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DIFFERENTIAL RESPONSE OF CARNATION VARIETIES (*Dianthus caryophyllus* L.) TO DIFFERENT LEVELS OF BORON UNDER POLYTUNNELS

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Abstract

Carnation (*Dianthus caryophyllus* L.) is one of the most commercially important cut flowers of the world. It can be used for cut flowers, bedding, edging, boarders, pots and rock garden. Four Spanish carnation varieties were tested with three levels of boron under ultra-violet stabilized polytunnels from August 2017 to April 2018 at Godawari, Nepal. The objective of the research was to evaluate vegetative, floral, and vase life parameters in relations to growth, yield and quality of carnation. The research was conducted in a randomized complete block design with 3 replications. The variety Baltico had the maximum leaf length (19.3 cm), numbers of lateral branches (10.5), internodal length (5.1 cm), flower diameter (8.6 cm), and vase life (24.0 days). The numbers of nodes (5) and flower weight (25.4 g) were highest in the variety Vinco with the lowest cracked area on the stem (0.2 cm^2/ crack). The numbers of stem cracks per plant significantly ($p \leq 0.01$) reduced with an increasing level of boron though non-significant relation was observed on 60 ppm and 120 ppm. Variety Baltico was found as a better variety compared to the Vinco, Cervantes and Master varieties according to the vegetative, floral, yield and vase life parameters. Among the levels of boron tested, 60 ppm was found as the optimum dose. Thus, variety Baltico and 60 ppm boron is suggested to be used at the climatic condition of Lalitpur.

Keywords: Carnation, stem crack, post-harvest, reproductive characters, vegetative characters.

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Introduction

Carnation (*Dianthus caryophyllus* L.), the symbol of pride and beauty is considered as a preferred flower for different occasions and belongs to the family Caryophyllaceae. It is indigenous to the Mediterranean region and generally grows well in 30° N or S latitudes as well as on the Western edges of the continent (Akram et al., 2017). Carnations are excellent for cut flowers, bedding, pots, borders, edging and rock gardens (Biondo and Noland, 2000; Dole and Wilkins, 2005) and are now gaining popularity for their potential use in floral arrangement (Kiss et al., 2001). Globally, it ranks second in commercial importance next only to rose, on account of its excellent keeping quality, the wide range of forms and colors (Jawaharlal et al., 2010).

The daily demand of standard carnation cut flowers is 7000 - 9000 in the Nepalese market (FAN, 2017). It requires a balanced amount of fertilizer application for optimum growth, yield and quality. Boron is one of the major constituents of carnation fertilization and its optimum application significantly influences the physical characteristics of carnation (Ahmad et al., 2010). Deficiency and toxicity of boron differ among plant species, and its availability decreases with increasing soil pH and drought condition (Raj et al., 2016). Deficiency of boron in carnation is characterized by calyx splitting, bud abortion, reduced flower diameter, and flower production. Foliar boron levels less than 20 to 25 ppm cause shortened internodes, clubbiness, distorted flower buds, and 'witch's broom' symptoms. In contrast, excess boron (3000 - 5000 ppm) has been found to have toxic effect on the plants and shows symptoms such as leaf tip burn (Jawaharlal et al., 2010). Thus, an optimum dose of boron application has been felt crucial for growth and development of carnation plant. Hence, this study was conducted at Lalitpur condition aiming to evaluate carnation varieties, to determine the suitable dose of boron and to study interactive effect of varieties and doses of boron on growth parameters, yield and quality of carnation.

Materials and methods

Experimental site

This research was conducted at the Floriculture Development Centre, Godawari, Lalitpur, Nepal under UV stabilized polytunnel from August 2017 to April 2018 (Figure 1). It is located at 27°35'28'' North latitude and 85°22'46'' East longitude with an elevation of 1515 meters above sea level. During the research period the average temperature and total precipitation was 14.86°C and 89.30 cm, respectively at ambient atmospheric condition.

