Bangladesh J. Agril. Res. 25(4) : 663-670, December 2000

EFFECT OF SULPHUR FERTILIZATION ON THE YIELD AND QUALITY OF SUNFLOWER SEED

SHAMIMA NASREEN, S. M IMAMUL HUQ[2], MD. AHSANULLAH[3], ABDUL LATIF[3] AND KRISHNA CHOUDHURY[4]

Abstract

Field experiment was conducted during the rabi seasons of 1996-97 and 1997-98 on silty clay loam at Grey Terrace soil to study the effect of sulphur levels on seed yield, oil and protein contents, fatty acid composition and chemical properties of oil of sunflower (cv. Kironi). Application of S in sunflower @ 80 kg/ha increased significantly the seed yield, oil and protein contents, iodine value, saponification vlaue, palmitic and linoleic acids of oil followed by 60 kg S/ha. Acid value, free fatty acids, unsaponifiable matter, stearic and oleic acids decreased consistently with the increase in S levels in both the years. The results suggest that sulphur fertilization is beneficial in sunflower production in enhancing both quantity and quality.

Introduction

Sunflower (*Helianthus annuus* L.) is a new oilseed crop in Bangladesh. The climatic condition of Bangladesh favours its growth almost throughout the year. Sunflower seed contains 15-20% assimilable protein and 40-42% edible oil which has a high biological value as it contains a high quality of linoleic and oleic acid (Khaleque, 1985).

Bangladesh has been facing acute shortage of edible oil for the last several decades. The shortage of edible oil has become a chronic problem for the nation as the population increases. Sunflower can play an important role in reducing the chronic shortage of edible oil in the country. However, the average yield of sunflower in Bangladesh is low (1400 kg/ha) as compared to other developed countries (FAO, 1999). Reasons for low yield of sunflower may be poor fertilizer management and lack of high yielding varieties. Therefore, per acre production of sunflower can be increased by adopting proper fertilization, especially S. Sulphur is known as a secondary element and recently raised as the fourth major nutrient after nitrogen,

[1]Soil Science Division, BARI, Joydebpur, Gazipur 1701, [2]Deptt. of Soil Science, University of Dhaka, [3]Oilseed Research Centre, BARI, Joydebpur, Gazipur, [4]Fats and Lipid Section, BCSIR, Dhaka, Bangladesh.

phosphorus and potash (Noggle, 1986). Sunflower have high sulphur requirements owing to higher seed and oil yield (Aulakh *et al.*, 1980; Singh and Shaha, 1986; Gangadhara *et al.*, 1990; Jaggi *et al.*, 1993). Saraf (1988) reported that sulphur application not only improved grain yield of legumes but also their superior nutritional and market quality. Sunflower also need sulphur in sufficient quantity for synthesis of proteins and essential amino acids, such as cystein, cystine and methionine (Aulakh and Pasricha, 1988). On the other hand, due to lack of its (sulphur) optimum supply, the plant growth is hampered resulting yield reduction. Severe sulphur deficiency during seed formation have detrimental effects on yield quantity as well as reduction of oil content of sunflower seeds (Hocking *et al.*, 1987). Dube and Misra (1970) also reported that sulphur deficiency resulted in 20 to 30% reduction in the protein content of grain legumes. However, research programmes of sunflower in Bangladesh is now mainly concentrated on varietal development, irrigation management, cultural practices and plant protection measures. But very limited research has been done in respect of physio-chemical aspects of sunflower with sulphur fertilizer. The present experiment was, therefore, undertaken to study the effect of sulphur fertilizer on seed yield, oil and protein contents, fatty acid composition and chemical properties of oil of sunflower.

Materials and Methods

Field experiments were conducted at the Grey Terrace soil of Mdhupur tract (AEZ 28), Gazipur during November to March of 1996-97. The soil is silty clay loam and acidic in reaction (pH 6.0) with low contents of total nitrogen (0.035), available phosphorus (7.02 ppm) and available sulphur (10 ppm). The mean monthly maximum temperature was 34.9°C and the mean minimum was 10.5°C. The amount of rainfall received during the cropping period 122 mm and 54.8 mm in 1996-97 and 1997-98, respectively.

