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Impact of plant growth regulators and nutrients on guava (*Psidium guajava*) yield in south- eastern Rajasthan

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Abstract

The experiment was conducted at Horticulture Research Farm, Career Point University, Kota, during 2023-24 to examine the influence of plant growth regulators and nutrients on fruit setting and physiochemical attributes of guava (*Psidium guajava* L.) cv. L-49. The plants received first dose of PGRs and nutrients at fruit setting and second at fruit development stage. Foliar application of potassium sulphate (1.0 %) significantly reduced fruit drop (39.77%), while improved fruit setting (71.05%) and fruit retention (60.23%). The foliar application of potassium sulphate (1.0%) increased fruit weight (142.43g), fruit length (8.71cm), fruit width (7.89cm), fruit volume (132.77cc), TSS (11.70%), TSS: acid ratio (30.00), vitamin C (174.10), pectin (1.83 %), reducing sugar (3.80%), non-reducing sugar (3.45%) and total sugars (7.25%) and minimum acidity (0.39%). The foliar application of potassium sulphate (1.0%) also improved the fruiting and physiochemical characteristics of guava cv. L-49 as compared to the control.

Key words: Fruit drop, Fruit retention, Fruit setting, PGRs, Sugars, Vitamin C

Guava (*Psidium guajava* L.) is extensively cultivated in tropical and subtropical regions of India. In India, it is cultivated in 2.70 million ha with an annual production of 26.29 tonnes/ ha (FAOSTAT, 2022). The application of exogenous plant growth regulators can help enhance fruit setting. The total soluble solid and vitamin C levels are raised and its acidity is decreased by applying NAA (Lenka *et al.* 2019). Flowering and fruiting of guava fruit was significantly enhanced by foliar application NAA (Sharma and Tiwari, 2015). GA_3 may have contributed to the fruit's higher TSS content by stimulating the activity of several enzymes involved in physiological processes in guava (Lal and Das, 2017). In a variety of physiological and biochemical processes essential to plant growth, yield, and quality as well as under stressful circumstances, potassium plays a significant role (Kumar *et al.* 2017). Because potassium makes it easier for photosynthates to transport from leaves to immature fruits, (Kumar *et al.* 2017). Keeping in view, an experiment was conducted to investigate the impact of plant growth regulators (PGRs) and nutrients on fruiting characteristics and physiochemical attributes of guava.

MATERIALS AND METHODS

The experiment was conducted in 14-year-old guava orchards during 2023-24 at the Horticultural Research Farm, Career Point University, Kota, Rajasthan. The experimental site covers a tropical climate region with temperatures ranging from 3°-48° C and an annual rainfall of 660 mm. The soil texture was black soil, which is well-drained and well-aerated with a pH of 7.2-8.5 and plant-available KMnO4- 166.09 mg/kg, Olsen-P- 10.50 mg/kg, and NH4OAc-K- 177.9 mg/kg. Fourteen-year-old uniform guava (cv. L-49) plants spaced 6 x 6 m apart were chosen for the study. The experiment had nine treatments consisting of NAA (50 ppm), NAA (100 ppm), GA_3 (25 ppm), GA_3 (50 ppm), Potassium sulphate (1%), Potassium sulphate (2.0%), Calcium nitrate (1.0%), Calcium nitrate (2.0%), and control plants sprayed with normal water, along with four replications and was set up in a Randomized Block Design. The crop received its initial foliar spray of nutrients and plant growth regulators in the first week of August, coinciding with the fruit set stage. The same treatment was applied again in the second week of September, during the fruit development stage.

Fruit set, fruit retention, and fruit drop were evaluated as per the standard formula described by (Darshan *et al.* 2023).

$$\text{Fruit drop (\%)} = \frac{\text{Total number of fruits set} - \text{total number of fruits retained}}{\text{Total number of fruits set}} \times 100$$

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flower appeared}} \times 100$$

$$\text{Fruit retention (\%)} = \frac{\text{Total number of fruits retained}}{\text{Total number of fruits set}} \times 100$$

The weight of five fruits from each replication was measured with help of digital weighing balance and results were expressed as gram. The length and width of five fruits from each replication was measured with help of a

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Vernier Callipers, and the results were expressed as cm and mm, respectively. Water displacement method was followed to obtain the fruit volume and the results were expressed as cubic centimetres (Darshan *et al.* 2023). The total soluble solids (TSS) content was measured using an Erma hand-held refractometer from Japan, and expressed as a percentage of soluble solids after correcting for temperature at 20°C (Gill *et al.* 2016). Ascorbic acid and titratable acidity were determined following the method outlined by the AOAC, (2005). Pectin was quantified using the gravimetric method described by Gill *et al.* (2016), where pectin was precipitated as calcium pectate from an acidic solution through the addition of calcium chloride. The precipitate was washed with water until free of chlorine, then dried and weighed, with results reported as a percentage of calcium pectate. Reducing, non-reducing, and total sugars contents were measured according to the method by Priyadarshi *et al.* (2018), with results expressed as percentages.

