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EFFECT OF PLANT GROWTH REGULATORS ON YIELD AND QUALITY OF WINTER SEASON GUAVA (*PSIDIUM GUAJAVA* L.) CV. L-49

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ABSTRACT

An investigation was conducted at Research Farm Akma, Department of Fruit Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), India during 2021-22 to assess the effect of plant growth regulators on yield and quality of winter season guava (*Psidium guajava* L.) cv. L-49. The experiment was conducted in a Randomized Block Design with three replications. The experiment consisted of nine treatments including two concentration of NAA (150 ppm and 200 ppm), and two concentrations of Benzyl adenine (15ppm and 20 ppm), combinations of aforesaid (NAA & BA) *i.e.*, NAA (75 ppm) + BA (15 ppm), NAA (75 ppm) + BA (20 ppm), NAA (100 ppm) + BA (15 ppm), NAA (100 ppm) + BA (20 ppm) and a Control (Water spray). The results showed significant effect of various concentrations of PGRs and recorded maximized physical attributes *viz.*, fruit weight (155.36g), fruit length (7.67cm), fruit width (7.53cm), fruit volume (140.67ml), pulp content (96.62%), pulp : seed ratio (28.64), fruit yield per tree (61.61kg), fruit yield per ha (171.13q), and specific gravity (1.11g/cc) with foliar application of T_2 (NAA 200 ppm), however the seed weight (5.24 g) was minimized. The chemical characters *i.e.*, TSS (12.01 ^{0}brix), ascorbic acid (234.14 mg/100 g), reducing sugar (4.21%), non-reducing sugar (3.72%) and total sugars (7.93%) were also significantly high with foliar application of T_2 (NAA 200 ppm). Further, it was found that the application of NAA 200 ppm (T_2) increased the benefit: cost ratio (3.77:1) of guava cv. L-49.

Key words : Guava, Growth regulator, NAA, Benzyl adenine, B:C ratio.

Introduction

Guava (*Psidium guajava* L.) is one of the most important fruit crops grown well under tropical and sub-tropical conditions. It's popularly known as 'Apple of Tropics' or 'Poor man's apple' belongs to family 'Myrtaceae' and sub family 'Myrtoideae". It's originated from tropical America and adopted well for commercial cultivation throughout tropics due to its hardy nature, prolific bearing, high ascorbic acid content (Negi and Rajan, 2007). Guava ripe rapidly and being highly perishable, it can be stored for 2 to 3 days under ambient condition (Bassetto *et al.*, 2005). The quality of guava fruit is greatly affected by temperature and humidity. The development of sweetness, color and aroma depends on low temperature and dry atmosphere, due to which the fruit quality of winter fruits is better than rainy. Rainy season crop has high production but quality is poor due to insipidness (Singh *et al.*, 1996) and infestation of pest (Rawal and Ullasa, 1988). Though the fruit quality of winter season crop is better, but fruits remain smaller in size, become too hard and lack ripening due to low temperature. Thus, there is need of standardization of practices to bring further improvement in fruit yield and quality in winter season.

Growth regulators like NAA and Benzyl adenine affects flower and fruit setting, cell growth, apical dominance, geotropism and photoperiod. The growth regulators spray in addition increases fruit weight, total soluble solids (TSS), fruit weight, carotene, reducing sugars, total sugars and vitamin-C and decreased tannin and fruit acidity. Naphthalene acetic acid (NAA) is an important bioregulator of the auxin group, which increases fruit set and decreases fruit drop. These activities improve the width and length of the fruits, which ultimately increases the yield of fruits. The work done by earlier researchers revealed that foliar feeding of boron increased fruit set, reduced fruit drop and also improved the fruit quality in various fruits. Keeping this in view, the study was undertaken to assess the influence of foliar feeding of NAA and boron on growth, flowering, fruiting and yield pertaining to guava. Thus, study was carried out to identify the effectiveness of growth regulator (NAA and Benzyl adenine) to improve yield and quality attributes of winter season guava cv. L-49.

