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Effect of irrigation and nitrogen on oil percentage, yield and water-use efficiency of winter sunflower (*Helianthus annuus*)

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ABSTRACT

An experiment was conducted to study the influence of irrigation and nitrogen on oil (%) and seed yield of 'Arun Hybrid' of sunflower (*Helianthus annuus* L.). Significant increase in yield (17.4 and 18.0 q/ha) was recorded up to 3 irrigations with IW : CPE ratio of 0.8. Oil yield and net returns were also maximum at this level. The crop showed significant response up to 40 kg N/ha. The leaf-area index and other ancillary characters were also maximum in case of 3 irrigations and 40 kg N/ha. Oil (%) and water-use efficiency were higher at 1 irrigation but from the economic point of view, 3 irrigations resulted in more net returns. Soil-moisture depletion in 0–60 cm layer was higher than that in 60–90 cm soil layer, but the relative depletion in 60–90 cm layer was more in rainfed due to penetration of roots in search of soil moisture.

Key words : Winter, Sunflower, Nitrogen, Irrigation, Water-use efficiency, Soil-moisture depletion

In India sunflower is cultivated generally as rainfed crop in rainy season, however it is also grown on residual moisture in winter. High yield can be obtained when irrigation is applied at proper time (Vivek and Sharma, 1994). Oil content of sunflower is affected due to variation in soil moisture, especially in reproductive phase (Sharma and Gaur, 1988). Thus proper irrigation schedule is required to be evaluated for higher achene yield and oil content. The crop responds well to applied nitrogen (Vivek and Sharma, 1994). As the nitrogen requirement of winter sunflower has yet not been quantified for different agro-climatic conditions of Bihar, the present experiment was planned to study the effect of irrigation and nitrogen on yield, oil (%) and water-use efficiency.

MATERIALS AND METHODS

A field experiment was conducted during winter season of 1996–97 and 1997–98 at University farm of Rajendra Agricultural University, Pusa, Bihar. The treatment comprised 4 levels of irrigation

based on IW : CPE ratio of 0.4, 0.6, 0.8 and a rainfed control and 4 levels of N (0, 20, 40 and 60 kg/ha). The experiment was laid out in randomized block design with 3 replications. The soil was sandy loam, Entisol and contained 249 kg N, 11.2 kg P (Olsen's P) and 109 kg K (NH_4 OAC-K)/ ha. The pH of the soil was 8.2 and contained 26.8% $CaCO_3$. Field capacity (w/ w), permanent wilting point and bulk density in 0–30 cm soil layer were 22.5% 8.2% and 1.45 g/cc respectively. The experiment was sown with variety 'Arun Hybrid' on 26 October 1996 and 12 November 1997 in rows 50 cm apart and plant-to-plant distance was 30 cm. The crop was harvested on 21 March 1997 and 7 April 1998 respectively. A dose of 90 kg P_2O_5 and 40 kg K_2O was applied at the time of sowing. In order to create uniformity between irrigated and rainfed treatments, all N was applied at the time of sowing. The irrigation (6 cm depth) was applied when cumulative pan evaporation reached 150, 100 and 75 cm in case of 0.4, 0.6 and 0.8 IW : CPE ratios. The total number of irrigation at 0.4, 0.6 and 0.8 ratios came out to be 1,2 and 3 respectively. The mean minimum temperature was 6.7°C and 7.2°C and mean maximum temperature 32.3°C and 29.0°C during 1996–97 and 1997–98 respectively. The total rainfall received during crop period was 15.4 and 69.3 mm in first and second year respectively.

Leaf area of 5 plants/plot was measured through automatic leaf area meter LI 2000. This leaf area was divided by the land area occupied by these 5 plants which finally gave the leaf-area index (LAI). After harvest 5 sample plants/plot were used for calculating achenes/head, 1,000-grain weight and filled grains/head. The oil (%) was determined by Nuclear Magnetic Resonance technique for rapid and non-destructive determination of oil in oilseed developed at the Nuclear Research Laboratory, IARI, New Delhi.

