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Original article

Synchronization of Boron application methods and rates is environmentally friendly approach to improve quality attributes of *Mangifera indica* L. On sustainable basis

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ABSTRACT

Micronutrient deficiency in the soil is one of the major causes of mango fruit and yield's poor quality. Besides, the consumption of such a diet also causes a deficiency of micronutrients in humans. Boron deficiency adversely affects the flowering and pollen tube formation, thus decreasing mango yield and quality attributes. Soil and foliar application of B are considered a productive method to alleviate boron deficiency. A field experiment was conducted to explore the Boron most suitable method and application rate in mango under the current climatic scenario. There were nine treatments applied in three replications. The results showed that application of T8 = RD + Borax (75 g plant $^{-1}$ as a basal application) + H_3BO_3 (0.8% as a foliar spray) and T9 = RD + Borax (150 g plant $^{-1}$ as a basal application) + H_3BO_3 (0.8% as a foliar spray) significantly enhanced the nitrogen, potassium, proteins, ash, fats, fiber, and total soluble solids in mango as compared to the control. A significant decrease in sodium, total phenolics contents, antioxidant activity, and acidity as citric acid also validated the effective functioning of T8 = RD + Borax (75 g plant $^{-1}$ as a basal application) + H_3BO_3 (0.8% as a foliar spray) and T9 = RD + Borax (150 g plant $^{-1}$ as a basal application) + H_3BO_3 (0.8% as a foliar spray) as compared to

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control. In conclusion, T8 = RD + Borax (75 g plant $^{-1}$ as a basal application) + H_3BO_3 (0.8% as a foliar spray) and T9 = RD + Borax (150 g plant $^{-1}$ as a basal application) + H_3BO_3 (0.8% as a foliar spray) is a potent strategy to improve the quality attributes of mango under the changing climatic situation.

1. Introduction

Micronutrient deficiency is a major concern in human health globally especially, among women and children, in the developed regions (Cakmak and Kutman, 2018). It is also required for the optimum growth and regulation of metabolic processes in the plants in small quantities (Marschner, 2011). Unfortunately, many environmental factors influence low micronutrient uptake by the roots in the plants. These factors include soil texture and structure, calcium carbonate contents, soil pH, aluminum and iron oxides, nutritional status, organic matter, soil fauna and flora, bicarbonate, and sulfur content. Besides this, the soil's redox potential, poor irrigation, and management practices are also responsible. These soil properties change frequently with land use (Marfo et al., 2019; Theodore Danso Marfo et al., 2019). Soil pollution is also one of the main factors for low nutrient uptake by the pant. Soil rhizobacteria help in the phytoremediation of contaminated soil (Danish et al., 2020; Zafar-ul-Hye et al., 2020b, 2020c, 2020a). These factors also restrict the translocation and accumulation of micronutrient inconsumable parts of the crops, thus adversely affecting the yield (Bibi et al., 2019; White and Broadley, 2001).

To overcome the micronutrient deficiency, fertilizer application in the soil is one of the common methods, Use of Biostimulants reduces the need for fertilizers (Abbas et al., 2020; Izhar Shafi et al., 2020; Pathan et al., 2018; Ullah et al., 2020). These micronutrients can be added to the soil via band placement, broadcasting, or fertigation (Amin et al., 2011; Jankowski et al., 2019; Shirgure, 2012). On the other hand, foliar application of nutrients is also an important crop strategy to optimize the crop yields and micronutrients in the edible parts (Anees et al., 2011; Fatma Bibi et al., 2019). Several studies have shown that the foliar application of the nutrients (Esfandiari and Abdoli, 2016) can increase the crops' growth and yield (Ahmad et al., 2018; Fatma Bibi et al.)

Among different micronutrients, boron (B) is essential, as all the plants require it. Although B is a component of the cell walls, limited literature is documented on its biochemical functions. In the maintenance of membrane function, B plays an imperative role (Abdoli, 2020). It also supports metabolic activities in plants. However, higher uptake of B in the plants can also cause severe toxicity (Aftab et al., 2010). Boron occurs as uncharged boric acid $[B(OH)_3]$ in the soil solution. Fruit setting and its retention percentage are attributed to boron (B) concentration in fruit (Dell and Huang, 1997).

Less availability of B in floral structure results in less fruit setting from flowers. It also minimizes the percent fruit retention on the panicle (Bibi et al., 2019). Balance B uptake increases the thickness of cell wall thickness through specific complexes. Besides, the increase in flower number and retention, germination, pollen tube elongation, seed and fruit development are other benefits associated with balance B uptake. Boron also controls the translocation of photosynthates and less IAA oxidation (Jatav et al., 2020).

Mango (*Mangifera indica* L.) is a popular fruit crop of the family Anacardiaceae. It is cultivated in tropical and subtropical areas of the world. Less fruit setting and retention is a severe problem of mango. During the early development stages, fruitlet abscission is a complex physiological process. The role of micronutrients is crucial in this regard. Their acute deficiencies sometimes cause lower fruit yield and mango quality (Patil et al., 2018). Boron plays a vital role in hormone movement, flowering, activation of salt absorption, pollen germination fruiting process, and pollen tube growth (Robbertse et al., 1990). That's why the current study is conducted to explore the improvement in the quality and yield attributes of mango, amended with B fertilizer under B deficient conditions. It is hypothesized that the combined application of B, i.e., foliar and soil, is better than the sole application for improving the quality and yield characteristics of mango in B deficient conditions. The current study will help the farming community in managing B in the mango trees to achieve better fruit quality and yield.

2. Materials and methods

2.1. Treatment plan

There were 9 treatments with 3 replication following randomized complete block design. The treatments includes: T_1: Recommended dose (RD) of NPK + Borax (0 g plant^{-1} as a basal application) + H_3BO_3 (0% as foliar spray), T_2: RD + Borax (75 g plant^{-1}as basal application) + H_3BO_3 (0% as a foliar spray), T_3: RD + Borax (150 g plant^{-1} as a basal application) + H_3BO_3 (0% as a foliar spray), T_4: RD + Borax (0 g plant^{-1} as a basal application) + H_3BO_3 (0.4% as a foliar spray), T_5: RD + Borax (75 g plant^{-1} as a basal application) + H_3BO_3 (0.4% as a foliar spray), T_6: RD + Borax (150 g plant^{-1} as a basal application) + H_3BO_3 (0.4% as a foliar spray), T_7: RD + Borax (0 g plant^{-1} as a basal application) + H_3BO_3 (0.8% as a foliar spray), T_8: RD + Borax (75 g plant^{-1} as a basal application) + H_3BO_3 (0.8% as a foliar spray) and T_9: RD + Borax (150 g plant^{-1} as a basal application) + H_3BO_3 (0.8% as a foliar spray).

2.2. NPK application

Macronutrient application was made at the rate of 1.5 (N), 1(P), 1(K) kg/plant/year, respectively. All P amounts (1 kg) while half N (0.75 kg) and K (0.50 kg) were added at the end of July. However, the remaining half N and K were added before the 1st week of February (Bibi et al., 2019).

2.3. Boron application

Soil application was made before flowering; Foliar spray was done twice a year, first at the inflorescence stage and second when the fruits attain pea-size. At the end of the experiment, soil and leaf samples were collected, stored, and processed for analysis (Bibi et al., 2019).

2.4. Plants sampling

For the collection of leaf samples, 15 healthy mango plants were randomly nominated from the orchard. Nearly 20 developed leaves (4–6 months old) were collected randomly from all the canopy sides of the fruit-bearing and non-fruit-bearing twigs of mango trees. Samples were collected during July/August. Then leaves were washed out with distilled water and dried in the oven at 70 °C for 48 h. Oven-dried material was ground with the help of John Wiley mill and then passed through a 40-mesh screen.

