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Effect of bio-regulators on yield of guava (*Psidium guajava* L.) cv. Arka mridula and Arka amulya

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Abstract
An experiment was undertaken to study the effect of GA_3, NAA, BRs and ethrel on yield of guava cv. Arka mridula and Arka Amulya. Two guava varieties (12 year old trees of Arka mridula and Arka Amulya) and nine levels of bio-regulators (GA_3 50 and 100 ppm, NAA 100 and 500 ppm, BRs 0.5 and 1.0 ppm and ethrel 500 and 1000 ppm) comprised the treatment combinations. The experiment was laid out in factorial randomized block design with nine treatments and three replications in two season's *viz.*, June to July and January to February. Maximum values for fruit length, fruit diameter, fruit weight, fruit volume and yield per tree were observed in GA_3 50 ppm. The maximum fruit set percentage and number of fruits per tree was recorded in NAA 500 ppm, while the minimum values were recorded in control in both the seasons.

Keywords: guava, bio-regulators and yield characters

Introduction
Guava (*Psidium guajava* L.) is one of the most common and important fruit crop cultivated all over India. Botanically guava belongs to the family Myrtaceae. It is classified under the genus Psidium, which contains 150 species, but only *Psidium guajava* has been exploited commercially. It is called as "Apple of the Tropics" and is grown successfully throughout the tropical and subtropical region of India. It is one of the hardiest fruit trees, adaptable to a variety of soil and climatic conditions. Guava is an attractive fruit in appearance, shape, fragrance, nutritious and delicious with pleasing aroma. Guava is not only a delicious table fruit, but is also important in the processing industry. It is well suited for making jam, jelly, dried powder and fruit butter. The fruit is an excellent source of vitamin C, pectin, sugar, carbohydrate and contains an appreciable amount of minerals such as phosphorus, calcium and iron. Low percentage of flowering and fruiting, poor fruit retention, poor yield and quality fruits in guava are of major concern to the fruit grower. Plant growth regulators as foliar applications are the most powerful tools for manipulating tree growth, flowering, and yield and fruit quality particularly fruit size, as well as, controlling fruit maturation. Hence the present investigation was undertaken to find out the response of bio-regulators on the flowering and yield of guava cultivars Arka mridula and Arka Amulya.

Research methods
The present investigation on the effect of bio-regulators on yield of guava cv. Arka mridula and Arka Amulya was conducted at the orchard of the Department of Horticulture, Faculty of Agriculture, and Annamalai University during 2013-2015. Twelve year old plants of uniform size and vigour planted at 6 X 6 m were selected for the study. The experiment was conducted in factorial randomized block design with nine treatments and three replications. The treatments comprising of GA_3 50 and 100 ppm, NAA 100 and 500 ppm, BRs 0.5 and 1.0 ppm and ethrel 500 and 1000 ppm and control were applied as foliar spray. The spraying was done thrice *viz.*, first spray was given before flowering, second spray was given after 50 percent flowering and third spray was given at pea stage. The observations on fruit set percentage, number of fruits per tree, fruit weight and yield per tree were recorded according to the standard procedures. The data were statistically analysed as applicable to Factorial Randomized Block Design (Panse and Sukhatme, 1978) [7].

Research findings and discussion
It can be observed from the data in Table 1 that the fruit set percentage showed significant

differences among the varieties. In the variety Arka mridula, it was significantly higher when compared to the variety Arka Amulya in season I and season II respectively. In both the seasons, T_4 (NAA 500 ppm) registered the highest fruit set percentage of respectively. The least fruit set percentage was observed in T_9 (control) in both the seasons. Season I recorded highest fruit set percentage when compared to season II. Significant effects were observed with regard to the interaction between varieties and treatments. The maximum fruit set percentage of was recorded in T_4V_1 in season I and season II, while T_9V_2 registered the least fruit set percentage in season I and season II respectively. Exogenous application of NAA along with natural endogenous auxins might have been responsible for the increase in fruit set as opined by Agnihotri *et al.,* (2013) [1] in guava.

