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Major nutrient contents and their uptake by brinjal as influenced by phosphorus and sulphur

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Abstract

A pot experiment was conducted in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh to evaluate the influence of phosphorus (P) and sulphur (S) on major nutrient contents and their uptake by brinjal (cv. BARI brinjal-8) during the period from October, 2011 to May, 2012. The experiment was laid out in a completely randomized design with 12 treatments and 3 replications using four levels of P (0, 30, 60 and 90 kg P ha^{-1}) and three levels of S (0, 15 and 30 kg S ha^{-1}) along with the basal doses of urea, muriate of potash, boric acid, zinc oxide, cowdung and poultry manure. The study revealed that major nutrient contents and their uptake were significantly influenced by P and S interactions. They had positive significant effects on major nutrient contents and their uptake. Application of P increased N, P, K, Ca, Mg and S contents and their uptake upto 60 kg ha^{-1} and over the dose the values were reduced or near to control treatment. Similarly, the gradual increases of major nutrient contents and their uptake were found in S application upto 30 kg ha^{-1}. Among the treatments the combination of P @ 60 kg ha^{-1} and S @ 30 kg ha^{-1} showed the highest N, P, K, S, Ca and Mg contents and their uptake. The lowest values were found in control treatment. Results showed that an appropriate interaction of P and S increased major nutrient contents of brinjal.

Keywords: Phosphorus, Sulphur, Brinjal, Interaction, Major nutrient contents and their uptake

Introduction

Fertilizers supply one or more essential plant nutrients which are essential for the growth, yield and quality of crops. Among the essential plant nutrients P and S play a vital role on nutrient contents and uptakes of vegetable crops. As a popular and widely grown vegetable crop, brinjal *(Solanum melongena L.)* is grown extensively round the year in Bangladesh and ranks third in terms of consumption. Fruits of brinjal contain 92.7% water, 1.4% protein, 0.3% fat, 1.3% fibre and 4.0% carbohydrate, appreciable amount of Ca, Mg, P, S, K, Na, Fe, source of vitamin A and B but poor in vitamin C (Bose and Som, 1986). Generally, solanaceous vegetables require large quantities of major nutrients like N, P and K. In addition, some secondary nutrients such as Ca and S are largely required for better growth, fruit and seed yield. Among the plant nutrients P and S have a great influence on the nutrient contents and uptake by brinjal.

The most obvious effect of P is on the plant root system; it promotes root formation and the formation of lateral fibrous and healthy roots (Parihar and Tripathi, 2003). It was obtained that P is required for the formation of phosphides, nucleoproteins, nucleic acids, adenosine diphosphates, carbohydrates synthesis and nutrient contents like Ca, Mg, N, K and S (Badiger *et al.,* 2006). As an essential plant nutrient, S improves the yield and quality parameters of important vegetable crops. S is a constituent of secondary compounds *viz*., allin, cycloallin and thiopropanol which not only influence the taste, pungency and medicinal properties of vegetable crops but also induce resistance against pests and diseases (Tabatabai, 2001). But single and imbalanced application of P and S as fertilizers increases production cost and hampers the fruit quality of brinjal. As a result, a positive interaction is required between P and S for the better fruit quality of brinjal. To consider this matter, an experiment was conducted by interacting different levels of P and S to evaluate the effect of P and S on major nutrient contents and their uptake by brinjal.

Materials and Methods

The pot experiment was carried out in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during the period from October, 2011 to May, 2012. Soil sample was collected from Genetics and Plant Breeding field laboratory after harvesting of crop at fallow condition. The soil was silt loam in texture having pH 6.08 with 0.71% OC, 0.10% N, 12.60 µg g^{-1} available P, 10.90 µg g^{-1} available S and 0.14 cmol kg^{-1} exchangeable K. As a test vegetable crop, seeds of brinjal cv. BARI brinjal-8 were collected from BARI, Gazipur. There were 12 treatment combinations with four levels of P (0, 30, 60 and 90 kg P ha^{-1}) and three levels of S (0, 15 and 30 kg S ha^{-1}). The experiment was laid out in completely randomized design with three replications. Recommended doses of urea, MoP, boric acid, zinc oxide, cowdung and poultry manure were mixed thoroughly with soil according to the