The experiment was laid out as per Randomized Block Design, and data were analysed using statistical software SAS 9.4 (V 9.4, SAS Institute Inc., USA) package. The interaction means were subjected to analysis of variance and pairwise comparison using Tukey HSD ($p \leq 0.05$) where found significant.

RESULTS AND DISCUSSION

Pre-harvest application of plant growth regulators (PGRs) and nutrients significantly reduced fruit drop of guava cv. L-49 (Fig. 1A). The application of lower concentration of PGRs (NAA and GA_3) and potassium sulphate, while the higher concentration calcium nitrate is more effective for reducing fruit drop percentage of guava. Foliar application of potassium sulphate 1.0% recorded minimum fruit drop percentage (39.77 %), which was statistically at par with NAA 50 ppm (41.67%) and GA_3 25 ppm (42.05%). However, significantly the maximum fruit drop percentage was recorded in plants sprayed with water (61.24%). Many fruiting plants face a severe economic risk from fruit drop, with about 50% of the blossoms and immature fruits falling off during growth due to a variety of pressures (Iqbal *et al.* 2009). The foliar application of K_2SO_4 leads to enhanced lignin and cellulose formation because the synthesis of both polymers is necessary to start the process of endogenous hormone synthesis. It also improves plant structure because the synthesis of carbohydrates prevents the formation of the abscission layer, which reduces drop at an early stage (Reetika *et al.* 2018). Similar outcomes were also observed in date palm by Khan *et al.* (2022).

Fruit set and fruit retention percentage in guava fruits was significantly altered by foliar application of plant growth regulators (PGRs) and nutrients (Fig. 1B and C). The plants received lower concentration of PGRs (NAA and GA_3) and potassium sulphate, whereas the higher concentration of calcium nitrate noted significantly maximum percentage of fruit set and fruit retention. The plants sprayed with potassium sulphate 1.0% recorded significantly maximum fruit set (71.05%) and fruit retention percentage (60.23%), which was followed by NAA 50 ppm (68.67 % and 58.33%). The control plant (sprayed with normal water) recorded significantly minimum fruit set (46.32%) and fruit retention (38.76%) percentage. The role that potassium plays in preserving cell water content, in the production of carbohydrates, and in the subsequent translocation and mobilization of carbohydrates in plant tissues may account for the improved fruit set and fruit retention observed with potassium administration. Consequently carbohydrates played important role in fruit set (Shareef, 2016). Similar results were reported by Singh *et al.* (2022) who reported highest fruit set and with application of 0.50 % potassium sulphate in ber cv. Umran.

Fruit weight and fruit volume of guava cv. L-49 was significantly influenced by the foliar application of plant growth regulators (PGRs) and nutrients (Fig. 1D and G). The plants sprayed with potassium sulphate 1.0 % produced maximum fruit weight (142.43g) and fruit volume (132.77cc) which was followed by NAA 50 ppm (130.11g and 123.56cc, respectively) and calcium nitrate 1.0 % (127.66g and 125.76cc, respectively) and potassium sulphate 2.0% (126.88g and 12177cc, respectively). On the other hands, plants sprayed with water (control) produced minimum fruit weight (111.34g) and fruit volume (112.33cc). The increase in fruit weight and fruit volume could be due to the reinforcement of the middle lamella and subsequent cell wall strengthening, which may have facilitated the enhanced movement of solutes into the fruits. This increase in volume and growth may be explained by better metabolite production, better water absorption, and better mobilization of carbohydrates and minerals inside the mesocarp enlarged cells and intercellular space. Application of potassium sulphate showed an enhancement in fruit weight in date palm (Omar *et al.* 2017) and fruit volume in Washington Navel Orange (Ali *et al.* 2015).

The data highlighted in Fig. 1E and F showed that foliar application of plant growth regulators (PGRs) and nutrients significantly improved the fruit length and fruit width of guava cv. L-49. Foliar application of nutrients (potassium sulphate 1.0%) produced significantly maximum fruit length (8.71cm) and fruit width (7.89mm) which was followed by NAA 50 ppm (8.54cm and 7.44mm). However, the plants sprayed with normal water (control) produced significantly minimum fruit length (7.13cm) and fruit width (6.15mm). The increased in length and width in fruits could be the result of potassium, a mineral that appears to play an indirect role in accelerating the process of cell division and elongation. As a result, the fruit's size may have improved (Mishra *et al.* 2017). Similar increase in fruit length and fruit breadth with potassium applications was reported by in pear (Gill *et al.* 2012).

