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Pod and Seed Production Potential of Vegetable Pea (*Pisum sativum* L.) as Influenced by Different Levels of Sulphur and Boron in Calcareous Soil of North Bihar

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ABSTRACT

Background: Vegetable pea is one of the relevant vegetable crops grown in the cool season all over the India. Sulphur deficiency is becoming more prevalent in Bihar due to the less use of boron and sulphur-containing fertilizer in calcareous soils and the consequent decrease in sulphur and boron nutrients. On the other hand, organic matter-rich manures, are utilized in very small quantities which is a source of a macro-and micronutrients, including sulphur and boron. As a consequence, soils have become deficient in sulphur and boron, which is detrimental to crop production. In the absence of these sulphur and boron in the soil, different legume crops such as vegetable pea suffer from reduced growth, yield and nodule formation.

Methods: In this field investigation during 2020-2022, experiments were conducted in Factorial Randomized Block Design using fifteen different combinations of Boron and Sulphur doses in Azad Pea-3 variety of vegetable pea in three replications and different pod and seed yield attributing traits were studied.

Result: Among the different treatments, it has been inferred that treatment combination 40 kg S ha^{-1} + 2 kg B ha^{-1} exhibited superiority over rest of the treatment combinations with respect to pod and seed yield attributes of vegetable pea.

Key words: Boron, Nutrients, Pod, Seed, Sulphur, Yield.

INTRODUCTION

Pea (*Pisum sativum* L.) is a very popular leguminous vegetable crop grown in the cool season throughout the world. In India, pea is grown as winter vegetable in the northern plains, while in hilly terrain it is grown as off-season vegetable during summer and winter seasons. Vegetable pea is used as a green vegetable, dehydrated and in canned form. The place of pea as a vegetable and as a pulse in human diet has been recognized since long. It is usually grown for its green pod containing immature seeds which are cooked as a vegetable as well as used for fresh consumption. In India pea cover an area of 568 thousand ha with an annual output of 5848 metric tonnes. (Anonymous, 2020). In Bihar pea is cultivated across an area of 9.66 thousand hectares with an annual output of 57.77 metric tonnes (Anonymous, 2020).

There are factors, such as seed, sowing time, spacing, nutrient management, *etc* which influence the yielding capacity of the crop. Out of these, seed is a very important input on which the ultimate yield of the crop depends. The availability of good seed in sufficient quantity is very important for its successful production. Therefore, increase in quality seed production of pea is the need of the time to boost up the production of crop.

Various external factors (*i.e.* nutritional and environmental) are responsible for growth and yield of pea. Sulphur is responsible for stimulation of seed formation and promotion of root nodule formation on leguminous crops (Gilbert, 1951). Boron is involved in the functioning of plant reproductive tissues. Mahler and Shafii (2009). reported that B is found to be essential for pollen tube germination, cell elongation, cell division, male flower sterility and fruit and seed formation in plants.

Sulphur deficiency is becoming more prevalent in Bihar due to the less use of boron and sulphur-containing fertilizer in calcareous soils and the consequent decrease in sulphur

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and boron nutrients. On the other hand, organic matter-rich manures, are utilized in very small quantities and are a source of a variety of macro-and micronutrients, including sulphur and boron. As a consequence, soils have become deficient in sulphur and boron, which is detrimental to crop production. In the absence of these sulphur and boron in the soil, different legume crops such as vegetable pea suffer from reduced growth, yield and nodule formation (Singh *et al*., 2006).

Keeping in view the importance of secondary element sulphur and micronutrient boron, an investigation has been carried out to assess the effects of sulphur and boron for higher seed yield in vegetable pea in calcareous soil of North Bihar.

MATERIALS AND METHODS

The field experiments were conducted at the experimental field of Vegetable Research Farm of Department of Horticulture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur during rabi 2020-21 and 2021-22.The research farm lies on 25.98°N latitude and 85.68°E longitudes with an altitude of 52.0 m above MSL (Kumar *et al*., 2021). The soil of the experimental field is deep, *Entisols* in origin. The soil texture was loamy sand, whitish-brown in color and alkaline in reaction due to presence of excess free $CaCO_3$ (26.52 %). The pH of the experimental field soil was 8.21 with Electrical Conductivity 0.34 dSm^{-1}, Cation Exchange Capacity 12.52(cmol(p+) kg^{-1}) and having organic carbon from 0.42%. The soil was low in available nitrogen (180.21 kg ha^{-1}), available P (18.22 kg ha^{-1}) and medium in available K (121.77 kg ha^{-1}). Low in S (7.83 ppm) and B (0.4 ppm) content.