fertilizer recommendation guide (BARC, 1997). Cowdung and poultry manure were mixed with soils 7 days before pot preparation and the other recommended fertilizers were given to the soil before transplanting the brinjal seedling. Urea was applied in 3 split applications. The pots were filled with 10 kg soil. Seeds were sown in separate pot and then, seedlings were transplanted when they were 30 days age. All necessary intercultural operations were performed as and when necessary throughout the growing period of brinjal. Irrigation was given everyday upto 45 DAT and then every alternate day upto the harvest. The brinal fruits were collected in the laboratory and N, P, K, S, Ca and Mg contents of brinjal fruits were determined by semi-micro kjeldahl method (Jackson, 1973 and Page *et al.*, 1982), spectrophotometric method (Page *et al*., 1982), flame emission spectrophotometric method (Ghosh *et al.*, 1983), complexometric method of titration using Na_2-EDTA (Page *et al*., 1982) and turbidimetrically (Tandon, 1995) respectively. The nutrients uptake by brinjal were calculated by using yield data that was represented by Hasan *et al.* (2013). Analysis of variance was done with the help of computer package program MSTAT-C according to Gomez and Gomez (1984) and the mean differences among different treatments were adjudged by DMRT test at 5% level of probability.

Results and Discussion

Nutrient contents in brinjal

Nitrogen content: Phosphorus had significant effect on N content of brinjal. The highest content 1.10% was observed from the treatment of 60 kg P ha^{-1} (Table 1) and the lowest content (0.79%) was found in the control treatment. The above findings were similar to those of Dass and Mishra (2002) who reported that N content in fruit was increased with the increasing rate of P application and P @ 60 kg ha^{-1} produced maximum N content in chilli. The content of N in brinjal fruits was statistically influenced due to S application. The maximum content (0.97%) was observed from treatment of 30 kg S ha^{-1} (Table 2) and the minimum content (0.86%) was found in the control treatment. The above findings are similar to those of Sivakumaran (2005) who reported that S application increased N content in coriander fruit. It appears from the results due to the application of increased level of S up to 40 kg ha^{-1}. This result might be due to a synergistic effect between S and N. The interaction effects of P and S on N content was statistically significant. The highest content (1.27%) was observed from the treatment of $P_{60}S_{30}$ and the lowest content (0.62%) was found in the control treatment (Table 3). This finding was similar to those of Hariyappa (2006) and reported that N content increased in $P_{60}S_{30}$ level in onion.

Phosphorus content: The experimental results showed that P content of brinjal was statistically affected by the application of P. The maximum content (0.53%) was observed from 60 kg P ha^{-1} and the lowest content (0.39%) was found in control (Table 1). The above findings were similar to those of Balasubramanian *et al.* (2005) who reported that P content increased significantly with P application but above 70 kg P ha^{-1} application, P content was reduced. The content of P in brinjal fruit was significantly influenced by S. The highest P content (0.51%) was found from 30 kg S ha^{-1} and the lowest content (0.44%) was observed from control (Table 2). The above findings were similar to those of Sivakumaran (2005) and reported that P content in coriander increased with increased level of applied S. The interaction effects of P and S on P content was significant. The highest P content (0.67%) was found from P_{60} x S_{30} kg ha^{-1} and the lowest content (0.34%) was observed from control (Table 3). It was occurred due to the synergistic effect of the combination of P and S and availability of P in soil.

