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Effect of Zn and B on Growth, Yield and Nutritional Quality of Garden Pea (*Pisum sativum* L)

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Abstract

Garden Pea, (*Pisum sativum*), herbaceous annual plant in the family Fabaceae, grown virtually worldwide for its edible seeds. Peas can be bought fresh, canned, or frozen, and dried peas are commonly used in soups.The experiment was conducted at the experimental field of Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, Bangladesh. The soil of the experimental plot was silty clay loam in texture having pH 6.3 and the soil type belongs to the shallow red brown terrace soil under Salna series of Madhupur tract in Agro Ecological Zone (AEZ) 28. The experiment was conducted with garden pea variety BARI Motorshuti-3. The experiment consisted of two factors: Factor A: Zinc (0, 2, 4 and 6 kg ha^{-1}) and Factor B: Boron (0, 1, 2 and 3 kg ha^{-1}). The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications. Results reveal that all the Growth and yield parameter of garden pea except days to first flowering responded significantly due to interaction of Zn and B. The maximum dry seed yield (3.97 tha^{-1}) was recorded with the treatment Zn_4B_2 (Zn @ 4 t and B @ 2 t ha^{-1}). Nutritional quality of garden pea except protein and ascorbic acid responded significantly due interaction of Zn and B. The highest amount P, K and β–carotene was recorded with Zn_4B_2. Whereas, maximum amount of Ca and total sugar was recorded with Zn_6B_2. The results suggest that the application of Zn_4B_2 kg ha^{-1} along with with NPK and cow dung @ 40, 20, 25 kg ha^{-1} and 5 t ha^{-1} can support the higher yield of garden pea in shallow red brown terrace soils of Bangladesh.

Keywords: Zinc and boron, growth, yield and nutritional quality.

Introduction

The maximum yield potential of any crop can be exploited through genetic and agronomic manipulation, especially through adoption of proper fertilizer management practices. Optimal fertilizer management and efficient use of zinc (Zn) and boron (B) along with N, P, K are necessary to improve yield and quality and to reduce production cost (Fageria, 2002). In our country, zinc and boron micronutrients are serious constraints to productivity and are becoming more serious year by year. Due to intensive cultivation of modern varieties and the use of higher doses of NPK fertilizers, crop yield has increased but mining out the inherent micronutrients from the soils. Nutrient mining may eventually cause soil degradation and affect crop production. Therefore, deficiency of these nutrients is very much pronounced in some parts of the country and causes yield reduction in the recent years. Farid *et al*. (2003) reported that zinc deficiency severe in low water logging condition and calcareous soil. Boron deficiency is found in well drained, sand and soils with less water holding capacity. The garden pea crop requires optimum quantity of minor nutrients like boron and zinc along with NPK for improving its vegetative and reproductive characteristics leading to higher seed yield and quality in garden pea. Among the micro elements, boron and zinc play an important role directly and indirectly in improving the yield and quality of garden pea in addition to checking various diseases and physiological disorders (Magalhaes *et al.,* 1980). Zinc application helps in increasing the uptake of nitrogen and potash. Application of zinc sulphate stimulates chlorophyll synthesis and fruit quality of garden pea (Kalloo, 1985). Zinc is known to play an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin, which produces more plant cells and more dry matter (Darwish *et al*., 2002). Boron is essential for cell division, particularly in the process of pollen tube development. Therefore, boron deficiency may cause sterility i. e. less pods and less seeds per pod that lead to lower seed yield (Islam and Anwar,1994; Gupta, 1980). Positive responses of cereals, pulses, oil seeds and cash crops to B (0.5 to 2.5 kg Bha^{-1}) have largely been reported from India (Takkar *et al*., 1997). Boron

Table 1. Interaction effect of zinc and boron on the growth and yield parameter of garden pea

