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EFFECT OF BORON ON GROWTH AND SEED YIELD OF PEA CULTIVARS

Izhar Ullah[1*], Mithat DİREK[2], Dina Chamidah[3]

*[1]Centre of Plant Biodiversity and Conservation, University of Peshawar, Peshawar Pakistan-25120
[2]Selçuk Üniversitesi, Ziraat Fakültesi, Tarım Ekonomisi Bölümü, Cad. No: 369, Konya/Türkiye-442130
[3]Department of Biology Education, Faculty of Teacher Training and Education, Universitas Wijaya Kusuma Surabaya, Surabaya, East Java, Indonesia

E-mail: izharullah@uop.edu.pk, mdirek@selcuk.edu.tr, dinachamidah_fbs@uwks.ac.id

ABSTRACT

An experiment was conducted to know the "Effect of boron on growth and seed yield of pea cultivars" under the agro climatic conditions of Palosi Peshawar at the Horticulture Research Farm, The University of Agriculture Peshawar, during 2022. Experiment was laid out in randomized complete block design with split plot arrangement and replicated three times. The experiment consisted of two factors: First factor was different levels of boron, control, 0.50%, 0.75%, 1.0 %, and boron were added to the main plot, while the other was the pea cultivars Climax, Leena Pak, and Meteor, which were planted in the sub-plot. Different pea cultivars and the foliar application of boron both have a significant impact on pea growth, yield, and seed production. The number of primary branches per plant (13.1), the number of leaves per plant (120.8), the height of the plant (103.5 cm), number of pods per plant (16.6), the length of pod (11.1 cm), the diameter of pod (13.8 mm), number of seeds per pod (10.3), seed yield per plant (160.5), root fresh weight (4.6 g) and the total yield per hectare were all significantly increased by foliar spray of boron. According to the research, foliar application of boron should be applied at a rate of 0.75 % for better growth and production. Pea cultivar Climax should be grown under the agro climatic conditions Peshawar.

Keywords: *Boron, growth and seed yield, pea cultivars.*

I. INTRODUCTION

Garden pea (Pisum sativum L.) is a cool season vegetable crop of the family Fabaceae. It is one of the major, highly valued and extensively cultivated legume crops throughout the world. Globally, it is grown in approximately 5.5 million hectares per year and ranks as the third most important grain legume crop after soybean and common bean (Rana et al., 2017). A single or two flowers per peduncle are seen in the majority of cultivars, while other genotypes have three or more flowers per peduncle. Peas are planted for their succulent, nutritious green seeds as well as the benefits they provide to soil fertility. It is enriched with protein, vitamins, and minerals. Hundred grams of green pea contains protein (7.3 g), carbohydrates (14.6 g), vitamin A (138 mg), vitamin C (10 mg), calcium (21 mg) and phosphorous (140 mg) (Khichi et al., 2016).

Pea is mostly cultivated as a cool season legume crop on more than 25 million acres around the globe. Pea is mostly grown in Russia and China, with Australia, Canada, European countries, and the United States following closely after the United States, However, Europe is the leading exporter of peas, followed by Australia, Canada, and the United States (Ashraf et al., 2011). Garden peas can be harvested before they reach seed maturity, while snow peas and snap peas can be harvested pre mature for the fresh market because inner pod is lacking fibers and parchment. On the other hand, field pea is harvested after seed maturity. Its seeds are consumed by livestock. It is mostly used as ornamental pea because of pinkish purple flowers as compared to garden pea which has mostly white flowers maturity (Elzebroek and Wind, 2008).

Peas may be cultivated in a variety of soils. However, well-drained sandy loam soil is preferable to heavier soils since it matures faster on well-drained soils. Draining excess water from the root zone could help to prevent disease and infection. Powdery mildew is the most frequent disease that affects peas (Falloon et al., 2001). Pea is a popular cash crop, accounting for 40% of pulses trade after soybeans, groundnuts, and beans, Peas are grown in numerous countries throughout the world, in both sub-tropical and temperate climates (Khan et al., 2002). The ideal temperature for pea seed germination is around 22 °C (Hartmann et al., 1988). pH levels should be between 5.5 and 7.0. Sowing at a depth of 1.5 to 2 cm and spacing of rows 30 to 45 cm, it produces superior product (Elzebroek and Wind, 2008).

Pea was grown on a total of 24854 hectares in Pakistan in 2018-19, with a total production of 170836 tonnes. Peas were planted on 1959 hectares in Khyber Pakhtunkhwa, yielding 15789 tones. Pea was grown on a total of 19865 hectares in Punjab, with a total yield of 134657 tonnes. Sindh produced 7528 tonnes of peas, which were grown on 1904 hectares. The pea was cultivated on 1126 hectares in Balochistan, with a total harvest of 12862 tonnes (MINNFSR, 2019). In plain regions of Khyber Pakhtunkhwa, it is usually grown as a winter vegetable, whereas in hilly areas, it is mostly grown as a summer vegetable. Pakistan has a low average green pod production of peas (7.2 tonnes ha-1) when compared to numerous other nations where the average yield is over 11 tones ha-1 (Amjad and Anjum, 2002).

Micronutrients are well-known for acting as a stimulant in plant organic reactions, as well as in the development of plant condition. Plant's resistance to environmental pressure can be improved by using micronutrients. Foliar spray is a good way to apply certain micronutrients because they are only used in small amounts (Patil et al., 2013). Foliar applications of micronutrients give excellent crop nourishment at anthesis and stage of seed filling that sequentially boost the yield (Karthick et al., 2017).

Foliar application is a very good method of applying water-soluble fertilizers to the leaves of the plants. A technique of feeding plants with liquid fertilizers is known as foliar fertilization. It was discovered that feeding plants with liquid fertilizers are more beneficial than soil application for different micro nutrients like Zn, Fe and B (Dixon, 2003). Single nutrient less in concentration than the needs of the plant

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causes problem in proper production of a crop, since metabolic pathways get seriously affected. Different plants require different concentration of nutrients for their proper growth, below which their growth may retarded. Such lack of nutrient can be given in the form of foliar fertilization (Alam et al., 2010).

For foliar fertilization, only the fertilizers that can be dissolved in water. If fertilizers applied more in concentration than plants need it may cause leaf spots, scorch and tip burn. To avoid. dead areas between the veins and margins of leaves low concentration of liquid fertilizers are mostly used. As compared to the soil application, feeding plants with liquid fertilizer is laborious. If the nutrient sprayed has a low capacity of movement in the plants, flushes may develop after the application which may have symptoms of deficiency (Fagaria, 2009).

