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YIELD AND NUTRIENTS UPTAKE OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) AS INFLUENCED BY DIFFERENT LEVEL OF NITROGEN AND SULPHUR

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ABSTRACT
An attempt was initiated during three consecutive *rabi* seasons during 2011-12 to 2013-14 at the farm of the Subdivision Adaptive Research Station, Nakasipara, Nadia, West Bengal, India to ascertain the response of nitrogen and sulphur on hybrid sunflower (*Helianthus annuus*L.). The experiment comprised four levels of nitrogen (50, 75, 100 and 125 kg N ha^{-1}) and five levels of sulphur (0, 20, 30, 40, and 50 kg S ha^{-1}) in factorial randomized block design replicated thrice. The seed yield increased significantly upto 100 kg Nha^{-1} (1816 kg ha^{-1}) after that it declined. With the increasing level of sulphur, oil content (%) also increased. Application of sulphur upto 40 kg ha^{-1} increased the seed yield and thereafter it showed a decline trend indicating a quadratic fashion of response. Seed yield was found positively correlated with seeds capitulum^{-1} and 100-seed weight. Highest accumulation of nitrogen, sulphur, phosphorus and potasiumwas in head as compared with stem, leaf and petioles.Application of nitrogen upto 100 kg ha^{-1} and sulphurupto 40 kg ha^{-1}would be required to realize satisfactory level yield in hybrid sunflower.

INTRODUCTION

The lower Gangetic Plains of the eastern part, spread over 19, 389 km^{2}is a part of Indo-Gangetic Plain (IGP) and is the most important agricultural eco-regions (Timsina and Connor, 2001). Sunflower holds a great promise in meeting out the shortage of edible oils in India with higher yield potential and healthy oil quality. Because of its short duration life cycle, and photo and thermo-insensitivity, the crop has wider adaptability in different agro-climatic regions and soil types. India produces 1.44 million ton (mt) of total sunflower seed from an area of about 2.34 million ha (m ha), with an average productivity of 615 kg ha^{-1} (Shekhawat and Shivay, 2008).Since introduction of this crop in India during 1970s, productivity has remained low as compared to world average productivity though the area under this crop has increased markedly (Krishnamurthy *et al.*, 2011). Adoption of high yielding varieties and multiple cropping systems require more attention with regard to nutrient management to increase crop yield and quality. Reports suggest that the soils of Eastern IGP are deficient in N, P, K and S (Islam and Hossain, 1993). Nitrogen is the major nutrient that enhances the metabolic processes that lead to increase in vegetative, reproductive and yield of crops. Sulphur, the fourth major nutrient plays an important role in oilseed production as a constituent of sulphur containing amino acids (Gangadhara *et al.* 1990). S is best known for its role in the formation of amino acids methionine (21% S) and cysteine (27% S); synthesis of proteins and chlorophyll; oil content of the seeds (Jamal *et al.*, 2010). Most of the studies on fertilizer management is eastern IGP is based on crops like groundnut, soybean and other crops. This study is the culmination of an effort to understand the effect of N and S fertilization on growth, yield and nutrient uptake of sunflower in the eastern part of India.

MATERIALS AND METHODS

Site selection

A field experiment was conducted from *rabi* 2011-12 to 2013-14 at the farm of the Zonal adaptive research Station, Krishnagar, Nadia, West Bengal, India, located in the Gangetic Flood Plain of the Eastern IGP (lat. 23°24$^{/}$, long. 88°31). Prior to the experiment, the field had been under irrigated rice-wheat cropping system for 5 years. The soil of the experimental field is a very deep, well drained, sandy clay loam (Inceptisol) with 56% sand, 24% silt and 20% clay in the surface layer (0-15cm). Initial properties of a composite soil sample collected at the beginning of the field experiment were 4.6 g kg^{-1} organic carbon (Walhley - Black), 0.44 g kg^{-1} total N (Kjeldahl), 24 kg ha^{-1} available P (Bray-1), 140 kg ha^{-1} available K (1N NH4-acetate) and a pH of 7.5 (1:2.5 soil: water).

Treatments details and design

The field experiment was laid out in a factorial randomized complete block design with 9m X 6m plots and it had randomized thrice. Factors are nitrogen with 4 levels (50, 75, 100 and 125 kg ha^{-1}) and sulphur with 5 levels (0, 20, 30, 40 and 50 kg ha^{-1}). The N and S were supplied in the form of urea andcosavetrespectively.