Treatment	Plant height (cm)	Number of primary branches/plant	LAI (cm^2)	Days to first flowering	Number of pod/plant	Pod yield (t/ha)		Number of seed/pod	Seed yield (t/ha)	
						Green pod stage	Brown pod stage		Green	Dry
T_1- Zn_0B_0	36.30k	0.56d	32.85j	33.63	4.86g	10.64h	4.20f	7.25g	2.81h	6.04g
T_2- Zn_0B_1	39.00ij	0.96cd	35.42ij	35.00	5.36fg	11.75g	4.30f	7.81d-g	2.77h	6.29fg
T_3- Zn_0B_2	44.63def	1.66cd	40.54fg	34.27	6.66cd	14.32bc	4.80bcd	8.41c-e	2.99g	6.41efg
T_4- Zn_0B_3	39.47i	1.66cd	38.95fgh	36.03	5.86def	11.84g	4.40ef	7.56e-g	2.83h	6.37efg
T_5- Zn_2B_0	42.90fg	2.00c	44.44de	34.57	6.10cdef	12.67efg	5.03bc	8.63cd	2.96g	6.81d-g
T_6- Zn_2B_1	44.87def	1.66cd	51.09b	36.10	6.96c	13.04def	4.86bc	8.41c-e	3.17de	7.06c-f
T_7- Zn_2B_2	47.87bc	1.43cd	51.28b	33.80	6.83c	13.31cde	4.90bc	8.82bc	3.28d	7.34b-e
T_8- Zn_2B_3	41.33ghi	1.80cd	39.58fgh	33.60	5.70efg	12.30efg	5.00bc	7.81d-g	3.00fg	6.72d-g
T_9- Zn_4B_0	46.63bcd	1.33cd	41.36ef	35.20	6.86c	14.05cd	5.03bc	8.23c-f	3.42c	7.09c-f
T_{10}- Zn_4B_1	48.60ab	4.06b	48.82bc	33.27	7.86b	15.15b	5.16b	8.72bc	3.49c	7.91bc
T_{11}- Zn_4B_2	50.80a	5.33a	58.29a	34.50	8.83a	16.20a	5.50a	9.48ab	3.97a	8.94a
T_{12}- Zn_4B_3	43.87ef	2.00c	51.52b	36.17	6.53cde	12.37efg	4.96bc	7.59e-g	3.65b	8.10ab
T_{13}- Zn_6B_0	36.90jk	1.06cd	47.23cd	34.10	5.40fg	11.56gh	4.50def	8.25c-f	2.97g	6.90c-g
T_{14}- Zn_6B_1	42.37fgh	2.03c	37.47ghi	33.67	6.23c-f	13.22cde	4.73cde	8.74bc	3.01fg	7.36b-f
T_{15}- Zn_6B_2	45.87cde	2.00c	44.29de	35.20	6.26c-f	13.87cd	5.03bc	9.81a	3.13ef	7.48bcd
T_{16}- Zn_6B_3	40.07hi	1.13cd	36.74hi	34.27	4.80g	12.02fg	4.46def	7.53fg	2.79h	6.30fg
LS	**	**	*	NS	*	*	*	**	**	*
CV (%)	4.43	15.11	6.23	7.03	7.90	5.14	5.98	7.81	6.13	7.42

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability; * indicates significant at 1% level of probability ;** indicates significant at 1% level of probability; NS indicates non significant; LS indicates Level of Significance

also has a profound influence on advanced growth stages. In a study on pea *(Pisum sativum* L.), Kumar *et al.* (2008) reported increased plant height, fruiting and pod yield when seeds were primed in 0.5% B solution with a concomitant reduction in days to 50% flowering. Despite evidence of benefits of fertilization, scanty work has been carried out on the effect of Zinc and boron on this latest released variety of garden pea. Therefore, the present study was initiated to know the effect of Zn and B on growth, yield and quality of garden pea.

Materials and Methods

The experiment was conducted at the experimental field of Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh. The soil of the experimental plot was silty clay loam in texture having pH 6.3 and the soil type belongs to the shallow red brown terrace soil under Salna series of Madhupur tract in Agro Ecological Zone (AEZ) 28. The experiment was conducted with BARI Motorshuti-3which is cultivated mainly for green pod purpose. The experiment consisted of two factors: Factor A: Zinc (0, 2, 4 and 6 kg ha^{-1}) and Factor B: Boron (0, 1, 2 and 3 kg ha^{-1}). Four levels of zinc and four levels of boron in combination made 16 treatment combinations viz., T_1- Zn_0B_0, T_2- Zn_0B_1, T_3- Zn_0B_2, T_4- Zn_0B_3, T_5- Zn_2B_0, T_6- Zn_2B_1, T_7- Zn_2B_2, T_8- Zn_2B_3, T_9- Zn_4B_0, T_{10}- Zn_4B_1, T_{11}- Zn_4B_2, T_{12}- Zn_4B_3, T_{13}- Zn_6B_0, T_{14}- Zn_6B_1, T_{15}- Zn_6B_2 and T_{16}- Zn_6B_3. The two factor experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications. The unit plot size was 2.0×1.5 m. The unit plots and blocks were separated by 0.50 m and 1.0 m respectively. Every unit plot had 10 rows with 30 plants each. Plant to plant and row-to-row distance were 20 cm and 10 cm. Treatments were randomly allotted in different plots of each block. Zinc and boron were applied as zinc sulphate and borax (according to treatment combination). The crop was also fertilized with NPK and cow dung @ 40, 20, 25 kg and 5 t/ha. Full doses of well decomposed cow dung, TSP, MOP, zinc sulphate and borax were incorporated into the prepared plots a few days before planting. Urea was applied in two equal installments i. e. half of the quantity of urea was incorporated into the soil before sowing of seeds. Rest of urea was top dressed at 20 days after sowing. The experimental plot was kept weed free by hand weeding. Proper irrigation was done as and when necessary. Staking was done for 10 selected plants in each plot for green pod stage and matured seed stage observation separately. Pods were harvested at green pod stage and brown pod stage from randomly selected 10 plants of each plot. Data on growth, yield and quality of garden pea were recorded timely. Chemical analysis of garden pea seeds was done about 20-25 days after pod formation at green pod stage to assess the nutrient content of garden pea seeds. Chemical analysis of garden pea seeds was done to determine ascorbic acid, total sugar, β-carotene, protein, P, K and Ca at green pod stage. The ascorbic acid content was determined as per the procedure described by Pleshkov (1976). β - carotene was estimated as per the procedure described by Nagata *et al*.,1992. Sugar contents (total and reducing) were estimated according to Somogyi (1952) using Bertrand A, Bertrand B and Bertrand C solutions. Estimation of total nitrogen was done by "Colorimetric method" described by Lindner (1944). The oven dried seeds were ground and total nitrogen content was determined by modified Kjeldahl digestion colorimetric method (Cataldo *et al*., 1975) by using $CuSO_4$ and K_2SO_4 mixture (1: 9) as catalyst. Protein content in green pod and mature seed was estimated by multiplying 6.25 to the value of total nitrogen (%). Pea seed samples containing minerals such as phosphorus (P), Potassium (K) and calcium (Ca) were estimated by "Perchloric acid digestion method" proposed by Yamakawa (1992). After digestion of pea seed sample, the amount of phosphorus was determined by "Venamolybdate colorimetric method" by Yamakawa (1992). The recorded data on different parameters were compiled and statistically analyzed by using MSTAT software to find out the significance of variation resulting from the experimental treatments following the ANOVA technique. The mean separation was done by the DMRT at 5% or 1% level of probability.