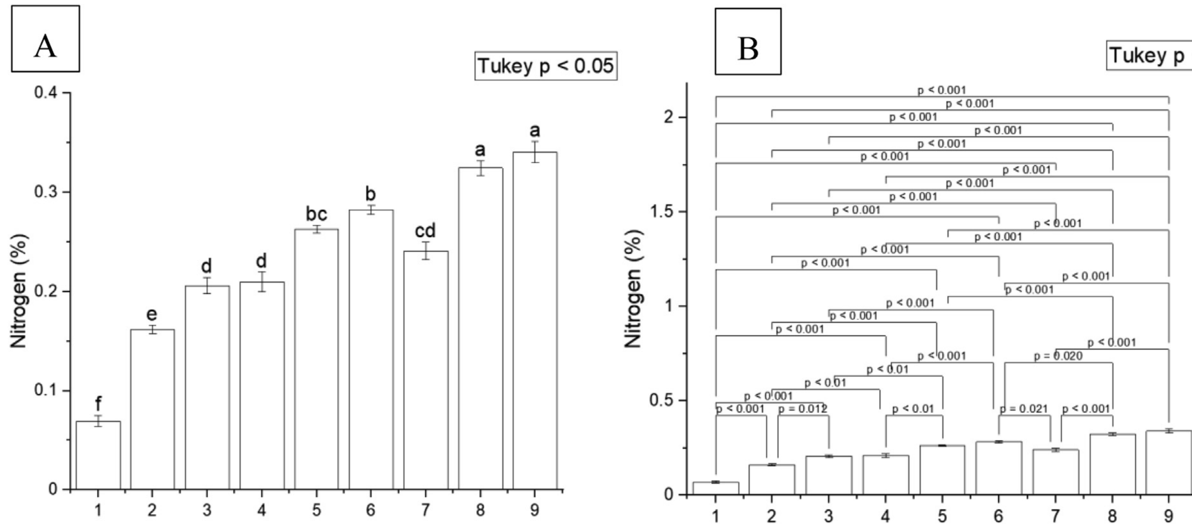

Fig. 1. Effect of the treatments on the nitrogen concentration of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the nitrogen concentration.

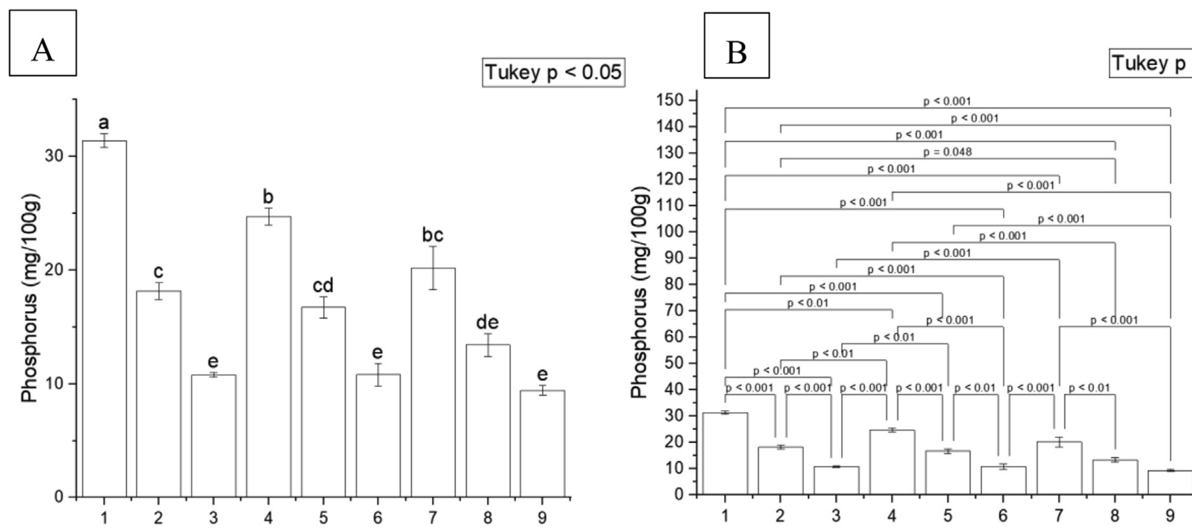

Fig. 2. Effect of the treatments on the phosphorus concentration of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the phosphorus concentration.

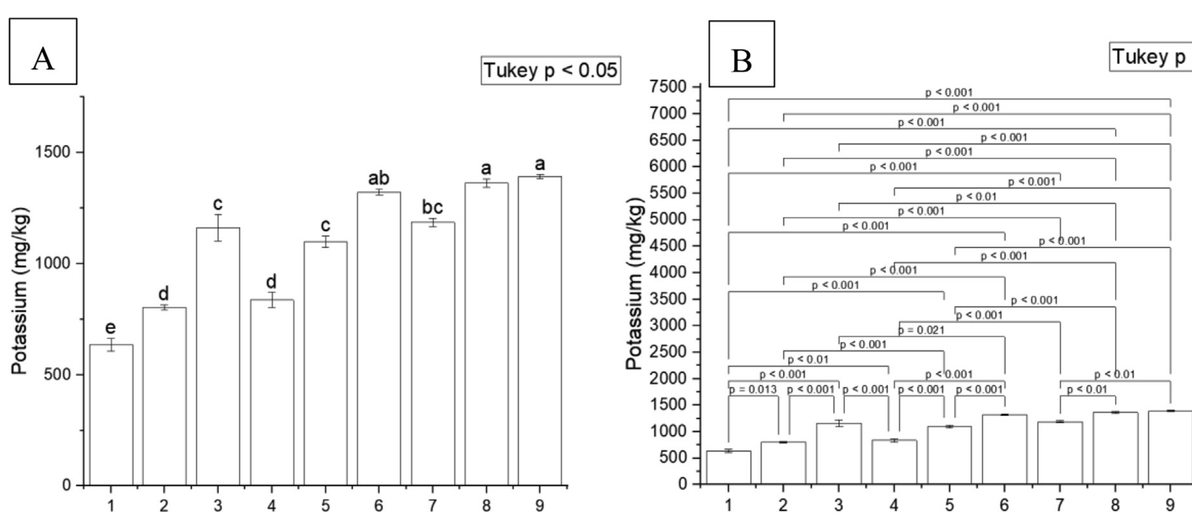

Fig. 3. Effect of the treatments on the potassium concentration of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the potassium concentration.

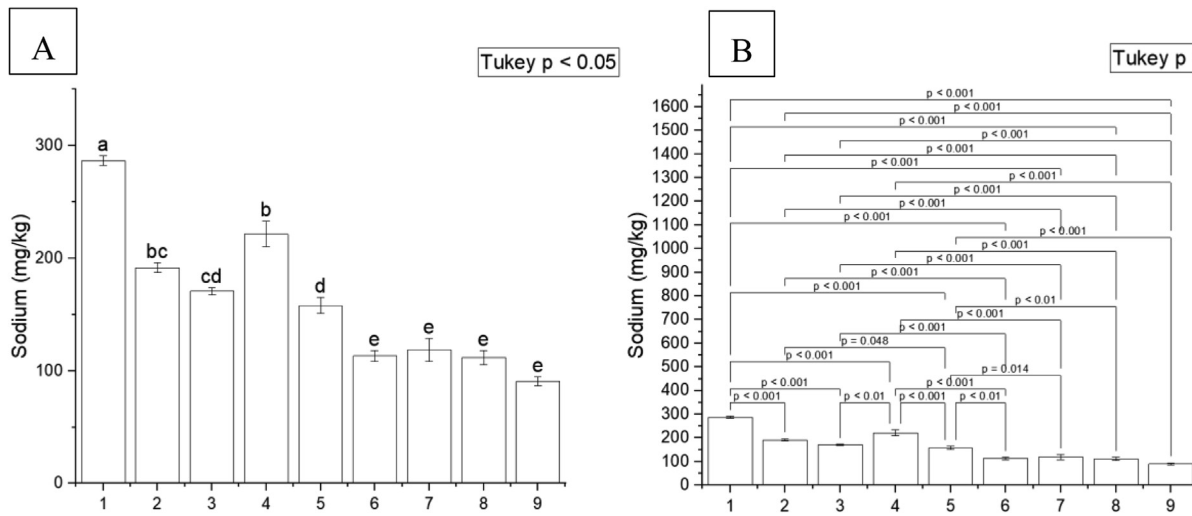

Fig. 4. Effect of the treatments on the sodium concentration of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the sodium concentration.

