International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 1404-1413

Received: 09-05-2018
Accepted: 12-06-2018

VC Rane
PG Student, Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

Dr. AM Bhosale
Assistant Professor, Department Of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

SJ Syed
Ph.D. Scholar, Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

Correspondence
VC Rane
PG Student, Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

Effect of different grades and times of application of micronutrient mixture on physical and biochemical qualitative attributes of custard apple (*Annona squamosa* L.) cv. Balanagar

VC Rane, Dr. AM Bhosale and SJ Syed

Abstract
The experimentation entitled, "Studies on different grades and times of application of micronutrient mixture on growth yield and quality of Custard apple (*Annona squamosa* L.) Cv. Balanagar" was carried out on the field of Custard apple Research Station, Ambejogai, Dist.-Beed, during mrig bahar in 2017-18. The experiment was laid out in factorial randomized block design with two factors i.e. factor A- micronutrient mixture grade (G) and factor B- time of application (T). These factors consist of four and three levels respectively, twelve treatment combinations with three replications. Among the different treatment combination the treatment G_4T_1 (Grade-4 chelated by foliar application monthly) noted the significant effect in respect to, physico-chemical parameters, recorded maximum in respect to length of fruit (8.50 cm), breadth of fruit (8.50 cm), number of seeds/fruit (38.67), weight of seeds (24.58 g), weight of pulp (89.22 g), weight of peel (109.13 g), pulp (40.08%), peel (49.01%), pulp to peel ratio (0.82), TSS (24.13%), ascorbic acid (22.43%), reducing sugar of fruit (13.55%), non-reducing sugar (3.08%) and total reducing sugar (16.63%) with reduction in acidity (0.35%).

Keywords: Chelate, micronutrients, FRBD, quality, Balanagar

1. Introduction
Custard apple (*Annona squamosa L.*) is the most anciently land fruit crop in India. It is originated from tropical region of America and widely distributed throughout the tropics and subtropics. Annonaceous fruits form an important part of diet of the people in the South India. The origin of different species of annona is reported to be at different regions. *Annona squamosa* is originated in Central America from there; it was distributed to Mexico and Tropical America (Popenoe, 1974) [9].

The fruits are medium in size (250-250 g), globular, green skin, conspicuous reticulation on fruit surface, non-acidic, having good quality and sweet pulp. Edible portion or pulp of fruit is creamy, granular with good blend of sweetness and acidity which vary with the species. Fruit pulp contains proteins, fatty acids, fibre, carbohydrates, minerals and vitamins (Rajput *et al*., 1991, Babu *et al*., 2005, Rawat *et al*., 2010 etc.) [12, 1, 11]. The pleasant flavour and mild aroma have universal liking. The fruit contains vitamin C and minerals such as calcium, phosphorus and potassium.

Custard apple has slightly granular, creamy, yellow or white, sweet pulp with good flavour and low acidity, thus it is considered the sweetest fruit of the other annonas (FAO, 1990) [2]. Fruit contains sugar 16-20 per cent and lipids 0.35 per cent of edible part of fruit (Leal, 1990) [5]. One of the main reasons for low custard apple orchard productivity of Marathwada region is nutrient deficiencies. The soils of this region are mostly derived from basaltic parent material and are commonly deficient in multiple nutrients, including N, P, Fe, Mn and Zn that is why the conventional nutrient management strategy based mainly on macronutrient application in custard apple orchards has not been very successful in raising the productivity level (Srivastava *et al.*, 2009) [13]. Relatively, small amount of micronutrients are required as compared to those of primary nutrients, but these are equally important for plant metabolism (Katyal, 2004) [3]. Even though micronutrients are present in soil, their absorption may be hindered by other nutrients by interaction between nutrients. For instant, zinc deficiency often occurs due to heavy phosphate application.

Manganese deficiency occurs especially due to over liming, heavy phosphate application and excess of iron, copper and zinc in the soil. Copper deficiency is induced by heavy liming and excessive application of nitrogen and phosphate.

Table 1: Nutritional composition of custard apple (per 100 g of pulp)

S. No	Constituents	Values
1.	Carbohydrates	20-25.2 g
2.	Protein	1.17-2.47 g
3.	Fat	0.5-0.6 g
4.	Crude fibre	0.9-6.6 g
5.	Calcium	17.6-27 mg
6.	Phosphorus	14.7-32.1 mg
7.	Iron	0.42-1.14 mg
8.	Thiamine	0.075-0.018 mg
9.	Riboflavin	0.086-0.175 mg
10.	Niacin	0.528-1.190 mg
11.	Ascorbic acid	15.0-44.4 mg

(Navaneetha and Nattar, 2011).

Micronutrient plays many complex roles in plant nutrition and plant production, while most of micronutrients participate in the functioning of number of enzyme systems. There is a considerable variation in the specific function of the micronutrients in plant and microbial growth processes, for example, copper, iron and molybdenum are capable of acting as electron carriers in the enzyme system that bring about oxidation reduction reactions in plants. Such reactions are essential steps in photosynthesis and many other metabolic processes. Zinc and manganese functions in many enzyme systems as bridges to connect the enzyme with the substrate upon which it is meant to act (Raja *et al*., 2009) [10]. Boron is required for cell division and extension. The sixteen elements have been established to be essential for plant growth and development, in the complete absence of any of which the plant cannot function properly.