Results and Discussions

Growth and yield parameter of garden pea

Plant height

The interaction effect of Zn and B on plant height was also found significant (Table 1). The tallest plant (50.80 cm) was produced by the plants treated with Zn_4B_2 which was statistically similar to Zn_4B_1 (48.60 cm) and the shortest plant (36.60 cm) was found in the plants which treated with Zn_0B_0. Micronutrient enhanced the survival and multiplication of microorganism, more nitrogen fixation, transport of sugars and better uptake and assimilation of available nutrients by the plants during the entire growth period for higher growth and yields. Similar findings were reported by Agrawal and Sharma (2005). The main effect of zinc on plant height was found significant (Table 2). The tallest plant (47.47 cm) was found when the plants treated with Zn_4 (Zn @ 4 kg ha^{-1}) which was closely followed by Zn_2 (44.24 cm) and Zn_6 (41.30 cm). The shortest plant (39.85 cm) was found in Zn_0. Similar findings were reported by Alam *et al* (2020) and Alam *et al*. (2010). Significant variation on plant height was observed due to the effect of boron application. The plants treated with B_2 (B @ 2 kg ha^{-1}) produced the highest plant height (47.29 cm) followed by B_1 (43.71 cm) and B_3 (41.18 cm) whereas the lowest plant height (40.68 cm) was produced by the plants treated with B_0. Similar findings were reported by Shekhawat and Shivay (2012).

Table 2. Effect of zinc and boron on the growth and yield parameter of garden pea

Treatment	Plant height (cm)	Number of primary branches/plant	LAI (cm^2)	Days to first flowering	Number of pod/plant	Pod yield (t/ha)		Number of seed/pod	Seed yield (t/ha)	
						Green pod stage	Brown pod stage		Green	Dry
Zn_0	39.85d	1.21b	36.94d	34.73	5.69c	12.14c	4.42d	7.76b	2.85d	7.83c
Zn_2	44.24b	1.72b	46.60b	34.52	6.40b	12.83b	4.95b	8.42a	3.10b	8.74b
Zn_4	47.47a	3.18a	50.00a	34.78	7.52a	14.44a	5.16a	8.44a	3.64a	10.07a
Zn_6	41.30c	1.55b	41.43c	34.31	5.67c	12.67b	4.68c	8.58a	2.97c	8.76b
LS	**	*	**	NS	**	**	*	**	*	*
CV (%)	4.43	15.11	6.23	7.03	7.90	5.14	5.98	7.81	6.13	7.42
B_0	40.68c	1.24c	41.47c	34.38b	5.80c	12.23c	8.41b	4.69b	8.09bc	3.04c
B_1	43.71b	2.18bc	43.20b	34.51b	6.60b	13.27b	8.92ab	4.76b	8.42b	3.11b
B_2	47.29a	2.60a	48.60a	34.44b	7.15a	14.43a	9.46a	5.05a	9.13a	3.34a
B_3	41.18c	1.65bc	41.70bc	35.02a	5.72c	12.13c	8.60b	4.70b	7.62c	3.07bc
LS	**	*	*	*	**	*	*	*	**	*
CV (%)	4.43	15.11	6.23	7.03	7.90	5.14	7.42	5.98	7.81	6.13

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability; * indicates significant at 1% level of probability; ** indicates significant at 1% level of probability; NS indicates non-significant; LS indicates Level of Significance

