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Research Article

CROP REGULATION STUDIES IN GUAVA (*Psidium guajava* L) AT HIGHER ALTITUDE OF NORTHEAST INDIA

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Abstract: A field study was conducted to evaluate the efficiency of some chemicals in crop regulation of guava *cv.* Allahabad Safeda (10 years old) grown at higher altitudes of NE India having humid tropical climate to harvest quality fruits in winter season by avoiding rainy season crop. Removal of summer flush was done at two leaf pair (Stage-I), flower bud emergence (Stage-II) and full bloom (Stage-III) using same chemicals *viz*., Ethephon (600 and 900 ppm); Urea (10 and 15%); NAA (200 and 400 ppm); manual thinning (100%) and control following factorial randomized block design with three replications. Results indicated that, among phenological stages, flower bud emergence stage was found effective in crop regulation with higher physico-chemical quality of fruits during both the season. Spraying of NAA @ 200 ppm at Stage-II recorded delayed full bloom (76 days) and delayed fruit maturity (132 days) was recorded with urea @ 10%. At flower bud emergence stage, deblossoming with NAA @ 200 ppm recorded highest fruit retention (68.42%) and fruit yield (33.38 kg plant^{-1}) followed by urea @ 10% (66.67 % and 31.49 kg plant^{-1}) over control. Similarly, maximum fruit weight (157.45 g) was recorded in NAA @ 200 ppm at flower bud emergence stage followed by urea @ 10% (156.65 g). Fruit firmness was recorded highest in NAA @ 200 ppm application at Stage-III (6.53 kg/cm^2) followed by Stage-II (6.49 kg/cm^2). In fruit quality, spraying of NAA @ 200 ppm at flower bud emergence stage recorded highest TSS: acid ratio (20.00) followed by urea @ 10% (18.96), while ascorbic acid content was recorded highest in urea @ 10% at flower bud emergence stage (186.56 mg/100 g pulp). The findings revealed that the removal of summer season flush using NAA @ 200 ppm or urea @ 10% at flower bud emergence stage was found suitable in promotion of winter season crop in guava at higher altitudes of north east India.

Keywords: *Guava, Growth stage, Chemical maturity, Fruit quality*

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Introduction

Guava (*Psidium guajava* L.) is a delicious fruit belonging to Myrtaceae family cultivated in tropical to subtropical region of the world. Wider adoptability, tolerance to stresses eulogized guava as '*apple of tropics*' and "*super fruit*" due to high nutraceutical value [1]. In humid tropics of NE India, commercial orchards of guava are seen from lower altitudes of Assam to higher altitudes of Sikkim and Arunachal Pradesh having production of 126.33 thousand MT from 9.32 thousand ha area [2].

Generally, guava has two distinct flowering seasons, spring (March-April) and rainy (June-July) from which fruits ripen during rainy and winter season. But at higher altitudes of the NE India having humid climate, guava experiences only one harvest per year (rainy season crop), in which trees flower during April-May and fruit maturity coincides with rainy season *i.e*., August-September followed by sparse flowering and reduced vegetative growth in winter season [3] is the major constraints in production of export quality fruits from the region. Fruits of summer season crop are insipid, watery, poor in taste and quality [4] and prone to biotic and abiotic stress, while fruits of winter season are of superior quality and fetches high monetary returns [5]. Several investigations were made to reduce summer season crop and promote winter crop with better quality using defoliation, deblossom and shoot pruning at different stages [6]; manual thinning [7] and use of bio-regulators *viz*., NAA; urea and ethephon. But results of these experiments were not similar and response differed according to plant health, variety, soil and growing environment.

