Indian Journal of Agricultural Sciences **79** (12): 986–90, December 2009

Effect of nitrogen, sulphur and foliar spray of nitrate salts on performance of spring sunflower (*Helianthus annuus*)

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Received: 20 March 2009; Accepted: 23 September 2009

ABSTRACT

A field experiment was conducted at Baruipur Farm, Calcutta University during spring seasons of 2004 and 2005 on Entisol, to study the effect of nitrogen, sulphur and foliar spray of nitrate salts on sunflower (*Helianthus annuus* L.). Nitrogen application up to 120 kg/ha improved the physiological growth parameters, yield attributes and seed yield by 20% over 60 kg N/ha. A significant increase in the growth parameters was observed with 60 kg S/ha over 30 kg S/ha. Application of 60 kg S/ha resulted in significantly higher seed yield of 2.27 tonnes/ha which was 33% higher over no sulphur. Foliar spray of 0.406% $Ca(NO_3)_2$ at 50% flowering improved the yield attributes and seed yield over 0.50% KNO_3. Application of 120 kg N along with 60 kg S/ha and foliar nutrition of 0.406% $Ca(NO_3)_2$ was found most effective in increasing sunflower production in spring season on Entisol.

Key words: *Helianthus annuus*, Nitrate salts, Nitrogen, Spring season

Sunflower (*Helianthus annuus* L.), a photo-and thermo-insensitive, short-duration, deep-rooted, drought-resistant, widely adaptable crop (Sesha Saila Sree and Sridhar 2005) offers promise for its cultivation for boosting oilseed production. Among nutrients, nitrogen plays an important role in growth and yield of sunflower (Khaliq and Cheema 2005). Sulphur is important nutrient for sunflower (Maragatham *et al*. 2005). Foliar nutrition with N at later stage of crop growth delays the synthesis of abscisic acid and promotes cytokinin activity and causes high chlorophyll retention and thereby higher photosynthetic activity in effective leaves for supply of current photosynthates to the grains resulting in higher yield (Sarkar *et al*. 2007). Hence, an experiment was planned to study the influence of N, S and foliar spray of NO_3-salts on productivity of sunflower on Entisol.

MATERIALS AND METHODS

The experiment was conducted during the spring seasons (January–April) of 2004 and 2005 at the experimental farm of the Calcutta University (88° 28′ N, 22° 22′ E and 9.5 m above mean sea level), Baruipur, West Bengal, India. The soil was Gangetic alluvial clay loam (Entisol) having 0.72% organic carbon, 205, 22, 220 and 14 kg available N, P, K and S/ha respectively with a *p*H of 6.2. The treatments comprised three levels of N (0, 60 and 120 kg/ha), three levels of S (0, 30 and 60 kg/ha) and three foliar sprays of nitrate salts [control, 0.50% KNO_3 and 0.406% $Ca(NO_3)_2$]. Foliar sprays of KNO_3 and $Ca(NO_3)_2$ at their respective concentrations supplied equal amount of NO_3–N to the crop. The experiment was laid out in a factorial randomized block design with 3 replications. The gross plot size was 5 m × 4 m. The seed yield was computed on the basis of net plot (4.5 m × 3.7 m) harvested. The 'MSFH8' sunflower hybrid was sown at a spacing of 45 cm × 30 cm on 24 and 26 January 2004 and 2005, respectively. The N was applied in 2 splits, 1 half as basal before sowing and another half at 30 days after sowing (DAS). A dose 25.8 kg P and 33.2 kg K/ha and S as per treatment were applied as basal. Nitrogen was supplied through urea where as P, K and S were supplied through single super phosphate, muriate of potash and gypsum (13.5%) respectively.

The crop was given two irrigations at vegetative (30 days after sowing) and seed formation stage (60 DAS). Dilute solutions of nutrient salts as per treatment were applied @ 800 litres water/ha as foliar spray during 50% flowering stage of the crop. The required quantities of KNO_3 and $Ca(NO_3)_2$ were 4 and 3.24 kg/ha, respectively. For estimation of dry matter accumulation and measurement of leaf area, five plants in each plot were sampled in periodic interval till harvest. The crop was harvested at 92 days after sowing. Growth analysis was done as per methods laid by Radford (1967). To quantity the effect of nitrogen and sulphur on the nutrient

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use efficiencies in sunflower, computations were made for apparent recovery, agronomic efficiency and physiological efficiency as described by Singh and Agarwal (2004). The economical parameters, like net monetary returns and benefit: cost ratio were worked out by using the prevailing market price of inputs and outputs in the locality. Since error variance for growth and yield parameters of respective treatments during two years were found homogenous, pooling of the data was done.

