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Assessment of various levels of potassium citrate and sucrose along with boric acid on quality and yield of Sufaid Chaunsa

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Abstract

Deficiency of nutrients resulted in low quality and yield of fruits. It is an established fact that foliar application of nutrients can mitigate nutritional stress to some extent. Keeping in mind the economic value of Sufaid Chaunsa, a field study was conducted, to find the effect of co-application of sucrose or potassium citrate with boric acid on yield and quality of Sufaid Chaunsa. The study was designed with hypothesis that co-application of boric acid (BA) with potassium citrate (PC) or sucrose (S) would have potential to improve quality and yield of Sufaid Chaunsa. It was observed that BA (0.2%) + S1 (10%) remained significantly best for improvement (13%) in fresh fruit weight as compared to control. In connection with results, maximum increase in plant yield (19%), total soluble solids (29%) and reduction in fruit acidity (37%), it is clear that BA (0.2%) + S1 (10%) is a better approach. However, a significant increase (69%) in shelf life of Chunsa as compared to control also validated the efficacious functioning of BA (0.2%) + PC2 (0.4%). It is concluded that application of BA (0.2%) + S1 (10%) is a better approach for improvement in the quality of Sufaid Chaunsa. Comparative for yield, both BA (0.2%) + S1 (10%) and BA (0.2%) + PC2 (0.4%) are equally effective. However, for shelf life, application of BA (0.2%) + PC2 (0.4%) is more efficacious.

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Introduction

Mango (*Mangifera indica* L.) is considered, king of fruits due to its unique smell, dietary fibre, carbohydrates (Kumar *et al.,* 2017), flavour and nutritional value (Anees *et al.,* 2011). It is mostly cultivated in tropical and subtropical regions of the world (El-migeed, 2005). Among a large number of *Mangifera indica* L. varieties, there are few ones that are exported to earn foreign exchange (Lauricella *et al.,* 2017). Export of mango is done in both fresh and dry forms (Jarande *et al.,* 2013) that make *Mangifera indica* L. an important economic crop as well. The shape, size, acidity, colour and soluble sugar are such quality parameters that decide the economic value of *Mangifera indica* L. (Maqbool and Mazhar, 2007). However, imbalanced nutrition and poor management not only deteriorate the quality but also decreased the yield of *Mangifera indica* L. (Ahmad and Rashid, 2003).

Reduction in yield and low quality of fruit, due to deficiency of boron (B) in fruits is one of a major challenge for the agricultural scientists. Balance intake of B in plants not only increase the growth but also improves fruits retention and yield (Perica *et al.*, 2001; Abd-Allah, 2006). It also plays an important role in the germination of pollen grains, elongation of pollen tube and setting of fruits (Ahmad *et al.,* 2009). Proper fertilization of B facilitates the pollination and flowering that play an imperative role regarding improvement in yield (Rajput *et al.,* 1976). The acidity of fruits is significantly decreased when B is uptaken by plants at its optimum level (Dutta, 2004). However, the need of time is to improve the balance uptake of B (Moheyuddin *et al.,* 2013) to enhance the yield and quality of mango (Khalifa *et al.,* 2009).

Besides the deficiency of B, better uptake of potassium (K) also resulted in significant improvement of fruit setting and yield (Baiea *et al.,* 2015). In most plants, water use efficiency, the formation of protein, starch, photosynthesis and activation of enzymes are mainly controlled by K (Stino *et al.,* 2011; Abd El-Razek *et al.,* 2013). Many scientists have documented that optimum intake of K and B improved the physiological processes in the plants that resulted in significant increase of yield (Nunez-Elisea and Davenport, 1986; Bagel *et al.,* 2004). Both nutrients also controlled the assimilation of many enzymes that play an important role in the synthesis of plant hormones (Jarande *et al.,* 2013).

However, to overcome the problem of low yield, poor quality and less fruit setting due to limited availability of potassium and boron, foliar application of boron (B) and potassium (K) is usually suggested (Nunez-Elisea and Davenport, 1986; Bagel *et al.,* 2004).

So far, a lot of research work has been documented regarding the foliar application of K and B solely for their potential benefits on plant yield and quality of fruit. However, limited information is available regarding the co-application of boron with potassium citrate and sucrose on quality and yield attributes of *Mangifera indica* L. Keeping in mind the economic and nutritional importance of Sufaid Chaunsa (*Mangifera indica* L.), a field study was conducted with the novelty and aim, to find the effect of sucrose and potassium citrate with boric acid on yield and quality of Sufaid Chaunsa. It is hypothesized that co-application of boric acid with potassium citrate or sucrose would have potential to improve the quality and yield of Sufaid Chaunsa.

