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EFFECT OF PLANT SPACING ON GROWTH, YIELD AND SEED QUALITY IN RESTORER LINES OF SUNFLOWER HYBRIDS

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SUMMARY

A field trial was conducted to study the effect of plant spacing on growth and yield of different restorer lines of sunflower hybrids during the winter season of 1996-97 and 1998-99 at BHU Research Farm, Varanasi. Significant variation in restorer lines in all the physiological and reproductive characters were observed during both the years. Among the restorer lines, 6D-1 recorded the highest leaf area index, crop growth rate, net assimilation rate, more number of seeds capitulum^{-1} (365.8), 1000-seed weight (44.08 g) and seed yield plant^{-1} (12.69 g) than AK-1R and P-35 R. This ultimately led to maximum seed yield (10.8 q ha^{-1}) by 6D-1. Similarly, spacing S_1 (40 × 15 cm) registered 63.4, 50.9 and 20.0% more seed yield than S_4 (70 × 20 cm), S_3 (60 × 20 cm) and S_2 (50 × 15 cm) respectively. It was further observed that plant population had a linear functional relationship with seed yield (Y = 3.73 + 4.52x).

Key words:**Plant spacing, restorer line, seed quality, sunflower.**

INTRODUCTION

With the introduction of hybrids, sunflower has gained momentum and during the last decade its area under cultivation in the country has increased from 0.6 to 2.0 m ha (Giri 1996). However, for hybrid seed production inbred parental lines are the pre-requisite and its success primarily depends on the higher seed multiplication ratio of parental lines as every year fresh seeds are required for production of hybrids. The concept that technology generated for composite and hybrids is equally effective for inbred lines also is not true. Since, inbreds are brought to near homozygous levels after successive generation of selfing, they lose vigour due to inbreeding depression and consequently become less efficient in metabolic activities. This implies that inbreds require different package of practices for their proper growth and development. Keeping this in view a field trial was conducted to study the effect of plant spacing on the performance of different restorer lines of sunflower hybrids.

MATERIALS AND METHODS

The trial was conducted during winter seasons of 1996-97 and 1998-99 at the Research Farm of B.H.U., Varanasi. The trial consisting of 3 inbred lines (P-35 R, AK-1R and 6D-1) and four spacing (S_1, 40 × 15 cm; S_2, 50 × 15 cm; S_3, 60 × 20 cm and S_4, 70 × 20 cm) was laid out in a split plot design with 4-replications by keeping restorer lines in the main plot and spacings in the sub plot. A common dose of nutrients (90, 75, 60 and 15 kg ha^{-1} of N, P_2O_5, K_2O and borax) was applied through urea, DAP and muriate of potash respectively. Nitrogen was applied in 3 split doses. Half of the N was applied at the time of sowing and remaining N was split into two equal halves and applied at 45 and 75 days after sowing. P_2O_5, K_2O and

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borax were all applied as basal dose. The crop was sown on November 13 in 1996-97 and November 21 in 1998-99 and interculture operations along with irrigation were taken up as per requirements of the crop. Two hand weedings were done at 30 and 45 days after sowing (DAS) to manage the weed and it was followed by earthing up at 60 DAS. The soil was ustrocrepts, with a pH of 7.3 and available N, P and K was 196, 10.6 and 224 kg ha^{-1} respectively.

Observations on growth parameters were recorded on 30, 60, 90 and 120 days after sowing and yield components at maturity. CGR and NAR were calculated as per formula given below:

$$\underset{(g\ m^{-2}\ day^{-1})}{CGR} \quad \frac{1}{A} \times \frac{(W_2 - W_1)}{(t_2 - t_1)} \quad \text{(Watson 1958)}$$

where W_1 and W_2 are dry weight of plants at time t_1 and t_2 respectively.

$$\underset{(mg\ cm^{-2}\ day^{-1})}{NAR} = \frac{(W_2 - W_1)(\log_e L_2 - \log_e L_1)}{(t_2 - t_1)(L_2 - L_1)} \quad \text{(Watson 1952)}$$

where L_1 and W_1 are leaf area and dry weight at time t_1, while L_2 and W_2 are leaf area and dry weight of plant at time t_2.

RESULTS AND DISCUSSION

Inbred lines differed in LAI measured at different growth stages. The spacing brought about significant differences in LAI at all the stages of growth (Table 1). As expected LAI increased with the age of the crop, it reached maximum at 90 DAS and declined thereafter. Among the restorer lines, 6D-1 recorded the highest leaf area index and it remained significantly superior to both AK-1R and P-35R. On the other hand in crop geometry, the closest spacing S_1 (40 × 15 cm) produced significantly higher LAI than S_2 (50 × 15 cm), S_3 (60 × 20 cm) and S_4 (70 × 20 cm). Lower land area per plant quite obviously produced the higher LAI (Bindra and Kharwara 1994). Similar corresponding increase in the crop growth rate (CGR) was also observed during both the years (Table 1). Among the restorer lines, the critical LAI was found to be 3.19 in 6D-1 at 90 DAS when its corresponding CGR was maximum (12.87 g m^{-2} day^{-1} between 60-90 DAS stage and this was followed by AK-1R and P-35R respectively. In the same manner 40 × 15 cm spacing (S_1) depicted the optimum LAI of 3.78 when the maximum CGR of 15.72 g m^{-2} day^{-1} was found between 60-90 day period of its growth, beyond which the CGR decreased. Net assimilation rate (NAR) expresses plant's capacity to increase dry weight in terms of the area of its assimilatory surface (Reddy 2000) and reflects the photosynthetic efficiency of

Table 1. Leaf area index, crop growth rate and net assimilation rate in restorer lines as influenced by plant spacing (mean effects). Pooled data of two years.