Micronutrients play important role in crop production due to their essentiality in plant metabolism and adverse effects that manifest due to their deficiency. Besides affecting plant growth, micronutrients also play a major role in disease resistance in cultivated crop species. Micronutrients can tremendously boost horticultural crop yield and improve quality and post-harvest life of horticultural produce (Raja, 2009) [10].

Foliar spray of micronutrients is the common practice to overcome the micronutrients deficiency in order to improve the fruit quality. Nutrients are generally quickly available to plant by the foliar application than the soil application (Lal Bahadur*et al*. 1998).

In the areas, with intensive cultivation Zn and Fe deficiency are not uncommon. However, these can be corrected through use of organic matter and spray of $ZnSO_4$ and $FeSO_4$ during the active growth period of the custard apple tree. The role of Boron (B) has been understood very well in large numbers of crops. Application of micronutrients either through soil or foliar spray is important in flowering and quality fruit production and therefore present investigation was undertaken on the effect of foliar spray of micronutrients on flowering as well as, yield and fruit quality of custard apple.

Considering the above an investigation was planned to study the effect of micronutrient mixture on 'custard apple' with an objective to study the effect of different grades and times of application of micronutrient mixture on growth, yield and quality of Custard Apple (*Annona squamosa L.*) cv. Balanagar.

2. Material and Methods

The details of the material used and methods adopted during the course of the present investigation are described in this chapter under appropriate headings and sub headings.

- **Source of micronutrients and inorganic fertilizers**

Micronutrient mixture like Grade-1 and Grade-2 were purchased from market. Inorganic fertilizers like Urea, DAP and Muriate of potash were obtained from the Custard apple Research Station Ambejogai, Dist.-Beed.

Table 2: Source of micronutrients

Sr. No.	Trade/Common Name	Content
1	Green nutria (Grade-1 sulphate)	Fe-2%, Zn-5%, Mn-1%, Cu-0.5%, B-1%
2	Chelmixcombi (Grade-1 Chelated)	Fe-2.5%, Zn-3%, Mn-1%, Cu-1%, Mo- 0.1%, B-0.5%
3	Micnelf MS 32 (Grade-2 sulphate)	Fe-2.5%, Zn-3%, Mn-1%, Cu-1%, Mo- 0.1%, B-0.5%
4	Chelmixcombi (Grade-2 Chelated)	Fe-2.5%, Zn-3%, Mn-1%, Cu-1%, Mo- 0.1%, B-0.5%

Treatment details: The details of treatments are given in Table No. 3

Table 3: Treatment details

Factor	Symbol	Treatment
Factor: A Micronutrient mixture (G)	G_1	Soil application of Grade-1 sulphate @ 250 g/tree
	G_2	Soil application of Grade-1 chelated @ 25 g/tree
	G_3	Foliar application of Grade-2 sulphate @ 30 g/tree
	G_4	Foliar application of Grade-2 chelated @ 7 g/tree
Factor: B Time of application (T)	T_1	Monthly application
	T_2	Bimonthly application
	T_3	Trimonthly application

Table 4: Chemical composition of fertilizers

Organic Manures / Fertilizers	Nutrient contents		
	N (%)	P_2O_5 (%)	K_2O (%)
Urea	46	-	-
Single Super Phosphate	-	16	-
Muriate of Potash	-	-	60
Farm Yard Manure	0.75	0.20	0.50

Table 5: Methods used for biochemical analysis

S. No	Property	Standard method	Reference
1.	TSS (%)	Hand Refractometer	Ranganna, 1986.
2.	Reducing sugar (%)	Using DNS reagent	A.O.A.C., 1975.
3.	Non-reducing sugar (%)	Using DNS reagent	A.O.A.C., 1975.
4.	Ascorbic acid(mg/100g pulp)	Volumetric method	A.O.A.C., 1975.
5.	Acidity (%)	Titration with 0.1 N NaOH	A.O.A.C., 1975.

3. Results and Discussion

3.1 Physical quality attributes of fruits

3.1.1 Length of fruit (cm)

The different treatments of micronutrient mixture and time of application has significantly increased the length of fruit. The data is presented in Table-6. The average length of fruit was 6.34 cm.

Micronutrient Mixture Grade (G)

The application of micronutrient mixture significantly influenced the length of fruit. The treatment G_4 (Grade-4 chelate by foliar application) recorded highest length of fruit i.e. 7.00 cm, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 6.62 cm. The lowest length of fruit was recorded in G_2 (Grade-2 chelated by soil application) i.e. 5.43 cm.

Time of Application (T)

The time of application significantly influenced the length of fruit. The treatment T_1 (monthly application) recorded maximum length of fruit i.e. 7.26 cm followed by T_2 (bimonthly application) i.e. 6.37 cm. The treatment T_3 (trimonthly application) recorded lowest length of fruit i.e. 5.40 cm.

Interaction (G x T)

The interaction of micronutrient mixture and time of application significantly increased the length of fruit. The data is presented in Table-6. The treatment combination G_4T_1 (Grade-4 chelate foliar application, monthly) recorded highest fruit length i.e. 8.50cm. The treatment combination G_3T_1 (Grade-3 sulphate foliar application, monthly) i.e. 7.68 cm was at par. The lowest length of fruit was recorded in treatment combination G_4T_3 (Grade-4 chelated by foliar application, trimonthly) i.e. 4.63 cm.

3.1.2 Width of fruit (cm)

The different treatments of micronutrient mixture and time of application has significantly increased the width of fruit at harvest. The data related to the width of fruit is presented in Table-6. The average breadth of fruit at harvest was 6.18 cm.

