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Effect of Nano Chitosan and Nano Micronutrients on Fruit Drop, Yield and Quality of Guava (*Psidium guajava* L.)

Rishabh Mishra[1*], Saket Mishra[2] and Riddhima Tripathi[1]
[1]M.Sc. Research Scholar, Department of Horticulture,
NAI, SHUATS, Prayagraj (Uttar Pradesh), India.
[2]Assistant Professor, Department of Horticulture,
NAI, SHUATS, Prayagraj (Uttar Pradesh), India.

(Corresponding author: Rishabh Mishra)*
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ABSTRACT: The present investigation was carried out at the Research Farm, Department of Horticulture, SHUATS, Prayagraj, on Guava cv. Allahabad Safeda from January 2022 to July 2022 with find out the effect of suitable treatments of nano chitosan and nano micronutrients in relation to fruit drop, fruit set, yield, and quality of guava. The statistical design adopted for the experiment was randomized block design (RBD) with three replications and nine treatment combinations *viz.*, T_1 (ZnO @ 150 ppm), T_2 (FeO@ 100ppm), T_3 (Borax @ 100 ppm), T_4 (Chitosan @250ppm), T_5 (ZnO @ 150 ppm + chitosan @250ppm), T_6 (FeO@ 100ppm + chitosan @250ppm), T_7 (Borax@100ppm + chitosan @250ppm), T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm), T_9 (ZnO @ 150 ppm+ FeO@100ppm+chitosan @250ppm). The treatments were applied by soil drenching at the initiation of the experiment, pre-flowering stage and the last one at the time of the fruit setting stage to assess the effect on fruit set, fruit drop, yield and quality of Guava. Application of nano chitosan and nano micronutrients with combined application played an important role in relation to the vegetative as well as reproductive growth of plants in the form of physiological role in plants as cell division in plants and increased yield and quality parameters. The results of the present investigation revealed that, the treatment outstanding in all the aspects like; as maximum fruit set (89.13%), minimum fruit drop(10.87%), non-reducing sugar (13.35%), and benefit cost ratio (2.05) were found with T_9 (ZnO @ 150 ppm + FeO@100ppm + chitosan @250ppm) treatment; maximum number of flowers (287.70), number of fruits per plant (218.14), yield(26.73kg/plant), and juice content (12.50%) were recorded with T_8(ZnO @ 150 ppm + Borax @ 100ppm + chitosan @ 250ppm), maximum T.S.S. (11.52^{0}Brix), ascorbic acid (174.44mg/100g), and reducing sugar(5.92%) were found under T_3 (Borax @ 100 ppm); fruit diameter (9.25cm) was recorded with T_7 (Borax @100ppm + chitosan @ 250ppm) and least titratable acidity(0.40%) was found with T_6 (FeO @ 100ppm + chitosan @ 250ppm)treatment; and maximum fruit weight (145.20g) was recorded under treatment T_2(FeO @ 100ppm). Maximum acidity% and fruit drop with remaining all above observations recorded least value were found under T_0 (control) *i.e.*, water spray.

Keywords: Nano chitosan, micronutrients, ppm, T.S.S., yield and quality.

INTRODUCTION

Guava (*Psidium guajava* L.) also known as "Apple of Tropics" is one of the most common fruit crops of India, belongs to family "Myrtaceae". It can be grown widely in tropical to subtropical climate with soil pH ranging from 4.5 to 8.2. Among Indian fruits, guava is considered one of the exquisite, nutritionally valuable and remunerative crops, which are used for fresh consumption and processing. In Indian climatic condition three fruiting seasons are found in guava *i.e.*, Ambe bahar, Mrig bahar, and Hasth bahar. Among these, Mrig bahar guava is the best in quality, and fruits of Ambe bahar guava are the poorest in quality.

Chitosan (poly β-(1-4) *N*-acetyl-d-glucosamine), a deacetylated form of chitin, is a natural compound obtained from crustacean shells (crabs, shrimp and crayfishes) either by chemical or microbiological processes and can be produced by some fungi too *viz.*, *Aspergillus niger*, *Mycorriza*, *Penicillium notatum*. Zinc oxide nano-particles (Zn_S-NPs) are considered a safe material' for stimulation of seed germination and plant growth as well as disease suppression and plant protection by their antimicrobial activity, whereas, iron is an essential micronutrient for almost all living organisms because of it plays critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. Boron plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, and pollination and seed set.