Materials and methods

Selection of sit and plants

For experimental purpose disease free and physiologically same plants of Sufaid Chaunsa were selected in the orchard of research area (30.155013 N, 71.447300 E) of Mango Research Institute Multan.

The age of each plant was 15 Years. For determination of soil texture methodology of Gee and Bauder (1986) was adopted. Method of Walkley (1935) was used for determination of soil organic matter. Extractable soil potassium was assessed according to the methodology described by Nadeem *et al.* (2013). For extractable phosphorus, Olsen and Sommers (1982) method was used. The organic soil nitrogen was calculated by using the equation of Richards (1954):

$$\text{Organic N (\%)} = \frac{\text{Soil Organic Matter}}{20}$$

The physiochemical characteristic of orchard soil is provided in Table 1.

Table 1. Pre-experimental characteristics of soil.

Paramcters	Units	0-15 (cm)	15-30 cm
Sand	%	35	40
Silt	%	45	40
Clay	%	20	20
Texture		Loam	
OM	%	0.48	0.32
Organic N	%	0.024	0.016
Extractable P	μg^{-1}	6.90	4.50
Extractable K	μg^{-1}	145	132
Boron	μg^{-1}	0.70	0.50

Macronutrients

For each plant 1500g N, 1000g P and 1000g K were applied as basal dose on annual basis to fulfil the requirements of macronutrients.

Application rate of potassium citrate and sucrose

Potassium citrate (Sigma) was applied as a foliar application at the rate of 0.2% and 0.4% along with 0.2% boric acid. However, the sucrose was applied at the rate of 5% and 10% along with 0.2% solution of boric acid.

Time and frequency of foliar application

All the foliar treatments were applied at pre-flowering stage (February) and at marble stage (April). Foliar application of treatments was done in 2 splits.

Treatment plan and experimental design

There were 6 treatments with 4 replications following randomized completely block design (RCBD).

The treatments include: control (No boric acid + no potassium citrate + no sucrose), 0.2% Boric acid (BA), 0.2% Boric acid + 0.2% Potassium citrate (BA+PC1), 0.2% Boric acid + 0.4% Potassium citrate (BA+PC2), 0.2% Boric acid + 5% Sucrose (BA+ S1) and 0.2% Boric acid + 10% Sucrose (BA+ S2).

Harvesting

When fruits were fully developed harvesting was done by the end of July by using a clipper. All the fruits were collected in fruit baskets and brought in plant nutrition section of Mango Research Institute Multan.

Determination of total soluble solids in fruit

The total soluble solids (TSS) were assessed in the fruit by using Medline Scientific Ltd digital hand refractometer model SELECT045.

Analysis of titratable acidity

For the analysis of titratable acidity, titration was done by using 0.1N NaOH as described by the Rangana (1979).

Morphological attributes

No. of fruits per panicle was calculated manually by counting of fruits on panical in the field in 4 replica. The measuring tape was used to assess the panicle length in the field. Fresh weight of fruit was noted on top weight balance in plant nutrition section of Mango Research Institute Multan.

Statistical analysis

Statistical analysis of Sufaid Chaunsa fruit quality and yield attributes was done using standard statistical procedures (Steel *et al.,* 1997) using statistical software SPSS (PASW version 18.0). All the treatments were analyzed by one-way ANOVA while means of 4 replicates were compared by Tukey's test at $P \leq 0.05$.

Results and discussion

No. of fruit set panicle^{-1}

Statistical analysis confirmed that the effect of potassium citrate (PC) and sucrose (S) along with boric acid (BA) was significant ($P \leq 0.05$) for no. of fruit set panicle $^{-1}$. It was noted that BA+PC2, BA+S1 and BA+S2 were statistically alike to each other but significantly different as compared to control for no. of fruit set panicle^{-1}. The performance of BA+PC2 also remained significantly better as compared to BA and control. Both BA and control remained statistically alike to each other for no. of fruit set panicle^{-1}.

However, the application of BA+S2 remained significantly best among all the treatments for improvement in no. of fruit set panicle^{-1}. The maximum increase of 41% was noted in for no. fruit set panicle^{-1} as compared to control where BA+S2 were applied.

Penicle Length

Effect of potassium citrate (PC) and sucrose (S) along with boric acid (BA) was significant ($P \leq 0.05$) for penicle length. Results showed that BA+PC1, BA+PC2, BA+S1 and BA+S2 remained statistically alike to each other for penicle length. No significant improvement was noted among control, BA, BA+PC1, BA+PC2, BA+S1 for the improvement in penicle length. However, application of BA+S2 remained significantly best as compared to control for the improvement in the penicle length. The maximum increase of 16% was noted in for penicle length as compared to control where BA+S2 was applied.

