DOI : 10.5958/0974-0112.2020.00008.0

Indian J. Hort. 77(1), March 2020: 94-100

Efficacy of some chemicals for crop regulation in Allahabad Safeda guava under coastal Indian conditions of Odisha

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ABSTRACT

A crop regulation study was carried out on sixteen-year-old orchard of guava cv. Allahabad Safeda during 2016-18 to evaluate the efficacy of some chemical defoliants for avoiding rainy crop and inducing profuse flowering during rainy season (*Mrig bahar*) in order to get heavy crop load during desirable season, *i.e.*, winters. The experiment was laid out in randomized block design with 13 treatments consisted of ethephon (200, 400 and 600 ppm), ά-naphthalene acetic acid (500, 750 and 1000 ppm), ortho-phosphoric acid (1, 2 and 3%), and urea (5, 10 and 15%), and water spray as control. Foliar application of chemicals was done in the first week of May. Application of ethephon 600 ppm not only resulted in maximum defoliation (95.69%) and fruit abscission (98.61%) of rainy-season crop (*Ambe bahar*) but also recorded maximum flushing (19.17 shoots/m of branch), flowering (49.74%), No. of fruits/plant (146.14) and fruit yield (28.76 kg/plant) for winter crop. Ethephon treated plants produced smaller fruits (203.26±4.78 g) as compared to control (227.66 g), whereas, urea treated produced bigger fruits (234.05±4.09 g). With regard to fruit quality, none of the crop regulating treatments exhibited significant variation over control for pulp TSS and vitamin C, however, significant improvement in antioxidant properties was recorded with ethephon (200-600 ppm) and urea (10-15%) treatments. Fruits harvested from 600 ppm ethephon sprayed plants were superior in quality and scored the highest values for TSS: acid ratio (22.96), total phenolic content (147.25 mg GAE/100 g FW), total flavonoids (36.61 mg QE/100 g FW), ferric reducing antioxidant power (29.09 mM $Fe_{(II)}$/100 g FW) and scavenging activity (74.29%).

Key words: *Psidium guajava,* fruit quality, defoliation, ethephon, urea.

INTRODUCTION

Guava *(Psidium guajava* L.) belonging to family Myrtaceae is a wholesome fruit packed with the goodness of dietary fibre, pectin, vitamins (ascorbic acid, thiamine, riboflavin and niacin), minerals (potassium, phosphorus, calcium and iron) and antioxidants (polyphenols, lycopene, carotenoids, lutein and cryptoxanthanin), and is included in the category of super fruits. It is the 5th most important fruit crop cultivated in India after mango, citrus, banana and apple. Owing to its hardy nature, wider edapho-climatic adaptability, high production potential, and nutritional and processing values, it is cultivated throughout the tropical and sub-tropical parts of the country mainly in Uttar Pradesh, Bihar, Madhya Pradesh, Chhattisgarh, West Bengal, Odisha, Maharashtra, Gujarat, Haryana and Tamil Nadu. Depending upon climatic conditions of growing area, guava gives two to three crops in a year. Under hot and humid conditions of Odisha, it exhibits two distinct periods of flowering, *i.e.*, *ambe bahar* (March-April) and *mrig bahar* (July-August). *Ambe bahar* is intense and yields heavy crop during rainy season (August-October), whereas, *mrig bahar* is sparse and produces light crop during winters (December-January). Despite low yields, winter crop is preferred over rainy on account of better fruit quality and less incidence of fruit fly infestation and diseases. Hence, natural flowering and fruiting tendencies of guava are needed to be regulated towards induction of profuse *mrig bahar* so as to get heavy winter crop.

Crop regulation in guava has been achieved by various means, *viz*., shoot pruning, branch bending, withholding of irrigation, root exposure, root pruning and use of chemicals (Agnihotri *et al*., 2; Samant *et al*., 19; Majhi *et al*., 13; Dhillon *et al*., 8). Of these, use of chemicals holds potential due to its adoption on commercial scale since it is comparatively less labour intensive. However, the response of crop to chemicals may vary with cultivar and climatic conditions. Keeping this in view, a study was carried out to evaluate the efficacy of some chemicals for crop regulation in guava under hot and humid costal climatic condition of Odisha.