An increase in total soluble solids in guava cv. L-49 was recorded after foliar application of plant growth regulators (PGRs) and nutrients (Table 1). The improvement in total soluble solids content was recorded in response to plants received lower concentration of potassium sulphate 1.0% and NAA 50 ppm than the other treatments. Plants sprayed with potassium sulphate 1.0% exhibited maximum total soluble solids (11.70%) content, which was followed by foliar application of NAA 50ppm (11.43%). The reduction in acidity content was recorded in all the treated guava fruits, whereas untreated guava fruits recorded maximum acidity content. Foliar application of potassium sulphate 1.0% noted significantly minimum acidity (0.39%) content which was closely followed by foliar application of NAA 50 ppm and GA_3 50 ppm (0.41% and 0.42%, respectively). However, the plants sprayed with normal water (control) resulted maximum acidity (0.54%). The increased total soluble solids (TSS) content of guava fruits may be the result of potassium's significant role in the translocation of sugars, other soluble solids, and photo-assimilates, which raises TSS levels. The present results regarding to total soluble solids are in accordance with the earlier findings of Mandal *et al.* (2012) and Jitendra *et al.* (2015) in guava. The guava fruit pulp exhibited lower acidity with potassium treatments compared to other treatments. This might be due to a higher accumulation of sugars, improved translocation of sugars into fruit tissues, and the conversion of organic acids into sugars. Additionally, the neutralization of organic acids due to elevated potassium levels in the tissue could have contributed to the reduction in acidity (Kumar *et al.* 2017).

A significant variation was recorded in all the TSS: acid ratio and vitamin C content in guava fruits in response to foliar application of PGRs) and nutrients (Table 1). Foliar application of potassium sulphate 1.0% recorded maximum TSS: acid ratio (30.00) and vitamin C content (174.10 mg/100g), which was followed by NAA 50ppm (27.88 and 171.04 mg/100g). On the other hands, plants received only normal water (control) noted minimum TSS acid ration (18.09) and vitamin C (144.12 mg/100g) content. Potassium sulphates effect on this ratio can be explained through its influence on both the synthesis of soluble solids and the reduction of organic acids. Potassium contributes to the synthesis of organic compounds while also affecting the acid metabolism in plants. The reduction in acidity, alongside the increase in TSS, leads to an improved TSS: acid ratio, enhancing the sweetness and palatability of the fruits or produce. The present findings align with Zaied *et al.* (2006), who observed a significant increase in the T.S.S/acid ratio in juice with potassium application on Washington navel orange trees in both seasons. The increase in ascorbic acid content in guava fruit pulp with foliar potassium sprays may be attributed to the enhanced synthesis of certain metabolites and intermediate substances that promote the formation of ascorbic acid precursors. These results are consistent with the earlier findings of (Agarwal, 2012) and Manivannan *et al.* (2015) in guava fruits.

The data highlighted in (Table 1) showed that foliar application of plant growth regulators (PGRs) and nutrients increased the pectin content of guava fruits. The lower concentration of potassium sulphate and NAA 50 ppm is more effective for increasing the pectin content in guava fruits as compared to other treatments than control. The maximum pectin (1.83 %) was recorded in plants sprayed with potassium sulphate 1.0%, which was followed by NAA 50 (1.72%). However, the minimum

Table 1: Effect of plant growth regulators and nutrients on biochemical characteristics of guava cv. L-49.

