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Effect of pre-harvest application of ethephon and potassium sulphate on quality of winter season guava (*Psidiumguajava* L.)

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Abstract
The investigation entitled "Effect of pre-harvest application of ethephon and potassium sulphate on quality of winter season guava" was carried out at Research Orchard of Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 2017-18. The experiment was laid out in Factorial Randomized Block Design with three replications, three cultivars and nine treatments. Four year old plants of guava cultivars e, Hisar Safeda, Hisar Surkha and Lucknow-49 were sprayed with ethephon (200, 400, 600 and 800 ppm) and potassium sulphate (1, 1.5, 2 and 2.5%) in the last week of November. Observation revealed that pre-harvest application of different chemicals on different cultivars of guava significantly influenced the quality parameters except seed numbers, weight of 100 seeds, seed weight per fruit and non-reducing sugar. Number of days for ripening and fruit firmness was recorded minimum under the spray of ethephon @ 800 ppm. Hisar Surkha recorded minimum number of days for ripening and fruit firmness among all the three cultivars. Fruit colour was improved with the treatment of chemicals over the control. Maximum organoleptic rating, pulp weight per fruit, TSS, acidity, TSS: Acid ratio, ascorbic acid, total sugars, reducing sugars and pectin content was recorded under the treatment of potassium sulphate @ 2.5 per cent however among the cultivars, Lucknow-49 was found superior.

Keywords: Guava, ethephon, potassium sulphate, ripening.

Introduction
Guava (*Psidiumguajava* L.) is one of the most cherished and popular fruit crop and is widely grown in tropical and sub-tropical regions because of its wider adaptability and commercial importance. It is considered to be one of the exquisite, hardy, prolific bearing and remunerative fruit crop. It is generally believed that it originated in Tropical America and then spread across the world. Guava has gained considerable prominence on account of its high nutritive and medicinal values and also for its aroma and flavor. It is an ideal fruit crop for nutritional security since it is a rich source of vitamin C, pectin, fibres and potassium. Guava is available throughout the year except during the summer season. In Southern India and Deccan plateau, guava flowers thrice a year but in Northern India, it flowers twice a year, first in April-May for rainy season crop and in Aug-Sept for winter season crop. The quality of guava is greatly affected by temperature and humidity, because of these facts quality of winter season fruits is superiorthan rainy season. The foliar application of nutrients and growth regulators play vital role in improving the quality. In subtropical region insufficient heat calories during the winter months, a limiting factor for commercial production and it takes 200 days from anthesis to fruit harvest. The fruits remain hard and do not ripe properly on tree due to very low temperature in Dec-Jan. Potassium play an important role in various physiological and biochemical process in plant growth, yield and quality under stress conditions (Marschner 1995) [11]. Pre-harvest application of ethephon on guava promoted fruit surface colour, improved fruit quality and hastened fruit maturity (Singh *et al.*, 1978) [14]. Gill and Bal (2010) [6] showed that pre-harvest application of ethephon to guava promote colour development and improved fruit quality. Spraying of potassium significantly enhanced fruit size and quality of guava. Keeping this in view, present studies were planned for ripening and quality of winter season guava with the use of ethephon and potassium sulphate on guava cultivars Hisar Safeda, Hisar Surkha and Lucknow-49.

Materials and Method

The investigation was carried out at Research Orchard of Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 2017-18.The experiment was laid out in Factorial Randomized Block Design with three replications, three cultivars (C) *viz*., C_1-Hisar Safeda, C_2-Hisar Surkha and C_3-Lucknow-49 and nine treatments *viz*., T_1- Ethephon @ 200 ppm, T_2- Ethephon @ 400 ppm, T_3-Ethephon @ 600 ppm, T_4-Ethephon @ 800 ppm, T_5- Potassium sulphate @ 1%, T_6-Potassium sulphate @ 1.5%, T_7-Potassium sulphate @ 2%, T_8-Potassium sulphate @ 2.5% and T_9-control (water spray). The different concentrations of chemicals were sprayed to the plants at the end of November month. The chemicals were properly dissolved in water before spray. The fruits were harvested based on their maturity indices *viz*., change in fruit colour from dark green to light green. The observations on pulp weight per fruit, number of seeds per fruit, weight of hundred seeds, seed weight per fruit, TSS, acidity, ascorbic acid, total sugars, reducing sugars, non-reducing sugar and pectin content were recorded as per the standard procedures of AOAC (1990) [1]. The fruit firmness was recorded by penetrometer and expressed in kg/cm^2. The fruit colour was observed visually. Organoleptic rating was done by a panel of judges of different age groups for texture, flavor, taste and overall acceptability based on a 9 point hedonic scale (Amerine *et al*., 1965) [2]. Number of days for ripening was recorded by counting the days from fruit set to ripening. The recorded observations were statistically analyzed as per the methods given by Cochran and Cox (1992) [5].