MATERIALS AND METHODS

The present investigation was carried out during 2016-18 in the coastal region of India at the research farm of ICAR-IIHR-Central Horticultural Experiment Station, Bhubaneswar, Odisha, which is located at an altitude of 25.5 m above mean sea level and

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lies between coordinates of 20º 15'N latitude and 85º 52'E longitude. It has hot and humid tropical climate with the average minimum and maximum temperatures of 22.2 and 33.7ºC, respectively. The annual rainfall varies between 1400-1500 mm, whereas, relative humidity between 70-80%. Soil of experimental orchard is sandy loam, acidic (pH 4.3-4.7), low in organic carbon (0.32%), available nitrogen (186.74 kg/ha) and phosphorus (12.15 kg/ha), and medium in potassium (181.51 kg/ha). Sixteen-year-old guava plants cv. Allahabad Safeda of uniform vigour and size, planted at 5 m × 5 m spacing and maintained under uniform cultural practices were selected for the study. The experiment was laid out in randomized block design with 13 treatments. Each treatment was replicated thrice, and each replication had four plants. Chemical treatments consisted of various concentrations of four chemicals which are reported to have abscission effect on leaves and fruits, *viz.*, ethephon (T_1: 200, T_2: 400 and T_3: 600 ppm), naphthalene acetic acid, *i.e.*, NAA (T_4: 500, T_5: 750 and T_6: 1000 ppm), ortho-phosphoric acid, *i.e.*, OPA (T_7: 1, T_8: 2 and T_9: 3%), and urea (T_{10}: 5, T_{11}: 10 and T_{12}: 15%), and water spray as control (T_{13}). Treatments were applied in the first week of May as foliar sprays.

Removal of rainy-season crop was measured in terms of abscission of leaves and fruits. For estimation of these two parameters, plant basins were cleaned prior to imposition of treatments. Once treatments were imposed, leaves and fruits fallen under the plant were collected and counted on alternate day separately, till the process was over. Leaves and fruits retained on the plants were counted at the end of abscission phase, thereafter, leaf and fruit abscission was computed using following formulae;

$$\text{Leaf abscission \%} = \frac{\text{Total no. of abscised leaves}}{\text{Total no. of abscised leaves + Total No. of retained leaves}} \times 100$$

$$\text{Leaf abscission \%} = \frac{\text{Total no. of abscised fruits}}{\text{Total no. of abscised fruits + Total No. of retained fruits}} \times 100$$

To find out the influence of different crop regulation treatments on winter season crop, the following observations were recorded, namely, initiation of new flush (days after chemical spray, *i.e.*, DACS), flushing intensity (No. of shoots/ m of branch), length of flowering and non-flowering shoots (cm); characteristics of flowering and fruiting, *viz.*, flowering intensity (%), flower bud drop (%), fruit set (%), fruit drop (%) and fruit maturity duration (days after fruit set); yield (kg/plant); and fruit quality parameters, *viz.*, total soluble solids (ºB), acidity (% citric acid), and vitamin C (mg/100 g of pulp), total phenolic content, *i.e.*, TPC (mg gallic acid eqv. /100 g FW), total flavonoids (TFC) (mg quercetin eqv./ 100 g FW), scavenging activity (SCA %), and ferric reducing antioxidant power (FRAP mM $Fe_{(II)}$/100 g FW).

