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Effect of irrigation and nutrients levels on productivity and profitability of sunflower (*Helianthus annuus*)

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ABSTRACT

A field trial was conducted for 3 consecutive spring season from 2005-06 to 2007-08 on sandy loam soil to study the effect of irrigation and nutrients on productivity, profitability and water use efficiency of sunflower (*Helianthus annuus* L.) at Morena, Madhya Pradesh. Irrigation applied at 8 days interval significantly improved the plant height, leave/plant, head diameter, weight/head, seed weight/head, 1,000-seed weight, nutrient use (12.83 kg seed/kg nutrients), production efficiency (21.81 kg/ha/day), seed yield (1.86 t/ha), stalk yield (6.57 t/ha), N, P and K uptake, net profit (Rs 12,885/ha) and B:C ratio (1.85) and recorded 24.21% and 58.19% higher seed yield of sunflower over 12 and 16 days irrigation interval. However, maximum water use efficiency (65.45 kg/ha-cm) was obtained with 16 days irrigation interval. Similarly the nutrient treatment of 125% recommended dose of fertilizer, RDF (75-40-41.5 kg N-P-K/ha) recorded significantly higher water use efficiency, production efficiency, seed yield (1.76 t/ha), stalk yield (6.56 t/ha), N, P and K uptake, net income (Rs 11,784/ha) and B:C ratio (1.80) over other nutrient levels.

***Key words**:* Growth, Irrigation, Productivity, Profitability, Sunflower, Yield

Sunflower, (*Helianthus annuus* L.) holds great promise as an oilseed crop because of its short duration, photo-insensitivity, and wide adaptability to different agro-climatic regions and soil types. Spring sunflower best suits such conditions, with changes of area expansion and horizontal intensification for improving oil seed production in India. Sunflower can play an important role in meeting out the shortage of edible oils in the country. It covers 2.34 m ha area and provides 1.44 m t to total oil seed production with 615 kg/ha average productivity (Shekhawat and Shivay, 2008). The sunflower yield can be increased from 1.5-2.0 t/ha by adopting improved production technology (Sumathi and Rao, 2007). Thus, there, is a gap of 0.8 to 1.2 t/ha on yield recorded in between improved agronomic practice and farmers field.

Intensive cropping system has depleted the inherent soil fertility, leading to deficiency of important plant nutrients which finally causes poor productivity (Singh *et al*., 2006 and 2007). Thus augmenting of the nutrient supply assumes prime significance to improve sunflower productivity. Water is a key input for all recommended package of practices and therefore efficient utilization of irrigation water is essential for sunflower by adopting proper irrigation schedules (Thaku ria *et al*., 2004). Hence, the present investigation was under taken to test the effect of different levels of nutrients and irrigation on seed yield and economics of sunflower in Gird agro-climatic zone of Madhya Pradesh.

MATERIALS AND METHODS

A field experiment was conducted during spring seasons of 2005-06 to 2007-08 at RVS KVV, Zonal Agricultural Research Station, Morena, Madhya Pradesh. The soil of experimental field was low in available nitrogen (134.0 kg/ha), medium in available phosphorus (13.4 kg/ha), potash (310.2 kg/ha), with pH 7.8, field capacity (22.12%), permanent wilting point (6.88%), bulk density (1.40 g/cc), infiltration rate (15 mm/hr) and electrical conductivity (0.33 dS/m). The experiment was laid out in split plot design replicated four times. The main plot treatments comprised of three irrigation intervals *viz.*, irrigation at 8, 12 and 16 days intervals, whereas sub-plot treatments consisted of four levels of fertilizers viz. 50%, 75%, 100% and 125% recommended dose of fertilizers (RDF) i.e 30:17.6:16.6, 45:26.4:24.9, 60:35.2:33.2 and 75:40:41.5 N:P:K kg/ha. Full dose of P and K and half N were applied as basal and the rest of N was top dressed as per

