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

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

SJ Syed
PhD 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

Influence of different grades and times of application of micronutrient mixture on fruit set and yeild of custard apple *(Annona squamosa* L.) cv. Balanagar

VC Rane, AM Bhosale and SJ Syed

Abstract
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. The experiment was conducted on nine years old custard apple plants of Balanagar cultivar. The micronutrient mixtures i.e. Grade-1 sulphate by soil application, Grade-2 chelate by soil application, Grade-3 sulphate by foliar application and Grade-4 chelate by foliar application were applied monthly, bimonthly and tri monthly time variation. The results of present investigation indicated that, among the different treatment combination the treatment G_4T_1 (Grade-4 chelated by foliar application monthly) noted the highest fruit set (82.47 %), weight of fruit (222.61g), number of fruit per tree (68.33), yield/tree (14.75 kg), marketable yield per tree (10.31 kg), yield/ha (5.90 tonnes).

Keywords: Fruit set, micronutrients, grade, FRBD, yield, Balanagar

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. It comprises of 40 genera and 120 species of which only five of them produce edible fruits. Among the annonas, custard apple (*Annona squamosa L.)* is valued more than *Annona reticulata L.* (Ramphal), *Annona glabra L*., *Annona atemoya* (Hanumanphal) and *Annona cherimola* (Laxmanphal). 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 annonas are distributed in the entire globe, due to their suitability to different climatic conditions. Custard apple is grown commercially in West Indies, Florida, Mexico, Brazil, Malaysia, Thailand, Philippines and Egypt. 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].
It has many health and nutritional benefits. It is a rich source of dietary fibre, which helps in digestion. It contains magnesium, which plays a vital role in relaxing muscles and protecting heart against diseases. Flesh of the fruit is used for the preparation of milk shakes and ice-cream. Delicious sauce for cake and puddings can be made by blending the seeded flesh with mashed banana and with a little cream. The seeds of the fruits have insecticidal and abortifacient properties. Similarly, seed oil is suitable for soap making and seed cake can be used as manure (Naidu and Saetor, 1954) [5].
Custard apple has many alkaloids, such as aporohine, romerine, norocoydine, squamonine corydine, norisocroriydine, glaucine and anononaine in different parts of the plant (Kowlska and Putt, 1990) [4] 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. The yield of crops could be improved with little quantities of micronutrients applied either singly or in mixtures through soil or foliar feeding (Malewar, 2005) [6].

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).

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) [7].

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.

S. 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

3. Results and discussion

3.1. Fruit set (%)

The data related to the different treatments of micronutrient mixture and time of application significantly influenced the fruit set percentage and it is presented in Table-5. The average final fruit set percentage recorded was 73.17%.

Micronutrient mixture Grade (G)

The micronutrient mixture application non-significantly increased the final fruit set percentage. The treatment G_1 (Grade-1 sulphate by soil application) and G_4 (Grade-4 chelated by foliar application) recorded maximum final fruit set i.e. 74.55 % each, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 73.44 %. The minimum fruit set was recorded in G_2 (Grade-2 chelated by soil application) i.e. 70.11 %.

Time of application (T)

The time of application has significantly increased the final fruit set percentage. The treatment T_1 (monthly application) recorded maximum final fruit set i.e. 77.33 %, followed by T_2 (bimonthly application) i.e.75.05 %. The treatment T_3 (tri-monthly application) recorded lowest final fruit set percentage i.e. 67.11%.

Interaction (G x T)

The interaction of micronutrient mixture and time of application significantly influenced the fruit set per cent are presented in Table-5. The treatment combination G_4T_1 (Grade-4 chelate by foliar application, monthly) recorded maximum final fruit set i.e. 82.47 %. The treatment combinations G_4T_1 was followed by treatment combination G_4T_2 (Grade-4 chelate by foliar application, bimonthly) i.e. 80.92 %. The minimum fruit set percentage was recorded with treatment combination G_4T_3 (Grade-2 chelate by foliar application, tri monthly) i.e. 60.26 %.

Table 5: Effect of different grades of micronutrients mixture, time of application and their interaction on fruit set (%)

Factor/Treatment	Fruit set (%)
Factor A : Micronutrient mixture Grade (G)	
G_1	74.55
G_2	70.11
G_3	73.44
G_4	74.55
SE±	1.89
CD at 5%	5.52
Factor B : Times of Application (T)	
T_1	77.33
T_2	75.05
T_3	67.11
SE±	1.63
CD at 5%	4.78
Interaction (G x T)	
G_1T_1	76.53
G_1T_2	71.15
G_1T_3	75.98
G_2T_1	73.94
G_2T_2	69.72
G_2T_3	66.67
G_3T_1	76.39
G_3T_2	78.40
G_3T_3	65.54
G_4T_1	82.47
G_4T_2	80.92
G_4T_3	60.26
Mean	73.17
SE±	3.27
CD at 5%	9.57

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 Yield parameters

3.2.1 Weight of fruit (g)

The data related to the different treatments of micronutrient mixture and time of application increased the weight of fruit and data is presented in Table-6.The average weight of fruit recorded was 202.84 g.

