Journal of King Saud University – Science 35 (2023) 102858

Contents lists available at ScienceDirect

Journal of King Saud University – Science

journal homepage: www.sciencedirect.com

Original article

Foliar application of silicon and boron improves boll retention, lint yield and fiber quality traits of transgenic cotton

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ARTICLE INFO

Article history:
Received 14 July 2022
Revised 15 August 2023
Accepted 19 August 2023
Available online 24 August 2023

Keywords:
Bt cotton
Mineral nutrition
Fiber quality
Seed cotton yield, boll retention

ABSTRACT

Background: Cotton (*Gossypium hirsutum* L.) is an important fiber crop that has a widespread cultivation in tropical and subtropical regions globally. The decline in cotton production over the last two decades may be attributed to the effects of climate change and imbalances in mineral nutrition. However, mineral nutrition, particularly micronutrients has been less focused in cotton production. Silicon (Si) and boron (B) are considered crucial micronutrients that play diverse functions in the physiological and biochemical development of plants, as well as in enhancing their resistance to abiotic stress.
Methods: The present study investigated the impact of individual and combined foliar application of Si and B on the development of transgenic (*Bt*) cotton, as well as their impacts on boll retention, seed cotton production, and fiber quality indicators. Treatments included individual application of 2.0- and 4.0-mM Si and 0.5- and 1.0-mM B, and combined application 2.0 mM Si + 0.5 mM B, 2.0 mM Si + 1.0 mM B, 4 mM Si + 0.5 mM B and 4.0 mM Si + 1.0 mM B. Water spray and no foliar application were regarded as controls for comparison.
Results: Combined application of 4 mM Si + 1.0 mM B resulted in the highest ginning out turn (39%), fiber uniformity (83%) and fiber length (28 mm). The longest plant height and the highest number of closed bolls per plant were recorded with sole application of 0.5 mM B, while sole application of 1 mM B produced the highest number of monopodial branches (20.26), sympodial branches (33.53) and total number of bolls (37.03) per plant. The highest boll weight (18.39 g), boll retention (64.38%) and seed cotton yield (1253.7 kg ha^{-1}) were recorded for sole application of 1.0 mM B.
Conclusion: The results revealed that combined foliar application of 4.0 mM Si + 0.5 or 1.0 0.5 mM fiber quality traits, whereas sole application of 1.0 mM B improved growth and yield related traits. Therefore, B and Si can be applied in combination to improve the fiber quality, whereas sole application of B could increase yield-related traits.

1. Introduction

Cotton (*Gossypium hirsutum* L.) is the most widely produced fiber crop in the world (Shah et al., 2020). It is primarily grown for fiber; however, its seeds are used to produce animal feed (cotton seed cake) and extract vegetable oil (Ali et al., 2020). Erratic

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Peer review under responsibility of King Saud University.

https://doi.org/10.1016/j.jksus.2023.102858
1018-3647/

precipitation during sowing, late planting, increased temperature during flowering phase, inappropriate seedbed preparation, and imbalanced use of nutrients are the major reasons responsible for low cotton yield in Pakistan (Baffes, 2005; Ullah et al., 2018). Cotton is known as "White Gold" and is very important to the global economy. It is grown in > 80 countries throughout the world (Rajalakshmi et al., 2018). Asia and America account for > 80% of global cotton production, and Asia is the world's largest cotton-growing region (Khan et al., 2019). Cotton cultivation in Pakistan spans over an annual land area of 2.53 million hectares, making a modest contribution of 0.8% to the country's gross domestic product (GOP, 2021). Cotton exports contribute significantly to Pakistan's foreign exchange earnings (Ahmad et al., 2009). The primary emphasis in cotton crop research has been on enhancing resistance to biotic and abiotic stresses, as well as optimizing the application of nitrogen (N), phosphorus (P), and potassium (K), whereas the consideration of micronutrients has been neglected (Fageria et al., 2009). The management of the mineral nutritional regime of crop plants is a crucial technique aimed at improving both the quantity and quality of the produce (Zohaib et al., 2018). Cotton has a significant role as a cash crop in Pakistan, serving as a crucial pillar in the support of the country's fabric and other industries reliant on cotton.