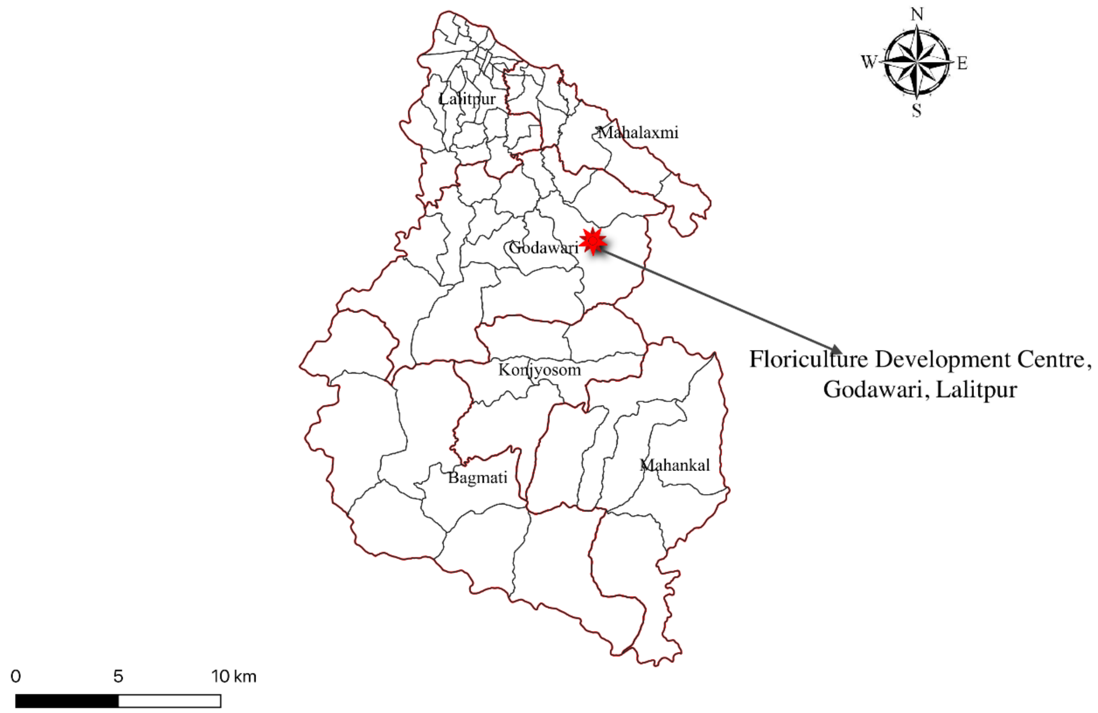

Figure 1. Location map of Floriculture Development Centre in Lalitpur district

Experimental details

Soil test was carried out in Agriculture Technology Centre, Pulchowk, Lalitpur, Nepal to find out the initial boron concentration of the experimental field. The experiment was a 4 × 3 factorial experiment in randomized complete block design with three replications. There were 4 varieties (Vinco, Baltico, Cervantes and Master) with 3 levels of boron (0, 60 and 120 ppm). Randomization of treatment was done through the lottery method. Four varieties of carnation at 6-8 leaf stage was imported from B & B flowers, Spain. Borax (11% B) was used to supply different levels of boron.

Limonium flower was cultivated in the polytunnel before carnation flower for this experiment. The polytunnel was of size 5 m × 36 m. Well decomposed farmyard manure @ 25 kg m^{-2}, vermicompost @ 5 kg m^{-2}, single super phosphate @ 200 g m^{-2}, potassium sulphate @ 150 g m^{-2}, magnesium sulphate @ 50 g m^{-2}, calcium nitrate @ 50 g m^{-2} and zinc @ 2.5 g m^{-2} was applied as basal dose of fertilizer. Calcium nitrate @ 25 g m^{-2} was used for 2 times to top-dress the crop at an interval of 30 days. Borax @ 0.27 g L^{-1} of water and 0.54 g L^{-1} of water was mixed to prepare the 30 ppm and 60 ppm boron solution respectively. Doses of boron were applied for 5 times at an interval of 15 days from bud formation stage. Transplantation was done at plant to plant and row to row spacing of 20 cm × 25 cm as practiced by Floriculture Development Centre, Godawari. Light irrigation was provided just after transplantation and the gap-filling was done within a week after transplantation. All the intercultural operations like weeding, hoeing, removal of excessive branches, and off-shoots were carried out for 8 times during the research period. Irrigation was provided at 5-6 days intervals. Pinching of plantlets was carried out at 25 days after transplanting. Carbendazim fungicide 50 % WP @1.5 g L^{-1} of water was drenched for two times at seedling stage to control damping-off of seedlings after transplantation. Netting was done 45 days after transplantation to support the plants. Three flowers were harvested from each plot during the month of February and kept in distilled water for the study of vase life. Flowers were evaluated in a room under ambient conditions.

