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SOIL SULPHUR STATUS AND RESPONSE OF GARLIC TO SULPHUR IN RELATION TO PHOSPHORUS

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ABSTRACT

One hundred and fifty soil samples collected from Mahamaya Nagar district of Uttar Pradesh were analysed for available S. Available S in these soils ranged from 7.0 to 22.0 mg kg^{-1} with a mean value of 12.3 mg kg^{-1}. About 41% soils were deficient in available S. Available S was significantly and positively correlated with organic carbon. Results of a field experiment revealed that the bulb yield and dry matter of garlic increased significantly with increasing doses of S and P. Significant positive interaction of P and S on bulb yield was noted with the combined application of 80 kg $P_2 O_5$ ha^{-1} and 40 kg S ha^{-1}. The uptake of P increased with increasing doses of P from 4.42 to 6.12 kg ha^{-1} with the addition of 120 kg P_2O_5 ha^{-1}. The uptake of sulphur increased from 5.51 to 8.96 kg ha^{-1} with the addition of 60 kg S ha^{-1}. The interaction between P and S resulted in an addition and beneficial effect on P and S uptake by the garlic crop.

Keywords: Sulphur status, response, garlic, sulphur, phosphorus

INTRODUCTION

Sulphur deficiency has been aggravated in western U.P. soils due to use of high analysis sulphur free fertilizers and continuous removal under intensive cropping of high yielding varieties. Acknowledge of sulphur status in soils helps in keeping a watch on sulphur nutrition of crops. Because of its involvement in vital functions in the plant metabolism, sulphur deficiency would lead to adverse effects on growth and yield in many crops. The responses to P and S are well recognized in a wide variety of crops. But information on garlic in these soils is quite limited and inconclusive. There are evidences of garlic responding to sulphur application (Singh and Singh 2005). Phosphorus, key nutrient for increasing productivity of vegetable crop, is required for plant growth and root development. Phosphorus deficiency in soils is widespread and crops grown under deficient situation show significant responses to fertilizer. A positive interaction between S and P was also observed in alluvial soils. The present study was undertaken with a view to assess the status of sulphur in soils and response of garlic to applied sulphur in relation to P in alluvial soil of Mahamaya Nagar district of western Uttar Pradesh.

MATERIALS AND METHODS

One hundred and fifty samples of soil were collected from garlic fields in Mahamaya Nagar district of U.P. The soil samples were drawn from 0-0.2 m. depth with the help of auger. The soil samples were air dried, pulverized to pass through 2 m.m. sieve and analyzed for some physico chemical properties by following standard methods (Jackson 1973). Available sulphur content extracted with $CaCl_2$ solution (0.15%) was determined by turbidimetric method (Chesnin and Yien 1951). A field experiment on sandy loam soil was conducted at Raja Balwant Singh College Farm Bichpuri Agra, during rabi seasons of 2009-10 with garlic. The soil has pH 7.8, organic carbon 3.5 g kg^{-1}; available N, P, K and S were 170, 8.5, 110 and 16.5 kg ha^{-1}, respectively. Four levels each of phosphorous (0, 40, 80 and 120 kg ha^{-1}) and sulphur (0, 20, 40 and 60 kg ha^{-1}) forming 16 treatment combinations were tested in randomized block design with three replications. Phosphorous in the form of DAP and sulphur through elemental sulphur was supplemented to the plots as per treatment at the time of sowing. The amount of N applied through DAP was adjusted in the amount applied through urea. A uniform dose of 200 kg N ha^{-1} and 100 kg K_2O ha^{-1} was applied through urea and muriate of potash, respectively. At maturity bulb samples were collected and analysed for P and S by vanadomolybadate yellow colour method (Jackson 1973) and turbidimetric method (Chesnin and Yien 1951) in diacid extract of bulbs.

