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INFLUENCE OF SULPHUR FERTILIZER ON GROWTH AND PRODUCTIVITY OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Key words: Sunflower, *Helianthus annuus*, Sulphur, Fertilizer, Growth, Yield

Abstract

Field experiments with seven levels of sulphur (0, 20, 40, 60, 80, 100 and 120 kg ha^{-1}) were carried out in silty clay loam of Grey Terrace soil (Albaquept) at the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the three consecutive years (1995-96, 1996-97 and 1997-98) to evaluate sulphur fertilizer effects on growth and productivity of sunflower (cv. Kironi). Dry matter production (DMP), crop growth rate (CGR), yield components, yield and harvest index significantly responded to the application of sulphur. Total dry matter (TDM) production increased gradually and reached it maximum at 75-90 days after emergence (DAE). Towards maturity, contribution of the leaf to total dry matter decreased faster than that of stem while the contribution of a head increased to a greater extent. CGR was higher during 75-90 DAE irrespective of sulphur levels. Relative growth rate (RGR) showed an ontogenetic downward drift with crop age. Increasing the levels of sulphur up to 80 kg ha^{-1} increased TDM including CGR, RGR, yield components and yield of sunflower which was statistically identical with 60 kg S ha^{-1}. Results of three year's study revealed that sunflower be grown with 60 kg S ha^{-1} for obtaining better growth and seed yield.

Introduction

Sunflower (*Helianthus annuus* L.) being a photo-insensitive plant has vast potential to produce edible oil. It contains high quality of edible oil (40-44%) and protein (20%). It is grown both in rabi (winter) and kharif (summer) seasons in Bangladesh. This crop has got considerable potentiality under Bangladesh condition as edible oil. However, the productivity of sunflower per unit area is quite low as compared to other sunflower producing countries of the world. The low yield of sunflower in Bangladesh is primarily due to lack of high yielding varieties, poor photosynthetic efficiency, inadequate cultural management and also lack of knowledge of farmers with the role of sulphur in crop production.

Seed yield is considered as a function of biomass accumulation and its partitioning to seed. Kumar and Gangwar (1985) reported that seed yield in *Brassica* species was highly associated with the production of dry matter. Biomass production of a crop largely depends on the function of leaf area development and consequential photosynthetic activity (Muthuchelian 1993). Accumulation of dry matter and subsequent partitioning of assimilates are of great importance in determining the final yield in crops (Wareing and Patric 1978). But sunflower in general has a high sulphur requirement for better seed formation and development of oil storage organs (Singh and Sahu 1986, Aulakh *et al.* 1980). Saraf (1988) reported that sulphur application in soil not only increases grain yield of crop but also their superior nutritional and market quality. Sunflower also needs sulphur in sufficient quantity for synthesis of protein and sulphur containing amino acids such as cysteine, cystine and methionine (Aulakh and Pashricha 1988). On the contrary, sulphur deficiency during seed filling has detrimental effect on yield, quality and also poor utilization of N, P and K of sunflower (Hocking *et al.* 1987). Information regarding sulphur fertilization effects on dry matter accumulation and their partitioning into different plant parts, growth characteristics and yield of sunflower under Bangladesh condition is scanty. Keeping this in view, the present experiment was undertaken to study the pattern of dry matter (DM) accumulation and distribution of DM into plant parts at various growth stages, growth characteristics and productivity of sunflower to different levels of sulphur fertilization.

Materials and Methods

Field experiments were conducted on a Grey Terrace soil (Albaquept) of Modhupur Tract (AEZ 28), Joydebpur, Gazipur during rabi seasons of 1995-96, 1996-97 and 1997-98 at the Bangladesh Agricultural Research Institute (BARI) located at 24º09´N Latitude and 90º26´E Longitude with sub-tropical climate. The soil was silty clay loam in texture and slightly acidic in reaction (pH 6.0) with low content of total N (0.035%), available P (7.02 ppm), exchangeable K (0.14 meq $100g^{-1}$ soil), available S (10.0 ppm), B (0.10 ppm) and Zn (0.20 ppm). The amount of rainfall during the cropping period was 88 mm in 1995-96, 71 mm in 1996-97 and 47 mm in 1997-98.

