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Effect of different levels of sulphur and boron on growth and nodulation of garden pea (*Pisum sativum* L.)

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ABSTRACT

A field experimental was conducted at Division of Vegetable Science, SKUAST-Kashmir, Shalimar during rabi 2009-2010 and 2010-2011 in randomized complete block design with sixteen treatment combinations consisting four levels of sulphur (0, 15, 30 and 45 kg S ha^{-1}) and boron (0, 1, 2 and 3 kg B ha^{-1}) replicated three times. Application of 30 kg S ha^{-1} showed marked improvement in growth and nodulation parameters in pea. Increasing dose of boron in the absence of sulphur up to 3kg ha^{-1} resulted marked improvement in growth and nodulation in garden pea. Higher values of plant height, number of branches $plant^{-1}$, fresh weight $plant^{-1}$, dry weight $plant^{-1}$, number of nodules $plant^{-1}$, fresh weight of nodules $plant^{-1}$ha- and dry weight of nodules plant $^{-1}$ were noticed with combined application of 30 kg S + 2 kg B ha^{-1}.

Key words: *Pisum sativum*, Growth, Sulphur, Nodule, Boron.

INTRODUCTION

Pea is an important crop grown throughout India mainly as a winter vegetable in northern plains and as a summer vegetable in the hills of other states. In Kashmir valley pea is mainly grown as *rabi* crop, however, in high altitudes it is grown as an off-season vegetable during summer. In India pea occupies an area of 362 thousand hectares with an annual production of 3011 metric tonnes. (Anonymous,2010). In Kashmir valley, pea is grown over an area of 2020 hectares with an annual production of 24240 tonnes (Anonymous, 2010). Garden peas are harvested in an immature stage, are used as vegetable and are marketed fresh, canned or frozen. Symbiotic association of peas with nitrogen fixing bacterium (*Rhizobium leguminosarium*) improves soil fertility by contributing nitrogen in soil with negligible expense. Use of sulphur free and less application of boron fertilizers has created deficiencies of these nutrients while as the organic manures are used in very less amount which are the source of different macro as well as micro-nutrients including sulphur and boron, this has resulted in the deficiencies of sulphur and boron in the soils. The deficiency of these nutrients in the soils limits the growth, yield and nodulation of various legume crops including garden pea, indicating the need of their application. Sulphur is a plant nutrient with a crop requirement similar to that of phosphorus and is considered as the fourth major plant nutrient (Gowswamy, 1986). Sulphur is an important constituent of sulphur containing amino acids cystine, cysteine and methionine and plays vital role in regulating the metabolic and enzymatic process (Kumar and Singh, 2009). Sulphur stimulates seed formation and promotes nodule formation on roots of legumes (Gilbert, 1951). Boron is one of the essential micronutrient required for normal growth of the plants and plays a vital role in promoting growth, yield and nodulation in garden pea (Bolanos *et. al*. 1994). Keeping in view the importance of sulphur and micronutrient boron, an investigation has been carried out to assess the effects of sulphur and boron on growth and nodulation in garden pea under temperate climatic conditions.

MATERIAL AND METHODS

The field experiment was conducted at the experimental field of Division of Vegetable Science, Sher-e- Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar during *rabi* 2009-2010 and 2010-2011.The soil was clay loam with pH 7.05, O.C 0.97%, E.C 235.20 dsm^{-1}, available N 235.20 kg ha^{-1}, P 21.05 kg $ha^{-1,}$ K 165.62 kg $ha^{-1,}$ S 10.52 kg ha^{-1} and B 0.42 ppm.. The experiment was laid out in randomized complete block design (RCBD) with sixteen treatment combinations consisting four levels of sulphur ($S_{0=}$0 kg S ha^{-1}, $S_{1=}$15 kg S ha^{-1} , $S_{2=}$ 30 kg S ha^{-1} and $S_{3=}$ 45 kg S ha^{-1}) and four levels of boron (B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1} and B_3= 3 kg B ha^{-1}).The seeds of peas Var.Arkel were sown in plots of 4.0 × 1.8 m size at a spacing of 30 × 10 cm in the last fortnight of October during both seasons. The sources of nitrogen, phosphorus, potassium, sulphur and boron were urea, diammonium phosphate, and murate of potash, elemental sulphur and borax respectively. The elemental sulphur was applied twenty days before sowing. All recommended cultural practices were adopted to raise the crop. Observations on various growth and nodulations

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characters were recorded, using standard procedures. The data thus collected was subjected to analysis of variance, using the method proposed by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Growth parameters and nodulation observations of garden pea showed similar results in both the years; hence pooled data is discussed below

Plant height : Data presented in Table 1 indicated that increasing levels of sulphur and boron significantly increased plant height. Maximum plant height of 71.36 cm was recorded with S_2 which was significantly superior to rest of the sulphur levels. Increasing dose of boron in the absence of sulphur up to 3kg ha^{-1} recorded maximum plant height of 71.00 cm and was found significantly superior to rest of boron levels. Interaction between sulphur and boron was significant on plant height. Treatment combination S_2 B_2 recorded maximum plant height of 76. 28 cm which was found significantly superior over rest of the treatment combinations.

