

$$SE(d) = \sqrt{\left(\frac{1}{6} + \frac{1}{15}\right) X \frac{E.M.S.}{r}}$$

6 parents vs 20 three-way crosses

$$SE(d) = \sqrt{\left(\frac{1}{6} + \frac{1}{20}\right) X \frac{E.M.S.}{r}}$$

$$CD \text{ at } 5\% = SE(d) \ X \ t \text{ at } 5\%$$

The magnitude of heterosis was worked out based on better parental value as given below (for this purpose, single crosses of three-way crosses were treated as individual parents).

$$\text{Heterosis} = \frac{F_1 - BP}{BP} \times 100$$

Where, F_1 = Yield of the hybrid
BP = Yield of the better parent

Heterosis was considered significant if the difference (between F_1 and better parent used for comparison) was found significant, as given below:

$$F_1 - BP > \sqrt{2.0 X \frac{E.M.S.}{r}} \ x \ t \text{ and } 5\%$$

RESULTS AND DISCUSSION

The analysis of the variance of the data for 6 parents, 15 single crosses and 20 three-way crosses was carried out for six traits. The mean squares for different traits are given in Table 2. The overall differences among entries were highly significant for all the traits. The mean values and ranges of

Table 2. Analysis of variance for different characters

Source	df	Mean sum of squares					
		No.of branches	No. of mature pods	20-pod weight	20-kernel weight	pod yield	Shelling outturn
Blocks	2	0.63	3.31	10.22	0.87	6.36	41.64
Entries	40	2.07**	73.76**	14.83**	3.64**	51.95**	138.03**
Error	80	0.54	8.73	2.03	0.25	6.31	12.25

** P = 0.01

Table 3. Mean performance and range of parents, single and three-way crosses for different character

Parents/crosses	No. of branches	No. of mature pods	20-pod weight (g)	20-kernel weight (g)	Pod yield (g)	Shelling outturn (%)
Parents (6)						
Mean	5.38	23.01	16.20	6.23	18.11	65.47
Range	4.97- 6.50	18.10- 28.20	13.47- 17.80	4.47- 7.97	15.20- 19.70	62.70- 69.30
SC (15)						
Mean	6.04	29.53	16.66	6.33	24.02	61.21
Range	4.23- 7.37	19.37- 43.13	13.37- 20.80	5.23- 8.53	14.80- 33.43	53.73- 68.83
TWC (20)						
Mean	6.00	25.36	17.27	7.00	21.60	73.86
Range	4.80- 7.66	21.43- 31.20	14.40- 22.57	4.66- 9.50	16.07- 25.40	67.67- 77.63
Overall mean	5.89	26.54	16.90	6.64	21.92	68.00
CD (0.05) for Group comparisons						
SC vs TWC	0.30	1.15	0.56	0.20	1.00	1.37
Parents vs SC	0.40	1.63	0.80	0.28	1.39	1.95
Parents vs TWC	0.40	1.57	0.76	0.26	1.35	1.87