Result and Discussion

In the present investigation pre-harvest application of different chemicals on different cultivars of guava significantly influenced the quality parameters except seed numbers, weight of 100 seeds, seed weight per fruit and non-reducing sugar. Significantly the highest number of days for fruit ripening was recorded in T_4 (plants sprayed with ethephon @ 800 ppm) which is closely followed by T_3 (plants sprayed with ethephon @ 600 ppm). However, C_2 (Hisar Surkha) recorded minimum number of days for ripening among all the three cultivars of guava (Table 1).

Table 1: Effect of ethephon and potassium sulphate on number of days for ripening, fruit firmness (kg/cm^2) and organoleptic rating (10 point scale) in guava

Chemical Spray (S)	Number of days for ripening				Fruit firmness (kg/cm^2)				Organoleptic rating (10 point scale)			
	Cultivars (C)				Cultivars (C)				Cultivars (C)			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
T_1	120.7	111.0	126.0	119.2	8.73	8.22	8.70	8.55	7.96	7.50	7.63	7.70
T_2	117.7	108.0	123.0	116.2	8.17	7.87	8.37	8.13	8.14	7.64	7.86	7.88
T_3	115.7	106.3	121.0	114.3	7.87	7.43	7.93	7.74	7.95	7.72	7.92	7.86
T_4	113.7	104.3	119.0	112.3	7.47	7.03	7.47	7.32	8.07	7.67	7.88	7.87
T_5	123.7	114.0	129.0	122.2	9.63	9.33	9.61	9.53	7.78	7.31	7.49	7.53
T_6	122.7	113.0	128.0	121.2	9.07	8.77	9.37	9.07	7.95	7.43	7.60	7.66
T_7	120.7	111.0	126.0	119.2	8.73	8.40	9.08	8.74	8.05	7.53	7.68	7.75
T_8	119.7	109.7	125.0	118.1	8.37	8.26	8.96	8.53	8.17	7.60	7.89	7.89
T_9	126.7	117.0	132.0	125.2	9.67	9.63	9.63	9.64	7.45	7.20	7.40	7.35
Mean	120.1	110.5	125.4		8.63	8.33	8.79		7.95	7.51	7.71	
CD at 5%	C: 0.4 S: 0.9C x S: NS				C: 0.10S: 0.20C x S: NS				C: 0.04S: 0.09C x S: NS			

The decrease in number of days for ripening of fruit might be due to ethephon inducing early ripening, as it is the key plant hormone responsible for ripening and due to early maturity of Hisar Surkha. Further, partial leaf shedding due to ethephon, particularly at the higher dose, may be another factor which enabled light-penetration and a rise in temperature, resulting in early fruit ripening. The present result elucidates the previous work of Brar and Bal (2010) [4] in guava. Fruit firmness was found to be significantly minimum in T_4 (plants sprayed with ethephon @ 800 ppm) followed by T_3 (plants sprayed with ethephon @ 600 ppm). However, C_2 (Hisar Surkha) recorded minimum fruit firmness among all the three cultivars of guava (Table 1). The softening of fruit with Ethel may be attributed to its action on cell wall hydrolysis and changes in complex substances to simpler ones as carried out in ripening which is under control of ethylene (Yadav *et al*., 2001) [16]. The results are in conformity with the findings of Kaur and Dhillon (2006) [7]. The maximum organoleptic rating was recorded in T_8 (plants sprayed with potassium sulphate @ 2.5 per cent). However, C_1 (Hisar Safeda) recorded highest organoleptic rating among all the three cultivars of guava. The treatments T_2 (plants sprayed with ethephon @ 400 ppm), T_3 (plants sprayed with ethephon @ 600 ppm) and T_4 (plants sprayed with ethephon @ 800 ppm) were also found equally good in improving the organoleptic rating of fruits (Table 1). These results were supported by Bhatia *et al*., (2001) [3].

Significantly the highest pulp weight per fruit (Table-2) was recorded in T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent). However, C_3 (Lucknow-49) recorded maximum pulp weight among all the three cultivars of guava (Table 2).