Silicon (Si) is a crucial micronutrient that has a significant role in enhancing photosynthesis and increasing crop output, particularly in cotton plants grown under stressful environmental conditions (Safdar et al., 2023; Vasanthi et al., 2012). It is involved in the suitable arrangement of leaves, makes leaves' surface denser and helps the plants to intercept more sunlight (Waraich et al., 2011). It increases the production of plant growth regulator cytokinin that improves cell wall elasticity, firmness, and intensification, ultimately regulating plant growth and development under stressed environments (Ahmed et al., 2008; Vasanthi et al., 2012). It is reported that foliar application of Si increases photosynthesis rate in cotton, which ultimately improves cotton (de Souza Ferraz et al., 2014). The use of Si as bio-stimulant significantly improved growth, productivity, and quality attributes of various fiber crops under stressed environments. Silicon helps plants to tolerate drought stress by maintaining the capacity of compressed cells (Mamatha and Ramesh, 2015). Although it is micronutrient, due the offensive response of growth, yield and quality assurance of fiber crops towards its application it is considered as an important nutrient. It enables plants against various diseases (Gillman et al., 2003). It has direct influence on stretchiness and fineness therefore it is considered necessary nutrient to improve the productivity and quality of fibers under moisture deficit conditions (Luyckx et al., 2017). Among the fiber crops cotton is considered as an attractive crop towards Si accumulation therefore, it is necessary to identify its role in cotton plant towards growth and fiber quality (Shiferaw et al., 2013). Foliar application of Si has improved the productivity of cotton plants by enhancing Si accumulation, increased pigment formation, and higher quantum efficiency, all of which have the potential to positively impact physiological processes and yield (de Souza Junior et al., 2021).

Boron is as essential nutrient required in lower quantity by crop plants (Hussain et al., 2012). It plays several vital roles in plant growth and development. One of the significant limitations to crop production is the insufficient use of micronutrients, particularly Boron (B), which poses a substantial risk to the growth, yield, and quality attributes of cotton (Atique-ur-Rehman et al., 2022; Yeates et al., 2010). Physiological and biochemical processes of plants exhibit sensitivity to B deficiencies, while concentrations above acceptable levels result in reduced plant growth and development owing to toxic effects (Behera et al., 2023; Brdar-Jokanović, 2020; Landi et al., 2019). Boron plays an active role in flowering initiation, as well as in the production of seeds and fruits. Furthermore, B application has been shown to increase the uptake and integration of P inside plants, mostly via regulating the levels of root and floral development (Mehboob et al., 2022). Boron has a crucial role in facilitating pollen formation and boosting fertilization processes. This is achieved via the regulation of ideal hormone levels in the reproductive organs of plants, resulting in improved seed development, growth, and fiber quality (Rashidi and Seilsepour, 2009). Furthermore, excessive use B above the optimal level has detrimental effects on the health of plants, resulting in crop necrosis and decreased accumulation of dry matter. A recent study has shown a deficiency of B and Zn in the soil of Pakistan, which has been found to limit the output of cotton and negatively impact the quality of its fiber characteristics (Zafar-Ul-Hye et al., 2016).

B deficiency impairs photosynthesis and carbohydrate transport from leaves to fruits (Zhao and Oosterhuis, 2002). Moreover, B deficiency induces the shedding of squares and bolls throughout the maturation process, leading to diminished output and compromised fiber quality (Sankaranarayanan et al., 2010). Due to its indispensability for the development of cotton and its restricted ability to move inside the plant, the presence of B is important throughout the whole of the life cycle (de Oliveira et al., 2006; Rosolem and Costa, 2000). The concentration of carbohydrates in the plant, which is mainly affected by the transfer of photo-assimilates from leaves to fruits, has an impact on boll retention. On the contrary, a deficit in vitamin B leads to a reduction in the amount of carbohydrates present, leading to the shedding of bolls (Zhao and Oosterhuis, 2003).