2.5. Plant analyses

The leaf samples were digested in a diacid mixture to analyze B concentration (Gaines and Mitchell, 1979). Zinc and iron were determined and analyzed using a spectrophotometer/atomic absorption technique (Hettiarachchi et al., 2004). Leaf samples were digested and run through the absorption spectroscopy for P (Benton et al., 1991) and flame photometer for K and Na (Pratt, 1965). Kjeldahl's method was used for nitrogen analysis (Bremner, 1996).

2.6. Fruit retention

For the assessment of fruit retention, an area of 1.0 m^2 from all four sides of the tree was marked. Fruit retention was observed between the mustard stages to the marble stage by adopting the standard protocol.

2.7. Acidity

Titratable acidity as percent citric acid was assessed in fresh mango juice. Titration of the sample at pH 8.2 was done with sodium hydroxide (0.1 N) (Rangana, 1979).

$$Acidity\ (\%) = \left(\frac{Volume\ of\ 0.1N\ NaOH\ (mL)\ \times\ 0.067}{Volume\ of\ (mL)}\right) \times 100$$

2.8. Total soluble solids (TSS)

For total soluble solids (Brix○), "Medline Scientific Ltd. digital hand refractometer model SELECT045" was used. From each fruit, 20 g pulp was collected. It was homogenized for 60 s in 80 mL distilled water. Finally, 1 mL of homogenate was placed on the refractometer for TSS assessment (DRAKE et al., 1988).

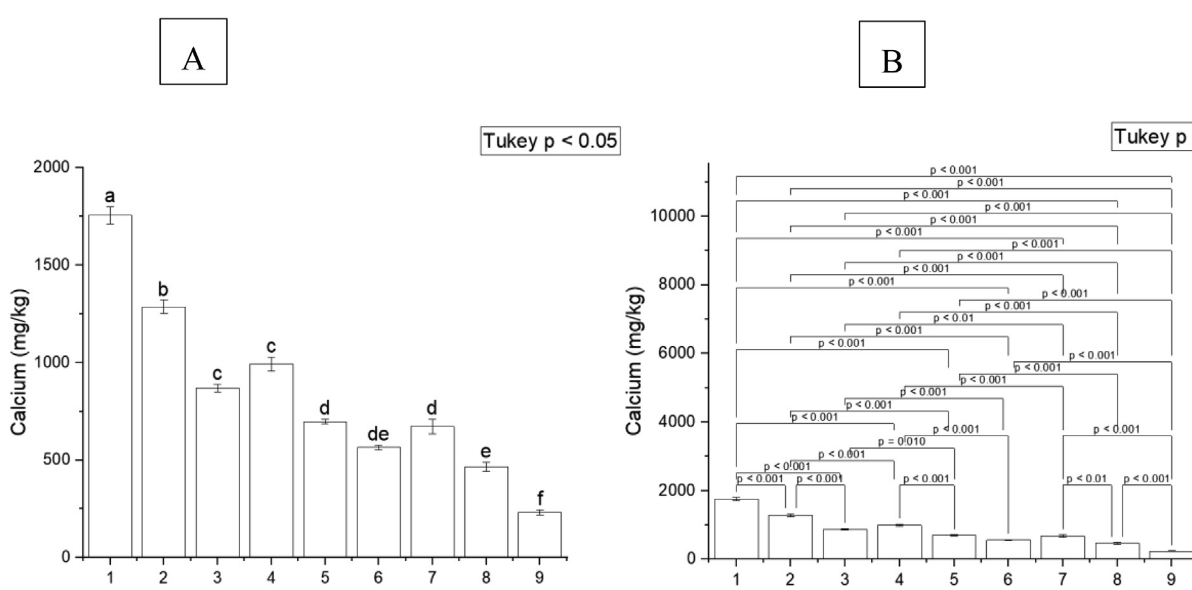

Fig. 5. Effect of the treatments on the calcium concentration of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the calcium concentration.

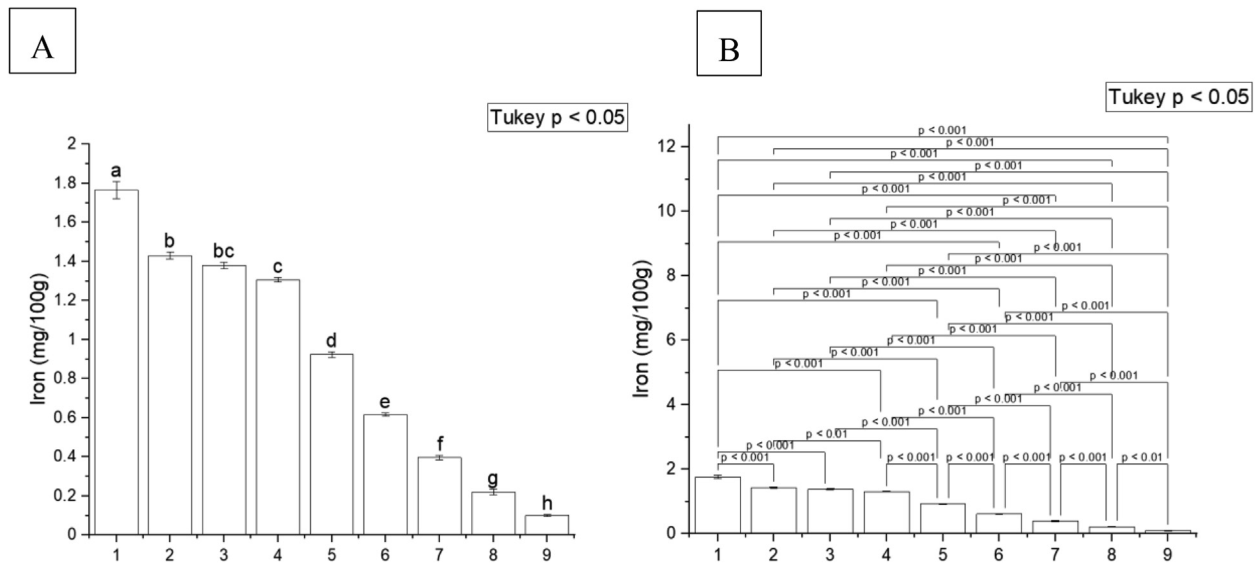

Fig. 6. Effect of the treatments on the iron concentration of mango. Different letters on the bars indicated a significant difference (Tukey test; p < 0.05) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the iron concentration.

2.9. Sugar contents

The total sugar content of mango pulp was determined calorimetrically by the anthrone method (Jayaraman and Jayaraman, 1981).

2.10. Total phenolic contents and vitamin C

The total phenolic content of the liqueurs was determined by the spectrophotometric method with Folin-Ciocalteu (Singleton and Rossi, 1965). Vitamin C was assessed in the mango fruit by adopting the methodology of Spencer et al. Spencer et al. (1956).

2.11. Statistical analysis

The collected data was examined statistically by applying the analysis of variance (ANOVA) and Tukey's test at $p \leq 0.05$. A statistical computer software package (Origin 2020b) was used for the statistical analysis (Steel et al., 1997).