Micronutrient mixture Grade (G)

The application of micronutrient mixture significantly increased the weight of fruit and data represented in table-6. The treatment G_4 (Grade-4chelate by foliar application) recorded highest weight of fruit i.e. 208.13 g, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 205.48 g. The lowest weight of fruit recorded in G_2 (Grade-2chelate by soil application) was 197.83g.

Time of application (T)

The time of application significantly increased the weight of fruit and data represented in table-6. The treatment T_1 (monthly application) recorded maximum weight of fruit i.e. 211.11 g followed by T_2 (bimonthly application) i.e. 205.19 g. The treatment T_3 (tri monthly application) recorded lowest weight of fruit i.e.192.23 g.

Interaction (G x T)

The data pertaining to the interaction of micronutrient mixture and time of application significantly increased the weight of

fruit. The data is presented in Table-6. The treatment combination G_4T_1 (Grade-4chelate foliar application, monthly) recorded highest fruit weight i.e. 222.61 g, followed by treatment combination G_4T_2 (Grade-4chelate foliar application, bimonthly) i.e. 216.80 g. The lowest weight of fruit was recorded in treatment combination G_4T_3 (Grade-3 chelate by foliar application tri monthly i.e. 184.99g.

3.2.2 Number of fruit per tree

The data related to the different treatments of micronutrient mixture and time of application increased the number of fruit per tree and data is presented in Table-6.The average number of fruit per tree recorded was 52.83.

Micronutrient mixture Grade (G)

The application of micronutrient mixture significantly increased the number of fruit per tree the data represented in table-6. The treatment G_4 (Grade-4chelate by foliar application) recorded highest number of fruit per tree i.e. 58.78, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 52.45. The lowest number of fruit per tree was recorded in G_2 (Grade-2chelate by soil application) 48.89.

Time of application (T)

The time of application significantly increased the number of fruit per tree. The treatment T_1 (monthly application) recorded maximum number of fruit per tree i.e. 57.50 followed by T_2 (bimonthly application) i.e. 54.92. The treatment T_3 (tri monthly application) recorded lowest number of fruit per tree i.e. 46.08.

Interaction (G x T)

The data pertaining to the interaction of micronutrient mixture and time of application significantly increased the number of fruit per tree. The data is presented in Table-6. The treatment combination G_4T_1 (Grade-4chelate foliar application, monthly) recorded highest number of fruit per tree i.e. 68.33, followed by treatment combination G_4T_2 (Grade-4chelate foliar application, bimonthly) i.e. 64.67. The lowest number of fruit per tree was recorded in treatment combination G_2T_3 (Grade-2 chelate by soil application, tri monthly) i.e. 42.33.

Table 6: Effect of different grades of micronutrients mixture, time of application and their interaction on weight of fruit and number of fruits per tree.

Factor/Treatment	Weight of fruit (g)	Number of fruits per tree
Factor A : Micronutrient mixture Grade (G)		
G_1	199.92	51.22
G_2	197.83	48.89
G_3	205.48	52.45
G_4	208.13	58.78
SE±	1.22	1.48
CD at 5%	3.59	4.33
Factor B : Times of Application (T)		
T_1	211.11	57.50
T_2	205.19	54.92
T_3	192.23	46.08
SE±	1.06	1.28
CD at 5%	3.11	3.75
Interaction (G x T)		
G_1T_1	198.30	51.33
G_1T_2	196.71	49.00
G_1T_3	204.76	53.33
G_2T_1	207.18	53.33
G_2T_2	198.49	51.00
G_2T_3	187.82	42.33
G_3T_1	216.33	57.00
G_3T_2	208.77	55.00
G_3T_3	191.34	45.33
G_4T_1	222.61	68.33
G_4T_2	216.80	64.67
G_4T_3	184.99	43.33
Mean	202.84	52.83
SE±	2.13	2.56
CD at 5%	6.23	7.50

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 Yield per tree (kg)

The data related to the different treatments of micronutrient mixture and time of application significantly increased the yield per tree (kg) and data is presented in Table-7. The average yield per tree was recorded 10.73 kg.

Micronutrient mixture Grade (G)

The application of micronutrient mixture significantly increased the yield of tree. The treatment G_4 (Grade-4 chelated by foliar application) recorded highest yield i.e. 12.14 kg, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 10.82 kg. The lowest yield was recorded in G_2 (Grade-2 chelate by soil application) i.e. 9.70 kg.