At higher altitudes, due to distinct winter plant sink strength develop tolerance mechanism to low temperature and drought stress reduces flowering during winter season as a result plant accumulates sufficient food reserves and produce new vegetative growth in summer season. The period from flowering to beginning of harvest in guava varied from 100 days at 8 above msl (hot sub humid) to 180 days at 2016 above msl (semi cool sub humid) and reported only one harvest at higher altitude [8]. Further, exposure of guava plant to low temperature induces biochemical and physiological changes [9], reduces growth with accumulation of anthocyanin in leaf. Considering the above facts, it is essential to develop effective crops regulation technique to harvest winter season crop for making guava cultivation more profitable and export oriented. However, such studies are limited in guava grown at higher altitude of NE India experiencing only one distinct crop per year. Therefore, the aim of present study was to understand the effect of crop regulation practices on maturity, yield and fruit quality of guava *cv.* Allahabad Safeda.

Materials and methods

Study was conducted during 2016 and 2017 on 10 years old guava *cv.* Allahabad Safeda at ICAR RC for NEH Region, Umiam, Meghalaya (91°55' to 92°17' E longitude and 25°41' to 26°22' N latitude) following recommended practices. Experimental site is sandy clay loam in texture, situated at 992 masl. During experiment mean max/min air temperature was 30.2/5.1°C and 28.4/5.5°C, mean max/min RH of 96/42.3% and 90.5/40.8% with precipitation of 2202.4 mm and 2729.7 mm, respectively.

Table-1 *Effect of crop regulation on days to full bloom; fruit maturity and fruit yield in guava cv. Allahabad Safeda*

Treatments	Days to full bloom (Nos.)				Days to fruit maturity (Nos.)				Fruit yield (kg plant^{-1})			
	Stage-I	Stage-II	Stage-III	Mean (T)	Stage-I	Stage-II	Stage-III	Mean (T)	Stage-I	Stage-II	Stage-III	Mean (T)
T_1-Ethephon @600 ppm	66	63	51	60	124	127	128	126	23.87	24.44	11.06	19.79
T_2-Ethephon @900 ppm	63	65	54	61	123	122	122	122	22.69	23.35	10.51	18.85
T_3-Urea @10%	71	70	62	67	124	132	132	129	27.49	31.49	13.86	24.28
T_4-Urea @15%	66	73	61	66	124	125	129	126	24.12	26.05	11.71	20.63
T_5-NAA @200 ppm	74	76	66	72	125	131	131	129	28.20	33.38	16.70	26.10
T_6-NAA @400 ppm	69	73	60	67	123	128	130	127	25.00	28.12	12.37	21.83
T_7-100% thinning	62	60	53	58	124	127	125	125	22.55	20.20	12.92	18.56
T_8-Control (water spray)	53	53	53	53	123	123	123	123	21.88	21.88	21.88	21.88
Mean (S)	65	66	57		124	127	127		24.48	26.11	13.88	
LSD ($P \leq 0.05$)												
Treatment (T)		2.56				2.69				2.76		
Growth Stage (S)		1.57				1.65				1.69		
T x S		4.43				NS				4.78		

Note: Stage-I: Two leaf pair; Stage-II: Flower bud emergence and Stage-III: Full bloom

Table-2 *Effect of crop regulation on fruit set; fruit retention and fruit weight in guava cv. Allahabad Safeda*

