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Response of garlic (*Allium sativum* L.) to phosphorous and sulphur application in acid alfisol of Meghalaya

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Abstract

In a field experiment with three levels of P (0, 50 and 100 kg P_2O_5 ha^{-1}) and four levels of S (0, 10, 15 and 20 kg S ha^{-1}) on a P and S deficient *Typic Hapludalf* of Meghalaya, the bulb and straw yield, nutrient uptake and protein content of garlic increased significantly with increasing levels of P and S application. The available P and S content in post harvest soil increased significantly with P and S application. The interaction effects of P and S were significant for bulb yield, N, P and S uptake and available P and S in post harvest soil and their highest values were recorded with P_{100} S_{20} treatment combination. P use efficiency increased with S levels and was higher at P_{50} as compared to P_{100} level. S use efficiency increased with increasing levels of P and S. Maximum P and S use efficiency were recorded with $P_{50}S_{20}$ and $P_{100}S_{20}$ treatment combinations, respectively.

Key words: acid soils, *Allium sativum*, phosphorus, sulphur

The availability of phosphorus and sulphur in soil and their uptake by plants are fairly proportionate and application of these nutrients together affects the availability of each other and thereby growth and yield of crops (Shinde *et al.* 1979). Bulb crops respond well to P and S application (Rohal & Kalra 1986; Singh *et al.* 1995). Garlic as a spice crop is becoming popular in Meghalaya. The soils of the state are highly acidic and low in available P and S contents (Prasad 1981). The information regarding P and S nutrition to garlic in the acid soils of north eastern hill region is lacking. Hence the present field experiment was conducted during *rabi* (winter) seasons of 1999 and 2000 at ICAR Research Complex for NEH Region, Umiam, Meghalaya (25° 41/N, 91° 63/E) to study the effect of P and S levels on yield, nutrient uptake, P and S use efficiency and build up of P and S in the soil. The experimental soil was *Typic Hapludalf* with sandy loam texture having pH 5.3, organic carbon 1.7 % and available N, P, K and S as 375, 10.8, 250 and 12.5 kg ha^{-1}, respectively. Three levels of P (0, 50 and 100 kg P_2O_5 ha^{-1} through diammonium phosphate) and 4 levels of S (0, 10, 15 and 20 kg S ha^{-1} through elemental sulphur) in 12 treatment combinations were applied and replicated thrice in factorial randomized block design. A common basal dose of 100 kg N as urea and 100 kg K_2O as muriate of potash and farmyard manure 10 t ha^{-1} was applied to all the plots. Lime @ 2 t ha^{-1} was also applied uniformly 15 days before planting the cloves during first year of the experiment. Half

dose of N was applied as basal and the remaining half was top dressed in two equal splits at 30 and 60 days after planting. Elemental sulphur was applied 15 days before planting so that the S could be oxidised to sulphate form. A local cultivar of garlic was planted (second week of September) with a spacing of 50 cm x 20 cm in plots of 6 m^2 size and harvested during second week of May. The bulb and straw samples collected at harvest were analysed for total N, P, K and S by micro-Kjeldahl, vanado-molybdate yellow colour, flame photometric and turbidimetric methods, respectively (Tandon 1993). Protein content in bulb was calculated by multiplying N content in bulbs with the factor 6.25. Available P and S in post harvest were extracted by Bray P1 extractant and 0.15 per cent $CaCl_2$, respectively and analysed following standard procedures (Page *et al.* 1982). Phosphorus Use Efficiency (PUE) and Sulphur Use Efficiency (SUE) were calculated as follows:

$$\text{PUE or SUE} = \frac{(\text{P or S uptake in treated plots} - \text{P or S uptake in control plots})}{\text{Fertilizer P or S applied}} \times 100$$

Yield and protein content

Increasing levels of phosphorus and sulphur significantly increased the bulb and straw yield of garlic (Table 1). This result confirms the findings of Singh *et al.* (1995) and Rohal & Kalra (1986). The interaction effect of P and S was significant for bulb yield and all the levels of S increased the bulb yield at every dose of applied P except that the effect of S_{10} and S_{15} was at par at zero level of P application. This increase in bulb yield might be due to increase in uptake of nutrients with the combined application of P and S, which favoured the better nutrition of garlic for optimum growth and development. The maximum bulb yield (64 q ha^{-1}) was recorded with a combination of 100 kg P_2O_5 and 20 kg S ha^{-1} which was 35.6% higher than control (P_0S_0). The protein content of bulbs increased significantly with increasing P and S levels. An increase of 31.6% and 17.2% in protein content of bulb were recorded due to application of 20 kg S and 100 kg P_2O_5 ha^{-1}, respectively.

