PRODUCTIVITY OF HYBRID SUNFLOWER AS INFLUENCED BY IRRIGATION, NITROGEN AND SULPHUR FERTILIZATION DURING THE SUMMER SEASON

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Abstract

A field experiment was conducted to study the productivity of hybrid sunflower as influenced by irrigation nitrogen and sulphur fertilization during the summer season. The results of the field trial indicated that scheduling the irrigation at a 1.00 irrigation water (IW)/cumulative pan evaporation (CPE) ratio produced higher seed yield of sunflower (2038 kg/ha) as compared to 0.80 (1,747 kg/ha) and 0.60 (1490 kg /ha) IW/CPE ratios. Nitrogen fertilization at 120 kg N/ha with recommended fertilizer rates of P and K (90 kg P2O5 and 60 kg K2O/ha, respectively) produced significantly higher seed yield (1,901 kg/ha) as compared to nitrogen fertilization at 60 kg N/ha (1,641 kg/ha) and 90 kg N/ha (1,733 kg/ha). Growth and yield components were favourably influenced by nitrogen fertilization. Sulphur fertilization at 60 kg S/ha recorded 4.48% higher seed yield over no sulphur application (1,720 kg/ha). Scheduling irrigation at a 1.00 IW/CPE ratio along with nitrogen and sulphur fertilization of 120 kg N and 60 kg S/ha, respectively, produced the highest seed yield (2,199 kg/ha) and oil yield (867 kg/ha) of sunflower as compared to scheduling irrigation at a 0.60 IW/CPE ratio along with nitrogen and sulphur fertilization of 60kg N and 0 kg S/ha, respectively. The total consumptive use of water was directly proportional to the seed yield and oil yield. Water use efficiency tended to decrease with frequent irrigation. Interaction effects of irrigation and nitrogen, nitrogen and sulphur had beneficial effects on seed and oil yield of sunflower.

Introduction

Sunflower is a potential remunerative oil seed crop of the world due to its desirable attributes such as early maturity, adaptability to a wide range of climate and soil, photo-thermo insensitiveness, drought tolerance and responsiveness to better production management practices. Being drought tolerant, it has tremendous production potential under irrigated conditions. Optimum irrigation scheduling is one of the most important production

management practices for increased water use efficiency in irrigated sunflower. Among the fertilizers, nitrogen and sulphur play an important role in increasing the productivity and quality of oilseeds particularly under irrigated farming situations. Keeping in view the above points, a field experiment was conducted during summer to study the effect of irrigation, nitrogen and sulphur fertilization on the seed yield, oil yield, nitrogen, and water use efficiency in hybrid sunflower (cv. DSH-1).

Materials and Methods

A field experiment was conducted in medium black clay soil at Main Agricultural Research Station (15˚26' N, 75˚07' E and 678 m above MSL), University of Agricultural Sciences, Dharwad (Karnataka State), India during the summer season of 1997. The total rainfall and the mean evaporation during the crop growth period of sunflower (97 days) were 52.9 mm (3 rainy days) and 3.43 mm/day, respectively. The initial soil test values were 0.60 per cent OC, 199.15 kg available N, 14.96 kg available P/ha, 273.9 kg available K/ha, 11.6 ppm S and 7.6 pH. The experiment consisted of three main plot treatments (irrigation regimes) (scheduling irrigation at 0.6, 0.8 and 1.00 IW/CPE ratio), three subplot treatments (nitrogen fertilizer rates) (60, 90 and 120 kg N/ha) and two sub-subplot treatments (sulphur fertilizer rates) (0 and 60 kg S/ha) (Tables 2 to 4). The experiment was laid out in split-split plot design and replicated three times with an individual subplot size of 11.52 m sq. Seeds of cv. DSH 1(an early and downy mildew resistant hybrid sunflower) were treated with Redomyl MZ (4 g/kg seed) and hand dibbled at a spacing of 60 cm × 30 cm. A plant density of 55,555 plants/ha was maintained from seeding to harvest. Nitrogen and P nutrients were applied through urea and diammonium phosphate (DAP); and K was applied through muriate of potash (MOP). Sulphur was applied in the form of elemental sulphur. At the time of sowing, the required quantity of fertilizer mixture containing half the dose of N as per the subplot treatments and entire dose of S as per the sub-subplot treatments; and common recommended dose of P (90 kg P2O5/ha) and K (60 kg K2O/ha) were applied in the furrows. Top dressing of remaining N (as per the subplot treatments) in the form of urea was given in band placement at 35 days after sowing (DAS). Experimental plots were kept weed free by hand weeding and intercultivations. The crop was kept disease and insect free. The details of irrigation as per the irrigation treatments (i.e., total number, interval and quantity of irrigation water) used during the course of experimentation are furnished in Table 1. The observations on seed weight/plant, seed yield, 1000-seed mass, seed oil content (%), oil yield, dry matter efficiency (g/g/day), consumptive use of water (Cu) and water use efficiency (WUE) were recorded.