Treatments	Fruit set %				Fruit retention %				Fruit weight (g)			
	Stage-I	Stage-II	Stage-III	Mean (T)	Stage-I	Stage-II	Stage-III	Mean (T)	Stage-I	Stage-II	Stage-III	Mean (T)
T_1-Ethephon @600 ppm	72.86(58.61)	62.50(52.27)	49.12(44.50)	61.49 (51.79)	45.00(42.12)	56.25(48.59)	57.14(49.11)	52.80(46.61)	128.31	141.25	145.49	138.35
T_2-Ethephon @900 ppm	66.18(54.58)	57.85(49.54)	49.30(44.59)	57.78(49.57)	40.00(39.22)	57.14(49.11)	50.00(45.00)	49.05(44.44)	131.17	145.03	150.11	142.10
T_3-Urea @10%	75.53 (60.39)	73.25 (59.08)	48.78 (44.30)	65.85 (54.59)	44.00(41.55)	66.67(54.80)	56.25(48.60)	55.64(48.32)	128.45	156.65	153.95	146.35
T_4-Urea @15%	73.07 (58.74)	69.47 (56.48)	50.00 (45.00)	64.18 (53.41)	40.91(39.76)	52.94(46.70)	57.14(49.13)	50.33(45.20)	127.62	151.45	154.11	144.39
T_5-NAA @200 ppm	73.46 (59.01)	69.34 (56.38)	58.59 (50.02)	67.13 (55.14)	41.67(40.19)	68.42(55.88)	66.67(54.75)	58.92(50.27)	127.62	157.45	156.11	147.06
T_6-NAA @400 ppm	74.17 (59.46)	67.42 (55.27)	52.29 (46.31)	64.62 (53.68)	34.78(36.14)	61.11(51.45)	62.50(52.26)	52.80(46.62)	126.25	152.81	150.88	143.31
T_7-100% thinning	78.77(62.56)	67.87(55.47)	46.15(42.79)	64.26(53.61)	33.33(35.25)	46.67(43.08)	50.00(45.00)	43.33(41.11)	130.35	131.19	136.04	132.53
T_8-Control (water spray)	83.22 (65.83)	83.22 (65.83)	83.22 (65.83)	83.22 (65.83)	31.25(33.93)	31.25(33.93)	31.25(33.93)	31.25(33.93)	114.42	114.42	114.42	114.42
Mean (S)	74.66 (59.90)	68.87 (56.29)	54.68 (47.92)		38.87(38.52)	55.06(47.94)	53.87(47.22)		126.77	143.78	145.14	
LSD ($P \leq 0.05$)												
Treatment (T)		2.76				2.64				3.04		
Growth Stage (S)		1.69				1.61				1.86		
T x S		4.79				4.57				5.26		

*Note: Stage-I: Two leaf pair; Stage-II: Flower bud emergence and Stage-III: Full bloom. *Figure in parentheses indicate Arcsine transform value*

Table-3 *Effect of crop regulation on TSS:acid ratio and ascorbic acid content in guava cv. Allahabad Safeda*

Treatments	Fruit firmness (kg/cm^2)				TSS:acid ratio				Ascorbic acid (mg/100 g pulp)			
	Stage-I	Stage-II	Stage-III	Mean (T)	Stage-I	Stage-II	Stage-III	Mean (T)	Stage-I	Stage-II	Stage-III	Mean (T)
T_1Ethephon @ 600 ppm	4.80	5.64	6.00	5.48	11.38	15.13	17.68	14.73	140.33	169.05	171.64	160.34
T_2Ethephon @ 900 ppm	4.66	5.50	5.81	5.32	10.74	14.42	17.21	14.12	143.65	175.38	178.23	165.75
T_3-Urea @1 0%	4.90	6.15	6.32	5.79	12.16	18.96	17.67	16.26	148.88	186.56	182.78	172.74
T_4-Urea @ 15%	4.86	5.99	6.11	5.65	11.54	16.92	18.31	15.59	142.77	179.72	182.45	168.31
T_5-NAA @ 200 ppm	5.11	6.49	6.53	6.04	12.64	20.00	19.16	17.27	144.99	173.05	180.40	166.15
T_6-NAA @ 400 ppm	5.00	6.18	6.31	5.83	13.21	15.75	18.60	15.86	139.99	177.11	178.20	165.10
T_7-100% thinning	4.48	5.20	5.32	5.00	10.00	13.01	16.58	13.20	136.10	163.00	166.60	155.23
T_8-Control (water spray)	4.03	4.03	4.03	4.03	9.70	9.70	9.70	9.70	132.12	132.12	132.12	132.12
Mean (S)	4.73	5.65	5.80		11.42	15.49	16.86		141.10	169.50	171.55	
LSD ($P \leq 0.05$)												
Treatment (T)		0.28				1.24				5.03		
Growth Stage (S)		0.17				0.76				3.08		
T x S		0.49				2.15				8.71		

Note: Stage-I: Two leaf pair; Stage-II: Flower bud emergence and Stage-III: Full bloom

