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Effect of Sulphur Fertilizer on Yield and Nutrient Uptake of Sunflower Crop in an Albaquept Soil

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Abstract: Yield and uptake of N, P, K and S at successive stages of growth in sunflower (cv. Kironi) were studied at 0, 20, 40, 60, 80, 100 and 120 kg S ha^{-1} grown in a typical Albaquept soil in field over a period of three years (1995-96, 1996-97 and 1997-98). Sulpher had synergistic effect on the yield and nutrients uptake. Application of sulphur between 60-80 kg ha^{-1} increased significantly the seed yield and uptake of N, P, K and S. Head accumulated the highest nutrients followed by stem and leaf. Higher dose of sulphur tended to decrease the yield and nutrient uptake in all the years. Plants grown without added S had lowest yield and nutrients uptake. Considering the sulphur cost, 60 kg S ha^{-1} would be required in this soil type to exploit the satisfactory yield of sunflower.

Key words: Sulphur fertilizer, nutrient uptake, yield, sunflower

Introduction

Bangladesh has been facing an acute shortage of edible oil for last several decades. The shortage of edible oil has become a chronic problem for the nation with increasing population. Sunflower can play an important role in reducing the chronic shortage of edible oil in the country. Although sunflower is cultivated on a limited scale in Bangladesh, the average yield of this oil seed crop however, is rather low (1400kg ha^{-1}) compared with other developed countries (FAO, 1999). However, the potential yield of sunflower is about 3t ha^{-1} in Bangladesh if the full package of production is followed. The ample scope for increasing production by use of high yielding varieties, agronomic as well as proper fertility management.

The practice of intensive cropping with high yielding varieties is a great endeavor to boost food production in Bangladesh and this has caused a marked depletion of inherent nutrient resources in soil. Consequently, along with N, P and K, the deficiencies of sulphur is frequently reported in soils of Bangladesh (Islam and Hossain, 1993). Sulphur is the fourth major nutrient and plays an important role in the nutrition of oilseed crop and as a constituent of sulphur containing amino acids (Gangadhara *et al.*, 1990). Beneficial effect of sulphur addition on sunflower has been reported by Tripathi (1992); Sreemannarayana and Raju (1994). The oilseeds require more sulphur than other crops, its concentration and uptake vary with the availability of sulphur in soil and its fertilization. Singh (1999) reported that the application of sulphur increased the uptake of various macro and micro nutrients in groundnut. Sharma and Gupta (1992) also reported that S fertilization up to 80kg ha^{-1} significantly increased the uptake of N, P, K and S by soybean. Non-application of sulphur in sulphur deficient soils has often resulted in low yield. Sulphur deficient plants have poor utilization of N, P, K and a significant reduction in sulphur content. However, meager information under Bangladesh condition is available on the response of sunflower to sulphur levels in respect to nutrient uptake pattern and productivity, and hence this study was taken up.

Materials and Methods

Field experiment was conducted on the Grey Terrace soil of Madhupur Tract (AEZ 28), Gazipur during November to March of 1995-96, 1996-97 and 1997-98. The soil is clay loam and acidic in reaction (pH 6.0) with low contents of total nitrogen (0.05%), available phosphorus (7.02ppm), exchangeable potassium (0.140 meq/100 g soil) and available sulphur (10.0 ppm). The soil belongs to the order albaquept. The amount of rainfall received during the cropping period was 88.4 mm, 61.0 mm and 116.8 mm in 1995-96, 1996-97 and 1997-98, respectively.

Seven levels of sulphur fertilizer (0, 20, 40, 60, 80, 100 and 120 kg ha^{-1}) constituted the experimental variables. The experiment was laid out in a randomized complete block design with four replications. The unit plot size was 5 x 3m^2. At the time of final land preparation, a blanket rate of fertilizers at 120 kg N, 90 kg P_2O_5, 80 kg K_2O, 5 kg Zn and 2 kg B ha^{-1} were applied in the form of urea, triple super phosphate (TSP), muriate of potash (MP), Zinc oxide and Soluber respectively. Sulphur from gypsum was applied in the plot as per treatment. The whole amount of TSP, MP, gypsum, zinc oxide, Soluber and half of urea were applied as basal dose. Seeds of sunflower (cv. Kironi) were sown at 25 cm spacing in rows 50 cm apart on November 4 in 1995, November 6 in 1996 and November 8 in 1997 with 12 kg seeds ha^{-1}. The remaining urea was applied in splits at 25 and 45 days after emergence (DAE) followed by irrigation. Third irrigation was made at 75 DAE. Weeding, mulching and plant-protection measures were undertaken as and when required.