Materials and Methods

Experiment was carried out under sodic soil condition and experimental site was located at the Main Experiment Station Akma, Department of Horticulture, Acharya Narendra Deva University of Agriculture and Technology Kumarganj (Ayodhya), U.P., India during the year 2021-22. Geographically, Akma, Kumarganj situated at 26.47 ^{0} North latitude and 80.120^0 East longitude and an altitude of 113-meter mean sea level. The site is located in typical saline - alkaline soils of the Indo Gangetic plains of eastern Uttar Pradesh, India.

Twenty-five years old guava plants cv. L-49, were planted at 6m × 6m apart, taken for present investigation. Other orchard management practices were followed as per recommended package and practices for guava. The experiment was conducted in a Randomized Block Design with three replications. The experiment consists of 9 treatments including control. T_1 (NAA 150 ppm), T_2 (NAA 200 ppm), T_3 (Benzyl adenine 15 ppm), T_4 (Benzyl adenine 20 ppm), T_5 (NAA 75 ppm+ BA 15 ppm), T_6 (NAA 75 ppm + BA 20 ppm), T_7 (NAA 100 ppm + BA 15 ppm), T_8(NAA 100 ppm + BA 20 ppm), T_9(Control *i.e.*, Water spray) were used. Spraying was done in twice *viz.* first, in the second week of September at marbel stage and second spraying after 15 days of first spray.

Observations recorded

Physical characteristics of fruits

Fruit weight (g) : Five randomly selected fruits were taken and weight on electronic balance and average were expressed in gram.

Fruit length (cm) : Fruit length was measured from the apex to stem end of the fruit with the help of Vernier caliper and mean values were expressed in centimeter.

Fruit width (cm) : The fruit width was measured at the widest point of fruit with the help of Vernier caliper and the mean value was expressed in centimeter.

Fruit volume (cc) : Volume of fruit was measured with the help of volumetric flask with water displacement method and expressed in cc.

Seed weight (g) : The seeds extracted from fruits with crushed and care that the seeds were not damaged in any way. After that, wash and clean the seeds thoroughly with tap water. The weight of seed was recorded with the help of electronic weighing balance. The weight of seed was calculated by formula:

Seed weight (g) = Total weight of fruit (g) – Pulp weight(g)

Pulp (%) : Pulp percent was calculated in relation to pulp weight and total fruit weight. The pulp percent was calculated by using following formula:

$$\text{Pulp \%} = \frac{\text{Pulp weight}}{\text{Fruit weight}} \times 100$$

Pulp: Seed ratio : Pulp weight was divided by Seed Weight to obtain the Pulp/ seed ratio.

Fruit yield (kg tree^{-1}) : The yield per tree was recorded at the time of fruit harvesting and expressed in kg/tree.

Fruit Yield (qha^{-1}) : Fruit weight was recorded in each treatment at each harvesting and the total fruit yield per hectare was calculated at the last harvest and expressed in quintal per hectare.

Specific gravity (g/cc) : The specific gravity was determined by fruit weight dividing by fruit volume using the following formula.

Specific gravity = Weight of fruit / Volume of fruit

Chemical parameters

Total soluble solids (^{0}Brix) : The total soluble solids of the crushed fruit samples were quantified using a hand refractometer in the 0 to 32 percent range. Values were corrected at 20°C and expressed as the percentage.

Ascorbic acid (mg/100g pulp) : For the determination of ascorbic acid, 5 g of fruit samples taken and crushed in a pestle and mortar with 3 percent metaphosphoric acid then filtered with a muslin cloth in a 50 ml volumetric flask. The volume was then made up with a 3% HPO_3 (metaphosphoric acid) solution. Then a 5 ml aliquot was titrated against a 2,6-dichloro-phenol-indophenol dye solution. The end point was marked as light pink, which persisted for 15 seconds. The ascorbic acid content was calculated with the help of the following formulas and expressed in mg/100 g.

Dye factor = 0.5/ Titrate volume of standard ascorbic acid

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titrate value} \times \text{Dyefactor} \times \text{Volume madeup}}{\text{Aliquot taken for estimation} \times \text{Volume of sample taken}} \times 100$$

Reducing sugars (%) : To determine the reducing sugar, 10 g fruit was blended with distilled water, filtered in 100 ml volumetric flask and volume was maintained with distilled water. A 5 ml sample was taken with 5 ml Fehling solution 'A' and 5 ml Fehling solution'B' in a 100 ml conical flask and titrated the solution against 1.0 per cent glucose, while boiling and checked by a methylene blue indicator. The end point was marked by the appearance of brick red colour.