Seven levels of sulphur fertilizer (0, 20, 40, 60, 80, 100 and 120 kg ha^{-1}) were used as treatment variables. The experiment was set up in a CRBD design with four replications. The unit plot size was 5m x 3m. A blanket rate of fertilizers at 120 kg N, 90 kg P_20_5, 80 kg K_20, 5 kg Zn and 1 kg B ha^{-1} as urea, triple super phosphate, muriate of potash, zinc oxide and soluber was applied. The sulphur was used as gypsum. The whole amount of triple super phosphate, muriate of potash, gypsum, zinc oxide, soluber and half of urea were applied as basal at the time of final land preparation. Seeds of sunflower (cv. Kironi) at the rate of 12 kg ha^{-1} were sown in the first week of November during three consecutive years maintaining 50 cm row to row and 25 cm plant to plant distance. The remaining urea was applied in two splits at 25 and 45 days after emergence (DAE). The crop was irrigated at 25, 45, and 75 DAE. Weeding and mulching were done as and when required. A regular precautionary measure was made to save the crop from parakeets.

Plants were sampled periodically at 15 day intervals from emergence to maturity to determine dry matter accumulation. At each sampling, five plants from each plot were cut at the ground level. The plant parts were segmented and dried at 70°C to a constant weight and dry weight recorded. Total dry matter (TDM) was computed from the sum of the dry weights of the different above ground parts of the plants and expressed in g m^{-2}. At maturity, additional ten plants were collected randomly from each plot for yield component characters and an area of 8 m^2 (4m x 2m) was harvested from centre of each plot each year for yield determination. Harvesting was done at 115-120 DAE. The harvested heads were dried in the sun (6-7 days) and seeds were separated, cleaned and weighed. Moisture content of the seeds was determined and the seed weight adjusted to 8% moisture. Data on yield and yield parameters were subjected to analysis of variance and the means were compared by Duncan New Multiple Range Test (Steet and Torrie 1960). Crop growth rate (CGR) and relative growth rate (RGR) of sunflower were computed using the following formulae (Gardner *et al.* 1985).

$CGR = 1/ GA \times W_2 - W_1 / T_2 - T_1$ g m^{-2} day^{-1}; $RGR = \text{Log}_e W_1 - \text{Log}_e W_2 / T_2 - T_1$ g g^{-1} day^{-1}

Where, GA= Ground area, W= Weight of dry matter and T= Time (days)

Results and Discussion

Dry matter accumulation, CGR and RGR of sunflower showed similar results in all years or seasons hence pooled data are discussed here.

Dry matter accumulation: Total dry matter of sunflower increased progressively over the growing season and there were differences in the pattern of dry matter accumulation due to different levels of sulphur fertilizer (Fig. 1). At the beginning of the growth cycle, the differences in TDM due to sulphur fertilizer application was less conspicuous but over time the difference widened up. Highest rate of TDM production was obtained from 60 to 90 DAE irrespective of sulphur levels. Increase in TDM production at this growth phase was possibly due to increased photosynthetic rate resulting in increased TDM production. Ali *et al.* (1995) reported similar increase in TDM of rapeseed due to sulphur fertilizer application. The plants grown without or with 20 kg S ha^{-1} produced the lowest TDM at all growth stages. Consistently higher TDM was obtained in plants treated with 60-80 kg S ha^{-1} irrespective of growth phases.