Nutrient uptake

Application of P and S significantly increased the P uptake by garlic bulb (Table 2) which might be due to increase in soil available P and its higher absorption by bulbs. Similar increase in P uptake by applied P was also reported by Verma *et al.* (1996). The interaction between P and S was positive for P uptake. P and S are absorbed as anions by plants, so if any one of them is available in higher amount, the available pool for other will also increase (Joshi & Seth 1975). The P uptake at P_0 with increasing levels of S was non significant, but at both P_{50} and P_{1000} all the S levels had significant positive response on P uptake. There was significant increase in P uptake at each S level with increasing levels of P from 0 to 100 kg P_2O_5 ha^{-1}.

Sulphur uptake increased significantly at all the levels of S application (Table 2), which might be the result of rapid absorption and translocation of it by the plant with adequate supply of S to the soil in combination with increase in bulb yield. Similar result has also been reported by Singh *et al.* (1995). S uptake by bulb also increased significantly by all the levels of applied P. The significant increase in S uptake by P application could be due to higher S absorption as a result of greater root proliferation and increase in the activity of S oxidizing bacteria (Singh *et al.* 1986). A significant interaction was found between P and S levels for S uptake. Sulphur uptake increased significantly by increasing S levels at zero level of P application but the differential response of S levels was non significant. However, at 50 and 100 kg P_2O_5 ha^{-1}, the response of all the S levels was significant over each other. Maximum S uptake (57.6 kg ha^{-1}) was recorded when 20 kg S was applied along with 100 kg P_2O_5 ha^{-1}.

The N and K uptake of garlic bulb increased significantly with P and S application, which was apparently the result of favourable effect of P and S on N and K absorption coupled with higher bulb production. The interaction between P and S was significant for N while it was non significant for K uptake and the maximum values of these parameters were recorded with a treatment combination of 100 kg P_2O_5 +

20 kg S ha^{-1}. A significant positive correlation between bulb yield and P uptake (0.99**) and S uptake (0.97**) indicated that application of both S and P is advantageous in this soil to get optimum yield of the garlic crop.

Phosphorus and Sulphur Use Efficiency

PUE was higher at P_{50} level as compared to P_{100} (Table 1). This might be due to the fact that plants being grown in soil, exhibited greater capacity for nutrient absorption at lower doses of P (Dubey 2000). However, there was an increase in PUE by S levels at each P level. Maximum PUE (61%) was recorded in the treatment combination of $P_{50}S_{20}$. PUE increased with S levels at both levels of P indicating synergism between P and S. SUE (Table 1) of garlic increased linearly with increasing levels of both P and S. SUE was very low at zero level of P application but increased to more than double at 100 kg P_2O_5 ha^{-1}. The highest value of SUE (121%) was recorded at $P_{100}S_{20}$ treatment combination.

Table 1. Effect of P and S on bulb and straw yield, P and S use efficiency and protein content of garlic; P and S on nutrient uptake by garlic bulb; P and S on available P and S in post harvest soil

	S_0	S_{10}	S_{15}	S_{20}	Mean
Dried bulb yield (q ha^{-1})					
P_0	43.20	46.20	47.50	49.80	46.70
P_{50}	47.40	50.30	52.90	62.00	53.10
P_{100}	52.00	54.30	57.90	64.00	57.00
Mean	47.50	50.20	52.70	58.60	
C.D. at 5%	P = 0.85 S = 0.98			PxS =1.70	
Dried straw yield (q ha^{-1})					
P_0	1.30	1.60	2.20	2.70	1.90
P_5	1.60	2.50	3.00	3.50	2.60
P_{100}	2.00	3.00	3.50	4.00	3.10
Mean	1.60	2.30	2.90	3.40	
C.D. at 5%	P = 0.26 S = 0.30			PxS = NS	
Protein content (%) in bulb					
P_0	5.60	6.10	6.60	7.30	6.40
P_{50}	5.95	6.90	7.30	8.10	7.05
P_{100}	6.45	7.30	7.90	8.40	7.50
Mean	6.00	6.75	7.25	7.90	
C.D. at 5%	P = 0.32 S = 0.37			PxS = NS	
P use efficiency (%)					
P_0	-	-	-	-	-
P_{50}	23.20	26.85	33.72	61.00	36.20
P_{100}	23.87	26.50	31.10	40.20	30.40
Mean	23.50	26.70	32.40	50.50	
S use efficiency (%)					
P_0	-	33.00	40.30	46.75	40.00
P_{50}	-	45.00	59.80	97.00	67.20
P_{100}	-	56.00	85.00	121.00	87.30
Mean	-	44.60	61.70	88.20	
N uptake (kg ha^{-1})					
P_0	38.80	45.25	50.35	58.30	48.20
P_{50}	45.00	55.30	61.90	80.60	60.70
P_{100}	55.60	63.50	73.00	85.70	69.45
Mean	46.45	54.70	61.75	74.85	
C.D.at5%	P = 2.60 S = 3.00			P x S = 5.30	