Data collection

Five random plants out of forty were selected from each plot and were tagged for the measurement of plant height, number of leaves, length of the leaves, breadth of the leaves, number of lateral branches and number of nodes per 25 cm of stem. Similarly, internodal length, number of stem cracks/plant, area/crack, number of flowers per plant, flower weight, flower and diameter were assessed. Vase lives of flowers were assessed visually. Ruler, vernier caliper and, weighing balance were used for the measurement of above-mentioned parameters.

Data analysis

All observed, measured and calculated data were encoded in Microsoft Excel for data curation and management. R-program (version 3.5.2) was used for data analysis. Two-way ANOVA was used to check significant differences between treatments and Least Significance Difference (LSD) at 0.05 significant level was used to compare differences between treatment means.

Results

Chemical analysis of initial soil sample revealed that the pH of soil was 6.6, indicating the soil is suitable for carnation cultivation. The soil was loamy in texture comprising 49.7 % sand, 37.7 % silt and 12.6% clay. Initial boron concentration of the experimental field was 7.11 ppm.

Vegetative characters

The finding showed that plant height, leaf numbers, leaf breadth, and the number of lateral branches were significantly different ($p \leq 0.05$) among the varieties but no significant differences ($p \leq 0.05$) on boron application levels. Similarly, no interaction effect ($p \leq 0.05$) of variety and boron was observed on these parameters. According to Table 1, variety Cervantes was observed the maximum in plant height (65.1± 1.2 cm) and leaf numbers (148.3±6.8), variety Baltico in leaf length (19.3±3.1 cm) and lateral branches (10.5±0.3) and variety Master (1.3±0.0 cm) in leaf breadth. Variety Vinco was found the minimum in plant height (50.8 ± 1.0 cm), leaf length (50.8 ± 1.0 cm) and leaf breadth (50.8 ± 1.0 cm), Master in leaf numbers per plant (125.5±4.4) and lateral branches per plant (7.6±0.4).

Table 1. Response of varieties to boron application and interaction of varieties and boron on various vegetative growth parameters.

Treatment details	Plant height (cm)	Leaf numbers	Leaf length (cm)	Leaf breadth	Lateral branches
A. Varieties					
Vinco	$50.8±1.0^{c}$	$136.4±4.3^{ab}$	$13.8±0.1^{a}$	$1.0±0.0^{b}$	$9.0±0.5^{b}$
Baltico	$59.4±1.8^{b}$	$142.5±2.6^{a}$	$19.3±3.1^{a}$	$1.0±0.0^{b}$	$10.5±0.3^{a}$
Cervantes	$65.1±1.2^{a}$	$148.3±6.8^{a}$	$15.5±0.3^{a}$	$1.1±0.0^{b}$	$9.6±0.4^{ab}$
Master	$56.9±1.1^{b}$	$125.5±4.4^{b}$	$15.4±0.2^{a}$	$1.3±0.0^{a}$	$7.6±0.4^{c}$
Pr(>F)	***	*	Ns	***	***
LSD	4.2	13.6	4.6	0.1	1.1
CV (%)	7.4	10.0	9.6	5.9	12.2
B. Boron					
0 ppm	$58.3±2.0^{a}$	$15.0±4.4^{a}$	$15.4±0.3^{a}$	$1.1±0.0^{a}$	$9.1±0.1^{a}$
60 ppm	$58.4±2.0^{a}$	$14.1±5.4^{a}$	$17.3±2.4^{a}$	$1.1±0.0^{a}$	$9.2±0.5^{a}$
120 ppm	$57.6±1.7^{a}$	$14.4±4.4^{a}$	$15.3±0.4^{a}$	$1.1±0.0^{a}$	$9.3±0.6^{a}$
Pr(>F)	Ns	Ns	Ns	Ns	Ns
LSD	3.6	11.7	8.0	0.1	1.0
CV (%)	7.4	10.0	9.6	5.9	12.2
C. Interaction					
Pr(>F)	Ns	Ns	Ns	Ns	Ns
LSD	7.3	23.6	8.0	0.1	1.9
CV (%)	7.5	10.0	9.6	5.9	12.2

*Mean within the column followed by same letter(s) does not differ significantly.