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treatments. Seven cm water was applied in each irrigation to the crop. No rainfall was received during the crop growth period. Sunflower 'Modern' was sown in third week of March and harvested in second week of June. The seed rate of 15 kg/ha was used for sowing at a geometry of 45 cm x 25 cm. The pre-sowing irrigation was given for land preparation and germination of seed. The initial soil moisture content at sowing and harvest was 15.87% and 10.11%, respectively. Hand-weeding was done twice at 25 and 45 days after sowing of the crop. Pearlmillet-mustard-sunflower cropping sequence was followed in all the 3 seasons. The water use efficiency (WUE) in kg/ha-cm was calculated by dividing the seed yield with respective total consumptive water use for the crop period. The nutrient use (kg seed/kg nutrient) was calculated by dividing the seed yield with total nutrient (N, P, and K) applied to the crop. The N, P and K uptake and nutrient status after harvesting of crop was analysed with standard methods. The production efficiency was calculated by dividing the seed yield with total days of crop period. The economics of various treatments were calculated based on market price. The selling rate of Rs 15,000/t for sunflower seed is used.

RESULTS AND DISCUSSION

Growth and yield

Irrigation schedules had significant effect on growth and yield contributing characters of sunflower (Table 1). The yield attributory values of sunflower were significantly reduced with increasing irrigation interval from 8 to 12 days and 12 to 16 days. Highest plant population, plant height, leaves/plant, head diameter, weight/head, seed weight/head, 1,000-seed weight and head weight (441 kg/ha) were observed under 8 days irrigation interval followed by 12 and 16 days interval. Singh (2004) and Thakuria *et al*. (2004) also reported similar results. Improvement in growth and yield attributes under less irrigation frequency due to higher availability of soil moisture might have helped in better nutrient uptake by the crop which is in turn resulted in assimilation of photosynthates towards sink as well as higher dry matter accumulation.

The seed yield and biological yield of sunflower improved markedly due to irrigation schedules (Table 1). Irrigation at 8 days interval resulted in highest seed yield (1.86 t/ha) which was 24.21% and 59.19% higher than irrigation applied at 12 and 16 days interval, respectively. Increase in yield was attributed to more vigorous growth and higher order of yield attributes under 8 days irrigation interval, as the atmosphere had high demand of evapotranspiration during crop period (summer). Mean stalk yield exhibited the trend similar to that of seed yield, being 13.53% and 43.43% higher under 8 days irrigation interval over 12 and 16 days interval, respectively.

There was significant and progressive increase in vegetative growth and yield components with successive increase in nutrient levels from 50% to 125% RDF except head dia meter and 1,000 grain weight (Table 1). The maximum plant population, plant height, leaves/plant, head diameter, weight/head, seed weight/head, 1,000-seed weight and head weight (443 kg/ha) were registered with 125% RDF. The response of sunflower to nutrient application may be attributed to the fact that addition of fertilizers improved the uptake of nutrients, which might have favoured the plant growth and yield contributing characters under 125% RDF. Singh, (2007) and Singh *et al*. (2006 and 2007) also reported the positive response to fertilizer application on growth and yield components of sunflower.

The nutrient significantly increased the seed yield as well as stalk yield of sunflower with subsequent increasing in fertilizer dose from 50% to 125% RDF in all the 3 years and pooled data (Table 1). The mean increase over 50% RDF in seed yield at 75, 100 and 125% RDF was 18.70%, 31.46% and 47.32% respectively. The maximum seed yield (1.76 t/ha) and biological yield (6.56 t/ha) were gained with 125% RDF. Similar to seed yield, 34.39%, 42.41% and 47.86% improvement in stalk yield was recorded with 75, 100 and 125% RDF over 50% RDF, respectively. Fertilizers application provided better conducive conditions for better uptake of nutrients and in turn helped the plants to boost their growth, leading to the development of yield attributes through supply of more photosynthates towards the reproductive sink. Maity and Gajendra (2003) and Sumathi and Rao (2007) also reported similar findings.