3. Results

3.1. N, P, and K of mango

The effect of the treatments was significant on the nitrogen (N), phosphorus (P), and potassium (K) concentration of mango. T8 and T9 were significant for improving the N of mango from control. A significant increase in N was also noted in T5and T6 from control for N in mango. Application of T7, T3, T2, and T4 also remained significant for N improvement over control (Fig. 1). In the case of phosphorus, a significant decrease was observed by the application of different levels of Zn. No significant change was observed in T3, T6, and T9, where Zn highest level was applied. It was noted that phosphorus concentration was also significantly high in T1, T4, and T7 over T2, T5, and T8 (Zn applied) (Fig. 2). Treatments T6,

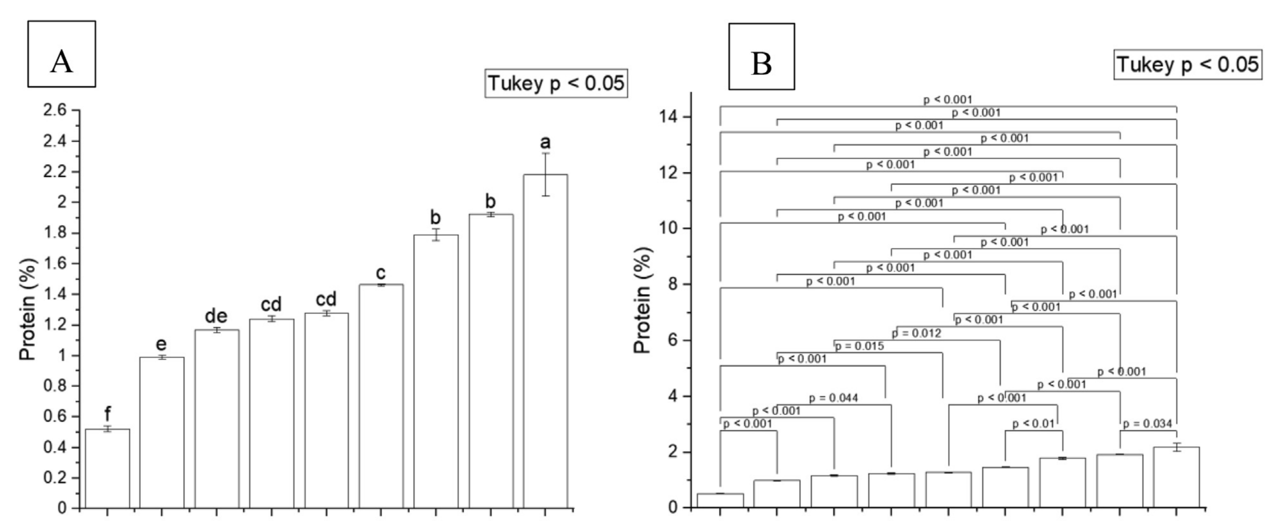

Fig. 7. Effect of treatments on protein contents of mango. Different letters on the bars indicated a significant difference (Tukey test; p < 0.05) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the protein concentration.

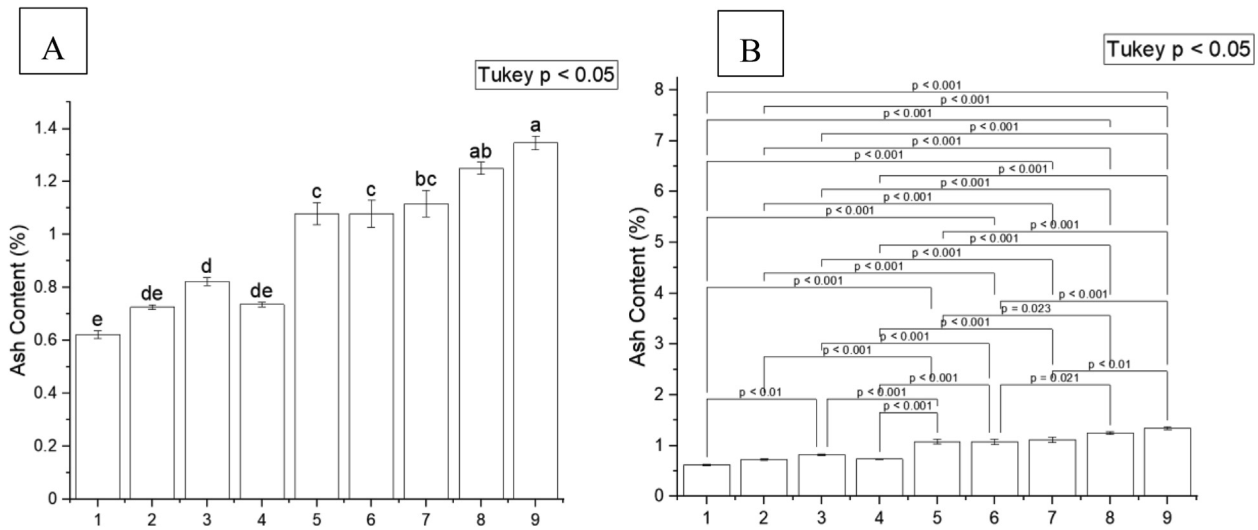

Fig. 8. Effect of the treatments on the ash contents of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the ash contents.

T8, and T9 remained significantly higher than T1 for K concentration. Applications of T3, T7, and T5 were also significantly different than T1 for K concentration (Fig. 3). Furthermore, for K concentration, T2 and T4 were higher than T1. The maximum increase in N, P, and K was noted in T9, T1, and T9compared to T1, T9, and T1, respectively. Pearson correlation showed that N was positive and significant in correlation with K. However, a significant negative correlation was noted between N, and P. Principal component analysis showed that N and K were closely associated with T8 and T9. However, P was more closely associated with T1 and T4.

3.2. Na, Ca, and Fe of mango

The effect of the treatments was significant on the sodium (Na), calcium (Ca), and iron (Fe) concentration of mango. Treatments T1 and T4 were significant for improvement in Na of mango from control. A significant increase was also noted in T2, T3, and T5 from control for Na in mango (Fig. 4). The application of T6, T7, T8, and T9 was non-significant for Na improvement with each other. In the case of calcium, a significant decrease was also observed by applying different levels of Zn. No significant change was observed between T6 and T8; however, minimum Ca was noted in T9, where Zn highest level was applied (Fig. 5). The application of T2, T3, T4, and T5 also significantly decreased Ca compared to T1. Furthermore, all the treatments for Fe concentration showed a significant decline compared to T1 (Fig. 6). The maximum Fe was noted in T9 compared to T1. Pearson correlation showed that Ca was positive and significant in correlation with Fe and Na. Similarly, a significant positive correlation was noted between Na and Fe. The principal component analysis showed that Na, Fe, and Ca were closely associated with T2.

3.3. Protein, Fats, Ash, and fiber contents of mango

The treatment's effect was significant on mango's protein, fats, ash, and fiber contents. Treatments T9 were significant for improv-

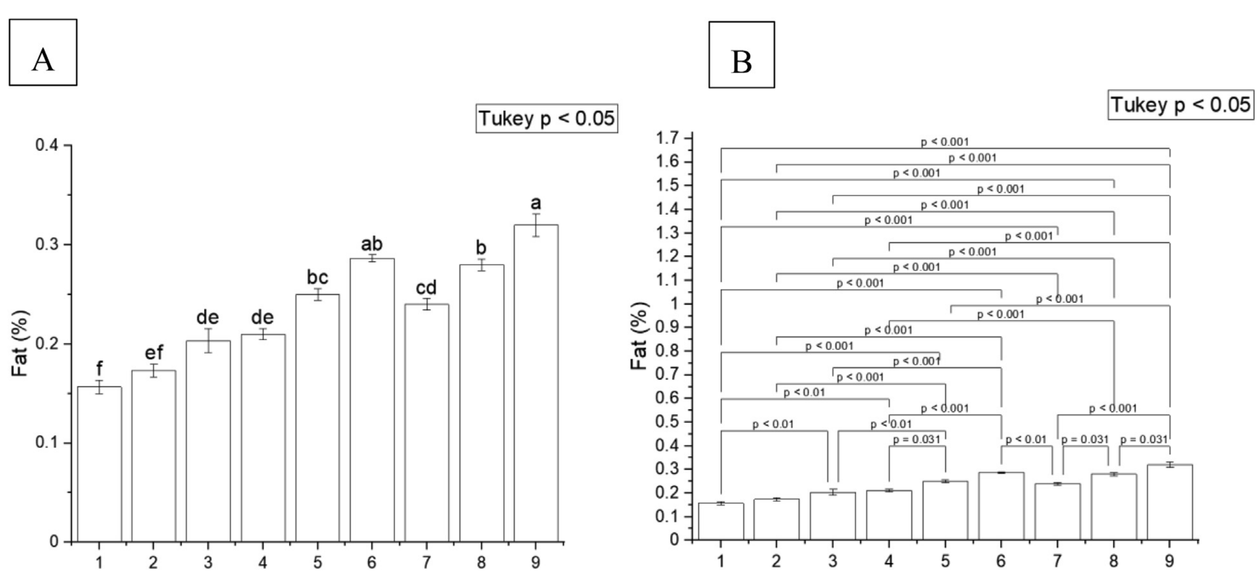

Fig. 9. Effect of the treatments on fats contents of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the fat contents.