The experiment was laid out in factorial randomized block design (FRBD) with fifteen treatment combinations consisting five levels of sulphur (0, 10, 20, 30 and 40 kg S ha^{-1}) and three levels of boron (0, 1 and 2 kg B ha^{-1}). The seeds of peas *var.* Azad Pea-3 were sown in plots of 2.5 × 1.8 m size at a spacing of 30 × 10 cm on 11th November 2020 and 1st November 2021. The sources of nitrogen, phosphorus, potassium, sulphur and boron were urea, diammonium phosphate, murate of potash, elemental sulphur and borax respectively. All recommended cultural practices were adopted to raise the crop. Observations on pod and seed yield of vegetable pea were recorded using standard procedures. The data thus collected was subjected to analysis of variance, using the method proposed by Panse and Sukhatme (1985). The statistical software OP stat online and Microsoft excel were used for the purpose of data analysis. Critical difference at 5% level was used for testing the significant difference among the treatment means.

RESULTS AND DISCUSSION

Plant height and number of branches per plant

The marked effect of sulphur showed (Table 1) significant effect of plant height and number of branches per plant and it was noted that with increase in sulphur doses, the plant height andnumber of branches per plant increased and the maximum plant height (56.97 cm) and number of branches per plant (4.11) was obtained at S_4 level *i.e.* (40 kg S ha^{-1}). The probable reason of the significant response from sulphur fertilizer on this character may be due to low soil status of available sulphur and boron 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 plant height and number of branches. Similar findings have also been reported by many workers in vegetable pea and other crops (Singh *et al*., 2006; Khanna and Gupta, 2005; Parry *et al*., 2016).

Number green pods $plant^{-1}$

It is evident from the data in Table 2 that increasing levels of sulphur and boron increased number of green pods per plant. Maximum number of green pods 21.76 per plant was recorded with 40 kg S ha^{-1} which was found superior to all other sulphur levels. Boron @ 2 $kgha^{-1}$ recorded maximum number of green pods 19.76 per plant which was superior to rest of the boron levels. Interaction of sulphur and boron on number of green pods per plant was significant. Combined application of 40 kg sulphur and 2 kg boron ha^{-1} recorded maximum number of green pods pods 24.96 per plant which was superior to all other treatment combinations.

Weight of 10 pods (g)

Data given in Table 2 revealed that increasing levels of sulphur and boron increased weight of 10 pods. Maximum weight of 10 pods (78.05 g) was recorded with 40 kg S ha^{-1}

Table 1: Effect of sulphur and boron on growth related attributes of vegetable pea (pooled).

Treatment	Plant height (cm)				Number of branches per plant			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
S_0	47.00	52.66	52.53	50.73	3.06	3.40	3.46	3.31
S_1	51.53	54.93	53.20	53.22	3.60	3.53	3.26	3.46
S_2	54.60	55.86	58.66	56.37	3.53	3.60	3.46	3.53
S_3	55.33	56.40	57.46	56.40	3.53	3.40	4.46	3.80
S_4	54.13	55.53	58.86	56.97	3.73	4.00	4.60	4.11
Mean	16.91	17.74	19.76		3.49	3.58	3.85	
CD (P≤0.05)	S			1.64				020
	B			1.27				0.16
	S × B			NS				0.35

and was found superior to rest of the sulphur levels. Boron @ 2 kg ha^{-1} registered maximum weight of 10 pods 72.56 g which was superior to rest of the boron levels. Interaction between sulphur and boron also revealed significant influence on weight of 10 pods. Application of 40 kg sulphur along with 2 kg B ha^{-1} recorded 79.50 g weight of 10 pods and was found superior to all other treatment combinations.

Green pod yield plant^{-1} (g)

It is evident from the data in Table 2 that increasing levels of sulphur and boron increased green pod yield per plant. Maximum green pod yield 43.30 per plant was recorded with 40 kg S ha^{-1} which was found superior to all other sulphur levels. Boron @ 2 kgha^{-1} recorded maximum green pod yield 42.20 per plant which was superior to rest of the boron levels. Interaction of sulphur and boron on green pod yield per plant was significant. Combined application of 40 kg sulphur and 2 kg boron ha^{-1} recorded maximum green pod yield pods 44.05 per plant which was superior to all other treatment combinations.

Pod yield (q ha^{-1})

Data given in Table 2 revealed that increasing levels of sulphur and boron increased pod yield. Maximum pod yield 134.08 q ha^{-1} was recorded with 40 kg S ha^{-1} and was found superior to rest of the sulphur levels. Boron @ 2kg ha^{-1} registered maximum pod yield 131.17 q ha^{-1} per pod which was superior to rest of the boron levels. Interaction between sulphur and boron also revealed significant influence on pod yield. Application of 40 kg sulphur along with 2 kg B ha^{-1} recorded 138.86 pod yield and was found superior to all other treatment combinations.