Potassium content: Application of P had significant effect on K content of brinjal fruit. The highest content (0.46%) was found from 60 kg P ha^{-1} and the lowest content (0.22%) was recorded from control (Table 1). The above findings were similar to those of Kadu *el al.* (2005) and reported that K percentage in grain of rice was the highest with N, P and K application. Sulphur fertilization had significant effect on K content of brinjal fruit. The maximum K content (0.38%) was found from the treatment of 30 kg S ha^{-1} and the minimum (0.28%) content was observed from control (Table 2). The above findings were similar to those of Satter and Ahmed (2008), who reported that K content in wheat grain was increased significantly with the application of 30 to 45 kg S ha^{-1}. The interaction effects of P and S on K content was also significant. The maximum content (0.59%) was observed from the treatment of P_{60} x S_{30} kg ha^{-1} and the minimum from control (Table 3). It might be occurred due to the synergistic effect of the combination of P and S that influenced the K content in brinjal.

Table 1. Effect of P on fruit nutrient contents and their uptake by brinjal cv. BARI brinjal-8

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur		Calcium		Magnesium	
	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})
P_0	0.79c	385c	0.39b	187b	0.22c	112c	0.10d	52c	0.39c	192c	0.28d	138c
P_{30}	0.96ab	458b	0.50a	309a	0.34b	211b	0.18c	112b	0.50b	309b	0.36c	224b
P_{60}	1.10a	659a	0.53a	372a	0.46a	317a	0.34a	234a	0.61a	419a	0.51a	354a
P_{90}	0.84bc	397bc	0.49a	221b	0.29bc	130c	0.24b	109b	0.52b	239bc	0.42b	190bc
SE±	0.094	0.042	0.047	0.021	0.055	0.021	0.050	0.017	0.045	0.021	0.049	0.020
CV (%)	8.04	11.41	6.87	17.99	9.27	19.02	6.87	25.38	6.05	11.21	8.92	11.11

N.B.: Means following by the same letter in a column are not significantly different at 5% level by DMRT.
CV=Coefficient of variation

Sulphur content: Phosphorus had significant effect on S content of brinjal fruit. The highest content (0.34%) was observed from 60 kg P ha^{-1} and the lowest content (0.10%) was found from control (Table 1). Nanadal *et al.* (2008) tried four levels of P such as 0, 30, 60 and 120 kg P ha^{-1} in tomato and reported that the superior amount of S was obtained with application of 60 kg ha^{-1}. Application of S had a significant effect on S content of brinjal fruit. The maximum S content (0.25%) was found from the treatment of 30 kg S ha^{-1} and the minimum (0.18%) content was observed from control (Table 2). Thakre *et al.* (2005) observed that the increased levels of S significantly increased the ash, ascorbic acid, S and protein contents in brinjal fruit. The values of these parameters were maximum with the application of 40 kg S ha^{-1} in the form of gypsum. The content of S in brinjal fruit was significantly influenced by the interaction effect of P and S. The highest content (0.44%) was observed from the treatment of P_{60} x S_{30} kg ha^{-1} and the lowest from control (Table 3).

Table 2. Effect of S on fruit nutrient contents and their uptake by brinjal cv. BARI brinjal-8

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur		Calcium		Magnesium	
	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})
S_0	0.86b	416b	0.44b	213b	0.28b	138b	0.18c	91b	0.48b	231b	0.37b	182b
S_{15}	0.92ab	556ab	0.48ab	283ab	0.32ab	190ab	0.21b	127b	0.50a	301ab	0.39ab	234ab
S_{30}	0.97a	625a	0.51a	322a	0.38a	250a	0.25a	161a	0.53a	335a	0.42a	263a
SE±	0.109	0.048	0.054	0.025	0.063	0.024	0.058	0.019	0.052	0.025	0.057	0.023
CV (%)	8.04	11.41	6.87	17.99	9.27	19.02	6.87	25.38	6.05	11.21	8.92	11.11

N.B.: Means following by the same letter in a column are not significantly different at 5% level by DMRT.
CV=Coefficient of variation

Table 3. Interaction effects of P and S on fruit nutrient contents and their uptake by brinjal cv. BARI brinjal-8