Number of primary branches per plant

Interaction effect of Zn and B was also found significant on number of primary branches/plant (Table 1). The plants under the treatment of Zn_4B_2 recorded maximum number of primary branches/plant (5.33) followed by Zn_4 B_1 (4.06) and the plants under the treatment of Zn_0B_0 had minimum number of primary branches/plant (0.56). This result confirmed the findings of Mary and Dale, 1990. Number of primary breaches per plant varied significantly due to the effect of Zn application (Table 1). The maximum number of primary branches/plant (3.18) was observed in the plants under the treatment of Zn_4 (Zn @ 4 kg ha^{-1}) followed by Zn_2 (1.72) which was statistically similar to Zn_6 (1.55) and Zn_0 (1.21). This results are in harmony with the findings of Togay et al. (2004). Number of primary branches/plant also varied significantly due to the influence of boron application. The plants treated with B_2 (B @ 2 kg ha^{-1}) produced maximum number of primary branches/plant (2.60) which was statistically identical with B_1 (2.18) and B_3 (1.65) while the plants treated with B_0 showed minimum number of primary branches/plant (1.24). Similar observations have been reported by Roshid (2021).

Leaf area index (LAI)

Leaf area index varied significantly due to interaction effect of Zn and B (Table 1). The plants under the treatment Zn_4B_2 recorded the highest LAI (58.29 cm^2) followed by Zn_4B_3 (51.52 cm^2) which was statically similar to Zn_2B_2 (51.28 cm^2), Zn_2B_1 (51.09 cm^2) and Zn_4B_1 (48.82 cm^2). The lowest leaf area index (32.85 cm^2) was recorded from the plants treated with Zn_0B_0. Zinc had significant effect on leaf area index (Table 2). The maximum LAI (50.00 cm^2) was obtained from the plants under the treatment of Zn_4 (Zn @ 4 kg ha^{-1}) followed by Zn_2 (46.60 cm^2) and Zn_6 (41.43 cm^2) whereas it was minimum (36.94 cm^2) in the plants treated with Zn_0. Boron had also significant effect on leaf area index (Table 2). The plants treated with B_2 (B @ 2 kg ha^{-1}) had maximum LAI (48.60 cm^2) followed by B_1 (43.20 cm^2) which was statistically identical with B_3 (41.70 cm^2) and LAI was minimum (41.47 cm^2) in B_0 which was also statistically similar to B_3 (41.70 cm^2). This result was at par with that of Padma et al (2005) who reported higher leaf area index with boron application in French bean.

Days to first flowering

Days to first flowering did not vary significantly due to interaction effect of Zn and B (Table 1). Numerically it varied from 33.27 to 36.17 days. Flowering was the earliest (33.27 days) in the plants which treated with Zn_4B_1 and it was most delayed (36.17 days) in Zn_4B_3. There was no significant variation on days to first flowering due to the influence of Zn (Table 1). Numerically it varied from 34.31 to 34.78 days. A similar result is also displayed by Bhamare et al. (2018). Boron had significant effect on days to first flowering. Flowering was the earliest (34.38 days) in B_0 which was statistically identical with B_2 (34.44 days) and B_1 (34.51 days) while it was most delayed in B_3 (35.02 days).

Number of pod per plant

Number of pod/plant varied significantly due to interaction effect of Zn and B (Table 2). The plants under the treatment of Zn_4B_2 produced maximum number of pod/plant (8.83) closely followed by Zn_4B_1 (7.86) and it was minimum (4.86) in Zn_0B_0. Zinc had significant effect on number of pod/plant (Table 1). The maximum number of pod/plant (7.52) was obtained from the plants treated with Zn_4 (Zn @ 4 kg ha^{-1}) followed by Zn_2 (6.40) and Zn_0 (5.69) which were statistically similar to Zn_6 (5.67). These results are in harmony with that of Borah and Saikia (2021) who reported higher number of pod with foliar application of zinc in garden pea. Boron had also significant effect on number of pod/plant. The plants treated with B_2 (B @ 2 kg ha^{-1}) recorded the highest number of pod/plant (7.15) followed by the plants treated with B_1 (6.60) and B_0 (5.80) which was statistically identical with B_3 (5.72).

Pod yield per hectare at brown pod stage

Interaction effect of Zn and B on pod yield per hectare at brown pod stage was found significant (Table 2). The plants under the treatment of Zn_4B_2 produced maximum pod yield (8.94 t/ha) which was statistically similar to Zn_4B_3 (8.10 t/ha) while it was minimum (6.04 t/ha) in the plants which treated with Zn_0B_0. Significant variation on pod yield/hectare at brown pod stage was found significant due to influence of Zn (Table 1). The plants treated with Zn_4 (Zn @ 4 kg ha^{-1}) produced the maximum pod yield/hectare (10.07 tons) followed by Zn_6 (8.76 tons) which was statistically alike to Zn_2 (8.74 tons) and it was minimum (7.83 t/ha) in Zn_0. Similar observations have been reported by Borah and Saikia (2021). Pod yield per hectare at brown pod stage varied significantly due to influence of boron. The highest pod yield (9.46 t/ha) at brown pod stage was recorded from the plants treated with B_2 (B @ 2 kg ha^{-1}) which was statistically similar to B_1 (8.92 t/ha). The lowest pod yield (8.41 t/ha) was obtained from the plants treated with B_0 which was also statistically identical with B_3 (8.60 t/ha) and B_1 (8.92 t/ha) Similar observations have been reported by Islam *et al* (2018).