Treatments consisted of removal of summer flush at three growth stages *viz*., two leaf pair (Stage-I), flower bud emergence (Stage-II) and full bloom (Stage-III) using same chemicals *viz*., T1-Ethephon @ 600ppm; T2-Ethephon @ 900ppm; T3-Urea @ 10%; T4-Urea @ 15%; T5-NAA @ 200ppm; T6-NAA @ 400ppm; T7-100 per cent manual thinning and T8-control. During 2016, treatments were imposed on 10th March (Stage-1); 7th April (Stage-II) and 2nd May (Stage-III) and during 2017, treatments were imposed on 16th March (Stage-1); 11th April (Stage-II) and 7th May (Stage-III). NAA was sprayed after dissolving in alcohol with solution of respective concentration. Water soluble chemicals ethephon and urea were sprayed with water at respective stage and repeated at 10 days after first application. In manual hand thinning leafs, buds and flowers were removed by hands at respective growth stages. Trees of uniform vigour were selected to record days to full bloom and fruit maturity; fruit set (%); fruit retention (%) and yield (kg plant^{-1}). Fruit yield was calculated by multiplying number of fruits with mean fruit weight. Fruit weight (g) was determined by weighing balance. Fruit firmness (kg/cm^2) was measured using a Stable Micro System TA-XT-plus texture analyzer (Texture Technologies Corp., UK). TSS (°B) was recorded using refractometer, titratable acidity (%) and ascorbic acid (mg/100g) were determined following standard method [10] and TSS:acid ratio was work out. Experiment was laid out in Factorial Randomized Block Design (FRBD) and treatments were replicated thrice with three trees in each treatment each replication. Pooled data of two years were analyzed by ANOVA using statistical software programme SPSS version 17.0 and difference were considered statistically significant at P=0.05.

Results and discussion

Removal of summer season flushes altered the days to full bloom and fruit maturity in guava *cv.* Allahabad Safeda [Table-1]. Maximum days to full bloom was recorded in deblossoming done at flower bud emergence stage-II (66 days) followed by two leaf pair stage-I (65 days), while minimum at full bloom stage-III (57 days). Among treatment T5 (NAA @ 200 ppm) took maximum days to full bloom (72 days). In interaction, T5xS2 (NAA @ 200 ppm x Stage-II) recorded maximum days to full bloom (76 days). Earliest fruit maturity was recorded in Stage-I (124 days) while, delayed fruit maturity in Stage-II and Stage-III (127 days each). Among treatment T3 and T5 took maximum days to fruit maturity (129 days each), while minimum was notice in T2-Ethephon @ 900 ppm (122 days) and control (123 days).

Interaction was found non-significant for days to fruit maturity. Advancement in fruit maturity by week in rainy and two weeks in winter season with ethephon reported [11]. Delayed flowering and fruit maturity with NAA and urea might be due to partitioning of photo-assimilate through modification in source-sink which leads to regulate natural flowering and promoted early winter crops in guava. Fruits ripen after second fortnight of October is of superior quality is reported by other coworkers. Pooled results were significant for fruit set and fruit retention [Table-2]. Linear decrease in fruit set was recorded with advance in growth stages from Stage-I (74.66%) to Stage-III (54.68%). Among treatments, least reduction in fruit set was recorded in T5 (67.13%) at par with T3 (65.85%) but significantly lower than control (83.22%). In interaction, treatment T7xS1 (78.77%) recorded minimum reduction in fruit set. Deblossoming at Stage-II (55.06%) recorded highest fruit retention at par with Stage-III (53.87%), while lowest in Stage-I (38.87%). Among treatments, highest fruit retention was recorded in T5 (58.92%) while lowest in T8 (31.25%). Interaction, significantly highest fruit retention was recorded in T5xS2 (68.42%) at par with T3xS2 and T5xS3 (66.67 % each). Removal of summer flush at different growth stages interrupt metabolite partitioning and less disturbances was observed at two leaf pair stage, produced maximum fruit set with low fruit retention might be due to fruit maturity coincided with rainy season (September). However, at flower bud emergence stage, deblossoming with NAA (200 ppm) and urea (10%) recorded significantly higher fruit retention due to optimum destruction and creation of food reserves and channelizing energy available for vegetative growth to reproductive growth.