Table 2: Effect of ethephon and potassium sulphate on pulp weight per fruit (g), number of seeds per fruit and weight of 100 seeds (g) in guava

Chemical Spray (S)	Pulp weight per fruit (g)				Number of seeds per fruit				Weight of 100 seeds (g)			
	Cultivars (C)				Cultivars (C)				Cultivars (C)			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
T_1	149.9	127.6	182.0	153.1	218.7	219.7	233.0	223.8	1.02	0.95	1.05	1.00
T_2	155.1	130.6	183.8	156.5	216.3	218.0	231.3	221.9	1.01	0.95	1.04	1.00
T_3	145.1	125.2	178.2	149.5	213.0	216.0	229.7	219.6	1.01	0.94	1.03	1.00

T_4	140.8	122.8	175.6	146.4	210.0	215.3	228.3	217.9	1.01	0.93	1.03	0.99
T_5	146.6	126.3	179.6	150.8	210.7	212.0	226.7	216.4	1.00	0.93	1.02	0.98
T_6	154.1	129.6	186.4	156.7	210.7	212.7	225.0	216.1	1.00	0.92	1.01	0.98
T_7	160.6	135.8	189.4	161.9	209.3	210.0	223.3	214.2	1.00	0.92	1.00	0.97
T_8	167.5	142.6	194.2	168.1	209.0	209.7	223.0	213.9	0.99	0.91	0.99	0.97
T_9	139.3	120.2	174.1	144.5	219.0	221.3	235.0	225.1	1.04	0.97	1.07	1.03
Mean	151.0	128.9	182.6		213.0	215.0	228.4		1.01	0.94	1.03	
CD at 5%	C: 1.0 S: 2.0C x S: 2.8				C: 3.8S: NSC x S: NS				C: 0.04S: NS C x S: NS			

Table 3: Effect of ethephon and potassium sulphate on seed weight per fruit (g), T.S.S (%) and acidity (%) in guava

Chemical Spray (S)	Seed weight per fruit (g)				T.S.S (%)				Acidity (%)			
	Cultivars (C)				Cultivars (C)				Cultivars (C)			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
T_1	2.22	2.08	2.45	2.25	11.41	11.77	10.20	11.12	0.41	0.39	0.45	0.42
T_2	2.18	2.08	2.40	2.22	11.54	11.83	10.24	11.21	0.40	0.38	0.44	0.41
T_3	2.15	2.04	2.37	2.19	11.43	11.69	10.11	11.08	0.42	0.39	0.46	0.42
T_4	2.13	2.01	2.34	2.16	11.58	11.62	10.05	11.08	0.42	0.39	0.46	0.42
T_5	2.11	1.97	2.30	2.13	11.39	11.72	10.16	11.09	0.42	0.40	0.46	0.42
T_6	2.11	1.96	2.28	2.12	11.45	11.73	10.17	11.12	0.41	0.39	0.45	0.42
T_7	2.09	1.92	2.23	2.08	11.59	11.80	10.24	11.21	0.41	0.38	0.44	0.41
T_8	2.08	1.90	2.24	2.07	11.60	11.86	10.65	11.37	0.39	0.37	0.43	0.40
T_9	2.27	2.15	2.51	2.31	11.19	11.55	9.97	10.90	0.43	0.41	0.48	0.44
Mean	2.15	2.01	2.35		11.46	11.73	10.20		0.41	0.39	0.45	
CD at 5%	C: 0.10 S: NSC x S: NS				C: 0.08S: 0.17C x S: NS				C: 0.01S: 0.01 C x S: NS			

