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Influence of plant growth substances on vegetative growth, flowering, fruiting and fruit quality of papaya

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ABSTRACT

The study revealed that gibberellic acid - GA_3 (100 and 150 ppm) increased the vegetative growth of papaya plant in terms of height and physical characters of fruit in terms of length, diameter and weight while 2, 3, 5 - triodo benzoic acid - TIBA (100 and 150 ppm) had a greater effect on increasing the girth of stem, spread of plant, number of fruits per plant and yield per plant. Among the PGRs, TIBA (100 and 150 ppm) and ethrel (200 and 300 ppm) proved to be best particularly in the reduction of number of days taken for sex differentiation and promotion of femaleness, respectively while both TIBA and ethrel were found to be best for improving the quality of fruit. Therefore, it is worthwhile to manipulate these plant growth substances for getting desirable characters like vegetative growth, appropriate sex form and better quality fruits in papaya.

Key words: Papaya, plant growth regulators, vegetative growth, flowering, fruiting, quality.

INTRODUCTION

Presently, papaya (*Carica papaya* L.) is one of the most important fruit crops of the tropical and sub-tropical countries of the world. Its ease in cultivation and quick return has attracted farmers for its cultivation on large scale (Drew *et al*., 5). India accounts for the production of 2.15 million tonnes of papaya out of 5.0 million tonnes produced in the world (Anon, 2). The net profit per ha of papaya cultivation for 30 months crop period is estimated to be around Rs. 1.56 lakhs in sub-tropical conditions (Singh *et al*., 11). According to a revised draft report prepared by Mittal (18) our country was marked 5th in production with 8.14 per cent share out of total world's production of papaya in 2004. It is a rich source of vitamins and minerals; several processed products are prepared from it.

Besides, the milky latex containing papaya is valued as an industrial product. In recent years attention has been mainly directed to the use of different PGRs in modification of growth, flowering, fruiting, fruit quality and yield of different fruits and vegetable crops. Different plant growth regulators are very effective in controlling and directing a number of plant metabolic processes. Keeping in view the above points, an experiment was laid out to find out the effect of different plant growth regulators on vegetative growth, flowering, fruiting and fruit quality of papaya.

MATERIALS AND METHODS

The present investigation was conducted at the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P during the period 2005-07. The variety Pusa Dwarf (1-45 D), a selection is very popular dwarf variety in Eastern UP for commercial production, was taken for this investigation. Four PGRs each at three levels (NAA - 50, 100 and 150 ppm; TIBA- 50, 100 and 150 ppm; GA_3 - 50, 100 and 150 ppm, and ethrel - 200, 250 and 300 ppm) along with control were tried using RBD design with three replications. Spraying of PGRs was done three times by hand sprayer as per treatment - the first one at 4-leaf stage, the second one at 6-leaf stage and the third one at 8-leaf stage - to wet both sides of the leaves. The control seedlings were sprayed with distilled water. The seedlings were transplanted in the pit size of 0.5 × 0.5 × 0.5 m at a distance of 1.8 m × 1.8 m. In order to assess the effect of various treatments more accurately all the plants were subjected to uniform cultural practices during the period of experimentation. The data on vegetative growth, flowering, fruiting and fruit quality were recorded and subjected for statistical analysis.

RESULTS AND DISCUSSION

The vegetative growth in terms of height of plant was significantly increased over the control due to application of GA_3 at various concentrations. Maximum height was recorded with GA_3 150 ppm (42.58 cm) followed by GA_3 100 ppm (40.10 cm) and GA_3 50 ppm (39.04 cm), whereas the minimum height was recorded in control at 200 days after sowing (Table 1). Since Pusa Dwarf variety of papaya is genetically a dwarf variety none of the PGRs under study had any dwarfing effect on it. However, GA_3 has a tendency to increase the height of plant due to its ability on overcoming genetic dwarfism mainly by cell division and cell

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elongation. Vu and Yelenosky (14) also reported increase in growth of rough lemon (*Citrus jambhiri* L.) with application of GA_3 at various levels.

