Original Research Article

Effect of Micronutrients on physico-chemical parameters of fruit and yield of Guava (*Psidium guajava* L.) cv. L-49.

Abstract

This research was done to find out the effect of micronutrients on physico-chemical parameters of fruit and yield of guava (*Psidium guajava* L.). For this purpose, guava var. L-49 was used in this research. The experiment consisted of eight treatment combinations having Zn, Mn and Fe concentrations of 0.5, 0.5 and 0.4 % respectively, in Randomized Block Design with three replications. There was a significant effect of micronutrients (Zn, Mn and Fe). According to the results, significant increases of fruit size (cm), fruit weight **(**gm), volume of fruit (cm^3), specific gravity and chemical parameters are Total soluble solids (TSS ^{0}Brix), acidity (%), ascorbic acid (Vitamin 'C') (mg/100gm pulp), of fruit were determined with increasing micronutrients application. This experimental research carried out at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Vidya-Vihar, Rae Bareli Road, Lucknow 226 025 (U.P.) during the summer season of 2019-20.

Keywords: Guava, Micronutrients, Physico-Chemical Parameters, Yield, Zn, Mn and Fe

Introduction

Guava (*Psidium guajava* L.) "Apple of the tropics" is an important fruit crop of the India, not because of its large area and production but due to its wider edapho-climatic adaptability, hardly to various biotic and abiotic stresses, precocious and prolific bearing habit, quality fruit with high nutritive value, medicinal attribute, use both as fresh fruit and after processing in different value-added products and considered as a multipurpose tree due to its utility as fruit, fuel, fodder, timber and it is a highly remunerative crop. It is a very rich source of vitamin C and A along with minerals like iron, calcium, and phosphorus. Guava is fourth the most important fruit crop in India after Mango, Banana and Citrus (Ray 2002). It also contains substantial quantities of carbohydrates, sugars and pectin. Owing to excellent taste and flavour, high nutritional value and wide availability at a moderate price the fruit is often called "Poor man's apple". The conventional products of guava are jelly, jam, pulp, concentrate, juice, cheese, toffee, dehydrated guava and canned guava. Subhash Chandra (2017).

Guava is commercially grown throughout the India, particularly in Maharashtra, Uttar Pradesh, Bihar, Orissa, Punjab, Uttarakhand, Gujarat, Madhya Pradesh, and West Bengal. Utter Pradesh is considered the most important guava-producing state of India, in which Allahabad (Prayagraj) region has the reputation of growing the best quality guava in the country as well as all over the world. It is cover around 3.7% (2.7 lakh ha) of the total area under fruit crops and contributes 3.3% (41.07 MT) of total fruit production (NHB 2017-18).

The spring flowering is called "Ambe Bahar", June or monsoon flowering is called "Mrig Bahar" and the third flowering which comes in October is called "Hast Bahar". Ambe Bahar fruits ripen from July to September and Mrig Bahar fruits ripen from November to February however, Hast Bahar fruits ripen in the spring season which is also known as the summer season.

The fruit is an excellent source of vitamin C (210 mg/100g) and pectin (0.60 %) but has low energy (66 cal /100g), protein content (1%) and dry matter (17%) and moisture (83%). The fruit is also rich in minerals like phosphorus (24-37mg/100g), calcium (14-30 mg/100g) and iron (0.6-1.4mg/100g) as well as vitamins like niacin, pantothenic acid, thiamine, riboflavin and vitamin A (Bose *et al*., 1990).

Foliar application is based on the principle that the nutrients are quickly absorbed by leaves and transported to different parts of the plant to the functional requirement of nutrition. This method is highly helpful for the correction of element deficiencies to restore disrupted nutrient supply, and overcome stress factors limiting their availability and it plays important role in improving fruit set, productivity and quality of fruits and recovery of nutritional and physiological disorders in fruit trees.

Zinc is an important constituent of several enzyme systems which regulate various metabolic reactions associated with water relations in the plant. Zinc is essential for auxin and protein synthesis, seed production and proper maturity. It also increases fruit size as well as yield. Zinc is essential for improving the vegetative growth of guava trees obtained in terms of terminal shoots, shoot diameter and number of leaves per shoot (Price *et al.*, 1972). Boron is a constituent of cell membrane and essential for cell division. It acts as a regulator of potassium/calcium ratio in the plant and helps in nitrogen absorption and translocation of sugar in plant. Boron increases nitrogen availability to plants. It is involved in the synthesis of cell wall components. It has a central role in pollen viability and good fruit set. It increases the elongation growth of primary and lateral roots (O' Kelley, 1957).