Crop management practices, yield attributes, seed yield and oil content measurements

Land was prepared with bullock drawn country plough followed by laddering. The hybrid seed DRSH 1 was sown on 27/11/2011, 24/11/2012 and 25/11/2013 respectively by maintaining a spacing of 60cm × 30cm. Insect and disease incidences were low during the three years of experimentation. The crop was harvested when it attained physiological maturity as indicated by yellow color on the backside of the capitulum. Five plants were randomly selected from each treatment for recording growth and yield parameters at harvest. Yield was recorded from net plots, leaving border and penultimate rows as per treatments. Oil content of seed was measured by rapid gravimetric method developed by Kartha and Sethi (1957). Oil yield was calculated on the basis of oil percentage and seed yield.

Plant analysis and uptake

18 plants from each plot were sampled at maturity stages to determine N, P, K and S contents. The above ground plant parts were segmented and then dried at 70°C to a constant weight was recorded. Plants samples are were taken for each crop season during the experiment for estimation of concentration of N through Modified micro Kheldahl method. For determination of P and K content, material was digested in tri-acid (HNO_3 : H_2SO_4 : $HClO_4$ :: 10:1:4) (Jackson, 1973) and estimated by spectrophotometer and flame photometer, respectively and sulphurwas estimated through colorimeter method.

Uptake of nutrients (N, P K and S) by the crop was estimated for three consecutive years (2011-12, 2012-13 and 2013-14) by multiplying the dry matter yield (after drying at 80^{0}C to a constant weight upon cooling) of each crop with their corresponding nutrient content.

Statistical analysis

The data were subjected to statistical analysis by analysis of variance method (Gomez and Gomez, 1984). As the error mean squares of the individual experiments were homogenous, combined analysis over the years were done through unweighted analysis. Here, the interaction between years and treatments were not significant.

RESULTS AND DISCUSSION

Effect of different level of nitrogen on growth and yield of sunflower

The experimental data reveals that growth and yield components of sunflower increased with increasing level of N application up to 100 kg ha^{-1}as against 50 kg N ha^{-1}(Table 1). Plant height and dry matter production is positively correlated with the increasing level of N dose. Positive effect of N fertilizer on dry matter production has earlier been demonstrated by Nasim *et al.* (2011). This may be due to N effects on cell elongation, as well as N being the principal component of proteins, enzymes, hormones, vitamins, chlorophyll and it accelerates the meristematic activity of plant which leads to progressive increases in internode length, protein synthesis and photosynthetic area leading to higher plant height and dry matter production. Similar result also found by Rasool*et al.*, 2013 and Patel *et al.*, 2013. Seed yield increased upto 100 kg N but there after decreased which is attributed as a result of decreasing the yield parameter like head diameter, seed capitillum^{-1}, 100 seed weight etc. resulted in higher yield

Table1: Effect of nitrogen and sulphur on growth, yield attributes and yield of sunflower (pooled data)

Treatment	Plant height (cm)	Dry matter (t ha^{-1})	Head diameter(cm)	Seeds capitulum^{-1}	100seed weight (g)	Seedyield (kg ha^{-1})	Oil content (%)
Nitrogen (kg ha^{-1})							
50	108.6	5.96	16.93	724	4.5	1570	36.4
75	110.3	6.04	17.13	747	4.9	1650	34.3
100	112.7	6.21	17.53	909	5.4	1816	33.2
125	113.5	6.23	16.87	864	4.8	1681	33.8
CD (p=0.05)	15.7	0.49	4.63	104	0.38	208	1.24
Sulphur (kg ha^{-1})							
0	112.3	6.23	14.74	809	4.1	1575	33.0
20	114.5	6.26	16.39	815	4.7	1621	34.4
30	120.4	6.75	17.25	811	5.3	1680	35.0
40	121.8	7.01	18.33	812	5.2	1800	35.1
50	123.6	7.13	18.87	808	5.2	1720	34.6
CD (p=0.05)	12.34	0.32	4.29	92	0.35	199	1.18

Table 2: Interaction effect of nitrogen and sulphur on pooled seed yield of sunflower

Treatment	Sulphur (kg/ha)					Mean
	0	20	30	40	50	
Nitrogen (kg ha^{-1})						
50	1466	1501	1642	1600	1641	1570
75	1590	1640	1670	1666	1684	1650
100	1722	1799	1855	1850	1849	1816
125	1522	1544	1553	2079	1706	1681
Mean (S)	1575	1621	1680	1798.75	1720	
Interaction CD (p=0.05)	182.0					

Table3: Effect of different level of nitrogen and sulphur on uptake of nitrogen and phosphorus (kg ha^{-1}) of sunflower at harvest (pooled data)