	Leaf area index				Crop growth rate ($g\ m^{-2}\ day^{-1}$)			Net assimilation rate ($mg\ cm^{-2}\ day^{-1}$)		
	30 DAS	60 DAS	90 DAS	120 DAS	30-60 DAS	60-90 DAS	90-120DAS	30-60DAS	60-90 DAS	90-120 DAS
Restorer lines										
P-35R	0.13	0.61	2.64	2.17	2.50	11.05	1.77	0.45	0.52	0.085
AK-1R	0.15	1.72	2.73	2.12	3.02	11.93	2.12	0.51	0.55	0.090
6D-1	0.15	1.94	3.19	2.80	3.43	12.87	2.46	0.56	0.58	0.095
Sd	0.004	0.010	0.013	0.010	0.08	0.09	0.10	0.010	0.010	0.025
CD (P=0.05)	0.010	0.030	0.031	0.030	0.20	0.23	0.25	0.025	0.025	NS
Plant spacing										
S_1 (40 × 15 cm)	0.20	2.41	3.78	3.23	3.66	15.72	2.63	0.43	0.55	0.095
S_2 (50 × 15 cm)	0.17	1.02	3.49	2.74	3.39	14.54	2.81	0.48	0.55	0.095
S_3 (60 × 20 cm)	0.11	1.43	2.35	1.87	2.53	9.19	1.66	0.54	0.54	0.085
S_4 (70 × 20 cm)	0.09	1.19	2.00	1.61	2.33	8.34	1.37	0.57	0.55	0.085
Sd	0.002	0.02	0.015	0.020	0.07	0.15	0.11	0.013	0.006	0.02
CD (P=0.05)	0.004	0.03	0.030	0.030	0.15	0.30	0.22	0.06	NS	NS

crop in general. Keeping in tune with LAI and CGR, same trend was observed in case of NAR also. Inbred line 6D-1 showed higher NAR (0.58 mg cm^{-2} day^{-1}) between 60-90 days period than the other two lines. Spacing, however, did not cause any significant effect on NAR during the last two stages of growth. Most probably more respiratory losses in higher plant population made the variation in NAR not significant among the four different spacings.

The yield attributes also varied significantly in restorer lines and were influenced by plant spacing (Table 2). Inbred line 6D-1 produced significantly bigger capitulum possessing maximum number of seeds with higher test weight and higher seed yield $plant^{-1}$. Overall 6D-1 recorded 24.7% and 12.6% more seed yield than P-35R and AK-1R respectively. In all yield attributing characters wider plant spacing S_4 (70 × 20 cm) registered higher values than narrow spacing S_1 (40 × 15 cm). Since, S_4 (70 × 20 cm) got wider space per plant for its growth and development, it produced bigger and heavier capitulum with more number of seeds. Similar results on yield attributes at higher plant spacing was also reproted by Rajput *et al.* (1994). Further, inbred lines interacted significantly with spacing in bringing about changes in seed yield $plant^{-1}$ which was found to be inversely proportional to plant population (Table 3). Inbred line 6D-1 produced the highest seed yield $plant^{-1}$ (14.01 g) at 70 × 20 cm (S_4), while P-35R recorded the lowest yield $plant^{-1}$ at 40 × 15 cm (S_1). Cumulative effect of these yield components ultimately led to higher seed and stalk yield ha^{-1} by the inbred line 6D-1 which remained significantly superior to other two lines (Table 4). Overall 6D-1 recorded 55.5% and 12.6% more seed yield ha^{-1} than P-35R and AK-1R respectively. Yield expressed on per hactare basis was found to decrease with increasing spacing and the highest seed yield was obtained at 40 × 15 cm (S_1) spacing, while 70 × 20 cm (S_4) recorded the lowest yield. Overall S_1 registered 63.4%, 50.9% and 20.0% more seed yield than S_4, S_3 and S_2 respectively. Further in the interaction effect, 6D-1 produced the highest yield at 40 × 15 cm spacing (Table 5). In the present study restorer lines of sunflower showed an obvious increase in yield with increase in plant population and is in conformity with the findings of Hegde and Havanagi (1987).