Micronutrient mixture Grade (G)

The micronutrient mixture application significantly increased the width of fruit. The treatment G_4 (Grade-4 chelate by foliar application) recorded highest width of fruit i.e. 6.97 cm, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 6.41 cm. The lowest width of fruit was recorded in G_2 (Grade-2 chelated by soil application) i.e. 5.43 cm.

Time of application (T)

The time of application significantly increased the width of fruit. The treatment T_1 (monthly application) recorded maximum width of fruit i.e. 6.99 cm, followed by T_2 (bimonthly application) i.e.6.43 cm. The treatment T_3 (tri monthly application) recorded lowest breadth of fruit i.e.5.23 cm.

Interaction (G x T)

The interaction of micronutrient mixture and time of application significantly increased the width of fruit. It is presented in Table-6. The treatment combination G_4T_1 (Grade-4 chelate foliar application, monthly) recorded highest width of fruit i.e. 8.50 cm. The lowest breadth of fruit was recorded in treatment combination G_4T_3 (Grade-4 chelated by foliar application, tri monthly) i.e. 4.88 cm.

3.1.3 Number of seeds per fruit

The different treatments of micronutrient mixture and time of application has significantly increased the number of seeds per fruit. The data related to the number of seeds per fruit is presented in Table-6. The average number of seeds per fruit was 30.97.

Micronutrient mixture Grade (G)

The micronutrient mixture application significantly increased the number of seeds per fruit. The treatment G_3 (Grade-3 sulphate by foliar application) recorded highest number of seeds per fruit i.e. 33.43, followed by G_4 (Grade-4 chelate by foliar application) i.e. 33.00. The lowest number of seeds per fruit was recorded in G_2 (Grade-2 chelated by soil application) i.e. 27.78.

Time of Application (T)

The time of application significantly increased the number of seeds per fruit. The treatment T_1 (monthly application) recorded maximum number of seeds per fruit i.e. 33.75, followed by T_2 (bimonthly application) i.e. 30.25. The treatment T_3 (trimonthly application) recorded lowest number of seeds per fruit i.e. 28.92.

Interaction (G x T)

The interaction of micronutrient mixture and time of application significantly increased the number of seeds per fruit. The data is presented in Table-6. The treatment combination G_4T_1 (Grade-4 chelate foliar application, monthly) recorded highest number of seeds per fruit i.e. 38.67. The treatment combination G_3T_1 (Grade-3 sulphate foliar application, monthly) i.e. 36.00 was at par. The lowest number of seeds per fruit was recorded in treatment combination G_4T_3 (Grade-4 chelated by foliar application, trimonthly) i.e. 24.67.

3.1.4 Weight of Seed (g)

The different treatments of micronutrient mixture and time of application increased the weight of seed and data is presented in Table-6. The average weight of seed recorded was 21.75 g.

Micronutrient Mixture Grade (G)

The application of micronutrient mixture significantly increased the weight of seed. The treatment G_3 (Grade-3 sulphate by foliar application) recorded highest weight of seed i.e. 22.34 g, followed by G_4 (Grade-4 chelate by foliar application) i.e. 22.24 g. The lowest weight of seed recorded in G_2 (Grade-2 chelate by soil application) was 20.61 g.

Time of application (T)
The time of application significantly increased the weight of seed. The treatment T_1 (monthly application) recorded maximum weight of seed i.e. 22.89 g followed by T_2 (bimonthly application) i.e. 22.24 g. The treatment T_3 (trimonthly application) recorded lowest weight of seed i.e.20.13 g.

Table 6: Effect of different grades of micronutrients mixture, time of application and their interaction on fruit length, fruit width, number of seed/fruit and weight of seed.

Factor/Treatment	Fruit Length (cm)	Fruit Breadth (cm)	number of seeds/fruit	Weight of seed (g)
Factor A : Micronutrient mixture Grade (G)				
G_1	5.96	5.93	29.67	21.83
G_2	5.43	5.43	27.78	20.61
G_3	6.62	6.41	33.43	22.34
G_4	7.0	6.97	33.00	22.24
SE+	0.20	0.19	0.68	0.27
CD at 5%	0.65	0.55	1.99	0.80
Factor B : Times of Application (T)				
T_1	7.26	6.99	33.75	22.89
T_2	6.37	6.34	30.25	22.24
T_3	5.40	5.23	28.92	20.13
SE+	0.19	0.16	0.59	0.24
CD at 5%	0.56	0.47	1.73	0.69
Interaction (G x T)				
G_1T_1	6.05	6.49	29.00	20.77
G_1T_2	5.43	5.23	28.33	21.86
G_1T_3	6.38	6.07	31.67	22.84
G_2T_1	6.80	6.20	31.33	22.49
G_2T_2	5.18	5.10	26.00	20.23
G_2T_3	5.31	4.98	26.00	19.09
G_3T_1	7.68	6.77	36.00	23.73
G_3T_2	6.91	7.48	31.00	22.85
G_3T_3	5.28	4.97	33.33	20.43
G_4T_1	8.50	8.50	38.67	24.58
G_4T_2	7.67	7.52	35.67	24.01
G_4T_3	4.63	4.88	24.67	18.13
Mean	6.34	6.18	30.97	21.75
SE+	0.38	0.32	1.18	0.47
CD at 5%	1.12	0.94	3.45	1.38
Micronutrient Mixture Grades (G) G_1- Grade-1 Sulphate (Soil) G_2- Grade-2 Chelated (Soil) G_3- Grade-3 Sulphate (Foliar) G_4- Grade-4 Chelated (Foliar)		Times of Application (T) T_1- Monthly T_2- Bimonthly T_3- Tri monthly		

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the weight of seed. It is presented in Table-6. The treatment combination G_4T_1 (Grade-4 chelate foliar application, monthly) recorded highest seed weight i.e. 24.58 g, followed by treatment combination G_4T_2 (Grade-4 chelate foliar application, bimonthly) i.e. 24.01 g. The lowest weight of seed was recorded in treatment combination G_4T_3 (Grade-4 chelate by foliar application, tri monthly) i.e. 18.13 g.