However, slightly higher dose of B could prove toxic for plant growth (Mehboob et al., 2021). Hence, determining toxicity and deficiency levels unique to a particular crop would have a substantial impact on enhancing both yield and economic returns. The primary function of B is to mitigate pollen sterility, which increases the number of flowers and subsequently enhances crop productivity. Numerous studies have optimized B doses for different crops. Nevertheless, the influence of foliar-applied B on boll retention and fiber quality attributes in cotton remains seldom investigated.

Several studies have been conducted to enhance our comprehension of the effects of Si and B on many morpho-physiological and biochemical traits in crops and a synergistic relationship was seen between these nutrients (Nagula et al., 2016). However, limited research has examined the individual effects of these two nutrients on the development and production of cotton. However, no study has investigated the combined application of Si and B on the morphology, lint yield, and fiber quality characteristics of cotton crops. Consequently, the current study investigated the impacts of individual and combined use of Si and B on boll retention, seed cotton yield, and fiber quality traits of cotton.

2. Materials and methods

2.1. Experimental site

Present experiment was performed to evaluate the potential of Si and B either sole or in combine form on boll retention, lint yield, and fiber quality of cotton crop. The experiment was conducted in earthen pots (45 × 30 cm) kept in an open space at College of Agriculture, Bahauddin Zakariya University, Bahadur Sub Campus Layyah Pakistan during the cotton season of 2019. Pots were filled with 30 kg sandy loam soil. There were 120 pots in current study. It contained 10 treatments and four replications per treatment and each replicate consisted of three pots with one plant per pot.

2.2. Experimental treatments and design

Experiment comprised of following treatments: Control (Ck), water spray, Si (2.0 mM), Si (4.0 mM), B (0.5 mM), B (1.0 mM), Si (2.0 mM) + B (0.5 mM), Si (2.0 mM) + B (1.0 mM), Si (4.0 mM) + B (0.5 mM) and Si (4.0 mM) + B (1.0 mM). Experimental treatments were laid out in quadruplicate completely randomized design (CRD).

Five de-linted true to type seeds of transgenic cotton variety 'IUB-13' were sown in each pot and after the germination, only two plants were maintained in each pot. Foliar application of Si and B was applied at squaring and flowering stage of cotton crop. Sodium silicate (Na_2SiO_3) and borax ($Na_2B_4O_7 \cdot 10H_2O$) were use as source of Si and B respectively.

To avoid water stress during the crop season, the soil moisture in the pots was kept at field capacity (gravimetric water contents). The soil was fertilized with NPK at the rates of 100, 30, and 40 mg kg^{-1}, respectively. Urea, di-ammonium phosphate, and potassium sulphate were used as fertilizers for N, P_2O_5, and K_2O, respectively. Insecticides were used to control insect pests, and the experimental field was checked daily. Except for Si and B treatment, all other cultural methods for crop management were kept the same in all experimental units.

2.3. Observations

2.3.1. Morphological traits

All the morphological traits were observed at harvesting stage. From every experimental treatment 5 plants were selected on random basis and their average plant height was recorded through meter scale. Number of vegetative branches (monopodial) and fruiting branches (sympodial) were counted manually and then averaged to notice the average number of monopodial and sympodial branches per plant.

2.3.2. Yield attributes

Number of open and closed and total bolls per plant and average boll weight was calculated from randomly selected plants at reproductive stage. Seeds cotton were separated from each boll of cotton and weighed by using weighing balance and seed cotton yield ($kgha^{-1}$) was observed.