Table 3. Interaction effect zinc and boron on nutrient status of green seed of garden pea.

Treatment	Protein (%)	Phosphorus (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Ascorbic acid (mg/100g)	β-carotene (µg/100g)	Total sugar (%)
T_1- Zn_0B_0	22.67	148.48ab	237.10d	19.00c	14.94	285.30c	2.25bcd
T_2- Zn_0B_1	25.82	153.44ab	245.10a-d	27.00abc	16.56	352.00abc	2.55abc
T_3- Zn_0B_2	26.60	140.44b	240.30cd	19.00c	17.76	336.10abc	2.30bcd
T_4- Zn_0B_3	25.82	150.39ab	236.40d	22.67bc	19.34	346.70abc	2.12d
T_5- Zn_2B_0	25.03	154.94ab	254.00ab	27.00abc	18.20	320.30abc	2.35a-d
T_6- Zn_2B_1	28.18	160.21a	258.40a	35.00a	18.20	292.20bc	2.35a-d
T_7- Zn_2B_2	28.18	155.56ab	245.20a-d	25.00bc	18.20	391.30abc	2.49a-d
T_8- Zn_2B_3	28.18	155.56ab	245.20b-d	27.00abc	18.02	331.30abc	2.31a-d
T_9- Zn_4B_0	24.24	153.41ab	245.20b-d	27.00abc	17.58	376.40abc	2.39a-d
T_{10}- Zn_4B_1	26.60	157.13a	237.70d	29.00ab	18.20	363.60abc	2.65ab
T_{11}- Zn_4B_2	29.75	162.07a	258.40a	27.00abc	20.22	421.40a	2.44abcd
T_{12}- Zn_4B_3	28.17	159.05a	254.00ab	23.00bc	19.08	347.10abc	2.35a-d
T_{13}- Zn_6B_0	24.24	150.64ab	240.80bcd	21.00ab	17.32	306.90abc	2.53a-d
T_{14}- Zn_6B_1	26.60	155.28ab	244.30bcd	29.00ab	18.46	340.70abc	2.72a
T_{15}- Zn_6B_2	29.75	162.38a	251.80abc	35.00a	19.34	411.80ab	2.30bcd
T_{16}- Zn_6B_3	28.18	152.50ab	240.60bcd	27.00abc	18.20	322.20abc	2.24cd
LS	NS	**	**	*	NS	*	*
CV (%)	5.63	4.27	2.59	5.21	7.62	4.82	4.51

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability; * indicates significant at 1% level of probability; ** indicates significant at 1% level of probability; NS indicates non significant; LS indicates Level of Significance

Pod yield per hectare at green pod stage

Interaction effect of Zn and B on pod yield/hectare at green pod stage was found significant (Table 2). The plants under the treatment of Zn_4B_2 produced the highest pod yield/hectare (16.20 tons) followed by Zn_4B_1 (15.15 tons) which was statistically same to Zn_0B_2 (14.32 tons) while it was the lowest (10.64 t/ha) in Zn_0B_0. Significant variation was observed on pod yield per hectare at green pod stage due to influence of Zn (Table 1). The plants which treated with Zn_4 (Zn @ 4 kg ha^{-1}) recorded the highest pod yield/hectare (14.44 tons) followed by Zn_2 (12.83 tons) which was statistically alike to Zn_6 (12.67 tons) and it was the lowest (12.14 t/ha) in Zn_0. These results are in harmony with that of Borah and Saikia (2021) who reported higher pod yield with foliar application of zinc in garden pea. Pod yield/hectare at green pod stage varied significantly due to the influence of boron. The maximum pod yield (14.43 t/ha) was obtained from the crop which treated with B_2 (B @ 2 kg ha^{-1}) followed by B_1 (13.27 t/ha) and it was minimum (12.13 t/ha) in B_3 which was statistically similar to B_0 (12.23 t/ha). These results are in close conformity with Islam *et al* (2018) who reported higher pod yield in French bean with boron application.