Fresh Fruit Weight

Application of various levels of potassium citrate (PC) and sucrose (S) along with boric acid (BA) significantly ($P \leq 0.05$) affected the fresh fruit weight. Application of BA significantly enhanced the fresh fruit weight. However, the performance of BA along with various levels of potassium citrate (PC) and sucrose (S) was significantly better as compared to BA for improvement in fresh fruit weight. Application of BA+PC1 and BA+PC2 were remained statistically alike to each other but significantly different as compared to control for improvement in fresh fruit weight. Among all treatments, BA+S2 and BA+S1 remained statistically alike and significantly best for an increase in fresh fruit weight. Maximum increase (13%) in fresh fruit weight was noted as compared to control where BA+S2 was applied.

Plant Yield

Addition of various levels of potassium citrate (PC) and sucrose (S) along with boric acid (BA) significantly ($P \leq 0.05$) modified mango plant yield. It was noted that BA, BA+PC1, BA+PC2, BA+S1 and BA+S2 were statistically alike to each other for plant yield. No significant increase in plant yield was observed among the treatments of control, BA and BA+PC1. However, the performance of BA+PC2, BA+S1 and BA+S2 remained significantly best as compared to control for plant yield. Maximum increase (19%) in plant yield was noted as compared to control where BA+S2 were applied.

Total Soluble Solids

Results showed that effect of various levels of potassium citrate (PC) and sucrose (S) along with boric acid (BA) was significant ($P \leq 0.05$) for total soluble solids (TSS) in fruit. The performance of BA+S1 and BA+S2 was significantly best as compared to control for total soluble solids (TSS) in fruit.

The treatments BA, BA+PC1 and BA+PC2 were statistically alike to each other but also remained significantly better as compared to control for total soluble solids (TSS) in fruit. As compared to BA, BA+PC1 and BA+PC2, application of BA+S1 and BA+S2 significantly increased total soluble solids in fruit. The maximum increase of 29% TSS was noted as compared to control where BA+S2 was applied.

Acidity

Statistical analysis confirmed that the effect of various levels of potassium citrate (PC) and sucrose (S) along with boric acid (BA) was significant ($P \leq 0.05$) for acidity in fruit. It was noted that the treatments BA+S1 and BA+S2 differ significantly as compared to control for the reduction in acidity of the fruit. Application of BA, BA+PC1 and BA+PC2 remained statistically alike to each other and did not differ significantly as compared to control. Maximum reduction (37%) in fruit acidity was noted as compared to control where BA+S2 was applied.

Shelf life

Application of various levels of potassium citrate (PC) and sucrose (S) along with boric acid (BA) significantly ($P \leq 0.05$) affected the shelf life of fruit. Results showed that BA+PC1 and BA+PC2 differ significantly and remained best as compared to control for improvement in the shelf life of fruit. Performance of BA+S1 also remained significantly better for the improvement in the shelf life of fruit as compared to control. However, applications of BA and BA+S2 were statistically alike to each other and did not differ significantly as compared to control for fruit shelf life. Maximum increase 69% in the shelf life of fruit was noted as compared to control where BA+PC2 were applied.

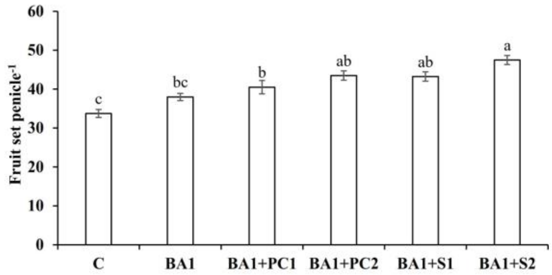

Fig. 1. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on fruit set penical^{-1} of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

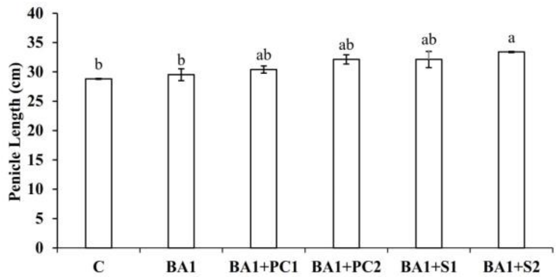

Fig. 2. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on penical length (cm) of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

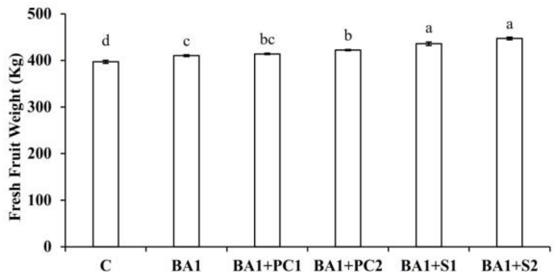

Fig. 3. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on fresh fruit weight (Kg) of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