Nano chitosan has broad antimicrobial activity against fungal pathogens however, the bulk size limits its solubility which affects the antimicrobial property. Chitosan nanoparticles have great potential over their bulk counterparts as size can alter several properties compared to bulk material. The exclusive properties of these materials, such as a large surface area and greater reactivity, have also raised concerns about adverse effects on environmental health, keeping all these in view, the present investigation was undertaken to study the effect of nano chitosan, nano micronutrients on fruit drop, yield and quality of guava.

MATERIALS AND METHODS

The experiment was conducted at the Research Farm, Department of Horticulture of Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.), from January 2022 to July 2022 on Guava *cv.* Allahabad Safeda with 10 treatments *viz.*, T_1 (ZnO @ 150 ppm), T_2 (FeO@ 100ppm), T_3 (Borax @ 100 ppm),T_4 (Chitosan @ 250ppm), T_5 (ZnO @ 150 ppm + Chitosan @ 250ppm), T_6 (FeO@ 100ppm + Chitosan @250ppm), T_7 (Borax @100ppm + Chitosan @ 250ppm), T_8 (ZnO @ 150 ppm + Borax @ 100ppm + Chitosan @ 250ppm), T_9 (ZnO @ 150 ppm + Feo@100ppm + Chitosan @ 250ppm) and T_0 (Control *i.e*. water spray), replicated thrice in Randomized Block Design (RBD). The recommended dose of fertilizers were applied in all treatments including control. The nano chitosan, nano micronutrients (ZnO and FeO) at different concentrations were sprayed on the treetwice, once before flowering on 05.02.2022 and secondly again at the pea stage of fruit on 15.03.2022 with a sprayer having a very fine nozzle. The detergent powder was well mixed in the spray solution which act as a sticker before spraying. The information recorded on different parameters during experimental period was statistically analyzed.

Observations on fruit setting and fruit drop percentage were recorded during the fruiting season. At each picking, data on fruit weight and yield per plant were recorded. The diameter of ten randomly selected fruits was measured with the help of vernier caliper and expressed in cm. The T.S.S. of fruits was recorded with the assistance of Erma hand refractometer. The titratable acidity and reducing and non reducing sugars contents were determined by the techniques suggested in AOAC (1980).

RESULTS AND DISCUSSION

A. Flowering and Yield Parameters

(i) Number of flowers: Treatment T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm) was significantly superior and recorded maximum number of flowers (287.7) followed by T_4 (Chitosan @250ppm) as compared to other treatments. However, it was recorded lowest (255) under T_0(Control) treatment (Table 1). The possible reason for increased number of flowers may be the foliar application ZnO, Borax and chitosan, which improves the physiological properties, shelf life and reproductive rate of the plant. These results are in accordance to the findings of Jat and Kacha (2014) in guava.

(ii) Fruits set (%): Treatment T_9 (ZnO @ 150 ppm + FeO@100ppm + chitosan @250ppm) was significantly superior and recorded maximum value of fruit set (89.13%) followed by T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm) as compared to other treatments. However, it was recorded lowest (70.69%) under T_0(Control)treatment (Table 1). The possible reason for increased maximum fruit set may be the foliar application of ZnO, FeO, and nano chitosan, which increase the vegetative growth and zinc content in leaves which ultimately encourage the endogenous production of auxin thereby reducing fruit drop and increase fruit set. These findings agree with the results of Chauhan *et al.* (2019); Tiwari *et al.* (2010); Jat and Kacha (2014) in guava and Das *et al.*, (2020) in ber.

(iii) Fruit drop (%). With the foliar application of nano chitosan, nano micronutrients, minimum fruit drop (10.87%) was noted under T_9 (ZnO@150ppm + FeO@100ppm + chitosan @250ppm) followed by T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm) as compared to other treatments, whereas, the maximum fruit drop (29.30%) was recorded in Control treatment (Table 1). This reduction in fruit drop of guava fruits might be due to the reason that borax and zinc sulphate is also an important part of the cell wall (middle lamella) of plant cells along with calcium pectate which plays an important role in the strengthening of pedicel attached to the proximal end of fruit which resulted in less fruit drop. Similarly, the reduction in fruit drop by the spray of borax may also be due to the indirect action of boron in auxin synthesis that delayed the formation of the abscission layer during the early stages of fruit development, which ultimately increases fruit retention percentage. These findings align with the result of Saraswat *et al.* (2006); Chauhan *et al.* (2019) in litchi and Tripathi *et al.* (2018) in aonla.