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur		Calcium		Magnesium	
	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})
P_0S_0	0.62g	213e	0.34e	117d	0.12f	39f	0.06g	21e	0.31e	107g	0.21f	70g
P_0S_{15}	0.85def	463cd	0.40de	218c	0.27e	146de	0.12f	65de	0.43d	234def	0.32e	174ef
P_0S_{30}	0.90cde	491cd	0.42cde	229c	0.28e	151de	0.13f	70de	0.44d	237def	0.31e	169ef
$P_{30}S_0$	0.77efg	439cd	0.49bc	276bc	0.32cde	179de	0.17ef	96cd	0.48cd	270de	0.36de	203de
$P_{30}S_{15}$	1.09b	658b	0.55b	330b	0.34bcd	205cd	0.19de	114cd	0.50c	304cd	0.35de	211cde
$P_{30}S_{30}$	1.01bc	702b	0.47bc	325b	0.36bc	250bc	0.18de	112cd	0.51bc	354c	0.37de	255c
$P_{60}S_0$	1.05b	541c	0.45bcd	231c	0.39b	258cd	0.27bc	138c	0.57b	291de	0.46bc	237cd
$P_{60}S_{15}$	0.98bcd	707b	0.47bc	338b	0.38b	270b	0.29b	208b	0.57b	411b	0.48b	346b
$P_{60}S_{30}$	1.27a	1030a	0.67a	543a	0.59a	478a	0.44a	356a	0.68a	551a	0.59a	478a
$P_{90}S_0$	1.01bc	476cd	0.49bc	231c	0.28e	130e	0.23cd	117cd	0.54bc	255ef	0.46bc	216cde
$P_{90}S_{15}$	0.78efg	395d	0.49bc	247bc	0.28e	140de	0.25bc	125cd	0.51bc	257ef	0.41cd	205de
$P_{90}S_{30}$	0.72fg	283e	0.48bc	187cd	0.30de	117e	0.25bc	96cd	0.52bc	203f	0.39d	148f
SE±	0.054	0.024	0.027	0.012	0.032	0.012	0.029	0.010	0.026	0.012	0.028	0.011
CV (%)	8.04	11.41	6.87	17.99	9.27	19.02	6.87	25.38	6.05	11.21	8.92	11.11

N.B.: Means following by the same letter in a column are not significantly different at 5% level by DMRT.
CV= Coefficient of variation

Calcium content: All the treatments of P had significant effect on Ca content of brinjal fruit. The highest content (0.61%) was found from 60 kg P ha^{-1} and the lowest content (0.39%) was observed from control (Table 1). Rachappa (2004) found higher Ca content in carrot with the application of P @ 60 kg ha^{-1} application. The content of Ca in brinjal fruit was significantly influenced by S fertilization. The maximum

Ca content (0.53%) was found from the treatment of 30 kg S ha^{-1} and the minimum (0.48%) content was observed from control (Table 2). It was similar to the result of Singh *et al.* (2007) who concluded that application of 30 kg S ha^{-1} as gypsum recorded significantly higher Ca content in potato. The interaction effects of P and S on Ca content was significant. The highest content (0.68%) was observed from the treatment of P_{60} x S_{30} kg ha^{-1} and the lowest from control (Table 3). It might be due to the synergistic effect of the combination of P and S with Ca.

Magnesium content: Phosphorus had significant effect on Mg content of brinjal fruit. The highest content (0.51%) was recorded from 60 kg P ha^{-1} and the lowest content (0.28%) was found from control (Table 1). Similar type of result was reported by Ananthi *et al.* (2004) in chilli. The effect of S on Mg content of brinjal fruit was statistically significant. The maximum Mg content (0.42%) was found from the treatment of 30 kg S ha^{-1} and the minimum (0.37%) content was observed from control (Table 2). Gangadhar (2009) noticed that significantly higher essential Mg content and yield were found in the treatment receiving 30 kg S ha^{-1} fertilizer levels over control in cauliflower. Mg content of brinjal fruit was significantly influenced by the interaction of P and S fertilizer. The highest Mg content (0.59%) was found from P_{60} x S_{30} kg ha^{-1} and the lowest content (0.21%) was observed from control (Table 3). It might be occurred due to the synergistic effect of the combination of P and S on Mg.