Table 1. Total number, interval, and quantity of irrigation water used during experimentation (Summer 1997).

Treatments	Total number of irrigations given* during crop growth period of sunflower	Interval of irrigation (Days)	Quantity of irrigation water applied (mm)
Irrigation scheduled at 0.60 IW/CPE ratio	2	35 and 27	240
Irrigation scheduled at 0.80 IW/CPE ratio	3	27 and 22	300
Irrigation scheduled at 1.00 IW/CPE ratio	4	22, 18 and 14	360

*: Total number of irrigations excludes two irrigations that were given to all treatments before imposing irrigation as per the irrigation treatments (i.e., at the time of establishment of plant stand).

Results and Discussion

Effect of Irrigation. The seed yield differed significantly due to irrigation (Table 2). Scheduling irrigation at an IW/CPE ratio of 1.00 produced higher seed and oil yield of sunflower (2,038 and 782 kg/ha, respectively) compared to scheduling irrigation either at the 0.80 IW/CPE ratio (1,747 and 663 kg/ha, respectively) or at the 0.60 IW/CPE ratio (1,490 and 550 kg/ha, respectively). Seed weight/plant, 1000-seed mass, dry matter efficiency, seed oil content and seed crude protein contents were greater with irrigation scheduled at an IW/CPE ratio of 1.00 (Tables 2 and 3). The higher oil yield in frequently irrigated treatments (irrigation at IW/CPE ratios of 1.00 and 0.80) was mainly due to higher seed yield and higher oil content. The oil content in seed increased from 36.22 to 38.46 percent with increasing irrigation frequency from 0.60 to 1.00 IW/CPE ratios. These results are in conformity with the findings of Vedsingh et al. (1997). Seed crude protein content was not influenced by irrigation. Water use efficiency (WUE) decreased with increase in irrigation frequency. Maximum WUE (6.89 kg/ha mm) was observed with irrigation scheduled at the 0.60 IW/CPE ratio compared to 0.80 (6.59 kg/ha mm) and 1.00 (6.48 kg/ha mm). Mean consumptive use of water (Cu) by sunflower increased with increase in irrigation frequency. Scheduling irrigation at the 1.00 IW/CPE ratio recorded higher Cu (314.50 mm) compared to the 0.80 (265.13 mm) and 0.60 (216.17 mm) IW/CPE ratios (Table 4).

Effect of Nitrogen Fertilization. Nitrogen fertilization had a significant effect on seed yield, oil content, oil yield, dry matter efficiency and crude protein content (Tables 2 to 4). Nitrogen fertilization at 120 kg N/ha produced 9.69 and 15.84 percent higher seed yield of sunflower over 90 kg N/ha and 60 kg N/ha (1,733 and 1,641 kg/ha, respectively). Mishra et al. (1995) reported significant increase in seed yields due to nitrogen fertilization. Nitrogen fertilization at 120 kg N/ha produced higher oil yield (733 kg/ha) compared to 90 kg N/ha (675 kg/ha) and 60 kg N/ha (587 kg kg/ha). Crude protein content increased from 19.38 to 20.67 percent with increasing N fertilization from 60 to 120 kg N/ha. Seed oil content of sunflower decreased with increasing nitrogen fertilization beyond 90 kg N/ha. Similar observations were made earlier by Sunil Kumar et al. (1991), where they observed decreased seed oil content of sunflower with increased rates of nitrogen fertilizers. Nitrogen fertilization at 120 kg N/ha resulted in higher water use efficiency (7.19 kg/ha mm) compared to 60 kg N/ha (6.23 kg/ha mm) and 90 kg N/ha (6.55 kg/ha mm). Consumptive use of water by sunflower, although not significant, was greater with higher rates of nitrogen fertilizers (Table 4).