SC : Single crosses ; TWC : Three-way crosses

Table 4. Heterosis (%) over better parent for different characters

Cross	No. of branches	No. of mature pods	20-Pod weight	20-kernel weight	Pod yield	Shelling outturn
$P_1 \times P_2$	1.03	49.15*	-3.56	-7.83	63.83*	-3.38
$P_1 \times P_3$	8.72	23.52*	-9.76	-23.50*	41.78*	-13.57*
$P_1 \times P_4$	-8.72	46.94*	15.92*	7.11	74.74*	-9.62*
$P_1 \times P_5$	5.13	19.17	-3.75	-23.04*	32.62*	-13.55*
$P_1 \times P_6$	3.59	40.13*	-5.82	-21.66*	36.41*	-12.29*
$P_2 \times P_3$	21.48	-4.37	-12.24	21.56*	-1.57	7.66
$P_2 \times P_4$	2.55	21.08*	-8.24	-27.62*	17.25	-17.27*
$P_2 \times P_5$	-16.17	-5.76	16.67*	20.25*	13.80	-5.22
$P_2 \times P_6$	-15.89	-17.24	-8.07	-21.89*	-19.57	-19.40*
$P_3 \times P_4$	2.55	10.87	16.85*	-4.60	71.08*	-15.97*
$P_3 \times P_5$	32.34*	52.96*	-11.04	-4.19	53.32*	-8.33
$P_3 \times P_6$	39.07*	16.67	-21.06*	-3.98	14.69	-5.35
$P_4 \times P_5$	4.79	-2.28	1.12	-16.32*	8.19	-0.67
$P_4 \times P_6$	-2.55	10.73	0.19	-7.11	15.00	-6.30
$P_5 \times P_6$	18.56	7.64	-14.96*	-20.90*	-5.38	-4.35
$(P_1 \times P_2) \times P_3$	-26.94*	-38.59*	10.51	5.85	-44.26*	14.31*
$(P_1 \times P_2) \times P_4$	-1.67	-35.73*	26.80*	-19.70*	-12.24	-0.91
$(P_1 \times P_2) \times P_5$	10.50	-13.38	-9.52	-30.13*	-19.88*	1.87
$(P_1 \times P_2) \times P_6$	-21.46*	-30.29*	-2.10	-20.90*	-29.14*	10.39*
$(P_1 \times P_3) \times P_4$	8.35	-31.87*	-3.54	-8.41	-24.90*	8.47*
$(P_1 \times P_3) \times P_5$	-2.97	-14.93*	6.86	22.24*	-6.03	13.85*
$(P_1 \times P_3) \times P_6$	-18.53*	-36.06*	-1.36	9.55	-31.30*	13.50*
$(P_1 \times P_4) \times P_5$	10.12	-22.73*	-14.83	-15.59*	-33.68*	16.86*
$(P_1 \times P_4) \times P_6$	4.55	-33.47*	-10.47	-15.59*	-39.66*	6.49
$(P_1 \times P_5) \times P_6$	-22.40*	-9.55	-8.95	4.48	-16.09	13.74*
$(P_2 \times P_3) \times P_4$	1.16	-1.00	-8.60	-21.46*	12.70	9.70*
$(P_2 \times P_3) \times P_5$	-4.98	15.68	-6.49	-10.49	19.34	7.75
$(P_2 \times P_3) \times P_6$	-3.81	-10.27	-8.03	7.83	0.32	10.33*
$(P_2 \times P_4) \times P_5$	-2.51	-17.86*	22.05*	45.58*	3.30	9.78*
$(P_2 \times P_4) \times P_6$	-8.75	-23.29*	27.76*	41.79*	4.64	12.54*
$(P_2 \times P_5) \times P_6$	7.36	14.38	-14.65*	-5.52	-1.13	11.89*
$(P_3 \times P_4) \times P_5$	5.21	-13.75	-26.30*	-8.82	-37.06*	10.09*
$(P_3 \times P_4) \times P_6$	10.43	-17.81*	-16.01*	-0.53	-31.78*	10.54*
$(P_3 \times P_5) \times P_6$	-14.11	-29.91*	-10.40	2.39	-22.24*	11.59*
$(P_4 \times P_5) \times P_6$	8.58	-8.64	17.94*	26.87*	13.53	9.73*

* $P = 0.05$

P_1 : ICGS 44; P_2 : Girnar 1 ; P_3 : ALR 2 ; P_4 : JL 24 ; P_5 : GG 2 P_6 : Co 2

parents and crosses are presented in Table 3. Heterosis over better parent in 15 single and 20 three-way crosses are presented in Table 4.

Number of branches

Single crosses were statistically on par with three-way crosses and both of them were superior to parents. In single crosses, the combinations ALR 2 x GG 2 and ALR 2 x Co 2 exhibited positive heterosis. None of the three-way crosses registered positive heterosis.