Five plants from each plot were sampled at vegetative, reproductive and 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 and the dry weight was recorded. Oven dried plant parts were ground finely and total nitrogen content was determined by modified Kjeldahl digestion colorimetric method (Cataldo *et al.*, 1974). Phosphorus concentration in plant tissue at different growth stages were determined by Vanadomolybdo phosphoric acid yellow colour method as described by Jackson (1962). For potassium determination, methods devised by Wilde *et al.* (1979) was followed. Sulphur content was determined by turbidimetric method using barium chloride and gum acacia as proposed by Chesnin and Yien (1951).

The crop was harvested at 110-115 DAE. An area of 8 m^2 was harvested from center of each plot avoiding the border effect to record yield. The heads were cut from the plants and dried on the threshing floor for about 6-7 days. The seed of plants from each plot were then recorded individually and adjusted to 8% moisture content. Collected data were statistically analyzed by Gomez and Gomez (1984).

Results and Discussion

Seed yield: Sulphur levels had a significant effect on seed yield of sunflower (Fig. 1). Application of sulphur fertilizer, in general, recorded higher yield than the control. The data show that there was a linear increase in seed yield with increase in sulphur fertilizer application up to 80 kg ha^{-1} followed by 60 kg ha^{-1} in all the years of experimentation. However, the yield levels at 60 and 80 kg S ha^{-1} were at par. Seed yield differed from 2.60 to 3.14 t ha^{-1} in 1995-96, 1.94 to 3.26 t ha^{-1} in 1996-97 and 1.80 to 3.68 t ha^{-1} in 1997-98. Application of sulphur between 60-80 kg out yielded all other treatments while plants grown without added sulphur or only 20kg ha^{-1} produced the lowest irrespective of years (Fig. 1).

Table 1: Influence of sulphur fertilizer on nitrogen uptake (kg ha^{-1}) by sunflower at different stages of plant growth (average of 3 years)

Sulphur levels	Vegetative stages					Reproductive stages					Maturity stages				
(kg ha^{-1})	Leaf	Petiole	Stem	Bud	Total	Leaf	Petiole	Stem	Head	Total	Leaf	Petiole	Stem	Head	Total
0	5.60c	0.46d	4.95e	-	11.55	11.22e	2.52e	16.72e	19.55e	50.01	10.01f	1.92e	17.59e	72.79e	102.31
20	7.29b	0.69c	6.43d	2.36d	16.77	15.34d	4.57d	25.12d	45.54d	90.57	12.53e	3.38d	29.50d	138.02d	183.43
40	9.23ab	0.76c	10.83c	3.94cd	23.76	26.08b	6.42c	32.97c	55.80c	121.27	22.07c	6.09b	34.81c	173.79b	236.76
60	11.38a	0.94b	13.74b	5.94b	32.00	29.86a	8.54b	38.26b	80.87b	157.53	26.10b	8.19ab	39.69b	209.32a	283.30
80	11.74a	1.16a	17.16a	7.54a	37.60	31.48a	10.67a	42.69a	93.38a	183.60	30.81a	9.64a	41.69a	210.13a	292.27
100	7.17b	0.61c	10.03c	5.74b	23.55	24.10b	7.34b	32.75c	53.16c	117.35	23.31c	7.00b	37.90b	168.45b	236.66
120	5.44c	0.47d	7.42d	3.60c	16.93	21.81c	5.18c	23.34d	44.80d	95.13	19.74d	5.00c	28.02d	158.65c	211.41
CV(%)	8.5	5.5	9.0	5.0		10.2	6.0	11.3	12.0		9.3	5.3	10.0	12.8	

Means having same or no letter(s) do not differ significantly at 5% level of probability

Table 2: Influence of sulphur fertilizer on phosphorus uptake (kg ha^{-1}) by sunflower at different stages of plant growth