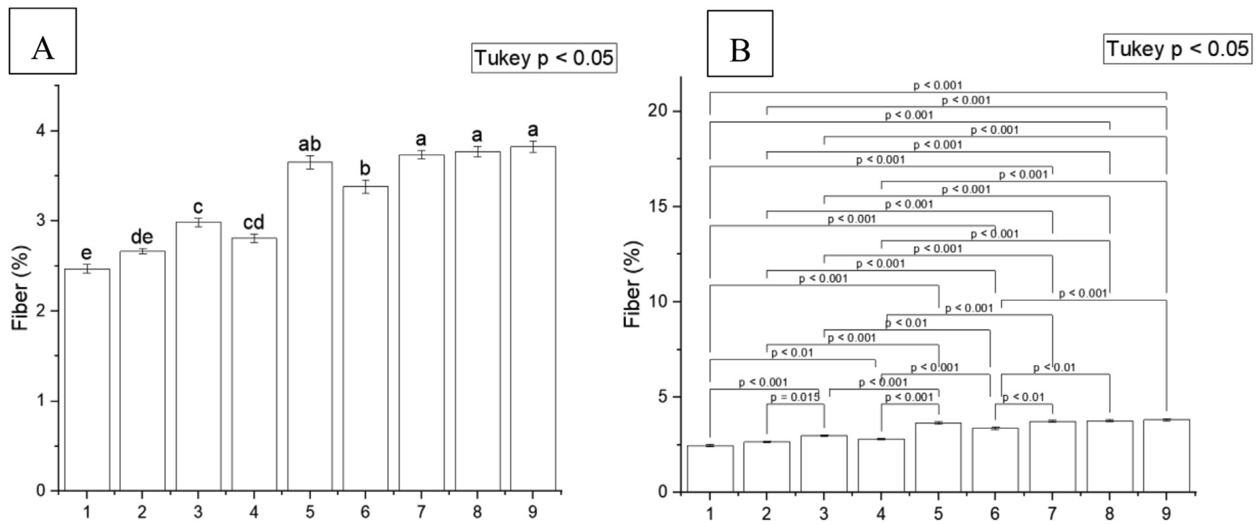

Fig. 10. Effect of the treatments on the fiber contents of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph number B to compare the changes in the nitrogen concentration.

ing the protein contents of mango from T1 control. A significant increase in protein was also observed in T7 and T8 (control) for mango's protein contents. Application of T2 along with T1 significantly improved the protein contents of mango (Fig. 7). For ash content, a significant increase was noted in T9 and T8 compared to T1. No significant change was observed between T8 and T7 regarding the ash contents. However, T5 and T6 also differed significantly for the ash contents compared to T1 (control). Statistical analyses also confirmed that T2 and T4 were non-significant compared to T1 (control) for ash contents in mango (Fig. 8). Treatments T6 and T9 remained significantly higher than T1 for fat contents. Application of T6, T5, and T8 also significantly increased the fat contents over T1. It was observed that T2 did not differ significantly for fat contents in mango compared to T1 (Fig. 9). For fiber contents of mango, T5, T7, T8, and T9 were statistically alike with each other but were significantly different compared to T1 (control). Application of T3, T4, and T6 also remained significant for improving the fiber contents compared to T1. However, T2 remained non-significant for fiber contents compared to T1 control (Fig. 10). Maximum increase in the protein, fats, ash, and fiber contents was noted in T9 compared to T1. Pearson correlation showed that the protein, fats, ash, and fiber contents were positive and significant in correlation with each other. Principal component analysis showed that protein, fats, ash, and fiber contents were closely associated with T8.

3.4. Moisture, TSS, TPC and antioxidant activity in mango

The effect of the treatments was significant on the moisture, TSS, TPC, and antioxidant activity in the mango. Treatments T9, T8, T6 were significant for improving mango's moisture contents compared to T1 control. A significant increase in protein was also observed in T7 and T8 than the control for mango's protein contents. Application of T3, T4, and T5 was significant too for improving the moisture contents than T1. Treatments T2 and T7 were statistically alike but differed significantly from T6 (control) for the moisture contents (Fig. 11). For total soluble solids (TSS), a significant increase was noted in T6 and T9 over T1. No significant change was observed among T2 and T1 for TSS from each other (Fig. 12). However, T3, T4, and T5 also differed significantly for

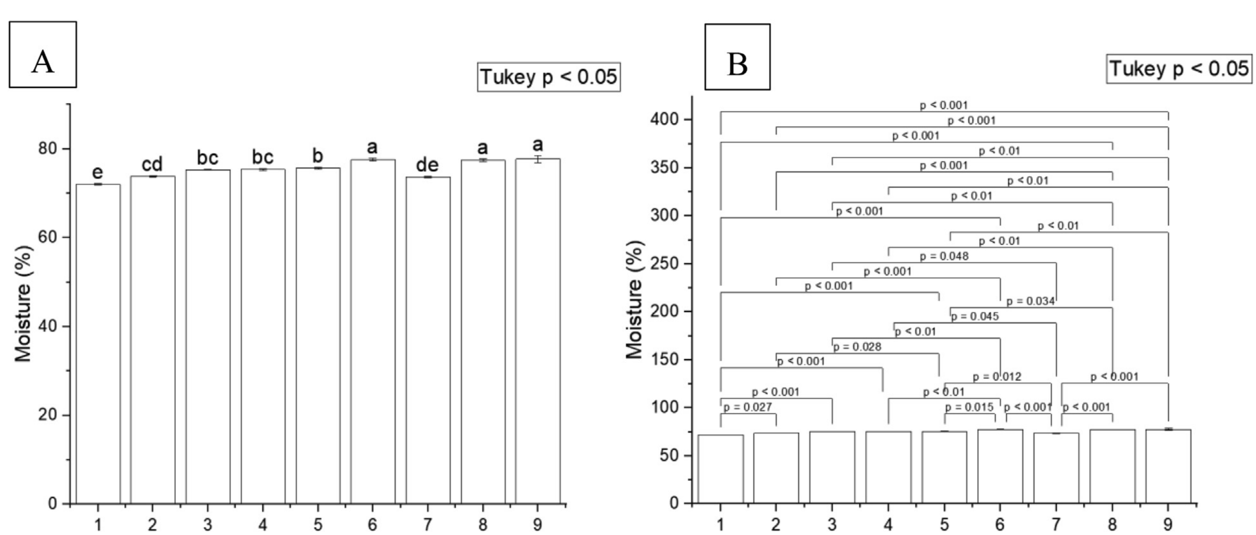

Fig. 11. Effect of the treatments on the moisture contents of mango. Different letters on the bars indicated significant differences (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in the moisture contents concentration.

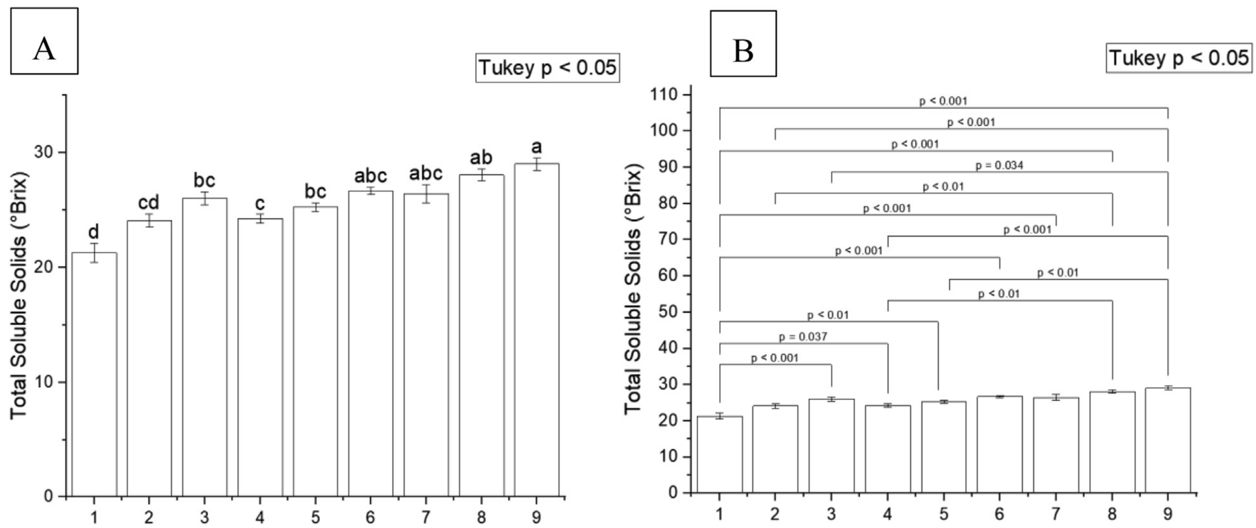

Fig. 12. Effect of the treatments on the total soluble solids of mango. Different letters on bars the indicated significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in the total soluble solids concentration.