Treatment	TSS (%)	Acidity (%)	TSS: acid ratio	Vitamin C (mg/100)	Pectin (per cent pectate)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)
NAA 50 ppm	11.43 ± 0.09^{b}	0.41 ± 0.00^{h}	27.88 ± 0.23^{b}	171.04 ± 1.64^{ab}	1.72 ± 0.01^{b}	3.71 ± 0.03^{b}	3.33 ± 0.02^{b}	7.04 ± 0.05^{b}
NAA 100 ppm	11.32 ± 0.09^{b}	0.43 ± 0.00^{f}	26.33 ± 0.22^{c}	153.88 ± 1.48^{f}	1.44 ± 0.01^{f}	3.40 ± 0.02^{d}	2.88 ± 0.02^{f}	6.28 ± 0.04^{e}
GA_3 25 ppm	10.47 ± 0.08^{d}	0.45 ± 0.00^{d}	23.27 ± 0.19^{e}	156.34 ± 1.50^{ef}	1.51 ± 0.01^{de}	3.33 ± 0.02^{de}	3.09 ± 0.02^{d}	6.42 ± 0.05^{cd}
GA_3 50 ppm	10.75 ± 0.08^{c}	0.42 ± 0.00^{g}	25.60 ± 0.21^{d}	162.88 ± 1.56^{d}	1.54 ± 0.01^{d}	3.52 ± 0.02^{c}	2.86 ± 0.02^{f}	6.38 ± 0.04^{de}
Potassium sulphate 1.0%	11.70 ± 0.10^{a}	0.39 ± 0.00^{i}	30.00 ± 0.25^{a}	174.10 ± 1.67^{a}	1.83 ± 0.01^{a}	3.80 ± 0.03^{a}	3.45 ± 0.02^{a}	7.25 ± 0.05^{a}
Potassium sulphate 2.0%	11.35 ± 0.09^{b}	0.44 ± 0.00^{e}	25.80 ± 0.21^{cd}	168.81 ± 1.62^{bc}	1.60 ± 0.01^{c}	3.49 ± 0.02^{c}	2.98 ± 0.02^{e}	6.47 ± 0.05^{cd}
Calcium nitrate 1.0%	10.60 ± 0.08^{cd}	0.49 ± 0.00^{b}	21.63 ± 0.18^{g}	160.77 ± 1.54^{de}	1.48 ± 0.01^{e}	3.39 ± 0.02^{d}	3.14 ± 0.02^{cd}	6.53 ± 0.05^{c}
Calcium nitrate 2.0%	10.71 ± 0.08^{cd}	0.48 ± 0.00^{c}	22.31 ± 0.19^{f}	164.81 ± 1.58^{cd}	1.63 ± 0.01^{c}	3.27 ± 0.02^{e}	3.18 ± 0.02^{c}	6.45 ± 0.05^{cd}
Water spray (Control)	9.77 ± 0.08^{e}	0.54 ± 0.00^{a}	18.09 ± 0.15^{h}	144.12 ± 1.38^{g}	1.22 ± 0.009^{g}	3.10 ± 0.02^{f}	2.67 ± 0.01^{g}	5.77 ± 0.04^{f}
Tukey HSD ($P \leq 0.05$)	**0.27**	**0.009**	**0.61**	**4.62**	**0.04**	**0.08**	**0.07**	**0.14**