3.1.5 Weight of pulp (g)
The different treatments of micronutrient mixture and time of application increased the weight of pulp and data is presented in Table-7. The average weight of pulp recorded was 81.73 g.

Micronutrient Mixture Grade (G)
The application of micronutrient mixture significantly increased the weight of pulp. The treatment G_4 (Grade-4chelate by foliar application) recorded highest weight of pulp i.e.84.29 g, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 83.69 g. The lowest weight of pulp recorded in G_2 (Grade-2 chelate by soil application) was 79.26 g.

Time of Application (T)
The time of application significantly increased the weight of pulp. The treatment T_1 (monthly application) recorded maximum weight of pulp i.e. 85.37 g followed by T_2 (bimonthly application) i.e. 82.67 g. The treatment T_3 (tri monthly application) recorded lowest weight of pulp i.e.77.15 g.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the weight of pulp. The data is presented in Table-7. The treatment combination G_4T_1 (Grade-4 chelate foliar application, monthly) recorded highest pulp weight i.e. 89.22 g, followed by treatment combination G_4T_2 (Grade-4 chelate foliar application, bimonthly) i.e. 89.02 g. The lowest weight of pulp was recorded in treatment combination G_4T_3 (Grade-4 chelate by foliar application, tri monthly) i.e. 74.62 g and G_2T_3 (Grade-2 chelate by soil application, tri monthly) i.e. 74.66 g.

3.1.6 Weight of Peel (g)
The different treatments of micronutrient mixture and time of application increased the weight of peel and data is presented in Table-7. The average weight of peel recorded was 99.40 g.

Micronutrient Mixture Grade (G)
The application of micronutrient mixture non-significantly increased the weight of peel. The treatment G_4 (Grade-4chelate by foliar application) recorded highest weight of peel i.e. 101.52 g, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 100.19 g. The lowest weight of peel recorded in G_2 (Grade-2chelate by soil application) was 97.67 g.

Time of Application (T)
The time of application significantly increased the weight of peel. The treatment T_1 (monthly application) recorded maximum weight of peel i.e. 103.22 g followed by T_2 (bimonthly application) i.e. 100.99 g. The treatment T_3 (tri monthly application) recorded lowest weight of peel i.e. 93.99 g.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the weight of peel. The data is presented in Table-7. The treatment combination G_4T_1 (Grade-4 chelate foliar application, monthly) recorded highest peel weight i.e. 109.13 g, followed by treatment combination G_3T_1 (Grade-3 sulphate foliar application, monthly) i.e. 106.58 g. The lowest weight of peel was recorded in treatment combination G_4T_3 (Grade-4 chelate by foliar application, tri monthly) i.e. 89.61 g.

Table 7: Effect of different grades of micronutrients mixture, time of application and their interaction on weight of pulp and weight of peel.

Factor/Treatment	Weight of pulp (g)	Weight of peel (g)
Factor A : Micronutrient mixture Grade (G)		
G_1	79.69	98.22
G_2	79.26	97.67
G_3	83.69	100.19
G_4	84.29	101.52
SE+	0.58	1.03
CD at 5%	1.70	3.03
Factor B : Times of Application (T)		
T_1	85.37	103.22
T_2	82.67	100.99
T_3	77.15	93.99
SE+	0.50	0.89
CD at 5%	1.47	2.62
Interaction (G x T)		
G_1T_1	80.29	96.91
G_1T_2	77.54	97.11
G_1T_3	81.23	100.63
G_2T_1	84.85	100.27
G_2T_2	78.26	99.52
G_2T_3	74.66	93.21
G_3T_1	87.12	106.58
G_3T_2	85.86	101.49
G_3T_3	78.09	92.49
G_4T_1	89.22	109.13
G_4T_2	89.03	105.82
G_4T_3	74.62	89.61
Mean	81.73	99.40
SE+	1.01	1.79
CD at 5%	2.95	5.24
Micronutrient Mixture Grades (G) G_1- Grade-1 Sulphate (Soil) G_2- Grade-2 Chelated (Soil) G_3- Grade-3 Sulphate (Foliar) G_4- Grade-4 Chelated (Foliar)		Times of Application (T) T_1- Monthly T_2- Bimonthly T_3- Tri monthly

3.1.7 Per cent of pulp (%)
The different treatments of micronutrient mixture and time of application significantly influenced on pulp percentage of fruits and data is presented in Table-8. The average pulp percentage recorded was 40.28%.

Micronutrient Mixture Grade (G)
The application of micronutrient mixture significantly increased the pulp percentage of fruit. The treatment G_3 (Grade-3 sulphate by foliar application) recorded maximum pulp percentage of fruit i.e. 40.74%, followed by G_4 (Grade-4 chelate by foliar application) i.e. 40.49%. The minimum pulp percentage of fruit was recorded in G_1 (Grade-1 sulphate by soil application) i.e. 39.86%.