Water use, production and nutrient use efficiency

Significant improvement in water use efficiency, production efficiency and nutrient use were observed due to irrigation (Table 2). The water use efficiency tended to decline with increasing frequency of irrigation from 8 to 12 days and 12 to 16 days. However, maximum water use efficiency (65.45 kg/ha-cm) was realized with 16 days irrigation interval. Water use efficiency is the function of economic produce to the consumptive use of water, the seed yield of sunflower/mm of water used decreased with increased water supply, thereby resulting in decline in water use efficiency under 8 and 12 days irrigation interval when compared with 16 days irrigation interval. Thus consumptive use of water was markedly higher with increase irrigations than that with reduced irrigations (Thakuria *et al.*, 2004). This might be due to the fact that under more irrigations, evaporation was at potential rate due to availability of more water than the crop irrigated with less irrigations. The production efficiency and nutri-

ent use decreased with increasing irrigation interval and was maximum under 8 days interval (21.81 kg/ha/day and 12.83 kg seed/ kg nutrient). This may attributed to higher seed yield under this treatment (Sumathi and Rao, 2007). Moisture depletion was higher with reduced frequency of irrigation (Fig. 1). More and more water extracted by sunflower from upper and middle layers when lower frequency (8 days interval) of water was applied. It may be due to better proliferation of roots in upper and middle layers because of lower resistance of soil attributed by lower irrigation frequency. When the crop suffered from scarcity of water (16 days interval) more water was extracted from lower layers (Thakaria *et al.*, 2004).

The consumption use of water by sunflower was observed maximum with 125% RDF followed by decreasing dose of fertilizers. Water use efficiency, production efficiency and nutrient use were affected significantly due to fertilizer levels. Increasing levels of fertilizers from 50% to 125% RDF also increased the water use efficiency and production efficiency. The maximum values of water use efficiency (71.83 kg/ha-cm) and production efficiency (20.94 kg/ha/day) were noticed with 125% RDF which was leading to their favourable effect on yield contributing characters and ultimately on seed yield (Kumar *et al.*, 2006 and 2007). Nutrient use was significantly enhanced with decreased dose of nutrient and was maximum with 50% RDF (13.65 kg seed/kg nutrient). This might have improved in seed yield in diminishing manner with pro-

Table 1. Growth and yield of sunflower as influenced by irrigation and nutrient management (pooled over 3 years)

Treatment	Plant stand at harvest (m^2)	Plant height (cm)	Leave/ plant (No.)	Head diameter (cm)	Weight /head (g)	Seed weight /head (g)	1,000 seed weight (g)	Head weight (kg/ ha)	Stalk production (t/ha)	Seed yield (t/ha)
Irrigation Interval(days)										
8	7.96	92.0	24.42	13.26	101.60	51.09	47.52	441	6.57	1.86
12	7.83	87.5	22.68	12.16	81.40	41.62	46.17	220	5.79	1.51
16	7.68	83.8	20.82	11.15	65.60	32.93	40.61	236	4.58	1.17
SEm±	0.03	1.3	0.34	0.28	3.92	2.93	1.13	33	0.32	0.11
CD (P=0.05)	0.10	4.1	1.77	0.90	11.80	8.78	3.41	93	0.98	0.34
Fertility levels (% of recommended dose of fertilizer)										
50	7.71	82.0	20.39	11.00	61.88	31.74	39.01	274	3.42	1.22
75	7.82	85.6	21.95	11.63	76.17	35.39	41.47	321	5.22	1.44
100	7.96	89.6	23.33	13.07	88.06	44.66	45.67	357	5.94	1.62
125	8.10	93.8	24.91	13.36	105.48	53.61	48.46	443	6.56	1.76
SEm±	0.04	1.3	0.50	0.22	4.49	2.39	1.03	14	0.33	0.04
CD (P=0.05)	0.12	3.8	1.46	0.71	13.53	7.25	3.11	44	1.03	0.13

Table 2. Effect of irrigation and nutrient on efficiencies, yield ,economics (Rs/ha), nutrient uptake and nutrient balance (kg/ha)of sunflower (mean data of 3 years)