Nutrient deficiency mostly arises in crop during the critical stages of crop growth which badly affects crop yield. For such situations foliar fertilization is the best way to overcome the deficiency. Availability of soil-applied nutrients is influenced by various factors of soil but nutrients applied by foliar spray penetrate the leaf cells fast and reach the cytoplasm of cells. High amount of nutrients if present in the soil decreases the seasonal nutrients availability to the plants. Sandy soils that are prone to nutrient loss due to leaching, diminish the low efficiency of nutrients given to the soil. High soil temperature and reduces the nutrient uptake by the plants. As the soil temperature increases the moisture of soil decreases which in turn wastes the nutrients applied to the soil. As a result, the normal function and growth of plants are disrupted and crop yields are reduced. Due to low soil moisture the general response is reflected in a reduction plant size, fruit size, leaf area and harvested yield (Shabnam and Kuruwanshi, 2015).

Deficiency of boron (B) is common in high calcarious soils, lime acid soils, lateritic soils and sandy leached soils. The availability of B is very important during the whole growing crop period. As B is not bound to clay and organic matter particles and leaches easily through the soil profile. However, foliar fertilization is the best way to overcome deficiency of B (Kuruppaiah, 2005). B is the most important nutrient for crop growth, development, yield, seed yield and quality. It is primarily involved in structural integration and cell wall synthesis in plants also have a role in different functions (Brown et al., 2002). The needs of growing tissues for B proves its importance in elongation and cell division (Dell and Huang, 1997). Root elongation is severely hampered by lack of B, with deformed fruit formation, whereas adequate B supply promotes root development (Gupta and Solanki, 2013).

B is an essential microelement required for growth and development of vascular plants. B promotes pollen germination by affecting H^+ -ATPase activity, which initiates pollen germination and pollen tube growth (Feijo et al., 1995, Obermeyer and Blatt 1995). B deficiency symptoms first appear at growing points, such as root tips and pollen tube tips (Loomis and Durst 1992). B deficiency reduces pollen germination rate, leading to retardation of pollen tube growth. B deficiency also causes morphological abnormalities, including swelling at the tip of the pollen tube. Similar findings have been reported for pollen tubes in several angiosperm species (Dickinson 1978, Yang et al., 1999).

Considering the above-mentioned facts, the present research work was planned to test the effect of boron on growth and seed yield of pea cultivars with the following objectives.

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Objectives:

1. To evaluate the optimum level of boron for the growth and yield of pea.
2. To determine which pea cultivars performs better under the agro-climatic conditions of Peshawar.
3. To determine the interaction of boron and cultivars on the growth and yield of pea.

II. METHODS

An experiment "Effect of boron on growth and seed yield of pea cultivars" was conducted during winter season of 2022 at Horticulture Research Farm Malakandhair, The University of Agriculture Peshawar.

2.1. Experimental design

The experiment was comprised of two factors. Boron was one factor, while cultivars was the second factor and was laid out in Randomized Complete Block design with a split plot arrangement having 12 treatments, which were replicated three times. The total numbers of experimental units were 36.

Factor A: Boron (%) (Main plot)

B0 : Control (0%)
B1 : 0.50
B2 : 0.75
B3 : 1.00

Factor B: Pea Cultivars (Sub plot)

C1 : Leena Pak
C2 : Meteor
C3 : Climax

Factor A contains different Boron levels such as Control, 0.50%, 0.75%, 1.00%.
Factor B contains different cultivars of pea (Leena Pak, Meteor, Climax).

2.2. Experimental procedure

2.2.1. Preparation of the field

Before sowing of seeds in the field, different cultural techniques such as ploughing and weeding were done for field preparation. The field was laid laid out according to the experimental layout, that had three replications and a total of 12 main plots. Before sowing, fertilizer was applied to the soil at a rate of 50:25:25 kg ha-1 NPK. Pea cultivar seeds were sown in the field on 18th October 2022 using these processes, with R×R spacing of 50 cm and a P×P distance of 20 cm. To maintain the recommended plant population, thinning and weeding was done on regular basis.

2.2.2. Preparation of boron foliar spray

For the preparation of foliar spray of boron (B). Boric acid (H3BO3) was used as source of B. For 0.5 % of boron, 2.86g of H3BO3 was mixed in one liter of water and transferred to the spray bottle. The same procedure was used for other levels of B. The plants were sprayed two times. First spray was applied 25 days after sowing and the second spray was applied 10 days after the first spray. Plants were sprayed until the mixture starts dripping from the leaves.

2.2.3. Parameters studied

The following parameters were studied in the experiment.

Days to emergence

Days from the date of sowing to emergence were counted of each pea cultivar and the mean was calculated.

Plant height (cm)

Before harvesting, the height of each pea plant was measured using a measuring tape through random selection of five plants in every treatment and replication and then their average was calculated.

Number of primary branches plant-1

Numbers of primary branches plant-1

were recorded in five randomly selected plants per treatment in all replications at the end of the experiment and then their mean was calculated.

Number of leaves plant-1

Through random selection of five plants per treatment, number of leaves plant-1 were counted in all replications and then their average was calculated.

Days to flowering

Days were counted from sowing to blooming for five randomly selected plants in each treatment and replication. Further, the average for days to flowering was calculated.

Days to pod formation

The days from blossoming to emergence of pod were recorded for each pea cultivar, and the mean was calculated.

Number of pods plant-1

Numbers of pods plant-1 were counted in five randomly selected plants per treatment of all replications and then their mean was calculated.

Pod length (cm)

Through random selection of five plants, pod length was measured with a measuring tape in every treatment of each replication and then their mean was calculated.

Pod diameter (cm)

The average diameter of 20 fully matured pods of five randomly selected plants of each treatment in each replication was measured using vernier caliper, and the average was calculated.

Chlorophyll content (SPAD)

In each treatment, dust particles were removed from the leaves of five plants chosen at random. The amount of chlorophyll was measured with a SPAD meter. The selected plants were used to calculate the average.

Seeds pod-1

For number of seeds pod-1 selected randomly five pods in five plants in every treatment were selected and then their average was calculated.

Seed yield plant-1

Through random selection of five plants per treatment in e-ach replication, number of seeds plant-1 were counted in all replications and then their average was calculated.

Root weight (g)

Average root weight of five randomly selected plants in each plot for each replication were measured with the help of electronic balance then their mean was calculated.

Total yield (tons ha-1)

The total yield in ton ha-1 was calculated using the formula below.

$$Total\ yield\ (ton\ ha^{-1}) = \frac{Yield\ of\ plot\ (kg)}{Area\ of\ plot\ (m^2)} \times \frac{10{,}000m^2}{1000(kg)}$$

Statistical analysis

With the help of the statistical tool statistix version 8.1, the ANOVA was calculated after all of the data has been analyzed. A least significant test (LSD) was used whenever the data is significant. (Steel and Torrie, 1997). STATISTIX 8.1 statistical program was used to measure LSD and ANOVA.

III. RESULTS AND DISCUSSION

Effect of boron on growth and seed yield of pea cultivars was studied at Horticultural Research Farm, Malakandhare, The University of Agriculture Peshawar, during the year 2022. Various growth and yield contributing parameters were examined during the research that were days to emergence, plant height (cm), number of primary branches plant-1, number of leaves plant-1, days to flowering, days to pod

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formation, number of pods plant-1, pod length (cm), pod diameter (cm), chlorophyll content (SPAD), seeds pod-1, seed yield plant-1, root weight (g) and total yield (tons ha-1). Data regarding different parameters are presented in Table 1a to 14a, while the analysis of variance (ANOVA) are presented in Table 1a to 14a for various parameters and replicated data are displayed in appendices I to XIV. The findings of the experimental results are discussed and presented below.