Time of application (T)
The time of application significantly increased the yield. The treatment T_1 (monthly application) recorded maximum yield i.e. 12.07 kg, followed by T_2 (bimonthly application) i.e. 11.22 kg. The treatment T_3 (tri monthly application) recorded lowest yield i.e. 8.89 kg.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the yield per tree and data is presented in Table-7. The treatment combination G_4T_1 (Grade-4 chelated by foliar application, monthly) recorded highest yield i.e. 14.75 kg. The treatment combinations G_3T_1 (Grade-3 sulphate by foliar application, monthly) 12.29 kg were at par. The lowest yield was recorded in treatment combination G_4T_3 (Grade-4 chelated by foliar application, tri monthly) i.e. 8.02 kg.

3.2.4 Marketable yield per tree (kg)
The data related to the different treatments of micronutrient mixture and time of application significantly increased the marketable yield per tree (kg) and data is presented in Table-7. The average yield per tree recorded was 6.37 kg.

Micronutrient mixture Grade (G)
The application of micronutrient mixture significantly increased the marketable yield of tree. The treatment G_4 (Grade-4 chelated by foliar application) recorded highest marketable yield i.e. 7.59 kg, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 6.32 kg. The lowest marketable yield was recorded in G_2 (Grade-2 chelate by soil application) i.e. 5.66 kg.

Time of application (T)
The time of application significantly increased the marketable yield. The treatment T_1 (monthly application) recorded maximum marketable yield i.e. 7.77 kg, followed by T_2 (bimonthly application) i.e. 6.70 kg. The treatment T_3 (tri monthly application) recorded lowest marketable yield i.e. 4.63 kg.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the marketable yield per tree and data is presented in Table-7. The treatment combination G_4T_1 (Grade-4 chelated by foliar application, monthly) recorded highest marketable yield i.e. 10.31 kg. The treatment combinations G_4T_2 (Grade-4 chelated by foliar application, bimonthly) recorded the marketable yield 8.43 kg. The lowest marketable yield was recorded in treatment combination G_3T_3 (Grade-3 sulphate by foliar application, tri monthly) i.e. 3.86 kg.

3.2.5 Yield (Tones ha^{-1})
The different treatments of micronutrient mixture and time of application significantly increased the yield per hectare (t) and data is presented in Table-7. The average yield per hectare recorded was 4.30 t.

Micronutrient mixture Grade (G)
The micronutrient mixture application significantly increased the yield. The treatment G_4 (Grade-4 chelated by foliar application) recorded highest yield per hector i.e. 4.86 t, followed by G_3 (Grade-3 sulphate by foliar application) i.e. 4.33 t. The lowest yield was recorded in G_2 (Grade-2 chelate by soil application) i.e. 3.89 t.

Time of application (T)
The time of application significantly increased the yield. The treatment T_1 (monthly application) recorded highest yield i.e. 4.83 t, followed by T_2 (bimonthly application) i.e. 4.49 t. The treatment T_3 (tri monthly application) had recorded lowest yield i.e. 3.56 t.

Interaction (G x T)
The interaction of micronutrient mixture and time of application significantly increased the yield per hectare. The data is presented in Table-7. The treatment combination G_4T_1 (Grade-4 chelated by foliar application monthly) recorded highest yield per hectare i.e.5.90 t, followed by G_4T_2 (Grade-4 chelated by foliar application bimonthly) i.e. 5.45 t. The treatment combinations G_2T_3 (Grade-2 chelated by soil application, tri monthly) and G_4T_3 (Grade-4 chelated by foliar application, tri monthly) i.e. 3.18 t and 3.21 t yield per hector respectively.

Table 7: Effect of different grades of micronutrients mixture, time of application and their interaction on yield per tree, marketable yield per tree and yield ha^{-1}

Factor/Treatment	Yield (Kg tree^{-1})	Marketable yield (Kg tree^{-1})	Yield (Tones ha^{-1})
Factor A : Micronutrient mixture Grade (G)			
G_1	10.25	5.91	4.10
G_2	9.70	5.66	3.89
G_3	10.82	6.32	4.33
G_4	12.14	7.59	4.86
SE+	0.30	0.17	0.12
CD at 5%	4.10	0.50	0.35
Factor B : Times of Application (T)			
T_1	12.07	7.77	4.83
T_2	11.22	6.70	4.49
T_3	8.89	4.63	3.56
SE+	0.26	0.15	0.10
CD at 5%		0.43	0.30
Interaction (G x T)			
G_1T_1	10.19	5.92	4.07
G_1T_2	9.64	5.06	3.86
G_1T_3	10.92	6.74	4.37
G_2T_1	11.04	7.13	4.42

G_2T_2	10.12	5.92	4.05
G_2T_3	7.95	3.91	3.18
G_3T_1	12.29	7.72	4.92
G_3T_2	11.49	7.73	4.59
G_3T_3	8.68	3.86	3.47
G_4T_1	14.75	10.31	5.90
G_4T_2	13.63	8.43	5.45
G_4T_3	8.02	4.01	3.21
Mean	10.73	6.37	4.30
SE+	0.52	0.30	0.21
CD at 5%	1.52	0.87	0.61
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	

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