RESULTS AND DISCUSSION

Effect of nitrogen

Increase in level of nitrogen from 0 to 120 kg/ha enhanced the plant height and dry matter accumulation in plants (Table 1). Since N is a major constituent of chlorophyll and protein and its adequate supply through fertilizer encouraged the photosynthesis, thereby resulting in stem elongation and increased dry matter accumulation during the whole growing season. Increase in levels of nitrogen fertilization up to 120 kg/ha enhanced leaf-area index and crop growth rate during 50% flowering stage. Application of 120 kg N/ha recorded higher leaf-area index and crop growth rate during peak stage of growth which might be accounted for increased leaf number and size and improved vegetative growth of plant. Application of N significantly improved the size of capitulum, seeds/capitulum, 1 000-seed weight up to 120 kg N/ha (Table 1). This might be due to synthesis of more photosynthates (Jat and Giri 2000) which might have resulted in better partitioning of photosynthates in yield attributes. Increase in physiological parameters (Table 1) and yield attributes of sunflower resulted in significant improvement in its seed yield in both the seasons (Table 1). On an average, N @ 120 kg/ha gave significantly higher seed yield by 90 and 20% compared with those of the control and 60 kg N/ha, respectively.

Increased availability of N @ 120 kg/ha resulted in higher biological yield corresponding to higher economic yield but reduced harvest index because seed production was not enhanced in the same proportion. The depression of harvest index was probably due to healthy vegetative growth. Maximum reduction in oil content in seed was recorded at 120 kg N/ha which might be due to degradation of carbohydrates into tricarboxylic acid cycle to acetyl COA (Legha and Giri 1999).

Effect of sulphur

Application of sulphur up to 60 kg/ha increased plant height, dry matter/plant, leaf-area index, crop growth rate at 50% flowering compared with the control (Table 1). The increase in these characters could partly be attributed to the beneficial effect of S fertilization as a nutrient which plays an important role in various metabolic processes in the plant. A significant increase in size of capitulum, number of seeds/capitulum and weight of 1 000-seed were recorded up to 60 kg S/ha. Sulphur is known to play vital role in formation of amino acids. Higher dry matter accumulation and better translocation of photosynthates led to increase in yield components which in turn resulted an increase in the seed yield (Table 1).

Sulphur application significantly increased the seed yield;

Table 1 Effect of nitrogen, sulphur and foliar spray of nitrate salts on growth, physiological parameters, yield attributes and yield of sunflower (mean of two years pooled data)

Treatment	Plant height (cm)	Dry matter accumulation (g/plant)	Leaf-area index at 50 days after sowing (DAS)	Crop growth rate (g/plant at 50–70 DAS	Diameter of capitulum (cm)	Filled seeds/ capitulum	1 000-seed weight (g)	Seed yield (tonnes/ha) 2004	2005	Pooled	Harvest index
Nitrogen (kg/ha)											
0	91.9	90.7	1.1	1.6	13.6	482.1	36.2	1.25	1.30	1.27	0.342
60	103.0	100.8	1.4	2.0	18.1	622.5	56.8	1.99	2.04	2.01	0.357
120	128.9	104.5	1.8	2.1	20.3	777.6	59.6	2.39	2.46	2.42	0.353
CD ($P = 0.05$)	0.6	0.6	0.01	0.07	0.13	15.4	0.5	0.1	0.08	0.03	0.003
Sulphur (kg/ha)											
0	104.0	95.0	1.3	1.7	16.2	571.4	49.4	1.72	1.69	1.71	0.348
30	109.9	100.1	1.5	2.0	18.0	635.4	51.0	1.93	2.05	1.99	0.352
60	112.0	103.2	1.7	2.0	20.8	665.4	53.5	2.21	2.32	2.27	0.352
CD ($P = 0.05$)	0.6	0.6	0.01	0.07	0.13	15.4	0.5	0.1	0.08	0.03	0.003
Foliar spray											
Control (no spray)	106.5	95.8	1.4	1.8	17.1	603.3	50.3	1.82	1.79	1.81	0.349
0.50% KNO_3	108.6	98.2	1.4	1.9	17.3	635.6	51.0	2.06	1.99	2.02	0.351
0.406% $Ca(NO_3)_2$	108.7	99.5	1.5	1.9	17.8	644.5	52.6	2.17	2.21	2.19	0.353
CD ($P = 0.05$)	0.6	0.6	0.01	NS	0.13	15.4	0.5	0.1	0.08	0.03	0.003