(iv) Number of fruits. Treatment T_9 (ZnO @ 150 ppm + FeO @100ppm + chitosan @250ppm) was significantly superior and recorded the maximum number of fruits (218.14) followed by T_9 (ZnO @ 150 ppm + FeO @100ppm+ chitosan @250ppm) as compared to other treatments. However, it was recorded lowest (127.50) underControl treatment (Table 1). The possible reason for increased number of fruits may be the foliar application ZnO, Borax and chitosan, which increase the vegetative growth and zinc content in leaves which ultimately encourage the endogenous production of auxin thereby reducing fruit drop and increase fruit set. These results collaborate the findings of Balakrishnan (2001); Singh, *et al.* (2023); Prasad *et al.* (2005) in guava.

(v) Fruit diameter(cm). Treatment T_7 (Borax@100ppm + Chitosan @250ppm) was significantly superior and recorded maximum fruits diameter (9.25cm) followed by T_6 (FeO@ 100ppm + chitosan @250ppm) as compared to other treatments. However, it was recorded lowest (7.55cm) under T_0 (Control) treatment (Table 1). This improvement in fruit size can thus be attributed due to the greater mobilization of food materials from the site of their production to the storage organs under the influence of applied micronutrients. Since boron plays an important role in nitrogen metabolism and other changes in fruits, thus it might have increased the fruit size. The results are in agreement with the findings of Singh *et al.* (2009); Shukla *et al.* (2011) in aonla cv. NA-7.

(vi) Fruit weight(g). Treatment T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm) was significantly superior and recorded maximum fruit weight (122.59g) followed by T_9 (ZnO @ 150 ppm + FeO@100ppm + chitosan @250ppm) with produced (119.34g) as compared to other treatments. However, it was recorded lowest (95.32g) under T_0 (Control) treatment (Table 1). The possible reason for increased fruit weight may be the foliar application ZnO, Borax, and chitosan, which helps in protein synthesis, cell elongation and the reproductive rate of the plant. As regards borax and zinc are concerned, these play a positive role in nucleoprotein, amino acids, amino sugars, and many other compound formation in plant systems. This would allow stretching of the cell wall along with greater water uptake and increased cell size which ultimately increase the size of fruits being directly responsible for the increase in weight of fruit also. These investigations get support from the findings of Jat and Kacha (2014) in guava; Kumar *et al.* (2017) in aonla; Mishra *et al.* (2012); Kaur (2017) in litchi; Singh *et al.* (2023) in mango.

(vii) Fruit yield (kg/plant). The plants sprayed with T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm) was found maximum fruit yield (26.73kg/per plant) followed by T_3 (Borax @ 100ppm) was found with (26.09kg) per plant. However, the minimum fruit yield (12.15kg/per plant) was obtained under control (Fig. 1). This increase in yield with application of nano micronutrients and nano chitosan proved highly helpful in increasing photosynthesis, mobilization of food material and accumulations of quality constituents promoting the physical attribute like fruit weight and size which ultimately increase the fruit yield. These findings are similar to the reports of Singh *et al.* (2017); and Singh *et al.* (2023) in mango. in mango and Chauhan *et al.* (2019) in litchi, Chaturvedi *et al.* (2005) in strawberry, Badal and Tripathi (2021) in guava.

B. Bio-Chemical Parameters

(i) Total Soluble Solids(°Brix). Data revealed that the maximum TSS (11.52ºB) was recorded, when plants treated with T_3 (Borax 100ppm) followed by T_4 (Chitosan @250ppm) and T_9(ZnO @ 150 ppm + FeO@100ppm + chitosan @250ppm), respectively. Whereas, minimum TSS(9.85ºB) was obtained from control treatment *i.e.*T_0(Fig. 2). The possible reason for the increased in T.S.S. may be the foliar application of borax and nano chitosan, which improves the physiological properties and shelf life of the plant. These findings are aligned with the results of Kaur (2017); in litchi, Singh, *et al.* (2017) in mango and Chaturvedi *et al.* (2005) in strawberry.

(ii) Reducing Sugar (%). Treatment T_1 (ZnO @ 150 ppm) was significantly superior and recorded maximum reducing sugar (6.42%) followed by T_3 (Borax @ 100 ppm) as compared to other treatments. However, minimum reducing sugar (4.97%) was found under control treatment (Table 2). This increase in reducing sugar with application of borax and zinc might be due to their increased active role in the mobilization of food material leading to the accumulation of quality constituents like carbohydrates which ultimately promoted the quality attributes. These findings are in accordance with the results of Kaur (2017); Singh *et al.* (2018) in litchi and Singh *et al.* (2017) in mango.