Non reducing sugar (%) : Non-reducing sugars were estimated by subtracting the reduced sugar quality from the total invert sugar and multiplying by the factor 0.95. The results were expressed as a percentage of non-reducing sugars.

Non reducing sugar (%) = {Total invert sugar (%) – Reducing sugar (%)} × 0.95

Total sugars (%) : Estimated values were expressed in total sugar, reducing sugar and non-reducing sugar content of fruits and were expressed as percentage of reducing sugar + reducing sugar and as percentage of total sugar was expressed in.

Total sugar (%) = Reducing sugar (%) + Non reducing sugar (%)

Estimation of benefit cost ratio

The benefit: cost ratio was calculated by the analysis of total cost (Rs.), gross income (Rs.) and net return (Rs.).

Total cost (Rs.) : The total cost was calculated for each treatment by adding the value of each inputs *i.e.* labour charged, planting materials etc. in each treatments during the experiments.

Gross income (Rs.) : Gross income was estimated on the basis of the average market price of fruit at the respective time.

Net income (Rs.) : Net income was calculated for each treatment by deducting the total cost from the gross income obtained in each treatment.

Benefit: cost ratio : The benefit: cost ratio was calculated using the following formula:

Benefit: cost ratio = Net return (ha^{-1}) / Total cost of cultivation (ha^{-1})

Statistical analysis

Statistical analysis of the data obtained in the different set of experiments was calculated as suggested by Panse and Sukhatme (1985).

Results and Discussion

Physical parameters

Fruit Weight (g) : The fruit weight of guava was recorded and data obtained were subjected to statistical analysis. A significantly maximum weight (155.36g) of guava fruit was obtained with NAA 200ppm (T_2) closely followed by NAA 100 ppm + BA 20 ppm (T_8), which was found significantly effective over rest of treatments. Significantly, lesser fruit weight (101.21 g) was recorded under control (T_9) during the corresponding year of study. Increased NAA concentration resulted in heavier fruits than other treatments, which may be explained by the higher level of metabolites that NAA mediated from the leaves to the fruits. The results are in accordance with findings of Application of NAA in winter season Guava cv. L-49 increases the fruit weight investigated by Yadav *et al*. Maximum fruit weight was detailed with NAA as indicated by Ram Asrey *et al.* (2001). Al-Juburi *et al.* (2001) discovered that NAA increased fruit weight per bunch and per tree. Ingle *et al.* (2001). The application of NAA induced cell elongation by enlargement of vacuoles and loosening of cell wall which caused increase in fruit weight, fruit number and yield (Dikshit and Agrawal, 2008).

Fruit length (cm) : The length of the fruit of guava was measured with the help of a Vernier caliper and data thus obtained were statistically analyzed. The length of fruit consistently increased up to 200 ppm NAA (T_2) revealed that significantly maximized length 7.67cm of fruit followed by NAA 100 ppm + BA 20 ppm (T_8) during the experiment trial investigation respectively. Control (T_9) revealed a significantly lesser diameter of guava fruit (6.12cm) compared with the rest of the treatments. The use of NAA may have contributed to the rapid development of fruit length by raising the auxin level of fruits, which may have boosted the mobilization of nutrients and minerals from other plant parts toward the development of fruits that are highly active metabolic sinks. Jain and Dashora (2011) also observed a maximum diameter of 7.30 cm due to pre-harvest application of 200 ppm NAA in guava. In a similar study, Banik and Dutta (2007) reported increased fruit size, weight and yield in sardar guava, when NAA and GA_3 with nutrients were applied before fruit setting and again 3 weeks after fruit setting. The current findings are also in agreement with the results proposed by Ranjan *et al.* (2003), who confirmed that stimulated cell division and cell elongation due to application of NAA may be the reason behind increased fruit size.