Days to emergence

The days to emergence data are presented in Table 1a and the analysis of variance is given in Table 1b, while the Appendix I represents the replicated data. Table 1a exhibited that days to emergence was significantly affected by pea cultivars.

The days to emergence of three different pea cultivars revealed that cultivar Climax had the maximum days to emergence (10.1 days), followed by cultivar Meteor with (8.3 days) and cultivar Leena Pak with the minimum days to emergence (6.0 days).

Significant variation among pea cultivars was observed for days to emergence. The results are in agreement with the findings of Shah et al. (2016). They assessed genetic differences among seven pea cultivars including one local cultivar namely Meteor. They also reported significant differences among studied material for days to emergence. Genetic differences among pea cultivars were also reported by Azmat et al. (2011) and Kumar et al. (2016). They also reported high degree of genetic diversity among pea cultivars for days to emergence. Days to emergence in most of the cases determine crop maturity. The cultivars which take lesser number of days to emergence usually mature earlier. Monpara and Dhameliya (2013) and Kosev (2013) reported that early maturing traits play vital role in the adaptation of cultivars to environments and cropping systems and have positive impact on yield.

Table 1a. Days to emergence of pea cultivars.

Cultivars	R_1	R_2	R_3	Mean
Leena Pak	6.02	5.4	6.45	6.0 C
Climax	9.75	10.06	10.3	10.1 A
Meteor	8.08	8.35	8.4	8.3 B

LSD ($P \leq 0.01$) for cultivar (C) = 1.02

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 1b. Analysis of variance for days to emergence of pea cultivars.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	1.611	0.8053		
Cultivar	2	100.117	50.0586	59.94	0.0000
Error	31	25.891	0.8352		
Total	35	127.619			

CV = 11.29 %

Plant height (cm)

Mean values of plant height (cm) and its ANOVA are given in Table 2a and 2b respectively, while the Appendix II provides the replicated data. Table 2b exhibited that plant height (cm) was significantly influenced by boron as well as pea cultivars, while the interaction of boron and pea cultivars was found non-significant.

Among the different levels of boron,

the taller plants (103.5cm) were observed at 0.75% of boron, closely followed by at 0.50% of boron (88.5cm), while shorter plants (62.1cm) were noticed in the control.

The plant height of three different pea cultivars revealed that cultivar Climax had the maximum plant height (98.6cm), followed by cultivar Leena Pak with (84.9cm), and cultivar Meteor with the minimum plant height (62.1cm).

Growth parameters were significantly affected by foliar spray of boron in both growing seasons, the concentration of 10 ppm gave the tallest plants, the highest number of leaves, number of branches, leaf area and chlorophyll content as well as the largest plant fresh weight in both seasons, whereas the untreated plants produced the lowest value of each character. The improving effects of boron may be attributed to the direct action of boron on the development of N-fixing root nodules (Bolanos et al., 1994) and translocation of sugars through cellular membranes (Dugger and Palmer, 1983), Similar finding have been reported Bakry et al., (1987). Singh et al., (1992) and Bin Ishaq, (2002) stated that spraying pea plants with various concentrations of boron resulted in more vigorous vegetative growth compared with the untreated ones. Similar finding have been reported by Prasad et al. (1998).

Boron foliar application helps in synthesis of auxin, cell differentiation and cell elongation of plants. The increase in height of plant might be due to effective role of micronutrients. Boron has also a necessary role in the plant for the growth and development of new cells. For synthesis of amino acids and protein boron is very necessary for plants also help in regulation of metabolism and carbohydrate (Dyar and Webb, 1961). It helps in photosynthesis which might have resulted in better vegetative growth. These results confirm the findings reported by Hatwar et al. (2003). The results are in partial agreement with the findings of kiran et al., (2010).

Table 2a. Plant height (cm) of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena pak	64.1	90.1	105.1	80.2	84.9 B
Climax	74.1	105.1	125.1	90.1	98.6 A
Meteor	48.1	70.1	80.1	50.2	62.1 C
Mean	62.1 D	88.5 B	103.5 A	73.5 C	

LSD (P≤0.01) for boron (B) = 8.83

LSD (P≤0.01) for cultivar (C)= 6.00

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 2b. Analysis of variance for plant height (cm) of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	50.8	25.42		
Boron level	3	8724.4	2908.14	113.80	0.0000
Error 1	6	153.3	25.56		
Cultivar	2	8155.3	4077.63	160.95	0.0000
Boron× Cultivar	6	377.0	62.84	2.48	0.0686
Error 2	16	405.4	25.34		

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Total	35	17866.3

CV main plot = 6.17 %

CV sub plot = 6.15 %

Number of primary branches plant-1

Mean values of number primary of branches-1 and its ANOVA are given in Table 3a and 3b respectively, while the Appendix III provides the replicated data. Table 3ba exhibited that number primary of branches-1 was significantly influenced by boron as well as pea cultivars, while the interaction of boron and pea cultivars was found non-significant.

Table 3a indicates that maximum mean values of number of primary branches-1 (8.9) were observed at 0.75% of boron, closely followed by (10.1) at 0.50% of boron. While, the minimum number of primary branches-1 (6.1) was reported in control.

The number primary of branches-1 of three different pea cultivars revealed that cultivar Climax had the maximum number primary of branches-1 (11.4), followed by cultivar Leena Pak with (9.4), and cultivar Meteor with the minimum number primary of branches-1 (7.3).

Application boron as a foliar spray had significant influence on the number primary of branches plant' as mentioned by Denre et al., (2014) also who reported boron also help in meristematic growth of plants. By the foliar spray of boron, the significant increase was noted in branches. When plant height is good it develops maximum branches. Growth parameters were significantly affected by foliar spray of boron in both growing seasons, the concentration of 10 ppm gave the tallest plants, the highest number of leaves, number of branches, leaf area and chlorophyll content as well as the largest plant fresh weight in both seasons, whereas the untreated plants produced the lowest value of each character. The improving effects of boron may be attributed to the direct action of boron on the development of N-fixing root nodules (Bolanos et al., 1994).

Sharma (1995) also said that tomato crop maximizes the branches when boron is applied at high dose as compared to lower dose. The similar results were reported by Malawadi (2003) by treating the chilli seedlings with micro nutrients. Hatwar et al. (2003) also reported that the spraying of boron along with recommended dose of NPK caused maximum number of branches per plant. Dutta et al., (1984) also observed that application of 1 Kg B/ha increased in leaf area ratio, leaf area index, number of branches/plant, number of pods/plant. Boron has a beneficial effect on morphological characters in different crop plants. Sinha et al. (1994) conducted an experiment on the effect of boron on morphological characters in lentil and showed that primary branches plant-1 and pods-1 increased significantly due to application of boron.