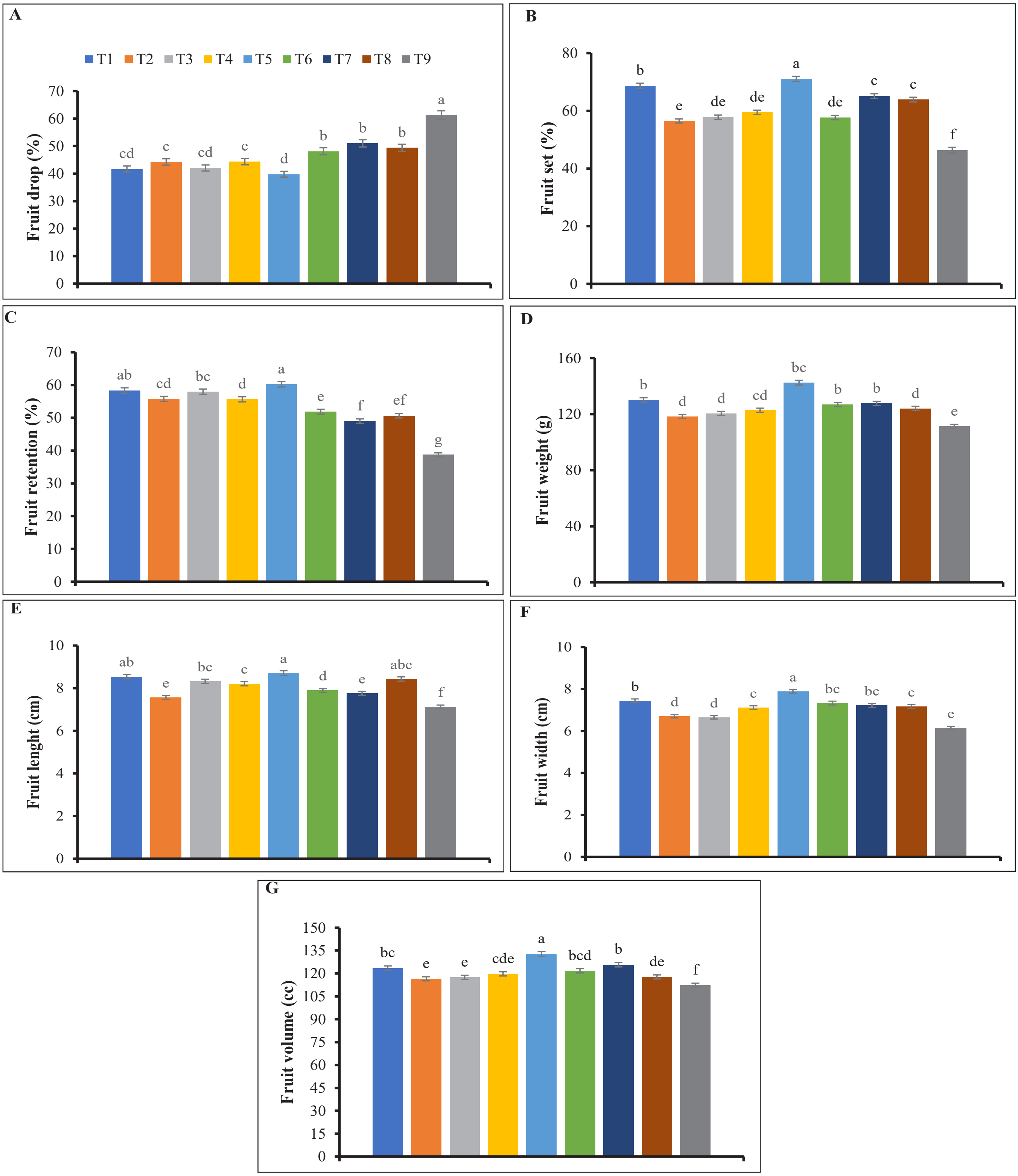

Fig 1: Effect of plant growth regulators and nutrients on biochemical characteristics on the (A) fruit drop; (B) fruit set; (C) fruit retention; (D) fruit weight; (E) fruit length; (F) fruit width; and (G) fruit volume of guava. Vertical bars represent the standard error of means for three replicates. Means with same letters are not statistically different from each other by Tukey HSD ($P \leq 0.05$). T_1 = NAA 50ppm, T_2 = NAA 100ppm, T_3 = GA_3 25ppm, T_4 = GA_3 50ppm, T_5 = Potassium sulphate 1.0 %, T_6 = Potassium sulphate 2.0 %, T_7 = Calcium nitrate 1.0%, T_8 = Calcium nitrate 2.0% and T_9 = Control

pectin (1.22 %) content was recorded in plants sprayed with normal water (control). Potassium enhances the pectin content in fruits by promoting the translocation of photosynthates from leaves to young fruits, which are partially utilized in the synthesis of pectic substances (Kumar *et al*. 2017).

A significant improvement was recorded in guava fruits after foliar application of plant growth regulators (PGRs) and nutrients (Table 1). The plants sprayed with lower concentration of nutrients (potassium sulphate 1.0%) significantly recorded maximum reducing (3.80%), non-reducing (3.45%) and total sugars content (7.25%), followed by foliar application of NAA 50ppm (3.71%, 3.33% and 7.04 %, respectively). However, the plants received only normal water (control) noted least amount of reducing (3.10%), non-reducing (2.67%) and total sugars (5.77%) content. The increase in reducing sugars in guava pulp following nutrient application through foliar sprays may be attributed to the enhancement of photophosphorylation and the dark reaction of photosynthesis by potassium.

This process results in the accumulation of more carbohydrates in the fruits and improves nutrient accessibility to developing fruits. Similar findings have been reported by Singh *et al*. (2002) in peach, Prasad *et al*. (2015) in pear, and Manivannan *et al*. (2015) in guava. The improvement in non-reducing sugars in guava pulp with nutrient application might be due to the activation of enzymes that hydrolyze polysaccharides into simpler forms such as mono and disaccharides. This process, along with better transportation of assimilates and nutrients from leaves to fruits, increases nutrient availability and enhances fruit quality. These results are consistent with the earlier findings of Kumar *et al.,* (1990) in grape cv. Delight and (Kaur and Dhillon, 2006) in guava. The increase in total sugars in guava pulp from pre-harvest potassium sprays might be due to the conversion of starch and acid into sugars, coupled with the continuous mobilization of sugars from leaves to fruits. These findings align with the results reported by Manivannan *et al*. (2015) and Jitendra *et al*. (2015) in guava.

CONCLUSION

Thus, foliar application of plant growth regulators and nutrients is most effective treatments as compared to the control. The lower concentrations of potassium sulphate 1.0 % and NAA 50 ppm is more effective than rest of treatments. Foliar application of potassium sulphate 1.0% significantly reduced fruit drop percentage, improved fruit set, fruit retention.

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