International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 858-862

Received: 04-05-2019
Accepted: 06-06-2019

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Effect of pruning and plant growth regulators on fruit quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda

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Abstract
A field experiment was conducted at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during the years 2015-16 & 2016-17 with a view to study the "Effect of Pruning and Plant Growth Regulators on Fruit Yield and quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda". The results pertaining to fruit yield and quality parameters with respect to pruning, significantly maximum shelf life (8.51, 8.57 and 8.54 days), the highest TSS (11.43, 11.46 and 11.44 ^{0}Brix), total sugar (7.78, 7.84 and 7.81 %), reducing sugar (5.13, 5.18 and 5.16 %), non-reducing sugar (2.52, 2.53 and 2.52 %), vitamin C content (179.79, 180.28 and 180.04 mg/100 g pulp) and minimum physiological weight loss (9.87, 9.17 and 9.52 %), the lowest acidity (0.75, 0.77 and 0.76 %) were recorded under 25 % shoot pruning during the years 2015-16, 2016-17 and in pooled analysis, respectively. In different plant growth regulator treatments maximum shelf life (8.64, 8.80 and 8.72 days), minimum physiological weight loss (9.19, 8.94 and 9.06 %), TSS (11.71, 11.72 and 11.74 ^{0}Brix), total sugars (8.06, 8.11 and 8.09 %), reducing sugar (5.25, 5.30 and 5.27%), non-reducing sugar (2.67, 2.68 and 2.67 %), minimum acidity (0.74, 0.76 and 0.75 %), vitamin C (181.54, 181.64 and 181.59 mg/100 g pulp) were recorded with GA_3 150 mg/l during the years 2015-16, 2016-17 and in pooled analysis, respectively.

Keywords: Guava (*Psidium guajava* L.), pruning, GA_3, NAA, fruit, quality

Introduction
Guava (*Psidium guajava* L.) is one of most important fruit crops of the tropics and sub-tropics parts of the world. It belongs to the family 'Myrtaceae'. Guava is often referred as the 'Apple of tropics' for its nutritive value. The fruit is rich in vitamin C. It is also rich in pectin, fiber and different minerals viz., calcium, phosphorus and iron. Apart from vitamin and minerals, it contains high level of powerful antioxidant polyphenols which protect our body from oxidative stress. *Mrig bahar* is considered as best fruiting season because of lower infestation of fruit fly and good quality fruits. In order to avoid heavy crop load during rainy season, chemicals and cultural means are important tools for crop regulation to get quantum and quality yield (Singh., 2001) [16]. Pruning is one of the most effective strategies for the improvement in fruit quality. Beneficial effects of pruning on fruit quality of guava have been reported by various workers (Jadhav *et al*., 2002, Dhaliwal and Kaur, 2003 and Dhaliwal and Singh., 2004) [7, 4, 5]. Considering all the above facts and with a view to have better quality of fruits, it was decided to carried out the experiment on 'Effect of Pruning and Plant Growth Regulators on Fruit quality of Guava (*Psidium guajava* L.) cv. 'Allahabad Safeda' for research.

Materials and Methods
A field experiment was carried out during two successive seasons 2015-16 & 2016-17 on 10 years old guava (*Psidium guajava* L.) trees planted at 6x6 meters surface irrigation and subjected to the same agriculture practices at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The soil of the experimental site was sandy loam, locally known as "Goradu". For this experiment 54 (18 x 3) plants of guava var. Allahabad Safeda were uniformly selected considering their age and canopy. Treatments were repeated for three times on the 54 selected plants. The experiment comprised of eighteen treatment combinations involving three levels of pruning at 0 *i.e.* Control (unpruned plants), 25, 50% and their combinations with plant growth regulators

