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Influence of irrigation and nutrients on growth, yield and oil content of spring sunflower (*Helianthus annuus*)

BIKAS MANDAL AND GAJENDRA GIRI

Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110 012

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ABSTRACT

An experiment was conducted at the farm of the IARI, New Delhi, during 1998 and 1999 on spring-season sunflower (*Helianthus annuus* L.). Three irrigations improved the growth and yield attributes of sunflower which in turn resulted in increase in seed and oil yield by 74.7 and 79.4 % over 2 irrigations. Application of nutrients also significantly enhanced the growth and yield of sunflower. However, highest (50.7%) increase in seed yield was recorded with 80 kg N/ha. Sulphur at 30 kg/ha increased the oil content in seed by 6.4% . Combined application of N, P and K under 3 irrigations was found most productive.

Key words : Sunflower, Irrigation, Nutrients, Yield, Oil content

Though sunflower has been considered as drought-resistant crop due to its deep-rooted system, it responds to higher levels of irrigation (Tomar *et al.,* 1997). Among nutrients , nitrogen plays an important role in growth and yield of sunflower (Tomar *et al.,* 1997) though the level of N for higher yield is variable depending on soil type, season and preceding crops grown. Phosphorus has a certain role in improving the 1,000-seed weight (Sarkar *et al.,* 1995). Bhattacharya *et al.* (1995) reported the beneficial role of K in improving the growth and yield attributes. Sulphur is important nutrient for sunflower, as it improves the oil content in its seed (Vasudevan *et al.,* 1997). However, since sunflower is a recent introduction in North-western parts of the country, very little work has been done on nutrient and irrigation management of this crop grown in spring season. Hence an experiment was conducted to study the effect of irrigation and nutrients, viz. N, P, K and S, on growth, yield and oil content of spring sunflower.

MATERIALS AND METHODS

The field experiment was conducted during the spring season of 1998 and 1999 at the Indian Agricultural Research Institute, New Delhi. The soil was sandy loam, low in organic carbon (0.4%), medium in available P (21.0 kg/ha), available K (232.0 kg /ha) and available S (49.7 kg/ha) and slightly alkaline in reaction (pH 7.2). The treatments comprising 3 levels of irrigation namely, 2 irrigations (one each at button and seed-development stage), 3 irrigations (one each at bud formation, flowering and seed-development stage) and 4 irrigations (one each at vegetative, button, seed formation and seed-development stage) were assigned to the main plots and 5 levels of nutrients (control, 80 kg N, 80 kg N+ 40 kg P_2O_5, 80 kg N+ 40 kg P_2O_5 + 40 kg K_2O and 80 kg N + 40 P_2O_5 + 40 kg K_2O + 30 kg S/ha) to the subplots. Thus 15 treatment combinations were tested in splitplot sesign with 3 replications. The sunflower hybrid 'MSFH 8' was sown on 6 March and 24 February in respective seasons with a pre-sowing irrigation. The N was applied in 2 splits, one-half as basal before sowing and another half at 30 days after sowing (DAS), whereas full dose of P, K and S were applied basal; P was applied through diammonium phosphate while K and S were applied through muriate of potash and gypsum (13.5% S) respectively. Irrigations were given as per the treatments each with 70 mm depth. The crop was harvested 91 and 93 days after sowing in 2 years respectively.

RESULTS AND DISCUSSION

Irrigation

A significant improvement in plant height and dry-matter accumulation was recorded with the increasing levels of irrigation. The favourable conditions created due to enhanced water uptake helped in accelerating the cell-division in the meristematic region, cell expansion and translocation of photosynthates to apical region. The consequent result was the increase in plant height. Higher availability of moisture might have helped in better nutrient removal by the crop which in turn resulted in assimilation of more photosynthates. The yield attributes of sunflower, viz. capitulum size, seeds/capitulum, seed weight/capitulum and 1,000-seed weight, were significantly enhanced by higher levels of irrigation over 2 irrigations in both the years. Higher availability of water (Mandal, 2001) was responsible for induced partitioning of assimilates in head and seed. As a result, the development of head and seed was enhanced. On the other hand, when only 2 irrigations were provided, moisture stress reduced the efflux of photosynthates from source to sink. Further, 4 irrigations did not increase 1,000-seed weight over 3 irrigations. As the crop was irrigated at seed-development stage under both 3 and 4 irrigations, 3 irrigations sufficiently met the crop demand. The seed and biomass yields and harvest index (HI) were significantly enhanced by 3 irrigations over 2 irrigations. This was obvious because dry-matter accumulation as well as its partitioning towards yield attributes were significantly increased by 3 irrigations. The harvest index in 4 irrigations was reduced significantly during 1998, because seed development was not enhanced in the same proportion.