Soil-moisture depletion was calculated in 0–90 cm soil layer at an interval of 30 cm by gravimetric method. The water-table ranged from 435 to 720 cm during the crop period. Water-use efficiency was calculated by dividing achene yield to that of water applied and the total evapotranspiration (ET) under that treatment.

RESULTS AND DISCUSSION

Achene yield

Significant effect of irrigation on the achene yield was obtained during both the years. Maximum yield was recorded at IW : CPE ratio of 0.8 with 3 irrigations (Table 1), which was significantly higher than 1 or 2 irrigations. However, achene yield at 2 irrigations (0.6 IW : CPE) was significantly higher than 1 irrigation (0.4 IW : CPE). Significant N response was recorded up to 40 kg/ha. Those results corroborate the findings of Bindra and Kharwar (1992) and Vivek and Sharma (1994).

Seed oil content and yield

Both irrigation and nitrogen significantly influenced the seed oil content (Table 1). The maximum seed oil content was recorded with 1 irrigation, whereas maximum oil yield with 3 irrigations. This might be owing to better filling of seeds as a result of less moisture-stress condition at the critical

Table 1. Effect of irrigation and N levels on yield attributes, achene and oil yield, oil per cent and net returns of winter sunflower

Treatment	Leaf-area index		Achenes/ head		1,000-grain weight (g)		Filled grains/head		Achene yield (q/ha)		Oil (%)		Oil yield (q/ha)		Net returns (Rs/ha)	
	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98
Irrigation(IW : CPE)																
0.4	3.6	3.5	609.3	622.1	58.2	59.2	579.3	586.2	12.90	13.59	33.8	32.9	4.3	4.5	6,239	6,370
0.6	3.9	4.0	660.9	654.2	63.9	63.1	630.5	621.1	15.92	16.56	31.1	31.6	5.3	5.2	9,617	10,170
0.8	4.2	4.3	750.9	692.4	66.2	68.2	718.1	692.7	17.45	18.00	32.6	32.2	5.7	5.8	11,178	11,280
Rainfed	2.5	3.1	533.8	521.3	47.9	49.1	503.1	498.2	8.52	8.92	33.1	33.0	2.9	2.9	1,328	1,470
CD (P=0.05)	0.4	0.4	14.6	21.9	7.1	9.2	15.0	22.8	1.17	1.32	1.0	0.1	0.4	0.3	284	297
Nitrogen (kg/ha)																
0	3.3	3.4	584.7	595.2	54.3	52.6	555.5	548.4	9.75	10.24	33.7	32.8	3.3	3.4	2,626	2,790
20	3.3	3.6	620.4	612.3	57.4	57.5	589.0	596.3	13.64	14.05	33.4	32.5	4.5	4.6	7,069	7,280
40	3.6	3.9	657.9	640.7	60.6	62.8	625.8	625.2	15.83	16.44	33.1	32.3	5.3	5.3	9,593	9,640
60	4.0	4.0	691.8	642.4	66.0	66.8	660.6	628.1	15.57	16.34	33.0	32.1	5.1	5.2	9,074	9,580
CD (P=0.05)	0.4	0.4	14.6	21.9	7.1	9.2	15.0	22.8	1.17	1.32	0.1	0.1	0.4	0.3	284	297

stage of seed filling.

Significant decrease in oil (%) was recorded with the increase in levels of N in both the years, whereas oil yield increased significantly up to 40 kg N/ha. No difference in oil yield at 40 kg and 60 kg N/ha was observed. Decrease in oil (%) due to higher level of N was because of more impurities, as also reported by Singh and Quadri (1984) and Sharma and Gaur (1988).

The leaf-area index (LAI) (90 DAS) influenced significantly due to irrigation levels (Table 1). The LAI at 2 and 3 irrigations were statistically similar, however latter treatment was significantly higher than 1 irrigation or the rainfed control. Among the N levels, maximum LAI was recorded at 60 kg N/ha which was significantly higher than other N levels during the first year and at par with 40 kg N/ha during the second year.

