The Pharma Innovation Journal 2022; 11(12): 5593-5597

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 5593-5597

www.thepharmajournal.com
Received: 16-09-2022
Accepted: 20-10-2022

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Effect of plant bio-regulators on side shoot induction in papaya (*Carica papaya*) var. red lady

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Abstract
Vegetative propagation of papaya on commercial scale have an inherent limitation due to difficulty in obtaining sufficient number of side shoots. This is primarily due to the strong apical dominance that occurs due to presence of auxin in the meristem zone. Overcome this problem, the effect of plant bio-regulators viz., Gibberllic acid (GA_3) and Benzyladenine (BA) were investigated, on six months old field grown papaya trees of variety Red Lady in induction of side shoots, to be used as scion for grafting in papaya at College of Agriculture, Vellayani, Thiruvananthapuram (Kerala) during October 2021 to June 2022. Among the treatments, it was revealed that GA_3 500 mg/L + BA 500 mg/L recorded minimum number of days for shoot initiation (3.74). In respect to number of shoots, BA 500mg/L produced a higher number of (32.58 and 38.72) shoots per plant at 15 and 30 days after spraying respectively. Whereas, GA_3 250 mg/L + BA 250 mg/L recorded more number of shoots per plant at 45 and 60 days after spray (40.50, 41.43). In respect of number of propagatable laterals, plants sprayed with GA_3 250 mg/L + BA 250 mg/L registered the maximum of 17.63, 20.58, 24.08 19.92 nos in Red Lady at 15,30 45 and 60 days after spraying. GA_3 500mg/L recorded maximum length and girth at 15 (9.71, 3.54), 30(11.81, 4.43), 45(12.81, 4.60) 60 (13.29, 4.78) days after spray followed by combination of GA_3 250 mg/L + BA 250 mg/L.

Keywords: Papaya, asexual propagation, gibberllic acid, benzyladenine, side shoot, red lady

Introduction
Papaya (*Carica papaya* L.) is one of the most important economic fruit crops of tropical and subtropical countries with higher production potential. India is the largest producer of papaya, contributing 44.06 per cent of world production from 30 per cent of the global area [1]. The total area occupied by papaya in India is estimated to be 0.142 million hectares with production of 6.01 MT and productivity of 43.3 tonnes/ha [2]. Propagation of papaya for commercial production is normally by seed, as a consequence, wide variability in sex expression and fruit characters are usually observed among the individuals in a population [3].This affects the potential productivity of papaya plantations since male plants are naturally unfruitful and cannot be distinguished from the female and hermaphrodite plants until they flower. Vegetative propagation method can be an alternative to seed propagation to overcome these constraints. Unlike other horticultural crops, vegetative propagation of papaya on commercial scale has having an inherent limitation due to difficulty in obtaining sufficient number of side shoots. This is primarily due to the strong apical dominance that occurs as a result of the presence of auxin in the meristem zone, thereby limiting the development of lateral meristem [4].

In recent years, attention has mainly directed to the use of different plant bio- regulators that are very effective in controlling and directing a number of plant metabolic processes. In order to promote growth of lateral buds which were held under apical dominance, different treatments have been applied to different plants [5]. Chemical branching stimulation usually involves application of either cytokinins (benzyladenine, BA) with or without gibberellins [6]. To overcome apical dominance and to induce lateral shoot production, use of growth regulators like GA_3 and BA was employed in crop like passion fruit [7], papaya [8,9] and cherry [10]. Keeping the above points in mind, an experiment was designed to investigate the effect of bio-regulators on the induction of side shoots for promoting propagatable shoots in papaya.

Materials and Methods
The experiment was laid out in the Instructional Farm attached to the College of Agriculture, Vellayani during October 2021 to June 2022. The experiment was conducted using the papaya

variety Red Lady and were subjected to ten treatments replicated thrice, which was laid out in Randomised block design with a Gross plot size of 32 m^2. Eight plants were maintained per plot, thus a total of 240 plants were maintained for the experiment. Two plant bio regulators, separately and their combinations at different levels viz., (T_2) GA_3 125 mg/L (T_3) GA_3 250 mg/L, (T_4) GA_3 500 mg/L, (T_5) BA 125 mg/L (T_6) BA 250 mg/L, (T_7) BA 500 mg/L, (T_8) GA_3 125 mg/L + BA 125 mg/L, (T_9) GA_3 250 mg/L + BA 250 mg/L (T_{10}) GA_3 500 mg/L + BA 500 mg/L along with (T_1) control.