2.3.3. Fiber quality traits

Cotton seed was separated from the seed cotton by using single roller laboratory gin and lint weight and cotton seed weight was measured by weighing balance. Ginning out turn (GOT) was recorded by following equation:

$$GOT\ (\%) = \frac{Lint\ weight\ in\ sample}{Seed\ cotton\ weight\ in\ sample} \times 100$$

2.4. Statistical analysis

The data acquired for all attributes were examined for normality and variance homogeneity to meet the normal distribution criteria of analysis of variance (ANOVA). The Arcsine transformation approach was employed to normalize some of the features because they had a non-normal distribution. The differences between the various qualities found during the study were then tested using one-way ANOVA. All of the observed data was analyzed using Fisher's technique. At a 95% confidence level, the means and differences between treatments were compared using statistics 8.1 software.

3. Results

3.1. Morphological parameters

Results of this study indicated that foliar applied Si and B significantly regulated the cotton morphological attributes including plant height, monopodial branches, and sympodial branches. Boron application with rate of 0.5 mM produced taller plants as compared to control and other treatments and it was statistically at par with the sole application of B with 1 mM rate and where Si and B were applied together with 4.0 mM and 1.0 mM respectively. Plant height was measured at a minimum in both the control and water spray treatments (Table 1). For monopodial branches per plant, there was no significant influence of any of the treatments, and for sympodial branches, maximum sympodial branches were observed under foliar applied B at a concentration of 1 mM, and minimum were observed in control and water sprayed plots (Table 2).

3.2. Yield parameters

Yield traits of cotton i.e., opened bolls, fully matured closed bolls, total number of bolls, seed cotton yield and boll retention were significantly affected by the Si and B application. More number of open bolls were observed with 1 mM B application that was statistically similar with 0.5 mM B application and combine application of Si and B with 2 mM and 1 mM respectively. Less number of open bolls per plant were recorded under control and water sprayed treatments (Table 3). Maximum numbers of closed boll per plant were counted with 0.5 mM B application that was statistically followed by 1 mM B application. Combine application of Si and B with both combinations with 2 mM and 1 mM respectively and 4 mM and 0.5 mM respectively was found statistically at par to sole application of Si and B as well as with each other. Minimum number of closed bolls per plant were observed under control and water sprayed treatments (Table 3). Maximum number of total bolls per plant, average boll weight, seed cotton yield and boll retention were recorded under 1 mM B application. Minimum values of all the yield related traits were observed under control and water spray treatments (Table 3). Maximum numbers of closed boll per plant were counted with 0.5 mM B application that was statistically followed by 1 mM B application. Combine application of Si and B with both combinations with 2 mM and 1 mM respectively and 4 mM and 0.5 mM respectively was found statistically at par to sole application of Si and B as well as with each other. Minimum number of closed bolls per plant were observed under control and water sprayed treatments (Table 3). Maximum number of total bolls per plant, average boll weight, seed cotton yield and boll retention were recorded under 1 mM B application. Minimum values of all the yield related traits were observed under control and water spray treatments (Table 3).

3.3. Fiber quality traits

Separate and combine application of Si and B significantly enhanced the quality traits of cotton plant like GOT%, fiber length, fiber uniformity, micronaire and fiber strength. Combine application of Si and B with 4 mM and 0.5 mM respectively produced maximum GOT (%) that was statistically at par with 4 mM Si + 1 mM B (Fig. 1). In case of fiber length combine application of Si and B with 4 mM and 1 mM respectively produced maximum fiber length that was statistically at par to the fiber length observed in combine application of Si and B with 4 mM and 0.5 mM rate respectively. In case of fiber uniformity (FU%) separate application of B with rate of 1 mM produced maximum fiber uniformity. In case of micron-

Table 1
Analysis of variance for the influence of individual and combined application of silicon and boron on morphological and yield and fiber quality traits of transgenic cotton.