Three irrigations also significantly enchanced the oil content in sunflower seed and total oil yield. This was due to favourable role of irrigations in improving the uptake of S (Mandal, 2001). Higher yield of oil owing to 3 irrigations was the result of increased oil content and higher seed yield. Four irrigations suppressed the oil content in seed. This was because irrigation given at vegetative stage encouraged the dry-matter accumulation which resulted in more absorption of N. This might have suppressed the oil synthesis and consequently gave low oil yield.

Nutrients

Application of 80 kg N/ha significantly enhanced the plant height and dry-matter accumulation in plant (Table 1). Low availability of N in this soil due to poor initial status might be responsible for good response to N application. N is a major constituent of chlorophyll and proteins and its adequate supply through fertilizer encouraged the photosynthesis. This resulted in stem elongation and increased total dry-matter accumulation during the whole growing season. Application of P, however, could not bring any change in final plant height in both the years and dry-matter accumulation in 1999. It reduced the dry-matter accumulation significantly in 1998. Potassium, with its active role in activating many enzymes for carbohydrate and protein metabolism and also in cell expansion, significantly enhanced the final plant height and dry-matter accumulation. Application of S significantly increased the dry-matter accumulation in 2 years. This might be due to the improvement of amino acids, proteins, chlorophyll and vitamins under the application of S.

Significant increase in growth parameters and finally dry-matter accumulation under N application resulted in improvement in yield attributes and seed yield (Tables 1, 2). Application of nitrogen increased the availability of nutrients which resulted in increased dry matter and better translocation of photosynthates. This was reflected by improved harvest index. Application of P recorded significant increase in seed yield in 1998. This was attributed to the significant increase in 1,000-seed weight owing to P application. Potassium played an important rôle in significantly increasing the size of capitulum in both the years and seed weight capitulum in 1998. Significant role of K in improving the dry-matter production and translocation of carbohydrates to the sink could demonstrate the improvement in these yield attributes. This finding confirms the results of Bhattacharya *et al.* (1995). The improvement in capitulum size and seed weight/capitulum contributed to the significant increase in seed yield in 1998 under K application. Application of S could not influence the yield attributes through improvement in dry-matter accumulation. Poor partitioning of photosynthates in the economic parts was responsible for poor improvement in the yield attributes and ultimately the seed yield.

Significant decrease in oil content due to application of N was recorded in both the years (Table 2). This might be owing to the degradation of carbohydrates to acetyl CoA in tricarboxylic acid (TCA) cycle. However, total oil yield was significantly improved owing to significant increase in seed yield in both the years.

Application of P and K significantly improved the oil yield though these nutrients did not encourage the oil content in seed. This was due to the significant increase in seed yield with the application of P and K. Enhanced availability of S increased the level of sulphur-containing

Table 1. Effect of irrigation and nutrient levels on growth and yield attributes of sunflower

Treatment	Plant height (cm)		Dry matter (g/plant)		Capitulum diameter (cm)		Seeds/ capitulum		1,000-seed weight (g)		Seed weight/ capitulum (g)	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Irrigation level												
2 irrigations	118.5	119.5	64.12	93.64	10.1	11.9	541	674	33.3	33.5	17.9	22.9
3 irrigations	131.0	131.8	84.77	110.92	13.7	14.7	658	894	35.9	36.9	21.1	30.9
4 irrigations	135.3	135.6	89.97	112.56	14.2	15.1	811	818	36.0	36.7	26.3	29.8
CD (P=0.05)	2.6	2.3	2.15	4.62	0.4	0.2	123	159	1.7	1.5	1.4	2.9
Nutrient level (kg/ha)												
Control	115.9	116.4	58.10	81.53	11.7	12.8	601	773	31.3	31.5	14.4	23.5
N_{80}	127.8	128.2	76.97	103.18	12.9	13.8	643	810	33.9	34.6	20.0	27.0
$N_{80}P_{40}$	128.7	129.0	72.56	100.95	13.0	13.9	699	797	36.4	37.1	23.6	28.4
$N_{80}P_{40}K_{40}$	134.3	135.3	91.30	117.08	13.5	14.4	715	807	36.4	37.4	25.1	29.6
$N_{80}P_{40}K_{40}S_{30}$	134.6	135.8	99.17	125.45	13.8	14.6	691	788	37.4	38.0	25.7	30.8
CD (P=0.05)	2.9	1.8	2.15	2.76	0.3	0.4	NS	NS	1.0	1.0	0.9	2.2