Time of Application (T)
The time of application non-significantly increased the pulp percentage of fruit. The treatment T_1 (monthly application) recorded maximum pulp percentage of fruit i.e. 42.45%, followed by T_2 (bimonthly application) i.e. 40.25%. Minimum pulp percentage of fruit i.e. 40.15%, was recorded in the treatment T_3 (tri monthly application).

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the pulp percentage of fruit. The data presented is in Table-8.The treatment combination G_3T_2 (Grade-3 sulphate foliar application, bimonthly) recorded maximum pulp percentage of fruit i.e. 41.12%, followed by G_3T_3 (Grade-3 sulphate foliar application, tri monthly) i.e. 40.82%. The minimum pulp

percentage was recorded with treatment combination G_1T_2 (Grade-1 sulphate by soil application, bimonthly) i.e. 39.40%.

3.1.8 Per cent of peel (%)

The different treatments of micronutrient mixture and time of application significantly increased in peel percentage of fruits and data is presented in Table-8. The average peel percentage of fruit was recorded 49.00%.

Micronutrient Mixture Grade (G)

The application of micronutrient mixture non-significantly increased the peel percentage of fruit. The treatment G_2 (Grade-2 chelate by soil application) recorded highest peel percentage of fruit i.e. 49.38%, followed by G_1 (Grade-1 sulphate by soil application) i.e. 49.13%. The lowest peel percentage of fruit was recorded in G_3 (Grade-3sulphate by foliar application) i.e. 48.73%.

Time of Application (T)

The time of application non-significantly increased the peel percentage of fruit. The treatment T_2 (bimonthly application) recorded highest peel percentage of fruit i.e. 49.23%, followed by T_1 (monthly application) and T_2 (bimonthly application) i.e. 48.88% each.

Interaction (G x T)

The interaction of micronutrient mixture and time of application non-significantly increased the peel percentage of fruit. The data is presented in Table-8. The treatment combination G_2T_2 (Grade-2 chelated bimonthly soil application) recorded highest peel percentage of fruit i.e. 50.14%. The treatment combinationsG_2T_3 (49.65%), G_1T_2 (49.37%), G_3T_1 (49.25%) and G_1T_3 (49.14%) were at par. The lowest peel percentage was recorded with treatment combination G_3T_3 (Grade-3 sulphate by foliar application, tri monthly) i.e. 48.33%.

3.1.9 Pulp to peel ratio (%)

The different treatments of micronutrient mixture and time of application significantly increased in pulp to peel ratio of fruits and data is presented in Table-8. The average peel percentage of fruit recorded was 0.82%.

Micronutrient Mixture Grade (G)

The application of micronutrient mixture significantly increased the pulp to peel ratio of fruit. The treatment G_3 (Grade-3 sulphate by foliar application) recorded highest pulp to peel ratio of fruit i.e. 0.84, followed by G_4 (Grade-4 chelate by foliar application) i.e. 0.83. The lowest pulp to peel ratio of fruit was recorded in G_1 (Grade-1 sulphate by soil application) and G_2 (Grade-2 chelate by soil application) i.e. 0.81 each.

Time of Application (T)

The time of application non-significantly increased the pulp to peel ratio of fruit. The treatment T_1 (monthly application) recorded highest peel pulp to peel ratio of fruit i.e. 0.83, followed by T_2 (bimonthly application) and T_3 (tri monthly application) i.e. 0.82 each.

Interaction (G x T)

The interaction of micronutrient mixture and time of application significantly increased the pulp to peel ratio of fruit. The data is presented in Table-8. The treatment combination G_2T_1 (Grade-2 chelate by soil application, monthly), G_3T_2 (Grade-3 sulphate by foliar application, bimonthly), G_3T_3 (Grade-3 sulphate by foliar application, tri monthly) and G_2T_1 (Grade-2 chelate by soil application, monthly) recorded highest pulp to peel ratio of fruit i.e. 0.84. The treatment combinationsG_2T_3 (49.65%), G_1T_2 (49.37%), G_3T_1 (49.25%) and G_4T_2 (0.84) were at par. The lowest pulp to peel ratio was recorded with treatment combination G_2T_2 (Grade-2 chelate by soil application, bimonthly) i.e. 0.78.

Table 8: Effect of different grades of micronutrients mixture, time of application and their interaction on per cent of pulp, Percent of peel and pulp: peel ratio.

Factor/Treatment	Pulp (%)	Peel (%)	Pulp : Peel Ratio
Factor A : Micronutrient mixture Grade (G)			
G_1	39.86	49.13	0.81
G_2	40.05	49.38	0.81
G_3	40.74	48.73	0.84
G_4	40.49	48.75	0.83
SE±	0.21	0.28	0.0064
CD at 5%	0.60	0.82	0.019
Factor B : Times of Application (T)			
T_1	40.45	48.88	0.83
T_2	40.25	49.23	0.82
T_3	40.15	48.88	0.82
SE±	0.18	0.24	0.006
CD at 5%	0.52	0.71	0.016
Interaction (G x T)			
G_1T_1	40.50	48.86	0.83
G_1T_2	39.40	49.37	0.80
G_1T_3	39.67	49.14	0.81
G_2T_1	40.95	48.39	0.84
G_2T_2	39.43	50.14	0.78
G_2T_3	39.76	49.62	0.80
G_3T_1	40.28	49.25	0.82
G_3T_2	41.12	48.61	0.84
G_3T_3	40.82	48.33	0.84
G_4T_1	40.08	49.01	0.82
G_4T_2	41.06	48.80	0.84
G_4T_3	40.34	48.41	0.83
Mean	40.28	49.00	0.82
SE±	0.36	0.48	0.011
CD at 5%	1.04	1.41	0.032
Micronutrient Mixture Grades (G) G_1- Grade-1 Sulphate (Soil) G_2- Grade-2 Chelated (Soil) G_3- Grade-3 Sulphate (Foliar) G_4- Grade-4 Chelated (Foliar)		Times of Application (T) T_1- Monthly T_2- Bimonthly T_3- Tri monthly	