Nutrient uptake by brinjal

Nitrogen uptake: Significant differences in the uptake of N were obtained due to various P levels. A significantly higher N uptake was recorded in P_{60} level (659 mg pot^{-1}) over P_{30} (458 mg pot^{-1}), P_{90} (397 mg pot^{-1}) and control (385 mg pot^{-1}). The concentration of N in fruit portion of vegetable crops was significantly influenced by the application of different levels of P. This result was similar to the result of Dass and Mishra (2002) that application of P @ 60 kg ha^{-1} produced maximum N uptake by chilli fruit. Different levels of S significantly influenced the N uptake. The highest N uptake of 625 mg pot^{-1} was obtained in S_{30} level (30 kg S ha^{-1}), which was significantly higher than other treatments and the lowest N uptake (416 mg pot^{-1}) was observed in control. A significantly higher concentration of N in fruit portion was recorded at 30 kg S ha^{-1}. This might be due to synergistic effect of S on N. Sivakumaran (2005) reported that S application significantly influenced the uptake of N. The maximum uptake of N was recorded at S_{30} level in crops. The interaction effects of P and S levels were significant. The maximum and minimum nitrogen uptakes were recorded in $P_{60}S_{30}$ (1030 mg pot^{-1}) and P_0S_0 (213 mg pot^{-1}), respectively. Similar result was reported by Singh and Rathore (2004) in linseed crop.

Phosphorus uptake: Application of P significantly increased the P uptake of brinjal. The treatment P_{60} level (60 kg P ha^{-1}) recorded significantly higher uptake of P (372 mg pot^{-1}), which was significantly higher than other treatments *viz.,* P_{30} (309 mg pot^{-1}), P_{90} (221 mg pot^{-1}) and P_0 (187 mg pot^{-1}). Application of P fertilizer increased particularly P content in fruit portion. This might be due to higher availability and uptake of P by the crop. Similar observations were made by Balasubramanian *et al.* (2005) in mustard crop. The application of different levels of S significantly influenced P uptake. Treatment S_{30} recorded significantly the higher uptake of P (322 mg pot^{-1}) compared to other treatments (S_{15} = 283 mg pot^{-1} and S_0 = 213 mg pot^{-1}). A significantly higher P content was observed with the application of S @ 30 kg ha^{-1}. This might be due to synergistic effect of S on P. Suresh (2008) reported similar result in lady's finger. The interaction effects of P and S was statistically significant. The highest and lowest P uptakes were found in $P_{60}S_{30}$ (543 mg pot^{-1}) and P_0S_0 (117 mg pot^{-1}), respectively. Application of P and S enhanced the uptake of P in plant. Thakre *et al.* (2005) observed similar findings in brinjal.

Potassium uptake: Uptake of K significantly influenced due to the application of different P levels. Uptake of K (317 mg pot^{-1}) was obtained with application of P @ 60 kg ha^{-1}, which was significantly higher than other treatments. The lowest uptake of K was obtained in control (112 mg pot^{-1}). This might be due to synergistic effect of P, which enhanced the uptake of K nutrient by the crop. These results were in agreement with the findings of Kadu *et al.* (2005) in rice. Sulphur fertilization had significant influence on K uptake. The values of 250 mg K pot^{-1} and 138 mg K pot^{-1} were recorded in S_{30} level and control, respectively. This might be due to synergistic effect of S on K. Gangadhar (2004) reported that different levels of S influenced the composition and uptake of K in lentil and maximum was recorded at 30-40 kg S ha^{-1} application. The combined application of $P_{60}S_{30}$ (60 kg P ha^{-1} x 30 kg S ha^{-1}) recorded the maximum K uptake (478 mg pot^{-1}) and the minimum (39 mg pot^{-1}) was in control. Interaction effect of P and S levels was significant. Similar beneficial effects of phosphorus and sulphur interaction @ 60 kg P ha^{-1} x 30 kg S ha^{-1} on K uptake in black gram was observed (Dwived *el al.,* 2007).