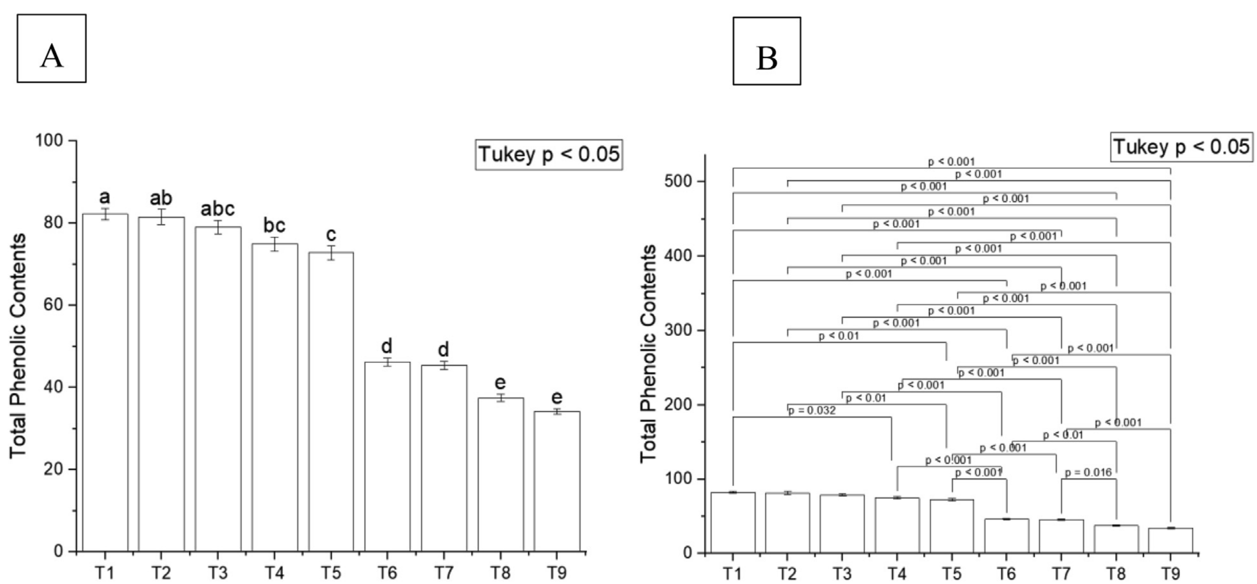

Fig. 13. Effect of the treatments on the total phenolic contents (gallic acid equivalents (GAE)/100 g) of mango. Different letters on the bars indicated a significant difference (Tukey test; $p < 0.05$) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in total phenolic contents.

TSS compared to the T1 control. Statistical analyses also confirmed that T8 and T9 were non-significant with each other but significant compared to T1 (control) for the total phenolic contents (TPC) in mango (Fig. 13). Treatments T6 and T7 cause a significant decrease in TPC than T1. Application of T4 and T5 also significantly decreased TPC than T1. No significant change in TPC among T1, T2, and T3 was observed. Furthermore, all the treatments showed a significant decline in antioxidants activity than T1, T4, and T7 (Fig. 14). A maximum increase in moisture, TSS, TPC, and antioxidant activity was noted in T9 compared to T1. Pearson correlation showed that moisture and TSS were positive and significant in correlation with each other. However, antioxidant activity and TPC showed a significant negative correlation with moisture, TSS. Principal component analysis showed that moisture, TSS, and antioxidant activity were closely associated with T6, T8, and T9, T8, and T1 and T7, respectively.

3.5. Acidity, SC, and vitamin C in mango

The effect of the treatments was significant on the acidity, sugar content (SC), and vitamin C in mango. All the treatments significantly decreased mango acidity from T1 control except T4 and T7 (Fig. 15). In the case of SC, a significant increase was noted in T9 compared to T1. No significant change was observed among T5, T6, and T8, but the results differed significantly from T1 for SC. In addition, T2, T3, and T4 also differed significantly for SC compared to T1, control (Fig. 16). Statistical analyses also confirmed that T2, T4, and T7 were non-significant with each other and T1 (control), for vitamin C in mango (Fig. 17). Treatments T3, T5, T6, T8, and T9 significantly decreased vitamin C than T1. A maximum increase in sugar content (SC) was noted in T9 compared to T1. However, T9 gave the maximum decrease in acidity and vitamin C in mango as compared to T1. Pearson correlation showed that

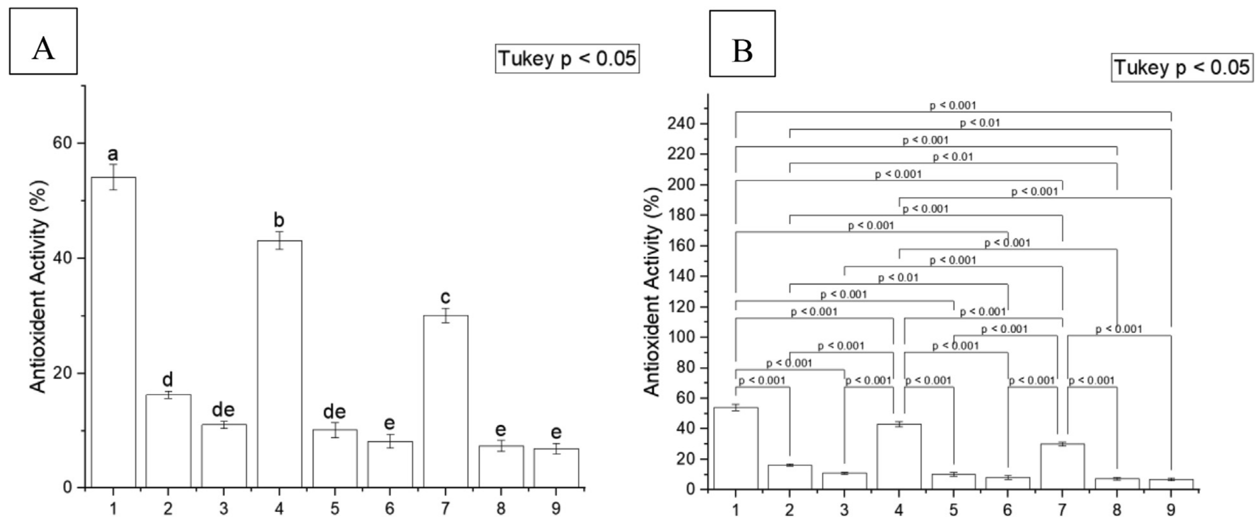

Fig. 14. Effect of the treatments on antioxidant activity in mango. Different letters on the bars indicated a significant difference (Tukey test; p < 0.05) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in the antioxidant activity in concentration.