Sulphur levels	Vegetative stages					Reproductive stages					Maturity stages				
(kg ha^{-1})	Leaf	Petiole	Stem	Bud	Total	Leaf	Petiole	Stem	Head	Total	Leaf	Petiole	Stem	Head	Total
0	0.28e	0.08d	0.27f	-	0.63	0.61f	0.15g	0.84e	1.86f	3.46	0.46e	0.13e	0.94f	7.28e	9.81
20	0.47c	0.13e	0.51e	0.10f	1.21	0.96e	0.48f	1.48c	3.61e	6.53	0.90b	0.40d	1.64e	16.22d	19.16
40	0.84b	0.17b	0.88c	0.21e	2.10	3.08b	0.82d	2.51c	4.46e	10.87	2.74b	0.71c	2.78c	21.02c	27.25
60	1.06a	0.22ab	0.98b	0.49c	2.74	3.68a	1.07b	3.12b	10.11b	17.98	2.80b	0.82b	3.43b	23.48f	31.03
80	1.05a	0.27a	1.17a	0.74a	3.23	3.84a	1.31a	3.97a	11.67a	20.79	3.04a	1.19a	3.98a	26.83a	35.04
100	0.48c	0.13c	0.79c	0.60b	2.00	2.47c	0.97c	2.49c	8.15c	14.08	1.82c	0.87b	3.22b	21.05c	26.96
120	0.36d	0.10d	0.63d	0.37d	1.46	2.16d	0.71e	2.22d	6.40d	11.49	1.00d	0.67c	2.45d	17.90d	22.02
CV (%)	4.6	6.0	5.0	3.6		6.6	5.9	6.1	7.2		4.8	4.0	6.0	10.2	

Means having same or no letter do not differ significantly at 5% level of probability

Table 3: Influence of sulphur fertilizer on potassium uptake (kg ha^{-1}) by sunflower at different stages of plant growth (average of 3 years)

Sulphur levels	Vegetative stages					Reproductive stages					Maturity stages				
(kg ha^{-1})	Leaf	Petiole	Stem	Bud	Total	Leaf	Petiole	Stem	Head	Total	Leaf	Petiole	Stem	Head	Total
0	0.32d	0.05c	0.53f	-	0.90	0.86e	0.31e	2.51f	4.79e	8.29	0.77e	0.24e	1.52e	12.13e	14.66
20	0.64c	0.14b	0.94e	0.33c	2.05	1.49d	0.76d	5.25e	8.20cd	15.70	1.38d	0.61d	6.55d	19.67d	28.21
40	0.88b	0.17b	1.76c	0.40c	3.21	2.13c	1.28c	7.38c	10.23c	21.02	2.01e	1.22c	8.70c	24.25c	36.18
60	1.32a	0.21ab	2.30b	0.75b	4.58	3.58a	1.78b	8.50b	13.47b	27.33	3.20a	1.54b	9.74b	27.91b	42.39
80	1.35a	0.25a	3.04a	0.89a	5.53	3.90a	2.17a	11.04a	15.64a	32.75	3.50a	2.05a	11.37a	30.86a	47.78
100	0.89b	0.15b	1.97c	0.68b	3.69	3.01b	2.00a	8.25b	9.39c	22.65	2.40b	1.63b	9.46b	23.16c	36.65
120	0.69c	0.12b	1.43d	0.40c	2.64	2.32c	1.63b	6.43d	7.20d	17.58	2.15bc	1.35c	7.51c	20.34d	31.35
CV(%)	7.0	6.3	5.3	4.2		8.1	4.0	9.1	11.6		5.5	6.4	8.0	10.0	

Means having same or no letter do not differ significantly at 5% level of probability

Table 4: Influence of sulphur fertilizer on sulphur uptake (kg ha^{-1}) by sunflower at different stages of plant growth (average of 3 years)

Sulphur levels	Vegetative stages					Reproductive stages					Maturity stages				
(kg ha^{-1})	Leaf	Petiole	Stem	Bud	Total	Leaf	Petiole	Stem	Head	Total	Leaf	Petiole	Stem	Head	Total
0	0.28d	0.03b	0.27g	-	0.58	0.61g	0.12e	0.67f	0.98e	2.38	0.51e	0.07d	0.94f	2.91e	4.43
20	0.49c	0.07a	0.45f	0.01b	1.02	1.09e	0.17e	1.03e	2.46d	4.75	1.00c	0.10d	1.47e	8.28d	10.85
40	0.68b	0.08a	0.95c	0.02b	1.73	1.94c	0.32cd	1.58d	3.53c	7.37	1.80b	0.24c	1.74c	10.51c	14.29
60	0.85a	0.09a	0.21b	0.04a	2.19	2.09b	0.46b	2.27b	4.94b	9.76	2.00a	0.40b	1.80c	12.64b	16.84
80	0.87a	0.09a	0.42a	0.06a	2.44	2.30a	0.74a	2.80a	6.77a	12.61	2.00a	0.53a	2.46a	14.31a	19.30
100	0.38c	0.06a	0.79d	0.05a	1.28	1.34d	0.37bc	1.96c	4.96b	8.63	1.10c	0.29c	2.08b	12.63b	16.10
120	0.27d	0.03b	0.64e	0.04a	0.97	0.99f	0.27d	1.05e	3.20b	5.51	0.86d	0.22c	1.63d	8.95d	11.66
CV(%)	4.4	6.2	5.4	3.0		6.2	5.1	7.0	8.3		7.0	6.0	4.9	9.2	