	S_0	S_{10}	S_{15}	S_{20}	Mean
P uptake (kg ha^{-1})					
P_0	20.80	23.10	25.15	27.90	24.25
P_{50}	25.60	28.70	32.25	40.90	31.85
P_{100}	30.70	34.20	38.20	44.80	37.00
Mean	25.70	28.70	31.90	37.90	
C.D.at5%	P = 1.50	S = 1.70	P x S = 3.00		
K uptake (kg ha^{-1})					
P_0	34.50	46.20	49.80	54.80	46.30
P_{50}	42.70	53.30	58.10	73.10	56.80
P_{100}	49.40	61.90	69.50	80.00	65.20
Mean	42.20	53.80	59.10	69.30	
C.D.at5%	P = 4.90	S = 5.65	P x S = NS		
S uptake (kg ha^{-1})					
P_0	25.95	29.10	31.85	34.90	30.45
P_{50}	29.40	33.70	38.10	48.40	37.40
P_{100}	33.80	39.10	46.30	57.60	44.20
Mean	29.70	33.95	38.75	46.95	
C.D.at5%	P = 2.00	S = 2.35	P x S = 4.10		
Available P (kg ha^{-1})					
P_0	8.90	9.50	10.90	12.00	10.30
P_{50}	10.10	12.50	13.80	16.50	13.20
P_{100}	13.60	15.20	16.70	18.60	16.00
Mean	10.80	12.40	13.80	15.30	
C.D.at5%	P = 0.54	S = 0.63	P x S = 1.10		
Available S (kg ha^{-1})					
P_0	10.00	11.20	12.50	14.00	11.90
P_{50}	11.40	12.70	14.20	16.00	13.60
P_{100}	12.50	14.50	17.00	18.80	15.50
Mean	11.30	12.80	14.00	16.30	
C.D.at5%	P = 0.54	S = 0.63	P x S = 1.10		

Soil nutrient status

The available phosphorus and sulphur in post harvest soil increased significantly with their respective application (Table 3). The available S content increased with P application and vice versa suggesting synergism between S and P. Similar result in acid soil has been reported by Majumdar & Venkatesh (2001). The interaction between P and S was significant and maximum values of available P (18.6 kg ha^{-1}) and S (18.8 kg ha^{-1}) were recorded at $P_{100}S_{20}$ treatment combination.

Thus, it can be inferred from the above study that both P and S levels showed synergistic effect for garlic bulb yield and the nutrient uptake. Application of 100 kg P_2O_5 with 20 kg S ha^{-1} is the optimum dose for higher production of garlic in acid Alfisol of Meghalaya.

References

Dubey S K 2000 Effectiveness of rock phosphate and superphosphate amended with phosphate solubilizing microorganisms in soybean grown on vertisols. J. Indian Soc. Soil Sci. 48 : 71-75.

Joshi D C & Seth S P 1975 Effect of sulphur and phosphorus application on soil characteristics, nutrient uptake and yield of wheat crop. J. Indian Soc. Soil Sci. 23 : 217-221.

Majumdar B & Venkatesh M S 2001 Influence of phosphorus and sulphur on residual nutrient availability and dry matter yield of soybean in acid Alfisol of Meghalaya. Indian J. Hill Farming 14 : 33-38.

Page A L, Miller R H & Keeney D R 1982 Methods of Soil Analysis, Part II. American Society of Agronomy Inc. and Soil Science Society of America Inc. Madison, Wisconsin, USA.

Prasad R N 1981 Soil science research in NEH region. In: Singh G B (Ed.) Proceedings of Workshop on Agricultural Research in NEH Region, (pp 89-101), ICAR Research Complex for NEH Region, Shillong, Meghalaya.

Rohal S V & Kalra G S 1986 Effect of different levels of nitrogen, phosphorus and sulphur on dry weight of leaves, bulb diameter and pungency (volatile sulphur) of onion bulbs. Indian J. Agric. Res. 20 : 47-50.

Shinde D A, Soni B K, Jha M N & Sinha S B 1979 Response of soybean to phosphorus and sulphur in black soil. Bull. Indian Soc. Soil Sci. 12 : 498-504.

Singh Vinay, Mehta M S & Singh Bani 1986 Individual and interaction effect of sulphur, phosphorus and molybdenum in mustard. J. Indian Soc. Soil Sci. 39: 535-538.

Singh Vinay, Singh Aneg & Mehta V S 1995 Effect of S sources and levels on yield and uptake of nutrients by garlic. Fert. News. 40 : 47-49.

Tandon H L S 1993 Methods of Analysis of Soil, Plant, Water and Fertilizers. Fertilizer Development and Consultation Organization, New Delhi.

Verma D P, Sharma B R, Chadha A P S, Bajpai H K & Bhaduria U P S 1996 Response of garlic to nitrogen, phosphorus and potassium levels. Advances in Plant Sciences 9 : 37-41.