Seven levels of sulphur fertilizer (0, 20, 40, 60, 80, 100 and 120 kg/ha) were used as treatment variables. The experiment was set up in a RCB design with 4 replications. The unit plot size was 5 m x 3 m. The plot was fertilized with $N_{120}P_{90}K_{80}Zn_5B_2$ kg/ha as urea for N, triple super phosphate (TSP) for P_20_5, muriate of ptash (MP) for K_20, zinc oxide for Zn, soluber for B and gypsum for S. 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 in the first week of November during 1996 and 1997 with 2 kg seeds/ha 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). Three irrigations were made at 25 and 75 DAE. Weeding and mulching were done as per requirement.

The corp was harvested at 110 DAE. The heads were cut from the plants and dried on the threshing floor for about 6-7 days. The winnowed seeds were dried in the sun for 3-4 days. The seeds of each plot were then recorded individually and adjusted to 8% moisture content. Sunflower's seed samples were collected separately from each plot for study of oil and protein contents, fatty acid composition and chemical parameters of the oils. Oil content in seed was determined according to Cocks and Van Rode (1966), Mehlenbacher (1960), and the fatty acid composition were determined according to Jellum and Worthington (1966) at Biochemical Laboratory of Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur using a Phillips PU 4500 Gas Liquid Chromatography with a Hydrogen Flame Ionization Detector (FID). The column, detector and injector temperatures were 185°C, 240°C and 220°C, respectively, and nitrogen was used as the carrier gas at the rate of 22 ml/ min. Protein content of seeds was determined by using Micro-Kjeldahl method. To calculate the protein percentage in whole seed, nitrogen percentage was multiplied by 6.25. Acid value, free fatty acid, iodine value, saponification value and unsaponifiable matter were determined following standard methods (Williams, 1966; Gunstone, 1958) at Fats and Lipid Section of the Institute of Food Science and Techology, Bangladesh Council for Scientific and Industrial Research (BCSIR), Dhaka. Collected data were statistically analysed by following Gomez and Gomez (1984).

Results and Discussion

Sulphur effect on seed yield, oil and protein contents of sunflower for the two years (1996-97 and 1997-98) are presented in Table 1. Seed yield varied from 1.94 to 3.26 t/ha in 1996-'97 and 1.80 to 3.68 t/ha in 1997-'98 significantly due to sulphur fertilization. In both the years, seed yield was highest for the plants grown with 80 kg S/ha and the control plants produced the least. The yield advantage due to sulphur fertilization at 80 kg/ha was 68% in 1996-'97 and 104% in 1997-'98 over the control (without S). The higher seed yield with the application of sulphur might be due to increased production of assimilates to fill the seed (sink). Moreover, the soil was deficient in sulphur that might have contributed to the higher yield response to added sulphur fertilizer. Dubey *et al.* (1993) and Tomer *et al.* (1996) also reported similar result. Samui and Bandopadhyay (1997) showed that application of sulphur through gypsum significantly increased the seed yield in Indian mustard. However, addition of sulphur (beyond 80 kg/ha) tended to decrease the seed yield in both the years. The negative response of higher doses of sulphur possibly due to the imbalance and toxic effect of raising sulphur level without increase in other frtilizers. Sulphur fertilizer has significant influence on the oil content of sunflower (Table 1). Average over years, it ranged between 41.81% and 43.13% and the lowest being recorded for the control treatment. Increase in sulphur levels increased oil content upto 80 kg/ha followed by 60 kg/ha and then tended to decrease in both the years. Pasricha and Aulakh (1991) reported that application of sulphur with balanced amount of other nutrients signifcantly increased oil content in peanut, linseed and soybean. Similar observations were also reported by Gangadhara *et al.* (1991) in sunflower. Protein content in seed of sunflower was found significant in respect of sulphur fertilization (Table 1). Averaged over years, 60 kg S/ha contained higher protein in seed which was 26% higher over the control

Table 1. Seed yield, oil and protein contents of sunflower as influenced by sulphur fertilization.