Means having same or no letter do not differ significantly at 5% level of probability

The yield difference between the highest and the lowest yielding treatments was nearly 74%. The positive response up to 80 kg S ha^{-1} could be due to increased absorption of sulphur from the soil resulting in increased formation of reproductive structure or sink strength and increased production of assimilates to fill the seeds. The results are in conformity with the observations of Pasricha and Aulakh (1991) in sunflower, Sharma and Gupta (1992) in soybean, Samui and Bandopadhyay (1997) in Indian mustard and Singh *et al.* (1998) in mustard. Moreover, the experimental soil was deficient in sulphur that might have contributed to the higher yield response to added sulphur fertilizer. On the other hand, sulphur stress or deficiency disturbed the balance of nutritional environment in plants, which has adverse effects on plant growth and ultimately reduced the yield of sunflower. However, with the help of pooled seed yield data, a quadratic model was fitted for S response to sulphur. The response equation worked out to be : $Y = 1.8117 + 0.0364 X - 0.0003 X^2$, $R^2 = 0.82$ (Fig. 2). The value R^2 (0.82) indicates that the sulphur levels can attribute to 82% of the total variation in seed yield. Higher dose of sulphur fertilizer beyond 80 kg ha^{-1} tended to decrease the seed yield in all the years. The negative response of higher doses of sulphur might be the imbalance and toxic effect caused by increasing sulphur level without increasing the rates of other fertilizers. This result showed that seed yield of sunflower was increased with the increase in sulphur application up to a certain limit.

Nutrient uptake: Results of nutrient uptake by different plant parts obtained for the three years were more or less similar. Hence, three year's results have been pooled.

Nutrient uptake by different plant parts of sunflower differed significantly due to sulphur fertilization (Table 1 to 4). The uptake of a nutrient element by the plant was taken as the total dry matter produced multiplied by the concentration of the given nutrient. Nitrogen uptake by sunflower plant and its distribution in different parts during the growing season as influenced by applied sulphur fertilizer is shown in Table 1. The total mean nitrogen uptake by sunflower plant at vegetative stage was 23.2 kg ha^{-1} and increased rapidly to 116.5 and 220.9 kg ha^{-1} during reproductive and maturity stages across the sulphur levels. As the total dry matter increased over time, nitrogen uptake also increased. Sreemannarayana and Raju (1994) also observed increased uptake of nitrogen by sunflower crop with sulphur