Mean Sum of Squares								
Source of Variance	**DF**	**Plantheight**	**Monopodial branches**	**Sympodial branches**	**Open bolls**	**Closed bolls**	**Total bolls**	**Seed cotton yield**
Treatment	9	208.18**	0.72**	15.65**	99.60**	1.1813**	26.25	2258.92**
Error	20	23.05	0.15170	1.83	12.12	0.0398	0.76	267.19
Mean Sum of Squares								
		Ginning out turn	**Fiber length**	**Fiber uniformity**	**Micronaire**	**Fiber strength**		
Treatment	9	1.17**	0.26**	3.69**	0.10**	1.09**		
Error	20	0.01	0.005	0.14	0.003	0.05		

Table 2
Influence of individual and combined application of silicon and boron on morphological attributes of cotton.

Treatments	PH (cm)	MB plant^{-1}	SB plant^{-1}	OB plant^{-1}	CB plant^{-1}	TB plant^{-1}
Control	78.07 e	2.22	12.73 d	13.06f	1.80 e	14.86f
Water spray	85.07 de	2.33	12.73 d	17.40 ef	1.90 e	19.30 ef
2.0 mM Si	89.67 cd	2.26	13.33 d	18.20 d-f	2.90 d	21.10 de
4.0 mM Si	97.73 bc	2.32	14.93b-d	22.20b-e	3.36 a-c	25.56b-d
0.5 mM B	107.33 a	2.33	16.60b	25.06 bc	3.63 a	28.70 bc
1.0 mM B	100.33 ab	2.36	20.26 a	33.53 a	3.50 ab	37.03 a
2.0 mM Si + 0.5 mM B	97.50 bc	2.40	14.80b-d	23.86b-d	3.10 cd	26.96b-d
2.0 mM Si + 1.0 mM B	94.73 bc	2.46	16.93b	33.53 ab	3.20b-d	31.00b
4.0 mM Si + 0.5 mM B	95.60 bc	2.53	16.13 bc	21.33c-e	3.16b-d	24.50c-e
4.0 mM Si + 1.0 mM B	99.27ab	2.46	13.86 cd	20.00c-e	3.16b-d	23.16c-e
LSD ≤ 0.05	**8.23**	**ns**	**2.32**	**5.97**	**0.3426**	**2.85**

Here, PH = plant height, MB = monopodial branches plant^{-1}, SB = sympodial branches plant^{-1}, OB = opened bolls plant^{-1}, CB = closed bolls plant^{-1}, TB = total bolls plant^{-1}, Means followed by different letters within a column are statistically different from each other at 95% probability level, ns = non-significant.

Table 3
Influence of individual and combined application of silicon and boron on average boll weight, boll retention rate and seed cotton yield of cotton.

Treatments	BW (g)	BRR (%)	SCY (kg ha^{-1})
Control	14.92 e	52.24 e	1150.7 d
Water spray	15.42 e	53.96 e	1176.5 cd
2.0 mM Si	16.47 d	57.63 d	1212.5b
4.0 mM Si	17.55b	61.42b	1213.3b
0.5 mM B	16.76 cd	58.67 cd	1215.5b
1.0 mM B	18.39 a	64.38 a	1253.7 a
2.0 mM Si + 0.5 mM B	17.39 bc	60.88 bc	1205.7b
2.0 mM Si + 1.0 mM B	17.30 bc	60.56 bc	1220.7b
4.0 mM Si + 0.5 mM B	17.38 bc	60.84 bc	1196.7 bc
4.0 mM Si + 1.0 mM B	16.50 d	57.74 d	1215.2b
LSD ≤ 0.05	**0.76**	**2.56**	**28.04**

Here, BW = boll weight, BRR = boll retention rate, SCY = seed cotton yield, Means followed by different letters within a column are statistically different from each other at 95% probability level.

aire maximum micronaire (µg^{-1}) was observed under sole application of Si with 4 mM sate that was statistically at par with the combine application of Si and B with 4 mM and 0.5 mM rate respectively. In case of fiber strength (g tex^{-1}) maximum fiber strength was found under combine application of Si and B with 4 mM and 0.5 mM rate that was statistically at par with combine application of Si and B with 4 mM and 1 mM rate. Minimum values of all the fiber quality traits were observed under control and water sprayed treatment where Si and B was not applied (Fig. 1).