Sulphur levels (Kg/ha)	Seed yield (t/ha)		Oil content (%)		Protein content (%)	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
0	1.94 c	1.80 e	41.68 e	41.94 c	17.16 g	17.68 e
20	2.14 c	2.22 d	42.08 de	42.19 bc	18.82 f	18.85 d
40	2.55 b	2.76 c	42.47 cd	42.78 ab	20.24 c	21.34 b
60	3.00 a	3.12 b	42.94 ab	42.94 a	21.86 a	21.93 a
80	3.26 a	3.68 a	43.16 a	43.10 a	21.49 b	21.78 a
100	2.56 b	2.62 c	43.12 a	42.90 a	21.16 c	21.23 b
120	2.47 b	2.34 d	42,56 bc	42.15 bc	20.83 d	20.74 c
CV (%)	6.9	6.5	0.70	1.0	0.80	0.70

Means having same letters do not differ significantly at 5% level of probability.

treatment. Joshi and Billore (1998) reported that application of 60 kg S/ha increased protein content of soybean. Further increase in sulphur fertilizer tended to decrease the protein content irrespective of years. Generally, plants grown without sulphur consistetly contain lower protein in seed.

Acid value, free fatty acid, iodin value, saponification and unsaponifiable matter of oil of sunflower as influenced by the application of sulphur fertilizer are shown in Table 2. However, sulphur fertilizer exerted significant effect on acid value of oil in both the years. The highest acid value was found in the oil of sunflower seeds at lower levels of sulphur (0-20 kg/ha) irrespective of years (Table 2). Acid value decreased with the increase of sulphur fertilization. This result indicates that the higher doses of sulphur is necessary for decreasing acid value and getting better quality of oil. Significant response of sulphur on free fatty acid (FFA) in oil of sunflower was also observed in both the years (Table 2). FFA content in oil decreased with increasing sulphur levels. Kale *et al.* 1992 reported the accumulation of lipids and protein in developing seeds of sunflower was accompanied by decrease of FFA. Marked variation in iodine value was observed due to sulphur fertilizaton (Table 2). The highest iodine value was obtained from 60-80 kg S/ha and the lowest was recorded from the control treatment. The increase in the iodine value due to sulphur application in the synthesis of fatty acid may be due to higher proportion of saturated fatty acids to unsaturated ones (Gangadhara *et al.*, 1990). The result implies that higher the sulphur dose, greater the iodine value or better is the quality of oil. Saponification values of oil produced by different sulphur levels were also found significant (Table 2). Plants treated with 60-80 kg S/ha produced the highest saponification value and the lowest from without sulphur fertilizer in both the years. Average over the years, the difference of saponificaion value between the highest and the lowest value treatments was 5.1%. On the contrary, increase of sulphur fertilizer application decrease the precentage of unsaponifiable matter from 1.90 to 1.50 in 1996-'97 and 1.70 to 1.14 in 1997-'98 of sunflower oil (Table 2), indicating that higher doses of sulphur is essential for reducing unsaponifiable matter of oil.

Application of sulphur fertilizer influenced on fatty acid composition of sunflower (Table 3). Palmitic acid increased with increasing levels of sulphur upto 80 kg/ha followed by 40 and 60 kg/ha and thereafter decreased in both the years. Stearic and oleic acids also decreased with each increment of

Table 2. Chemical characteristics of oil of sunflower as affected by sulphur fertilization.