Number of seed per pod

Interaction effect of Zn and B on number of seed/pod was found significant (Table 2). The plants under the treatment of Zn_4B_2 produced the highest number seed/pod (5.50) followed by Zn_4B_1 (5.16) which was statistically similar to Zn_2B_0 (5.03), Zn_2B_1 (4.86), Zn_2B_2 (4.90), Zn_2B_3 (5.00), Zn_4B_0 (5.03), Zn_4B_3 (4.96), Zn_6B_2 (5.03) and Zn_0B_2 (4.80) whereas it was the lowest (4.20) in Zn_0B_0. This result confirmed the findings of Hamsa and Puttaiah (2007). Significant variation on number of seed/pod was found due to application of Zn (Table 1). The plants which were treated with Zn_4 (Zn @ 4 kg ha^{-1}) produced the highest number of seed/pod (5.16) followed by Zn_2 (4.95) and Zn_6 (4.68) while it was the lowest (4.42) in the plants treated with Zn_0. Number of seed/pod also varied significantly due to application of boron. The maximum number of seed/pod (5.05) was produced by the plants treated with B_2 (B @ 2 kg ha^{-1}) followed by B_1 (4.76) which was statistically alike to B_3 (4.70) and B_0 (4.69).

Green seed yield per hectare

Green seed yield/hectare significantly influenced by the interaction of Zn and B (Table 1). The plants under the treatment of Zn_6B_2 produced the highest green seed yield/hectare (9.81 tons) which was statistically identical with Zn_4B_2 (9.48 tons) and it was the lowest (7.25 tons) in Zn_0B_0. The present results are in agreement with that of Alam *et al* (2010) who reported higher 1000 fresh seed weight with fertilizer application (N_{50} P_{26} K_{42} S_{12} & 1 kg/ha of Mo. B and Zn). Zinc had significant effect on green seed yield/hectare (Table 2). The plants which were treated with Zn_6 (Zn @ 6 kg ha^{-1}) recorded the highest green seed yield/hectare (8.58 tons) which was statistically similar to Zn_4 (8.44 tons) and Zn_2 (8.42 tons) while it was the lowest (7.76 tons) in Zn_0. Similar trend was also reported by Kasthurikrishna and Ahlawat (2000). Boron had significant effect on green seed yield/hectare (Table 2). The maximum green seed yield/hectare (9.13 tons) was obtained from B_2 (B @ 2 kg ha^{-1}) treatment followed by B_1 (8.42 tons) and B_0 (8.09 tons) which was statistically alike to B_3 (7.62 tons).

interaction of Zn and B. The tallest plant (50.80 cm), maximum number of primary branches/plant (5.33), the highest LAI (58.29 cm^2), maximum number of pod/plant (8.83), highest pod yield at green (16.20 t ha-1) and dry pod stage (8.94 t ha-1), highest number seed/pod (5.50) and maximum dry seed yield (3.97 tha-1) were recorded with the seeds of the plants treated with Zn_4B_2 (Zn @ 4 t and B @ 2 t ha-1). Whereas, maximum green seed yield ((9.81 tha-1) was recorded with the seeds of the plants treated with Zn_6B_2 (Zn @ 6 kg and B @ 2 kg ha^{-1}) but it was statistically at par with Zn_4B_2 (9.48 tons) regarding green seed yield. Márquez-Quiroz et al. (2015) reported that micronutrient application may enhance nutrition security through improving the grain quality in addition its role in increasing productivity.

Nutritional quality of garden pea:

Protein

Interaction effect on Zn and B on protein content of green seed was found insignificant (Table 4). Numerically it was maximum (29.75%) in Zn_4B_2 and minimum (22.67%) in Zn_0B_0.

Table 4. Effect of Zinc on nutrient status of green seed of garden pea

Treatment	Protein (%)	Phosphorus (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Ascorbic acid (mg/100g)	β-carotene (µg/100g)	Total sugar (%)
Zn_0	25.22	148.19b	239.70c	21.92b	17.15	330.00	2.31
Zn_2	27.39	156.57a	250.70a	28.50a	18.16	333.80	2.38
Zn_4	27.19	157.91a	248.80ab	26.50ab	18.77	377.10	2.46
Zn_6	27.19	155.20a	244.40bc	30.50a	18.33	345.40	2.45
LS	NS	*	**	**	NS	NS	NS
CV (%)	5.63	4.27	2.59	5.21	7.62	4.82	4.51
B0	24.04b	151.87	244.30b	26.00ab	17.01	322.20b	2.38ab
B1	26.80ab	156.51	246.40ab	30.00a	17.85	337.10b	2.57a
B2	28.57a	155.11	248.90a	26.50ab	18.88	390.10a	2.38ab
B3	27.59ab	154.37	244.10b	24.92b	18.66	336.80ab	2.26b
LS	*	NS	*	*	NS	*	*
CV (%)	5.63	4.27	2.59	5.21	7.62	4.82	4.51

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability; * indicates significant at 1% level of probability; ** indicates significant at 1% level of probability; NS indicates non significant;