Statistically significant differences were observed for number of fruits per tree among the varieties in both the seasons over the control (Table 2). Maximum number of fruits per tree was observed in Arka mridula, while Arka Amulya recorded the least number of fruits per tree in both the seasons respectively.T_4 (NAA 500 ppm) registered higher number of fruits per tree, while T_9 (control) was found to record the least number of fruits per tree in season I and season II respectively. Interaction between treatments and varieties was found to be significant. Higher number of fruits per tree was noticed in T_4V_1 in season I and season II respectively, while the least number of fruits per tree was observed in T_9V_2 in both the seasons. The increase in the number of fruits was associated with increased production of flowers, more fruit setting and higher fruit retention. This result is in conformity with the findings of Gaikwad *et al.,* (2011) [3] in guava. NAA increases the photosynthetic efficiency of the plant which resulted in the increased number of fruits as observed by Singh and Rethy (1996) [11].

Fruit length and diameter showed significant differences among the varieties (Table 3 & 4). Maximum fruit length and diameter was recorded in Arka mridula when compared to Arka Amulya in season I and season II respectively. In both the seasons, T_1 (GA_3 50 ppm) recorded maximum fruit length and diameter respectively when compared to the control (T_9) which registered the fruit length and diameter in season I and season II respectively. T_2 (GA_3 100 ppm) was found to be the next best treatment, which recorded a fruit length and diameter in season I and season II respectively. Interaction between varieties and treatments was found to be significant. Maximum fruit length and diameter was recorded in T_1V_1 in both the seasons respectively, while T_9V_2 registered the least fruit length and diameter in season I and season II. The reason for increase in fruit size in terms of length and girth due to GA_3 application might be due to the increased levels of carbohydrates and also GA_3 might have stimulated cell division and cell elongation resulting in larger fruit size as reported by Singh and Phogat, (1984) [10].

The results of the present study revealed that the fruit volume was significantly influenced by the application of various bio-regulators (Table 5). The fruit volume was maximum in Arka mridula, while Arka Amulya recorded the least fruit volume in both the seasons. The fruit volume was highest in GA_3 50 ppm, while the least fruit volume was observed in the control in both the seasons. The interaction effect of varieties and treatments was significant for this trait. T_1V_1 recorded the maximum fruit volume, while the least fruit volume was observed in T_9V_2 in both the seasons respectively. The reason for increase in fruit volume under GA_3 50 ppm application might be due to the increase in the fruit size and accumulation of more pulp. This result is in conformity with the earlier reports of Pandey *et al.* (2001) [6] and Narayan *et al.* (2013) [5] in guava,

The data presented in table 6 revealed that both the varieties recorded significantly higher fruit weight over the control in both the seasons. Among the varieties, Arka mridula recorded the highest fruit weight in season I and II respectively. The maximum fruit weight was observed in GA_3 50 ppm, while the least values for fruit weight was recorded in the control in both the seasons. Significant effects were observed with regard to the interaction between varieties and treatments. The highest fruit weight was recorded in T_1V_1 in both the seasons, while the least fruit weight was observed in T_9V_2 in season I and season II respectively. GA increased fruit weight which may be due to the fact that GA is associated with cell division and cell enlargement as reported by Ravi Kher and Bhat (2005) [8] and Singh *et al.,* (2009) [12] in guava.

The data with respect to yield per tree is given in table 7. Among the varieties, highest yield was observed in Arka mridula when compared to Arka Amulya in season I and season II respectively. The highest yield was recorded in $GA_3$50 ppm, while the least yield was recorded in the control. The interaction effect was significant for this trait. Among the varieties and treatments, T_1V_1 recorded the highest yield in both the seasons, while the least yield was recorded in T_9V_2 in season I and season II. Role of GA_3 in stimulating both cell division and cell enlargement which reflected on increased fruit weight and directly increased fruit yield was reported by Moore (1979) [4]. Similar results were also observed by Shinde *et al.* (2008) [9] and Debaje *et al.* (2010) [2] in acid lime.

It can be concluded from the findings of the present study that the performance of guava crop was found to be better in season I (June to July) when compared to season II (January to February). The guava cv. Arka mridula excelled Arka Amulya with regard to the yield parameters. Based on the performance of guava in terms of yield with the application of bio-regulators, it can be concluded that application of GA_3 50 ppm can be recommended for maximizing the yield of guava.