Sulphur levels (kg/ha)	Acid value		Free Fatty acid		Iodine value		Saponification value		Unsaponifiable matter	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
0	1.81 a	1.48 a	0.90 a	0.74 a	121.36 d	120,67 e	185.75 c	18275 c	1.90 a	1.70 a
20	1.40ab	1.39 a	0.71 b	0.69 b	122.79 cd	122.59 d	189.27 b	185.80 c	1.80 ab	1.58 b
40	1.37 b	1.23 b	0.68 b	0.61 c	123.48 c	128.55 c	193.75 a	189.75 b	1.80 ab	1.40 bc
60	1.05 c	0.89 c	0.52 c	0.44 d	124.56 bc	133.27 a	193.80 a	192.85 a	1.70 bc	1.35 cd
80	0.95 c	0.87 c	0.47 d	0.43 d	128.05 a	130.60 b	193.81 a	193.85 a	1.60 cd	1.20 e
100	0.90 c	0.90 c	0.45 d	0.45 d	126.09 ab	123.21 d	188.50 bc	184.68 c	1.80 b	1.15 e
120	1.08 c	1.15 b	0.43 d	0.44 d	123.92 c	121.45de	185.90 c	183.75 c	1.50 de	1.14 e
CV (%)	1.1	5.8	4.6	3.2	1.0	0.9	0.9	1.0	6.1	6.6

Means having same letters do not differ signifcantly at 5% level of probability.

sulphur fertilizer. Similar trends was reported by Jaggi *et al.* (1993) in linseed. However, linoleic acid followed exactly the opposite trend at the cost of other acid. Averaged over years, maximum linoleic acid was produced from the plants treated with 80 kg S/ha (Table 3). Application of sulphur fertilizer in excess of 80 kg/ha did not improve linoleic acid content in sunflower. Plants grown without applied sulphur showed consistently lower linoleic acid in both the years. However, linoleic acid content is important for the stand point of utilization of oil for food products. High content of linoleic acid helps in washing out cholesterol deposition in coronary arteries of heart and thus is good for heart patients (Skoric, 1988). It is noted that cholesterol is solid fatty alcohols. Although cholesterol is essential to the human body, excessive amounts can lead to heart disease. Cholesterol move through the blood stream by lipoproteins like low-density lipoproteins (LDL's) and high-density lipoproteins (HDL's). However, unused cholesterol accumulates on the artery walls and forms plaques, fatty deposits that contribute to hardening of the arteries. This accumulation is caused mostly by LDL's. Fatty deposits accumulate on the inner layer of the arterial wall. They narrow the internal diameter of the artery and the volume of blood that passes through the artery is decreased that leads to heart attack and stroke.

Table 3. Fatty acid composition (%) of sunflower as influenced by sulphur fertilization.

Sulphur levels (kg/ha)	Palmitic acid (16 : 0)		Stearic acid (18 : 0)		Oleic acid (18 : 1)		Linoleic acid (18 : 2)	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
0	6.15 d	6.19 d	2.91 a	2.96 a	32.50 a	32.50 a	55.85 c	56.90 e
20	6.38 b	6.37 c	2.94 a	2.92 a	28.02 b	30.15 b	61.83 b	61.87 c
40	6.55 a	6.49 ab	2.53 b	2.50 b	26.75 c	28.84 c	62.87 b	60.15 d
60	6.65 a	6.61 a	2.45 b	2.46 b	26.22 cd	28.18 c	63.50 ab	60.05 d
80	6.60 a	6.55 a	2.38 c	2.34 c	26.20 cd	26.69 d	65.00 a	65.56 a
100	6.35 b	6.42 bc	2.24 d	2.24 d	26.05 cd	26.05 de	62.82 b	63.82 b
120	6.21 c	6.31 c	2.22 d	2.24 d	25.52 d	25.47 e	62.50 b	62.75 b
CV (%)	2.4	1.2	0.6	0.6	2.0	1.4	2.5	1.2

Means having same letters don't differ significantly at 5% level of probability.

From the results of two years' study, it may be concluded that application of sulphur in sunflower @ 60 to 80 kg/ha increased seed yield, oil and protein contents, iodine value, saponification value, palmitic and linoleic acids of oil. Conversely, acid value, free fatty acid, no saponification value, stearic and olec acids decreased with each increment in sulphur levels.

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