Dry seed yield per hectare

Interaction effect of Zn and B was found significant on dry seed yield/hectare (Table 1). The plants which were treated with Zn_4B_2 produced maximum dry seed yield/hectare (3.97 tons) closely followed by Zn_4B_3 (3.65 tons), Zn_4B_1 (3.49 tons) and Zn_4B_0 (3.42 tons) where as it was minimum (2.77 tons) in Zn_0B_1. This results corroborates with the findings of Quddus et al (2018) who reported higher seed yield with combined application of Zn and B. Micronutrient enhanced the survival and multiplication of microorganism, more nitrogen fixation, transport of sugars and better uptake and assimilation of available nutrients by the plants during the entire growth period for higher yields. Similar observations have been reported by Valenciano et al. (2010). Significant variation on dry seed yield/hectare was found due to the influence of Zn (Table 2). The maximum dry seed yield/hectare (3.64 tons) was produced by the plants treated with Zn_4 (Zn @ 4 kg ha^{-1}) followed by Zn_2 (3.10 tons) and Zn_6 (2.97 tons) while it was minimum (2.85 tons) in Zn_0. Similar trend was also reported by Kasthurikrishna and Ahlawat (2000). Boron had significant effect on dry seed yield/hectare (Table 2). The plants under the treatment of B_2 (B @ 2 kg ha^{-1}) recorded the highest dry seed yield/hectare (3.34 tons) followed by B_1 (3.11 tons) which was statistically similar to B_3 (3.07 tons) while it was the lowest (3.04 tons) in the plants treated with B_0. Boron influences reproductive growth of crop (Chatterjee and Bandyopadhyay, 2015).

Results reveal that all the Growth and yield parameter of garden pea except days to first flowering responded significantly due to

This result corroborates with the findings of Quddus et al (2018) who reported higher protein content with Zn3B2 kg ha -1 in French bean. Protein content of green seed did not vary significantly due to the effect of Zn (Table 3). Numerically it was maximum (27.39%) in green seeds of plants which were treated with Zn_2 and it was minimum (25.22 %) in Zn_0. Proper doses of zinc application may enhance the synthesis of carbohydrates, nutrient and protein content and their transport to the site of seed formation (Mali et al., 2003). Boron had significant effect on protein content of green seeds of garden pea. The seeds of the plants treated with B_2 (B @ 2 kg ha^{-1}) contained the highest amount of protein (28.57%) which was statistically at par with B_3 (27.59%) and B_1 (26.80%) while it was the lowest (24.04%) in B_0. Similar observations have been reported by Quddus et al (2018).

Phosphorus

Interaction effect of Zn and B on phosphorus content of green seed was found significant (Table 4). The seeds of the plants treated with Zn_4B_2 showed the highest amount of phosphorus (162.07 mg/100g) which was statistically identical with all treatment combination except Zn_0B_2 (140.44 mg/100g). Similar observations have been reported by Quddus et al (2018). Phosphorus content of green seed varied significantly due to the influence of Zn (Table 3). Phosphorus content of seed was maximum (157.91 mg/100g) when the plants treated with Zn_4 (Zn @ 4 kg ha^{-1}) which was statistically alike to Zn_2 (156.57 mg/100g) and Zn_6 (155.20 mg/100g) while it was minimum (148.19 mg/100g) in Zn_0. Similar observations have been reported by Quddus et al (2018). Variation in phosphorus content of green seed was found non-significant due to influence of B. Numerically it varied from 151.81 to 156.51 mg/100g.

Potassium

Potassium content of seeds of garden pea significantly influenced by the interaction of Zn and B (Table 4) The seeds of the plant treated with Zn_4B_2 and Zn_2B_1 contained maximum amount of potassium (258.40 mg/100g) which was statistically similar to Zn_4B_3 (254.0 mg/100g), Zn_2B_0 (254.00 mg/100g), Zn_6B_2 (251.80 mg/100g) Zn_2B_2 (245.20 mg/100g) and Zn_0B_1 (245.10 mg/100g) while it was minimum (236.40 mg/100g) in Zn_0B_3. Similar observations have been reported by Quddus et al (2018). Zinc had significant effect on potassium content of green seed (Table 3). The seeds of the plants under the treatment of Zn_2 (Zn @ 2 kg ha^{-1}) had maximum amount of potassium (250.70 mg/100g) which was statistically at par with Zn_4 (248.80 mg/100g) and it was minimum (239.70 mg/100g) in the seeds of plants treated with Zn_0. Similar observations have been reported by Quddus et al (2018). Significant variation on potassium content of seed was found due to the effect of B. The highest content of potassium (248.90 mg/100g) was found in the seeds of plants treated with B_2 (B @ 2 kg ha^{-1}) which was statistically alike with B_1 (246.40 mg/100g) while it was the lowest (244.10 mg/100g) in B_3 which was also statistically at par with B_0 (244.30 mg/100g) and B_1 (246.40 mg/100g). Similar observations have been reported by Quddus et al (2018).