Table 3a. Number of primary branches plant-1 of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	6.1	10.1	13.1	8.1	9.4 B
Climax	8.1	12.2	15.1	10.1	11.4 A
Meteor	4.1	8.1	11.1	5.7	7.3 C
Mean	6.1 D	10.1 B	13.1 A	8.0 C	

LSD (P≤0.01) for boron (B) = 1.18

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LSD (P≤0.01) for cultivar (C) = 0.82

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 3b. Analysis of variance for number of primary branches plant-1 of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	1.236	0.6181		
Boron level	3	243.935	81.3115	175.79	0.0000
Error 1	6	2.775	0.4625		
Cultivar	2	101.121	50.5603	105.77	0.0000
Boron× Cultivar	6	0.228	0.0379	0.08	0.9975
Error 2	16	7.648	0.4780		
Total	35	356.942			

CV main plot = 7.28 %

CV sub plot = 7.40 %

Number of leaves plant-1

Mean values of number of leaves plant-1 and the analysis of variance data are presented in Table 4a and 4b, respectively, while the Appendix IV provides the replicated data. Table 4b exhibited that chlorophyll content was significantly affected by boron and pea cultivars, while the interaction of boron and pea cultivars was found non-significant.

The usage of boron had a significant impact on pea cultivars plant-1 leaf count. Plants given at 0.50% of boron had the second-highest number of leaves plant-1 (104.5), while plants treated with 0.75% of boron had the greatest number of leaves plant-1 (120.8). The control treatment, however, show that plant had fewest leaves (73.1).

The cultivar Climax of pea had maximum number of leaves plant-1 (114.9), followed by cultivar Leena Pak with the second highest number of leaves plant-1 (97.6), while Meteor cultivar had minimum number of leaves plant-1 (77.2).

An experiment carried out by Moghazy et al. (2014) to study the influence of a foliar application of boron improve vegetative growth traits of green pea, i.e., plant length, number of leaves, number of branches, fresh weight per plant, relative growth rate, yields and its components had high significant values by foliar spraying with boron. Growth parameters were significantly affected by foliar spray of boron in both growing seasons, the concentration of 10 ppm gave the tallest plants, the highest number of leaves, number of branches, leaf area and chlorophyll content as well as the largest plant fresh weight in both seasons, whereas the untreated plants produced the lowest value of each character. The improving effects of boron may be attributed to the direct action of boron on the development of N-fixing root nodules (Bolanos et al., 1994) and translocation of sugars through cellular membranes (Dugger and Palmer, 1983). Bin Ishaq, (2002) stated that spraying pea plants with various concentrations of boron resulted in more vigorous vegetative growth compared with the untreated ones. Similar finding have been reported by Prasad et al. (1998).

Table 4a. Number of leaves plant-1 of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	75.1	105.1	120.2	90.1	97.6 B
Climax	82.1	122.1	140.1	115.1	114.9 A
Meteor	62.1	86.1	102.1	58.4	77.2 C
Mean	73.1 D	104.5 B	120.8 A	87.9 C	

LSD ($P\leq0.01$) for boron (B) = 14.61
LSD ($P\leq0.01$) for cultivar (C)= 9.96

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 4b. Analysis of variance for number of leaves plant-1 of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	139.0	69.49		
Boron level	3	11466.6	3822.21	54.67	0.0001
Error 1	6	419.5	69.92		
Cultivar	2	8537.7	4268.87	61.17	0.0000
Boron× Cultivar	6	1040.1	173.35	2.48	0.0683
Error 2	16	1116.6	69.79		
Total	35	22719.5			

CV main plot = 8.66 %
CV sub plot = 8.65 %

Days to flowering

Mean values of days to flowering and analysis of variance are given in Table 5a and 5b respectively, while the Appendix V represents the replicated data. Statistically analyzed data showed that both boron and pea cultivars have significantly affected days to flowering of pea, while the interaction of boron and pea cultivars was found non-significant.

According to the mean values of days to flowering of pea treated with different levels of boron application, maximum days to flowering (44.5) was recorded in control plants, followed by 41.1 days at 1.0 % of boron, while lowest days to flowering (33.8) was reported at 0.75% of boron.

Mean values regarding pea cultivars revealed that the maximum days to flowering (42.4 days) were found in cultivar Climax, followed by cultivar Meteor with 39.9 days, while minimum days to flowering (36.6 days) was noted in cultivar Leena Pak.

Applying B as foliar spray at pre-flowering stage resulted in early flowering compared to control plots with no application of boron in ridge gourd. Similar results of early female flowering were reported by Vala and Savaliya (2014) in bitter gourd. Pandy et al., (2013) reported the importance of boron in inducing flowering. They observed that plants with boron deficiency showed delayed flowering and applying boron as foliar spray reduced days to flowering. The optimum application of micronutrients boron increased the plant nutrient concentration which promoted healthy growth and initiated early flowering. In plant cells boron is needed by many types of proteins and is part of the protein involved in the regulation of the time of flowering (Robson et al., 2001). Our results are in line with Narayanamma et al. (2009) and Fozia et al., (2018) who reported that the foliar spray of 5mg boric acid at three leaf stage reduced days to first flowering in bitter gourd.

Table 5a. Days to flowering of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	42.1	37.1	28.1	39.1	36.6 C
Climax	47.1	41.1	38.1	43.1	42.4 A
Meteor	44.1	39.1	35.1	41.1	39.9 B

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Mean	44.5 A	39.1 C	33.8 D	41.1 B

LSD (P≤0.01) for boron (B) = 3.50

LSD (P≤0.01) for cultivar (C) = 2.41

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 5b. Analysis of variance for days to flowering of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	8.265	4.132		
Boron level	3	540.669	180.223	44.69	0.0002
Error 1	6	24.195	4.032		
Cultivar	2	200.288	100.144	24.33	0.0000
Boron× Cultivar	6	45.273	7.545	1.83	0.1557
Error 2	16	65.856	4.116		
Total	35	884.545			

CV main plot = 5.07%

CV sub plot = 5.12%

Days to pod formation

Mean values of days to pod formation and its ANOVA are given in Table 6a and Table 6b, while the Appendix VI provides the replicated data. Statistically analyzed data showed that both boron and pea cultivars have significantly affected days to pod formation of pea, while the interaction of boron and pea cultivars was found non-significant.

According to the mean values of different levels of boron, maximum days to pod formation (9.4 days) was recorded in control plants, followed by 7.8 days at 1 % of boron, while lowest days to pod formation (4.2 days) was recorded at 0.75 % of boron.

Significant variations in days to pod formation were noted for in three different pea cultivars. The maximum days to pod formation was observed (8.2 days) in cultivar Climax, followed by cultivar Meteor with 7.0 days. Although the minimum days to pod formation (5.7 days) was noted in cultivar Leena Pak.