Treatment	Nitrogen uptake (kg ha^{-1})					Phosphorus uptake (kg ha^{-1})				
	Leaf	Petiole	Stem	Head	Total	Leaf	Petiole	Stem	Head	Total
Nitrogen (kg ha^{-1})										
50	9.2	0.7	9.2	126.8	145.9	2.7	0.7	2.6	18.2	24.2
75	22.9	5.9	29.4	196.2	254.4	2.6	0.7	1.7	17.8	22.8
100	18.0	5.5	30.3	152.5	206.3	2.2	0.5	2.2	10.6	15.5
125	19.1	4.2	29.7	152.5	205.5	0.7	0.2	1.6	10.1	12.6
CD (p=0.05)	0.21	0.38	2.29	20.9	32.3	0.22	0.15	0.42	2.09	3.96
Sulphur (kg ha^{-1})										
0	9.1	1.7	14.1	77.3	102.2	0.6	0.1	0.7	5.4	6.8
20	11.8	2.9	22.8	144.7	182.2	1.3	0.3	1.3	11.3	14.2
30	17.2	4.8	27.9	182.6	232.5	2.9	0.5	2.3	15.9	21.6
40	22.8	5.9	33.4	203.8	265.9	3.1	0.7	2.9	20.3	27.0
50	25.6	5.0	25.1	176.4	232.1	2.5	0.8	2.8	18.0	24.1
CD (p=0.05)	0.20	0.32	2.08	18.6	37.24	0.20	0.13	0.39	1.99	4.13

Table 4: Effect of different level of nitrogen and sulphur on uptake of potassium and sulphur (kg ha^{-1}) of sunflower at harvest (pooled data)

Treatment	Potassium uptake (kg ha^{-1})					Sulphur uptake (kg ha^{-1})				
	Leaf	Petiole	Stem	Head	Mean	Leaf	Petiole	Stem	Head	Mean
Nitrogen (kg ha^{-1})										
50	0.84	0.15	1.52	9.22	11.73	0.8	0.1	1.5	9.2	11.6
75	2.23	1.23	6.39	15.14	24.99	2.2	1.2	6.4	15.1	24.9
100	1.95	1.07	7.22	21.57	31.81	2.0	1.1	7.0	21.6	31.7
125	1.84	0.96	6.77	19.31	28.88	1.8	1.0	6.8	19.3	28.9
CD (p=0.05)	0.51	0.27	0.99	3.92	4.51	0.61	0.19	1.18	3.52	3.98
Sulphur (kg ha^{-1})										
0	0.65	0.20	1.55	8.87	11.27	0.7	0.2	1.5	8.9	11.3
20	1.19	0.51	4.71	14.94	21.35	1.2	0.5	4.7	14.9	21.3
30	1.75	0.95	6.55	18.20	27.45	1.8	0.9	6.6	18.2	27.5
40	2.80	1.27	7.41	21.74	33.22	2.8	1.3	7.2	21.7	33.0
50	2.19	1.32	7.16	17.80	28.47	2.2	1.3	7.2	17.8	28.5
CD (p=0.05)	0.39	0.27	0.82	2.52	3.16	0.47	0.15	0.88	2.99	4.02

upto 100 kg and there after it decreased (Fig. 1). Yield enhancing rate upto 15.7% with dose of by 100 kg N ha^{-1}over 50 kg N ha^{-1}. Higher seed yield of sunflower with increasing N rates is attributed to higher head diameter and seed weight (Abdel-Motagally and Osman, 2010). The findings are in conformity with those of Sarkar and Mallick (2009) who obtained significantly higher seed yield in with the increasing level of N fertilizer. Oil content (%) is inversely related with the higher doses of N levelwhich might be due to degradation of carbohydrates into tricarboxylic acid cycle to acetyl COA (Legha and Giri 1999).

Effect of sulphur level on growth and yield of sunflower

The data in the Table 1showed that increased plant height and dry matter at higher sulphur levels was observed during all three years of study. The scene behind this result might be due to metabolic processes enhancement in the plant cell, resulted increased meristamatic activities causing more apical growth. Hussain and Thomas (2010) also described that significance in boosting of plant height with the application of 60 kg S ha^{-1} as against 0 kg S ha^{-1}. As sulphur helps in better photosynthesis means more dry matter accumulation as sulphur is a constituent of succinyl Co-A which involved in chlorophyll in leaves and their activation at cellular level accelerate photosynthesis which ultimately promote vegetative growth.Similar results were reported by Ralsoolet *al.* (2013). Rani *et al.* (2009)reported that, increase in oil yield of sunflower with the application of S at 60 kg ha^{-1} was up to the tune of 23% as against control.Application of higher level of S significantly increased the 100 seed weight over the lower doses.

