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GROWTH, YIELD AND BIOCHEMICAL ATTRIBUTES OF PEA WITH SULPHUR FERTILIZATION IN NORTHERN INDIAN SOIL

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Pea (*Pisum sativum* L.) plants were raised in Gomti upland soil (Lucknow). The soil, rated sulphur deficient on the basis of available soil sulphur, was fertilized with calcium sulphate to provide sulphur at the rate of 10, 25, 50 and 100 mg kg^{-1} soil. Sulphur amendment at the rate of 50 mg kg^{-1} soil induced maximum shoot length and dry weight production in pea by 26.9 and 34.5%, respectively, whereas decreased with increasing S amendment in soil. S increased pod numbers, pod length and seed weight maximum at 50 mg kg^{-1} sulphur amendment in soil. Pigments (chlorophyll a, b, total and carotenoids), sugar contents showed maximum values at 50 mg S kg^{-1}in soil. Therefore, study concluded that, S amendment at the rate of 50 mg S kg^{-1} in alluvial soil may increase the growth and yield of pea.

Key words: Biochemical responses, *Pisum sativum*, Sulphur fertilization, Alluvial soil.

The reduction in crop production have prompted to look to some plant species as a source of pulse and vegetables specially in the areas where soil fertility pose a major constraint in food crop productions. In many tropical countries, extreme weathering and leaching losses deplete soil sulphur and cause sulphur deficiency resulting in adverse effects on crop yield and quality (Brady and Weil 2002). In the arid and sub arid regions, alluvial soil of northern India, where declining availability of micronutrients and sulphur (Agarwala and Sharma 1979) pose a major constraint to food grain production. The deficiency of sulphur in soil poses a major constraint to crop production (Pandey *et al.* 2009).

Pisum sativum (pea) usually grown as vegetable and pulse crop in all over the world of tropical and subtropical regions. In India, about 690000 ha of land are under pea cultivation, of which about 65% area is in the state of Uttar Pradesh.

Therefore, study was undertaken to find out effects of sulphur fertilization in mild calcareous alluvial soil collected from Gomti upland, Lucknow on growth, some biochemical constituents and reproductive yield of pea.

MATERIALS AND METHODS

The bulk of the composite soil sample was collected from Badshah bagh area located in Lucknow district (UP state, India). Soil sample was analysed for their some physico-chemical properties (Table.1). Soil was slightly alkaline in pH, mild calcareous (1.18%) and deficient in available sulphur ($CaCl_2$ extract 5.5 $\mu g\ g^{-1}$). The soil was adequetly fertilized through basal application of N, P, K, Zn, Cu, Mn, Mo, Fe and B at 25, 22.2, 40.5, 2.5, 2, 10, 0.5, 10 and 0.5 mg Kg^{-1} soil, respectively. The amended soil was devided into 5 lots. Each lot was separately amended with AR grade $CaSO_4.2H_2O$ to provide 10 (S_1), 25 (S_2), 50 (S_3) and 100 mg S kg^{-1} soil (S_4), with no sulphur amendment serving as control (S_0). The soil was filled in 25 cm clay flower pots whose inside surface, were painted with bitumen and lined with acid washed alkathene film. There were 4 pots for each treatment, randomized in 2 blocks. The 5 seeds of pea (*Pisum sativum* L., var. Orchid) were shown in each pot. Biochemical (pigments and sugar contents) responses of pea were observed at 65 days after the sowing.

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Table 1: Some Physico-chemical properties of composite soil sample collected from Badshah baugh area, Lucknow used in experiments.

Parameter	Texture	PH	O.M (%)	$CaCO_3$ (%)	E.C. (m mhos/cm)	Zn (ppm) (ppm)	Cu (ppm)	Fe (ppm)	S
Average value	Loamy sand	7.8	0.24	1.18	2. 8	1.20	0.85	2.10	5.5

O.M. – Organic matter; E.C. – electrical conductance

Table 2: Effect of graded sulphur ($CaSO_4.2H_2O$) fertilization of Gomti upland alluvial soil of Lucknow on soil availability of sulphur in two extractants after harvest (16 week after treatment) of pea plants grown in pot culture**.**

Extractants	S amendment in soil (mg kg $^{-1}$)					
	0 S_0	10 S_1	25 S_2	50 S_3	100 S_4	LSD P=0.05
	Available soil sulphur (mg g^{-1})					
Morgan's Reagent	10.5	14.8	16.0	23.5	25.0	10.4
0.15% $CaCl_2$	5.2	8.0	9.8	11.0	13.6	3.4

Table 3: Effect of S-amendment in alluvial soil on biochemical constituents in pea (*Pisum sativum* L.)

Growth and yield responses	S amendment in soil (mg Kg^{-1})					LSD P=0.05
	0 S0	10 S1	25 S2	50 S3	100 S4	
Shoot length (cm)	28.25	29.50	31.40	35.85	29.50	5.30
Dry weight plant^{-1} (g)	0.58	0.62	0.68	0.78	0.52	0.12
Pods plant^{-1}	2.0	4.0	5.0	5.0	2.0	1.0
Pod length (cm)	4.27	5.05	5.80	6.85	5.40	1.18
Weight seed^{-1} (g)	0.23	0.30	0.32	0.41	0.30	0.19

Table 4: Effect of S amendment in alluvial soil on growth and reproductive yield of pea (*Pisum sativum* L.)

