Growth, yield and nutritional responses of a sunflower hybrid grown under varying levels of planting geometry and fertilizer

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Abstract: Field experiments were conducted in Alfisol (red sandy loam) at Agricultural Research Station (Bhavanisagar), Tamil Nadu Agricultural University, India, to study the effect of planting geometry (spacing) and fertilizer levels on a sunflower hybrid (MSFH-17). The data revealed that the planting geometry of 45 x 30 cm in combination with 75 and 105 kg NP/ha produced the highest grain yield (2030 kg/ha) and oil yield (738 kg/ha). The study suggests that application of moderate amounts of fertilizer input in conjunction with medium level of spacing enable the sunflower hybrid to produce maximum returns under irrigated conditions.

Key words : Dry matter, Nitrogen, Phosphorus, Spacing, Sunflower.

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most promising oil seed crops in India because of its adaptability to a wide array of edaphoclimatic conditions, photoinsensitiveness, short duration and high yield potential. In the past decade, the area under sunflower in India has tripled and retains fourth position in vegetable oil seed production. Despite the increase in the area under sunflower cultivation, the production potential is yet to be fully realized. Attempts have been made to optimize the agronomic requirements of sunflower crop.

Planting geometry is an essential component in crop cultivation wherein row spacing between plants is adjusted in order to provide sufficient space for effective utilization of solar radiation and soil rhizosphere. Planting geometry affects growth and yield of sunflower in varying soil fertility and climatic conditions. Sunflower responds to fertilizer application and produces higher seed yield. The yield response to added nutrients depends on the variety, initial soil fertility status, and climatic conditions. Adequate fertilizer application is important to match the demand of high yielding varieties and hybrids. Sunflower utilizes both NO3-N and NH4-N but grows better with NO3-N (Hocking and Steer, 1982).

Recently, new sunflower hybrids have been developed in India in order to promote oil seed production of the country. Agronomic requirements of the newly evolved hybrids are yet to be determined. With a view to optimize the level of planting geometry and the fertilizer dose, field experiments were conducted.

Materials and Methods

Field experiments were carried out at the Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar during 1996-97, in two consecutive *Kharif* seasons using one of the most popular high yielding sunflower hybrids (MSFH 17). Experimental soil was Alfisol, red sandy loam in texture. pH 7.2, electrical conductivity 0.2 dSm-1, organic carbon 0.3% and low in available N (140 kg/ha) and P (8.5 kg/ha) and high in available K (376 kg/ha) status. The treatments consisted of three levels of planting geometry (S1: 30 x 30 cm, S2: 45 x 30 cm, S3: 60 x 30 cm) in main plot and four levels of fertilizer (60-90 F1; 75-105 F2: 90-120 F3: 105-135 F4 N-P kg/ha) in sub-plot replicated three times in a split plot design. Two seeds were dibbled per hill in designed levels of planting geometry (spacing). One seedling per hill was retained after the establishment of plant population. Fertilizers were applied to each plot as per the treatments. Of the total quantity of fertilizers, 50% N and K and 100% P were applied at the time of sowing as a basal dressing and the remaining N & K were applied in two splits, 25% at

Table 1. Effect of spacing (S) and fertilizer levels (F) on plant height, dry matter production (DMP), leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) at the harvest stage (n=3) and days to 50% flowering of sunflower hybrid (MSFH-17)

Treatments		Plant height (cm)	DMP (kg ha^{-1})	LAI	CGR (gm^{-2}d^{-1})	NAR (gm^{-2}d^{-1})	Days to 50% flowering
S1	F_1	172	5246	1.86	1.80	9.70	59
	F_2	179	6512	2.14	1.81	8.46	59
	F_3	173	5913	2.08	4.57	22.3	58
	F_4	173	6214	1.70	4.03	20.2	58
S2	F_1	173	6574	1.98	7.32	23.2	56
	F_2	181	7113	2.48	5.00	13.5	58
	F_3	180	7048	2.35	6.55	19.6	58
	F_4	178	7017	2.21	5.94	18.3	58
S3	F_1	173	6252	2.11	4.15	9.98	58
	F_2	176	6929	2.38	5.39	11.8	57
	F_3	176	6759	2.14	6.31	14.7	57
	F_4	176	6632	2.07	6.42	15.4	59
S	SEd	5.59	104	0.04	0.51	1.76	0.67
	CD (5%)	NS	289	0.11	NS	NS	NS
F	SEd	3.49	131	0.09	0.72	2.04	0.72
	CD (5%)	NS	274	0.18	NS	4.28	NS
S x F	SEd	6.5	223	0.15	1.25	3.53	1.27
	CD (5%)	NS	NS	NS	NS	NS	NS

the time of button initiation and 25% at the flowering. Irrigation was given once in a week. Need based plant protection measures were taken. During the experimentation, plant height, net assimilation rate (NAR), crop growth rate (CGR), dry matter production (DMP), leaf area index (LAI), days to 50% flowering and yield attributes such as head diameter, seed number, seed weight and seed yield were recorded.