Appearance of 25 sprouts after application of chemicals was considered as initiation of new flush. For estimation of intensity of flushing and flowering, four branches (one in each direction of plant canopy) were selected randomly. On these selected branches, flowering and total No. of shoots were counted after two months of flushing. Following formulae were used to determine the intensity of flushing and flowering.

$$\text{Flushing intensity} = \frac{\text{Total no. of shoots}}{\text{Length of branch (m)}}$$

$$\text{Flowering intensity} = \frac{\text{Total no. of flowering shoots}}{\text{Total no. of shoots}} \times 100$$

To record observations on shoot growth, flower bud drop, fruit set, and fruit drop, 40 flowering and 40 non-flowering shoots were tagged on each plant (10 flowering and 10 non-flowering shoots in each direction of plant canopy). Shoot length was measured after 180 days of emergence. Flower bud drop was computed using following formula.

$$\text{Flower bud drop} = \frac{FB_E - FB_A}{FB_E} \times 100$$

Where, FB_E = Total No. of flower bud emerged; FB_A = Total No. of flower bud reached anthesis. Fruit set at 21 days after anthesis and fruit drop were computed following the standard procedures.

Fruits were harvested at full maturity, counted and weighed with physical balance. Average fruit weight was computed by dividing the yield by the number of fruits. Ten mature fruits from each replication were taken randomly for recording observations on various chemical attributes. Total soluble solid content (TSS) was determined using hand-held digital refractometer (Hanna make). Acidity and vitamin C were estimated following AOAC (1), TPC and SCA were estimated using Folin-Ciocaltu (FC) reagent and 2-diphenyl-1-picrylhydrazyl (DPPH) free radical assay, respectively (Ikram *et al.*, 10). TFC was determined by aluminium chloride colorimetric method (Chang *et al.*, 7), whereas, FRAP assay was performed as per the method described by Benzie and Strain (3).

The data generated on various parameters during three consecutive years, were pooled and statistically analyzed using OPSTAT statistical package (Sheoran, 20).

RESULTS AND DISCUSSION

Of four chemicals, ethephon (400-600 ppm) and urea (10-15%) were found effective in inducing abscission of leaves and fruits, both, to the tune

of 80-96 and 75-99%, respectively (Fig. 1). The treatment 600 ppm ethephon (T_3) recorded the maximum values for defoliation (95.69%) and fruit abscission (98.61%), followed by 15% urea (95.64% defoliation and 95.53% fruit abscission). The effect of NAA on abscission of fruits was found to be more pronounced as compared to the leaf abscission. The maximum defoliation caused by the NAA treatment T_6 (750 ppm) was 51.16%, whereas, fruit abscission was 94.81%, which was at par with the ethephon treatments (T_1 and T_2) and urea (T_{12}). Leaf and fruit abscission due to exogenous application of ethephon could be attributed to its ethylene releasing ability in the higher pH of plant tissue synthesising cell wall degrading enzymes, *viz.*, cellulase and pectinase (Leslie *et al*., 12). Ethephon-induced abscission of leaves and fruits has been reported earlier by Chandra *et al*. (6) and Chander *et al.* (5) in case of pomegranate and sugar apple, respectively. Foliar application of urea might have resulted in accumulation of urea and ammonia (NH_4^+) in the leaves and developing fruits to a phytotoxic level causing severe tissue injury and subsequent abscission of these plant organs (Krogmeir *et al.*, 11; Singh *et al.*, 21).

The response of guava with respect to rainy-season flush varied significantly with the chemicals and their concentrations (Table 1). In general, urea treated plants recorded significant delay in emergence of new flush as compared to rest of the chemical defoliants. Days taken for initiation of new flush showed an increasing trend with the increase in concentration of urea, however, followed a reverse trend in case of ethephon, NAA and OPA. Plants sprayed with 15% urea (T_{12}) took the maximum days for emergence of new flush, whereas, the minimum days were recorded with 600 ppm ethephon. All the treatments of ethephon (T_1, T_2 and T_3) and NAA (T_4, T_5 and T_6), and 3% OPA (T_9) showed significant improvement in rainy-season flush over control. With the production of 19.17 shoots/m of branch, the treatment T_3 (600 ppm ethephon) was found to be the best for enhancing rainy-season flush in guava. Early and more flush were observed under ethephon treatments could be due to suppression of apical dominance and invigoration of latent lateral buds (Campos *et al*., 4).