Higher head diameter and number of seeds per capitulum is known to facilitate yield increase in sunflower (Nasim*et al.*, 2011). Application of S upto 40 kg S ha^{-1} increased the seed yield by 14.3% over 0 kg S ha^{-1}(Fig. 2). These results might be due to higher yield contributing characters that are directly responsible for higher seed yield which can found in Table 6 as there is almost positive correlation between different features of sunflower except seed capitulum^{-1}. The results are in association with those of Poomurugesan and Poonkodi (2008) who recorded maximum seed yield in higher S application than nil application. Rate of increasing in oil content (%) vary from 4.2 to 6.4% with the enhancement of S application and it is happened because S being a constituent of acetyl Co-A, is converted into maloyl Co-A in fatty acid synthesis and for this conversion an enzyme, thiokinase is involved (Rasool *et al.*, 2013).

Interaction effect

There was no effect in seed yield when nitrogenwas applied in the absence of sulphur. Application of N @ 125 kg in combination with 40 kg Sha^{-1}, proved to be the most effective in increasing seed yield but mean data showed that 100 kg N along with 40 kg S is the best (Table 2). There was a synergistic

Table 5: Correlation matrix among the different characters of sunflower influenced by various level of nitrogen

	Plant height	Dry matter	Head diameter	Seeds capitulum^{-1}	100 seed weight	Seed yield	Oil content
Plant height	1						
Dry matter	0.99**	1					
Head diameter	0.26	0.33	1				
Seeds capitulum^{-1}	0.92	0.95*	0.53	1			
100 seed weight	0.62	0.66	0.91	0.78	1		
Seed yield	0.75	0.80	0.83	0.90	0.97*	1	
Oil content	-0.89	-0.88	-0.58	-0.85	-0.858	-0.89	1

*and ** denote significant correlation at 5% and 1% level of significance, respectively

Table 6: Correlation matrix among the different characters of sunflower influenced by various level of sulphur

	Plant height	Dry matter	Head diameter	Seeds capitulum^{-1}	100 seed weight	Seed yield	Oil content
Plant height	1.00						
Dry matter	0.98**	1.00					
Head diameter	0.97**	0.94*	1.00				
Seeds capitulum^{-1}	-0.29	-0.39	-0.12	1.00			
100 seed weight	0.92*	0.84	0.90*	0.04	1.00		
Seed yield	0.87	0.89*	0.89*	-0.03	0.82	1.00	
Oil content	0.80	0.71	0.83	0.31	0.96*	0.81	1.00

*and ** denote significant correlation at 5% and 1% level of significance, respectively

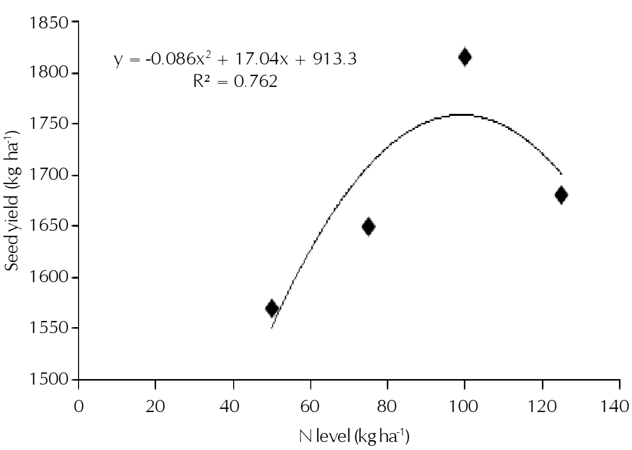

Figure 1: Regression curve fitting between Seed yield and level of nitrogen

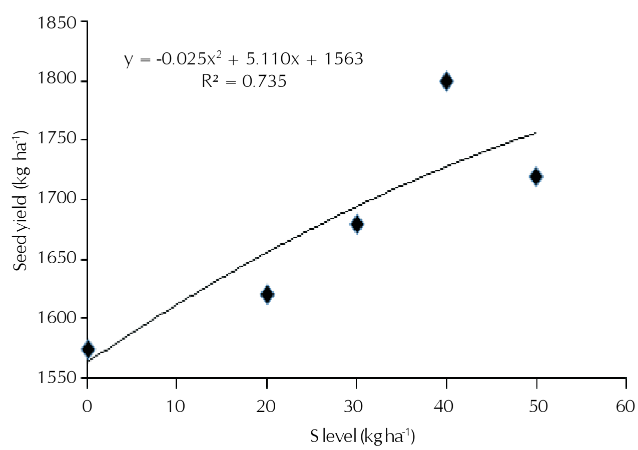

Figure 2: Regression curve fitting between Seed yield and level of Sulphur

effect interaction between N and S at their higher level of application on seed yield. Syed *et al.* (2006) also noted such type positive interaction effect of nitrogen and sulphur on yield of sunflower which correlates with the present one.