(iii) Non-reducing sugar (%). Treatment T_1(ZnO @ 150 ppm) was significantly superior and recorded maximum non reducing sugar (15.87%) followed by T_3 (Borax @ 100 ppm) as compared to other treatments. However, minimum non-reducing sugar (8.88%) was recorded under control (T_0) treatment (Table 2). This increase in non-reducing sugar with the application of zinc might be due to their increased active role in the mobilization of food material leading to the accumulation of quality constituents like carbohydrates which ultimately promoted the quality attributes. These findings are in accordance with the results of Kaur (2017) and Singh *et al.*, (2018) in litchi and Singh *et al.* (2017) in mango.

(iv) Ascorbic acid (mg/100g of fruit pulp). Treatment T_3Borax @100ppm was significantly superior and recorded maximum ascorbic acid (174.44mg/100g) followed by Treatment T_9 (ZnO@150ppm + Feo@100ppm + Chitosan @250ppm) as compared to other treatments. However, the lowest ascorbic acid (161.55mg/100g) was recorded under T_5 (ZnO @ 150ppm + chitosan @250ppm) treatment (Table 2). The possible reason for increased maximum value of ascorbic acid may be due to the foliar application of borax, which increases the vegetative growth and zinc content in leaves which ultimately encourages the endogenous production of auxin and reduces the ascorbic acid content. These findings are similar to the reports of Singh *et al.*, (2017) in mango and Chauhan *et al.* (2019) in litchi, Chaturvedi *et al.* (2005) in strawberry, Badal and Tripathi (2021) in guava.

(v) Titratable acidity (%). The minimum titratable acidity(0.40%) was found in the fruits which were produced from the plants treated with ZnO @ 150ppm (T_1) closely followed by T_3 (Borax @ 100ppm), whereas, the maximum titratable acidity (0.48%) were recorded from T_6 (FeO@ 100ppm + chitosan @250ppm) treatment (Table 2). The possible reason for decreased acidity may be the foliar application of ZnO which increases in vegetative growth and reproductive rate. These findings are in accordance with the results of Kaur (2017) and Singh *et al.* (2018) in litchi and Singh *et al.* (2017) in mango.

(vi) Juice content (%). Treatment T_8 (ZnO @ 150 ppm + Borax @100ppm + chitosan @250ppm) was significantly superior and recorded maximum juice content (12.50%) followed by treatment T_4(Chitosan @250ppm) as compared to other treatments. However, the lowest juice content (8.26%) was found with control treatment (Table 2). The possible reason for increased juice content may be due to the foliar application ZnO, Borax and chitosan, which have zinc content in leaves that ultimately encourage the endogenous production of auxin, the physiological properties, shelf life, and reproductive rate of the plant. These findings are accordance with the results of Kaur (2017); Singh *et al.* (2018) in litchi and Singh *et al.* (2017) in mango.

Table 1: Effect of nano chitosan and nano micronutrients on flowering, fruit drop, and fruit yield parameters of guava.

Treatments	No. of flowers per plant	Fruit Set (%)	Fruit drop (%)	No. of fruits/ plant	Fruit diameter (cm)	Fruit wt. (g)
T_0	255.00	70.69	29.30	127.50	7.55	95.32
T_1	262.30	80.44	19.56	169.74	8.64	115.30
T_2	277.30	79.51	20.48	175.26	8.69	145.20
T_3	280.00	79.76	20.24	179.90	8.48	144.93
T_4	281.00	79.79	20.20	179.26	8.45	109.20
T_5	272.00	85.75	14.24	200.40	8.76	114.17
T_6	267.70	79.22	20.77	168.45	8.90	115.27
T_7	272.00	79.55	20.44	172.19	9.25	119.29
T_8	287.70	87.08	12.91	218.14	8.35	122.59
T_9	274.30	89.13	10.87	217.92	8.16	119.34
S.E.(d)±	8.08	0.18	0.18	0.30	1.26	0.31
C.D. at 5%	16.97	0.37	0.37	0.64	2.65	0.65

Table 2: Effect of nano chitosan and nano micronutrients on fruit quality parameters of guava.