Fruit width (cm) : The width of guava fruit was measured with the help of a Vernier caliper and data thus obtained were statistically analyzed. The width of fruit consistently increased up to 200 ppm NAA (T_2) revealing non significantly maximized width of 7.53 cm followed by NAA 100 ppm + BA 20 ppm (T_8) during the trial year of investigation respectively. Control (T_9) revealed a non-significantly lesser diameter of guava fruit (6.35 cm) when compared with the rest of the treatments. The use of NAA may have contributed to the rapid expansion of fruit width by raising the auxin level of fruits, which may have boosted the mobilization of nutrients and minerals from other plant parts toward the development of fruits has very active metabolic sinks. Jain and Dashora (2011) also observed a maximum diameter of 7.30cm due to pre-harvest application of 200 ppm NAA in guava. In a similar study, Banik and Dutta (2007) reported that increased fruit size, weight and yield in sardar guava when NAA and GA_3 with nutrients were applied before fruit setting and again 3 weeks after fruit setting. The current findings are also in agreement with the results proposed by Ranjan *et al*. (2003), who confirmed that stimulated cell division and cell elongation due to application of NAA may be the reason behind increased fruit size.

Volume of fruit (cc) : Spray of NAA enhanced the fruit volume of guava (cc) and data obtained were analyzed statistically. Significantly lesser fruit volume (93.81cc) was recorded under control (T_9) during the corresponding year of study. The maximum (140.67cc) fruit volume was obtained with NAA 200 ppm (T_2), which was followed by NAA 100 ppm + BA 20 ppm (T_8) respectively during the year of trial. All treatments varied significantly during the year of study. Garasiya *et al.* (2013) revealed that the application of NAA 40 ppm as well as NAA 20 ppm on winter season guava (*Psidium guajava* L.) cv. L–49 (Sardar) is most effective in increasing the fruit volume. Tiwari and Sharma (2015) observed that the foliar spray of NAA (100 ppm) is best to increase the fruit volume of guava fruit. Tiwari *et al*. (2017) reported that higher concentration of NAA 20 ppm significantly increases fruit volume.

Seed weight (g) : Spray of NAA reduces the seed weight of guava (g) and data obtained were analyzed statistically. Significantly maximum seed weight (6.52g) was recorded under control (T_9) during the corresponding year of study. The minimum of (5.24g) seed weight was obtained with NAA 200 ppm which was followed by NAA 100 ppm + BA 20 ppm (T_8) respectively during the year of trial. All treatments varied significantly during the year of study. This reduction in seed weight with NAA applications might be due to reduction in number of healthy seeds especially at higher NAA concentrations. The outcomes of the current investigations are in line with the results obtained by Monselise and Lewin (1976), who reported a reduced number of healthy seeds with NAA application. Similarly, Agnihotri *et al*. (2013) had also reported minimum seed weight due to treatment with 300 ppm NAA. Singh *et al*. (2017) revealed that foliar application of NAA 200 ppm recorded minimum seed weight.

Pulp (%) : Spray of NAA enhanced the pulp (%) of guava and data obtained were analyzed statistically. Significantly lesser pulp (93.55%) was recorded under control (T_9) during the corresponding year of study. The maximum (96.62%) fruit pulp was obtained with NAA 200 ppm (T_2), which was followed by NAA 100 ppm + BA 20 ppm (T_8) respectively during the year of trial. All treatments varied significantly during the year of study. This increased Pulp weight with increased NAA concentration might be due to the fact that NAA mediated higher level of metabolites from the leaves towards fruits which resulted in heavier fruits than other treatments. Uniyal *et al*. (2015) concluded that NAA 20 ppm estimated highest pulp content. Tiwari *et al*. (2017) reported that higher concentration of NAA 20 ppm maximum pulp content was found. Jangid *et al.* (2018) revealed that maximum pulp content found by GA_3 @ 40 ppm + NAA @ 20 ppm.

Pulp: Seed ratio : Pulp content was divided by seed content to obtain the pulp: seed ratio. The data thus obtained were statistically analyzed. A significantly maximum (28.64) pulp: seed ratio of guava fruit was obtained when treated with NAA 200 ppm (T_2) closely followed by NAA 100 ppm + BA 20 ppm (T_8), which was found significantly effective over rest of treatments. Significantly lesser pulp: seed ratio (14.52) was recorded under control (T_9) during the corresponding year of study. Bhatt *et al.* (2017) concluded that the maximum pulp/ seed ratio was recorded under NAA (10 ppm) foliar application. Tiwari *et al*. (2017) reported that higher concentration of NAA 20 ppm significantly maximum pulp: stone ratio.