viz.; GA_3 (100 and 150 mg l^{-1}), NAA (150 and 200 mg l^{-1}) and control (water spray and absolute control) were embedded in Complete Randomized Design (Factorial) with three repetitions. The guava plants were pruned in last week of May during the years 2015-16 and 2016-17. As per total shoot length 25% and 50 % shots were pruned. Immediately after pruning, the cut ends were pasted with bordeaux paste to prevent the fungal and bacterial infection. First foliar spray of plant growth regulators treatments was done at the time of flowering and second was applied after three weeks of first spray on guava plants as per the treatments. Observations were recorded on the basis of five secondary branches selected per plant. Uniform and healthy five secondary branches were randomly selected in each direction and tagged on each plant of guava. On each selected secondary branch five shoots were tagged. Data for individual year were analyzed in order to study the average effect of different treatments over the years, the pooled analysis was also carried out as suggested by Gomez and Gomez (1996) [6]. Treatment means of all characters for individual as well as pooled analysis were compared by means of critical differences at 5% level of significance after employing "F" test.

Results and Discussion

Effect of different levels of pruning and plant growth regulators on fruit quality viz., shelf life of fruit after harvest, physiological weight loss, total soluble solids, reducing sugar, non-reducing sugar, total sugar, acidity and vitamin C content were found significant.

The data pertaining to the shelf life as influenced due to different levels of pruning and plant growth regulators treatments are presented in Table 1.It is observed from the Table 1 that there was significant difference among the treatments with regards to shelf life. During the years 2015-16, 2016-17 and in pooled analysis maximum shelf life (8.51, 8.57 and 8.54 days) was recorded by the P_2 (25 % shoot pruning) as compared to P_3 (50 % shoot pruning) *i.e.* 7.64, 7.74 and 7.69 days and P_1 (Unpruned) *i.e.* 7.08, 7.10 and 7.09 days respectively during both the respective years and in pooled. It might be due to the fact that shoot pruning increase the photosynthesis activity due to more vegetative growth after pruning and induce the level of photosynthates in plant which improves the overall fruit quality and thereby induces shelf life of fruit after harvest. The shelf life was significantly influenced with the application of different plant growth regulators treatments (Table 1). In the first year of experimentation, maximum shelf life (8.64 days) was recorded with the treatment of GA_3 150 mg/l as compared to rest of treatments except GA_3 100 mg/l 8.49 days and NAA 200 mg/l 8.28 days. While, in the second year and in pooled analysis. The maximum shelf life (8.80 and 8.72 days) was recorded with the same treatment *i.e.* S_2 (GA_3 150 mg/l) as compared to rest of treatments except S_1 (GA_3 100 mg/l) *i.e.* 8.53 and 8.51 days, respectively. The minimum shelf life (6.43, 6.46 and 6.44 days respectively) was observed under absolute control (S_6) which was found at par with water spray treatment (S_5) *i.e.* 6.45, 6.50 and 6.48, respectively during the years 2015-16, 2016-17 and in pooled data. The increase in shelf life might be due to antagonistic effect of gibberellic acid which inhibit ethylene production and delayed the conversion of starch to sugar. It helps in structural integrity of both the cell wall and plasma membrane thus delaying ripening and extending shelf life. The results are also supported by the findings of Yadav and Shukla (2009) [17] in aonla.

Table 1: Effect of different levels of pruning and plant growth regulators on fruit quality parameters