Treatments	Reducing Sugar (%)	Non-reducing Sugar (%)	Ascorbic acid (mg/100g)	Titratable Acidity (%)	Juice Content (%)	B:C Ratio
T_0	4.97	8.88	161.55	0.455	8.26	1.22
T_1	6.42	15.87	156.32	0.403	8.96	1.65
T_2	5.64	12.56	163.12	0.446	9.66	1.29
T_3	5.92	14.04	174.44	0.421	11.10	1.69
T_4	5.77	13.19	166.71	0.432	12.00	1.49
T_5	5.67	12.31	151.86	0.460	11.26	1.97
T_6	5.26	10.69	154.22	0.489	10.26	1.30
T_7	5.66	11.76	171.62	0.442	11.60	1.71
T_8	5.39	12.84	169.46	0.438	12.50	1.52
T_9	5.80	13.35	171.82	0.434	10.62	2.05
S.E.(d)±	0.03	2.62	4.70	0.001	0.51	
C.D. at 5%	0.07	3.20	9.88	1.230	1.08	

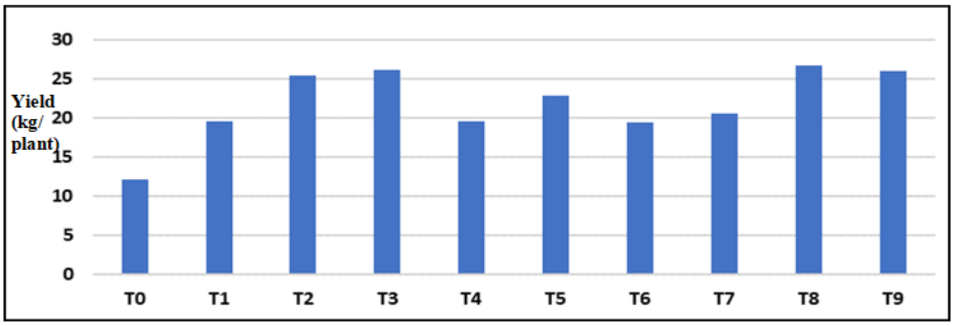

Fig. 1. Effect of nano chitosan and nano micronutrients on yield of guava.

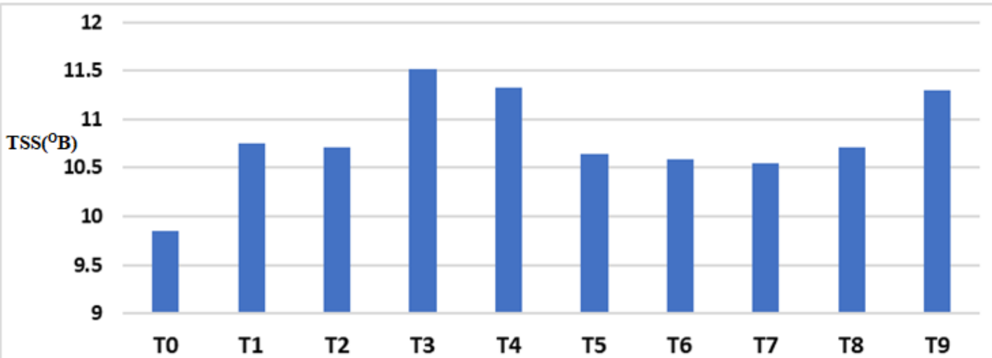

Fig. 2. Effect of nano chitosan and nano micronutrients on TSS(°B) of guava.

(vii) Benefit: cost ratio. The economic feasibility calculated for various treatments showed that the application of treatment of T_9 (ZnO @ 150 ppm + FeO@100ppm + chitosan @250ppm) was recorded highest as resulted the maximum benefit cost (2.05) ratio over control. While, the minimum (1.22) benefit-cost ratio was calculated under control treatment (Table 2). The present results are conformity with the findings of Dutta and Banik (2007) in guava.

Therefore, ZnO @ 150ppm + FeO@100ppm + chitosan @250ppm should be recommended as nano chitosan and micronutrients for enhancing fruit drop, yield, and quality of guava (*Psidium guajava* L.).

CONCLUSIONS

Based on the present investigation, it can be concluded that on behalf of various treatments were applied to enhance the yield and quality characters of guava cv. Allahabad Safeda, according to the above treatment. Treatment T_8 (ZnO @ 150ppm + Borax @100ppm + chitosan @250ppm) is best recommended for the overall growth and development of plants like; number of flowers, fruit weight, fruit yield and juice content % *etc*. Where, treatment T_9 (ZnO @ 150 ppm + FeO@100ppm + chitosan @250ppm) was found best in fruit set with minimal fruit drop and qualitative parameters like; TSS, titratable acidity, reducing, non-reducing sugar and benefit cost ratio also outstanding among the others.

FUTURE SCOPE

The use of nano chitosan and nano micronutrients assumes a significant part in increasing the yield of quality fruits with the reduction in fruit drop along with increased fruit set. Guava is an important fruit crop all over the world in sub-tropical climates. That's why in the future, more studies can be carried out on other cultivars alone or in a combination of both *i.e.*, nano chitosan and nano micronutrients on most of the parameters to standardize doses specific to the particular regions.

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Conflict of Interest. None.

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