Fruit yield per tree (kg) : Spray of NAA enhanced the yield of guava fruit and data obtained were analyzed statistically. Significantly minimum fruit yield per tree (37.12kg) was recorded under control (T_9) during the corresponding year of study. The maximum (61.61kg) fruit yield per tree was obtained with NAA 200 ppm (T_2) which was followed by NAA 100 ppm + BA 20 ppm (T_8) respectively during the year of trial. All treatments varied significantly during the year of study. The role of

Table 1 : Effect of plant growth regulators on various physical and chemical characters of winter season guava (*Psidium guajava* L.) cv. L-49.

Symbol	Treatments	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Fruit volume (cc)	Seed weight (g)	Pulp (%)	Pulp: Seed ratio	Fruit yield (kg/tree)	Fruit yield (q/ha)	Specific gravity	TSS (⁰Brix)	Ascorbic acid (mg/100g of fruit)	Redu-cing sugars (%)	Non-reducin-g sugar (%)	Total sugars (%)
T_1	NAA 150 ppm	148.40	7.52	7.41	135.23	5.44	96.34	26.43	55.12	153.10	1.09	11.85	229.12	4.14	3.54	7.68
T_2	NAA 200 ppm	155.36	7.67	7.53	140.67	5.24	96.62	28.64	61.61	171.13	1.11	12.01	234.14	4.21	3.72	7.93
T_3	Benzyl adenine 15 ppm	123.33	6.83	6.72	114.19	6.19	94.97	18.92	45.98	127.71	1.08	10.64	220.89	3.51	3.09	6.60
T_4	Benzyl adenine 20 ppm	130.50	6.98	6.87	118.95	6.08	95.33	20.46	48.32	134.21	1.09	10.98	222.74	3.68	3.17	6.85
T_5	NAA (75 ppm) + BA (15 ppm)	134.56	7.14	7.04	122.60	5.96	95.56	21.56	49.31	136.96	1.09	11.14	224.41	3.84	3.24	7.08
T_6	NAA (75ppm) + BA (20 ppm)	138.32	7.28	7.14	125.99	5.65	95.91	23.49	51.63	143.41	1.09	11.42	225.61	3.98	3.32	7.30
T_7	NAA (100 ppm) + BA (15 ppm)	147.02	7.44	7.32	132.81	5.48	96.27	25.91	53.60	148.88	1.10	11.74	227.42	4.06	3.48	7.54
T_8	NAA (100 ppm) + BA (20ppm)	150.11	7.58	7.50	136.31	5.36	96.42	27.01	58.72	163.10	1.10	11.94	232.31	4.16	3.61	7.77
T_9	Control (Water spray)	101.21	6.12	6.35	93.81	6.52	93.55	14.52	37.12	103.10	1.07	9.96	201.59	3.12	2.96	6.08
SE(m) ±		2.13	0.05	0.51	2.84	0.15	0.11	0.65	0.56	1.56	0.01	0.15	1.72	0.04	0.19	0.19
C.D. at 5%		6.38	0.14	NS	8.50	0.45	0.33	1.95	1.68	4.66	NS	0.45	5.16	0.11	N S	0.57

NAA in cell division and cell elongation improved length, breadth and weight of guava fruit which ultimately increased yield of guava fruit. The application of NAA induced cell elongation by enlargement of vacuoles and loosening of cell wall, which caused increase in fruit weight, fruit number and yield (Dikshit and Agrawal, 2008) and is being confirmed by the findings of Yadav *et al*. (2001) in guava fruits. Iqbal *et al.* (2009) reported that 45 ppm NAA spray increased yield in guava fruits.