Days to pod formation were significantly affected by boron levels. Plants treated foliar application of boron took the less time to develop pods, which might be due to the transport of nutrients to the needed tissue (Manivannan et al., 2009). The results are in line with (El-Aal at el. 2018) who reported that the earlier pods are produced in soybean plants when sprayed with foliar application of boron in contrast to untreated plants. The outcomes are also in line with the findings of Manivannan et al., (2009), who described that beans plant when treated with boron earlier pods as compared to untreated plant. Boron increased the availability of nutrients to the plants and also enhanced the production of pea pods by increasing the nutrients uptake of plants.

Boron were played an imporant role in earliness of fruit production as, Gogoier at el,(2014) Examined about solanaceae family that Proper application of Boron resulted in earliest fruiting (94 days) in Brinjal. Boron in improves fruit growth by synthesizing tryptophan and auxin, Wojcik and Wojcik (2003).

Table 6a. Days to pod formation of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	7.8	5.4	3.3	6.1	5.7 C
Climax	11.3	7.3	5.3	9.1	8.2 A

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Meteor	9.1	6.2	4.2	8.3	7.0 B
Mean	9.4 A	6.3 C	4.2 D	7.8 B	

LSD (P≤0.01) for boron (B) = 1.38

LSD (P≤0.01) for cultivar (C) = 0.85

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 6b. Analysis of variance for days to pod formation of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	1.437	0.7186		
Boron level	3	129.829	43.2763	69.25	0.0000
Error 1	6	3.749	0.6249		
Cultivar	2	40.042	20.0211	39.29	0.0000
Boron× Cultivar	6	3.838	0.6396	1.26	0.3312
Error 2	16	8.153	0.5096		
Total	35	187.049			

CV main plot = 11.38 %

CV sub plot = 10.28 %

Number of pods plant-1

The number of pods plant-1 data is presented in Table 7a and the analysis of variance is given in Table 7b, while the Appendix VII represents the replicated data. Table 7ba shows that number of pods plant-1 was significantly influenced by boron levels as well as pea cultivars, while the interaction was found non-significant.

In case of boron levels that maximum number of pods plant-1 (16.6) was recorded at 0.75% boron, followed by 14.2 at 0.50% of boron while minimum number of pods plant-1(10.2) was recorded in control.

In terms of pea cultivars, Climax had maximum number of pods plant-1 (15.3 pods), while followed by Leena Pak had (13.2 pods) and minimum number of pods plant-1 was recorded in Meteor (11.5 pods).

Boron spray caused a significant increase in plant pods number to 52.64 pods, compared to control treatment (40.67 pods). This is consistent with Jassem and Obaid, (2014) who showed a significant increase in plant pod number when boron spraying at 25 mg L-1 on broad bean plants. Boron spraying significantly increased plant pods number and the level 0.75% by giving the highest number (53.23 pods) compared to control treatment (38.90 pods). This is consistent with Shafeek et al., (2014) on pea and Al-Qazzaz, (2014) on chickpea.

Jana and Paria (1996) reported that the highest number of pods per plant of garden pea was obtained with higher doses boron application. Singh et al., (1992) also reported that boron application greatly improves the yield attributes, i.e., pods per plant and seeds per pod. Srivastava (1994) reported that application of boron increased the number of pods/plant and grain yield in a susceptible chickpea variety, Kalika.

Table 7a. Number of pods plant-1 of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	10.2	14.2	17.2	11.3	13.2 B
Climax	12.2	16.2	17.5	15.2	15.3 A
Meteor	8.2	12.2	15.3	10.2	11.5 C
Mean	10.2 D	14.2 B	16.6 A	12.2 C	

LSD (P≤0.01) for boron (B) = 1.60

LSD (P≤0.01) for cultivar (C)= 1.06

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Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 7b. Analysis of variance for number of pods plant-1 of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	0.663	0.3313		
Boron level	3	205.009	68.3362	80.87	0.0000
Error 1	6	5.070	0.8451		
Cultivar	2	87.275	43.6376	54.34	0.0000
Boron× Cultivar	6	11.727	1.9545	2.43	0.0727
Error 2	16	12.849	0.8031		
Total	35	322.593			

CV main plot = 6.90 %

CV sub plot = 6.72 %

Pod length (cm)

Mean values of pod length (cm) and its ANOVA are given in Table 8a and Table 8b, respectively, while the Appendix VIII provides the replicated data. Statistically analyzed data showed that both boron levels and pea cultivars have significantly affected pod length, while the interaction results between boron levels and pea cultivars was found non-significant.

Significant variations in pod length (cm) were noted in three different pea cultivars. When plants were sprayed with 0.75% of boron, maximum pod length (11.1 cm) was observed, followed by 9.1 cm with 0.50% of boron. Whereas, minimum pod length (6.6 cm) was noted in control.

The pod length (cm) of three different pea cultivars revealed that cultivar Climax had the maximum pod length (9.8 cm), followed by cultivar Leena Pak with 8.9 cm, and cultivar Meteor with the minimum pod length (7.5cm).

Foliar application boron caused a significant increase in (number of pods/ plant, average pod weight (g) / plant, pod length and pod diameter (cm) of cowpea in both seasons and the superior values were recorded when the plant sprayed with boron compared with control. These results agree with those obtained by Srivastava et al. (1996) who mentioned that micronutrients have considerable significant effects, as limiting factors, on the productivity of legumes. The increase in fruit length and fruit diameter might be due to more accumulation of photosynthesis which were synthesized in the leaf and trans located towards the fruit. The increased and accumulation of photosynthesis was probably due to more vigor and growth (Trehan and Gre wal 1981). Boron significantly increase in fruit length. (Wojcik and Wojcik, 2003). Treatment also enhances both the size and no. of cell in plant (Khayyat et al. 2007). Natesh et al. (2005) also observed that fruit length was increased by foliar spray of micronutrients at flowering stage. Similar result was also obtained by Yadav et al. (2001). Baloch et al., (2008) found similarity through foliar spray of micro nutrients in chilli resulted significantly longer fruits in green chilli.

Table 8a. Pod length (cm) of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	7.2	9.1	11.0	8.2	8.9 B
Climax	7.5	10.1	12.2	9.2	9.8 A
Meteor	5.2	8.1	10.1	6.4	7.5 C

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Mean	6.6 D	9.1 B	11.1 A	7.9 C	

LSD (P≤0.01) for boron (B) = 0.74

LSD (P≤0.01) for cultivar (C) = 0.55

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 8b. Analysis of variance for Pod length (cm) of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	1.067	0.5334		
Boron level	3	98.624	32.8746	180.40	0.0000
Error 1	6	1.093	0.1822		
Cultivar	2	32.115	16.0574	75.23	0.0000
Boron× Cultivar	6	1.780	0.2966	1.39	0.2779
Error 2	16	3.415	0.2134		
Total	35	138.093			

CV main plot = 4.91 %

CV sub plot = 5.31 %

Pod diameter (mm)

Mean values of pod diameter (mm) and its ANOVA are given in Table 9a and Table 9b, respectively, while the Appendix IX provides the replicated data. Statistically analyzed data showed that both boron levels and pea cultivars have significantly affected pod diameter (mm), while the interaction of boron levels and pea cultivars was found non-significant.