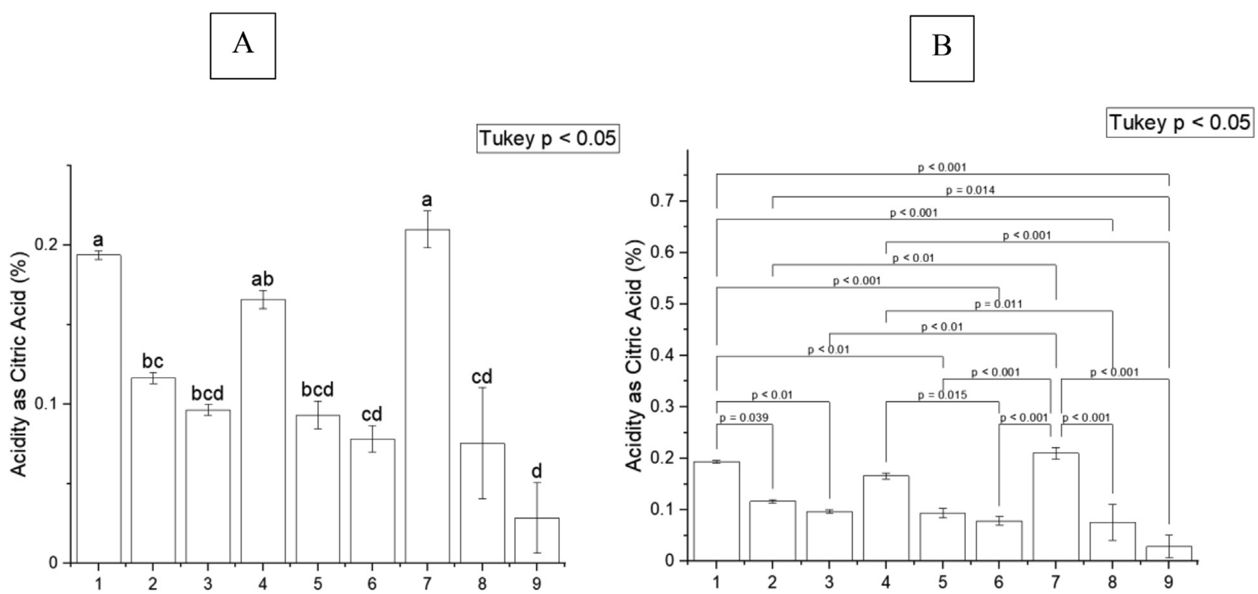

Fig. 15. Effect of treatments on acidity as citric acid mango. Different letters on the bars indicated significant difference (Tukey test; p < 0.05) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in acidity as citric acid concentration.

sugar content showed a significant negative correlation with acidity and vitamin C (Fig. 18). The principal component analysis showed that acidity, sugar content (SC), and vitamin C were closely associated with T4, T6, and T7, respectively (Fig. 19).

4. Discussion

Optimum uptake of B is essential for normal growth and enhancing quality attributes in fruiting plants (Marschner, 2011). A large number of studies indicated that B played an immense role in the higher uptake of nitrogen. Plants showed minimum nitrate reductase (NR) activity. It is also sensitive to nitrate accumulation when there is a severe B deficiency (Shen et al., 1993). In addition to N, higher uptake of B also facilitates the P and K intake in plants. It increases the permeability of roots, which facilitates the P and K uptake. However, B application as a treatment also decreases Ca uptake (Misaghi and Grogan, 1978; Morsey and Taha, 1986). Our findings also justified these arguments. Results showed that the increasing level of B also enhanced the N, P, and K concentration of mango. It also decreases the Ca uptake in mango due to its antagonistic relationship with B. It plays a key role in pollen germination, pollen tube formation, and other development. Hence, a limited number of flowers, poor fruit quality, and yield are major drawbacks of B deficiency (Mozafar, 1989). Application of boron as foliar becomes the part of plants through the superiority of phloem filter plates in the basipetal flow of sucrose. It stabilizes the nuclear membrane and ribonucleic acid metabolism and thus plays an imperative role in the assimilation of sugar contents (Marschner, 2011). The current study results also agree with these findings as they show that the foliar application of micronutrient B and Zn as T9 significantly enhanced the sugar contents of mango. It has been observed that B has a crucial role in phenolic metabolism. It activates the enzyme phenylalanine ammonium-lyase (PAL) under deficient conditions, which significantly increased phenolic.

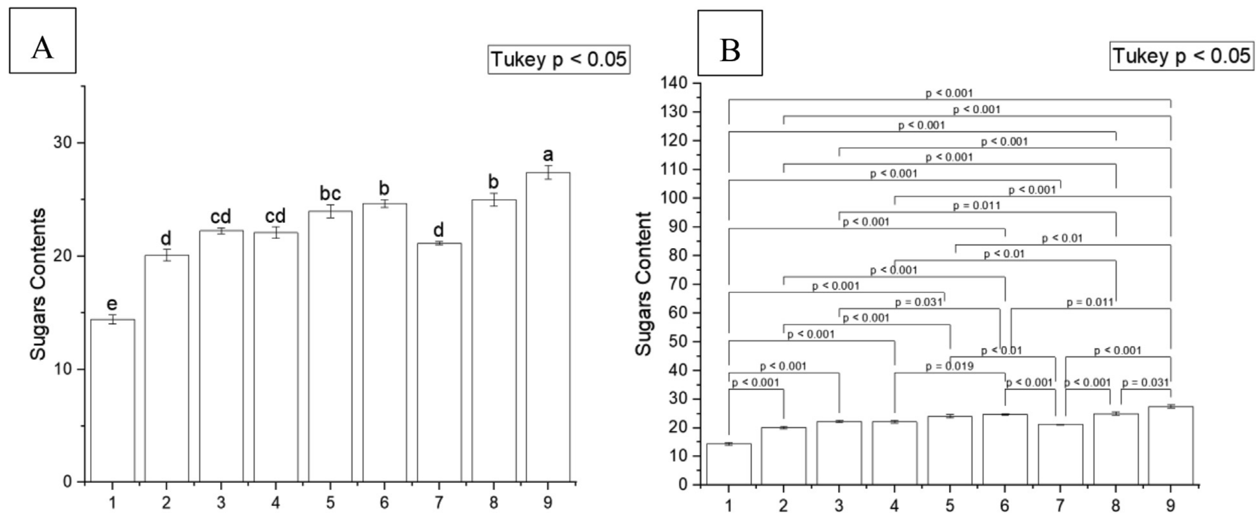

Fig. 16. Effect of the treatments on the sugar contents (%) of mango. Different letters on the bars indicated a significant difference (Tukey test; p < 0.05) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in the sugar contents.

Higher accumulation of phenolic is catalytic as it is oxidized by polyphenol oxidase (PPO) enzyme activity. Such oxidation results in the production of quinones that decrease the cell membrane's integrity (Camacho-Cristóbal et al., 2002). Findings of the current study also signify that phenolics contents were decreased by increasing B soil and foliar application. The reduction in phenolic would have been due to B better uptake and the alleviation of B deficiency in the mango plants. In the plant, a cell wall growth deficiency of B also decreases glycoproteins. Most surface proteins remain bound with the membrane through glycosylphosphatidylinositol anchors such as arabinogalactan proteins (AGP). These glycosylphosphatidylinositol anchors, such as arabinogalactan proteins (AGP) provide bindings sites for putative B-binding structures(Goldbach and Wimmer, 2007; Redondo-Nieto et al., 2007). The same changes are also observed in the pollen tubes, where cell walls are made up of pectins. The results of the current study are also in line with the above arguments. They show that the highest application rate of B significantly increases proteins in mango. This increase in protein contents was due to the significant enhancement in nitrogen uptake, which is a key part of amino acids and protein synthesis. Marschner (Marschner, 2011) documented that B deficiency enhanced reactive oxygen species (ROS) formation. Higher ROS restricts glutathione and ascorbic acid metabolism through oxidative damage. To overcome such a situation, a significant quantity of antioxidants is produced in the plants to alleviate the oxidative damages (Han et al., 2008). Low antioxidants detection in T9 and higher in T1 signifies that T9 alleviates B deficiency in the plants more efficaciously than the other treatments. Higher permeability of roots facilitates the uptake of P and K and enhances the uptake of water. Both P and K are widely taken up in the plants through soil solution (Misaghi and Grogan, 1978; Morsey and Taha, 1986). Thus improvement in the moisture contents of mango in the current study also justified the higher uptake of P, and K. Thomidis and Exadaktylou (Thomidis and Exadaktylou, 2010) argued that higher uptake of K by the application of B promotes the firmness of fruit and total soluble solids. This optimum uptake of K decreases the acidity of the fruit juice regulated by the balanced application of B as a foliar and soil application (Ekbic et al., 2018). The findings regarding improvement in the total soluble solids and decrease in the acidity of mango fruit juice in T9 validated the efficacious functioning of B when applied as a foliar application, in combination with the soil application.