Effect of crop regulation at different growth stages on fruit yield was significant [Table-1]. The Stage-II recorded maximum fruit yield (26.11 kg plant^{-1}) at par with Stage-I (24.48 kg plant^{-1}), while minimum at Stage-III (13.88 kg plant^{-1}). Among treatments, T5 recorded highest fruit yield (26.10 kg plant^{-1}) at par with T3 (24.28 kg plant^{-1}) while significantly lowest fruit yield was recorded in control (21.88 kg plant^{-1}). From interaction it is clear that, T5xS2 produced highest fruit yield (33.38 kg plant^{-1}) followed by T3xS2 (31.49 kg plant^{-1}). In present experiment, deblossoming with NAA (200 ppm) followed by urea (10%) at flower bud emergence stage significantly increased fruit yield in guava *cv.* Allahabad Safeda. Thus, application of chemicals at appropriate growth stages decides fruit yield in forthcoming season by creation and destruction of food reserves [11,12].

Fruit weight is important parameter in terms of influences consumer acceptance. The crop regulation using chemicals at full bloom stage [Table-2] noticed highest fruit weight (145.14 g) followed by flower bud emergence Stage (143.78 g). Significantly highest fruit was recorded in treatment NAA @200 ppm (147.06 g) followed by Urea @10% and Urea @15%. In interaction effect, treatment combination of NAA @200 ppm x flower bud emergence stage (T5xS2) recorded highest fruit weight (157.45 g) followed by Urea @10% x flower bud emergence stage (156.65 g). Fruit firmness [Table-3] is used to assess the quality at harvest and was recorded highest in full bloom Stage (5.80 kg/cm^2) followed by flower bud emergence Stage (5.65 kg/cm^2). Firmness of the fruit was observed highest in treatment NAA @200 ppm (6.04 kg/cm^2). Among the treatment combinations, NAA @200 ppm x full bloom stage recorded highest fruit firmness (6.53 kg/cm^2) followed by T5xS2 (6.49 kg/cm^2). The above results may be due to optimum utilization of essential nutrients from the source organ to the fruit [13] due to different crop regulation treatments leads to higher firmness and chemical constituents in winter fruit [14].

In fruit quality, TSS:acid ratio of fruit is measure of sugar versus acidity gives fruits characteristic taste and flavour. Highest TSS:acid ratio [Table-3] was recorded in Stage-III (16.86) while lowest in Stage-I (11.42). Among treatments, highest TSS:acid ratio was recorded in T5 (17.27) followed by T3 (16.26). In interaction, T5xS2 recorded highest TSS:acid ratio (20.00) followed by T3xS2 (18.96). Ascorbic acid used in judging the fruits antioxidant and reducing capacity [Table-3] and recorded highest in Stage-III (171.55 mg/100 g pulp) at par with Stage-II (169.50 mg/100 g pulp). Among treatments, highest ascorbic acid was recorded in T3 (172.74 mg/100 g pulp). In interaction, T3xS2 recorded highest ascorbic acid content (186.56 mg/100 g pulp). Treatments shown positive effect on fruit quality *viz*., TSS:acid ratio and ascorbic acid suggested a slight advancement, might be due to more synthesis, transport and accumulation of nutrients during winter season. These results are in line with 10 and 14.

Conclusion

Removal of summer season flush using NAA (200 ppm) or urea (10 %) at flower bud emergence stage was found suitable in promoting winter season crop in guava *cv.* Allahabad Safeda at higher altitudes of NE India.

Application of research: Results are helpful in effective utilization of chemicals in harvest of winter season crop in guava at higher altitude

Research Category: Horticultural crops

Abbreviations: % - Per cent, kg plant^{-1}- Kilogram per plant
mg- milligram, g- Gram, cm^2- Centimetre square

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Author Contributions: All authors equally contributed

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Study area / Sample Collection: Horticultural Experimental Farm, Umiam, 793103, Meghalaya

Cultivar / Variety / Breed name: Guava (*Psidium guajava* L) *cv.* Allahabad Safeda

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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