Calcium

Calcium content of seeds significantly influenced by the interaction of Zn and B (Table 4). The seeds of the plants treated with Zn_6B_2 and Zn_2B_1 had maximum amount of calcium (35.00 mg/100g) which was statistically identical with all treatment combinations except Zn_4B_3 (23.00 mg/100g), Zn_2B_2 (25.00 mg/100g), Zn_0B_3 (22.67 mg/100g), Zn_0B_2 (19.00 mg/100g) and Zn_0B_0 (19.00 mg/100g). Similar observations have been reported by Quddus et al (2018). Zinc had significant effect on calcium content of seed (Table 3). The seeds of the plants treated with Zn_6 (Zn @ 6 kg ha^{-1}) had maximum content of calcium (30.50 mg/100g) which was statistically at par with Zn_2 (28.50 mg/100g) and Zn_4 (26.50 mg/100g) while it was minimum (21.92 mg/100g) in Zn_0 which was also statistically similar to Zn_4 (26.50 mg/100g). Similar observations have been reported by Quddus et al (2018). Significant variation on calcium content of seed was found due to influence of boron. The highest content of calcium (30.00 mg/100g) was found in the seeds of plants treated with B_1 (B @ 1 kg ha^{-1}) which was statistically identical with B_2 (26.50 mg/100g) and B_0 (26.00 mg/100g) while it was the lowest (24.92 mg/100g) which was also statistically similar to B_2 (26.50 mg/100g) and B_0 (26.00 mg/100g). Similar observations have been reported by Quddus et al (2018).

Ascorbic acid

Interaction effect of Zn and B was also found insignificant on ascorbic acid content of seed. Numerically it varied from 14.94 to 20.22 mg/100g (Table 1). Zinc had no significant effect on ascorbic acid content of seed (Table 2). Numerically it varied from 17.15 to 18.77 mg/100g. Boron had no significant influence on ascorbic acid content of seed. Numerically it varied from 17.01 to 18.88 mg/100g) (Table 2).

β-carotene

Β-carotene content of seeds significantly varied due to the interaction effect of Zn and B (Table 4). The seeds of the plants treated with Zn_4B_2 had maximum amount of β–carotene (421.40 µg/100g) which was statistically similar to all treatment combinations except Zn_2B_1 (292.20 µg/100g) and Zn_0B_0 (285.30 µg/100g). Zinc had no significant influence on β–carotene content of seed (Table 3). Numerically it ranged from 330.00 to 377.10 µg/100g. Significant variation on β–carotene content of seed was found due to influence of B. The highest amount of β–carotene (390.10 µg/100g) was found in the seeds of plants treated with B_2 (B @ 2 kg ha^{-1}) which was statistically identical with B_3 (336.80 µg/100g) while it was the lowest (322.20 µg/100g) in B_0 which was also statistically similar to B_1 (337.10 µg/100g) and B_3 (336.80 µg/100g).

Total sugar (%)

The percentage of total sugar of seeds significantly varied due to the interaction effect of Zn and B (Table 4). The seeds of the plants treated with Zn_6B_1 had maximum percentage of total sugar (2.72) which was statistically identical with Zn_0B_1 (2.55%), Zn_2B_0 (2.35%), Zn_2B_1 (2.35%), Zn_2B_2 (2.49%), Zn_2B_3 (2.31%), Zn_4B_0 (2.39%), Zn_4B_1 (2.65%), Zn_4B_2 (2.44%), Zn_4B_3 (2.35%) and Zn_6B_0 (2.53%). The minimum percentage of total sugar (2.12) was found in the seeds of plants treated with Zn_0B_3. Zinc had no significant effect on the parentage of total sugar (Table 3). Numerically it varied from 2.31 to 2.46%. Significant variation on the percentage of sugar was found due to the effect of boron. The highest percentage of total sugar (2.57) was found in the seeds of plants treated with B_1 (B @ 1 kg ha^{-1}) which was statistically similar to B_2 (2.38%) and B_0 (2.38%) while it was the lowest (2.26%) in B_3 which was also statistically at par with B_2 and B_0.

Results reveal that all the Nutritional quality of garden pea except protein and ascorbic acid responded significantly due interaction of Zn and B. The highest amount of phosphorus (162.07 mg/100g), maximum amount of potassium (258.40 mg/100g) and maximum amount of β–carotene (421.40 µg/100g) were recorded with the seeds of the plants treated with Zn_4B_2 (Zn @ 4 t and B @ 2 t ha-1). Whereas, maximum amount of calcium (35.00 mg/100g) were recorded with the seeds of the plants treated with Zn_6B_2 (Zn @ 6 kg and B @ 2 kg ha^{-1}) and Zn_2B_1 (Zn @ 2 kg and B @ 1 kg ha^{-1}) but it was statistically at par with Zn_4B_2. As well as maximum percentage of total sugar (2.72) were recorded with the seeds of the plants treated with Zn_6B_1 (Zn @ 6 kg and B @ 1 kg ha^{-1}). Márquez-Quiroz et al. (2015) reported that micronutrient application may enhance nutrition security through improving the grain quality in addition its role in increasing productivity. Karim (2016) reported that combined application of Zn, B and Mo contributed to higher nutrient contens (5.04% N, 0.36% P, 0.86% K, 0.34% S, 72.4 ppm Zn and 41.5 ppm B) in lentil seed.

Conflict of interest

The authos declare there is no conflict of interest.

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