3.2 Biochemical attributes of fruits

3.2.1 Total Soluble Solids (%)

The different treatments of micronutrient mixture and time of application significantly influenced on T.S.S. content of fruits and data is presented in Table-9. The average T.S.S. recorded was 21.32%**.**

Micronutrient Mixture Grade (G)

The application of micronutrient mixture significantly increased the T.S.S. of fruit. The treatment G_4 (Grade-4chelate by foliar application) recorded highest T.S.S. of fruit i.e. 22.13%, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 21.28%. The lowest T.S.S. was recorded in G_2 (Grade-2chelate by soil application) i.e. 20.76%.

Time of Application (T)

The time of application significantly increased the T.S.S of fruits. The treatment T_1 (monthly application) recorded maximum T.S.S. of fruit i.e.22.21%, followed by T_2 (bimonthly application) i.e. 21.74%. The treatment T_3 (tri

monthly application) had recorded lowest T.S.S. of fruit i.e. 20.01%.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the T.S.S. of fruit. The data is presented in Table-9. The treatment combination G_4T_1 (Grade-4 chelated by foliar application, monthly) recorded highest T.S.S. i.e. 24.13%, followed by treatment combination G_4T_2 (Grade-4 chelated by foliar application, bimonthly) i.e. 23.11%. The lowest T.S.S. was recorded with treatment combination G_4T_3 (Grade-4chelate by foliar application, tri monthly) i.e. 19.15% and G_2T_3 (Grade-2chelate by soil application, tri monthly) i.e. 19.80%.

3.2.2 Ascorbic acid (mg/100g juice)
The data presented in Table-9, revealed that different treatments of micronutrient mixture and time of application influenced the ascorbic acid of fruit. The average ascorbic acid of fruit recorded was 20.08 mg/100g.

Micronutrient mixture Grade (G)
The application of micronutrient mixture significantly affected the ascorbic acid of fruit. The treatment G_3 (Grade-3 sulphate by foliar application) recorded maximum ascorbic acid of fruit i.e. 22.35 mg/100g, followed by G_4 (Grade-chelate by foliar application) i.e. 21.96 mg/100g. The minimum ascorbic acid of fruit was recorded in G_1 (Grade-1 sulphate by soil application) i.e. 17.10 mg/100 g.

Time of application (T)
The time of application significantly affected the ascorbic acid of fruit. The treatment T_1 (monthly application) recorded maximum ascorbic acid of fruit i.e. 21.51 mg/100g, followed by T_2 (bimonthly application) i.e. 21.29 mg/100g. The treatment T_3 (tri monthly application) recorded minimum ascorbic acid of fruit i.e. 17.44 mg/100g.

Interaction (G x T)
The interaction of micronutrient mixture and time of application non- significantly influenced the ascorbic acid of fruit. The treatment combination G_4T_2 (Grade-4 chelated by foliar application, bimonthly) recorded highest ascorbic acid i.e. 27.82 mg/100g, followed by G_3T_1 (Grade-3 sulphate by foliar application, monthly) i.e. 25.44 mg/100g. The treatment combination G_1T_2 (Grade-1 sulphate soil application, bimonthly) recorded lowest ascorbic acid i.e.15.15 mg/100g. Rest of the interactions were intermediate in ascorbic acid contents.

Table 9: Effect of different grades of micronutrients mixture, time of application and their interaction on total Soluble Solids and ascorbic acid.

Factor/Treatment	Total Soluble Solids (%)	Ascorbic Acid (mg/100g fruit pulp)
Factor A : Micronutrient mixture Grade (G)		
G_1	21.11	17.10
G_2	20.76	18.92
G_3	21.28	22.35
G_4	22.13	21.96
SE+	0.27	0.58
CD at 5%	0.79	1.69
Factor B : Times of Application (T)		
T_1	22.21	21.51
T_2	21.74	21.29
T_3	20.01	17.44
SE+	0.24	0.50
CD at 5%	0.69	1.47
Interaction (G x T)		
G_1T_1	21.17	16.80
G_1T_2	20.90	15.15
G_1T_3	21.27	19.35
G_2T_1	21.33	21.38
G_2T_2	21.13	18.30
G_2T_3	19.80	17.10
G_3T_1	22.20	25.44
G_3T_2	21.80	23.90
G_3T_3	19.83	17.70
G_4T_1	24.13	22.43
G_4T_2	23.11	27.82
G_4T_3	19.15	15.62
Mean	21.32	20.08
SE+	0.47	1.00
CD at 5%	1.38	2.93

Micronutrient Mixture Grades (G)	Times of Application (T)
G_1- Grade-1 Sulphate (Soil) G_2- Grade-2 Chelated (Soil) G_3- Grade-3 Sulphate (Foliar) G_4- Grade-4 Chelated (Foliar)	T_1- Monthly T_2- Bimonthly T_3- Tri monthly

3.2.3 Acidity (%)
The data presented in Table-10 revealed that different treatments of micronutrient mixture and time of application influenced the acidity of fruit. The average acidity of fruit recorded was 0.41%.

