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EFFECTS OF BORON AND CALCIUM ON SEED YIELD AND QUALITY OF ONION

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Abstract

A field experiment with onion var. BARI piaz1 was conducted in the research farm of Sher-e-Bangla Agricultural University, Dhaka, during the winter season (October to February) to find out the response of boron and calcium on seed yield and quality of onion. The experiment was carried out with four levels of boron viz., B_0 (0 ppm), B_1 (500 ppm), B_2 (1000 ppm) and B_3 (2000 ppm); and three level of calcium viz., Ca_0 (0 ppm), Ca_1 (2500 ppm) and Ca_2 (5000 ppm). This experiment was laid out in RCBD with three replications. The results showed that the treatments significantly influenced the plant height and number of leaves at all growth stages except harvesting time. At harvest, boron and calcium significantly increased the umbel per plot, flowers per umbel, fruits per umbel, fruit set (%), yield per plant, 1000-seed weight, seed yield per ha, germination and normal seedling percentage; and reduced the abnormal seedling percentage. Combined application of boron and calcium also significantly increased the all above parameters mentioned except abnormal seedling percentage of onion. The highest result of all parameters including yield showed from B_3Ca_2 but this treatment reduced production of abnormal seedling. Besides, combined of boron and calcium treatment B_3Ca_2 gave the highest plant height, leaf number and chlorophyll content. The application of 2000 ppm of boron together with 5000 ppm of calcium (B_3Ca_2) treatment gave the best performance showing the yield and quality of onion seed.

Keywords: Boron, Calcium, Onion seed, Quality, Yield.

Introduction

In Bangladesh, onion stands out as the foremost spice crop in terms cultivation area of 86,429 hectares and total onion production is 5,89,410 m tons. BBS (2017) reported that the average yield of onion in Bangladesh was 10.27 tons per hectare being produced from1.85 lakh hectares of land in 2016-17 with production 19 lakh tons of onion but imported 15 lakh tons of onion in the same year and there was a shortage of 8.05 lakh tons in that particular year. Seeds are produced by limited number of farmers in particular areas such as Faridpur, Natore and Rajshahi districts of Bangladesh (BBS, 2016). Bangladesh requires some 1,300 tons of onion seed per year, of them, about 300

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tons are managed through farmer-to-farmer exchange while seed firms can supply only 100 tons and the remaining seed from import (BBS, 2017). There are still opportunities to increase the yield of onion seed by modifying the cultivation practices including fertilization in particular with boron and calcium and also by adopting cultural management practices.

Boron is a vital micronutrient for increasing the onion seed production. Many researchers have the opinion that some secondary and trace elements like boron (B) and manganese (Mn) can play vital role in escalating the yield of onion seed (Rao and Deshpande, 1971). Micronutrients play a vital role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzymes activity, nitrogen fixation etc., they play an essential role in improving yield and quality (Alam *et al*., 2010). Manna and Maity (2016) reported that foliar applications of micronutrient such as boron was effective in improving growth, yield and quality of onion. Boron at different doses had significant effects on the production of leaf, plant height, root numbers, seed yield and 1000- seeds weight (Bhonde *et al.*, 1999). Macronutrient like Calcium, plays a vital role in crop growth and development. It maintains cell wall structure, stabilizes membranes, enhances pollen germination, regulates enzymes, and promotes overall plant health and vigor. Additionally, calcium boosts root growth, early crop development, and disease resistance. Sullivan *et al.* (1974) showed that calcium deficiency has also been shown to decrease seed quality by inhibiting plumule development.

Onion var. BARI piaz1 is a popular onion variety extensively cultivated in Bangladesh. Its seeds are primarily produced using the bulb to seed method in specific regions. However, the impact of plant nutrients, especially boron (B) and calcium (Ca), on the seed production of BARI piaz1 in Bangladesh on seed production in Bangladesh is currently lacking. This study aims to investigate the impact of varying levels of B and Ca on the growth, yield, and quality of onion seed production.

Materials and Methods

The experiment was conducted at the Experimental shed of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, from October 2018 to February 2019. The soil, classified as non-calcareous dark grey soil, belonged to the Madhupur tract (AEZ No. 28), with a pH value of 5.7. The experimental area experienced a sub-tropical climate characterized by high temperature, humidity, heavy precipitation, and occasional winds. Onion var. BARI piaz1 is a Rabi season crop with a life cycle of 130-140 days, reaching a height of 50-55 cm. Its yield ranges from 12-16 tons of bulbs per hectare and 800-1000 kg of seeds per hectare. The experiment was followed a Randomized Completely Block Design (RCBD) with three replications. The trial was conducted with four levels of boron. 1.0 ppm (B_0), 2. 500 ppm (B_1), 3.1000 ppm (B_2) 4. 2000 ppm (B_3). The source of boron was borax ($Na_2 B_4O_7.10 H_2O$) and three levels of calcium. 1. 0 ppm (Ca_0), 2. 2500 ppm (Ca_1) 3. 5000 ppm (Ca_2). The source of calcium was gypsum. Medium-sized bulbs, approximately 3.5 cm in diameter, were planted in 6 rows with 7 bulbs each. A total of 42 bulbs were planted per $1.5m^2$ plot on October 16, 2018, maintaining row and bulb distances of 25 cm and 20 cm, respectively. Ca or damaged bulbs were replaced with healthy plants from the border as needed. Weeding and mulching were performed to maintain soil moisture and aeration. The crop was irrigated eight times by using a water can. Control measures were applied against cutworms and field crickets. Germination tests for harvested seeds were conducted in the laboratory using petri dishes and filter paper soaked with water. Data collection occurred 10 days after germination, with seedlings classified as normal or abnormal following ISTA guidelines (1999).