Number of branches $plant^{-1}$: It is evident from the data in Table 1 revealed that increasing levels of sulphur and boron significantly increased number of branches $plant^{-1}$. Application of 30kg S ha^{-1} recorded maximum number of branches 4.25 $plant^{-1}$ which was significantly superior to rest of the sulphur levels. Boron @ 3kg ha^{-1} recorded maximum number of branches 4.23 $plant^{-1}$ and was found significantly superior to rest of boron levels. Interaction between sulphur and boron also revealed significance of S_2 B_2 over rest of the treatment combinations recording maximum number of branches 4.54 $plant^{1}$.

The increase in growth and growth related attributes of pea crop due to Sulphur and boron could be attributed to metabolic regulation and enzymatic process including photosynthesis, respiration and symbiotic nitrogen-fixation. Similar findings have also been reported by other workers in garden pea and several other crops (Jeeven and Singh, 2009 and Kaisher *et al.*, 2010).

Fresh weight $plant^{-1}$: The data (Table 1) indicated that increasing levels of sulphur and boron significantly increased fresh weight $plant^{-1}$. Maximum fresh weight of 87. 00 g $plant^{-1}$ was recorded with S_2 and was found significantly superior to S_0 and S_1 but was at par with S_3. Boron @ 3kgha^{-1}(B_3) recorded maximum fresh weight of 85.30 g $plant^{-1}$ which was significantly superior over rest of the boron levels. Interaction of sulphur and boron was significant on fresh weight $plant^{-1}$. Treatment combination S_2 B_2 recorded a fresh weight of 95.27 g $plant^{-1}$ and was significantly superior to all other treatment combinations but was at par with S_2 B_3.

Dry weight $plant^{-1}$: Significant variation of sulphur and boron on dry weight $plant^{-1}$ was revealed (Table-1). Maximum dry weight of 0.44 $plant^{-1}$ was registered with S_2 which was significantly superior to S_0 and S_1 but was at par with S_3 . Among boron levels, B_3 registered maximum dry weight of 0.43 g $plant^{-1}$ but was at par with B_1 and B_2. Interaction between sulphur and boron was significant on dry weight $plant^{-1}$. Treatment combination S_2 B_2 recorded maximum dry weight of 0.4 8 g $plant^{-1}$ which was significantly superior to S_0B_0, S_0B_1, S_1B_0, S_2B_0, S_3B_0, but was statistically at par with S_0B_2, S_0B_3, S_1B_1, S_1B_2, S_1B_3, S_2B_1, S_2B_3, S_3B_1, S_3B_2, and S_3B_3.

Increase in fresh and dry weight of garden pea due to due to sulphur and boron could be attributed to low soil status of available S and B of and due to the stimulating effect of applied sulphur in the synthesis of chloroplast, resulting in enhanced photosynthesis which might have led to an increase in fresh and dry weight of pea. Similar findings have also been reported by many workers in garden pea and other crops (Singh *et al.*, 2003, Khanna and Gupta 2005).

Number of nodules $plant^{-1}$: Data given in Table 1 revealed the significance of sulphur and boron on number of nodules $plant^{-1}$. Maximum number of nodules 38.0 $plant^{-1}$ was registered with S_2 which was Significantly superior to other sulphur levels. Among boron levels, B_3 recorded maximum number of nodules 34.70 $plant^{-1}$and was significantly superior to B_0 and B_1 but was at par with B_2. Interaction between sulphur and boron also exhibited significant influence on number of nodules $plant^{-1}$. Treatment combination S_2B_2 registered maximum number of nodules 44.50 $plant^{-1}$ which was significantly superior to rest of the treatment combinations.

Fresh weight of nodules $plant^{-1}$: Increasing levels of sulphur and boron significantly increased fresh weight of nodules $plant^{-1}$(Table-1). Sulphur @ 30kg ha^{-1}(S_2) recorded maximum fresh weight of nodules 0.50g which was significantly superior to S_0 and S_1 but at par with S_3. Among boron levels, B_3 registered maximum fresh weight of nodules of 0.48 g $plant^{-1}$ and was at par with $B_1$and B_2. Interaction between sulphur and boron also exhibited significant influence on fresh weight of nodules $plant^{-1}$. Treatment combination S_2B_2 registered maximum fresh weight of nodules 0.53 $plant^{-1}$ and was found significantly superior to rest of the treatment combinations but at par withS_2B_1, S_2B_3 and S_3B_1.