Specific gravity (g/cc) : The data derived for the specific gravity of guava fruit were subjected to statistical analysis. The treatment NAA 200ppm was showed non-significantly effect on maximized specific gravity (1.11g/cc) closely followed by NAA 100ppm + BA 20ppm (T_8) which was found non-significantly effective over rest of treatments. Non-Significantly lesser specific gravity (1.07g / cc) was recorded under control (T_9) during the corresponding year of study. The decrease in specific gravity of fruits during ripening might be due to conversion of insoluble starch into soluble sugars. Thus, pre-harvest application of plant growth hormones reduced the weight loss and respiration losses, which were helpful in maintaining higher value of specific gravity (Kale and Godge, 1991). Singh *et al*. (2017) revealed that foliar application of NAA 200 ppm recorded maximum specific gravity. Tiwari *et al*. (2017) reported that higher concentration of NAA 20 ppm significantly increased specific gravity.

Chemical parameters

Total soluble solids (⁰Brix) : The TSS content of guava fruits was recorded under each treatment and data obtained were statistically analyzed. The NAA at 200 ppm (T_2) recorded significantly highest T.S.S.(12.01⁰Brix) content in guava fruits followed by NAA 100 ppm + BA 20 ppm (T_8). The control (T_9) treatment exhibited significantly lowest T.S.S. (9.96⁰Brix). The increase in T.S.S. might be due to the increase in mobilization of carbohydrates from the source to sink (fruits) by auxin which may be attributed to the fact that application of NAA might have increased α-amylase activity and thus there was a conversion of starch into sugars and hence improved total soluble solids content.Similarly, Rajput and Singh (1977) estimated a higher percentage of total soluble solids from the fruits treated with NAA over control. Yadav *et al.* concluded that TSS content of guava fruits can be improved with application of NAA. Sawale *et al.* found good quality fruits with respect to TSS after treatment with NAA.

Ascorbic acid (mg/100g pulp) : Guava fruits at the ripe stage were estimated for their ascorbic acid content under all the treatments during the year of experimentation. The data obtained were subjected to statistical analysis. The application of 200 ppm NAA (T_2) showed significantly maximized vitamin-C content (234.14 mg/100g) in guava fruits followed by NAA 100 ppm + BA 20 ppm (T_8) during the year of investigation. Control (T_9) exhibited 201.59 mg/100g vitamin-C content being significantly minimum during the year of experimentation. The increase in ascorbic acid content may have resulted owing to enhanced synthesis of ascorbic acid due to favorable metabolic activity involving certain enzymes and metallic ions under the influence of plant growth regulators like NAA. An increase in ascorbic acid content might be due to the perpetual synthesis of glucose-6-phosphate throughout the growth and development of the fruits which is thought to be the precursor of vitamin C. The result of the present investigation is in agreement with the findings of Jain and Dashora (2011) reported maximum ascorbic acid (205.18 mg/100g pulp) due to application of 200 ppm NAA treatment. This result is in accordance with the result obtained by Garasiya *et al.* (2013) in guava fruits.

Reducing sugars (%) : The data obtained were subjected to statistical analysis. NAA 200 ppm (T_2) proved most effective and significantly maximized reducing sugar content of guava (4.21%) followed by NAA 100 ppm + BA 20 ppm (T_8) whereas, the control (T_9) revealed significantly minimum (3.12%) reducing sugar content during corresponding year of study. Higher quantity of soluble carbohydrates in the cell sap and higher glucose concentration in fruits treated with NAA was due to marked increase in carbon assimilation, thereby favoring better electrolytic composition. Kassem *et al.* (2010) and Chaudhary *et al.* (1990) revealed that reducing sugar content significantly increased with foliar application of NAA, which confirms the findings of present investigation and is in agreement with the results obtained by Garasiya *et al.* (2013) in guava fruit.

Non-reducing sugar (%) : The non-reducing sugar percent of guava fruits was estimated during the year of experimentation. The data thus obtained were subjected to statistical analysis. The treatment NAA 200 ppm (T_2) recorded the highest non-reducing sugar content in fruits (3.72%) followed by NAA 100 ppm + BA 20 ppm (T_8) and whereas, control (T_9) exhibited the least non-reducing sugar content *i.e.*, 2.96% respectively during the corresponding year of study. Higher quantity of soluble carbohydrates in the cell sap and higher glucose concentration in fruits treated with NAA was due to marked increase in carbon assimilation, thereby favoring better electrolytic composition. The result of the present investigation is in agreement with the findings of Dodiya *et al.* (2018), Sharma and Tiwari (2015), Abbas *et al.* (2014), Iqbal *et al.* (2009), Singh and Bal (2006), Dubey *et al.* (2002) and Yadav *et al.* (2001) in guava, Sharma *et al.* (2005) in litchi, Dhakad *et al.* (2020) in mulberry and Yadav *et al.* (2010), Kumar *et al.* (2017) in aonla.