The possible reason for increase in pulp weight may be the reflection of increased vegetative growth as well as chlorophyll content of leaves which might have resulted in the synthesis of more metabolites. These metabolites were trans located to the fruits by which pulp weight increased with the chemical spray (Manivannan *et al*., 2015) [10]. The present study reveals that the effect of various chemicals on number of seeds, weight of 100 seeds and seed weight per fruit was not very encouraging; however higher doses of chemicals reduced the seed numbers marginally as compared to control treatment (Table 2 and Table 3). The maximum TSS was recorded in T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) closely followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent) and T_2 (plants sprayed with ethephon @ 400 ppm). However, C_2 (Hisar Surkha) recorded highest TSS in all the three cultivars of guava (Table 3). The possible reason behind the increased TSS may be because potassium play significant role in accumulation of sugars and other soluble solids in the fruit and it find support from the well-established fact that potassium is important in sugar translocation and increase in TSS with ethrel might be due to its action on converting complex substances into simpler ones and increased TSS in HisarSurkha was due to superior quality of the cultivar. The present results regarding to total soluble solids are in accordance with the earlier findings of Kaur and Dhillon (2006) [7]. Fruit acidity was found to be significantly minimum in T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) closely followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent) and T_2 (plants sprayed with ethephon @ 400 ppm). However, C_2 (Hisar Surkha) recorded minimum acidity among all the three cultivars of guava (Table 3). Under the influence of chemicals, the acids might have been quickly converted into sugars and its derivatives by the reactions involving reversal of glycolytic pathway. The results are in line with findings of Kumar *et al.*, (2017) [18]. The maximum TSS to acid ratio was recorded in T_8 (plants sprayed with potassium sulphate @ 2.5 per cent). However, C_2 Hisar Surkha) recorded highest TSS to acid ratio in all the three cultivars of guava (Table 4). The results are in accordance with the findings of Sharma *et al*. (2008) [13] in beer. The maximum ascorbic acid content was recorded under T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) closely followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent) and T_2 (plants sprayed with ethephon @ 400 ppm). However, C_3 (Lucknow-49) recorded maximum ascorbic acid among all the three cultivars of guava (Table 4).

Table 4: Effect of ethephon and potassium sulphate on T.S.S: Acid ratio, ascorbic acid (mg/ 100g pulp) and total sugars (%) in guava

Chemical Spray (S)	T.S.S : Acid ratio				Ascorbic acid (mg/ 100g pulp)				Total sugars (%)			
	Cultivars (C)				Cultivars (C)				Cultivars (C)			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
T_1	27.83	30.43	22.51	26.93	191.3	186.3	193.6	190.4	6.11	6.08	6.89	6.36
T_2	28.86	31.42	23.31	27.86	193.0	186.9	194.4	191.4	6.32	6.15	6.97	6.48
T_3	27.45	29.72	21.84	26.34	188.8	185.3	191.9	188.7	6.14	6.02	6.86	6.34
T_4	27.57	29.82	21.69	26.36	186.9	184.0	191.0	187.3	6.30	5.98	6.73	6.34
T_5	27.13	29.54	22.26	26.31	187.1	184.1	190.8	187.4	6.40	5.99	6.66	6.35
T_6	27.95	30.09	22.79	26.94	189.3	185.7	192.9	189.3	6.23	6.09	6.78	6.36
T_7	28.52	30.79	23.47	27.59	192.2	188.5	194.1	191.6	6.31	6.15	6.98	6.48
T_8	29.54	32.37	24.97	28.96	192.7	189.4	194.9	192.3	6.38	6.24	7.05	6.56
T_9	26.02	28.18	20.93	25.04	185.6	183.3	190.0	186.3	6.02	5.91	6.50	6.14
Mean	27.87	30.26	22.64		189.7	186.0	192.6		6.25	6.07	6.82	
CD at 5%	C: 0.38 S: 0.80C x S: NS				C: 0.5S: 1.0C x S: NS				C: 0.09S: 0.19 C x S: NS			

The increase in ascorbic acid content in the pulp of guava fruits with foliar sprays of different nutrients might be attributed to the higher synthesis of some metabolites and some intermediate substances which promotes the synthesis of precursors of ascorbic acid and increased ascorbic acid in Lucknow-49 was due to genetically superiority of the cultivar with respect to quality. The results are in line with the findings of Kumar *et al*., (2017) [18]. The maximum total sugar content was recorded under T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) closely followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent) and T_2 (plants sprayed with ethephon @ 400 ppm). However, C_3 (Lucknow-49) recorded maximum total sugars among all the three cultivars of guava (Table 4). The possible reason for increase in per cent total sugars in guava pulp by pre harvest sprays of potassium might be due to the conversion of starch and acid into sugars in addition to the continuous mobilization of sugars from leaves to fruits. The results are in accordance with the findings of Gill and Bal (2010) [6].

The maximum reducing sugar content was recorded under T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) closely followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent) and T_2 (plants sprayed with ethephon @ 400 ppm). However, C_3 (Lucknow-49) recorded maximum reducing sugars among all the three cultivars of guava (Table 5).