Dry weight of nodules $plant^{-1}$: The data (Table 1) revealed the significance of sulphur and boron on dry weight of nodules $plant^{-1}$. Maximum dry weight of nodules 0.08g $plant^{-1}$ was registered with S_2 but was at par with S_1 and S_3. Among boron levels, B_3 recorded maximum dry weight of nodules of 0.08 g $plant^{-1}$ and was at par with B_1 and B_2 . Interaction between sulphur and boron also exhibited significant influence on dry weight of nodules $plant^{-1}$. Treatment combination S_2B_2 registered maximum dry weight of nodules 0.09 $plant^{-1}$ and was found significantly superior to S_0B_0 and S_0B_2 but was at par with rest of the treatment combinations.

Table 1: Effect of sulphur and boron on various growth and nodulation parameters in garden pea (pooled)

Treatment	Plant height(cm)					Number of branches plant^{-1}					Fresh weight plant^{-1} (g)					Dry weight plant^{-1} (g)				
	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean
S_0	50.56	56.37	59.92	65.78	**58.16**	3.02	3.38	3.59	3.94	**3.48**	38.82	71.37	51.17	83.68	**61.14**	0.22	0.32	0.37	0.40	**0.33**
S_1	57.47	64.27	68.95	71.82	**65.63**	3.45	3.83	4.12	4.34	**3.93**	87.66	55.59	73.72	80.03	**74.25**	0.30	0.37	0.39	0.42	**0.37**
S_2	61.13	73.50	76.28	74.54	**71.36**	3.67	*4.37*	4.54	4.42	**4.25**	67.14	91.48	95.27	93.83	**87.00**	0.33	0.46	0.48	0.47	**0.44**
S_3	61.59	73.23	74.15	71.70	**70.13**	3.66	4.34	4.39	4.25	**4.16**	82.26	90.24	89.46	83.68	**86.41**	0.35	0.45	0.44	0.41	**0.41**
Mean	**57.69**	**66.84**	**69.82**	**71.00**	-	**3.45**	**3.98**	**4.16**	**4.23**	-	**69.00**	**77.17**	**77.24**	**85.30**	-	**0.30**	**0.40**	**0.42**	**0.43**	-
CD(P=0.05)	**S**				**0.199**					**0.023**					**2.39**					**0.06**
	B				**0.199**					**0.023**					**2.39**					**0.006**
	S × B				**0.398**					**0.046**					**3.38**					**0.012**

Treatment	Number of nodules plant^{-1}					Fresh weight of nodules plant^{-1} (g)					Dry weight of nodules plant^{-1} (g)				
	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean	B_0	B_1	B_2	B_3	Mean
S_0	21.72	23.72	27.33	31.16	**26.00**	0.18	0.32	0.40	0.47	**0.37**	0.03	0.07	0.05	0.07	**0.06**
S_1	22.66	28.66	29.33	34.0	**28.66**	0.48	0.40	0.43	0.44	**0.44**	0.08	0.06	0.07	0.07	**0.07**
S_2	24.83	40.66	44.50	42.00	**38.00**	0.41	0.51	0.53	0.52	**0.50**	0.06	0.08	0.09	0.08	**0.08**
S_3	26.33	37.50	36.00	31.66	**32.87**	0.49	0.51	0.50	0.45	**0.49**	0.08	0.08	0.08	0.07	**0.07**
Mean	**23.88**	**32.63**	**34.29**	**34.70**	-	**0.39**	**0.46**	**0.46**	**0.48**	-	**0.06**	**0.07**	**0.07**	**0.08**	-
CD(P=0.05)	**S**				**0.853**					**0.003**					**0.001**
	B				**0.853**					**0.003**					**0.001**
	S × B				**1.106**					**0.007**					**0.003**

Improvement in nodule growth, their fresh and dry weight due to due to sulphur and boron could be attributed to increasing leghaemoglobin pigment formation in nodules. Our results are in conformity with the findings of other workers (Azevedo *et al;* 2002; Hamdaoui *et al*; 2003 and Khanna and Gupta 2005).

CONCLUSION

From the present investigation, it is concluded that combined application of sulphur @ 30kg + 2 kg boron ha^{-1} along with RFD is an optimum nutrient combination for enhancing growth and nodulation in garden pea under temperate climatic conditions.

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