Biomolecules	S amendment in soil (mg Kg^{-1})					LSD P=0.05
	0 S0	10 S1	25 S2	50 S3	100 S4	
Chlorophyll a (mg g^{-1} f.w.)	1.17	1.75	2.10	2.67	1.54	0.40
b	0.28	0.34	0.42	0.49	0.37	0.06
Total	1.25	1.74	1.92	2.50	2.05	0.56
Carotenoids (mg g^{-1} f.w.)	0.95	1.09	1.24	1.12	1.10	0.13
Total sugar (mg g^{-1} f.w.)	260	27.50	310.60	340.00	325.80	41.86

Total sugar was determined following the method of Dubois *et al.* (1956). Growth (shoot length, dry weight yield) and reproductive yield (Pod numbers, Pod length and seed weight) was observed after harvesting the plant at maturity (16 week after treatment). Pigments were estimated by the method of Lichtenthaler and Welburn (1983). All the data were statistically analyzed (Panse and Suklatme, 1961) for L.S.D. value and tested for significance at P= 0.05.

RESULTS AND DISCUSSION

Soil (Gomti upland alluvial soil of Lucknow) used to grow pea was mild calcareous and deficient in available sulphur. Plants grown in soil without S amendment developed visible symptoms of deficiency on terminal leaves as pale green to yellow colour observed at 4 weeks after sowing. The older and middle leaves developed mild purple tints on lamina which later turned deep purple. Severity of deficiency symptoms was less at S_1 level, while not developed at higher S levels in soil (S_2, S_3 and S_4). These symptoms were similar with those reported earlier in mustard (Agarwala *et al.* 1984). Sulphur deficiency greatly reduced number of flowers. Pea plants were raised in the sulphur amended soil (at the rate 25 mg S kg^{-1} soil) showed increased shoot length and dry matter yield by 26.9 and 34.5%, respectively. The increase in growth could be attributed due to the increased level of available S in soil (Pandey *et al.* 2009). Sulphur amended soil increased the pigment contents (chlorophyll a, b and total) upto 50 mg S kg^{-1} amendment in soil. The promotory effects of S amended soil on pigments content might be due to providing available S and other nutrients to the pea involve in synthesis of pigments. At increased level of S in soil (100 mg kg^{-1}) there was slight depression in yield, but no visible toxicity symptoms were produced. Carotenoids content was not found increased, significantly, at all levels of S amendment in alluvial soil. Sugar content was found more stimulatory with S, fertilized in S- deficient alluvial soil. Sugar content increased with increase in S level in soil upto 50mg S kg^{-1} in soil. Further increase in S level (100 mg S kg^{-1} soil) started to slight decrease in sugar content in pea leaves. Increased sugar content in pea leaves could be favoured with increase in growth and chlorophyll contents in pea leaves (Agarwala and Sharma 1979). It has been reported that, S amendment in alluvial soil increases growth of plants (*Grindellia camporum*), because most of the calcareous soil in northern India are deficient in available sulphur. Sulphur increases sugar in mustard plant has been reported (Agarwala *et al*. 1984). Sulphur is an important constituent of acetyl Co- enzyme, which is involved in fatty acid metabolism. The promotory effect of S on increased sugar content might be due to the involvement of certain sulphur containing amino acids which may be involved in synthesis mechanism of sugar (Marschner 1988). The S amendment was not increased the carotenoids content in pea leaves resulted that, S has no effect on synthesis of carotenoids content. The pigment, carotenoids play an important role in stress conditions against production of reactive oxygen species (ROS) in plant cells. Sulphur considerd as a macro essential element in the plants, thus it could not create the stress conditions in the soil up to 100 mg S kg^{-1} amendment. Sulphur amendment in alluvial soil, also increased the reproductive yield of pea at 50 mg S kg^{-1} soil. Maximum pod length, pod number and seed weight was observed in pea grown in the soil amended with sulphur at the rate 50 mg S kg^{-1} soil. The increase in reproductive yield could be attributed due to the more availability of essential elements facilitated by S in soil (Sharma *et al*. 1985).

Available soil S was increased with increase in quantity of S-fertilizer ($CaSO_4.2H_2O$) amended in soil (Table 2). The trend was similar in 0.15% $CaCl_2$ and Morgan's reagent extractants. Interactive effects of soil factors provide available nutrient ions into the soil solution. Sulphur application in the anionic form (SO_4^{-2}) is generally not fixed in soil (Kardos 1964). Maximum improvement in vegetative and reproductive yield was observed at S_3 level (50 mg S kg^{-1} soil) where, the available S in soil was 23.5 and 11 mg kg^{-1} soil with Morgan's reagent and 0.15% $CaCl_2$ extractants, respectively. Further increase in available S showed declining rate of growth and reproductive yield in pea. Soil amended with 100 mg S kg^{-1} soil decreased growth, yield and biochemical responses in pea. Therefore, study concluded that, S fertilization in S- deficient an alluvial soil of northern India increases growth and reproductive yield in pea plants. S-amended soil at the rate 50 mg S kg^{-1} increases pigment (chlorophyll a, b and total) and sugar contents. The application of sulphur in such mild calcareous alluvial soil may improve the growth and yield of other crops.

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