Total sugars (%) : Foliar spray of NAA greatly influenced total sugars (%) in guava fruits thus, the data derived were subjected to statistical analysis. The NAA 200 ppm concentration significantly maximized (7.93%) total sugars (%) followed by NAA 100 ppm + BA 20 ppm (T_8) and significantly lowest (6.08%) total sugars (%) were noted under control (T_9) during the year of trial. This increase in total sugars with the application NAA might be due to the fact that NAA is helpful in the process of photosynthesis, which leads to the accumulations of oligosaccharides and polysaccharides in higher amounts besides this also regulates the enzymatic activity and the enzymes that metabolize the carbohydrates into simple sugars. The result of the present investigation is in agreement with the findings of Dodiya *et al.* (2018), Sharma and Tiwari (2015), Abbas *et al.* (2014), Iqbal *et al.* (2009), Singh and Bal (2006), Dubey *et al.* (2002) and Yadav *et al.* (2001) in guava, Sharma *et al.* (2005) in litchi, Dhakad *et al.* (2020) in mulberry and Yadav *et al.* (2010), Kumar *et al.* (2017) in aonla.

Benefit cost ratio

Foliar spray of NAA greatly influenced the benefit: cost ratio in guava fruits thus, the NAA 200 ppm concentration significantly maximized (3.77:1) benefit: cost ratio followed by NAA 100 ppm + BA 20 ppm (T_8) and lowest (1.94:1) benefit: cost ratio was noted under control (T_9) during the year of trial. This increased benefit: cost ratio with increased NAA concentration might be due to the fact that NAA mediated higher level of metabolites from the leaves towards fruits which resulted in heavier fruits than other treatments and higher yield.

Table 2 : Effect of plant growth regulators on benefit: cost ratio of winter season guava (*Psidium guajava* L.) cv. L-49.

Treatments	Yield (q/ha)	Gross income (Rs.)	Cost of production (Rs.)	Net Income (Rs.)	Benefit: cost ratio
T_1: Naphthalene Acetic Acid 150 ppm	153.10	137790	32080	105710	3.29:1
T_2: Naphthalene Acetic Acid 200 ppm	171.13	154017	32252	121765	3.77:1
T_3: Benzyl adenine 15 ppm	127.71	114417	31622	82795	2.61:1
T_4: Benzyl adenine 20 ppm	134.21	120789	31643	89146	2.81:1
T_5: NAA (75 ppm) + BA (15 ppm)	136.96	123264	31883	91381	2.86:1
T_6: NAA (75 ppm) + BA (20 ppm)	143.41	129069	31903	97166	3.04:1
T_7: NAA (100 ppm) + BA (15 ppm)	148.88	133992	31969	102023	3.19:1
T_8: NAA (100 ppm) + BA (20ppm)	163.10	146790	31989	114801	3.58:1
T_9: Control (Water spray)	103.10	92790	31560	61230	1.94:1

Vani NU *et al*. (2021) revealed that Maximum B:C ratio (5.07) was recorded in NAA@200ppm. Agnihotri *et al*. (2016) reported that Maximum B: C ratio (2.81:1) was recorded maximum in NAA @ 1000 ppm.

Conclusion

It is clearly evident from the above-mentioned results that foliar spray of NAA 200ppm (T_2) improved various physical characters and yield of guava fruit *viz.,* fruit weight, fruit length, fruit width, fruit volume, pulp percent, pulp: seed ratio, fruit yield (kg tree^{-1}), fruit yield (qha^{-1}), specific gravity, together with maximum benefit cost ratio. However, it also recorded minimum seed weight under NAA 200 ppm (T_2) application. Various fruit quality parameters such as: ascorbic acid, TSS (^{0}brix), sugars were also improved with the foliar application of NAA 200 ppm (T_2). Based on these results, it could be recommended to guava growers in Eastern Uttar Pradesh.

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