The increase in yield related attributes of garden pea due to S, B and their interaction could be attributed to the low status of both nutrients in the soils and the greater requirement of these nutrients by crop and also with increasing supply of S and B, the process of tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial might have increased, resulting in more flower and yields. Similar observations have also been reported by other workers (Singh *et al*., 1998; Prasad *et al*., 1998; Kasturi Krishana and Ahlawat 1999; Singh *et al*., 2002; Prasad and Prasad 2003; Nasreen and Farid 2003, Khanna and Gupta 2005, Kumar and Singh 2009, Parry *et al*., 2016) in garden pea and several other crops.

Seed yield per plant

Data presented in Table 3 that increasing levels of sulphur and boron enhance seed yield per plant. Maximum seed yield 6.45 g per plant was recorded with 40 kg S ha^{-1} which was superior to all other sulphur levels. Boron @ 2 kg ha^{-1} registered maximum seed yield of 6.29 g per plant and was found superior to rest of the boron levels. Combined application of 40 kg sulphur and 2 kg boron ha^{-1} recording maximum seed yield of 6.69 g per plant which was superior to rest of the treatment combinations.

Table 2: Effect of sulphur and boron on pod yield and related attributes of vegetable pea (pooled).

Tr	Number green pods plant^{-1}				Weight of 10 pods (g)				Green pod yield plant^{-1} (g)				Pod yield (q ha^{-1})			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
S_0	11.54	12.91	13.94	12.80	64.33	64.83	65.30	64.82	34.52	37.25	40.37	37.38	114.80	119.33	121.53	118.55
S_1	16.53	17.06	17.33	16.97	66.83	66.96	67.50	67.10	35.11	41.88	42.62	39.87	124.20	125.80	127.73	125.91
S_2	18.41	18.97	18.66	18.68	72.16	74.16	74.33	73.55	37.51	39.81	41.81	39.71	129.06	130.06	131.60	130.24
S_3	18.46	19.06	20.93	19.48	73.50	73.33	76.16	74.33	41.79	42.54	42.16	42.16	128.13	129.13	136.13	131.13
S_4	19.61	20.72	24.96	21.76	76.50	78.16	79.50	78.05	42.45	43.39	44.05	43.30	131.73	131.66	138.86	134.08
Mean	16.91	17.74	19.76		70.66	71.49	72.56		38.28	40.97	42.20		125.58	127.20	131.17	
CD	S			1.67				1.85				0.26				1.91
($P \leq 0.05$)	B			1.29				1.59				0.24				1.74
	S × B			2.97				3.49				0.55				3.76

Number of seeds per pod

Data given in Table 3 revealed that increasing levels of sulphur and boron increased number of seeds per pod. Maximum number of seeds 9.34 per pod was recorded with 40kg S ha^{-1} and was found superior to rest of the sulphur levels. Boron @ 3kg ha^{-1} registered maximum number of seeds 8.72 per pod which was superior to rest of the boron levels. Interaction between sulphur and boron also revealed significant influence on number of seeds per pod. Application of 40 kg sulphur along with 2 kg B ha^{-1} recorded 9.40 seeds per pod and was found superior to all other treatment combinations.

100-Seed weight

Data presented in Table 3 revealed that application of 40kg sulphur ha^{-1} recorded maximum 100-seed weight of 21.10 g which was significantly superior to other sulphur levels. Application of 2 kg ha^{-1} boron registered maximum 100-seed weight of 19.54 g which was significantly superior to rest of boron levels. Interaction between sulphur and boron depicted a significant effect on 100-seed weight. Combined application of 40 kg sulphur and 2 kg boron ha^{-1} recorded maximum 100-seed weight of 22.16 g which was significantly superior to rest of the treatment combinations.

Seed yield per ha

It is evident from the data in Table 3 that application of 40kg sulphur ha^{-1} recorded maximum seed yield of 19.46 q ha^{-1} which was superior to all other sulphur levels. Boron @ 2 kg ha^{-1} registered maximum seed yield of 17.45 q ha^{-1} which was superior to rest of the boron levels. Combined application of 40 kg sulphur and 2 kg boron ha^{-1} recorded significantly maximum seed yield of 20.01 q ha^{-1} as compared to rest of the treatment combinations.

Improvement in seed yield and related attributes of garden pea due to S, B and their interaction could be attributed to fulfilment of crop demand by higher assimilation and translocation of photosynthates from leaves to seeds and with increasing sulphur and boron, the process of tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial might have increased resulting in more flowers and higher seed yield. Similar observations have also been reported by other workers (Budhar and Tamilselvan 2001; Prasad and Prasad 2003; Singh *et al.*, 2003; Nasreen and Farid 2003; Singh *et al.*, 2006 and Kumar and Singh 2009 and Parry *et al.*, 2016) in garden pea and several other crops.