Plant height and no. of leaves was measured from 10 sample plants at 30, 45, 60, 75, and 90 days after planting. Additionally, five leaves per pot were randomly selected, and their top, middle, and base lengths were measured using a Leaf device. The average length was then used to calculate total chlorophyll content in SPAD units. The number of emerged umbels per plot was counted before flowering, while the total number of flowers per umbel was determined at flowering. Seeds from 15 randomly selected sample plants were weighed individually to determine the average seed weight per plant. Additionally, for each treatment, the average weight of 1,000-seed was counted. Seed yield per hectare was calculated by converting the seed yield per plot value. Statistical analysis was conducted using computer-based software statistix 10.0 and mean separation was performed by using LSD at 5% level of significance.

Results and Discussions

Crop Morphological parameters

Plant height (cm)

A significant variation was found in plant height from combined application of boron and calcium (Table 1.) whereas plant heights at 30 DAP ranged from 8.03 to 13.10cm. The maximum plant height (13.10cm) was recorded from B_3Ca_2 (2000ppm boron and 5000ppm calcium) treatment, whereas the minimum plant height (8.03cm) in B_0Ca_0 (0ppm Boron and Calcium) treatment i.e., plant height increased 63.14% over (control treatment. At 45DAP, plant height ranged from 12.43 to 16.23 cm. The maximum plant height (16.23 cm) was recorded from B_3C_2 treatment whereas the minimum plant height (12.43cm) in B_0Ca_0 treatment where plant height increased 30.57% over B_0Ca_0 treatment. At 60DAP, plant height ranged from 20.47 to 25.03 cm. The highest plant height (25.03cm) was recorded from B_3Ca_2) treatment whereas the lowest plant height (20.47cm) in B_0Ca_0 i.e., plant height increased 22.28% over B_0Ca_0 treatment. At 75 DAP, plant height ranged from 29.57 to 38.43cm. The highest plant height (38.43cm) was recorded from B_3Ca_2 whereas the lowest plant height (29.57cm) in B_0Ca_0 treatment. Plant height increased 29.96% over control treatment. At 90 DAP, plant height ranged from 42.07 to 53.67 cm. The maximum plant height (53.67cm) was recorded from B_3Ca_2 whereas the minimum plant height (42.07cm) in B_0Ca_0 treatment.

After application of B_3Ca_2 treatment, Plant height increased 27.57% over B_0Ca_0 treatment. At harvest, plant height ranged from 41.97 to 53.97cm. The maximum plant height (53.97cm) was recorded from B_3Ca_2 whereas the minimum plant height (41.97cm) in B_0Ca_0 treatment. After application of B_3Ca_2 treatment, plant height increased 29.27% over B_0Ca_0 (control) treatment.

Table 1. Effects of boron and calcium on plant height of onion at different days after planting

Treatment	Plant height (cm)					
	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	At Harvest
B_0Ca_0	8.03g	12.43h	20.47h	29.57i	42.07g	41.97h
B_0Ca_1	8.70f	12.83gh	20.80gh	29.97hi	43.33fg	43.13gh
B_0Ca_2	9.03f	13.17fg	21.63fg	30.57ghi	43.67efg	43.60fg
B_1Ca_0	9.43e	13.50ef	21.80f	31.03fgh	44.27def	44.43efg
B_1Ca_1	10.47d	14.53d	22.83de	32.03ef	44.93def	45.17def
B_1Ca_2	11.27c	15.27bc	23.13cd	33.13de	45.43d	46.40cd
B_2Ca_0	9.80e	13.77e	22.10ef	31.33fg	44.80def	45.13def
B_2Ca_1	11.37c	15.70ab	23.93bc	33.67cd	45.90cd	46.17cd
B_2Ca_2	11.97b	15.90a	24.17ab	34.87bc	47.30bc	47.37bc
B_3Ca_0	10.77d	14.87cd	22.83de	32.57de	45.17de	45.43de
B_3Ca_1	11.93b	15.80ab	24.15ab	35.70b	48.10b	48.47b
B_3Ca_2	13.10a	16.23a	25.03a	38.43a	53.67a	53.97a
$LSD_{(0.05)}$	0.3762	0.5789	0.8952	1.2188	1.6955	1.5748
CV (%)	2.12	2.36	2.32	2.20	2.19	2.02