Treatments	Shelf life of fruit (Days)	Physiological Loss in Weight (%)	Total soluble solids (^{0}Brix)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)	Acidity (%)	Vitamin C content (mg/100 g pulp)
2015-16								
P_1	7.08	14.35	10.73	6.91	4.65	2.09	0.80	173.66
P_2	8.51	9.87	11.43	7.78	5.13	2.52	0.75	179.79
P_3	7.64	11.48	11.08	7.31	4.86	2.33	0.78	176.57
S.Em.±	0.11	0.56	0.10	0.07	0.06	0.03	0.01	1.33
CD at 5 %	0.32	1.59	0.28	0.21	0.18	0.09	0.02	3.81
S_1	8.49	9.60	11.48	7.83	5.13	2.57	0.75	180.26
S_2	8.64	9.19	11.71	8.06	5.25	2.67	0.74	181.54
S_3	8.16	10.75	11.19	7.49	4.90	2.46	0.77	178.66
S_4	8.28	9.66	11.29	7.57	4.97	2.26	0.76	178.95
S_5	6.45	15.46	10.44	6.61	4.53	1.98	0.82	171.51
S_6	6.43	16.74	10.36	6.44	4.51	1.94	0.82	169.12
S. Em.±	0.157	0.79	0.14	0.10	0.09	0.04	0.01	1.88
CD at 5 %	0.45	2.25	0.39	0.29	0.26	0.12	0.03	5.39
CV %	6.07	19.82	3.71	4.16	5.60	5.51	4.09	3.19
P x S	Sig.	NS	NS	NS	NS	Sig.	NS	NS
2016-17								
P_1	7.10	14.16	10.64	6.97	4.74	2.12	0.83	173.72
P_2	8.57	9.17	11.46	7.84	5.18	2.53	0.77	180.28
P_3	7.74	12.03	11.01	7.37	4.90	2.34	0.81	177.15
S.Em.±	0.11	0.56	0.10	0.07	0.06	0.03	0.01	1.32
CD at 5 %	0.30	1.48	0.29	0.21	0.18	0.09	0.03	3.78
S_1	8.53	9.37	11.55	7.88	5.21	2.54	0.78	181.14
S_2	8.80	8.94	11.74	8.11	5.30	2.68	0.76	181.64
S_3	8.20	10.13	11.23	7.55	4.97	2.45	0.79	178.88
S_4	8.32	9.57	11.33	7.63	5.03	2.47	0.78	179.90
S_5	6.50	16.34	10.32	6.67	4.57	1.99	0.85	171.57
S_6	6.46	16.38	10.06	6.50	4.56	1.85	0.85	169.18
S. Em.±	0.150	0.73	0.14	0.10	0.09	0.04	0.01	1.86

CD at 5 %	0.43	2.10	0.41	0.29	0.26	0.12	0.04	5.34
CV %	5.78	18.62	3.93	4.13	5.53	5.59	5.42	3.16
P x S	Sig.	NS	NS	NS	NS	NS	NS	NS
POOLED								
P_1	14.26	14.26	10.68	6.94	4.69	2.10	0.82	173.69
P_2	9.52	9.52	11.44	7.81	5.16	2.52	0.76	180.04
P_3	11.75	11.75	11.04	7.34	4.88	2.34	0.79	176.86
S.Em.±	0.38	0.38	0.07	0.05	0.05	0.02	0.01	0.94
CD at 5 %	1.07	1.07	0.20	0.14	0.13	0.06	0.02	2.64
S_1	9.48	9.48	11.52	7.86	5.17	2.56	0.76	180.70
S_2	9.06	9.06	11.72	8.09	5.27	2.67	0.75	181.59
S_3	10.44	10.44	11.21	7.52	4.94	2.45	0.78	178.77
S_4	9.62	9.62	11.31	7.60	5.00	2.36	0.77	179.43
S_5	15.90	15.90	10.38	6.64	4.55	1.99	0.83	171.54
S_6	16.56	16.56	10.21	6.47	4.53	1.89	0.84	169.15
S. Em.±	0.54	0.54	0.10	0.07	0.06	0.03	0.01	1.32
CD at 5 %	1.51	1.51	0.28	0.20	0.18	0.09	0.03	3.73
CV %	19.23	19.23	3.82	4.15	5.57	5.55	4.82	3.17
P x S	Sig.	NS	NS	Sig.	NS	Sig.	NS	NS