the mean increase was 33% with 60 kg S/ha over no S. This is also confirmed by the trend in harvest index. Increase in yield characters and finally crop yield could be ascribed to overall improvement in plant growth, vigour and production of sufficient photosynthates through increased leaf-area. Increase in sunflower yield due to S application could be ascribed to its important role in the synthesis of protein and methionine (Gupta *et al*. 2004). Increase in oil content by S application might be due to involvement of S in biosynthesis of oil and protein molecules.

Effect of foliar spray of NO_3 salts

Foliar spray of KNO_3 and $Ca(NO_3)_2$ during 50% flowering improved growth parameters like plant height, dry matter/plant, leaf-area index, crop growth rate over unsprayed control probably due to overall improvement in growth, vigour, production of photosynthates leading to increased availability, absorption and translocation of nutrients. Foliar spray also improved yield components and yield of sunflower than unsprayed control during both the years (Table 1). Foliar sprayed nutrients are readily absorbed and utilized more efficiently than soil application. Foliar application of nitrate salts at the beginning of reproductive growth of plants involve in number of physiochemical changes which led to change the growth parameters and ultimately increased the yield of the crop. Besides flowering, two other important critical

Table 2 Effect of nitrogen, sulphur and foliar spray of nitrate salts on oil content, uptake of nutrients and nutrient-use efficiency by sunflower (mean of two years pooled data)

Treatment	Oil content (%)	Total N uptake (kg/ha)	Total S uptake (kg/ha)	Apparent recovery (%)	Agronomic efficiency (kg grain added/kg nutrient applied)	Physiological efficiency (kg grain/kg nutrient uptake)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit: cost ratio
Nitrogen (kg/ha)										
0	37.8	36.2	5.8				12 250	19 050	6 800	1.53
60	35.5	51.0	12.6	24.7	12.4	50.1	13 850	30 150	16 300	2.17
120	34.8	84.3	15.0	40.1	9.6	23.9	15 050	36 300	21 250	2.41
CD ($P = 0.05$)	1.1	1.62	0.34							
Sulphur (kg/ha)										
0	34.5	40.3	6.8				12 450	25 650	13 200	2.06
30	36.7	51.0	15.9	30.3	9.5	31.2	13 150	29 850	16 700	2.26
60	38.0	60.4	18.4	19.3	9.3	48.2	13 450	34 050	20 600	2.53
CD ($P = 0.05$)	1.1	1.62	0.34							
Foliar spray										
Control	35.4	41.2	6.7				13 500	27 150	13 650	2.01
0.50% KNO_3	37.6	46.4	11.7		52.5	40.4	14 660	30 300	15 640	2.06
0.406% $Ca(NO_3)_2$	37.8	49.2	14.6		123.4	47.5	14 395	32 850	18 455	2.28
CD ($P = 0.05$)	1.1	1.62	0.34							

Rate of nutrient: N Rs 10/kg; S Rs 5/kg; KNO_3 Rs 290/kg; $Ca(.NO_3)_2$ Rs 270/kg; Value of sunflower seed Rs 15/kg

Table 3 Interaction effect of nitrogen, sulphur and foliar spray of nitrate salts on pooled seed yield of sunflower

Treatment	Sulphur (kg/ha)									Mean (N)
	0			30			60			
	Control	KNO_3	$Ca(NO_3)_2$	Control	KNO_3	$Ca(NO_3)_2$	Control	KNO_3	$Ca(NO_3)_2$	
Nitrogen (kg/ha)										
0	1.02	1.14	1.23	1.18	1.32	1.43	1.35	1.51	1.63	1.27
60	1.61	1.80	1.95	1.87	2.09	2.27	2.14	2.38	2.59	2.01
120	1.94	2.16	2.35	2.26	2.52	2.73	2.57	2.87	3.11	2.42
Mean (S)		1.71			1.99			2.27		
Mean (FS)				1.81	2.02	2.19	N×S×FS			
				N×S	N×FS	S×FS				
CD ($P = 0.05$)				0.054	NS	NS	NS			

stages are bud initiation and seed filling. Flowering with onset of reproductive growth stage as affected by nutrients seems to be most important in determining crop productivity.