* Represents the level of significance: *** at 0, * at 0.05 and Ns- Non-significant.

As shown in the result, number of nodes/25 cm length of the stem, internodal length, and area/crack (cm^2) varied significantly ($p≤0.05$) among the varieties but boron levels resulted no significant difference (Table 2.). However, in context of the number of stem cracks/plant, boron levels were significantly different but the varieties didn't have significant influence ($p≤0.05$). Interaction effect was not found on any parameters. Variety Baltico observed the maximum in internodal length (5.1±0.2 cm) and area/ crack (0.5±0.1), Vinco in number of nodes/25 cm of stem (4.5±0.1). The minimum number nodes/25 cm stem was observed in the variety

Baltico (3.6±0.1). While, Vinco had minimum internodal length (4.0±0.2 cm), number of cracks (1.3±0.2) and area/crack (0.2±0.0 cm^2).

Table 2. Response of varieties to boron application and interaction of varieties and boron on various vegetative growth and stem crack parameters.

Treatment details	Nodes/25 cm of stem	Internodal length (cm)	Number of stem cracks/plant	Area/crack (cm^2)
A. Varieties				
Vinco	4.5 ± 0.1^{a}	4.0 ± 0.2^{c}	1.3 ± 0.2^{a}	0.2 ± 0.0^{c}
Baltico	3.6 ± 0.1^{c}	5.1 ± 0.2^{a}	1.7 ± 0.3^{a}	0.5 ± 0.1^{a}
Cervantes	3.7 ± 0.1^{bc}	4.7 ± 0.1^{b}	1.5 ± 0.2^{a}	0.3 ± 0.1^{bc}
Master	4.0 ± 0.1^{b}	4.9 ± 0.2^{ab}	1.7 ± 0.3^{a}	0.4 ± 0.1^{ab}
Pr(>F)	***	***	Ns	*
LSD	0.3	0.4	0.5	0.2
CV (%)	8.6	8.8	3.4	4.3
B. Boron				
0 ppm	3.9 ± 0.1^{a}	4.6 ± 0.2^{a}	2.1 ± 0.3^{a}	0.4 ± 0.1^{a}
60 ppm	4.0 ± 0.1^{a}	4.8 ± 0.2^{a}	1.3 ± 0.1^{b}	0.4 ± 0.1^{a}
120 ppm	4.0 ± 0.6^{a}	4.7 ± 0.1^{a}	1.2 ± 0.2^{b}	0.3 ± 0.0^{a}
Pr(>F)	Ns	Ns	***	Ns
LSD	0.3	0.3	0.5	0.1
CV (%)	8.6	8.8	3.4	4.3
C. Interaction				
Pr(>F)	Ns	Ns	Ns	Ns
LSD	0.6	0.7	0.9	0.3
CV (%)	8.6	8.8	3.4	4.3

*Mean within the column followed by same letter(s) does not differ significantly.

* Represents the level of significance: *** at 0, * at 0.05 and Ns- Non-significant.

Floral characters

A significant response ($p\leq0.05$) of variety was observed on the parameters such as stalk length, weight of the flower and flower diameter but no significant differences ($p\leq0.05$) on boron application levels (Table 3.). Flower stalk/plant was not significantly affected ($p\leq0.05$) by any treatments applied. Interaction effect of varieties and boron was not observed on the parameters studied beside flower diameter. Variety Baltico had the maximum flower diameter (8.6±0.3 cm), Vinco had the maximum flower weight (25.4±0.7 g.) and Cervantes (75.5±2.1 cm) had longest flower stalk. Variety Vinco was observed with the minimum flower stalk (60.6±0.9 cm) and Cervantes in flower weight (21.9±0.7 g.). The productivity ranged from 3.3±0.3 to 2.9±0.3 flower stalks/plant but none of the varieties were significantly different from each other.

Table 3. Response of varieties to boron application and interaction of varieties and boron on various flower traits.