Plant samples collected at the time of harvest were analyzed for its nutrient concentration by adopting a standard procedure (Subramanian and Charest, 1997). NAR and CGR were estimated using the following formula.

$$\text{Net Assimilation Rate (NAR)} = \frac{(W_2-W_1)\ \text{Log}\ L_2-\text{Log}\ L_1}{(t_2-t_1)\ (L_2-t_1)} = g^{-2}\ day^{-1}$$

$$\text{Crop Growth Rate (CGR)} = \frac{W_2-W_1}{(t_2-t_1)}\ g^{-2}\ day^{-1}$$

Where, W_2W_1 = Initial and final plant materi per unit area (g)

T_2, T_1 = Initial and final day of observation

L_2, L_1 = Initial and final leaf area (m

Results and Discussion

Dry matter production

Dry matter production (DMP) of sunflow plants at the harvest stage significantly influenc by both planting geometry and fertilizer leve (Table 1). Planting geometry of 45 x 30 c had accumulated the highest amount of DM (6938 kg/ha) which was 15% higher than t lower spacing of 30 x 30 cm but on p with the wider spacing of 60 x 30 cm. T data suggest that the optimal spacing for t newly introduced sunflower hybrid is 45

Table 2. Effect of spacing (S) and fertilizer levels (F) on head diameter, percentage of filled grains, 100 seed weight, grain yield, stalk yield and oil yield of sunflower hybrid MSFH-17 (n=3)

Treatments		Head diameter (cm)	% of filled grains	100 seed weight (g)	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Oil yield (kg ha^{-1})
S1	F_1	12.3	84.5	4.07	1817	3119	659
	F_2	12.8	85.5	4.87	1974	3743	721
	F_3	12.5	83.6	4.17	1733	3601	627
	F_4	12.3	85.5	4.33	1802	3506	664
S2	F_1	12.3	87.4	4.23	1879	4046	684
	F_2	12.7	89.7	4.63	2104	4474	766
	F_3	12.6	88.0	4.33	2136	4617	772
	F_4	12.4	88.0	4.33	1995	4545	732
S3	F_1	12.4	87.1	4.63	1728	3797	624
	F_2	12.8	88.3	4.80	2012	4688	729
	F_3	12.6	87.1	4.77	1906	4512	685
	F_4	12.4	85.6	4.73	1875	4260	683
S	SEd	0.08	1.72	0.29	86.3	433	31.1
	CD (5%)	NS	NS	NS	NS	NS	NS
F	SEd	0.08	2.00	0.35	57.9	246	22.7
	CD (5%)	0.16	NS	NS	NS	517	47.8
S x F	SEd	0.15	3.47	0.61	112.5	500	42.0
	CD (5%)	NS	NS	NS	NS	NS	NS

30 cm and any alteration would affect the DMP of the crop. The highest DMP recorded at the optimal planting geometry may be as a consequence of large canopy spread area and leaf area index. Effective utilization of natural resources such as water, soil nutrients and solar radiation would have supported the plants to gain greater net assimilation rate and produced higher DMP in 45 x 30 cm spacing. The results are in conformity with the findings of Singh and Pacheria (1981). Application of 75:105 NP kg/ha (F2) yielded significantly higher DMP than F1 but the values are comparable to higher levels of fertilizer application (F3 and F4). The data suggest that the yield maximization is achievable even at F2 level. Interaction effect was absent.

Seed yield

Seed yield of sunflower hybrid was significantly influenced by both planting geometry and fertilizer levels. The seed yield recorded in the optimal planting geometry (45 x 30 cm) was 2029 kg/ha and this value was 10% higher than the closer planting geometry (30 x 30 cm) (Table 2). The data are in agreement with the findings of Sarmah *et al.* (1992) who have reported that the seed yield of sunflower is drastically reduced by any spatial adjustment made in the planting geometry. Similarly, plant population studies conducted at the Coimbatore centre have revealed that seed yield increased significantly with the corresponding increase in the plant spacing upto 45 x 30 cm (74,074 plants/ha) under irrigated conditions. The lowest seed yield obtained in the higher planting intensity (30 x 30 cm) may be due to the mutual shading or cowdung of plants in the treatment. On the other hand, wide planting intensity (60 x 30 cm) produced the lower seed yield as a result of smaller plant population per unit area. This study clearly suggests that the provision of optimal plant spacing is essential for sunflower hybrid to gain greater seed yields.