Table 2. Seed weight/plant, seed yield and 1000-seed mass of sunflower as influenced by irrigation, nitrogen and sulphur fertilization during summer season (1997).

Irrigation levels (IW / CPE ratio)	Sulphur fertilizer level (kg/ha)	Nitrogen fertilizer level (kg/ha)											
		Seed weight (g/plant)				Seed yield (kg/ha)				1000-Seed mass (g)			
		60	90	120	Mean	60	90	120	Mean	60	90	120	Mean
0.60	**0**	21.00	26.27	28.00	**25.09**	1367	1467	1545	**1460**	32.93	39.07	41.06	**37.69**
	60	22.03	27.10	32.00	**27.04**	1368	1483	1709	**1520**	35.00	39.71	43.59	**39.43**
	Mean	**21.51**	**26.68**	**30.00**	26.07	**1368**	**1475**	**1627**	1490	**33.97**	**39.39**	**42.32**	38.56
0.80	**0**	31.23	31.80	34.40	**32.48**	1609	1667	1868	**1715**	41.41	42.60	44.74	**42.92**
	60	30.23	33.00	40.00	**34.41**	1623	1681	2034	**1779**	41.32	42.23	48.06	**44.54**
	Mean	**30.73**	**32.40**	**37.20**	33.44	**1616**	**1674**	**1951**	1747	**41.37**	**43.42**	**46.40**	43.73
1.00	**0**	35.50	37.50	42.00	**38.33**	1896	2012	2050	**1986**	46.59	47.25	**49.11**	**47.65**
	60	36.30	44.00	45.17	**41.82**	1982	2089	2199	**2090**	46.98	51.18	52.62	**50.26**
	Mean	**35.90**	**40.75**	**43.58**	40.08	**1939**	**2051**	**2125**	2038	**46.78**	**49.21**	**50.87**	48.95
For comparing sulphur and nitrogen levels													
	0	29.24	31.86	34.80	**31.97**	1624	1715	1821	**1720**	40.31	42.97	44.97	**42.75**
	60	29.52	34.70	39.07	**36.93**	1658	1751	1981	**1797**	41.10	45.04	48.09	**44.74**
	Mean	**29.38**	**33.28**	**36.93**	33.20	**1641**	**1733**	**1901**	1758	**40.71**	**44.01**	**46.53**	43.75
For comparing the means of		**S.E ±**		**LSD (p=0.05)**		**S.E ±**		**LSD (p=0.05)**		**S.E ±**		**LSD (p=0.05)**	
Irrigation (**I**)		0.287		1.13		6.164		24		0.312		1.23	
Nitrogen (**N**)		0.404		1.25		7.625		24		0.313		0.96	
Sulphur (**S**)		0.335		1.00		7.240		22		0.208		0.62	
N at same **I**		0.700		NS		13.208		41		0.542		1.67	
S at same **I**		0.580		NS		12.539		NS		0.361		NS	
S at same **N**		0.580		1.72		12.539		37		0.361		1.07	
S at same **I** and **N**		1.005		NS		21.719		NS		0.625		NS	

IW / CPE ratio: Irrigation water / Cumulative pan evaporation **NS**: Non-significant

Table 3. Seed oil content, oil yield and seed crude protein content of sunflower as influenced by irrigation, nitrogen and sulphur fertilization during summer season (1997).