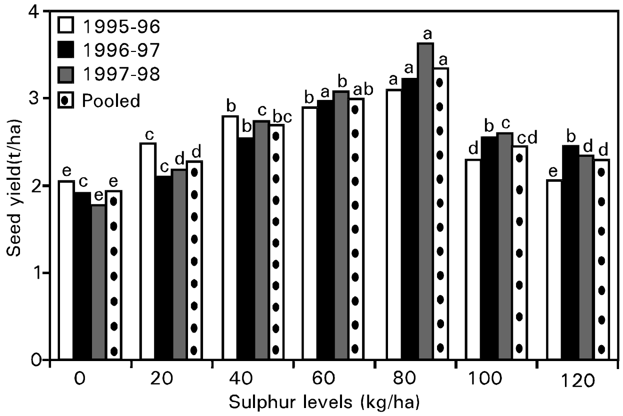

Fig. 1: Yield of sunflower as influenced by sulphur fertilization during 1995-98

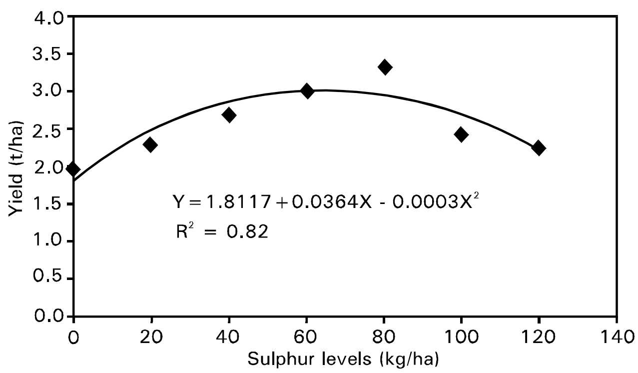

Fig. 2: Functional relationship between seed yield and sulphur levels

levels due to increased biomass yield. Increasing rates of applied sulphur up to 80kg ha^{-1} enhanced the nitrogen uptake by different plant parts followed by 60kg S ha^{-1} irrespective of growth stages. The increased uptake of N by sunflower was due to synergistic interaction effect of N and S. The results are in agreement with those of Khandkar and Shinde (1991) in blackgram. Higher rates of sulphur did not improve the uptake of nitrogen. Plants treated with 60-80kg S ha^{-1} had the highest nitrogen uptake by different plant parts which was 177-225% at vegetative, 215-267% at reproductive and 117-186% at mature stages over the control plot (without S). Tiwari (1999) reported that sulphur and nitrogen has a positive interaction in their uptake by mustard plant. Generally, the rate of nitrogen uptake in sunflower was higher in reproductive stage than in vegetative or maturity stages. Application of sulphur at higher levels (beyond 80 kg ha^{-1}) had antagonistic effect on the uptake of N resulting in decreased uptake of N by sunflower plant. The uptake of nitrogen by leaf and petiole increased from vegetative to reproductive stage and declined at maturity. Less leaf biomass and nitrogen content was the probable reason for low nitrogen uptake by the foliage. These results are similar to those reported by Kumar and Rao (1991) in soybean. The stem and head including seeds showed different trend in nitrogen uptake. It progressively increased up to maturity, irrespective of levels of S applied, which may be attributed to higher dry matter of weight produce by stem and head. Phosphorus uptake followed a pattern similar to that obtained for nitrogen uptake (Table 2). It is noted that sulphur was found to have a synergistic effect on phosphorus uptake by sunflower except at its higher dose. Singh and Chaudhuri (1996) found similar results in groundnut.

The uptake of potassium by plant components of sunflower with seven levels of sulphur showed significant differences over the growth stages (Table 3). Regardless the treatment differences, potassium uptake by leaf and petiole continued to increase up to reproductive stage and decreased at maturity, indicating the translocation of potassium to developing heads or seeds. Uptake of potassium by stem, on the other hand, increased over time across the treatments, which was associated with increased stem dry matter. Stem served as the largest reservoir for potassium throughout the growth period of sunflower. The increasing trend of potassium uptake by head including seed was further accelerated by the application of sulphur irrespective of growth stages. Potassium accumulation on an average of sulphur levels, was low at vegetative stage (3.2 kg ha^{-1}) and enhanced with age of the plant reaching maximum at mature stage (36.18 kg ha^{-1}). Plants treated with 80 kg S ha^{-1} accumulated greater dry matter followed by 60 kg ha^{-1} and thus the uptake of potassium was also higher. Singh and Chaudhari (1996) reported that the application of sulphur increased the potassium and sulphur concentration and their uptake in groundnut. Sulphur uptake by leaves and petioles were also significantly influenced due to sulphur fertilizer application. It was higher at reproductive stage than at vegetative and maturity stages (Table 4). On the contrary, stem and head continued to accumulate sulphur uptake till maturity regardless the treatment due to its relative contribution to dry matter yield. The mean total uptake of sulphur by the plant parts was 1.6 kg ha^{-1} at vegetative, 7.3 kg ha^{-1} at reproductive and 13.4 kg ha^{-1} at maturity stages, and it also varied due to treatment variation. Sulphur uptake by sunflower increased significantly with increasing levels from 0 to 80 kg ha^{-1} followed by 60 kg S ha^{-1} irrespective of growth stages. This might be attributed to higher dry matter production as well as higher S content at this level. Singh and Saran (1987) reported that increase in uptake of sulphur with sulphur application in linseed and rape. However, the uptake of sulphur decreased at the higher levels of sulphur possibly due to depressive or antagonistic effect on the uptake of sulphur.

In general, nutrient uptake and yield of sunflower were highest with the application of sulphur fertilizer between 60-80 kg ha^{-1} irrespective of growth stages. Results indicate that the dry matter synthesis and accumulation of nutrients are interrelated. Post-flowering phase is more important for dry matter and nutrient accumulation. Considering the sulphur cost and for efficient sunflower production in this soil, application of 60 kg S ha^{-1} along with other essential nutrients had beneficial effects on yield as well as nutrient uptake.

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