The data with respect to physiological weight loss of fruit as affected by various levels of pruning and plant growth regulators treatments are presented in Table 1. An appraisal of data (Table 1) indicates that significantly minimum physiological weight loss (9.87,9.17 and 9.52 %) was recorded under 25 % shoot pruning (P_2) as compared to 50 % shoot pruning (P_3) *i.e.* 11.48, 12.03 and 11.75 % and control (P_1) *i.e.* 14.35, 14.16 and 14.26 % during 2015-16, 2016-17 and in pooled data, respectively. It was observed that the various plant growth regulators treatments exerted significant effect on physiological weight loss. Significantly minimum physiological weight loss (9.19, 8.94 and 9.06 %) was recorded under GA_3 150 mg/l (S_2) followed by 9.60, 9.37 and 9.48 % in GA_3 100 mg/l (S_1), 9.66, 9.57 and 9.62 % in NAA 200 mg/l (S_4), 10.75, 10.13 and 10.44 % in NAA 150 mg/l (S_3) over absolute control (S_6) *i.e.*16.74, 16.38 and 16.56 % during 2015-16, 2016-17 and in pooled analysis, respectively. The possible reason for reduced weight loss by growth regulators may be due to cause some biochemical changes within the fruits resulting in retention of more water against the rate of evaporation. Further, it may be possible due to the alteration of some proteinous constituents of the cell and thus increase in affinity towards water (Mitchell, 1949). Similar results were also reported by Singh *et al*. (2009) [13] and Bisen and Thakur (2012) [1] in guava.

The data regarding to TSS as affected by various levels of pruning and plant growth regulator treatments are presented in Table 1. Significantly the highest TSS (11.43, 11.46 and 11.44 ^{0}Brix) was observed under the 25 % shoot pruning as compared to 11.08, 11.01 and 11.04 % in 50 % shoot pruning and unpruned (P_1) (10.73, 10.64 and 10.68 ^{0}Brix) was noted during the years 2015-16, 2016-17 and in pooled analysis, respectively. Increased TSS content in pruned plants might be due to better absorption of nutrients by these plants and its action on converting complex substances into simple ones, which enhances the metabolic activity in fruits and it results in increased TSS of fruit. The present results on Total Soluble Solid (TSS) are in conformity with the results achieved by Pratibha and Lal (2012) [10] and Singh *et. al.* (2012) [15] in guava. During the year 2015-16, 2016-17 and in pooled data significantly maximum TSS (11.71, 11.74 and 11.72 ^{0}Brix) was observed under the treatment S_2 (GA_3 150 mg/l) which was found at par with S_1 (GA_3 100 mg/l) and the values being 11.48, 11.55 and 11.52 ^{0}Brix, respectively. While in the year 2016-17 treatment S_2 (GA_3 150 mg/l) was found at par with S_1 (GA_3 100 mg/l) *i.e* 11.55 ^{0}Brix and S_4 (NAA 200 mg/l) *i.e.* 11.33 ^{0}Brix.This significant response in improving TSS content of fruit might be due to the fact that gibberellic acid stimulated the functioning of number of enzymes involved in the physiological process which probably caused and increased in TSS content of fruit. Gibberellic acid at higher concentration augmented TSS content of the fruit. This has been reported to divert more solids towards developing fruits and might also enhance the conversion of complex polysaccharide into simple sugars. These results are in conformity with those of Sharma and Tiwari (2015) [12], Javed *et al.* (2016) and Lal and Das (2017) [9] in guava.

The total sugars content in guava fruit was significantly influenced by the pruning and PGRs treatments. The results are presented in Table 1. The highest total sugars (7.78, 7.84 and 7.81 %) was recorded under 25 % shoot pruning (P_2) as compared to 50 % shoot pruning (7.31, 7.37 and 7.34 %) and in unpruned treatment, respectively in the years 2015-16, 2016-17 and in pooled data. While significantly the lowest total sugars (6.91, 6.97 and 6.94 %) was recorded under unpruned (P_1) during both the years and in pooled, respectively. This is due to its action on converting complex substances into simple ones, which enhances the metabolic activity in fruits and it results in increased total sugars of fruit. The result of the present study is in conformity with the results achieved by Brar *et al*. (2007) [3] and Singh and Bal (2007) [14] in guava.