Treatment	CU of water (mm)	WUE (kg/ ha-cm)	PE (kg/ ha/ day)	Nutrient use (kg seed /kg nutrients)	Cost of cultivation	Net income	Net B:C ratio	Nutrient uptake			Available nutrient status		
								N	P	K	N	P	K
Irrigation Interval(days)													
8	219.5	57.85	21.81	12.83	14,545	13,385	0.95	80.8	20.2	93.0	125	12.9	305
12	185.2	59.95	17.68	10.34	14,045	8,605	0.60	70.6	17.4	85.5	127	13.0	310
16	162.4	65.45	14.57	7.91	13,545	4,050	0.30	62.8	14.7	68.5	128	13.2	318
SEm±		1.25	0.79	0.80				2.9	0.8	4.0	1.3	0.3	4.4
CD (P=0.05)		3.81	2.40	2.42				9.0	2.6	12.1	NS	NS	NS
Fertility levels (% of recommended dose of fertilizer)													
50	152.9	48.78	14.30	13.65	12,722	5,593	0.44	58.7	14.2	67.5	132	13.0	314
75	183.2	58.34	16.93	10.67	13,384	8,246	0.62	68.3	16.6	78.7	134	13.2	317
100	193.3	65.39	19.01	8.97	14,045	10,285	0.73	76.1	18.6	88.0	134	13.6	318
125	227.0	71.83	20.94	8.15	14,706	11,784	0.80	82.2	20.1	93.8	136	13.6	320
SEm±		2.56	0.72	0.62				2.6	0.6	2.8	0.6	0.1	0.7
CD (P=0.05)		7.66	2.19	1.81				7.7	1.9	8.6	2.0	0.2	3.2

gressive increasing in nutrient levels (Singh *et al.*, 2006 and 2007). The rate of moisture increased with progressive increase in fertility levels, perhaps due to improved vegetative growth and extensive root system, which enable the plant to utilize more moisture from soil layers (Fig. 1). This might be attributed to increased root activity and proliferation of root system, due to translocation of more photosynthates to the roots, thereby resulting in greater extraction of moisture with increase levels of fertility. However, under decreased fertilization treatment the root growth was not much extensive and hence moisture extraction has progressively decreased.

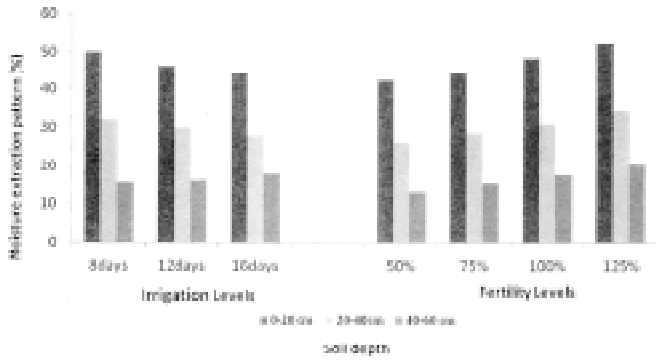

Fig. 1. Effect of irrigation and fertility levels on moisture extraction pattern (%) from different soil depth

Nutrient uptake and fertility status

Irrigation schedules showed significant effect of nutrient uptake of sunflower (Table 2). The N, P and K uptake of sunflower decreased with increasing intervals of irrigation from 8 to 12 days and 12 to 16 days. Maximum N, P and K uptake were associated with the less irrigation frequency applied to sunflower might be due to efficient root system with improved permeability, coupled with better absorption due to better availability of nutrients in the soil solution. Sumathi and Rao (2007) also reported similar results. This may be ascribed to increase in seed and straw yield of sunflower under less irrigation frequency. Irrigation schedules did not show significant effect on nutrient status of soil after harvest of the crop.

Increasing levels of fertility from 50 to 125% RDF had positively influenced the total uptake of various nutrients by sunflower (Table 2). The total uptake of N, P and K was found maximum under 125% RDF which was significantly superior to all others fertility treatments. The increased total biological yield with increasing nutrient application, thereby activating greater absorption of all the nutrients from soil resulted in higher total uptake of various nutrients. These results confirm the findings of Shekhawat and Shivay (2008). Nutrient status of the soil also influenced with the increasing levels of fertility. The maximum N, P and K contents in soil were found under 125% RDF which were significantly superior over 50% RDF.

Economics

The mean values of 3 years data of net returns (Rs 13,385/ ha) and net B:C ratio (0.95) realized from 8 days irrigation interval were higher than those between 12 and 16 days interval (Table 2) due to higher yields. The maximum net returns (Rs 11,784/ha) and net B: C ratio (0.80) was observed at 125% RDF. These observations are in agreement with the findings of Kumar *et al*. (2006 and 2007). The impact of irrigation and nutrients on improvement in seed yield might have helped in accruing higher profit.

It was concluded that irrigation at 8 days interval for sowing of sunflower in spring with a fertilizer dose of 125% RDF can be better and profitable option.

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