Table 1. Effect of crop regulating chemicals on rainy-season flush of guava.

Treatment	Initiation of new flush (DACS)	No. of shoots emerged /m of branch	Shoot length (cm) (180-day-old)	
			Flowering	Non-flowering
T_1	23.75	12.04	32.32	54.83
T_2	20.67	15.46	31.28	53.24
T_3	19.88	19.17	30.67	53.48
T_4	27.03	14.24	44.41	67.54
T_5	24.40	14.71	47.25	68.65
T_6	24.15	13.86	49.19	69.14
T_7	25.41	8.11	28.52	53.62
T_8	24.29	8.76	29.61	54.08
T_9	23.80	12.45	28.40	53.50
T_{10}	30.35	7.16	36.86	62.50
T_{11}	33.16	8.26	24.27	43.88
T_{12}	35.65	5.56	17.71	37.33
T_{13}	-	6.31	33.91	59.71
CD *(P=0.05)*	2.14	3.07	8.9	7.2

DACS = Days after chemical spray

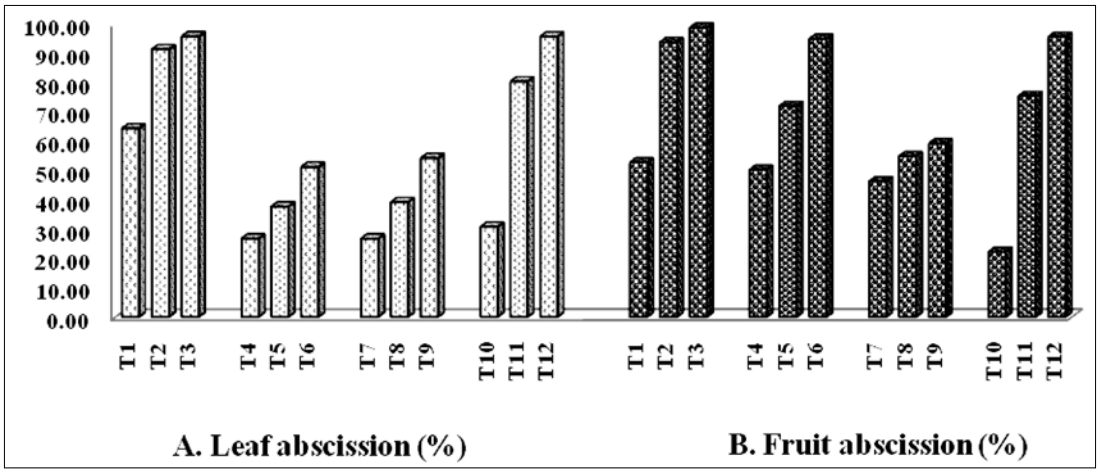

Fig. 1. Effect of crop regulating chemicals on leaf and fruit abscission.

The perusal of data in Table 1 further suggested differential shoot growth response in guava on account of foliar application of defoliants, yet the growth response of flowering and non-flowering shoots was observed to be unidirectional for a particular chemical. Significant increase in shoot length was recorded under NAA treatments (T_4, T_5 and T_6), whereas, significant reduction in shoot length was observed due to application of 10 and 15% urea (T_{11} and T_{12}). The highest dose of NAA (1000 ppm) produced the longest flowering and non-flowering shoots (49.19 and 69.14 cm), while shortest (17.71 and 37.33cm) were recorded with the maximum dose of urea (15%). Positive influence of NAA on shoot growth has also been reported earlier by Wahdan *et al*., (22) and Phawa *et al*., (17) in mango and pomegranate, respectively. Exogenous application of NAA could have elevated the level of endogenous auxin, which in turn might have stimulated cell elongation and expansion in newly emerged shoots resulting in their better growth (Pandey and Sinha, 15).