In case of micronaire maximum micronaire (µg^{-1}) was observed under sole application of Si with 4 mM sate that was statistically at par with the combine application of Si and B with 4 mM and 0.5 mM rate respectively. In case of fiber strength (gtex^{-1}) maximum fiber strength was found under combine application of Si and B with 4 mM and 0.5 mM rate that was statistically at par with combine application of Si and B with 4 mM and 1 mM rate. Minimum values of all the fiber quality traits were observed under control and water sprayed treatment where Si and B was not applied (Fig. 1).

4. Discussion

Management of mineral nutritional regime of crop plants is an important practice to enhance the produce quantity and quality (Oosterhuis and Zhao, 2001). Cotton is a cash crop with central position in supporting fabric and other cotton-based industry of Pakistan (Karar et al., 2020). The present research study was conducted to evaluate the response of cotton in terms of morphological, yield and quality attributes in relation to different applied concentrations of silicon, boron and their combinations.

Silicon helps plants to tolerate drought stress by maintaining the capacity of compressed cells (Sattar et al., 2016; Waraich et al., 2011). Although it is micronutrient but due the offensive response of growth, yield and quality assurance of fiber crops towards its application it is considered as an important nutrient. It enables plants against various diseases (Ijaz et al., 2021; Sattar et al., 2016) It has direct influence on stretchiness and fineness therefore it is considered necessary nutrient to improve the productivity and quality of fibers under moisture deficit conditions (Luyckx et al., 2017). Among the fiber crops cotton is considered as an attractive crop towards Si accumulation therefore, it is necessary to identify its role in cotton plant towards growth and fiber quality (Reynolds et al., 2016).

Boron is as essential nutrient required in lower quantity by crop plants (Hussain et al., 2012; Rehim et al., 2012). It plays several vital roles in plant growth and development. However, slightly higher dose of B could prove toxic for plant growth (Farooq et al., 2012). Therefore, resolving the toxicity and deficiency range for specific crop would significantly increase yield and economic returns per unit area. The most important role of B is to lower pollen sterility, which results in higher number of flowers; thus, resulting in improving crop yields. Several studies have optimized B doses for various crops; however, the impact of B on boll retention and fiber quality traits in cotton is rarely tested. There are a