Number of mature pods

Single crosses were superior to both three-way crosses and parents. Similarly, three-way crosses also outyielded parents. Six combinations of the single crosses *viz.*, ALR 2 x GG 2, ICGS 44 x Girnar 1, ICGS 44 x JL 24, ICGS 44 x Co 2, ICGS 44 x ALR 2 and Girnar 1 x JL 24 registered heterosis. Most of the three-way cross combinations recorded negative heterosis for this trait.

Pod weight

Three-way crosses were significantly superior over both single crosses and parents. However, single crosses were only on par with parents. Four three-way crosses (Girnar 1 x JL 24) x Co 2, (ICGS 44 x Girnar 1) x JL 24, (Girnar 1 x JL 24) x GG 2 and (JL 24 x GG 2) x Co 2 exhibited heterosis.

Similarly ALR 2 x JL 24, Girnar 1 x GG 2 and ICGS 44 x JL 24 registered positive heterosis.

Kernel weight

Three-way crosses significantly outyielded single crosses and parents whereas single crosses were on par with parents. Four three-way combinations *viz.*, (Girnar 1 x JL 24) x GG 2, (Girnar 1 x JL 24) x GG 2, (JL 24 x GG 2) x Co 2 and (ICGS 44 x ALR 2) x GG 2 recorded heterosis. In single crosses, Girnar 1 x ALR 2 and Girnar 1 x GG 2 registered positive heterosis.

Pod yield

Single crosses ranked first followed by three-way crosses and both of them were superior to the parents. Seven single crosses comprising all the five combinations involving ICGS 44 as pistillate parent besides ALR 2 x JL 24 and ALR 2 x GG 2 exhibited heterotic effects. None of the three-way crosses registered significant positive heterosis.

Shelling out turn

Three-way crosses were superior to both single crosses and parents. However, single crosses failed to outyield the parents. None of the single crosses recorded significant positive heterosis. Sixteen out of 20 three-way crosses exhibited positive heterosis for this trait.

The range of the mean values revealed that the three-way crosses recorded narrow range for four out of six traits studied *viz.*, number of branches, number of mature pods, pod yield and shelling out turn. This suggests that three-way crosses have more buffering capacity compared to single crosses. Similar results were obtained in several crops.

Arunachalam *et al.* (1984) pointed out that the heterotic hybrids can also produce desirable transgressive segregants in advanced generations. In the present study high level of heterotic effects were recorded by three-way crosses for the traits *viz.*, shelling out turn, pod weight and kernel weight. Hence, for the improvement of these traits three-way crosses may yield fruitful results than single crosses.

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RESIDUAL EFFECT OF ORGANIC MANURES AND INORGANIC FERTILIZERS ON SUCCEEDING RATOON RICE

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ABSTRACT

A two year field experiment was conducted to determine the residual effects of different organic and inorganic sources of nitrogen on the succeeding ratoon crop of rice (cv.IR 36). Eighteen treatments consisting of five green manure crops *viz.*, Azolla (*Azolla pinnata* R.Brown); Ipomoea (*Ipomoea carnea*) water hyacinth (*Eichhornia crassipes* Mart Solms) *Pistia* sp. and blue green algae (BGA) and one farm yard manure (FYM) combination with various rates of inorganic N fertilizer were evaluated. Only 42.0 to 58.0 per cent culms regenerated in ratoon crop from the 50 hills/m^2 of plant crop. Variation in the grain yields (1.32 to 2.42 t/ha) of ratoon crop was a consequence of the residual fertility left by the different sources of N applied to the preceding plant crop. Incorporation of *Azolla* and BGA to the preceeding plant crop resulted in higher grain and straw yield of ratoon crop. Concentration of N,P and K in grain and straw of ratoon rice was higher in the treatments having higher fertility. Residual status of N,P and K in the soil after ratooning declined compared with initial values.

KEY WORDS : Plant crop, ratoon crop, residual fertility