Foliar application of ethephon (200-600 ppm) induced significant improvement in flowering, whereas, application of urea above 5% caused a significant reduction (Table 2). Rest of the treatments did not show significant variation for flowering and were at par with the control. The beneficial effect of ethephon on flowering increased with the increase in dose. The treatment 600 ppm ethephon (T_3) registered the maximum flowering intensity, followed by 400 and 200 ppm ethephon (T_2 and T_1), whereas, the lowest flowering intensity was obtained with 15% urea (T_{12}). Ethephon induced profuse flowering recorded in present study is in agreement with the finding of Ghadage *et al*. (9) and Maloba *et al.* (14). Application of NAA above 500 ppm was found to be phytotoxic and resulted in significant increase in bud and fruit drop on new flush, however, rest of the treatments remained at par with the control. For fruit set, variations recorded among treatments were non-significant. Fruit maturity got delayed by more than a week due to application of NAA (750-1000 ppm), on the other hand, hastened by 6-9 days due to ethephon (400-600 ppm). Yadava (23) and Rathod *et al*. (18) also reported advancement in fruit maturity due to ethephon.

Quantum of winter crop was significantly improved by ethephon and OPA, however, the effect of ethephon was more pronounced (Table 2). Fruit yield in terms of weight and number, followed an increasing trend with the increase in concentration of ethephon and OPA, whereas, in case of NAA and urea, fruit yield showed a reverse trend. The ethephon treatment T_3 recorded the maximum values for fruit yield (8.76 kg/plant) and No. of fruits/plant (146.14), while, plants sprayed with 15% urea recorded the lowest values (3.88 kg/plant and 16.33 fruits/plant). Yield enhancement as a result of ethephon treatments might be due to more No. of fruits and its positive

Table 2. Effect of crop regulating chemicals on flowering and fruiting of winter season crop in guava cv. Allahabad Safeda.

Treatment	Flowering intensity (%)	Bud drop (%)	Fruit set (%)	Fruit drop (%)	Period of fruit maturity (DAFS)	Yield (kg/ plant)	No. of fruits/ plant	Av. fruit wt. (g)
T_1	35.16	15.10	62.71	46.42	131.77	18.84	91.19	208.03
T_2	42.48	14.79	64.94	47.52	125.53	25.32	125.33	200.65
T_3	49.74	16.81	63.10	44.62	123.28	28.76	146.14	198.48
T_4	26.18	20.28	62.57	51.44	133.71	11.43	52.85	216.09
T_5	25.71	30.64	61.57	62.09	141.26	8.75	40.62	216.36
T_6	24.86	34.81	64.85	65.88	140.41	6.28	28.47	221.47
T_7	26.48	15.81	60.56	45.21	133.72	9.61	41.54	229.68
T_8	28.87	14.01	63.47	46.40	131.85	11.58	51.49	226.99
T_9	30.35	15.66	64.78	44.97	132.13	14.68	66.96	219.57
T_{10}	24.73	16.97	63.21	47.30	133.16	7.54	32.93	229.96
T_{11}	17.91	15.42	61.56	48.45	134.69	4.72	20.13	235.40
T_{12}	15.26	17.90	62.15	45.74	133.71	3.88	16.33	238.14
T_{13}	25.08	16.56	60.19	48.19	132.37	6.14	26.90	227.66
CD *(P=0.05)*	5.9	6.07	NS	9.39	5.24	3.09	17.62	18.40

DAFS = Days after fruit set

influence on flushing and flowering (Table 1). As evident in Fig. 2, there was a strong correlation between yield and No. of fruits. Average fruit weight noted in various treatments of chemical defoliants remained at par with the control (227.66 g) except for ethephon treatments, which exhibited significant reduction in average fruit weight. The highest fruit weight was recorded in T_{12} (238.14 g), whereas, the lowest was in T_3 (198.48 g). The possible reason behind the significant reduction in fruit weight could be heavy crop load on ethephon treated plants as fruit weight was found to be negatively correlated with the No. of fruits (Fig. 2). Under heavy crop load condition, it is obvious that there would be more competition for photo-assimilates among developing fruits resulting into reduced fruit size and weight. Our findings are in agreement with the findings of Patil *et al*. (16).