In regression analysis, palnt population was found to hava a linear relationship with seed yield ($\hat{Y}$ = 3.73 + 4.52x) indicating that there might be further scope of increasing yield by increasing the plant population of parental lines (Fig. 1). Inbred line 6D-1 also produced signficantly higher oil (3.99 q ha^{-1}) and protein yield (1.72 q ha^{-1}) and at 40 × 15 cm spacing registered the higher values in these parameters. More yield at higher planting density led to the corresponding higher oil and protein yield (Rao and Saran 1991).

Table 2. Yield components in restorer lines as influenced by plant spacing. (Pooled data of two years).

	Capitulum diameter (cm)	Seed number $capitulum^{-1}$	1000 Seed weight (g)	Seed yield (g $plant^{-1}$)
Restorer lines				
P-35R	8.43	325.5	40.85	10.18
AK-1R	8.82	357.8	39.76	11.27
6D-1	8.66	365.8	44.08	12.69
Sd	0.12	3.07	0.27	0.24
CD (P=0.05)	0.29	7.52	0.66	0.59
Plant spacing				
S_1 (40 × 15 cm)	7.69	314.5	38.37	9.90
S_2 (50 × 15 cm)	8.06	339.9	39.92	10.89
S_3 (60 × 20 cm)	8.94	363.4	43.07	12.15
S_4 (70 × 20 cm)	9.86	373.1	44.90	12.57
Sd	0.17	3.11	0.54	0.21
CD (P=0.05)	0.34	6.39	1.10	0.43

Table 3. Interaction effect of restorer line and plant spacing on seed yield (g $plant^{-1}$).

	P35-R	AK-1R	6D-1	Mean
S_1 (40 × 15 cm)	9.0	9.98	10.71	9.90
S_2 (50 × 15 cm)	9.67	10.82	12.17	10.89
S_3 (60 × 20 cm)	10.47	12.12	13.87	12.15
S_4 (70 × 20 cm)	11.57	12.14	14.01	12.57
Mean	10.18	11.27	12.69	
Sd for restorer line mean at same spacing		0.40		
CD (P = 0.05)		0.88		
Sd for spacing mean at same restorer line		0.51		
CD (P = 0.05)		1.05		

Table 4. Yield and seed quality in restorer lines as influenced by plant spacing. (Pooled data of two years).

	Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})	Oil yield (q ha^{-1})	Protein yield (q ha^{-1})
Restorer lines				
P-35R	6.74	19.79	2.52	1.02
AK-1R	9.31	24.05	3.61	1.49
6D-1	10.80	26.58	3.99	1.72
Sd	0.20	0.28	0.08	0.04
CD (P=0.05)	0.48	0.68	0.20	0.09
Plant spacing				
S_1 (40 × 15 cm)	11.39	26.97	4.30	1.80
S_2 (50 × 15 cm)	9.49	24.39	3.62	1.48
S_3 (60 × 20 cm)	7.55	21.99	2.91	1.23
S_4 (70 × 20 cm)	6.96	20.56	2.66	1.14
Sd	0.23	0.38	0.09	0.04
CD (P=0.05)	0.46	0.77	0.18	0.08

Table 5. Interaction effect of restorer line and plant spacing on seed yield (q ha^{-1}).

	P35-R	AK-1R	6D-1	Mean
S_1 (40 × 15 cm)	8.50	12.50	13.17	11.39
S_2 (50 × 15 cm)	7.47	10.59	10.40	9.49
S_3 (60 × 20 cm)	5.79	7.51	9.33	7.55
S_4 (70 × 20 cm)	5.20	6.66	9.02	6.96
Mean	6.74	9.31	10.48	
Sd for restorer line mean at same spacing		0.39		
CD (P = 0.05)		0.84		
Sd for spacing mean at same restorer line		0.55		
CD (P = 0.05)		1.13		

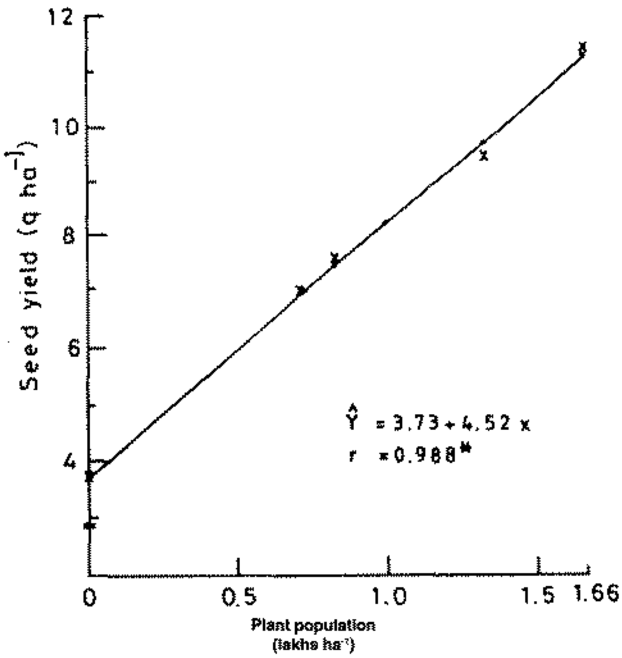

Fig. 1. Functional relationship between plant population and seed yield (Pooled of 2 years)

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