RESULTS AND DISCUSSION

Data on the physic-chemical properties (Table 1) indicate that the soils were alkaline in nature with pH ranging between 7.2 and 9.4. Electrical conductivity varied between 0.12 and 0.57 dSm^{-1}, characteristics of the normal soils. The soils had, in general, low organic carbon content ranging from 2.5 to 5.5 g kg^{-1}. Calcium carbonate content of the soils varied from 5.0 to 35.0 g kg^{-1}. Available sulphur (extracted by 0.15% $CaCl_2$ solution) is used as an index of S availability in many soils, since the variation in this form causes variation in yield and

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uptake of S in crops. The amount of available sulphur in the soils of Mahamayanagar district of Uttar Pradesh ranged between 7.0 and 22.0 mg kg^{-1} with an average of 12.3 mg kg^{-1}. This variation in available S may be attributed to the differences in soil properties, crop, management practices and organic matter. Singh et al. (1995) and Ali (2010) reported similar results in Meerut and Agra soils. It is well known that plant roots absorb sulphur in SO_4^{--}ion from the soil solution. Taking 10 mg kg^{-1} SO_4-S (as extracted by 0.15% $CaCl_2$ solution) as the critical limit (Metha et al., 1988), about 41% soil samples were found to be deficient in available sulphur. Singh et al. (1995) reported that 59% soil samples of Meerut are deficient in sulphur. The content of available S had a significant and positive correlation with organic carbon (r = 0.572**). A significant and positive correlation of available S has also been reported by Sharma et al. (2000). The observed significant positive correlation of SO_4 – S with organic carbon suggests that sulphur supplying power of these soils is largely dependent upon this parameter. It had also significant and positive relationship with $CaCO_3$ (r = 0.45**) as reported by Trapathi et al. (2000). Sulphur-S on the other hand, did not exhibit any significant relationship with pH and EC. These results are in accordance with those of Das et al. (2012).

Table1: Soil characteristics and status of available S in Mahamayanagar district of U.P

Soil Characteristics	Range	Mean	% Deficient
pH	7.2-9.4	-	
EC(dSm^{-1})	0.12-0.57	0.23	
Organic carbon(g kg^{-1})	2.5-5.5	4.1	
$CaCO_3$ (g kg^{-1})	5.0-35.0	16.5	
Available S (mg kg^{-1})	7.0-22.0	12.3	41.0

Bulb yield of garlic increased significantly with increasing levels of both phosphorus and sulphur over control (Table 2). The percent increase in bulb yield due to 80 kg P_2O_5 and sulphur (40 kg S ha^{-1}) application from 17.3 and 16.0%, respectively. The magnitude of response to garlic yield was more in case of phosphorus as compared to sulphur. Further synergistic effect of P and S interaction on bulb yield of garlic was significant at 80 kg P_2O_5 + 40 kg S ha^{-1} followed by 40 Kg P_2O_5 + 20 kg S ha^{-1}. The magnitude of increase in bulb yield was 34.3 % due to combined application of P and S (80 kg P_2O_5 + 40 kg S ha^{-1}) over control. The synergistic effect of P and S may be due to utilization of large quantities of nutrients through well developed bulbs which might have resulted in better plant development and ultimate yield at low initial status of available P and S in the soil. These results confirm the findings of Singh and Singh (2005). Dry matter yield of garlic bulb increased significantly with application of 80 kg P_2O_5 and 40 kg S ha^{-1} individually as well as in combination over control (Table 2). However, the maximum increase of 10.26 q ha^{-1} in dry matter was obtained when 120 Kg P_2O_5 and 60 Kg S ha^{-1} were applied together the increase was 49.7 % over control (6.85q ha^{-1}). The response to applied P with respect to dry matter in garlic bulbs is attributed low status of available P and possibly low P fixing capacity of this alkaline light textured (sandy loam) soil. Similar results were reported by Singh and Singh (2005). Increasing levels of S resulted in a significant increase in dry matter yield of garlic bulbs. The positive response to sulphur is assigned to low status of available S of soil or due to stimulating effect of applied sulphur in the synthesis of chloroplast-protein resulting in greater photosynthetic efficiency, which in turn translated in terms of increase in yield. Singh et al. (1996) and Raina and Jaggi (2008) reported similar results.

