International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 598-601

Received: 27-03-2018
Accepted: 28-04-2018

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Short Communication Paper

Effect of pre-harvest spray of plant growth regulators and nutrients on post-harvest quality of guava (*Psidium guajava* L.)

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Abstract
A field experiment to study the effect of pre-harvest application of plant growth regulators and nutrients namely giberellic acid, naphthalene acetic acid, calcium nitrate and zinc sulphate on post-harvest quality of guava was conducted at Fruit Orchard, College of Agriculture, RVSKVV, Gwalior (M.P.) during the year of 2015-16 and . The experiment was laid out with thirteen treatments replicated three times in a Randomized Block Design. Results revealed that guava fruits treated with 0.6% zinc sulphate increased the post-harvest quality of guava fruits on 9th days over control and proved superior to maintain the considerable physico-chemical composition (TSS, acidity, TSS/ acid ratio, reducing sugar, non-reducing sugar, ascorbic acid content and pectin content) of guava fruits as compared to control and different doses of other chemicals. Spray of other chemicals spray proved inferior to zinc sulphate and superior to control with respect to physic-chemical composition of fruits. The lower values of physico-chemical composition of guava fruit were recorded in control

Keywords: Pre-harvest application, growth regulators, nutrients, quality, guava

Introduction

Guava (*Psidium guajava* L.) the apple of the tropics, is one of the most popular fruit grown in tropical, sub-tropical and some parts of arid regions of India, that belongs to the family Myrtaceae. Guava is one of the choicest fruits due to its delicacy and nutritive value. It exceeds most other fruits in productivity and is highly remunerative. The fruit is an excellent source of vitamin C containing 2-5 times more than oranges and 10 times more than tomatoes. Under agro climatic conditions of Madhya Pradesh, guava bears two crops in a year. Winter season crop, though good in quality needs prolong stroreability. However, large quantity of fruit is lost after harvest due to inherent bio-chemical changes. Chemicals like plant growth regulators (GA_3 and NAA) and nutrients (calcium nitrate and zinc sulphate) has various effects on guava fruits with respect to its growth, yield, and Quality like TSS, sugar, acidity, ascorbic acid also on shelf life. Plant growth regulators like auxins and gibberellins are being used for improving the fruit quality, delaying deterioration in storage and increasing the shelf life (Tandon *et al*., 1989) [24]. By the application of NAA, T.S.S. and Ascorbic- acid content of fruits are increased and acidity is reduced. Calcium has been shown to affect a wide range of physiological processes in plants and fruits (Wvn-Jones and Lunt, 1967) [26] and to inhibit specific aspects of abnormal senescence in numerous fruits. Calcium compounds extend the shelf-life of fruits by maintaining firmness, minimizing rate of respiration, protein breakdown, disintegration of tissues and disease incidence (Bangerth *et al.*, 1972) [2]. Zinc is an essential trace element for plants, being involved in many enzymatic reactions and is necessary for their good growth and development. Zinc is also involved in regulating the protein and carbohydrate metabolism **(**Patel and Tiwari, 2014) [20]. Hence, keeping this in view present investigation was conducted to find out the effect of pre-harvest spray of plant growth regulators and nutrients individual on growth, yield and post-harvest behavior of guava fruits.

Materials and method

The experiment was conducted to see the effect of pre harvest application different doses of chemicals on shelf life of guava fruits on twelve year old guava plants cv. G-27. The present investigations were conducted at Pomology orchard, College of Agriculture, RVSKVV, Gwalior (M.P.) during the year 2015-16. The experiment was laid out in randomized block design (RBD) with three replications. The treatments were imposed on guava fruit plants by pre-harvest spray of water (control), 30, 60 and 90 ppm of giberellic acid, 30, 60 & 90 ppm of naphthalene acetic acid 1.0, 1.5 and 2.0% of calcium nitrate solution and 0.3, 0.6 and 0.9% of zinc sulphate, aqueous solution during November, 2015. Two sprays were done at 15 days interval before harvesting. The ten fresh, good looking, fully mature and uniform fruits of guava cv. G-27 were taken for each treatment in each replication. The physico-chemical composition values of guava fruits were taken on 0, 3, 6 and 9 days of storage. The TSS of fruits was measured with the help of Hand Refractometer of 0-320 ºBrix range. The acidity content was determined as per AOAC (1970) [1]. The sugar in fruit juice estimated by the method suggested by Nelson (1944) [18]. Assay method was followed given by Ranganna (1977) [21] for determining the ascorbic acid. Observations were recorded and statistically analyzed as per the methods given by Panse and Sukhatme (1984) [19]. The details of the treatment of experiment are given in tables.