Red Lady is a gynodioecious F_1 hybrid of Known you company groups belong to Taiwan. It is very popular hybrid and the plants are semi-dwarf, good yielding, fruits are medium to big size, pulp deep orange-red in colour and sweet in taste. Healthy seeds of papaya variety Red Lady were obtained from Known you seeds (India) Pvt Ltd. Pune, Maharashtra. The seeds were treated with 200 ppm GA_3 for 8 hours for uniform germination and were sown in portrays filled with a mixture of FYM, soil and sand in equal proportions. Seeds germinate in one week and two weeks old seedlings were transplanted into polythene bags of 20 cm x 15 cm size. Two months old seedlings were transplanted into main field. Seedlings were planted at a depth of 15-20cm taken at 2 m x 2 m spacing. The requirement of lime and phosphorus were calculated and applied uniformly to all treatments. Organic manure (15 kg FYM $plant^{-1}$) were given uniformly to all treatments as basal and all the management practices were given as per the Package of Practices Recommendations, Crops 2016 for 'Papaya' [11].

The treatment combinations were tried three times at weekly intervals on field grown papaya plants just after flowering (6 month old). The following operations were carried out in the plants during the experimental study [12].

Step1- The leaves of selected trees were defoliated with sharp knife, by leaving 3-4 leaves at the terminal portion.

Step 2- The flowers and fruits in the trees were removed with sharp and clean knife, before the foliar spray of growth regulators.

Step 3- Three days after 1st spray, the apical portion of the plants were removed.

Step 4- Three sprays were given at weekly intervals at 150 ml per tree.

The observation regarding days taken for 1st shoot initiation, number of shoots per plants, number of propagatable shoots, length of shoot (cm) and girth of shoot (cm) were recorded fortnightly intervals after first spray and up to 60 days and subjected to statistical analysis GRAPES (General R-shiny based Analysis Platform Empowered by Statistics) by applying the techniques of analysis of variance [13]. Wherever the effects were found to be significant, critical difference values were calculated by using standard technique.

Number of days taken for 1st shoot initiation

The data were recorded by the first appearance of the shoots on the tree after application of different treatments.

Number of shoots per plant

Total number of shoots per plant was counted after the application of treatments upto 60 days after spraying at fortnightly intervals.

Length of shoots (cm)

Length of shoot was recorded in centimetres from the initiation point to tip of growing point upto 60 days after spraying at fortnightly intervals.

Girth of shoots (cm)

The shoot girth was measured at the base by a vernier caliper and the values were expressed in centimetres upto 60 days after spraying at fortnightly intervals.

Number of propagatable shoots per plant

The number of shoots having propagatable size (>6mm and >5 cm) were counted upto 60 days months after spraying at for nightly intervals [12].

Results and Discussion

In the present study, significant differences were observed among the treatments for days to 1 st shoot initiation, number of shoots per plant, number of propagatable shoots per plant, length of laterals and girth of laterals.

Days to 1st shoot initiation

The days to 1st shoot initiation were significantly influenced by various levels of plant bio-regulators (Table 1). Among the treatments, those sprayed with combination of GA_3 500 mg/L + BA 500 mg/L recorded significantly minimum number of days for shoot initiation (3.74) and which was on par with combination of GA_3 250 mg/L + BA 250 mg/L (4.20) and GA_3 125 mg/L + BA 125 mg/L (4.50). Similar results also reported by [14] in papaya variety 'Sunrise Solo'. The application of BAP (500 mg/L) and GA (500 mg/L) on twelve months old 'Sunrise Solo' plants by means of spraying, boosted highest proliferation of lateral shoots, at 30, 55 and 86 days after decapitation.

Table 1: Effect of plant bio regulators on days to 1st shoot initiation in papaya

Treatments	Days to 1st shoot initiation
T_1- Control	12.20
T_2- GA_3 125 mg/L	10.59
T_3- GA_3 250 mg/L	10.08
T_4- GA_3 500 mg/L	9.43
T_5- BA 125 mg/L	8.25
T_6- BA 250 mg/L	7.54
T_7- BA 500 mg/L	7.32
T_8- BA 125 mg/L+ GA_3 125 mg/L	4.54
T_9-BA 250 mg/L+ GA_3 250 mg/L	4.20
T_{10}- BA 500 mg/L+ GA_3 500 mg/L	3.74
CD (5%)	0.41
CV%	3.09

Number of shoots per plant

Among the treatments the plants sprayed with highest dose of BA (500 mg/L) recorded higher number of shoots per plant at 15 and 30 days after spray (32.58 and 38.92 respectively) followed by combination of GA_3 250 mg/L + BA 250 mg/L (31.17 and 36.79). Whereas, combination of GA_3 250 mg/L + BA 250 mg/L recorded more number of shoots per plant at 45 days and 60 days after spray (40.50 and 41.43) followed by BA 500mg/L (38.95 and 38.97) and GA_3 125 mg/L + BA 125 mg/L (36.04 and 37.43) (Table 2). The rate of percentage of increase in number of shoots per plant was higher during 15-30 days interval in all treatments it is due to the weekly application of bio- plant growth regulators in the first 21 days (fig.1). Cytokinin is strongly linked with the onset of growth of lateral buds and application of it stimulates cell division

and growth of buds in many species. After decapitation, auxin level in lateral buds increases, the level of ABA decreases and transport of nutrients and cytokinins from roots increases lateral bud production [4].