It can be seen from Table 1 that total sugars was increased with the application of different levels of plant growth regulators. In first and second year significantly maximum total sugars (8.06 and 8.11 %) was recorded by the S_2 (GA_3 150 mg/l). It was at par with S_1 i.e. GA_3 100 mg/l (7.83 and 7.88 %). Whereas, in pooled analysis the highest total sugars 8.09 % was also recorded in same treatment i.e. GA_3 150 mg/l. During both the years and in pooled data significantly minimum total sugars (6.44, 6.50 and 6.47 %) was recorded in the absolute control.

The reason for increased sugar content in gibberellic acid treatment might be due the increased the activity of the hydrolytic enzyme which converted the complex polysaccharides into simple sugar. Plant growth regulators also increase translocation of photosynthetic metabolites from other parts of the plant towards to developing fruits. These findings are in conformity with those reported by Sharma and Tiwari (2015) [12] and Lal and Das (2017) [9] in guava.

The data pertaining to reducing sugar (%) as affected by various levels of pruning and plant growth regulator

treatments are presented in Table 1. It is seen from the Table 1 that there were significant differences among the different levels of pruning treatments. During the years 2015-16, 2016-17 and in pooled analysis significantly the highest reducing sugar (5.13, 5.18 and 5.16 %) was recorded under P_2 *i.e.* 25 % shoot pruning as compared to P_3 *i.e.*50 % shoot pruning (4.86, 4.90 and 4.88 %) and unpruned (P_1) (4.65, 4.74 and 4.69 %), respectively. Significantly maximum reducing sugar (5.25, 5.30 and 5.27%), respectively was recorded under S_2 (GA_3 150 mg/l) which was at par with S_1 (5.13, 5.21 and 5.17 %, respectively) in the years 2015-16, 2016-17 and in pooled analysis. While the minimum reducing sugar (4.51, 4.56 and 4.53 %, respectively) observed in absolute control. The reason for increase in the reducing sugar content might be due to delayed ripening of fruit and fruits remained on tree for long period during which they accumulated more carbohydrates within them. Increase in sugar content may be due to the higher concentration of gibberellic acid which promotes hydrolysis of starch into sugar. These results are in conformity with the findings Sharma and Tiwari (2015) [12] in guava.

The data pertaining to non-reducing sugar as influenced by various pruning and plant growth regulators treatments are presented in Table 1. The data (Table 1) showed that the non-reducing sugar was significantly affected during both the years as well as in pooled analysis. Significantly the highest non-reducing sugar (2.52, 2.53 and 2.52 %) was recorded with P_2 levels *i.e.* 25 % shoot pruning as compared to P_3 *i.e.* 50 % shoot pruning (2.33, 2.34 and 2.34 %) and control P_1 *i.e.* unpruned plants (2.09, 2.12 and 2.10) in both the years and in pooled data, respectively. Similar results were also reported Brar *et al*. (2007) [3] and Singh *et al*. (2007) [14] in guava. Significantly maximum non-reducing sugar (2.67, 2.68 and 2.2.67 %) was recorded with S_2 (GA_3 150 mg/l) as compared to rest of the treatments during the years 2015-16, 2016-17 and in pooled data while, in the year 2015-16 GA_3 100 mg/l (2.57 %) was found at par with GA_3 150 mg/l. Significantly minimum non-reducing sugar (1.94, 1.85 and 1.89 %) was recorded in absolute control (S_6) in the respective years 2015-16, 2016-17 and in pooled analysis. Increase in sugar content may be due to the higher concentration of gibberellic acid which promotes hydrolysis of starch into sugar. Also, efficient translocation of photosynthates to the fruits by regulation of gibberellic acid. The reason for increase in the content of non-reducing sugar might also be due to delayed ripening of fruit and provided a long period of fruits to remain on tree, during which they accumulated more carbohydrates within them. These results are in conformity with the findings of Bisen *et al.* (2014) [2] in guava.