Table 2. Effect of irrigation and nutrient levels on seed yield, harvest index, biomass and content and yield of oil of sunflower

Treatment	Seed yield (q/ha)		Total biomass (q/ha)		Harvest index (%)		Oil content (%)		Oil yield (q/ha)	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Irrigation level										
2 irrigations	10.4	9.6	43.0	62.7	24.3	15.3	40.7	40.4	4.3	3.9
3 irrigations	18.0	16.9	56.8	74.2	31.7	22.0	42.5	41.7	7.6	7.1
4 irrigations	17.2	14.9	60.3	75.4	28.6	19.9	39.5	38.6	6.8	6.1
CD (P=0.05)	1.2	2.3	1.4	2.8	2.4	2.3	2.0	NS	0.8	0.8
Nutrient level (kg/ha)										
Control	8.8	8.9	38.9	54.6	22.6	16.2	41.6	41.2	3.6	3.6
N_{80}	13.6	13.0	51.6	69.1	26.4	18.8	39.5	37.4	5.0	4.9
$N_{80}P_{40}$	15.6	15.1	48.6	67.6	32.0	22.4	40.0	40.6	6.3	5.9
$N_{80}P_{40}K_{40}$	19.0	16.9	61.2	78.4	31.0	21.5	40.2	40.0	7.7	6.8
$N_{80}P_{40}K_{40}S_{30}$	19.2	15.1	66.4	84.1	28.9	17.9	42.7	42.6	8.2	7.2
CD (P=0.05)	1.4	3.1	1.4	1.9	3.0	1.7	1.2	2.4	0.7	0.5

co-enzymes which are involved in the synthesis of fatty acids. This was the probable reason for significant increase in oil content under S application. However, oil yield did not increase because application of S did not bring any change in the seed yield in both the years (Table 2).

Irrigation and nutrient interaction

Under 2 irrigations, N application over the control and P application over N did not increase the seed yield. Only combination of N and P brought significant improvement over the control. But application of K over N and P combination and application of S over N, P and K combination gave a significant boost to seed yield (Table 3). This happened because in the absence of sufficient moisture the crop could not utilize applied N, But P application might have helped in utilization of applied N. Thus, P application might have promoted root growth which resulted in more extraction of moisture from deeper soil layers and gave higher yield. Application of K further brought significant improvement because of increased resistance against moisture stress. Promoted root growth and enhanced moisture stress resistance might have utilized applied S which resulted in higher seed yield . On the other hand, application of N and K enchanced the seed yield over respective controls under 3 irrigations. This was because the availability of sufficient moisture might have helped the crop to utilize these nutrients more efficiently. Availability of adequate moisture with N and K application might have utilized native P and S. Therefore, it did not respond to applied P and S under 3 irrigations. However, under 4 irrigations, sufficient availability of moisture right from the vegetative stage helped utilize applied N, P and K. Hence the crop responded to these nutrients individually and resulted in higher seed yield. Diversion of photosynthates was suppressed because of reduced P content under 4 irrigations due to application of S. This was the reason for reduction in seed yield under 4 irrigations in combination with S application (Table 3).

Application of 4 irrigations without nutrients significantly increased the seed yield over 2 irrigations because irrigation at vegetative stage enabled the crop to utilize the native nutrients to some extent. But when nutrients were applied, 3 irrigations also resulted in the significant increase in seed yield. This happened because 3 irrigations might have made the crop to

Table 3. Effect of interaction between irrigation and nutrient levels on seed yield (q/ha) of sunflower in 1998

Nutrient (kg/ha)	Number of irrigations		
	2	3	4
Control	7.07	8.43	10.90
N_{80}	8.47	17.07	15.33
$N_{80}P_{40}$	9.57	18.73	18.43
$N_{80}P_{40}K_{40}$	12.30	22.83	21.77
$N_{80}P_{40}K_{40}S_{30}$	14.83	22.97	19.79
CD (P=0.05)		2.47	

utilize the applied nutrients to a large extent. Therefore, under the nutrient application, 4 irrigations did not further increase the seed yield. Rather under 4 irrigations, S application proved to be detrimental. This might be because irrigation given at vegetative stage might have caused more P available to the crop which in turn offered competition for S absorption.

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