Table 2: Effect of plant bio- regulators on number of shoots per plant in papaya

Treatments	Number of shoots per plant			
	15 days after spraying	30 days after spraying	45 days after spraying	60 days after spraying
T_1- Control	11.38	20.88	23.92	23.95
T_2- GA_3 125 mg/L	18.54	23.71	25.71	25.80
T_3- GA_3 250 mg/L	21.58	28.25	31.29	31.71
T_4- GA_3 500 mg/L	26.21	30.05	31.92	32.37
T_5- BA 125mg/L	27.00	29.71	31.67	32.73
T_6- BA 250mg/L	30.96	33.79	35.42	35.55
T_7- BA 500 mg/L	32.58	38.92	38.95	38.97
T_8- BA 125 mg/L+ GA_3 125 mg/L	25.96	30.84	36.05	37.43
T_9-BA 250 mg/L-+ GA_3 250 mg/L	31.17	36.79	40.50	41.43
T_{10}- BA 500 mg/L+ GA_3 500 mg/L	27.04	30.88	31.92	32.03
CD (5%)	1.40	0.77	0.83	0.75
CV%	3.25	1.45	1.48	1.32

Number of propagatable shoots per plant

The results obtained from the current trial revealed that there is a significant impact on spray of different levels of plant bio-regulators on number of propagatable shoots per plant (Table 3). Among the treatments, those sprayed with the combination of GA_3 250 mg/L + BA 250 mg/L produced maximum number of propagatable laterals per plant at 15, 30, 45 and 60 days after spray (17.63, 20.58, 24.08, 19.82 respectively) followed by combination of GA_3 125 mg/L + BA 125 mg/L (14.74, 16.21, 19.79, 13.85 respectively). [12,15] also opined that the treatment of plants with GA_3 125 mg/L + BA 125 mg/L and GA_3 250 mg/L + BA 250 mg/L promoted the development and the subsequent growth of side shoots.

Table 3: Effect of plant bio- regulators on number of propagatable shoots per plant in papaya

Treatments	Number of propagatable shoots per plant			
	15 days after spraying	30 days after spraying	45 days after spraying	60 days after spraying
T_1- Control	0.00(0.70)	2.46	3.42	1.11
T_2- GA_3 125 mg/L	6.12(2.57)	12.17	13.59	10.00
T_3- GA_3 250 mg/L	9.91(3.23)	14.00	14.92	12.32
T_4- GA_3 500 mg/L	12.00(3.54)	15.89	15.59	13.80
T_5- BA 125mg/L	2.62(1.77)	4.71	6.09	4.34
T_6- BA 250mg/L	6.99(2.74)	9.54	10.42	7.934
T_7- BA 500 mg/L	8.25(2.96)	11.34	11.50	9.99
T_8- BA 125 mg/L+ GA_3 125 mg/L	14.75(3.91)	16.21	19.79	13.85
T_9-BA 250 mg/L-+ GA_3 250 mg/L	17.63(4.26)	20.58	24.09	19.92
T_{10}- BA 500 mg/L+ GA_3 500 mg/L	12.25(3.57)	14.21	15.17	12.18
CD (5%)	0.15	0.78	0.88	0.83
CV%	3.01	3.85	3.80	4.59

Length and girth of laterals

In respect to Length and girth of laterals in papaya GA_3 500 mg/L recorded maximum length and girth at 15 (9.71,3.54), 30(11.81,4.43), 45(12.81,4.60) and 60 (13.29, 4.78) days after spray followed by combination of GA_3 250 mg/L + BA 250 mg/L and GA_3 125 mg/L + BA 125 mg/L (Table 4, 5) The role of gibberellins were found to enhance the stem length in higher plants due to cell elongation in the internodes and to stimulate the cell division, and increase volume of individual cells [16, 17].