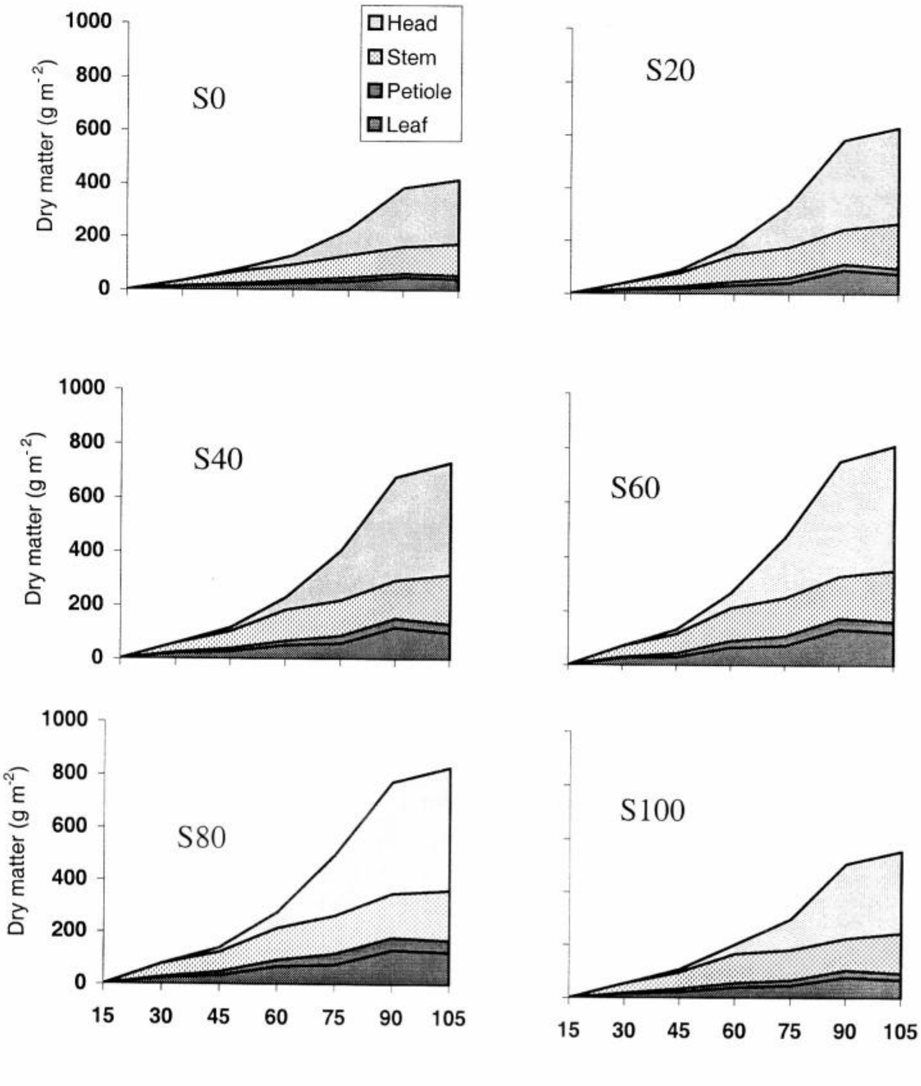

Fig. 1.Dry matter accumulation in different parts of sunflower at different growth stages as influenced by fertilization

Further increase in sulphur rate (beyond 80 kg ha^{-1}) tended to depress dry matter accumulation and that could probably be due to toxic effect of sulphate ions (SO_4^{2-}) in the plant system (Tiwari *et al.* 1992). Dry matter partitioning of leaves and petioles increased upto 90 DAE and thereafter it declined irrespective of sulphur levels (Fig.1). The rate of increase in dry weight of leaves and petioles of sunflower were maximum during 75 to 90 DAE across the sulphur levels in all the years. Dry matter in leaves declined after the attainment of the peak might be due to translocation of carbohydrates for the development of head or seeds and also because of leaf senescence. On the contrary, stem continued to accumulate dry matter till 105 days at all the sulphur levels (Fig. 1). Application of sulphur fertilizer also caused a remarkable variation in partitioning of dry matter into heads in all the years. Head development started slowly in early stages but the growth increased sharply later on. The sharp rise in head development at later phase is presumably due to increased partitioning of photosynthates in response to great sink demands.

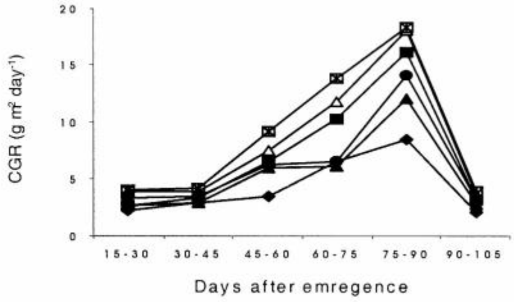

Fig. 2. CGR of sunflower as affected by sulphur

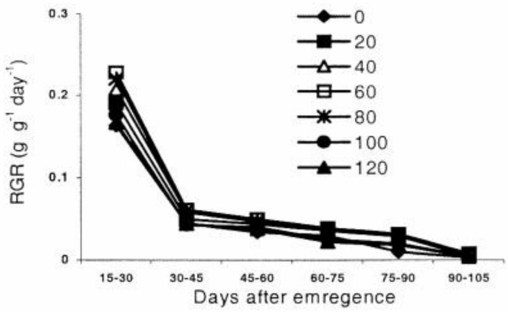

Fig. 3. RGR of sunflower as affected by sulphur fertilizer at different growth stages