Table2: Effect of sulphur and phosphorus on yield and their uptake in garlic

Sulphur (kg ha^{-1})	Phosphorus(kg ha^{-1})				
	0	40	80	120	Mean
Bulb yield (q ha^{-1})					
0	52.75	55.00	59.11	62.5	56.84
20	55.00	58.95	62.00	63.9	59.96
40	58.00	63.45	70.85	71.45	65.94
60	59.15	64.55	71.9	72.88	67.12
Mean	56.22	60.48	65.96	67.18	
CD(P=0.05)	S 2.21	P 2.21	S X P 4.42		
Dry Matter(q ha^{-1})					
0	6.85	7.14	7.78	7.84	7.4
20	7.33	7.96	8.27	8.51	8.02
40	7.94	8.69	9.57	9.79	8.99
60	8.29	9.09	9.29	10.26	9.23
Mean	7.6	8.22	8.73	9.1	
CD(P=0.05)	S 0.38	P 0.38	S X P 0.76		
Sulphur uptake (kg ha^{-1})					
0	4.72	4.99	6.07	6.27	5.51
20	5.64	6.37	6.95	7.23	6.55
40	6.75	7.65	8.9	9.59	8.22
60	7.46	8.54	9.29	10.57	8.96
Mean	6.14	6.89	7.8	8.41	
CD(P=0.05)	S 0.84	P 0.84	S X P 1.68		
Phosphorus uptake(kg ha^{-1})					
0	3.69	3.99	4.67	5.02	4.34
20	4.1	4.62	5.13	5.62	4.87
40	4.76	5.39	6.32	6.66	5.78
60	5.14	5.63	6.32	7.18	6.07
Mean	4.42	4.90	5.61	6.12	
CD(P=0.05)	S 0.74	P 0.74	S X P 1.48		

Increasing levels of P significantly increased the uptake of P by garlic bulbs over control. The response was observed up to the highest level of P addition. The P uptake increased from 4.42 to 6.12 kg ha^{-1} with higher level of P (120 kg ha^{-1}). The increase in P uptake with higher application of P resulted from enhanced supply of P in the plant during early growth stage at which it was utilized in larger quantities. Similar results have been reported by Singh and Singh (2005). Application of S significantly increased the uptake of P by garlic over control. The increase in P uptake by tuber bulbs due to S addition was from 4.34 to 6.07 kg ha^{-1} with 60 kg S ha^{-1} (Table 2). As regards the S uptake by garlic bulb, application of P significantly increased the S uptake from 6.14 to 8.96 kg ha^{-1} with 120 kg P_2O_5 ha^{-1}. Application of S significantly increased its uptake by garlic bulbs from 5.51 to 8.96 kg ha^{-1} with rise in S levels from 0 to 60 kg ha^{-1}. Highest S uptake was found with 60 kg S ha^{-1} (8.96 kg ha^{-1}) and lowest in control (5.51 kg ha^{-1}). The increase in S uptake with 60 kg S ha^{-1} was 62.6 percent. Singh et al. (1995) also reported similar results. The higher uptake of nutrient by application of S and P might be due to increased bulb yield and higher nutrient demand for plant growth. Moreover, the uptake followed the yield pattern, as the yield was higher so was the uptake. Josephine et al. (2005) reported similar results. Interactive effect of P and S was found to be significant. Among the various treatment combinations, application of 120 kg P_2O_5 ha^{-1} along with 60 kg S ha^{-1} resulted in the maximum uptake of P (7.18 kg ha^{-1}). The maximum uptake of S (10.57 kg ha^{-1}) was recorded under the combined application of 60 kg S and 120 kg P_2O_5 ha^{-1}. Results corroborate the findings of Singh and Singh (2005).

Foregoing results revealed that 41 percent soil samples of Mahamaya Nagar district of Uttar Pradesh are deficient in available S. The yield of garlic can be increased by addition of sulphur in combination with phosphorus.

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