Number of leaves

A significant variation in the total number of leaves per plant was found among the treatments at all growth stages (Table 2.) 30 DAP, leaf numbers ranged from 2.37 to 2.95. The maximum leaves (2.95) were recorded from B_3Ca_2 whereas the minimum leaves (2.37) in B_0Ca_0 treatment. After application of B_3Ca_2 treatment leaf numbers increased 24.47% over B_0Ca_0 (control) treatment. At 45 DAP, leaf numbers ranged from 4.20 to 6.73. The maximum leaves (6.73) were recorded from B_3Ca_2 whereas the minimum leaves (4.20) in B_0Ca_0 treatment. The B_3Ca_2 treatment leaf numbers increased 60.23% over B_0Ca_0 treatment. At 60 DAP, leaf numbers ranged from 5.23 to 7.47. The highest leaves (7.47) were recorded from B_3Ca_2 whereas the lowest leaves (5.23) in B_0Ca_0 treatment. After application of B_3Ca_2 treatment leaf numbers increased 42.82% over B_0Ca_0 (control) treatment. At 75 DAP, leaf numbers ranged from 6.33 to 8.63. The highest leaves (8.63) were recorded from B_3Ca_2 whereas the lowest leaves (6.33) in B_0Ca_0 (0ppm Boron and Calcium) treatment. After application of B_3Ca_2 treatment leaf numbers increased 36.33% over B_0Ca_0 treatment. At 90 DAP, leaf numbers ranged from 7.20 to 9.03. The maximum leaves (9.03) were recorded from B_3Ca_2 whereas the minimum leaves (7.20) in B_0Ca_0 treatment. After application of B_3Ca_2 treatment leaf numbers increased 25.42% over B_0Ca_0 treatment. At harvest, leaf numbers ranged from 5.20 to 8.17. The maximum leaves (8.17) were recorded from B_3Ca_2 whereas the minimum leaves (5.20) in B_0Ca_0 treatment. After application of B_3Ca_2 treatment leaf numbers increased 57.11% over B_0Ca_0 treatment.

Table 2. Effects of boron and calcium on leaf number of onion at different days after planting

Treatment	Leaf number at					
	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	At Harvest
B_0Ca_0	2.37h	4.20j	5.23h	6.33i	7.20g	5.20i
B_0Ca_1	2.44g	4.60i	5.53g	6.66gh	7.53efg	6.30fg
B_0Ca_2	2.47g	4.87h	5.67g	6.76gh	7.90cd	6.60de
B_1Ca_0	2.58f	5.00gh	5.81fg	6.49hi	7.37fg	5.90h
B_1Ca_1	2.64e	5.27ef	6.00 ef	7.13de	7.73cde	6.80d
B_1Ca_2	2.72d	5.73d	6.33d	7.43d	7.97cd	7.23c
B_2Ca_0	2.58f	5.15fg	6.10de	6.80fg	7.50efg	6.13gh
B_2Ca_1	2.72d	5.90cd	6.73c	7.77c	8.03c	7.47bc
B_2Ca_2	2.79c	6.00c	6.97bc	8.00bc	8.43b	7.63b
B_3Ca_0	2.69de	5.43e	6.33d	7.10ef	7.67def	6.47ef
B_3Ca_1	2.85b	6.27b	7.03b	8.10b	8.70ab	7.73b
B_3Ca_2	2.95a	6.73a	7.47a	8.63a	9.03a	8.17a
$LSD_{(0.05)}$	0.0579	0.2140	0.2825	0.3122	0.3536	0.2834
CV (%)	1.29	2.33	2.66	2.54	2.64	2.46

Physiological parameters

Chlorophyll content

Combined treatment of boron and calcium showed the significant variation on chlorophyll content on leaves (Fig. 1). Chlorophyll content on leaves ranged from 40.20 to 50.80 mg cm^{-2}. Among the treatments the maximum chlorophyll content (50.80 mg cm^{-2}) on leaves was observed in B_3Ca_2 (2000 ppm boron and 5000 ppm calcium) treatment while minimum chlorophyll content (40.20 mg cm^{-2}) was in B_0Ca_0 (0ppm Boron and Calcium). B_1Ca_2 and B_2Ca_1 treatment showed the statistically similar. B_3Ca_2 treatment increased 26.37% chlorophyll content on leaves over B_0Ca_0.

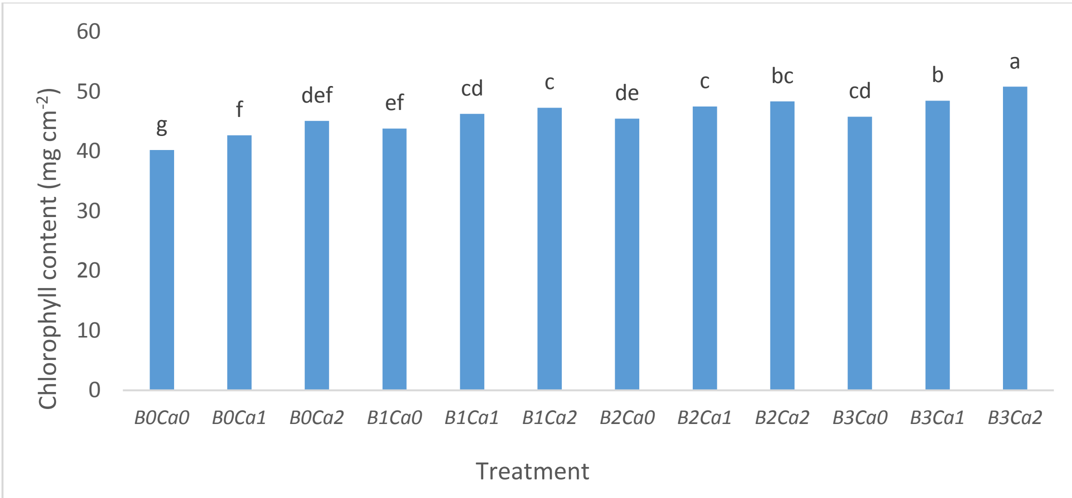

Fig. 1. Combined effects of boron and calcium treatments on chlorophyll content of onion leaves