Irrigation levels (IW / CPE ratio)	Sulphur fertilizer level (kg/ha)	Nitrogen fertilizer level (kg/ha)											
		Seed oil content (%)				Oil yield (kg/ha)				Seed crude protein content* (%)			
		60	90	120	Mean	60	90	120	Mean	60	90	120	Mean
0.60	**0**	34.07	36.83	35.35	**35.41**	466	540	604	**536**	18.85	19.50	20.13	**19.49**
	60	35.55	38.25	37.26	**37.02**	486	567	637	**563**	19.19	20.13	20.77	**20.03**
	Mean	**34.84**	**37.54**	**36.30**	36.22	**476**	**554**	**620**	550	**19.02**	**19.81**	**20.45**	19.76
0.80	**0**	35.85	38.95	38.16	**37.65**	576	649	713	**546**	19.06	19.81	20.29	**19.72**
	60	36.29	39.57	38.75	**38.21**	589	665	788	**681**	19.81	20.40	21.15	**20.44**
	Mean	**36.07**	**39.26**	**38.46**	37.93	**583**	**657**	**751**	663	**19.44**	**20.09**	**20.72**	20.08
1.00	**0**	36.39	39.43	38.58	**38.14**	690	794	791	**758**	19.27	20.06	20.31	**19.88**
	60	36.90	40.04	39.42	**38.79**	713	836	867	**806**	20.06	20.63	21.40	**20.69**
	Mean	**36.65**	**39.74**	**39.00**	38.46	**702**	**815**	**829**	782	**19.67**	**20.34**	**20.85**	20.29
For comparing sulphur and nitrogen levels													
	0	35.43	38.40	37.36	**37.07**	577	661	703	**647**	19.06	19.79	20.24	**19.70**
	60	36.25	39.29	38.48	**38.00**	596	690	764	**683**	19.69	20.38	21.10	**20.39**
	Mean	35.84	38.84	37.92	37.54	**587**	**675**	**733**	665	**19.38**	**20.08**	**20.67**	20.04

For comparing the means of	S.E ±	LSD (p=0.05)	S.E ±	LSD (p=0.05)	S.E ±	LSD (p=0.05)
Irrigation (**I**)	0.193	0.76	7.500	30	0.275	NS
Nitrogen (**N**)	0.177	0.55	4.046	13	0.311	0.96
Sulphur (**S**)	0.169	0.50	3.962	12	0.205	0.61
N at same **I**	0.306	NS	7.008	22	0.538	NS
S at same **I**	0.292	NS	6.863	NS	0.355	NS
S at same **N**	0.292	NS	6.863	20	0.355	NS
S at same **I** and **N**	0.506	NS	11.887	NS	0.615	NS

IW / CPE ratio: Irrigation water / Cumulative pan evaporation*. % N × 6.25 **NS**: Non-significant

Table 4. Dry matter efficiency, consumptive use of water (Cu) and water use efficiency (WUE) in sunflower as influenced by irrigation, nitrogen and sulphur fertilization during summer season (1997).

Irrigation levels (IW / CPE ratio)	Sulphur fertilizer level (kg/ha)	Nitrogen fertilizer level (kg/ha)											
		Seed oil content (%)				Oil yield (kg/ha)				Seed crude protein content* (%)			
		60	90	120	Mean	60	90	120	Mean	60	90	120	Mean
0.60	0	34.07	36.83	35.35	**35.41**	466	540	604	**536**	18.85	19.50	20.13	**19.49**
	60	35.55	38.25	37.26	**37.02**	486	567	637	**563**	19.19	20.13	20.77	**20.03**
	Mean	**34.84**	**37.54**	**36.30**	36.22	**476**	**554**	**620**	550	**19.02**	**19.81**	**20.45**	19.76
0.80	0	35.85	38.95	38.16	**37.65**	576	649	713	**546**	19.06	19.81	20.29	**19.72**
	60	36.29	39.57	38.75	**38.21**	589	665	788	**681**	19.81	20.40	21.15	**20.44**
	Mean	**36.07**	**39.26**	**38.46**	37.93	**583**	**657**	**751**	663	**19.44**	**20.09**	**20.72**	20.08
1.00	0	36.39	39.43	38.58	**38.14**	690	794	791	**758**	19.27	20.06	20.31	**19.88**
	60	36.90	40.04	39.42	**38.79**	713	836	867	**806**	20.06	20.63	21.40	**20.69**
	Mean	**36.65**	**39.74**	**39.00**	38.46	**702**	**815**	**829**	782	**19.67**	**20.34**	**20.85**	20.29
For comparing sulphur and nitrogen levels													
	0	35.43	38.40	37.36	**37.07**	577	661	703	**647**	19.06	19.79	20.24	**19.70**
	60	36.25	39.29	38.48	**38.00**	596	690	764	**683**	19.69	20.38	21.10	**20.39**
	Mean	35.84	38.84	37.92	37.54	**587**	**675**	**733**	665	**19.38**	**20.08**	**20.67**	20.04
For comparing the means of		**S.E ±**		**LSD (p=0.05)**		**S.E ±**		**LSD (p=0.05)**		**S.E ±**		**LSD (p=0.05)**	
Irrigation (**I**)		0.193		0.76		7.500		30		0.275		NS	
Nitrogen (**N**)		0.177		0.55		4.046		13		0.311		0.96	
Sulphur (**S**)		0.169		0.50		3.962		12		0.205		0.61	
N at same **I**		0.306		NS		7.008		22		0.538		NS	
S at same **I**		0.292		NS		6.863		NS		0.355		NS	
S at same **N**		0.292		NS		6.863		20		0.355		NS	
S at same **I** and **N**		0.506		NS		11.887		NS		0.615		NS	