Treatment details	Flower stalk / plant	Stalk length (cm)	Flower weight (g)	Flower diameter (cm)
A. Varieties				
Vinco	3.3 ± 0.2^{a}	60.6 ± 0.9^{c}	25.4 ± 0.7^{a}	7.9 ± 0.1^{b}
Baltico	3.2 ± 0.1^{a}	70.0 ± 1.1^{b}	22.6 ± 0.8^{b}	8.6 ± 0.3^{a}
Cervantes	3.3 ± 0.3^{a}	75.5 ± 2.1^{a}	21.9 ± 0.7^{b}	7.9 ± 0.3^{b}
Master	2.9 ± 0.3^{a}	68.1 ± 1.3^{b}	22.1 ± 0.6^{b}	7.9 ± 0.1^{b}
Pr(>F)	ns	***	***	***
LSD	1.6	4.1	1.7	0.5
CV (%)	4.8	6.2	7.6	5.8
B. Boron				
0 ppm	3.2 ± 0.3^{a}	67.5 ± 1.8^{a}	23.1 ± 0.7^{a}	8.0 ± 0.1^{a}
60 ppm	3.1 ± 0.3^{a}	68.5 ± 2.3^{a}	23.0 ± 0.9^{a}	7.8 ± 0.1^{a}
120 ppm	3.2 ± 0.3^{a}	69.7 ± 1.8^{a}	22.9 ± 0.5^{a}	8.0 ± 0.1^{a}
Pr(>F)	Ns	Ns	Ns	Ns
LSD	1.4	3.6	1.5	0.4
CV (%)	4.8	6.2	7.6	5.9
C. Interaction				
Pr(>F)	Ns	Ns	Ns	*
LSD	2.8	4.2	2.9	0.8
CV (%)	4.8	6.2	7.6	5.9

*Mean within the column followed by same letter(s) does not differ significantly.

* Represents the level of significance: *** at 0, * at 0.05 and Ns- Non-significant.

An interaction effect of variety and boron was observed on the parameter flower diameter. It is evident from the Table 4 that the maximum flower diameter was observed in the variety Baltico with control boron level (9.1±0.2 cm) however, was not significantly different from the treatment combination of Baltico and 120 ppm boron level (8.7±0.3 cm) and Cervantes and 120 ppm boron level (8.5±0.2 cm). The minimum flower diameter was observed on the variety Master with 60 ppm boron level (7.2±0.3 cm).

Table 4. Interaction effect of varieties and boron on flower diameter(cm).

Boron/Varieties	Vinco	Baltico	Cervantes	Master
0 ppm	7.8 ± 0.2^{cde}	9.1 ± 0.2^{a}	7.3 ± 0.5^{e}	7.6 ± 0.2^{de}
60 ppm	7.8 ± 0.2^{cde}	7.9 ± 0.5^{bcde}	8.5 ± 0.2^{abc}	7.2 ± 0.3^{e}
120 ppm	8.1 ± 0.0^{bcd}	8.7 ± 0.3^{ab}	7.9 ± 0.4^{bcde}	7.5 ± 0.1^{de}

*Mean within the column followed by same letter(s) do not differ significantly.

Post-harvest characters

Vase life was significantly different ($p \leq 0.05$) in the tested carnation varieties (Table 5). Variety Baltico had the maximum vase life (24.0±2.2 days) which was not significantly different from the variety Master (22.9±0.9 days). However, both these varieties were found to have significantly longer vase life than varieties Cervantes (18.9±0.3 days) and Vinco (18.4±0.5 days). Vase life of the carnation varieties did not differ significantly according to the level of boron applied and interaction of varieties and boron levels.

Table 5. Response of varieties to boron application and interaction of varieties and boron on vase life of carnation flower.

Treatment details	Vase life (days)
A. Varieties	
Vinco	18.4 ± 0.5^{b}
Baltico	24.0 ± 2.2^{a}
Cervantes	18.9 ± 0.3^{b}
Master	22.9 ± 0.9^{a}
Pr(>F)	*
LSD	3.8
CV (%)	8.6
B. Boron	
0 ppm	21.6 ± 0.3^{a}
60 ppm	20.2 ± 0.3^{a}
120 ppm	21.4 ± 0.3^{a}
Pr(>F)	Ns
LSD	3.3
CV (%)	8.6
C. Interaction	
Pr(>F)	Ns
LSD	6.6
CV (%)	8.6

*Mean within the column followed by same letter(s) do not differ significantly.

* represents the level of significance: * at 0.05 and Ns- Non-significant.

Discussion

The results revealed that there was variation on different vegetative, floral, and vase life parameters among the tested varieties but the level of boron and interaction between varieties and levels of boron did not show significant impact on the parameters studied except numbers of stem cracks/plant where levels of boron exhibited significant effect. Interaction effect of varieties and boron was observed only for flower diameter.