Yield contributing characters

Umbels per plot

In case of combined treatments of boron and calcium showed a significant variation on numbers of umbel per plot (Fig. 2). Number of umbels per plot from combined treatment ranged from 62.33 to 68.03. B_2Ca_2 (boron 1000 ppm and calcium 5000 ppm) treatment showed the highest number of umbels per plot (68.03). The treatment B_1Ca_1, B_2Ca_1, B_3Ca_1 and B_3Ca_2 gave the statistically similar result. The lowest number of umbel per plot was recorded in B_0Ca_0 treatment (62.33). B_2Ca_2 treatment increased the umbel number per plot 9.14% over B_0Ca_0 treatment.

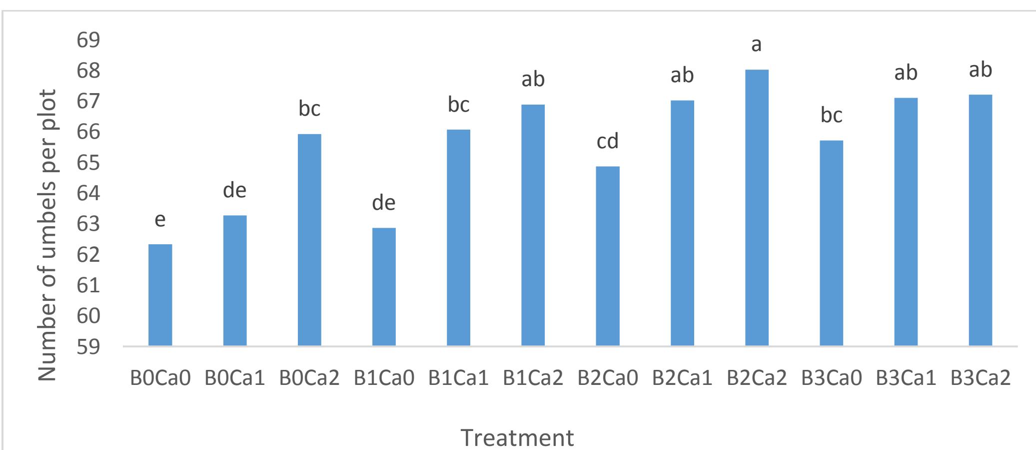

Fig. 2. Combined effects of boron and calcium on number of umbels per plot of onion

Flowers per umbel

The variation in the number of flowers per umbel was significant due to the combined effect of boron and calcium (Fig. 3). Number of flowers per umbel from combined treatment ranged from 149.03 to 169.77. Fig. 3 showed that B_2Ca_2 (boron 1000 ppm and calcium 5000 ppm) treatment produced the highest number of flowers per umbel (169.77) followed by B_3Ca_2 treatment (165.67). B_0Ca_0 gave the lower flowers per umbel (149.03) which was statistically similar with B_0Ca_1 treatment (150.77). B_2Ca_2 treatment increased the number of flowers per umbel 13.92% over B_0Ca_0 treatment.

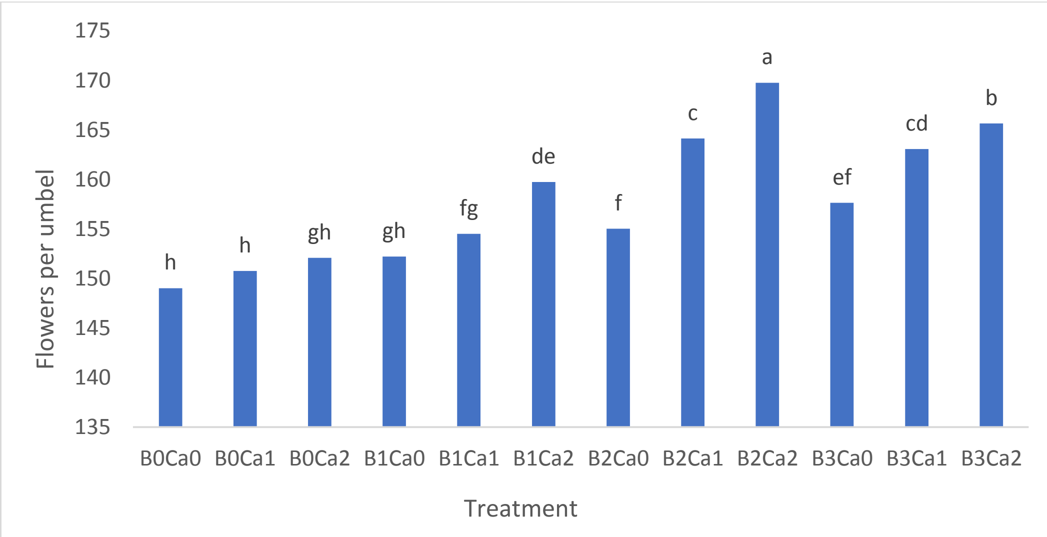

Fig. 3. Combined effects of boron and calcium treatments on flowers per umbel of onion