IW/CPE ratio: Irrigation water / Cumulative pan evaporation. % N × 6.25 **NS**: Non-significant.

Effect of Sulphur Fertilization. Sulphur fertilization significantly improved the seed yield, oil yield, seed oil content and seed crude protein content of sunflower (Tables 2 and 3) Sulphur fertilization at 60 kg S/ha produced significantly higher seed yield (1,797 kg/ha) and oil yield (683 kg/ha) compared to no S fertilization (1,720 and 647 kg/ha, respectively). Sulphur fertilization at 60 kg/ha produced higher oil content (38%) and higher crude protein content (20.39%) over no S fertilization (37.07 and 19.70%, respectively). These results are in conformity with the findings of Tamak et al. (1997). Sulphur fertilization had no significant effect on WUE and Cu of water by sunflower.

Performance of Sunflower under Different Irrigation Regimes, Nitrogen and Sulphur Fertilization. Interaction effects of irrigation and nitrogen were significant with respect to seed yield and oil yield (Tables 2 and 3). Irrigating the sunflower at the 1.00 IW/CPE ratio along with the application of 120 kg N/ha produced higher seed and oil yield (2,125 and 829 kg/ha, respectively) compared to rest of the combinations. Interaction effects of nitrogen and sulphur were significant in increasing seed and oil yield of sunflower (Tables 2 and 3). The maximum seed yield (1,981 kg/ha) and oil yield (764 kg/ha) were recorded with combined application of 120 kg N/ha and 60 kg S/ha compared to other combinations of the levels of nitrogen and sulphur. This indicates that the sunflower crop responds greatly to the application of higher rates of nitrogen fertilizers when applied with sulphur fertilizer.

Conclusions

Higher seed and oil yields of sunflower during the summer season were realized either with irrigation scheduled at the 1.00 IW/CPE ratio (three irrigations) or with the application of nitrogen fertilizer at 120 kg N/ha or with the application of sulphur at 60 kg/ha. Growth and yield components were favourably influenced by irrigation at a IW/CPE ratio of 1.00 and higher rates of N (120 kg N/ha) and S (60 kg S/ha). Scheduling of irrigation at the 1.00 IW/CPE ratio along with nitrogen and sulphur fertilization at 120 kg N and 60 kg S/ha, respectively resulted in higher seed and oil yields of sunflower compared to scheduling of irrigation at 0.60 and 0.80 IW/CPE ratios along with nitrogen and sulphur fertilization of 60 to 90 kg N/ha and 0 kg S/ha, respectively. The total consumptive use of water was directly proportional to the seed yield and oil yield. Water use efficiency decreased with increasing numbers of irrigation. Interaction effects of irrigation and nitrogen, nitrogen and sulphur had beneficial effects on seed and oil yield of sunflower.

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