Results and discussion

Total Soluble Solids (TSS%): The data presented in table (4.20) revealed that there was increase in total soluble solids content up to 3rd day of storage in all the treatments including control and thereafter significant variation seen in treated and untreated fruits. Among treatments T_{11} ($ZnSO_4$ @ 0.6%) recorded maximum TSS content of (9.95 ºBrix) up to 9thday, whereas minimum (7.93 ºBrix) under control at the end of storage. The increase of TSS during storage upto 3rd day of storage in all the treatments including control may be due to the breakdown of complex polymers into simple substances by hydrolytic enzymes, that may have further metabolized during respiration and level got decreases during subsequent storage, the more retention of TSS during storage might be due to decrease in physiological loss in weight and decay loss which resulted into slow degradation of soluble contents of the fruits. Similar improvement and retention of TSS has also been reported in guava with zinc sulphate by Wali and Kumar (2006) [25], Singh *et al.* (2007) [23], Goswami *et al.* (2012) [13], Patel and Tiwari, (2014) [20], Bisen *et al*. (2014) [6] and also in mango with zinc sulphate by Bhowmick *et al.* (2011 and 2012) [7, 8] and Chouhan *et al.* (2015) [10].

Acidity: It is clear from table (1), that in some treatments the acidity initially increased on 3rd day storage. The initial increase might be due to the start of anaerobic respiration, thereafter the decrease in acidity during storage could be attributed to the conversion of acids into salt and sugars by the enzymes particularly invertase. Since the juice became concentrated (loss of moisture during storage), the increase in per cent acidity was obvious. The minimum (0.24%) acidity during storage was observed in fruits treated with T_{11} ($ZnSO_4$ @ 0.6%) followed by T_{10} (Calcium nitrate @ 2.0%) against the maximum (0.39%) under control. The decrease in acidity with zinc sulphate has also been reported in guava by Wali and Kumar (2006) [25], Singh *et al.,* (2007) [23], Goswami *et al.,* (2012) [13], Patel and Tiwari. (2014) [20], Bisen *et al*., (2014) [6] and also reported in mango by Bhowmick *et al.,* (2012) [8].

TSS/acid ratio: Data on TSS/acid ratio are presented in Table (1). During storage TSS/acid ratio recorded a continuous increase with the advancement of storage period. The increasing trend may have been resulted due to much decrease in acid content and less decrease in TSS content of fruits during storage. The maximum mean value of average TSS/acid ratio during 9th days of storage was recorded with zinc sulphate @ 0.6% (40.92) followed by 0.3% zinc sulphate (39.62) and 2.0% calcium nitrate (36.74), while the minimum (20.50) TSS/acid ratio was recorded under the control. This also coincided with the high TSS content as well as low acid contents recorded in these two treatments during storage. Similar findings was also reported by Patel and Tiwari, (2014) [20],