Fruits per umbel

Combined treatment of boron and calcium showed significant variation on fruits per umbel (Fig. 4). Number of fruits per umbel from combined treatment ranged from 110.33 to 157.67. B_2Ca_2 (boron 1000 ppm and calcium 5000 ppm) treatment produced the highest number of fruits per umbel (157.67). Second highest fruits per umbel (152.67) were found in followed by B_3Ca_2 treatment. Lower fruits per umbel (110.33) were recorded in B_0Ca_0 treatment. B_1Ca_1, B_0Ca_0 and B_3Ca_0 gave the statistically similar result on fruits per umbel. B_2Ca_2 treatment increased 42.91% fruits per umbel over B_0Ca_0 treatment.

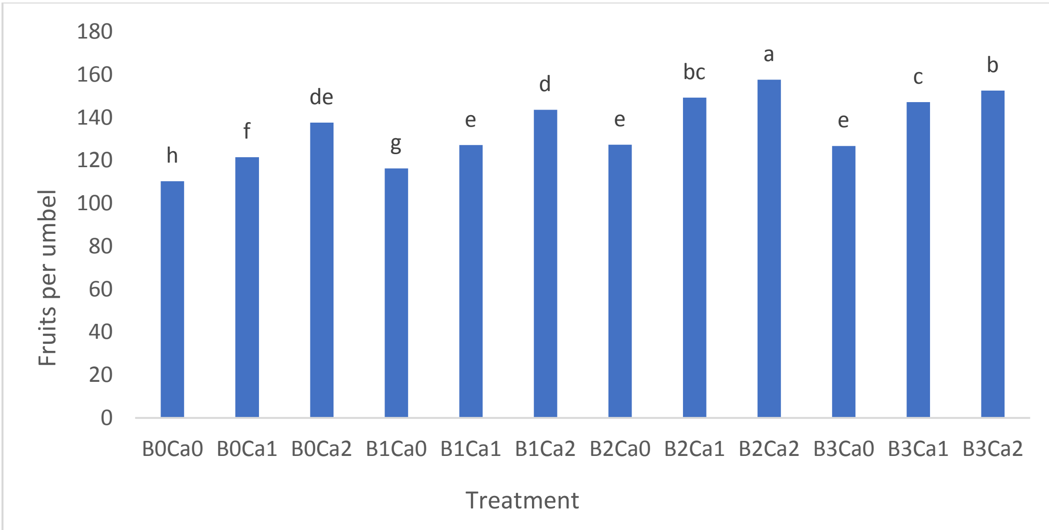

Fig. 4. Combined effects of boron and calcium on fruits per umbel of onion

Fruit set (%)

The variation in percentage of fruit set was found significant due to the combined application of boron and calcium (Fig. 5). Percentage of fruit set from combined treatment ranged from 74.03 to 92.93. The treatment B_2Ca_2 gave the highest percentage of fruit set (92.93 %). Also B_2Ca_1, B_3Ca_1 and B_3Ca_2 gave the statically similar result. Lowest percentage of fruit set (74.03%) was found in the B_0Ca_0 treatment. B_0Ca_0 and B_1Ca_0 showed the statistically similar result. Also B_1Ca_1 and B_2Ca_0 gave the statistically similar result.

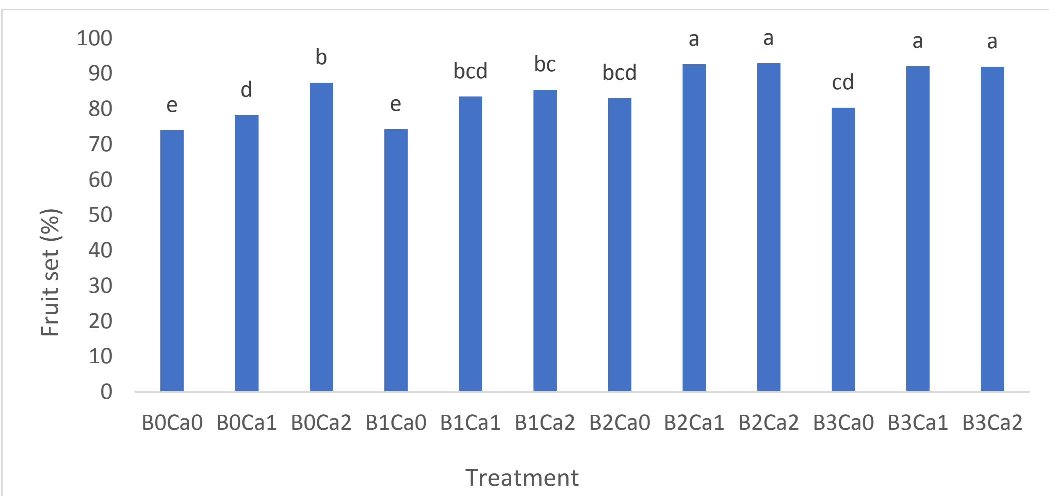

Fig. 5. Combined effects of boron and calcium treatments on fruit set (%) of onion

Seed yield per plant

Combined treatment of boron and calcium was significantly influence the seed yield per plant (Fig. 6). Seed yield per plant from combined treatment ranged from 1.95 to 3.14g. The treatment B_2Ca_2 gave the highest seed yield per plant (3.14 g) followed by B_3Ca_2 treatment. B_0Ca_1 and B_0Ca_2 gave the statistically similar result. Lowest seed yield per plant (1.95g) was found from B_0Ca_0 treatment. Application of B_2Ca_2 treatment increased 61.02% seed yield per plant over B_0Ca_0 treatment.