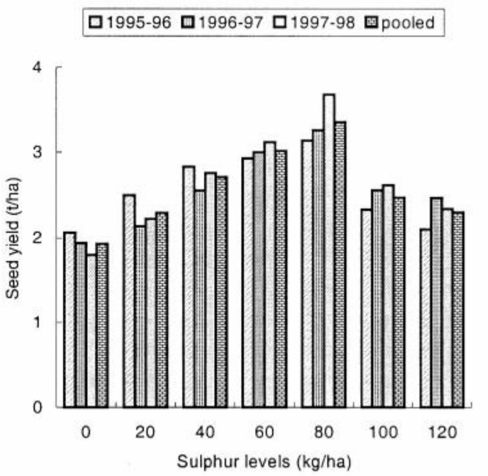

Fig. 4. Yield of sunflower as influenced by sulphur fertilization during 1995-98

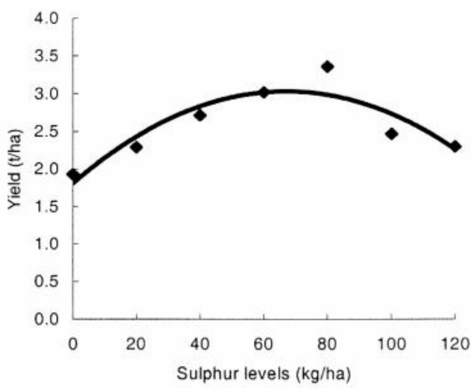

Fig. 5. Functional relationship between seed yield and sulphur levels

Averaged over sulphur levels, results revealed that at the vegetative stage leaves accumulate 25% and stem 58% of dry matter and at the reproductive stage accumulation of dry matter were 16% in leaves, 23% in stems and 57% in head. However, application of 60 to 80 kg S ha^{-1} consistently showed better performance in respect of partitioning of dry matter into heads irrespective of years.

Crop growth rate: The growth of sunflower was considerably affected by the sulphur fertilization. In all the treatments, CGR values increased progressively with time reaching peak at 75-90 DAE and thereafter declined sharply (Fig. 2). Growth rate decreases as the plant matures because of cessation of vegetative growth, loss of leaves and senescence. However, application of 60 kg S ha^{-1} registered a maximum CGR during the whole growth period and at 75-90 DAE it was 118% higher over the control (without S). CGR in general depends mainly on the amount and intensity of energy intercepted and the photosynthetic efficiency of the leaf or crop canopy. Presumably, optimum dose of sulphur along with other essential elements enhanced leaf growth, reduced senescence and help intercept more radiation and resulting in greater amount of photosynthesis. This result is in agreement with the findings of Misa *et al.* (1994). Higher levels of sulphur decreased the CGR values irrespective growth stages.

Relative growth rate: RGR values of sunflower as influenced by sulphur fertilization are presented in Fig. 3. Irrespective of treatments, RGR values were higher during early in the season and showed a decreasing trend as crop advanced in age. RGR decrease with plant age due to the fact that increasing of the plant is structural rather than metabolically active tissue and as such does not contribute to growth. The decline in RGR was also due to the decrease in assimilation rate. However, variations in RGR across the treatments were not remarkable. But the differences observed were due to different growth period. Application of 60 kg S ha^{-1} maintained relatively higher RGR value during the whole growth period.

Yield and yield attributes: Plant height, diameter of head, number of filled and unfilled seeds/head, 1000-seed weight and harvest index of sunflower showed significant variations across the levels of sulphur fertilization in all the years (Table 1). There was gradual increase in quality of characters mentioned above as the sulphur quantity was increased upto 80 kg ha^{-1}. Application of sulphur beyond this rate had deleterious effects on sunflower. Diameter of heads, number of filled grains $head^{-1}$ and seed weight were highest at 80 kg ha^{-1} and statistically different from other treatments. However, harvest index at 60 and 80 kg ha^{-1} sulphur was statically similar (Table1). The yield advantage of sulphur fertilizer application at 60–80 kg ha^{-1} was 52, 68 and 104% higher over the control (without S) in 1995-96, 1996-97 and 1997-98, respectively. Soil test value showed that the experimental field was deficient in sulphur that might have contributed to the higher yield response to added sulphur fertilizer. Samui and Bandopadhyay (1997) showed that application of sulphur through gypsum significantly increased the seed yield in mustard. Dubey *et al.* (1993) in soybean and Singh *et al.* (1998) in mustard also reported similar results. Addition of sulphur beyond 80kg ha^{-1} tended to decrease the seed yield of sunflower irrespective of years. This might be due to the imbalance and toxic effect caused due to raising sulphur level without increase of other fertilizer. However, TDM and CGR were higher during 75–90 DAE irrespective of sulphur levels. RGR showed an ontogenetic downward drift with crop age. Increasing the levels of sulphur upto 80 kg ha^{-1} increased TDM, CGR, RGR and seed yield of sunflower which was statistically identical with 60 kg S ha^{-1}.