Foliar spray of $Ca(NO_3)_2$ proved superior to KNO_3 in improving crop productivity possibly due to prevalence of Ca^{++} as cation. The results confirm the findings of Sarkar and Pal (2006). Increased harvest index under $Ca(NO_3)_2$ is attributable to increased physiological capacity of the crop to metabolize the photosynthates towards economic yield.

Interaction effect

Application of N in the absence of S and foliar spray of NO_3 salts had no effect on seed yield. Application of 120 kg N in combination with 60 kg S/ha, irrespective of foliar spray of NO_3 salts proved to be the most effective in increasing seed yield (Table 3). Positive interaction between N and S at their higher level of application on seed yield could be attributed to their synergistic effect. Despite higher yield recorded under 120 kg N/ha along with 60 kg S/ha in presence of foliar spray of $Ca(NO_3)_2$, it could not reach the level of significance (Table 3). The interaction effect of N and S on yield as observed in the present study, is in accord with the findings of Syed *et al*. (2006) who also noted such interaction effect on yield of sunflower.

Uptake of nutrients

Increasing levels of nitrogen up to 120 kg/ha significantly enhanced N and S uptake by the crop (Table 2). Increasing doses of S up to 60 kg/ha significantly increased N and S uptake over the preceding level. Foliar spray of 0.50% KNO_3 and 0.406% $Ca(NO_3)_2$ increased uptake of N and S over the control treatment. However, foliar fertilization of $Ca(NO_3)_2$ showed higher uptake of both N and S over KNO_3. The concentration of nutrients also increase due to N, S, KNO_3 and $Ca(NO_3)_2$ application possibly because of improved nutritional environment in *Rhizosphere* and in plant system and consequently greater uptake by the crop.

Apparent recovery and nutrient-use efficiency

Apparent recovery of N was increased from 24.7% at 60 kg N/ha to 44.1% with 120 kg N/ha (Table 2). The higher level of N enhanced the apparent recovery of N by 15.4% compared with 60 kg N/ha. Apparent recovery of S was reduced from 33.3% at 30 kg S/ha to 19.3% at 60 kg S/ha application. Application of 60 kg S/ha reduced the apparent recovery of S by 11% compared with 30 kg S/ha. Higher apparent recovery of fertilizer S with lower rate of S application might be due to lower S losses and synchronization of S with crop needs.

Agronomic efficiency of N reduced from 12.4 at 60 kg N/ha to 9.6 kg grain added/kg N at 120 kg N/ha application. Agronomic efficiency was improved by 2.7 kg grain added/kg N with application of 60 kg N/ha compared with 120 kg N/ha. Application of 30 kg S/ha recorded higher agronomic efficiency over 60 kg S/ha. The higher agronomic efficiency may be attributed to more efficient utilization of applied N and S for grain production under judicious fertilization practice. Physiological efficiency of N decreased by 26.2 kg grain/kg N at 120 kg N/ha compared to 60 kg N/ha. The higher physiological efficiency of 48.2 kg grain/kg S was recorded at 60 kg S/ha application (Table 2). It is probably that at moderate level of S application, the absorbed nutrient is efficiently used for grain formation in sunflower. Foliar nutrition of $Ca(NO_3)_2$ recorded higher agronomic and physiological efficiency over KNO_3 possibly due to efficient absorption and utilization of foliage applied nutrient for grain production.

Economics

The net returns and benefit:cost ratio (Table 2) increased with increase in the level of N and S application. The application of 120 kg N/ha and 60 kg S/ha recorded higher mean net returns and benefit: cost ratio over preceding lower level. Higher net returns and benefit:cost ratio at higher level of N and S was due to higher yield. Foliar nutrition of $Ca(NO_3)_2$ gave higher net returns and benefit:cost ratio than KNO_3 mainly due to higher yield realized under $Ca(NO_3)_2$.

It is concluded that application of 120 kg N/ha and 60 kg S/ha along with foliar spray of 0.406% $Ca(NO_3)_2$ at 50% flowering would be judicious practice for realizing the best growth of plant, seed yield and net returns in sunflower crop.

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