TIBA at 150 ppm had a significant effect on increasing the girth of stem (2.65 cm) and spread of plant (9981.33 cm^2) followed by TIBA 100 ppm (2.58 cm and 9752.66 cm^2) and TIBA 50 ppm (2.57 cm and 9543.33 cm^2) respectively, while ethrel recorded minimum values especially with increase in its concentration at 200 days after sowing (Table 1). It has been established by many scientists working with a number of fruit crops, *e.g.* mango, citrus, papaya, etc. that plant growth regulators particularly ethrel decreases the growth of shoot with increased rate of concentration. Ethrel releases ethylene which regulates the growth by altering the transport or metabolism of auxin and also stimulates important enzyme systems associated with cell membrane, thus aiding in the excretion of certain enzymes important for growth (Weaver, 15).

From Table 1 it is evident that plants treated with different concentrations of TIBA (150, 100 and 50 ppm) required minimum number of days for sex differentiation (207, 208.3 and 211.6 days, respectively) while control treatment plants took more days (241.6). All the treatments, which showed less number of days for sex differentiation compared to control, ascertained that PGRs promote early sex differentiation especially TIBA promotes formation and translocation of flowering stimulus as hormones from leaf to axil of leaves. Ethrel played a greater role in changing the sex forms of papaya flowers where 300 ppm ethrel recorded maximum number of female flowers (88.87) and minimum male flowers (11.17) followed by 250 ppm (77.57 and 22.23) and 200 ppm ethrel (77.40 and 22.58, respectively). Ethrel is found to be very effective in inducing flowering in the 'off' years in mango. Promotion of female flowers in pineapple by application of ethrel has been reported by Edgerton and Greenhalgh (6) in apple and peach, Chacko *et al.* (3, 4), in mango. Maximum female flowers with ethrel is due to its role in the translocation from DNA to RNA and then to protein and may also be due to incorporation of ethylene in RNA, which would contribute to the regulation of flowering (Weaver, 15). However, lower concentrations of TIBA and NAA (50 ppm each) and control treatment recorded minimum female flowers.

Foliar spraying of different concentrations of growth substances clearly indicated that length, diameter and weight of fruit were significantly improved in all the treatments than control (Table 2). Maximum value was obtained under GA_3 100 ppm (16.3 cm) followed by GA_3 150 ppm (15.9 cm). The physiological basis for increase in fruit size and weight appears to be due to an increase in growth rate by cell division and cell enlargement and an alteration in maturity of fruit (Weaver, 15). The increase in fresh weight and size of fruit may also be explained by the fact that hormones play a regulatory role in the mobilization of metabolites within the plant and it is a well established fact that developing fruits are the extremely active metabolites 'sink', which mobilize metabolites and their flow from vegetative structure (Weaver, 15).

Table 1. Effect of plant growth regulators on vegetative growth and flowering of papaya.

Treatment (ppm)	Height (cm)			Girth of stem (cm)			Spread (cm^2)			Days to sex differentiation	Sex forms	
	70 DAS	135 DAS	200 DAS	70 DAS	135 DAS	200 DAS	70 DAS	135 DAS	200 DAS		No. of male flowers	No. of female flowers
NAA - 50	7.89	17.08	33.11	0.69	1.89	2.3	1236.66	3270.00	8989.33	232.00	55.70	44.27
NAA - 100	7.55	15.39	34.19	0.75	1.9	2.28	1218.00	3360.66	9378.00	232.00	44.77	55.53
NAA - 150	8.18	16.11	34.21	0.78	1.92	2.29	1279.33	3333.33	9481.33	235.00	33.57	66.00
TIBA - 50	8.34	16.21	34.05	0.86	2.02	2.57	1355.37	4143.33	9543.33	211.66	66.73	33.53
TIBA - 100	8.21	16.38	34.18	0.91	2.02	2.58	1068.00	4481.33	9752.66	208.33	44.53	55.67
TIBA - 150	8.64	15.42	32.92	0.96	2.08	2.65	1290.00	4362.66	9981.33	207.00	33.40	66.45
GA_3 - 50	13.04	27.99	39.04	0.67	1.83	2.34	1283.33	3642.00	9360.66	237.66	33.57	66.4
GA_3 - 100	12.87	26.41	40.1	0.77	1.82	2.32	1291.00	3648.66	9320.66	232.66	33.54	66.4
GA_3 - 150	13.08	24.01	42.58	0.77	1.84	2.31	1353.00	3550.00	9162.66	233.66	55.47	44.57
Ethrel - 200	8.04	14.14	28.07	0.86	1.85	2.27	906.66	3204.00	8745.33	235.33	22.58	77.4
Ethrel - 250	8.17	16.08	28.26	0.76	1.74	2.25	1006.00	3245.33	9076.66	236.33	22.23	77.57
Ethrel - 300	8.35	18.14	27.88	0.87	1.78	2.23	937.33	3238.66	9033.33	233.33	11.17	88.87
Control (Dis. water)	6.86	15.86	24.55	0.72	1.74	2.25	1084.33	3357.33	8930.00	241.66	55.33	44.27
CD at 5%	0.29	0.14	0.5	0.03	0.02	0.05	11.92	5.72	20.64	8.45	5.76	4.41

Table 2. Effect of plant growth regulators on physical and chemical characters of papaya fruit.