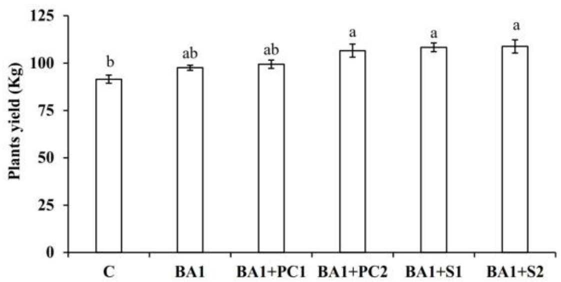

Fig. 4. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on plant yield (Kg) of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

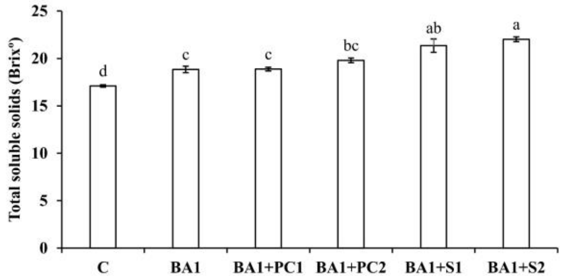

Fig. 5. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on total soluble solids (Brix°) of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

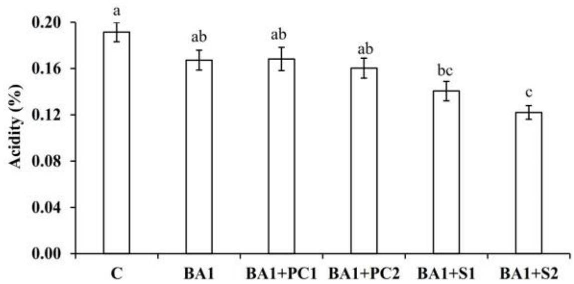

Fig. 6. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on acidity (%) of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

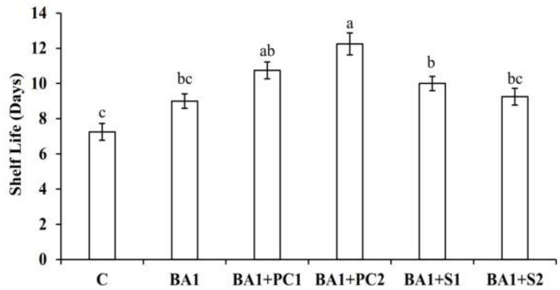

Fig. 7. Effect of potassium citrate (0.2% and 0.4%) and sucrose (5 and 10%) along with boric acid (0.2%) on shelf life (Days) of Sufaid Chaunsa. Means are compared with Tukey's test at $P \leq 0.05$.

Discussion

In current experiment, the improvement in the quality (TSS and acidity) and yield (fruit fresh weight) of Sufaid Chaunsa (*Mangifera indica* L.) were might be due to the efficacious functioning of auxin via foliar application of 0.2% boric acid with and without potassium citrate and sucrose. The findings of Jarande *et al.* (2013) also justified our argument for the improvement in the fruit quality by application of boric acid.

They suggested that it is boric acid that stimulates auxin to catalyzed the redox process and control the enzymatic activity which plays an imperative role in the manufacturing of carbohydrates in the fruit (Dutta, 2004). As compared to control similar result was noted in those treatments where potassium citrate was applied along with boric acid which decreased titratable acidity in fruit. Many researchers have also reported a significant increase in the total soluble solids (TSS) with the reduction in the titratable acidity of fruit (Padda *et al.,* 2011; Sajib *et al.,* 2014). A significant improvement in the panicle length (Fig. 2), fresh weight (Fig. 3) and plant yield (Fig. 4) of mango in the current study also signified the efficacious function of sucrose as compared to control. According to Saleh and El-Monem (2003) it is better uptake of potassium that enhanced the sugar level which eventually increased the tolerance in fruit and fruit set (Fig. 1). It is also involved in the photo assimilation and photophosphorylation through the sink of phloem and activation of enzymes (Usherwood, 1985). The results of the current study also validated above facts, where the application of potassium citrate enhanced the shelf life of Sufaid Chaunsa (*Mangifera indica* L.) by enhancing their tolerance against deterioration.

Conclusion

From results, it is concluded that application of sucrose or potassium citrate are equally effective regarding the improvement in yield of Sufaid Chaunsa (*Mangifera indica* L.) when applied with boric acid. To enhance the shelf life of fruit, foliar application of 0.4% potassium citrate + 0.2% boric acid could be an effective approach. However, for significant improvement in TSS, reduction in acidity and fruit setting, foliar application of 10% sucrose + 0.2% boric acid is more efficacious.

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