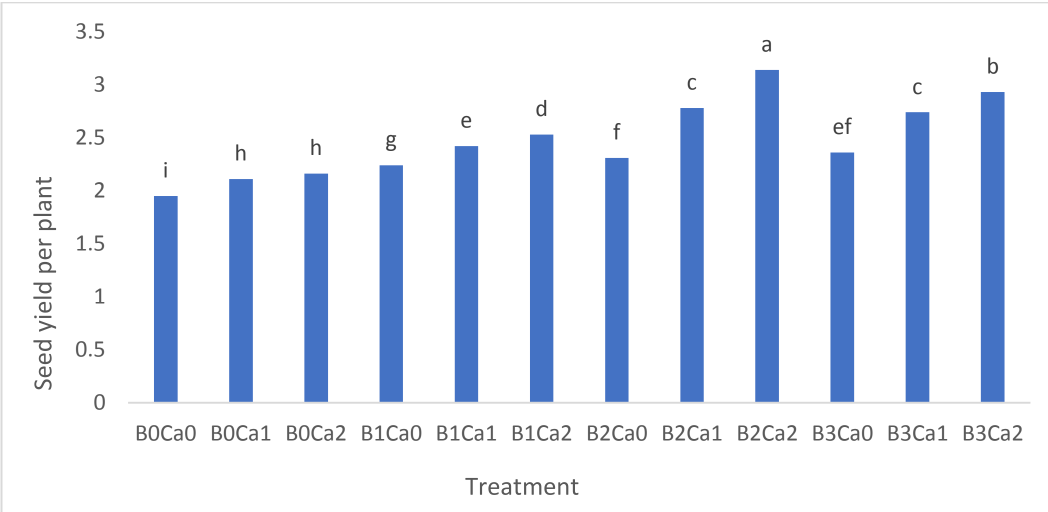

Fig. 6. Combined effects of boron and calcium on seed yield per plant of onion

1000-seed weight

Combined treatment of boron and calcium was significant on 1000-seed weight of onion (Fig. 7). Thousand seed weight from combined treatment ranged from 2.03 to 3.70g. Higher thousand seed weight (3.70 g) was observed in the treatment of B_2Ca_2 followed by B_2Ca_1 treatment. B_2Ca_1 and B_3Ca_2 treatment gave the statistically similar result. Lowest 1000-seed weight (2.03g) was found in B_0Ca_0 treatment. Application of B_2Ca_2 treatment increased 82.27% seed yield per plant over B_0Ca_0 treatment.

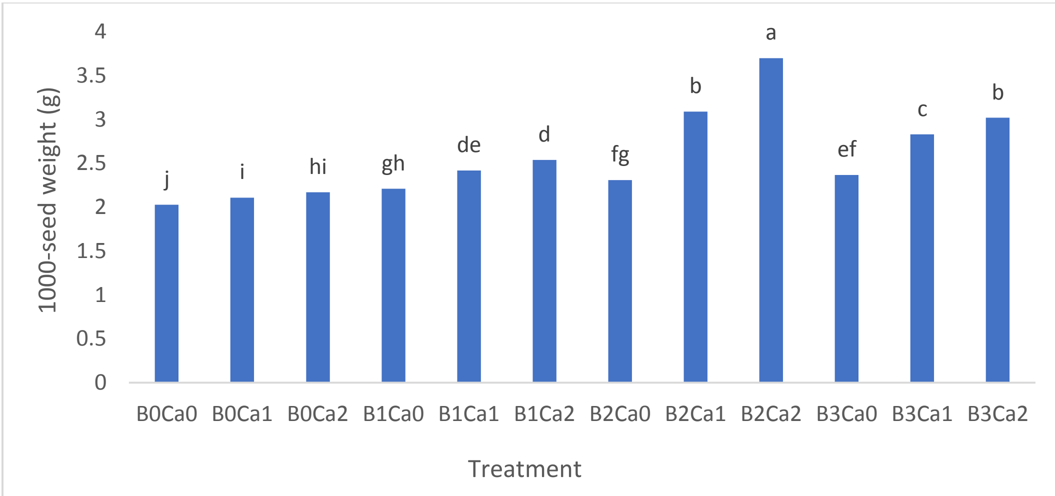

Fig. 7. Combined effects of boron and calcium on 1000-seed weight (g) of onion

Seed yield per hectare

Response of calcium and boron significantly influenced the per hectare seed yield of onion (Fig. 9). Seed yield per hectare from combined treatment ranged from 423.22 to 681.05 kg. Higher seed yield per hectare (681.05 kg) was recorded in B_2Ca_2 treatment followed by B_3Ca_2 treatment (645.67kg). B_2Ca_1 and B_3Ca_1 combined treatment gave the statistically similar result for seed yield per hectare. The lowest seed yield per hectare (423.22kg) was noticed in B_0Ca_0 treatment. Application of B_2Ca_2 treatment increased 60.92% seed yield per hectare over B_0Ca_0 treatment.