Sugar (%): The data on total sugar, reducing sugar and non-reducing sugar are presented in table (2). Total sugar, reducing sugar and non-reducing sugar increased up to 3rd days of storage at room temperature followed by decreasing trend. The total sugar contents in fruits were found to be increased by all treatments over the control. The maximum mean value of total sugar retention (%) on 9th day of storage (7.10) with 0.6% zinc sulphate followed by (6.80%) 0.3% zinc sulphate and (6.74%) with 2.0% calcium nitrate, whereas the minimum (5.55) was recorded under the control. The similar finding were also observed by Singh *et al.* (2004) [22] and Patel and Tiwari (2014) [20] who also reported that pre-harvest spray of zinc sulphate enhanced the total sugar retained on 9th day of storage. The increase in total sugars can be attributed to the accumulation of oligosaccharides and polysaccharides in higher amount in almost all treatments Goswami *et al.* (2014) [12]. It was reported that these micronutrients in association with growth retardant might have increased the activity of hydrolyzing enzyme, which converted complex polysaccharides into simple sugars (Brahmachari and Rani, 2001) [4]. The maximum mean value of reducing sugar retention (%) on 9th day of storage (3.59%) with 0.6% zinc sulphate followed by (3.44%) 0.3% zinc sulphate and (3.41%) with 2.0% calcium nitrate, whereas the minimum (2.64) was recorded under the control. The initial increase may be due to the conversion of starch into simple sugars and decrease later on could possibly be due to utilization of these sugars in respiration during storage. The increase in reducing sugar might be due to increased rate of starch degradation by amylase activity (Hiwale and Singh, 2003) [14]. Conversation of starch and polysaccharides in to simple sugar with the advancement of storage was responsible for the increase of reducing sugar and onward decline was due to the utilization of sugar in evapo-transpiration and other biochemical activities (Kumar *et al.,* 2012) [16]. These results are in accordance with the findings of Hiwale and Singh (2003) [14]. Application of chemicals retained higher sugar content over control during storage. They might have reduced the rate of respiration and delayed the onset of senescence. In the present investigation fruits treated with T_{11} ($ZnSO_4$ @ 0.6%) recorded maximum average total sugar and reducing sugars. Similar results were also reported by Wali and Kumar (2006) [25], Singh *et al.,* (2007) [23] Goswami *et al.,* (2012) [13], Patel and Tiwari (2014) [20], Bisen *et al.,* (2014) [6] in guava and Bhatt *et al.* (1997) in cherry cv. Makhmali and Zinc sulphate were also reported in mango cv. Dashehari by Kumar and Kumar (1989) [15] and Bhowmick *et al.,* (2011 and 2012) [7, 8] in mango during storage.

Ascorbic acid content (mg/100g pulp): The results on the change in ascorbic acid content presented in table (3). All the treatments were significantly effective in increasing the ascorbic acid content of fruits as compare to control, revealed marked increase in ascorbic acid content upto first three days of storage and a significant decrease in all treatments was observed during later period of storage. However, treated fruits recorded higher amount of ascorbic acid during storage over the control fruits. The initial increase was perhaps due to the reason that during this period there was availability of fruit sugar which is the precursor of ascorbic acid synthesis and therefore synthesis of L-ascorbic acid from fruit sugar continued while the loss in ascorbic acid content of fruits during prolonged storage was mainly due to the activation of enzymes like ascorbic acid oxidase, peroxidase and catalase which oxidized L-ascorbic acid into dehydro ascorbic acid. During storage maximum average ascorbic acid content on 9th day of storage 183.31-mg/100 g pulp was recorded with T_{11} (0.6% Zinc sulphate), followed by 177.17 mg with T_{10} (0.3% Zinc sulphate) and 175.24 with T_9 (2.0% Calcium nitrate). Similar results have been obtained in guava by Goswami *et al.* (2012) [13]. Higher ascorbic acid content in these treatments might have been due to the inhibitive influence of these chemicals on the oxidative enzymes and hence the rate of degradation of L-ascorbic acid was slowed down. Pre-harvest spray of zinc sulphate enhanced the ascorbic acid content in fruits of guava (Mansour and Sied, 1985; El-Sherif *et al.*, 2000). The application of growth regulators (GA_3 & NAA) and nutrients (Zinc sulphate and Calcium nitrate) may have favorably influenced the metabolic activities possibly due to their increased endogenous level following external application. These may have enhanced the process of synthesis, translocation and accumulation of quality constituents like TSS, sugars and ascorbic acid following strong source sink relationship. Metallic ions in the present study may have further helped in the synthesis of ascorbic acid content in the fruits of guava. The application of mineral nutrients has favourably influenced the metabolic activities possibly due to their increased endogenous level following external application. These may have enhanced the process of synthesis, translocation and accumulation of quality constituents like TSS, sugars and ascorbic acid following strong source sink relationship (Goswami *et al*., 2014) [12].