Table 1: Effect of bio-regulators on fruit set percentage in guava cv. Arka mridula and Arka Amulya

Treatments	Fruit set percentage					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	91.00	88.22	89.61	89.90	86.68	88.29
T_2- GA_3 100 ppm	80.30	79.92	80.11	87.30	77.29	82.29
T_3- NAA 100 ppm	89.90	86.16	88.03	81.90	80.06	80.98
T_4- NAA 500 ppm	96.10	91.64	83.86	94.21	89.85	92.03
T_5- Brassinosteroids 0.5 ppm	83.50	81.72	82.61	79.25	74.47	76.86
T_6- Brassinosteroids 1.0 ppm	78.70	75.92	77.31	76.34	75.90	76.12
T_7- Ethrel 500 ppm	85.10	82.63	93.86	83.50	75.02	79.26

T_8- Ethrel 1000 ppm	81.90	80.51	81.20	80.23	71.88	75.55
T_9- Control	73.60	71.05	72.32	70.21	68.30	69.30
V- Mean	84.44	81.97	83.21	82.42	77.71	80.06

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.39	0.78	T	0.37	0.75
V	0.35	0.70	V	0.33	0.67
T X V	0.69	1.38	T X V	0.65	1.31

Table 2: Effect of bio-regulators on number of fruits per tree in guava cv. Arka mridula and Arka Amulya

Treatments	Number of fruits per tree					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	204.42	199.69	202.05	197.63	193.25	195.44
T_2- GA_3 100 ppm	186.32	172.90	179.61	181.36	166.32	173.84
T_3- NAA 100 ppm	196.21	192.37	194.29	195.63	186.66	191.14
T_4- NAA 500 ppm	208.63	204.30	206.46	201.09	198.12	199.60
T_5- Brassinosteroids 0.5 ppm	171.36	168.02	169.69	166.32	161.65	163.98
T_6- Brassinosteroids 1.0 ppm	163.91	162.32	163.11	160.98	156.21	158.59
T_7- Ethrel 500 ppm	176.28	173.42	174.85	172.86	169.69	171.75
T_8- Ethrel 1000 ppm	170.63	167.16	168.89	164.51	153.62	159.06
T_9- Control	152.19	150.21	151.20	150.32	146.84	148.58
V- Mean	181.10	176.71	178.90	176.74	170.26	173.50

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.69	1.38	T	0.59	1.19
V	0.60	1.21	V	0.51	1.03
T X V	1.12	2.23	T X V	1.00	2.01

Table 3: Effect of bio-regulators on fruit length (cm) in guava cv. Arka mridula and Arka Amulya

Treatments	Fruit length(cm)					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	9.60	6.31	7.95	7.99	5.98	6.98
T_2- GA_3 100 ppm	8.20	6.09	7.14	7.31	5.62	6.46
T_3- NAA 100 ppm	7.88	5.82	6.85	6.23	4.88	5.55
T_4- NAA 500 ppm	6.95	6.01	6.48	7.20	5.00	6.10
T_5- Brassinosteroids 0.5 ppm	5.95	4.59	5.27	5.20	4.21	4.70
T_6- Brassinosteroids 1.0 ppm	6.72	5.36	6.04	6.12	3.69	4.90
T_7- Ethrel 500 ppm	5.02	4.01	4.51	4.23	3.03	3.63
T_8- Ethrel 1000 ppm	5.46	4.12	4.79	4.98	3.21	4.09
T_9- Control	4.98	3.21	4.09	3.92	3.01	3.46
V- Mean	6.75	5.05	5.90	5.90	4.29	5.01

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.10	0.21	T	0.09	0.18
V	0.08	0.17	V	0.07	0.10
T X V	0.15	0.32	T X V	0.13	0.25

Table 4: Effect of bio-regulators on fruit diameter (cm) in guava cv. Arka mridula and Arka Amulya

Treatments	Fruit diameter(cm)					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	7.27	7.01	7.14	7.13	6.96	7.04
T_2- GA_3 100 ppm	7.06	6.86	6.96	6.92	6.72	6.82
T_3- NAA 100 ppm	6.86	6.12	6.49	6.50	6.02	6.26
T_4- NAA 500 ppm	6.92	6.00	6.21	6.73	5.99	6.36
T_5- Brassinosteroids 0.5 ppm	5.93	5.21	5.57	5.61	5.42	5.51
T_6- Brassinosteroids 1.0 ppm	6.12	5.93	6.02	6.01	5.83	5.92
T_7- Ethrel 500 ppm	5.04	4.97	5.00	4.63	4.32	4.47
T_8- Ethrel 1000 ppm	5.66	5.03	5.34	4.98	4.93	4.95
T_9- Control	4.51	4.32	4.41	4.32	3.98	4.15
V- Mean	6.15	5.71	5.90	5.87	5.57	5.72