According to the mean values of different boron levels, maximum pod diameter (13.8 mm) was recorded when plants were treated with 0.75 % of boron, followed by 10.7 mm with 0.50% of boron. While the minimum number of pod diameter (8.6mm) was reported in control.

Significant variations in pod diameter (mm) were noted in different three pea cultivars. Maximum pod diameter (12.4mm) was observed in cultivar Climax, followed by 10.7 with cultivar Leena Pak. While, minimum number of pod diameter (9.4mm) was noted in cultivar Meteor.

Boron has considerable significant effects, as limiting factors, on the productivity of legumes. The increase in fruit length and fruit diameter might be due to more accumulation of photosynthesis which were synthesized in the leaf and translocated towards the fruit. The increased and accumulation of photosynthesis was probably due to more vigor and growth (Trehan and Gre wal 1981). Foliar application boron caused a significant increase in (number of pods/ plant, average pod weight (g) / plant, pod length and pod diameter (cm) of cowpea in both seasons and the superior values were recorded when the plant sprayed with boron compared with control. These results agree with those obtained by Srivastava et al. (1996) who mentioned that boron significantly increase in fruit length. (Wojcik and Wojcik, 2003). Treatment also enhances both the size and no. of cell in plant (Khayyat et al. 2007). Natesh et al. (2005) also observed that fruit length was increased by foliar spray of micronutrients at flowering stage. Similar result was also obtained by Yadav et al. (2001). Baloch et al., (2008) found similarity through foliar spray of micro nutrients in chilli resulted significantly longer fruits in green chilli.

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Table 9a. Pod diameter (mm) of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	8.2	11.4	13.5	9.6	10.7 B
Climax	9.7	13.3	15.4	11.3	12.4 A
Meteor	7.7	9.0	12.5	8.6	9.4 C
Mean	8.6 D	11.2 B	13.8 A	9.8 C	

LSD (P≤0.01) for boron (B) = 1.04

LSD (P≤0.01) for cultivar (C)= 0.73

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 9b. Analysis of variance for Pod diameter (mm) of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	1.036	0.5182		
Boron level	3	135.132	45.0440	126.85	0.0000
Error 1	6	2.131	0.3551		
Cultivar	2	53.382	26.6912	70.59	0.0000
Boron× Cultivar	6	5.208	0.8681	2.30	0.0863
Error 2	16	6.050	0.3781		
Total	35	202.940			

CV main plot = 5.50 %

CV sub plot = 5.67 %

Chlorophyll content (SPAD)

The mean values related with chlorophyll content are given in Table 10a and the duplicated data are presented in the Appendices, while the ANOVA findings are shown in table 5b. The information demonstrated that the amount of chlorophyll in pea was influenced by boron levels and pea cultivar however, their interaction had no significant effect on the amount of chlorophyll in pea.

Table 10a presents that maximum chlorophyll content (75.1) was recorded at 0.75 % of boron, followed by 56.1 with 0.50 % of boron. While the minimum chlorophyll content (28.2) was reported in control plants.

The mean table shows that cultivar Climax had the greatest chlorophyll content (61.4) among pea cultivars, followed by cultivar Leena Pak (50.3) while lowest chlorophyll content recorded in cultivar Meteor (39.7).

Growth parameters were significantly affected by foliar spray of boron in both growing seasons, the concentration of 10 ppm gave the tallest plants, the highest number of leaves, number of branches, leaf area and chlorophyll content as well as the largest plant fresh weight in both seasons, whereas the untreated plants produced the lowest value of each character. The improving effects of boron may be attributed to the direct action of boron on the development of N-fixing root nodules (Bolanos et al., 1994) and translocation of sugars through cellular membranes (Dugger and Palmer, 1983) .An experiment carried out by Moghazy et al. (2014) to study the influence of a foliar application of boron improve vegetative growth traits of green pea, i.e., plant length, number of leaves, number of branches, fresh weight per plant, chlorophyll content, relative growth rate, yields and its components had high significant values by foliar spraying with boron.. Bin Ishaq, (2002) stated that spraying pea plants with various concentrations of boron resulted in more vigorous vegetative growth compared with the untreated ones. Similar finding have been reported by Prasad et al. (1998).

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Table 10a. Chlorophyll content (SPAD) of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	28.2	55.1	74.8	43.2	50.3 B
Climax	38.2	65.2	90.2	52.2	61.4 A
Meteor	18.2	48.1	60.2	32.1	39.7 C
Mean	28.2 D	56.1 B	75.1 A	42.5 C	

LSD (P≤0.01) for boron (B) = 5.03

LSD (P≤0.01) for cultivar (C) = 3.88

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 10b. Analysis of variance for chlorophyll content (SPAD) of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	31.9	15.93		
Boron level	3	10779.9	3593.32	432.21	0.0000
Error 1	6	49.9	8.31		
Cultivar	2	2843.9	1421.91	133.87	0.0000
Boron× Cultivar	6	151.1	25.18	2.37	0.0786
Error 2	16	170.0	10.62		
Total	35	14026.7			

CV main plot = 5.71%

CV sub plot = 6.46 %

Seed pod-1

Seed pod-1 data are presented in Table 11a and the analysis of variance is given in Table 11b, while the Appendix XI represents the replicated data. Table 11b exhibited that number of Seed pod-1 was significantly affected by boron levels and pea cultivars, while the interaction results between boron levels and pea cultivars was non- significant.

Mean data regarding boron application showed that maximum seed pod-1 (10.3 seeds) was noted for foliar spraying of boron at 0.75 %, followed by 0.50 % of boron 8.1 seeds. However, minimum seed pod-1 (5.8 seeds) was recorded in control plants It was also resemblance with the findings of Kaisher et al. (2010)..

Significant variations in seed pod-1were noted in different pea cultivars. Maximum number of seed pod-1 (9.2 seeds) was observed in cultivar Climax, followed by 7.9 seeds with cultivar Leena Pak. Although the minimum number of seed pod-1 (6.2 seeds) was noted in cultivar Meteor.

The effect of boron on yield and its role in increasing photosynthesis speed and its products transfer from to (pods), which leads to an increase in its number and weight and then increases yield (Moore, 2004). As well as the increased carbohydrates that lead to increase seeds and increase the yield. Boron also plays an important role in stimulating the formation of growth hormone cytokinin that accelerates the flowering process and then increases the proportion of pollination and fertilization thus increases the yield (Tariq and Mott, 2007). Singh et al. (1992) reported that application of 10 kg B/ha increased yield of vegetable pea. Increase in seeds and straw yield of gram was observed due to 1kg B/ha application. (Singh et al., 2004). (Jana and Paria, 1996) found that application of boron increased pod yield in pea. Prasad et al. (1998) conducted an experiment and reported that foliar application of 2.5 kg borax/ha increased yield of pea. Increase in seeds yield of gram was observed due to 1kg B/ha application. (Singh et al., 2004). (Jana and Paria, 1996) found that application of boron increased pod yield in pea. Singh et al. (2002) conducted an

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experiment and reported that increasing levels of boron application as borax up to 4 kg/ha in pea and black gram increased the seed yield. Bolanos et al. (1994) reported that boron application increased the number, size and weight of seeds in pea. Hassanein et al. (1999) observed that application of boron in cow pea significantly increased growth parameters and yield components.