Data regarding acidity of guava fruit as influenced under various treatments was recorded and presented in Table 1. It is evident from the data furnished in Table 1 that during the years 2015-16, 2016-17 and in pooled significantly the lowest acidity (0.75, 0.77 and 0.76 %) was recorded under P_2 *i.e.* 25 % shoot pruning as compared to P_3 *i.e.* 50 % shoot pruning (0.78, 0.81 and 0.79 %) and in control *i.e.*unpruned plants (0.80, 0.83 and 0.82 %). The decrease in acidity may be due to lower rate of reduction of starch to sugars. These results are in close conformity to those of Brar *et al*. (2007) [3] and Sharma *et al.* (2013) [11] in guava. Significantly minimum acidity (0.74, 0.76 and 0.75 %, respectively) was recorded by S_2 *i.e.* GA_3 150 mg/l. It was found at par with S_1 (0.75, 0.78 and 0.76 %), S_4 (0.76, 0.78 and 0.77 and S_3 (0.77, 0.79 and 0.78 %) in the years 2015-16, 2016-17 as well as in pooled analysis. The reason for reduction in acidity by plant growth regulator treatments may be due to rapid utilization of organic acid during respiration at maturity. It appears that acid under the influence of higher concentration of plant growth regulators might have either fast been converted into sugar and their derivatives by reactions involving reverse glycolytic pathways or might have been used in respiration or both. These results are in accordance with the findings of Javed *et al.* (2016) and Lal and Das (2017) [9] in guava.

The data on vitamin C as influenced by various levels of pruning and plant growth regulators are furnished in Table 1. It is observed from the data presented in Table 1 that there was a significant difference among the different pruning levels. In first and second year significantly the maximum vitamin C (179.79 and 180.28 mg/100 g pulp, respectively) was recorded with the P_2 *i.e.* 25 % shoot pruning, however it was at par with P_3 i.e. 50 % shoot pruning (176.57 and 177.15 mg/100 g pulp), respectively. While in the pooled data significantly the highest vitamin C content (180.04 mg/100 g pulp) was noted under the same treatment P_2 i.e. 25 % shoot pruning as compared to 50% shoot pruning (P_3) and unpruned (P_1). During both the years and in pooled data significantly minimum vitamin C content (173.66, 173.72 and 173.69 mg/100 g pulp, respectively) was observed under control *i.e.* unpruned plants. During the years 2015-16, 2016-17 and in pooled data significantly maximum vitamin C (181.54, 181.64 and 181.59 mg/100 g pulp, respectively) was recorded in the treatment GA_3 150 mg/l. It was found at par with the treatments *i.e.* S_1 (180.26, 181.14 and 180.70 mg/100 g pulp, respectively), S_4 (178.95, 179.90 and 179.43 mg/100 g pulp, respectively) and S_3 (178.66, 178.88 and 178.77 mg/100 g pulp, respectively) except both the controls i.e. S_5 (171.51, 171.57 and 171.54 mg/100 g pulp, respectively) and S_6 (169.12, 169.18 and 169.15 mg/100 g pulp, respectively). The reason for increase in ascorbic acid of fruit by gibberellic acid treatment might be due to perpetual synthesis of glucose-6-phosphate throughout the growth and development of fruit which is thought to be the precursor of vitamin-C. The possible catalytic influence of gibbrellic acid on biosynthesis of ascorbic acid from sugar or inhibition of oxidative enzymes or both. Similar trend was also observed by Sharma and Tiwari (2015) [12] and Lal and Das (2017) [9] in guava.

Conclusion

On the basis of two years investigation, it can be concluded that for getting higher yield the guava shoots should be pruned at 25 % level in the last week of May and plants sprayed with NAA 200 mg per litre at the time of flower initiation and second spray given after three weeks of first spray for *Mrig bahar* crop.

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