Table 4: Effect of plant bio- regulators on length of laterals in papaya

Treatments	Length of laterals			
	15 days after spraying	30 days after spraying	45 days after spraying	60 days after spraying
T_1- Control	1.38	5.39	6.61	7.06
T_2- GA_3 125 mg/L	6.12	8.27	8.95	9.34
T_3- GA_3 250 mg/L	7.58	9.59	9.94	10.42
T_4- GA_3 500 mg/L	9.71	11.81	12.82	13.29
T_5- BA 125 mg/L	5.60	6.28	6.77	7.29
T_6- BA 250 mg/L	6.12	7.27	7.71	8.17
T_7- BA 500 mg/L	6.26	7.61	8.18	8.65
T_8- BA 125 mg/L+ GA_3 125 mg/L	8.17	10.39	11.03	11.36
T_9-BA 250 mg/L-+ GA_3 250 mg/L	8.99	10.45	11.32	11.89
T_{10}- BA 500 mg/L+ GA_3 500 mg/L	7.50	8.46	9.27	9.82
CD (5%)	0.36	0.65	0.10	0.10
CV%	3.11	4.41	0.65	0.63

Table 5: Effect of plant bio- regulators on girth of laterals in papaya

Treatments	Girth of laterals			
	15 days after spraying	30 days after spraying	45 days after spraying	60 days after spraying
T_1- Control	0.51	1.93	2.42	2.85
T_2- GA_3 125 mg/L	2.03	2.92	3.09	3.17
T_3- GA_3 250 mg/L	2.53	3.33	3.47	3.59
T_4- GA_3 500 mg/L	3.54	4.43	4.60	4.78
T_5- BA 125 mg/L	1.98	3.19	3.35	3.66
T_6- BA 250 mg/L	2.47	2.52	2.72	3.22
T_7- BA 500 mg/L	2.62	2.88	3.44	3.66
T_8- BA 125 mg/L+ GA_3 125 mg/L	2.88	3.59	3.87	4.09
T_9-BA 250 mg/L-+ GA_3 250 mg/L	3.33	3.72	3.93	4.21
T_{10}- BA 500 mg/L+ GA_3 500 mg/L	2.65	3.26	3.41	3.66
CD (5%)	0.39	0.14	0.09	0.11
CV%	9.37	2.48	1.66	1.71

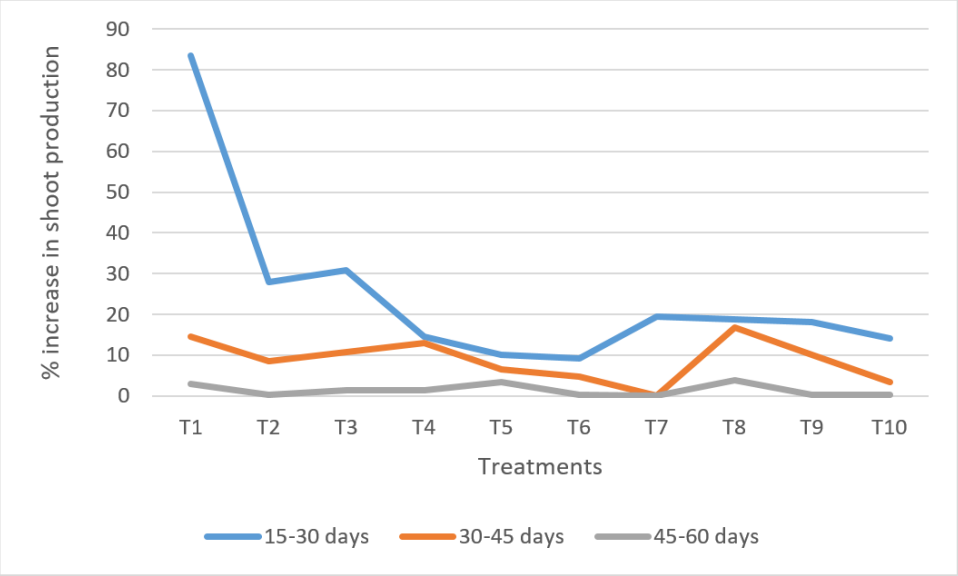

Fig 1: Effect of plant bio- regulators on percentage increase in number of shoot production in papaya

Conclusion

The present study clearly indicated that different treatments of plant bio-regulators significantly influenced the number of days taken for 1st shoot initiation, number of shoots per plant, number of propagatable shoots per plant, length of laterals and girth of laterals. Application of GA_3 250 mg/L + BA 250 mg/L recorded minimum days to 1 st shoot initiation next to GA_3 500 mg/L + BA 500 mg/L and produced maximum number of propagatable shoots with optimum length and girth suitable for grafting. Hence, from the evidence recorded, it can be concluded that the best plant growth regulators combination for lateral shoots development in papaya variety Red Lady is GA_3 250 mg/L + BA 250 mg/L spray.

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