Generally, vegetative parameters are related to the yield and yield-related attributes. However, it also has exceptions. A huge variation on the data of vegetative parameters (plant height, number of leaves, leaf length, leaf breadth, number of lateral branches, nodes/25 cm of the stem, internodal length, number of stem cracks/plant and area/crack) due to the influence of varieties were recorded during this study. Maitra and Roychowdhury (2013) also reported variation in height among ten standard carnation cultivars at winter temperature range of 9.9 ^{0}C -19.9 ^{0}C in West Bengal, India. The number of leaves varied significantly among varieties in this study and this variation might be due to differences in height of the plant as reported earlier by Sarkar and Sharma (2016) and Tarannum and Hemlanaik (2014). Leaf length and breadth is related to the area that absorbs sunlight for photosynthesis and variation observed in these parameters is due to the genetic variation among varieties. Such variation in these parameters was also observed by Gharge et al. (2011). Variation in lateral branches is supported by the finding of Gharge et al. (2011) and Kumar and Singh (2003). Similarly, variation on internodal length agrees with the finding of Patil (2001). The number of nodes and internodal length are interrelated as number of nodes decreases with increment in nodal length. Similar to our finding, variations in numbers of nodes due to varieties were observed by Devi et al. (2017) and Gharge et al. (2011). The length of flower stalk was also different according to the varieties and difference in the length of flower stalk was also observed by Tarannum and Hemla Naik (2014) and Devi et al. (2017).

Floral traits (number of flower stalks/plant, stalk length, flower weight, flower diameter) determines the quality of the flower. Based on these traits, consumers choose flower varieties. The difference was observed in the flower varieties in this study. Mehmood et al. (2014) also reported the range of numbers of flower stalks/plant and it is in close proximity to the research findings. Patil (2001) also evaluated 10 varieties and recorded the same range of flower stalks per plant. Regarding the fresh weight of flower, Madhuri and Barad (2018) reported similar finding in the research conducted at Junagadh, India. Singh et al. (2013) also found the same kind of variation on flower diameter on the test conducted with eight cultivars at Lohaghat, Uttarakhand, India. Similar trend was recorded by Jose et al. (2017) in the research conducted at Allahabad, India.

Vase life is another important parameter which is related to consumer’s preferences. In accordance to our research, a similar range on the vase life of carnation was recorded in the research conducted at Lohaghat, Uttarakhand, India (Singh et al., 2013). A similar case was also reported by Pun et al. (1999) and therefore selection of variety for a market can be based on demand of the market based on colour and vase life.

The number of cracks / plant was significantly influenced by the level of boron applied in this study irrespective of the variety. Blaney (1961) also observed cracking in the stem and flower bud by the deficiency of boron. According to Xu et al. (2007), the tissue of boron deficient plants breaks down prematurely this might be the reason for cracking stem in the present study. Similar to the findings in this study, no significant influence of boron level towards the tested vegetative and floral parameters was reported by Maitra and Roychowdhury (2014).

Conclusion

In conclusion, under UV-stabilized polytunnel at Lalitpur, Nepal the variety Baltico was better in terms of lateral branches, leaf length, internodal length, flower diameter, and vase life compared to the other varieties. Similarly, the numbers of leaves were higher in this variety as it was not significantly different from the variety Cervantes. The flower stalks/plant was not significantly different due to the varieties. However, Baltico was the susceptible variety to the level of boron as number of stem cracks and area/crack were higher in this variety compared to others. Thus, Baltico variety can perform better where farmers have easy access to the micronutrient boron. There is no significant difference in 60 ppm and 120 ppm of boron applications with regards to the number of stem cracks and therefore to improve the quality of flower stalks 60 ppm boron is better to apply from an economical point of view. Thus, at the climatic condition of Godawari, Lalitpur, variety Baltico and 60 ppm boron is suggested for cultivation of this crop. However, further experiments are recommended for wider application since this is one year and one location experiment.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Authors contribution

JD, DA and UKP conceptualized the research. JD had conducted the field work and data collection. JD and DA had done statistical analysis, prepared the draft and UKP improved the discussion and advised for necessary correction to prepare the current manuscript. At last all authors read and approved for the final.

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