Iron play's a critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. It serves as a component of many vital enzymes such as cytochromes of the electron transport chain, and it is thus required for a wide range of biological functions. In plants, iron is involved in the synthesis of chlorophyll, and it is essential for the maintenance of chloroplast structure and function (Rout and Sahoo, 2015).

Manganese plays an essential role in respiration and N metabolism in plants. Also act as an activator for the enzymes, nitrite reductase and hydroxylamine reductase. Manganese is directly or indirectly involved in chloroplast formation and probably in their multiplication and also involved in various oxidation-reduction reactions in photosynthesis (Nijjar, 1990).

Material and methods

The present investigation was carried out at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae Bareli Road, Lucknow 226 025 (U.P.), India during 2019-20. The Horticulture Research Farm, Department of Applied Plant Science Horticulture, Babasaheb Bhimrao Ambedkar University, Vidya- Vihar, Rae Bareli Road, Lucknow is situated at an elevation of 111 meters above mean sea level in the subtropical tracts of Central U.P. at 260-560 North latitude. The experiment is laid out in randomized block design with a factorial concept containing 8 treatment combinations (T_0, T_1, T_2, T_3, T_4, T_5, T_6, T_7) in which T_0: Control (Water Spray). T_1: Zinc Sulphate 0.5%, T_2: Manganese Sulphate 0.5%, T_3: Iron Sulphate 0.4% T_4: Zinc Sulphate + Manganese Sulphate 0.5% + 0.5%, T_5: Zinc Sulphate + Iron Sulphate 0.5% + 0.4%, T_6: Manganese Sulphate + Iron

Sulphate 0.5% + 0.4%, T_7: Zinc Sulphate + Manganese Sulphate + Iron Sulphate 0.5% + 0.5% + 0.4%. Application of treatment was given in two doses 1st spray at Fruit Set and 2nd Spray 15 days after Fruit Set.

Table:1. Treatment details

S. No.	Treatment notation	Treatment content
1.	T_0	Control (Water Spray)
2.	T_1	Zinc Sulphate (0.5 %)
3.	T_2	Manganese Sulphate (0.5 %)
4.	T_3	Iron Sulphate (0.4%)
5.	T_4	Zinc Sulphate + Manganese Sulphate (0.5 % +0.5 %)
6.	T_5	Zinc Sulphate + Iron Sulphate (0.5 %+0.4%)
7.	T_6	Manganese Sulphate + Iron Sulphate (0.5 %+0.4%)
8.	T_7	Zinc Sulphate + Manganese Sulphate + Iron Sulphate (0.5 %+ 0.5 %+0.4%)

Plant parameters recorded during experiment are Physico-chemical characteristics., fruit size (cm), fruit weight (gm), volume of fruit (cm^3), specific gravity and chemical parameters are Total soluble solids (TSS ^{0}Brix), acidity (%), ascorbic acid (Vitamin 'C') (mg/100gm pulp), reducing sugars (%), non-reducing sugar (%) and total sugar (%) are recorded. The data mended during the experimentation were statistically by randomized block design as suggested by Panse *et al*. (1995).

Results and Discussion

Fruit characteristics (physical) of guava

The result revealed the application of micronutrients on Physico-chemical parameters and yield of guava. The parameters *viz.* Fruit length, Fruit breadth, Fruit weight, Fruit volume, Fruit set, Fruit drop, Total soluble solids (TSS), total sugar, ascorbic acid content, number of fruits per plant, yield and yield efficiency.

Fruit length and breadth the data reveal that different micronutrients application exhibited a significant influence on fruit length and breadth during the study. Maximum fruit length (64.33 mm) was recorded in T_7. Whereas, the minimum fruit length (54.73 mm) was observed under treatment T_2. Maximum fruit breadth (68.03 mm) was recorded in T_7. Minimum fruit breadth (61.12 mm) was, however, observed in T_0 (control).

The data on fruit weight as influenced by different micronutrients application reveals that different micronutrients application had a significant effect on fruit weight which ranged from 116.93 g – 165.37 g. Maximum fruit weight (165.37 g) was recorded in T_7. The minimum fruit weight (116.93 g) was, however, observed in T_0 (control).

Different micronutrients affected fruit volume considerably whose value varied from 121.67 cc to 182.67 cc. The highest fruit volume (168.33 cc) was in T_7 and the minimum (121.67 cc) in T_0 (control). As indicated above, the application of different micronutrients alone or in combination has a significant effect on fruit size (length and breadth), weight and volume. The possible reason for this effect might be because mineral nutrients appear to have an indirect role in hastening the process of cell division and cell elongation due to which the size of the fruit might have improved. The increase in fruit weight may also be due to the rapid increase in the size of cells or it is also because foliar application of boron increased the fruit weight eventually by maintaining a lighter level of auxins in various parts of the fruits which helped in increasing the fruit growth (Kaur, 2017). The findings are similar to those reported by Bagali *et al*., (1993), Pal *et al*., (2008), Kumawat *et al*., (2012) in guava and Meena *et al*., (2014) in aonla who recorded maximum fruit size and weight with the foliar application of micronutrients.