Effect of different level of nitrogen and sulphur on nitrogen uptake in sunflower

Nutrient uptake by different parts of sunflower with different levels of nitrogen at the time of harvesting is shown in the Table 3.Nutrient uptake (N, P, K and S) by different parts of sunflower differs significantly due to different level of nitrogen fertilization. Among the different level of nitrogen and sulphur it was found that nitrogen level upto 75 kg ha^{-1} produced highest total nitrogen uptake though it was not significantly different from its higher dose of 100 kg N ha^{-1}. Increasing level of sulphur, upto 40 kg ha^{-1} enhanced nitrogen uptake in different plant parts. Head followed by stem accumulated more nitrogen as compared with leaf and petiole because of less biomass in leaf and petioles where nitrogen concentration generally is very low. Kumar and Rao (1991) also found such type of nitrogen uptake in different plant parts in soybean. There is a synergistic relationship between sulphur and nitrogen which might increase the nitrogen uptake when sulphur level was increased. The results are the agreement of those finding suggested by Ganie*et al.*, 2014 and Khandkar and Shinde, 1991. When sulphur level was increased there may be an antagonistic effect which ultimately pictured as reduction of total nitrogen uptake.

Effect of different level of nitrogen and sulphur on phophorus uptake in sunflower

Phophorus uptake by different parts of sunflower shown in Table 3 reveals that there is a negative impact in phosphorus uptake when level of nitrogen was increased. Among the different parts of sunflower,uptake of head was highest because of higher biomass followed by stem. Sulphur had positive relationship with phosphorus uptake in sunflower in all part except in higher dose. Nasreen and Imamul Hug (2002) findings' also match with this present research work. Variation in total phosphorus uptake by different level of sulphur in sunflower plant varies from 108.8 to 297.05%.

Effect of different level of nitrogen and sulphur on potassium uptake in sunflower

Different level of nitrogen and sulphur showed variation in potassium uptake in different parts of sunflower (Table 4). Total potassium uptake by sunflower crop was not affected significantly due to different nitrogen level at it higher dose though at lower level of application total uptake was found statistically at par with the higher one. Different level of sulphur application significantly increased total potassium uptake in different plant parts of sunflower crop. Percent increased in total uptake of potassium was 26.2% when sulphur was applied @ 40 kg ha^{-1} as compared with control. Increase in potassium uptake with the increase rate of sulphur also reported by Shekhawat*et al.* (2008).

Effect of different level of nitrogen and sulphur on sulphur uptake in sunflower

Effect of different level of nitrogen and sulphur on the uptake sulphur shown in Table 4 indicated that with the increase in nitrogen level upto 100 kg ha^{-1}, sulphur uptake is in a positive manner but after that it goes downward because of antagonistic relationship at the higher dose. Uptake of sulphur at different level of sulphur application indicated that dose upto 40 kg ha^{-1} significantly increased sulphur uptake but after that it declined. Sarkar and Mallik (2009) also registered that with increase in nitrogen and sulphur level uptake of nitrogen and sulphur vary in a positive manner generally.

Correlation matrix

There was a high positive correlation between different characters of sunflower i.e. Plant height, dry matter, head diameter seedcapitulum^{-1}, 100 seed weight, seed yield was observed although these all character showed a negative correlation with oil content(Table 5) due to different level of nitrogen fertilizer. Plant height had a positive correlation with dry matter (r=0.99) where it has a negative correlation with oil content (r= -0.89).Different level of sulphur also resulted in a positive correlation among different character but only seed capitulum^{-1} resulted negative correlation with other character like Plant height (r = -0.29), dry matter (r= -0.0.39), head diameter (r= -0.0.12) and seed yield (r=-0.03) (Table6). All other feathers have a positive correlation among themselves. Correlation matrix varies due to different nutrient management experiment also reported byNadagouda and Hiremath (2014).

From the experiment it can be concluded that nitrogen application upto 100 kg ha^{-1} and sulphur to the tune of 40 kg ha^{-1} may be recommended for higher sunflower yield in the eastern Indo-Gangetic plain of West Bengal.

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