Table 11a. Seeds pod-1 of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	6.2	8.2	10.2	7.1	7.9 B
Climax	7.2	10.1	11.3	8.3	9.2 A
Meteor	4.1	6.2	9.3	5.3	6.2 C
Mean	5.8 D	8.1 B	10.3 A	6.9 C	

LSD (P≤0.01) for boron (B) = 0.82

LSD (P≤0.01) for cultivar (C) = 0.66

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 11b. Analysis of variance for Seeds pod-1 1 of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	0.991	0.4953		
Boron level	3	97.461	32.4871	144.45	0.0000
Error 1	6	1.349	0.2249		
Cultivar	2	54.501	27.2504	87.47	0.0000
Boron× Cultivar	6	3.360	0.5600	1.80	0.1630
Error 2	16	4.984	0.3115		
Total	35	162.647			

CV main plot = 6.09 %

CV sub plot = 7.17 %

Seed yield plant -1

Seed yield plant -1 data are presented in Table 12a and the analysis of variance is given in Table 12b, while the Appendix XII represents the replicated data. Table 12b exhibited that seed yield plant -1 was significantly affected by boron levels and pea cultivars, while the interaction results between boron levels and pea cultivars was non-significant.

Table 12a presents that maximum seed yield plant -1 (160.5 seeds) was recorded at 0.75% of boron, followed by 105.4 seeds at 0.50 % of boron. While minimum seed yield plant -1 (63.1 seeds) was reported in control.

Pea cultivar seed yield plant -1 was significantly impact by the use of boron levels and cultivars. The mean statistics showed that cultivar Climax had the highest seed yield plant -1 (122.6 seeds), followed by 100.0 seeds with cultivar Leena Pak and lowest seed yield plant -1 (84.8 seeds) was recorded in cultivar Meteor.

Singh et al. (2002) conducted an experiment and reported that increasing levels of boron application as borax upto 4 kg/ha in pea and black gram increased the seed yield. Bolanos et al. (1994) reported that boron application increased the number, size and weight of seeds in pea. Hassanein et al. (1999) observed that application of boron in cow pea significantly increased growth parameters and yield components. Increase in seeds yield of gram was observed due to 1kg B/ha application. (Singh et al., 2004). (Jana and Paria, 1996) found that application of boron increased pod yield in pea. The effect of boron on yield and its role in increasing photosynthesis speed and its products transfer from to (pods), which leads to an increase in

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its number and weight and then increases yield (Moore, 2004). As well as the increased carbohydrates that lead to increase seeds and increase the yield. Boron also plays an important role in stimulating the formation of growth hormone cytokinin that accelerates the flowering process and then increases the proportion of pollination and fertilization thus increases the yield (Tariq and Mott, 2007). Singh et al. (1992) reported that application of 10 kg B/ha increased yield of vegetable pea. Increase in seeds and straw yield of gram was observed due to 1kg B/ha application. (Singh et al., 2004). (Jana and Paria, 1996) found that application of boron increased pod yield in pea.

Table 12a. Seed yield plant-1 of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	56.8	105.4	160.5	77.2	100.0 B
Climax	84.2	120.4	180.5	105.2	122.6 A
Meteor	48.2	90.4	140.5	60.2	84.8 C
Mean	63.1 D	105.4 B	160.5 A	80.9 C	

LSD (P≤0.01) for boron (B) = 11.66

LSD (P≤0.01) for cultivar (C) = 8.02

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 12b. Analysis of variance for seed yield plant-1 of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	84.7	42.4		
Boron level	3	48520.0	16173.3	362.95	0.0000
Error 1	6	267.4	44.6		
Cultivar	2	8664.8	4332.4	95.62	0.0000
Boron× Cultivar	6	306.9	51.2	1.13	0.3896
Error 2	16	725.0	45.3		
Total	35	58568.8			

CV main plot = 6.51 %

CV sub plot = 6.57 %

Root fresh weight (g)

Pea cultivars root fresh weight (g) is significantly influenced by organic media, although the effect of their interaction was not statistically significant. Table 13a provides the mean values for root fresh weight (g), and Table 13b provides the analysis of variance for same data. The replicated original data is present in Appendices.

According to the average table, plants treated with 0.75 % of boron had the highest root weight (4.6 g), which were followed by plants treated with 0.50 % of boron (2.9 g), Plants that did not get boron had less root weight (0.9 g).

Data regarding cultivar Climax had the largest root weight (3.3g), followed closely by the cultivar Leena Pak (2.6 g), while the cultivar Meteor had the lowest root weight (1.8 g).

Bonilla et al. (2004) observed that application of boron increased seed germination, root weight, plant development and mineral composition of pea. Boron plays a key role in increasing the activity of a specific enzymatic system in roots that significantly contributes to nutrient uptake. This system creates a gradient in root cells (i.e., across the root cell membranes), and works as the driving force for active uptake and transport of some of the mineral nutrients, especially K. When

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boron supply is low, this driving force necessary for nutrients uptake is significantly reduced. These results highlight the critical role of boron in root nutrients uptake. Plants with low boron supply undergo significant physiological and morphological changes. More than 90% of plant boron exists in cell walls, indicating boron very important role in plant growth (Brown, et al. 2002). In a boron deficient environment, structural stability and biological functions of cell walls are severely impaired, including a reduction of root weight and elongation. The quickest response to boron deficiency is a reduction in root growth, (Marschner, 2012). Boron helps in the normal growth of plant and in absorption of nitrogen from soil, translocation of sugars, cell wall synthesis, root elongation and nucleic acid synthesis (Chadha, 2010).

Table 13a. Root fresh weight (g) of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	1.0	3.1	4.2	2.1	2.6 B
Climax	1.3	3.4	5.9	2.7	3.3 A
Meteor	0.3	2.2	3.6	1.1	1.8 C
Mean	0.9 D	2.9 B	4.6 A	2.0 C	

LSD (P≤0.01) for boron (B) = 0.34

LSD (P≤0.01) for cultivar (C) = 0.54

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 13b. Analysis of variance for root fresh weight (g) of pea cultivars. as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	0.0674	0.0337		
Boron level	3	67.1255	22.3752	565.28	0.0000
Error 1	6	0.2375	0.0396		
Cultivar	2	14.1069	7.0535	34.32	0.0000
Boron× Cultivar	6	2.4770	0.4128	2.01	0.1241
Error 2	16	3.2882	0.2055		
Total	35	87.3025			

CV main plot = 7.71 %

CV sub plot = 17.57 %

Total yield (tons ha -1)

Total yield (tons ha-1) data are presented in Table 14a and the analysis of variance is given in Table 14b, while the Appendix XIV represents the replicated data. Table 14b exhibited that total yield tons ha-1 was significantly affected by boron levels and pea cultivars, while the interaction results between boron levels and pea cultivars was non-significant.