Pectin content (%): The data on pectin content presented in table (3). All the treatments significantly increased pectin content up to 3rd days of storage at room temperature thereafter significantly decrease up to 9th days of storage. Maximum pectin per cent (0.70%) was observed with zinc sulphate (0.6%), whereas the minimum (0.36%) was recorded under the control. The fruit firmness is closely related with pectin of guava fruit decreased progressively during the storage. The reduction in pectin content during the storage may be due to degradation of insoluble protopectin enzyme. These findings are also reported by Bhattacharya and Ghosh (1972) [3] in banana. Zinc sulphate (0.6%) maintains the firmness of fruits by retarding the breakdown of pectin during the storage. Higher retention of pectin it might be due to softness occurring in fresh fruits after maturity at the peak of ripening which is generally associated with fairly narrowing down of firmness. Pectin methyl esterase (PME) enzyme activity increased as ripening advanced in guava. These findings are in accordance with results of Chaitanya, 1984 in guava.

Table 1: Effect of pre-harvest spray of plant growth regulators and nutrients on TSS (%), acidity and TSS/ acid ratio of guava (*Psidium guajava* L.) during different storage period

Treatments	TSS (ºBrix) during different storage period				Acidity (%) during different storage period				TSS/ acid ratio during different storage period			
	0 Days	3 Days	6 Days	9 Days	0 Days	3 Days	6 Days	9 Days	0 Days	3 Days	6 Days	9 Days
T_0 Control	9.51	10.76	8.82	7.93	0.53	0.56	0.45	0.39	18.05	19.24	19.62	20.50
T_1 GA_3- 30 ppm	10.70	11.84	10.71	9.24	0.47	0.50	0.44	0.37	22.60	23.72	24.33	25.18
T_2 GA_3- 60 ppm	10.84	11.98	10.85	9.38	0.46	0.49	0.43	0.36	23.74	24.62	25.43	26.30
T_3 GA_3- 90 ppm	11.02	12.16	11.03	9.56	0.43	0.47	0.41	0.34	25.44	26.07	27.13	28.41
T_4 NAA-30 ppm	10.80	11.94	10.81	9.34	0.47	0.50	0.44	0.37	22.85	24.04	24.76	25.04
T_5 NAA-60 ppm	11.10	12.24	11.11	9.64	0.42	0.45	0.39	0.32	26.28	27.41	28.74	29.82
T_6 NAA-90 ppm	10.98	12.12	10.99	9.52	0.44	0.48	0.42	0.35	25.16	25.44	26.39	27.48
T_7 $Ca(NO_3)_2$- 1.0%	11.12	12.26	11.13	9.66	0.41	0.44	0.38	0.30	26.90	28.07	29.54	32.56
T_8 $Ca(NO_3)_2$- 1.5%	11.13	12.27	11.14	9.67	0.41	0.43	0.37	0.29	26.92	28.75	29.84	32.96
T_9 $Ca(NO_3)_2$- 2.0%	11.25	12.39	11.26	9.79	0.39	0.41	0.35	0.27	28.61	30.48	32.50	36.74
T_{10} $ZnSO_4$- 0.3%	11.32	12.46	11.33	9.86	0.38	0.39	0.33	0.25	30.07	32.24	34.70	39.62
T_{11} $ZnSO_4$- 0.6%	11.41	12.55	11.42	9.95	0.36	0.33	0.29	0.24	32.01	38.44	39.86	40.92
T_{12} $ZnSO_4$- 0.9%	11.23	12.37	11.24	9.77	0.40	0.42	0.36	0.28	28.32	29.70	31.53	35.33
S.Em$\pm$	0.08	0.09	0.08	0.09	0.006	0.005	0.004	0.005	0.35	0.41	1.02	0.66
C.D.	0.22	0.26	0.22	0.27	0.017	0.014	0.012	0.015	1.01	1.20	2.96	1.92

Table 2: Effect of pre-harvest spray of plant growth regulators and nutrients on total sugar, reducing sugar (%) and non reducing sugar (%) of guava (*Psidium guajava* L.) during different storage period