The fruit set was not much influenced by micronutrients application during the study (Table 2). However, the maximum fruit set (61.32 %) was recorded in T_7 and the minimum (60.03%) in T_1. As is evidenced from the data in Table 3, the micronutrients alone or in combinations had no significant effect on the fruit set. The possible reason for non-significant effect on the fruit set in the present study might be because the foliar application of micronutrients started after the fruit set.

It is evident from the data presented in Table 2 that those different treatments of micronutrient application exhibited a marked influence on the extent of fruit drop during the study. Minimum fruit drop (42.08 %) was recorded in T_7. Maximum fruit drop (58.60 %) was recorded in T_0 (control).

The data in Table 2 indicate that the foliar application of different micronutrients alone or in combination resulted in a significant effect on fruit drop. The minimum fruitdrop was observed in trees sprayed with zinc sulphate @ 0.5% + manganese sulphate @ 0.5% + iron sulphate @ 0.4% (T_7). The results conform with those of Hada *et al*. (2014); Bagali *et al*. (1993); Balakrishnan (2000) who found a reduction in fruit drop in guava with foliar application of micronutrients. The reduction in fruit drop might be because the foliar application of micronutrients affected metabolic activities of the tree, improved the source-sink relationship and favourably influenced the metabolic status resulting in better control of drop and enhancing the retention of the fruits (Katiyar *et al*., 2008). Wright (1956) also suggested that the primitive effect of growth substances attributed to greater retention of fruit and reduction in fruit drop. There is a correlation between fruit drop and endogenous hormonal status, and the existence of a high level of internal auxin is useful for preventing fruit drop. Since a high level of endogenous hormones might help in building up endogenous hormones at level that might be potent enough to reduce the fruit drop. The application of zinc could have promoted the auxin synthesis in the plant system which might have delayed the formation of the abscission layer during the early stages of fruit development (Nason and McElroy, 1963).

Treatments	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Fruit volume(cc)	Fruit set(%)	Fruit drop(%)
T_1	59.46	64.86	136.43	140.00	60.03	45.66
T_2	54.73	63.22	123.33	127.33	60.08	48.84
T_3	55.98	63.29	120.70	126.33	60.89	49.16
T_4	62.65	66.63	155.07	158.00	61.01	43.62
T_5	59.14	65.08	140.10	145.67	60.66	44.29

T_6	55.12	63.45	125.53	130.67	60.33	48.52
T_7	64.33	68.03	165.37	168.33	61.32	42.08
T_0	55.16	61.12	116.93	121.67	61.34	58.60
$CD_{0.05}$	4.87	2.49	2.41	4.88	NS	1.91

Table 2. Effect of micronutrients on fruit characteristics (physical) of guava

Chemical parameters of fruits

The result revealed the application of micronutrients to chemical parameters of guava. Data about the effect of micronutrients application on total soluble solids in fruits are given in Table 3. It is evident from the data that the application of micronutrients exerted a significant influence on the total soluble solid contents of fruits. Maximum total soluble solids (10.63º B) were recorded in the fruits of the plants treated. The minimum total soluble solids (8.45º B) were, however, found in T_0 (control). The increase in TSS has also been recorded by Yadav *et al*. (2018), Awasthi and Lal (2009), and Singh *et al*. (2004) in guava. An increase in total soluble solids might be because boron helped in trans-membrane sugar transport. Micronutrients play important role in vital plant metabolic functions such as chlorophyll synthesis, various enzymatic reactions, respiration and photosynthesis. Given that the main product of photosynthesis is sugar, so increasing the photosynthesis, leads to an increase in the sugarcompounds and causes more soluble solids in fruit juice (Ram and Bose, 2000).

The scrutiny of data given in Table 3 indicates that the application of different micronutrients and their combinations exerted a significant effect on total sugars during present study. The highest total sugars (7.51%) were induced in fruits under T_7. While the lowest total sugars (5.74%) were recorded with T_0 (control).

Statistical analysis of data about the ascorbic acid content of guava provides substantiation that different micronutrients application individually or in combinations pronouncedly increased the ascorbic acid content as per Table 3. Maximum ascorbic acid content (161.77 mg/100 g pulp) was recorded with T_7. Whereas, minimum ascorbic acid content (140.04 mg/100 g pulp) was found in T_0 (control).