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.09	0.18	T	0.05	0.11

V	0.05	0.10	V	0.04	0.09
T X V	0.11	0.23	T X V	0.10	0.20

Table 5: Effect of bio-regulators on fruit volume (cc) in guava cv. Arka mridula and Arka Amulya

Treatments	Fruit volume(cc)					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	176.25	151.91	164.08	167.66	148.61	158.13
T_2- GA_3 100 ppm	140.67	136.98	138.82	135.30	134.41	134.85
T_3- NAA 100 ppm	125.83	123.11	124.47	124.65	120.63	122.34
T_4- NAA 500 ppm	110.30	118.38	109.41	107.98	112.33	110.15
T_5- Brassinosteroids 0.5 ppm	101.33	108.53	104.93	98.63	102.63	100.63
T_6- Brassinosteroids 1.0 ppm	89.67	99.38	94.52	86.21	92.11	89.16
T_7- Ethrel 500 ppm	126.33	102.53	114.43	124.93	99.96	112.44
T_8- Ethrel 1000 ppm	100.67	98.38	99.52	98.21	95.06	96.63
T_9- Control	89.59	76.17	82.88	77.12	74.08	75.60
V- Mean	117.85	111.04	114.47	113.34	108.87	111.03

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.85	1.71	T	0.81	1.63
V	0.79	1.53	V	0.75	1.51
T X V	1.60	3.20	T X V	1.51	3.02

Table 6: Effect of bio-regulators on fruit weight (g) in guava cv. Arka mridula and Arka Amulya

Treatments	Fruit weight(g)					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	180.37	177.20	178.78	172.63	169.63	171.13
T_2- GA_3 100 ppm	143.29	140.20	141.74	139.06	136.29	137.67
T_3- NAA 100 ppm	106.60	103.86	105.28	101.18	100.61	100.89
T_4- NAA 500 ppm	109.67	100.63	105.15	105.61	96.00	100.80
T_5- Brassinosteroids 0.5 ppm	101.33	96.28	98.80	98.12	90.21	94.16
T_6- Brassinosteroids 1.0 ppm	90.31	88.76	89.53	88.11	85.62	86.86
T_7- Ethrel 500 ppm	100.68	93.54	97.11	96.06	89.98	93.02
T_8- Ethrel 1000 ppm	105.33	98.00	101.66	98.41	92.51	95.46
T_9- Control	80.33	76.26	78.29	78.21	76.09	77.15
V- Mean	113.10	108.30	110.70	108.60	104.10	106.35

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.76	1.53	T	0.58	1.16
V	0.90	1.80	V	0.65	1.30
T X V	1.60	3.21	T X V	1.19	2.39

Table 7: Effect of bio-regulators on yield (kg/tree) in guava cv. Arka mridula and Arka Amulya

Treatments	Yield (kg per tree)					
	Season I			Season II		
	V_1-Arka mridula	V_2- Arka Amulya	T-Mean	V_1-Arka mridula	V_2- Arka Amulya	T-Mean
T_1-GA_3 50 ppm	34.10	32.06	33.08	32.31	30.05	31.08
T_2- GA_3 100 ppm	32.23	30.29	31.26	30.75	28.56	29.65
T_3- NAA 100 ppm	30.36	27.68	29.02	27.01	21.06	24.03
T_4- NAA 500 ppm	30.28	28.61	29.94	29.91	23.69	26.80
T_5- Brassinosteroids 0.5 ppm	27.23	23.21	25.22	27.92	19.69	23.80
T_6- Brassinosteroids 1.0 ppm	29.16	27.00	28.08	27.81	20.53	24.16
T_7- Ethrel 500 ppm	23.10	19.82	21.46	22.45	18.03	20.24
T_8- Ethrel 1000 ppm	26.62	20.61	23.61	24.82	19.23	22.02
T_9- Control	19.62	18.21	18.91	18.63	16.62	17.16
V- Mean	28.18	25.27	26.73	26.84	21.93	24.39

Factor	S. Ed.	CD(p=0.05)	Factor	S. Ed.	CD(p=0.05)
T	0.31	0.62	T	0.29	0.58
V	0.25	0.50	V	0.21	0.43
T X V	0.55	1.10	T X V	0.50	1.01

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