Treatments	Total sugar (%) during different storage period				Reducing sugar (%) during different storage period				Non reducing sugar (%) during different storage period			
	0 Days	3 Days	6 Days	9 Days	0 Days	3 Days	6 Days	9 Days	0 Days	3 Days	6 Days	9 Days
T_0 Control	6.61	7.16	6.31	5.66	3.04	3.39	2.96	2.64	3.57	3.77	3.35	3.02
T_1 GA_3- 30 ppm	7.06	7.61	6.86	6.21	3.26	3.61	3.23	2.91	3.80	4.00	3.63	3.30
T_2 GA_3- 60 ppm	7.13	7.68	6.93	6.28	3.33	3.68	3.30	2.98	3.80	4.00	3.63	3.30
T_3 GA_3- 90 ppm	7.33	7.88	7.13	6.48	3.48	3.83	3.45	3.13	3.86	4.06	3.69	3.36
T_4 NAA-30 ppm	7.10	7.65	6.90	6.25	3.31	3.66	3.28	2.96	3.78	3.98	3.61	3.28
T_5 NAA-60 ppm	7.35	7.90	7.15	6.50	3.49	3.84	3.46	3.14	3.86	4.06	3.69	3.36
T_6 NAA-90 ppm	7.25	7.80	7.05	6.40	3.44	3.79	3.41	3.09	3.81	4.01	3.64	3.31
T_7 $Ca(NO_3)_2$- 1.0%	7.36	7.91	7.16	6.51	3.58	3.93	3.55	3.23	3.78	3.98	3.61	3.28
T_8 $Ca(NO_3)_2$- 1.5%	7.38	7.93	7.18	6.53	3.59	3.94	3.56	3.24	3.80	4.00	3.63	3.30
T_9 $Ca(NO_3)_2$- 2.0%	7.59	8.14	7.39	6.74	3.76	4.11	3.73	3.41	3.83	4.03	3.66	3.33
T_{10} $ZnSO_4$- 0.3%	7.65	8.20	7.45	6.80	3.79	4.14	3.76	3.44	3.86	4.06	3.69	3.36
T_{11} $ZnSO_4$- 0.6%	7.95	8.50	7.75	7.10	3.94	4.29	3.91	3.59	4.01	4.21	3.84	3.51
T_{12} $ZnSO_4$- 0.9%	7.58	8.13	7.38	6.73	3.74	4.09	3.71	3.39	3.84	4.04	3.67	3.34
S.Em$\pm$	0.063	0.053	0.064	0.065	0.028	0.024	0.027	0.028	0.071	0.070	0.076	0.084
C.D.	0.184	0.156	0.185	0.191	0.080	0.069	0.080	0.083	NS	NS	NS	NS

Table 3: Effect of pre-harvest spray of plant growth regulators and nutrients on ascorbic acid content (mg/100g pulp) and pectin of guava (*Psidium guajava* L.) during different storage period

Treatments	Ascorbic acid content (mg/100g pulp) during different storage period				Pectin content (%) during Different storage period			
	0 Days	3 Days	6 Days	9 Days	0 Days	3 Days	6 Days	9 Days
T_0 Control	174.83	183.20	167.81	148.58	0.44	0.53	0.40	0.36
T_1 GA_3- 30 ppm	184.36	192.73	177.34	158.11	0.51	0.59	0.46	0.42
T_2 GA_3- 60 ppm	186.36	194.73	179.34	160.11	0.54	0.62	0.49	0.45
T_3 GA_3- 90 ppm	192.68	201.05	185.66	166.43	0.61	0.69	0.56	0.52
T_4 NAA-30 ppm	185.92	194.29	178.90	159.67	0.51	0.60	0.47	0.43
T_5 NAA-60 ppm	193.76	202.13	186.74	167.51	0.62	0.70	0.57	0.53
T_6 NAA-90 ppm	190.60	198.97	183.58	164.35	0.54	0.63	0.50	0.46
T_7 $Ca(NO_3)_2$- 1.0%	194.76	203.13	187.74	168.51	0.61	0.70	0.57	0.53
T_8 $Ca(NO_3)_2$- 1.5%	195.17	203.54	188.15	168.92	0.62	0.71	0.58	0.54
T_9 $Ca(NO_3)_2$- 2.0%	201.49	209.86	194.47	175.24	0.71	0.79	0.66	0.62
T_{10} $ZnSO_4$- 0.3%	203.42	211.79	196.40	177.17	0.72	0.81	0.68	0.64
T_{11} $ZnSO_4$- 0.6%	209.56	217.93	202.54	183.31	0.78	0.87	0.74	0.70
T_{12} $ZnSO_4$- 0.9%	200.72	209.09	193.70	174.47	0.70	0.78	0.65	0.61
S.Em$\pm$	1.41	1.45	1.61	1.53	0.019	0.017	0.014	0.018
C.D.	4.10	4.22	4.71	4.46	0.056	0.049	0.040	0.052

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