The data pertaining to various chemical attributes are presented in Table 3. Crop regulating treatments did not differ significantly from control with respect to total soluble solids. The values of TSS under various defoliants ranged between 10.42 to 11.14ºB with a mean of 10.72ºB, as against 10.37ºB recorded in case of control. Application of urea (10-15%) resulted in significant increase in titratable acidity. The treatment T_{13} (15% urea) recorded the maximum acidity (0.7%), while T_3 (600 ppm ethephon) recorded the lowest (0.47%). Similar effect of urea on fruit acidity was earlier reported by Majhi *et al.* (13) in guava. The TSS: acid ratio which is considered an important index of fruit quality was found best in T_3, followed by T_9, T_6 and T_8 treatments. On the other hand, the lowest TSS: acid ratio was noted in T_{12}, followed by T_{11}.

Fruits harvested from ethephon (200-600 ppm) and urea (10-15%) sprayed trees were of superior quality in terms of antioxidant properties (TPC, TFC, FRAP and SCA). The treatment T_3 scored the highest values for TPC (147.25 mg GAE/100 g FW), TFC (36.61 mg QE/100 g FW), FRAP (29.09 mM $Fe_{(II)}$/100 g FW) and SCA (74.29%), whereas, control recorded the lowest values. Severe defoliation and

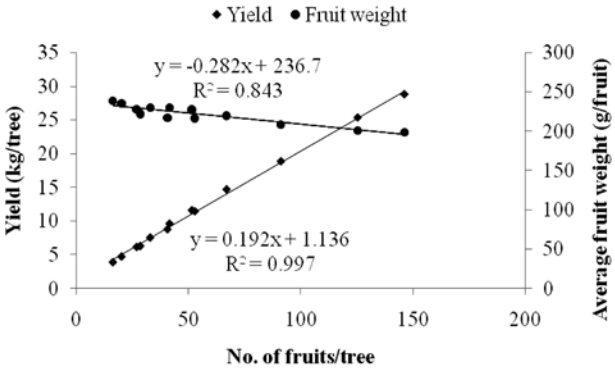

Fig. 2. Yield and fruit weight as affected by No. of fruits in guava.

Table 3. Effect of crop regulating chemicals on fruit quality of winter season guava crop.

Treatment	TSS (ºBrix)	Acidity (%CA)	TSS: acid ratio	Antioxidant component			Antioxidant activity	
				Vit. C (mg/100 g pulp)	TPC (mg GAE/100 g FW)	TFC (mg QE/100 g FW)	FRAP (mM $Fe_{(II)}$/100 g FW)	SCA (%)
T_1	10.43	0.54	19.45	163.40	136.26	31.21	27.44	69.51
T_2	10.45	0.51	20.63	165.23	143.49	35.57	28.61	73.57
T_3	10.72	0.47	22.96	166.42	147.25	36.61	29.09	74.29
T_4	10.70	0.55	19.70	163.24	132.24	28.35	26.59	67.48
T_5	10.86	0.51	21.17	164.05	134.41	30.04	26.95	67.97
T_6	10.95	0.50	21.81	162.38	135.23	29.17	27.02	68.74
T_7	10.83	0.53	20.56	163.75	131.19	26.84	26.34	67.34
T_8	10.90	0.51	21.71	165.25	132.10	28.61	26.43	67.40
T_9	11.14	0.51	21.88	166.76	133.26	28.01	26.86	67.87
T_{10}	10.42	0.56	18.74	162.44	131.13	27.59	26.65	66.89
T_{11}	10.57	0.67	15.79	160.89	142.51	35.45	28.38	73.31
T_{12}	10.68	0.70	15.25	165.74	145.40	36.06	28.77	73.72
T_{13}	10.37	0.55	18.85	159.33	129.41	27.16	26.24	65.32
CD *(P=0.05)*	NS	0.10	2.57	NS	5.94	4.00	1.05	3.67