From the regression analysis it was observed that seed yield was related to sulphur levels with a quadratic relationship (Fig. 5) and the response of the functional relation was: $Y= 1.8171 + 0.0364 X - 0.0003 X^2$, $R^2 = 0.82$. The value of R^2 (0.82) indicates that 82% of the total variation in seed yield could be accounted for by a quadratic function of the sulphur levels. Quadratic regression with yield and sulphur levels suggesting that the yield of sunflower increased with the increase of sulphur application up to a certain limit. Sulphur treated plants also gave higher harvest index (HI) over the control in all the years (Table 1). The highest HI was recorded for 60-80 kg S ha^{-1} and the lowest for without sulphur. Higher HI in 60–80 kg S ha^{-1} possibly due to favourable partitioning resulting from increased physiological capacity and mobilization of photosynthates and transfer of it towards seed.

Table 1. Plant height, diameter of heads, number of filled and unfilled seeds/head, 1000-seed weight and harvest index of sunflower as influenced by sulphur fertilization.

Sulphur levels (kg/ha)	Years	Plant height (cm)	Diameter of heads (cm)	No. of filled seeds/head	No. of unfilled seeds/head	1000-seed weight (g)	Harvest index (%)
0	1995-96	142.16 b	11.04 e	369.39 e	52.61 a	53.75e	37.99 c
	1996-97	141.00 e	12.00 f	590.62 e	70.25 a	54.75 e	34.09 d
	1997-98	133.66 c	11.86 d	440.21 f	71.15 a	54.25 e	35.44 d
20	1995-96	149.37 c	14.41 d	664.71 d	47.36 b	68.16 cd	39.44 bc
	1996-97	146.05 d	13.82 e	907.37 de	49.87 b	70.96 d	35.21 cd
	1997-98	148.79 b	14.49 c	615.50 e	63.06 b	62.75 d	36.44 cd
40	1995-96	156.88 b	15.09 cd	724.06 c	38.89 c	76.72 bc	39.65 b
	1996-97	154.00 bc	15.73 d	727.66 b	38.46 d	82.17 b	36.75 c
	1997-98	153.58 ab	15.50 bc	768.00 cd	51.68 d	86.20 c	40.15 a
60	1995-96	158.08 ab	16.55 b	872.81 b	30.28 d	78.78 b	41.48 a
	1996-97	157.25 ab	16.45 b	912.25 b	27.95 e	85.30 b	40.36 ab
	1997-98	159.17 a	16.49 b	933.50 b	45.89 e	84.55 b	40.52 a
80	1995-96	159.75 a	18.12 a	951.90 a	31.99 d	90.47 a	41.45 a
	1996-97	159.50 a	18.16 a	1140.25 a	30.36 d	91.55 a	41.41 a
	1997-98	159.25 a	18.72 a	1081.75 a	44.88 e	91.32 a	41.25 a
100	1995-96	154.62 b	16.45 bc	758.75 c	35.93 c	73.13 bcd	39.67 a
	1996-97	153.25 bc	15.91 bc	837.87 bc	40.44 cd	76.78 c	39.49 b
	1997-98	151.52 b	15.61 b	797.50 c	56.23 c	68.97 c	39.26 ab
120	1995-96	150.40 c	15.61.c	726.25 c	36.24 c	51.69 d	39.57 b
	1996-97	149.75 cd	15.66 c	798.37 c	42.73 c	66.87 d	36.33 c
	1997-98	149.37 b	15.12 c	729.25 cd	51.69 d	71.95 cd	37.62 b

In a column, values followed by a common letter do not differ significantly at 5% level

Results of three year's study indicated that dry matter production and its favourable partitioning at the later stage into the reproductive organs might be important for yield improvement. However, for the optimum growth and productivity, the optimum sulphur rate of sunflower under Grey Terrace soil (Albaquept) of Madhupur Tract (AEZ 28) is collected to be around 60 kg ha^{-1}.

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