Table 3. Influence of spacing (S) and fertilizer level (F) on uptake of nitrogen, phosphorus, and potassium and oil content and crude protein content in sunflower hybrid MSFH-17 (n=3)

Treatments		Nutrient uptake (kg ha^{-1})			Oil content	Crude protein
		N	P	K	(%)	(%)
S1	F_1	45.7	18.2	39.6	36.3	18.2
	F_2	71.2	31.0	48.1	36.2	19.9
	F_3	68.5	29.5	47.2	36.5	19.1
	F_4	62.4	24.8	46.5	36.9	18.2
S2	F_1	49.2	19.9	45.6	36.4	18.3
	F_2	75.6	34.5	56.4	36.3	18.3
	F_3	71.4	29.4	54.2	36.4	19.0
	F_4	70.6	26.7	54.2	36.7	19.1
S3	F_1	47.5	18.7	43.7	36.4	19.0
	F_2	72.5	33.2	48.0	35.9	19.2
	F_3	65.6	28.1	49.7	36.2	19.0
	F_4	59.8	23.5	47.6	36.4	18.8
S	SEd	0.88	0.68	0.66	0.23	0.12
	CD (5%)	2.45	NS	1.82	NS	0.42
F	SEd	0.90	0.63	0.54	0.31	0.4
	CD (5%)	1.88	1.31	1.14	NS	NS
S x F	SEd	1.58	1.10	0.97	0.52	0.74
	CD (5%)	3.46	NS	2.25	NS	NS

Application of fertilizers at the incremental levels favourably enhanced the seed yield of sunflower hybrid but the increase was more pronounced at lower level (F2). This shows that the maximum response had been achieved at F2 level itself. Under optimal fertilizer level, the biomass production, LAI, and the % filled grains were higher than other treatments. Seed yield obtained under F2 fertilizer dose was significantly higher than other levels. Higher biomass production and larger canopy spread would have induced the optimally fertilized plants to mobilize sufficient amounts of minerals and metabolites to the developing seed. The increase in seed yield commensurate with the larger mineral concentration especially nitrogen and phosphorus (Table 3). The experimental soil is relatively poor in available nutrient status and the added fertilizer would have been better utilized by the sunflower hybrid to produce higher seed and stalk yields. Field experiments conducted at various centres of All India Co-ordinated Research Project (AICRP) for sunflower have indicated that the response of fertilizer N was more pronounced upto 90 kg/ha (Rao *et al.* 1984). Nandhagopal and Subramanian (1990) observed that the added P linearly increased the seed yield of sunflower upto 90 kg/ha in soils of low available P status.

Oil yield

The oil yield was slightly higher in S2 treatment but the increase was not significant. The oil yield increase is mainly due to the increase in seed yield but not by the oil synthesis in the seed itself. Both planting geometry and fertilizer levels did not affect oil content and crude protein content of sunflower seeds (Table 3).

Nutrient uptake

Nutrient uptake pattern of sunflower hybrid has significantly affected by the spacing and fertilizer levels. Uptake of N and P increased

significantly by 35-55% in treatment that received F2 level of fertilizer application and S2 planting geometry. As the nutritional status of F2 plants was higher, the plants were enable to produce higher biomass and seed yield. The data further suggest that the F2 level of fertilizer is optimal in terms of economic return and N nutritional improvement. The results are agreement with the findings of Mishra *et al.* (1995). The improved nutritional status of sunflower is mainly attributed to higher DMP and to a lesser extent caused by the increased N or P nutrient concentrations.

Overall, the present study suggess that sunflower responds to planting geometry and fertilizer levels significantly. Optimal population density per unit area is essential to gain higher seed yield and oil yield in sunflower. Further, sunflower hybrid (MSFH-17) produced higheryield than the varieties. Therefore, it is imperative to apply larger amounts of fertilizer to compensate the nutrients depleted. The data clearly indicated that application of 90:105:60: N:P:K kg/ha in combination with optimal plant spacing (45 x 30 cm) enable the sunflower hybrid to produce higher yield and maximum returns under irrigated conditions.

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(Received: July 2001; Revised: July 2003)