Sulphur uptake: Stepwise increase in P application resulted in significant influence on the uptake of S by fruit portion. The application of 60 kg P ha^{-1} recorded significantly the higher S uptake (234 mg pot^{-1}) compared to other P levels. The lowest S uptake of 52 mg pot^{-1} was obtained in control treatment. Nanadal *et al.* (2008) observed similar result in tomato. Significant differences were noticed in the uptake of S by fruit portion of brinjal due to different application of S. The significantly higher S uptake of 161 mg pot^{-1} was noticed in the S_{30} treatment, which was significantly superior to other treatments. The lowest uptake of S was obtained in control (91 mg pot^{-1}), which was significantly inferior to other treatments. Significantly higher S content was observed with the application of S @ 30 kg ha^{-1}. This might be due to greater availability of S from the soil and its subsequent translocation into the plant. Thakre *et al.* (2005) reported that the increasing levels of S significantly increased S content in brinjal fruit and maximum content was recorded with application of 40 kg S ha^{-1}. S uptake of 356 mg pot^{-1} and 21 mg pot^{-1} were obtained in the $P_{60}S_{30}$ and P_0S_0 respectively. Interaction effects of P and S was found to be statistically significant. Sharma and Singh (2003) reported similar result found in green gram.

Calcium uptake: Different levels of P significantly influenced the uptake of Ca by fruits of brinjal. Among different levels of P, P_{60} level recorded significantly the higher uptake of Ca (419 mg pot^{-1}) compared to other treatments and control (192 mg pot^{-1}). This might be due to synergistic effect of P on Ca. This finding was similar to the result of Suresh (2008) in lady's finger. Sulphur fertilization also had significant response on Ca uptake. Treatment S_{30} recorded significantly the higher Ca uptake (335 mg pot^{-1}) over other S levels. This might be due to synergistic effect of S on Ca. Singh *et al.* (2007) found that in potato, there was a gradual increase in Ca uptake with increasing levels of S upto 30 kg ha^{-1}. The highest (551 mg pot^{-1}) and lowest (107 mg pot^{-1}) uptakes of Ca were recorded in $P_{60}S_{30}$ and P_0S_0 levels, respectively. Interaction effect was found to be significant. Combination of P and S fertilizers enhanced Ca uptake. This was similar to the findings of Misra (2003).

Magnesium uptake: The data on uptake of Mg revealed that the application of 60 kg P ha^{-1} recorded significantly higher Mg uptake (354 mg pot^{-1}) by fruit of brinjal over other treatments. The lowest uptake of Mg was noticed in control (138 mg pot^{-1}). Majumdar *et al.* (2007) observed similar type of result. Significant differences with respect to uptake of Mg were observed due to application of different levels of S. A significantly higher uptake of Mg (263 mg pot^{-1}) was observed in S_{30} level over S_{15} level (234 mg pot^{-1}) and control (182 mg pot^{-1}). This might be due to synergistic effect of S on Mg. Gangadhar (2009) observed that the application of S increased the uptake of Mg by 70.2 per cent compared to control upto 30 kg S ha^{-1} in vegetable crop like cauliflower. Interaction effects of P and S showed significant difference with respect to uptake of Mg by brinjal fruit. The maximum (478 mg pot^{-1}) and minimum (70 mg pot^{-1}) uptakes were found in $P_{60}S_{30}$ and P_0S_0 treatments, respectively. Different levels P and S influenced the uptake of Mg. Application of P and S @ 60 kg ha^{-1} x 30 kg ha^{-1} promoted the highest uptake of Mg. Misra (2003) reported similar result in tomato.

Conclusion

Single application of P upto 60 kg ha^{-1} and S upto 30 kg ha^{-1} increased N, P, K, S, Ca and Mg contents in brinjal fruit. Interaction effect of P x S on chemical and biochemical constituents of brinjal were also significant. The overall results suggest that P @ 60 Kg ha^{-1} and S @ 30 Kg ha^{-1} along with other recommended fertilizers can be used for cultivation of better nutrient contents brinjal in the agro-climatic condition of BAU.

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