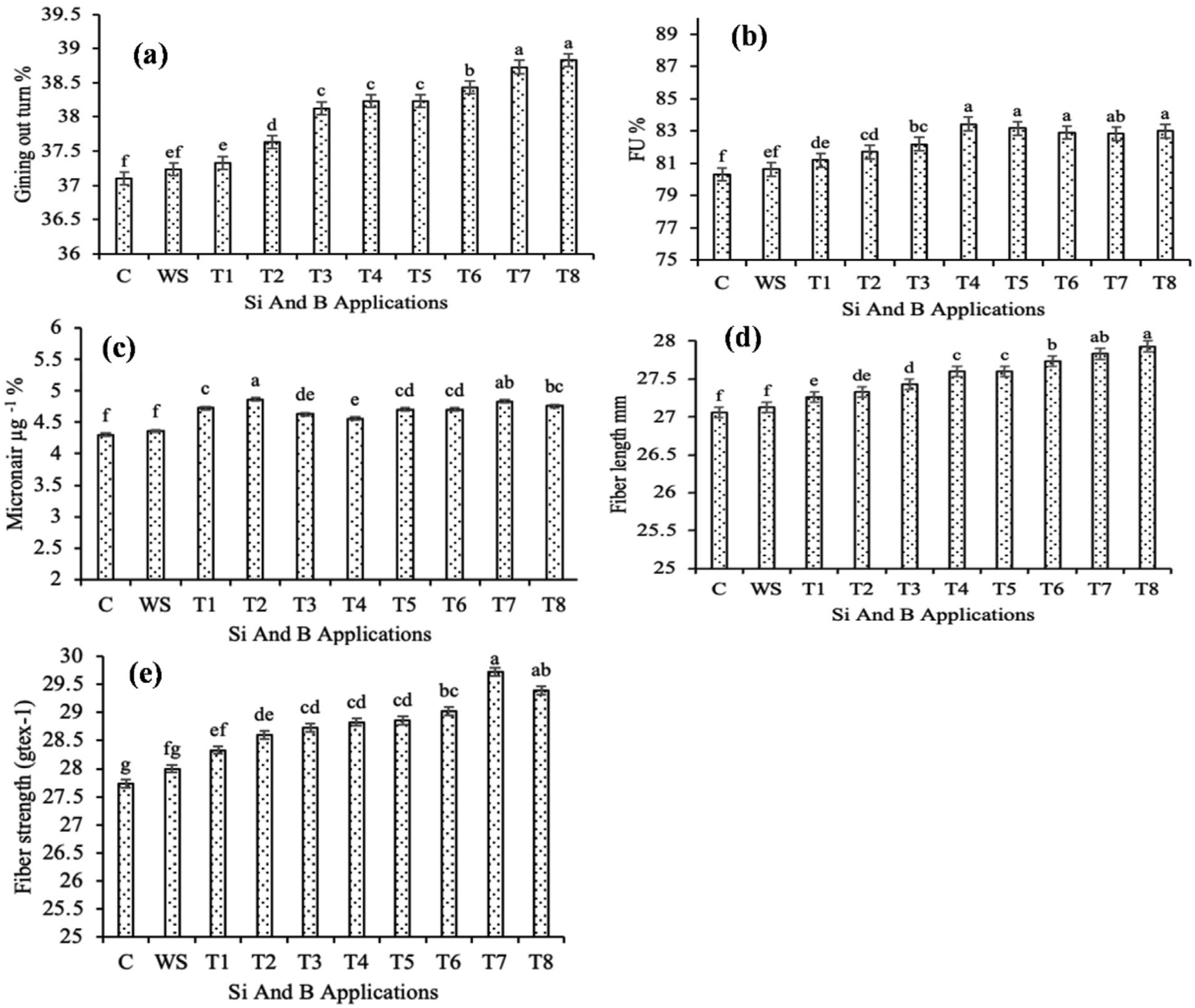

Fig. 1. The impact of individual and combined application of Si and B on fiber quality traits, i.e., ginning out turn (a), fiber uniformity (b), micronaire (c), fiber length (d) and fiber strength (e). In the x-axis, C = control, WS = water spray, T1 = 2 mM Si, T2 = 4 mM Si, T3 = 0.5 mM B, T4 = 1 m M B, T5 = 2 mM Si + 0.5 m M B, T6 = 2 mM Si + 1 m M B, T7 = 4 mM Si + 0.5 mM B and T8 = 4 mM Si + 1 mM B. The bars with different letters denote that the means are statistically different from each other at 95% probability level,

few studies which have determined the impact of B on other yield-related traits; however, boll retention and fiber quality were ignored.

The sole application of B and in combination with Si stimulated maximum plant height, monopodial and sympodial branches of cotton (Table 2) that is attributed towards B application because being an important micronutrient, it impacts on cell division, cell wall elasticity and phytohormones Günes et al. (2003) that increases distance between nodes and internodes of the stem which ultimately enhance plant height (Marschner, 2011). Moreover, the role of B is supported by Si, which also contributes to maintenance of cell wall turgidity, strength and elasticity that ultimately increases plant height (Abdelhafez et al., 2012). Silicon supports the cell wall thickness and size of vascular bundles, therefore provide strength to growing plants. Ahmad et al. (2009) confirmed the synergistic response of B and Si in rice, in terms of plant morphology. Si and B application improved the cotton monopodial and sympodial branches (Table 2). The increased number of monopodial branches because of B and Si application resulted in strong plant frame while sympodial branches enhancement leads to improved yield. This increase of vegetative branches was due to an increase in photosynthates source through B and Si application that improves translocation of these assimilates to reproductive branches.