Achene

The maximum achenes/head was recorded at 3 irrigations which was significantly higher than all other irrigation treatments. Similarly, achenes/head were maximum with 60 kg N/ha; however during the second year 40 and 60 kg/ha N were at par with each other.

The 1,000-grain weight was significantly affected due to irrigation and nitrogen levels. The maximum value was recorded with 3 irrigations which was at par with 2 irrigations during 1996–97. During 1997–98 no significant variations due to 1,2 and 3 irrigations were observed. Statistically at par 1,000-grain weight was recorded at 2 successive N doses.

Fertile grains

Maximum filled grains were recorded with 3 irrigations which was significantly higher than other irrigation levels. This may probably attributed to availability of optimum moisture and nutrient to the crop. More filled grains/head were recorded at increased N levels.

Water-use efficiency

Water-use efficiency was highest at 1 irrigation, followed by 2 and 3 irrigations. This was directly reflected to difference in yield. Water-use efficiency based on soil-moisture depletion was the highest (99.23 kg/ha-cm) with 1 irrigation in the first year, while in the rainfed control during second year it was 96.9 kg/ha-cm. Water-use efficiency decreased with the increase in soil-moisture depletion.

Soil-moisture depletion

A major part of soil moisture was depleted from 0–60 cm soil layer. The depletion from the lower most layer of 60–90 cm was 20.0–28.4% in the first year and 22.0–26.6% in the second year. Among the irrigation treatments, maximum depletion at 0–30 cm layer was recorded under the highest frequency of irrigation (IW : CPE 0.8). In this layer a decrease in the frequency of irrigation simultaneously reduced the depletion. This might be due to lack of water, which resulted in less ET from the upper layers. Under rainfed, moisture extraction (%) was more from 60–90 cm soil layer compared with that from higher frequencies of irrigation, might be due to development of roots at deeper depths for want of water due to paucity of soil moisture.

Table 2. Soil-moisture depletion and water-use efficiency of winter sunflower as affected by irrigation level

Irrigation (IW : CPE)	Soil-moisture depletion								Water-use efficiency based on irrigation water applied (kg/ha-cm)		Water-use efficiency based on soil-moisture depletion (kg/ha-cm)	
	0–30 cm depth		30–60 cm depth		60–90 cm depth		Total 0–90 cm depth					
	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98	1996–97	1997–98
0.4	5.6	4.8	4.8	5.1	2.6	3.3	13.0	14.6	215	227	99.2	93.1
	(43.1)	(42.2)	(36.9)	(35.2)	(20.0)	(22.6)	(100.0)	(100.0)				
0.6	8.9	9.1	5.7	6.4	4.0	4.9	18.6	20.4	132	138	85.6	81.2
	(47.8)	(44.6)	(30.6)	(31.4)	(21.6)	(24.0)	(100.0)	(100.0)				
0.8	11.8	12.0	6.2	7.0	4.9	5.4	22.9	24.4	97	100	76.2	73.8
	(51.5)	(49.4)	(27.1)	(28.6)	(21.4)	(22.0)	(100.0)	(100.0)				
Rainfed	3.8	3.8	3.0	3.0	2.7	2.4	9.5	9.2			89.7	96.9
	(40.0)	(41.0)	(31.6)	(32.4)	(28.4)	(26.6)	(100.0)	(100.0)				

Figures in parentheses indicate % value

IW : CPE, Irrigation water : cumulative pan evaporation

Net return

During both the years, maximum net returns were recorded at 3 irrigations, being significantly higher than 2, 1 and the rainfed control. Among the N levels, maximum bet return was recorded at 40 kg N/ha. Further increase in the level of nitrogen to 60 kg/ha depressed net return significantly in the first year while during the second year, it was at par with 40 kg N/ha.

Thus in North Bihar agro-climatic condition, winter sunflower responds well up to 3 irrigations, each having a depth of 6 cm at irrigation water : cumulative pan evaporation (IW : CPE) of 0.8. Significant N response was observed at 40 kg N/ha.

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