Treatment (ppm)	Fruit length (cm)			Fruit diameter (cm)			No. of fruits / plant	Weight of fruit (g)	No. of seeds/ fruit	Yield/ plant (kg)	TSS (%)	Acidity (%)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS						
NAA - 50	6.63	10.50	15.20	4.15	6.90	9.50	23.66	850	26.0	19.61	8.50	0.0980
NAA - 100	5.63	5.80	12.80	4.00	7.40	9.35	24.00	880	22.0	21.00	9.30	0.1030
NAA - 150	4.53	8.30	11.50	4.30	7.60	9.20	23.33	460	19.4	11.00	9.00	0.0990
TIBA - 50	5.13	8.60	12.30	4.50	7.50	10.20	25.00	715	27.0	18.00	10.00	0.1030
TIBA - 100	6.00	9.30	14.00	4.80	8.00	10.40	33.00	660	26.5	23.60	10.50	0.1020
TIBA - 150	5.80	8.90	12.80	4.80	7.60	10.23	34.00	730	20.0	24.90	10.80	0.1045
GA_3 - 50	8.00	11.80	15.20	5.80	8.80	11.50	24.66	900	16.0	20.00	9.50	0.0980
GA_3 - 100	8.50	13.00	16.30	6.30	8.90	12.10	22.00	930	16.5	19.40	9.50	0.1007
GA_3 - 150	6.30	9.75	15.90	6.30	9.30	12.00	22.66	900	18.0	19.90	9.00	0.0997
Ethrel - 200	7.70	11.60	15.50	5.75	8.10	10.30	26.66	645	19.0	18.40	10.15	0.1150
Ethrel - 250	6.30	9.90	13.40	6.70	8.70	11.50	27.00	700	17.7	17.30	10.5	0.1149
Ethrel - 300	7.70	11.20	15.00	6.40	8.60	11.80	29.33	900	22.3	21.75	11.00	0.1100
Control (Dis. water)	5.80	8.10	11.10	5.60	6.40	9.00	24.00	660	22.0	15.00	8.30	0.1000
CD at 5%	0.29	0.14	0.51	0.19	0.09	0.32	2.58	17.82	2.21	2.69	0.86	0.04

Maximum number of fruits per plant (34) and yield per plant (24.90 kg) has been recorded under TIBA 150 ppm followed by TIBA 100 ppm (33 and 23.60 kg^2, respectively. Similar results were obtained by Lokonova and Kolomitseva (7) in apple and Smirnov (13) in cv. Kismish chernyl of grape by use of growth retardants. Though spraying of GA_3 reduced the number of fruits per plant, it has positive effect on increase in weight of fruit and decrease in number of seeds per fruit and acidity content of fruit. Recently several authors reported similar findings regarding weight of fruits, *e.g.* Singh and Bal (12), Singh and Randhawa (10) in *ber*. Regarding minimum number of seeds, similar observations were reported by Agnihotri and Bhullar (1) in guava cv. Allahabad Safeda with GA_3 application. Results regarding low acidity were also reported. Ethrel treated plants also showed increase in weight of fruit and thereby yield.

Maximum TSS was recorded under ethrel 300 ppm (11.00 %) followed by TIBA 150 ppm (10.50 %) and ethrel 250 ppm (10.50 %) as shown in Table 2. The improved quality of fruit in the present investigation can be attributed to the fact that foliar application of ethrel causes stress and might have caused cell elongation accompanied by considerable increase in sugar content. TIBA application also leads to improved partitioning to developing fruits resulting from reduced vegetative growth. In general, the increased TSS and reduced acidity might be owing to the high conversion of starch into reducing and non-reducing sugars during rapid ripening process as reported by Sims *et al*. (9).

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