CA = Citric acid, GAE = Gallic acid equivalent, QE = Quercetin equivalent

fruit abscission under ethephon and urea treatments might have caused stress induced up regulation of defence mechanism in plants, *i.e.*, more production of secondary metabolites, *viz.*, phenols, as reported by Chander *et al.* (6) in sugar apple. As far as, Vitamin C is concerned, none of the crop regulating treatments had significant influence on it. Total phenolic and flavonoid contents exhibited a strong co-relation with antioxidant activity, whereas, vitamin C showed a weak co-relation (Fig. 3). Hence, the higher antioxidant activity observed in fruits harvested from ethephon and urea treated plants could be attributed to better TPC and TFC.

Thus, from the present investigation, it could be concluded that under hot and humid climate of Odisha, foliar application of 600 ppm ethephon in guava during first week of May is effective for reducing rainy crop load and enhancing quantum and quality of winter crop.

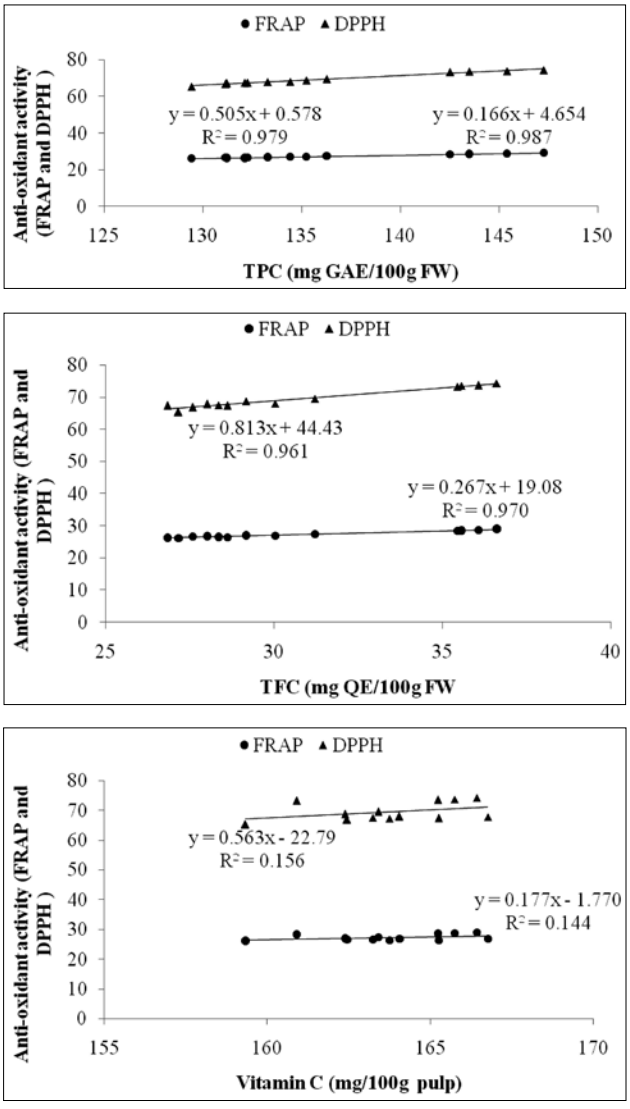

Fig. 3. Relation between anti-oxidant activity and antioxidant compounds in guava fruit.

ACKNOWLEDGEMENTS

Authors are thankful to the Director, ICAR-IIHR, Bengaluru and Head, ICAR-IIHR-CHES, Bhubaneswar for providing facilities and suggestions.

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Received : July, 2019; Revised : January, 2020;
Accepted : February, 2020