Economics of seed production in vegetable pea

Income distribution and benefit cost ratio

Perusal of Table 4 revealed the position of input and output in terms of economics of production. Maximum cost of cultivation (Rs. 85189 ha^{-1}) was estimated in S4B2 (40 kg S ha^{-1} + 2kg B ha^{-1}) and lowest in S0B0 (0 kg S ha^{-1} + 0 kg B ha^{-1}) which accounted for Rs. 79249 ha^{-1}.The treatment wise cost

Table 3: Effect of sulphur and boron on seed yield and related attributes of vegetable pea (pooled).

Tr	Seed yield plant^{-1} (g)				Number of seeds pod^{-1}				100 Seed weight (g)				Seed yield (q ha^{-1})			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
S_0	4.79	4.98	5.28	5.02	7.21	7.53	7.74	7.49	17.20	17.42	17.50	17.37	12.83	14.70	15.03	14.19
S_1	5.24	6.00	6.43	5.89	8.01	8.11	8.33	8.15	18.40	18.50	18.73	18.54	15.03	15.20	15.73	15.32
S_2	6.17	6.37	6.48	6.34	8.26	8.53	8.86	8.55	18.42	18.80	19.13	18.78	16.03	16.50	17.26	16.60
S_3	6.19	6.39	6.55	6.38	8.93	8.99	9.26	9.06	19.45	19.82	20.17	19.81	17.30	17.80	18.73	17.94
S_4	6.22	6.44	6.69	6.45	9.25	9.36	9.40	9.34	20.13	21.01	22.16	21.10	18.76	19.60	20.01	19.46
Mean	5.72	6.04	6.29		8.33	8.50	8.72		18.72	19.11	19.54		15.99	16.76	17.35	
CD	S			0.12				0.27				0.97				1.11
($P \leq 0.05$)	B			0.14				0.27				0.42				0.97
	S × B			0.28				0.60				1.81				1.18

Table 4: Economics and net profit per hectare as influenced by various treatments.

Treatment	General cost of cultivation (Rs)	Additional cost of sulphur and boron application (Rs)	Total expenditure (Rs)	Pooled seed yield (q/ha)	Gross income (Rs)	Net profit/ha (Rs)	B: C ratio
S_0B_0	79249	0	79249	12.83	192450	113201	2.43
S_0B_1	79249	970	80219	14.7	220500	140281	2.75
S_0B_2	79249	1940	81189	15.03	225450	144261	2.78
S_1B_0	79249	1000	80249	15.03	225450	145201	2.81
S_1B_1	79249	1970	81219	15.2	228000	146781	2.81
S_1B_2	79249	2940	82189	15.73	235950	153761	2.87
S_2B_0	79249	2000	81249	16.03	240450	159201	2.96
S_2B_1	79249	2970	82219	16.5	247500	165281	3.01
S_2B_2	79249	4940	84189	17.26	258900	174711	3.08
S_3B_0	79249	3000	82249	17.3	259500	177251	3.16
S_3B_1	79249	3970	83219	17.8	267000	183781	3.21
S_3B_2	79249	3940	83189	18.73	280950	197761	3.37
S_4B_0	79249	4000	83249	18.76	281400	198151	3.38
S_4B_1	79249	4970	84219	19.6	294000	209781	3.49
S_4B_2	79249	5940	85189	20.01	300150	214961	3.52

of cultivation and their returns revealed that maximum net returns of Rs. 214961 were observed in S_4B_2 (40 kg S ha^{-1} + 2 kg B ha^{-1}) followed by S4B1 (40 kg S ha^{-1} + 1 kg B ha^{-1}), S_3B_0 (40 kg S ha^{-1} + 0 kg B ha^{-1}), S_3B_2 (30 kg S ha^{-1} + 2 kg B ha^{-1}) with returns per rupee invested of 3.52, 3.49, 3.38 and 3.37 respectively. However the lowest net returns of Rs. 79249 was observed in S_0B_0 with returns of 2.43 per Rs invested. Similar trend has also been reported by various workers (Prasad and Prasad 2003 and Parry *et al*., 2016) in various crops.

CONCLUSION

From the present investigation, it is concluded that combined application of 40 kg sulphur and 2 kg boron ha^{-1} along with RFD is an optimum nutrient combination for enhancing pod and seed yield and its related attributes of vegetable pea Var. Azad Pea-3 under calcareous soil of North Bihar.

Conflict of interest: None.

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