Micronutrient Mixture Grade (G)
The application of micronutrient mixture non-significantly affected the acidity of fruit. The treatment G_4 (Grade-4 chelated by foliar application) and G_3 (Grade-3 sulphate by foliar application) recorded minimum acidity of fruit i.e. 0.39%, followed by G_1 (Grade-1 sulphate by soil application) 0.41%. The highest acidity of fruit was recorded in G_2 (Grade-2 chelate by soil application) i.e. 0.42%.

Time of Application (T)
The time of application significantly affected the acidity of fruit. The treatment T_2 (bimonthly application) recorded minimum acidity of fruit i.e. 0.39% followed by T_1 (monthly application) i.e. 0.40%. The treatment T_3 (tri monthly application) recorded highest acidity of fruit i.e. 0.43%.

Interaction (G x T)
The interaction of micronutrient mixture and time of application non-significantly influenced the acidity of fruit. The treatment combination G_4T_1 (Grade-4 chelated by foliar application, monthly) recorded lowest acidity i.e. 0.35%, followed by G_3T_2 and G_4T_2 i.e. 0.36%. The highest acidity of fruit was recorded with treatment combination G_2T_3 (Grade-2 chelate by soil application, tri monthly) and G_4T_3 (Grade-4 chelate by foliar application, tri monthly) i.e. 0.45% and 0.44% respectively.

Table 10: Effect of different grades of micronutrients mixture, time of application and their interaction on acidity.

Factor/Treatment	Acidity (%)
Factor A : Micronutrient mixture Grade (G)	
G_1	0.41
G_2	0.42
G_3	0.39
G_4	0.39
SE±	0.012
CD at 5%	0.034
Factor B : Times of Application (T)	
T_1	0.40
T_2	0.39
T_3	0.43
SE±	0.010
CD at 5%	0.030
Interaction (G x T)	
G_1T_1	0.41
G_1T_2	0.41
G_1T_3	0.42
G_2T_1	0.41
G_2T_2	0.41
G_2T_3	0.45
G_3T_1	0.39
G_3T_2	0.36
G_3T_3	0.42
G_4T_1	**0.35**
G_4T_2	0.36
G_4T_3	0.44
Mean	0.41
SE±	0.020
CD at 5%	0.060
Micronutrient Mixture Grades (G) G_1- Grade-1 Sulphate (Soil) G_2- Grade-2 Chelated (Soil) G_3- Grade-3 Sulphate (Foliar) G_4- Grade-4 Chelated (Foliar)	Times of Application (T) T_1- Monthly T_2- Bimonthly T_3- Tri monthly

3.2.4 Reducing sugar (%)
The different treatments of micronutrient mixture and time of application significantly influenced on reducing sugar content. The data is presented in Table-11. The average reducing sugar content was recorded 12.04%.

Micronutrient Mixture Grade (G)
The application of micronutrient mixture non-significantly influenced the reducing sugar. The treatment G_4 (Grade-4 chelated by foliar application) recorded maximum reducing sugar i.e. 12.37%, followed by G_1 (Grade-2 sulphate by soil application) i.e. 12.26%. The minimum reducing sugar was recorded in G_2 (Grade-2 chelate by soil application) i.e. 11.56%.

Time of Application (T)
The time of application significantly affected the reducing sugar. The treatment T_1 (monthly application) recorded maximum reducing sugar i.e. 12.63%, followed by T_2 (bimonthly application) i.e. 12.29%. The treatment T_3 (tri monthly application) recorded minimum reducing sugar i.e. 11.20%.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly influenced the reducing sugar. The treatment combination G_4T_1 (Grade-3 sulphate foliar application, monthly) recorded maximum reducing sugar i.e. 13.15%, followed by and G_3T_1 (Grade-3 sulphate foliar application, bimonthly) and G_3T_2 (Grade-3 sulphate foliar application, bimonthly) i.e. 13.15%. 12.84%. The lowest reducing sugar was recorded with treatment combination G_3T_3 (Grade-3 sulphate by foliar application, tri-monthly) i.e. 9.58%.

3.2.5 Non-reducing sugar (%)
The different treatments of micronutrient mixture and time of application significantly influenced on non-reducing sugar content. The data is presented in Table-11. The average non-reducing sugar content was recorded 2.61%.

Micronutrient Mixture Grade (G)
The application of micronutrient mixture non-significantly influenced the non-reducing sugar. The treatment G_4 (Grade-4 chelate by foliar application) recorded maximum non-reducing sugar i.e. 2.75%, followed by G_1 (Grade-1 sulphate by soil application) i.e. 2.67%. The minimum non-reducing sugar was recorded in G_2 (Grade-2 sulphate by soil application) i.e. 2.44%.

Time of Application (T)
The time of application non-significantly affected the non-reducing sugar. The treatment T_3 (tri monthly application) recorded maximum non-reducing sugar i.e. 2.68%, followed by T_2 (bimonthly application) i.e. 2.60%. The treatment T_3 (tri monthly application) has recorded minimum non-reducing sugar i.e. 2.57%.

Interaction (G x T)
The data about the interaction of micronutrient mixture and time of application non-significantly influenced the non-reducing sugar. The treatment combination G_4T_1 (Grade-4 chelated by foliar application, monthly) recorded maximum non-reducing sugar i.e. 3.08%, followed by G_3T_3 2.84%. The minimum non-reducing sugar was recorded in treatment combination G_3T_1 (Grade-3 sulphate by foliar application, tri monthly) i.e. 2.37%.