The above observations of the present study indicate that the total sugars, reducing sugars, non-reducing sugars and ascorbic acid content were significantly affected by micronutrients applications alone or in combination (Table 3). These results conform with the results achieved by Kumar *et al.*, (2015) and Jat and Kacha (2014). According to them, micronutrients application increased the quality parametersof guava fruit. The increase in the sugars content might be due to the more rapid translocation of sugars from leaves to developing fruits. Boron facilitated sugar transport within the plant. It was also reported that borate reacted with sugar to form a sugar-borate complex. Boron acted as a switcher in the degradation of glucose either by glycolysis or by pentose sugar pathway (Singh and Kaur 2016). The improvement in the quality of fruit might be due to the catalytic action of micronutrients particularly at higher concentrations. The foliar application of micronutrients quickly increased the uptake of macronutrients in the tissues and organs and improves fruit quality.

The boron also plays an important role in activating the synthesis of ascorbic acid (Baranwal *et al.*, 2017). The present results on ascorbic acid conform with the results achieved by Jeyabaskaran and Pandey (2008).

Table 3. Effect of micronutrients on TSS and titratable acidity of guava

Treatments	TSS (^{o} B)	Total sugar (%)	Ascorbic acid (mg/100 g pulp)
T_1	10.63	7.12	164.24
T_2	9.66	6.69	147.66
T_3	9.50	6.76	146.79
T_4	10.26	7.05	159.49
T_5	9.90	6.66	156.40
T_6	9.75	6.53	152.79
T_7	10.56	7.51	161.77
T_0	8.45	5.74	140.04
$CD_{0.05}$	0.40	0.35	6.46

YIELD PARAMETERS:

Data about the effect of different micronutrients and their combinations on several fruits per plant in guava is summarized in Table 4. The data indicated that the number of fruits per plant in guava increased significantly with the foliar application of micronutrients. The maximum number of fruits per plant (45.33) was recorded under treatment T_7. The minimum number of fruits per plant (37.00) was recorded under treatment T_0 (control).

It is clear from the data given in Table 4 that the application of micronutrients exerted a significant effect on fruit yield per plant during study. Maximum fruit yield (7.50 kg/ tree) was observed under T_7. While the minimum fruit yield (4.33 kg/ tree) was recorded in treatment T_0 (control), which was significantly lower than all other treatments.

The application of micronutrients exerted a significant influence on yield efficiency (kg/cm2 TCSA) during study. The data in the Table 3 showed that the highest yield efficiency of 0.35 kg/cm2 TCSA was recorded in T_7 and the lowest yield efficiency of 0.16 kg/cm2 TCSA was recorded in T_5. As far as the effect of micronutrients on guava yield and yield efficiency is concerned, the increase in fruit yield with the application of micronutrients may be attributed to increased fruit size, fruit weight, and minimum fruit drop resulting from the effects of micronutrients on cell division, cell elongation and translocation of photosynthetic and metabolites from leaves and others parts of plants to the developing fruits. The highest fruit yield which was obtained by foliar spray of micronutrients may be attributed to better uptake and mobilization of nutrients to the sink which caused better fruit development. These findings are also supported by earlier reports by Bagali *et al.* (1993), Rajkumar *et al.* (2014), Jat and Kacha (2014), and Gaur *et al.* (2014a) who also found that foliar application of micronutrients increases the yield of guava.

Table 4: Effect of micronutrients on number of fruits per plant, yield, and yield efficiency of guava

Treatments	Number of fruits/plants	Yield (kg/tree)	Yield efficiency (kg/cm^2 TCSA)
T_1	42.67	5.82	0.23
T_2	40.67	4.91	0.20
T_3	44.33	6.87	0.27
T_4	43.33	6.07	0.24
T_5	41.33	5.19	0.16
T_6	46.00	7.35	0.34
T_7	45.33	7.50	0.35
T_0 (control)	37.00	4.33	0.25
CD (5%)	1.91	0.31	0.02

1. CD has been calculated based on percentage value

Conclusion

On the basis of the results obtained in the present investigation, it is concluded the combined foliar application of zinc sulphate ($ZnSO_4$) @ 0.5% + manganese ($MnSO_4$) (0.5%) + iron sulphate ($FeSO_4$) (0.4%) (T_7). Therefore, combined spray of $ZnSO_4$ (0.5%) + $MnSO_4$ (0.5%) +$FeSO_4$(0.4%) can be advocated to guava growers for maximum physical, chemical and yield parameters of guava.

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