Table 5: Effect of ethephon and potassium sulphate on reducing sugars (%), non-reducing sugars (%) and pectin (%) in guava

Chemical Spray (S)	Reducing sugars (%)				Non-reducing sugar (%)				Pectin (%)			
	Cultivars (C)				Cultivars (C)				Cultivars (C)			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
T_1	3.78	3.74	3.90	3.81	2.33	2.35	2.99	2.56	0.73	0.69	0.80	0.74
T_2	3.85	3.79	3.99	3.88	2.46	2.37	2.98	2.60	0.77	0.73	0.86	0.79
T_3	3.74	3.67	3.84	3.75	2.40	2.35	3.02	2.59	0.72	0.68	0.79	0.73
T_4	3.68	3.63	3.79	3.70	2.62	2.35	2.94	2.64	0.69	0.67	0.78	0.72
T_5	3.71	3.61	3.79	3.70	2.70	2.38	2.87	2.65	0.71	0.70	0.75	0.72
T_6	3.77	3.66	3.88	3.77	2.46	2.43	2.90	2.60	0.72	0.72	0.79	0.74
T_7	3.85	3.80	4.01	3.89	2.46	2.35	2.97	2.59	0.78	0.78	0.86	0.81
T_8	3.86	3.81	4.04	3.91	2.51	2.42	3.01	2.65	0.82	0.81	0.88	0.84
T_9	3.64	3.56	3.74	3.65	2.37	2.35	2.76	2.50	0.58	0.60	0.68	0.62
Mean	3.77	3.70	3.89		2.48	2.37	2.94		0.73	0.71	0.80	
CD at 5%	C: 0.01 S: 0.03C x S: NS				C: 0.09S: 1.0C x S: NS				C: 0.04S: 0.09 C x S: NS			

An increase in reducing sugars percentage in guava pulp with the application of chemicals through foliar sprays might be involved in the enhancement of photophosphorylation and dark reaction of photosynthesis by potassium which resulted in accumulation of more carbohydrates in the fruits and helps in better accessibility of nutrients to the developing fruits. The results were supported by Pal *et al.*, (2008) [12] and Yadav *et al.*, (2011) [17] in guava. The effect of various chemicals on non-reducing sugar was non-significant (Table 5). Significantly the highest pectin was recorded in T_8 (plants sprayed with potassium sulphate @ 2.5 per cent) closely followed by T_7 (plants sprayed with potassium sulphate @ 2 per cent) and T_2 (plants sprayed with ethephon @ 400 ppm). However, C_3 (Lucknow-49) recorded maximum pectin content in all the three cultivars of guava (Table 5). Potassium increased the pectin content of the fruits as it facilitates the process of translocation of photosynthates from leaves to young fruits, which are partly used in the synthesis of pectin substances (Whiting, 1970) [15]. The increase in pectin content with potassium sulphate is further supported by the findings of Kumar *et al*., (2015) [19] and Kumar *et al*., (2017) [18] in guava.

The intensity of fruit colour changes from greenish in control to attractive medium yellow in ethephon (600 and 800 ppm) in all the three cultivars of guava (Table 6).

Table 6: Effect of ethephon and potassium sulphate on fruit colour (visual) in guava

Chemical Spray (S)	Fruit colour (Visual)		
	Cultivars (C)		
	HisarSafeda	Hisar Surkha	Lucknow-49
Ethephon 200 ppm	Yellowish green	Yellowish green	Yellowish green
Ethephon 400 ppm	Greenish yellow	Greenish yellow	Greenish yellow
Ethephon 600 ppm	Medium yellow	Medium yellow	Medium yellow
Ethephon 800 ppm	Medium yellow	Medium yellow	Medium yellow
Potassium sulphate 1.0%	Yellowish green	Yellowish green	Yellowish green
Potassium sulphate1.5%	Yellowish green	Yellowish green	Yellowish green
Potassium sulphate2.0%	Greenish yellow	Greenish yellow	Greenish yellow
Potassium sulphate2.5%	Greenish yellow	Greenish yellow	Greenish yellow
Control (Water spray)	Greenish	Greenish	Greenish

The possible reason in fruit colour improvement in ethephon treatment may be due to ripening enhancing properties of ethephon. The results are in accordance with the findings of Gill and Bal (2010) [6] in guava.

Conclusion

On the basis of results obtained in the present study of pre-harvest application of ethephon and potassium sulphate on winter season guava we can conclude that there was significant improvement in the ripening and quality parameters with the potassium sulphate @ 2.5 per cent,

potassium sulphate @ 2 per cent and ethephon @ 400 in all the three cultivars. However, among the cultivars Lucknow-49 found superior.

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