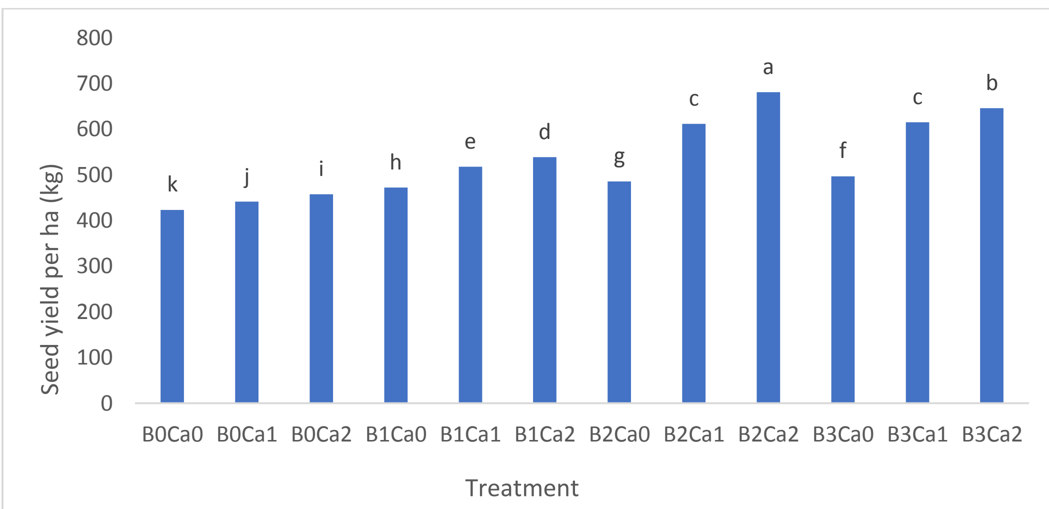

Fig. 8. Combined effects of boron and calcium treatments on seed yield per ha(kg) of onion

Seed quality parameters

Germination percentage

Combined application of calcium and boron significantly increased the germination percentage (Fig. 10). Germination percentage from combined treatment ranged from 96 to 71.67%. Germination percentage was highest in B_2Ca_2 (boron 1000 ppm and calcium 5000 ppm) where 96% germination was observed but 93.11% of germination from B_3Ca_2 treatment. B_2Ca_1 and B_3Ca_0 treatment gave the statistically similar result on germination percent. Lowest germination percentage (71.67%) was observed in B_0Ca_0 combined treatment. B_2Ca_2 treatment increased 33.94% of seed germination over B_0Ca_0 treatment.

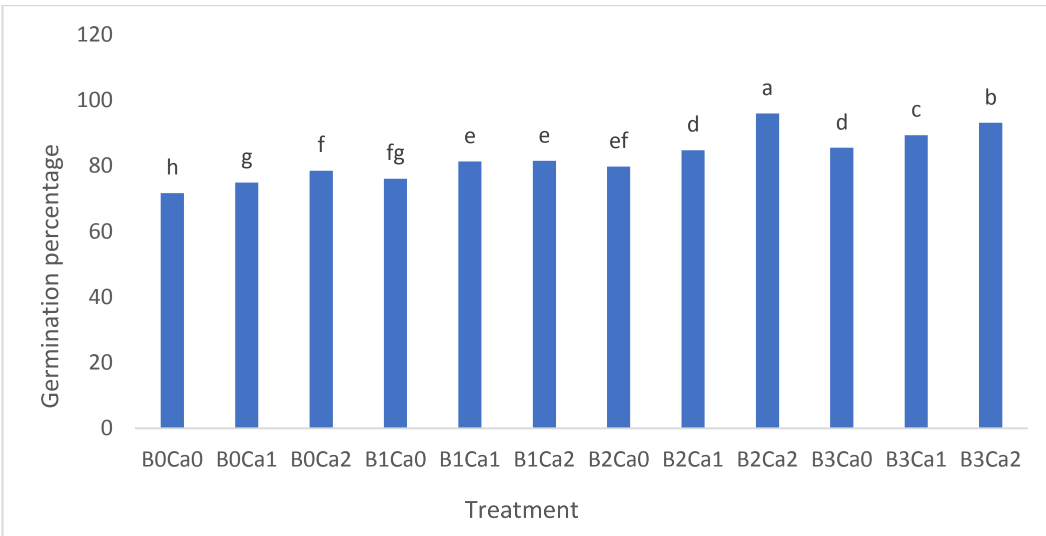

Fig. 9. Combined effects of boron and calcium ton germination percentage of onion seed

Normal seedling (%)

Variation was observed for normal seedling production due to combined application of boron and calcium (Fig. 11). Normal seedling percentage from combined treatment ranged from 92.69 to 53.67%. Among all the combined treatment B_2Ca_2 produced the highest normal seedling (92.69%) than other treatment where treatment B_3Ca_2 produced 89.32% normal seedling. B_0Ca_0 produced 53.67% of normal seedling which was the lowest percentage of normal seedling. B_2Ca_2 treatment increased 72.70% of normal seedling over B_0Ca_0 treatment.