Table 14.a presents that maximum total yield (9.5 tons ha-1) was recorded at 0.75 % of boron, followed by 7.1 tons at 0.50 % of boron. While minimum total yield (3.7 tons ha-1) was reported in control.

Pea cultivars yield was significantly impacted by use of boron different levels and cultivars. The mean statistics showed that cultivars Climax had the highest yield (7.5 tons ha-1), with Leena Pak being the cultivar to follow (6.5 tons ha-1) and minimum yield was recorded in cultivar Meteor (5.2 tons ha-1).

The effect of boron on yield and its role in increasing photosynthesis speed and its products transfer from to (pods), which leads to an increase in its number and weight and then increases yield (Moore, 2004). As well as the increased carbohydrates that lead to increase seeds and increase the yield. Boron

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also plays an important role in stimulating the formation of growth hormone cytokinin that accelerates the flowering process and then increases the proportion of pollination and fertilization thus increases the yield (Tariq and Mott, 2007). Singh et al. (1992) reported that application of 10 kg B/ha increased yield of vegetable pea. Increase in seeds and straw yield of gram was observed due to 1kg B/ha application. (Singh et al., 2004). (Jana and Paria, 1996) found that application of boron increased pod yield in pea. Prasad et al. (1998) conducted an experiment and reported that foliar application of 2.5 kg borax/ha increased yield of pea. Highest yield of pea was observed with 1.5 kg B/ha. (Dwivedi et al., 1992). Gulati (1980) reported that1.5 ppm of boron application recorded highest fruit yield of tomato. Jena et al. (2009) found that application of 2 kg boron ha-1 in cabbage increased the yield. Hatwar et al. (2003) also said that treatment of boron were used which give the improvement of growth and yield of chilli.

Table 14a. Total yield (tons ha-1) of pea cultivars as affected by boron levels.

Cultivars	Boron levels (%)				Mean
	0	0.50	0.75	1.0	
Leena Pak	3.7	7.1	9.5	5.5	6.5 B
Climax	4.7	8.1	10.5	6.6	7.5 A
Meteor	2.7	6.2	8.5	3.4	5.2 C
Mean	3.7 D	7.1 B	9.5 A	5.2 C	

LSD ($P \leq 0.01$) for boron (B) = 0.68

LSD ($P \leq 0.01$) for cultivar (C) = 0.44

Means followed by different letter(s) are statistically different at 1% levels of significance.

Table 14b. Analysis of variance for total yield (tons ha-1) of pea cultivars as influenced by boron levels.

SOV	DF	SS	MS	F-Value	Probability
Rep	2	0.97	0.4633		
Boron level	3	169.266	56.4220	369.18	0.0000
Error 1	6	0.917	0.1528		
Cultivar	2	31.115	15.5574	111.67	0.0000
Boron× Cultivar	6	2.011	0.3351	2.41	0.0753
Error 2	16	2.229	0.1393		
Total	35	206.464			

CV main plot = 6.12 %

CV sub plot = 5.85 %

The current research was performed to explore the “Effect of boron on growth and seed yield of pea cultivars” at Horticulture Research Farm, The University of Agriculture Peshawar, during winter cropping season of 2022. There were two factors, i.e., Boron levels and Pea cultivars. The experimental layout was designed on Randomized Complete Block Design (RCBD) with split plot arrangements and three replications. Boron levels allotted to main plot of experimental design and pea cultivars were subjected to sub plot. The experimental plots were properly ploughed and prepared before seed sowing. All the cultural and agronomic practices were kept constant including irrigation, weeding and hoeing from sowing till picking.

The findings indicated that the boron levels remarkably influenced all the studied parameters. The maximum plant height (103.5 cm), number of branches plant-1(13.1), number of leaves plant-1 (120.8), days to flowering (44.5), Days to pod formation (9.4), number of pods plant-1 (16.6), pod length (11.1cm), pod diameter (13.8 mm),

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chlorophyll content (75.1 SPAD), seed pod-1 (10.3), seed yield plant-1 (160.5), root fresh weight (4.6 g) and total yield (9.5 tons ha-1) was recorded for treatment of at 0.75 % boron. Whereas the minimum plant height (62.1cm), number of branches plant-1(6.1), number of leaves plant-1 (73.1), days to flowering (33.8), Days to pod formation (4.2), number of pods plant-1 (10.2), pod length (6.6 cm), pod diameter (8.6 mm), chlorophyll content (28.2 SPAD), seed pod-1 (5.8), seed yield plant-1 (63.1), root fresh weight (0.9 g) and total yield (3.7tons ha-1) was recorded in control.

The experimental results revealed that among the different pea cultivars, cultivar Climax produced taller plants height (98.6cm), maximum number of branches plant-1(11.4), number of leaves plant-1 (114.9), days to flowering (42.4), days to pod formation (8.2), number of pods plant-1 (15.3), pod length (9.8 cm), pod diameter (12.4 mm), chlorophyll content (61.4 SPAD), seed pod-1 (9.2), seed yield plant-1 (122.6), root fresh weight (3.3 g) and total yield (7.5 tons ha-1) Exceptionally days to flowering (36.6) and days to pod formation (5.7) was found minimum in Leena Pak cultivar. However shorter plant height (62.1cm), minimum number of branches plant-1(7.3), number of leaves plant-1 (77.2), number of pods plant-1 (11.5), pod length (7.5 cm), pod diameter (9.4 mm), chlorophyll content (39.7 SPAD), seed pod-1 (6.2), seed yield plant-1 (84.8), root fresh weight (1.8 g) and total yield (5.2 tons ha-1) were observed in Meteor cultivars.

IV. CONCLUSION

Based on study conclusions, it was determined that foliar application of boron and specific Pea cultivars significantly influenced the onion crops development, productivity, and seed production. The findings were as follow:

1. For most of the studied parameters, foliar application of boron @ 0.75 % gave better results as compared to untreated and other levels.
2. Foliar application of boron at 0.75% also reduced days to flowering and days to pod formation.
3. Pea cultivar climax was significantly better in growth and yield attributes compared to other cultivars. Specifically, plant height, number of primary branches, number of leaves, number of pods plant-1, pod length (cm), pod diameter (mm), chlorophyll content (SPAD), seeds pod-1, seed yield plant-1, root fresh weight (g) and overall yield (tons ha-1) of pea.

Recommendations

Based on the conclusions, it is possible to draw the following recommendations:

1. Foliar applications of boron @ 0.75 % are recommended for better growth and yield of pea.
2. It is recommended that climax cultivar should be grown under the agro climatic conditions of Peshawar.
3. Further research work should be carried out to test the effect of foliar spray of boron on other pea cultivars and on other vegetables.

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