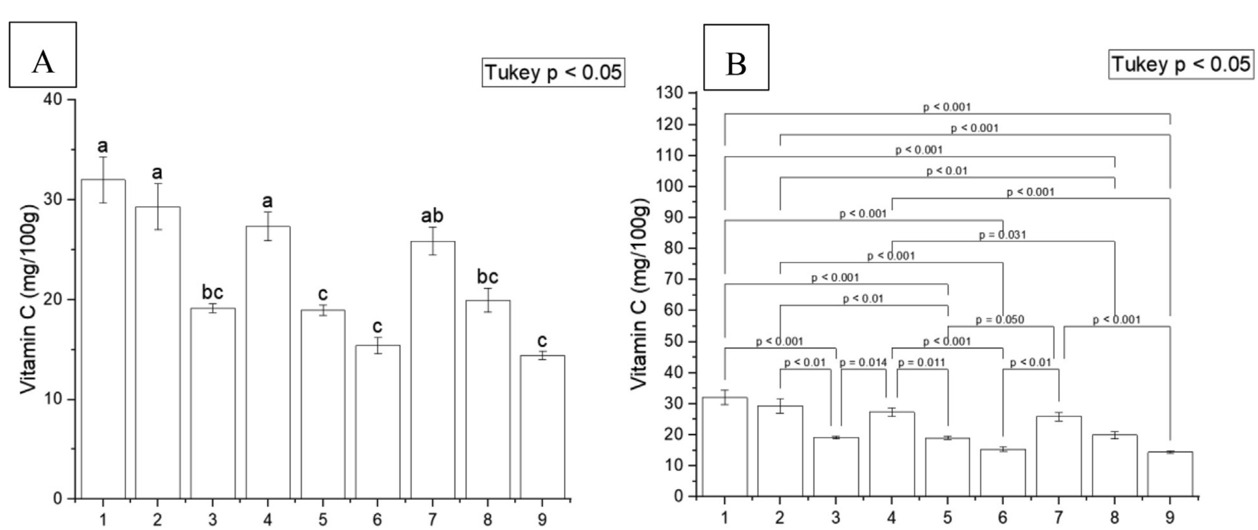

Fig. 17. Effect of the treatments on the vitamin C of mango. Different letters on the bars indicated a significant difference (Tukey test; p < 0.05) Tukey test. P values for each applied treatment are provided in graph B to compare the changes in vitamin C concentration.

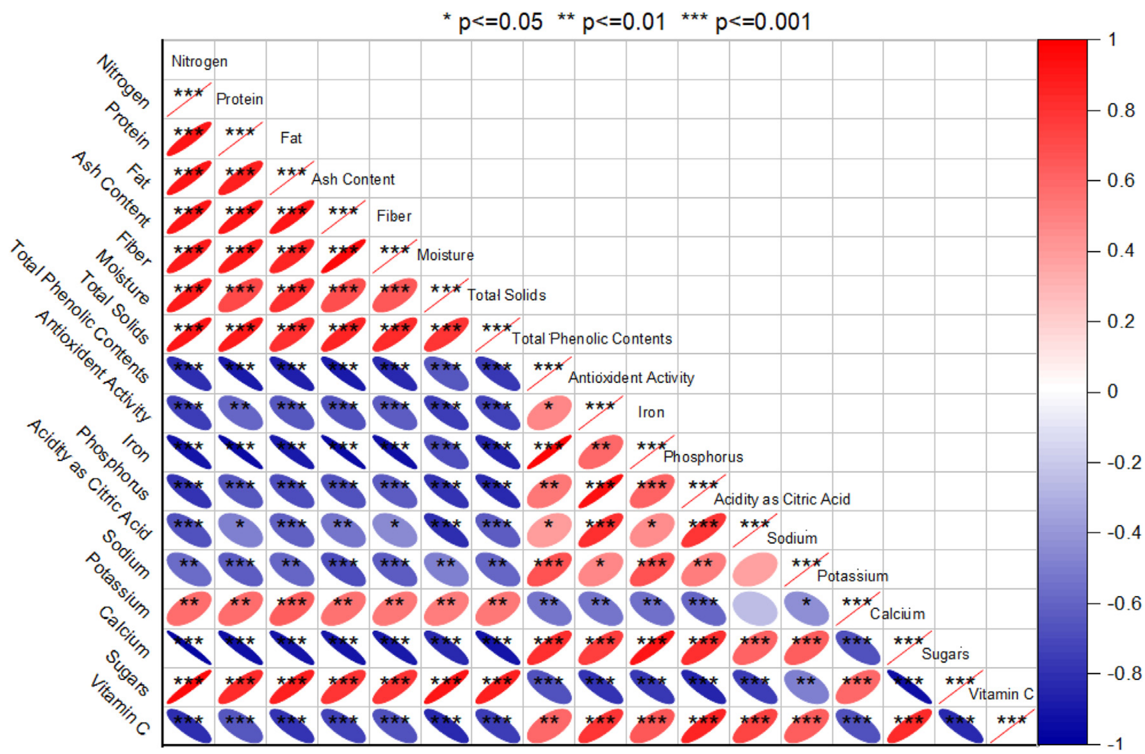

Fig. 18. Pearson correlation of different mango quality attributes and nutrients contents.

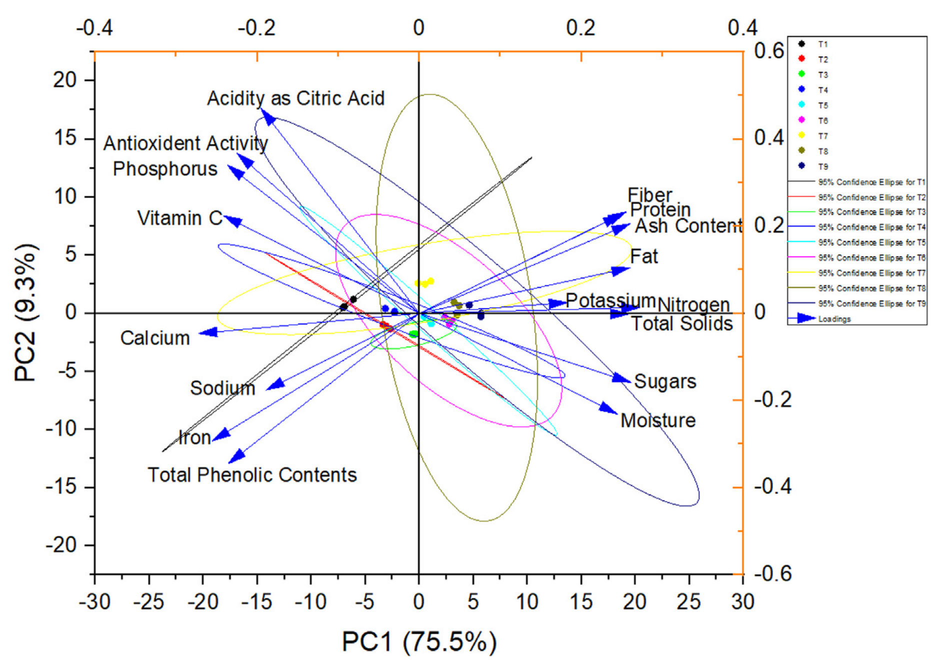

Fig. 19. Principle component analyses of different mangoes quality attributes and nutrients contents.

5. Conclusions

From the study, we conclude that the application of boron can improve mango quality attributes and nutrients contents. Soil and foliar application are essential for the uptake of B in mango plants. However, more productive results can be obtained through B combined application as a foliar and soil application. Applying 150 g Boron per plant as a basal dose + 0.8% as a foliar in combination is recommended to alleviate B deficiency and improve mango quality and nutrients contents in the B deficient soils. More investigations are suggested on the different mango varieties to establish and declare a narrow range of B application rates for mango.

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.

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