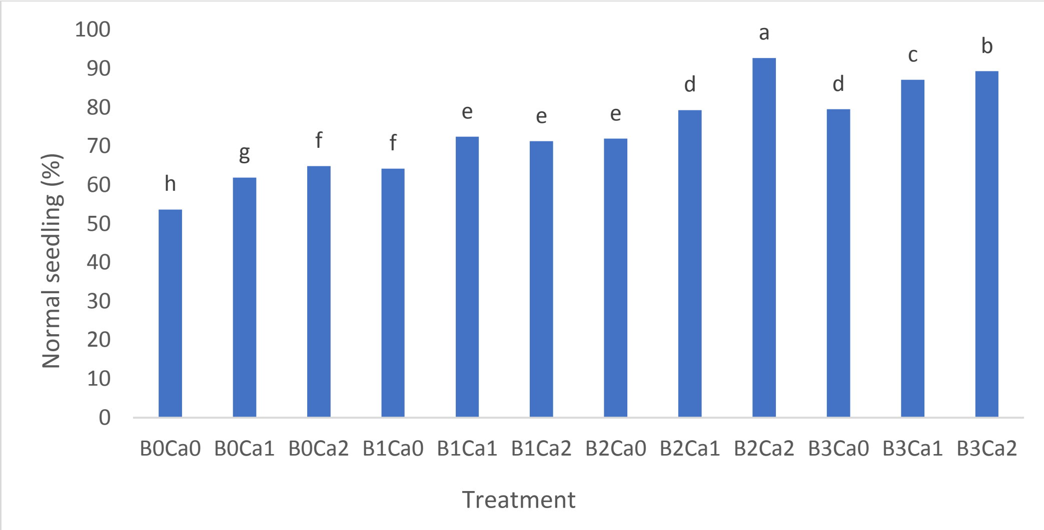

Fig. 10. Combined effects of boron and calcium on normal seedling (%) of onion

Abnormal seedling (%)

For various combined applications of boron and calcium significant variation was observed in abnormal seedling production (Fig. 12). Abnormal seedling percentage from the combined treatment ranged from 3.33 to 18%. Large number of abnormal seedling (18%) was found from B_0Ca_0 treatment. B_0Ca_1 and B_0Ca_2 treatment produced 15.56 and 15.33% of abnormal seedling, respectively which were statistically similar. Lower number of abnormal seedling (3.33%) was found from B_2Ca_2 treatment which reduced the abnormal seedling by 81.5% over B_0Ca_0 treatment.

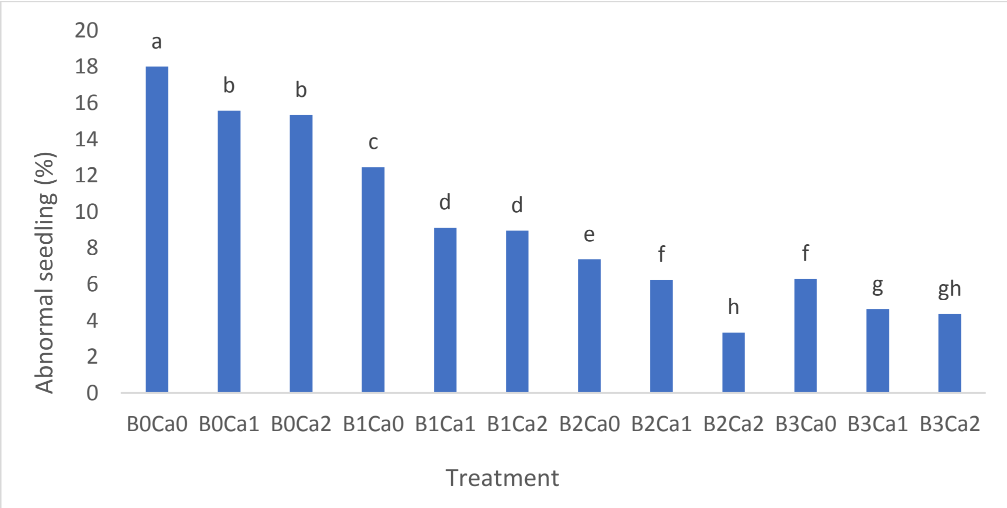

Fig. 11. Combined effects of boron and calcium on abnormal seedling (%) of onion

Conclusion

The results revealed that boron and calcium treatments had significant effect on crop growth parameters e.g. plant height and leaf number at different DAP. Different boron and calcium treatments had significant effect on the physiological parameters viz., chlorophyll content was highest in B_3Ca_2 treatment (50.80 mg cm^{-2}), and also yield and yield contributing characters viz., umbel per plot, flowers per umbel, fruits per umbel, fruit set (%), yield per plant, 1000-seed weight, yield per hectare. The highest germination percentage (96 %) was observed in B_2Ca_2 with normal seedling percentage (92.69 %) and reduced the abnormal seedling percentage (3.31%). These findings suggest that boron and calcium application effectively enhance onion growth, physiology, yield components, germination, and seedling quality.

Author's contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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