3.2.6 Total Sugar (%)

The different treatments of micronutrient mixture and time of application significantly influenced on total sugar content. The data is presented in Table-11. The average total sugar content was recorded 14.64%.

Micronutrient mixture Grade (G)

The application of micronutrient mixture significantly influenced the total sugar. The treatment G_4 (Grade-4 chelated by foliar application) recorded maximum total sugar i.e. 15.12%, followed by G_1 (Grade-1 sulphate by soil application) i.e. 14.87%. The minimum total sugar recorded in G_2 (Grade-2 chelate by soil application) was 14.00%.

Time of Application (T)

The time of application non-significantly affected the total sugar. The treatment T_1 (monthly application) recorded maximum total sugar i.e. 15.20%, followed by T_2 (bimonthly application) i.e. 14.84%. The treatment T_3 (tri-monthly application) has recorded minimum total sugar i.e. 13.88%.

Interaction (G x T)

The interaction of micronutrient mixture and time of application significantly influenced the total sugar. The treatment combination (G_4T_1) (Grade-4 chelate by foliar application, monthly) recorded maximum total sugar was 16.63% followed by G_3T_2 i.e. 15.75%. The minimum total sugar recorded was 12.41% with treatment combination G_3T_3 (Grade-3 sulphate by foliar application, tri monthly).

Table 11: Effect of different grades of micronutrients mixture, time of application and their interaction on reducing sugar, non-reducing sugar and total sugar.

Factor/Treatment	Reducing Sugar (%)	Non-reducing Sugar (%)	Total Sugar (%)
Factor A : Micronutrient mixture Grade (G)			
G_1	12.26	2.67	14.87
G_2	11.56	2.44	14.00
G_3	11.96	2.60	14.56
G_4	12.37	2.75	15.12
SE+	0.21	0.12	0.20
CD at 5%	0.62	0.36	0.59
Factor B : Times of Application (T)			
T_1	12.63	2.57	15.20
T_2	12.29	2.60	14.84
T_3	11.20	2.68	13.88
SE+	0.18	0.11	0.17
CD at 5%	0.53	0.31	0.51
Interaction (G x T)			
G_1T_1	12.40	2.39	14.79
G_1T_2	11.54	2.83	14.19
G_1T_3	12.84	2.77	15.61
G_2T_1	12.42	2.42	14.84
G_2T_2	11.98	2.28	14.26
G_2T_3	10.29	2.61	12.91
G_3T_1	13.15	2.37	15.52
G_3T_2	13.15	2.60	15.75
G_3T_3	9.58	2.84	12.41
G_4T_1	13.55	3.08	16.63
G_4T_2	12.47	2.67	15.15
G_4T_3	12.08	2.49	14.57
Mean	12.04	2.61	14.64
SE+	0.37	0.21	0.35
CD at 5%	1.07	0.62	1.02
Micronutrient Mixture Grades (G) G_1- Grade-1 Sulphate (Soil) G_2- Grade-2 Chelated (Soil) G_3- Grade-3 Sulphate (Foliar) G_4- Grade-4 Chelated (Foliar)		Times of Application (T) T_1- Monthly T_2- Bimonthly T_3- Tri monthly	

References

1. Babu KD, Yadav DS. Foliar spray of micronutrients for yield and quality improvement in Khasi mandarin (Citrus reticulate Blanco.). Indian Hort. J. 2005; 62:280-281.
2. FAO. Utilization of tropical fruits and leaves, FAO, Food and Nutrition Paper. 1990; 47(7):10-14.
3. Katyal JC. Role of micronutrients in ensuring optimum use of macronutrients. IFA International Symposium on Micronutrients, New Delhi, India. 2004, 3-17.
4. Kowlska MT, Putt D. Potential Biomedical application for tropical fruit product, tropical garden fruit world. 1990; 1(4):126-127.
5. Leal F. "Sugar apple" in: fruits of tropical and subtropical origin, composition, properties and uses. Edited by S. Nagy, Shaw, P. E. and Worpowasi, W. F., Florida Science., inc. Lake, alfede Fla. 1990, 149-158.
6. Malewar GU. Micronutrient stresses in soil and crops: Serious sickness and clinical approaches for sustainable agriculture. J Indian Soc. Soil Sci. 2005; 53(4):484-489.
7. Navaneethakrishnan K, Nattar S. Custard apple. Kisan world. 2011, 15-19.
8. Naidu. Sactor, Fruit culture in India, I. O. A. R., New Delhi. 1954, 225-259.
9. Papenoe W. Manual of tropical and sub-tropical fruits. MacMillan Pub. Co. Inc. New York. 1974, 334-352.

10. Raja EM. Importance of Micro-nutrients in the changing horticultural sceinario. Indian Journal of Hort Sci. 2009; 4:1-27.
11. Rawat V, Tomar YK, Rawat JMS. Influence of foliar application of micronutrients on the fruit quality of guava cv. Lucknow-49. Journal of Hill Agriculture. 2010; I(I):63-66.
12. Rajput RS, Shigh AR, Pande NC. Role of potas and zinc on the biochemical parameters of Kagzi lime. J.I. Hort. Sci. 1991; 18:41-50.
13. Srivastava AK, Shyam S, Diware VS, Hamandeep S. Site-specific nutri-11, 2009.