According to Atique-ur-Rehman et al. (2020) B is involved in carbohydrate metabolism and its translocation, thus improves source-sink balance which supports its role in production of a greater number of vegetative and reproductive branches. More reproductive branches per plant leads to increased yield in terms of opened bolls/plant, fully mature closed bolls/plant, total no. of bolls/plant and seed cotton yield. In current investigation, the boron applied alone (higher concentration) and in combination with Si gave higher number of open bolls, closed bolls and total number of bolls (Table 1). This improvement in cotton quality traits is attributed towards the B application because it is involved in balanced photo assimilates distribution, so resulted in improved fiber quality parameters. Boron also helps pollen growth and increases fertilization processes, by controlling optimal hormonal levels in the reproductive parts of the plant, enhancing better seed, growth and fiber quality (Rashidi and Seilsepour, 2009). Fiber maturity is depicted in terms of micronaire. Textile industry is highly concerned about this quality parameter as fiber of low micronaire produces weak yarn, resulting in various problems in spinning and dying. Si is already established its role as strengthening agent thus the resultant combination of Si with B produces superior quality fiber with maximum length, strength and uniformity.

Si application is reported to improve photosynthates production in crop plants (Hamoda, 2017), that was due to B application because it increases the assimilation of photosynthates as well as Si is involved in translocation of carbohydrate translocation within plant body therefore open, closed, and total number of bolls were increased due to Si and B application. Silicon concentration applied alone, did not supported the yield parameters, however, its combination with B stimulated the above-mentioned yield parameters. It might suggest the synergistic relationship of both applied nutrients (Günes et al., 2003). Its use as bio stimulant significantly improved the growth, productivity, and quality attributes of various fiber crops (Zhao and Oosterhuis, 2003).

The portion of lint which is recovered from seed cotton is referred to as Ginning out turn (GOT) (Shah et al., 2020, 2017). In case of micronaire maximum micronaire (μg^{-1}) was observed under sole application of Si with 4 mM sate that was statistically at par with the combine application of Si and B with 4 mM and 0.5 mM rate respectively. In case of fiber strength ($gtex^{-1}$) maximum fiber strength was found under combine application of Si and B with 4 mM and 0.5 mM rate that was statistically at par with combine application of Si and B with 4 mM and 1 mM rate. Minimum values of all the fiber quality traits were observed under control and water sprayed treatment where Si and B was not applied (Fig. 1).

Application of B and Si stimulated the GOT % in tested cotton variety (Fig. 1). It can be attributed to boron's association with reproductive growth of the plant in terms of facilitating pollen tube growth and seed development (Zhao and Oosterhuis, 2003). The quality parameters including fiber length, fiber uniformity percentage, micronaire quality trait and fiber strength were also reported to be maximized with B and Si application (Fig. 1). This improvement in cotton quality traits is attributed towards the B application because it is involved in balanced photo assimilates distribution, so resulted in improved fiber quality parameters. Boron also helps pollen growth and increases fertilization processes, by controlling optimal hormonal levels in the reproductive parts of the plant, enhancing better seed, growth, and fiber quality (Rashidi and Seilsepour, 2009). Fiber maturity is depicted in terms of micronaire. Textile industry is highly concerned about this quality parameter as fiber of low micronaire produces weak yarn, resulting in various problems in spinning and dying. Si is already established its role as strengthening agent thus the resultant combination of Si with B produces superior quality fiber with maximum length, strength, and uniformity.

5. Conclusion

From the results of this study, it was concluded that optimum concentration of Si and B could be helpful for improving the cotton growth, yield, and quality. Although, B alone produces maximum growth traits and seed cotton yield, but best fiber quality was observed with combination of B and Si. Before commercial recommendation, economic factors of the two nutrients must be considered.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors extend their appreciation to the Researchers supporting project number (RSPD2023R1091), King Saud University, Riyadh, Saudi Arabia.

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