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Studies on influence of plant growth regulators on flowering, fruiting, fruit setting, and maturity of papaya (*Carica papaya* L.) cv. Red Lady under net house condition

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Abstract
An experiment was conducted during 2019-20 and 2020-21 at Research Farm of Centre of Excellence on Protected Cultivation and Precision Farming under net house, College of Agriculture, IGKV, Raipur to study the response of various plant growth regulators at different concentrations namely, NAA (100, 150, 200 ppm), GA_3 (100, 150, 200 ppm) and BA (100, 150, 200 ppm) on flowering, fruit setting, fruiting and maturity of papaya cv. Red Lady. As far as the days to first flowering and days to first fruiting is concerned the treatment of gibberellic acid 200 ppm treated plants comes early flowering (71.9 days) and fruiting (73.37 days) as compared to other treatments, while the maximum days to first flowering (83.04 days) and fruiting (87.77 days) were observed under the treatment T_0 (control). Similarly the same treatment (T_6) was taken maximum fruit set per cent (83.99) lowest time for flowering to maturity (189.38 days) as compared to other treatments. Thus, a spray of gibberellic acid 200 ppm is best for early flowering, fruiting, days to flowering to maturity and maximum fruit setting percentage of papaya.

Keywords: Plant growth regulators (PGR), flower characters and papaya

Introduction
Papaya is botanically known as *Carica papaya* L. and belongs to the family Caricaceae having 48 known species and among them, *Carica papaya* L. is only species grown for edible fruits (Chadha, 1992) [1]. Papaya is originated from tropical America, (Hafmer, 1938) [6] and it was introduced in India in 16th century from Malacca (Kumar and Abrahm, 1943) [8]. It has become a popular fruit due to its fast growth, high yield, long fruiting period and high nutrient value as well. In addition, it has been used as vegetable, fruit processing and papain production at immature stage. It beaver a highly profitable crop now.

Under net house cultivation of papaya revealed that environment factors such as light, wind, edaphic, soil characteristics temperature, soil relative humidity and biotic factors such as mycorrhizal fungi and genotype significantly affect the productivity and physiology of papaya (Nakasone and Paul, 1998) [11]. Mature fruits are net house to safe gourd against virus vector in tropical and sub tropical condition.

The use of plant growth regulators has assumed an integral part of modern fruit production to improve the quality and production of fruits, and it has resulted in outstanding achievements in a number of fruit crops with regard to improvements in yield and quality (Jain and Dashora 2011) [5]. Because of its diverse effects, it is possible to use certain growth regulating chemicals at particular stages of fruit growth and development to exhibit maximum effects. Occasionally, they are needed to be supplemented exogenously for additional stimulus for plants such as papaya, which require quick responses for increased growth, fruit set and yield (Singh and Singh 2009) [12]. These Plant Growth Regulator's includes auxins, gibberellins, cytokinin, ABA along with a wide range of growth promoters and inhibitors.

Materials and Methods
The Experiment was conducted at Research Farm of Centre of Excellence on Protected Cultivation and Precision Farming under net house, College of Agriculture, IGKV, Raipur Chhattisgarh during the years 2019-20 and 2020-21. The experiment was laid out in a randomized complete block design.

There were 16 treatments T_0 : control, T_1 : Naphthalene Acetic Acid (NAA) 100 ppm, T_2 : Naphthalene Acetic Acid (NAA) 150 ppm, T_3 : Naphthalene Acetic Acid (NAA) 200 ppm, T_4 : Gibberellic Acid (GA_3) 100 ppm, T_5 : Gibberellic Acid (GA_3) 150 ppm, T_6 : Gibberellic Acid (GA_3) 200 ppm, T_7 : Benzyl Adenine (BA) 100 ppm, T_8 : Benzyl Adenine (BA) 150 ppm, T_9 : Benzyl Adenine (BA) 200 ppm, T_{10} : 2,4 –Dichloro phynoxy Acetic Acid 10 ppm, T_{11} : 2,4 –Dichloro phynoxy Acetic Acid 15 ppm, T_{12} : 2,4 –Dichloro phynoxy Acetic Acid 15 ppm, T_{13} : Ethrel 200 ppm, T_{14} : Ethrel 300 ppm, T_{15} : Ethrel 300 ppm, replicated thrice in 48 well raised plots of 7.2 x 7.2 m size with transplanting distance of 1.8 m. x 1.8 m. healthy saplings of almost equal size and vigor were transplanted evening hours. All culture practices and plant protection measures were applied uniformly to the entire experiment plot as per the package of practices for papaya cultivation. Spraying with NAA, GA_3, BA, 2,4 – D and Ethrel was done 30, 45 and 60 days after transplanting. The stock solution of NAA, GA_3, BA and 2,4-D was prepared by dissolving the weighed quantity of these chemical in alcohol. The quantity was measured by measuring cylinder and dissolving in alcohol and then distilled water was added to makes up the required amount of solution. The plants were sprayed with the help of knap sack sprayer with fine nozzle having mist droplets and the sprayer was washed thoroughly before spraying to avoid contamination.

The observations recorded on days to first flowering, days to first fruiting, fruit setting percentage and days to flowering to maturity of papaya. The data collected were subjected to statistical analysis suggested by Gomez and Gomez (1984) [4].

Results and Discussion

The data pertaining to flowering, fruiting, fruit set per cent and days to flower to maturity are presented in a Table: 1

Days to first flowering

The significant effect of various plant growth regulators on days to first flowering is displayed in Table 1. The plants treated with 200 ppm gibberelic acid required minimum days to flowering during based on pooled mean (71.91 days), however the plants recorded with control took maximum days in flowering (83.04 days) under the present investigation. The minimum days to first flowering in GA_3 treated plants may be due to GA_3 promotes the formation and translocation of flowering stimuli as hormone from the leaf to axil of the leaves and thus produces early flowering as compared with other treatments. The present findings are accordance with the results obtained by Ghanta and Mitra (1998) [3] and Syamal *et al.* (2010) [13] and Hetram (2017) [7] in papaya and Kumar *et al.* (2012) [9] in strawberry.

Days to first fruiting

As regards the pooled mean, the papaya plants treated with GA_3 200 ppm (T_6) took minimum days to first fruiting 73.37, which was differed significantly from rest of the treatments tested under the present investigation. Furthermore the treatments T_4, T_5 & T_{12} and T_{11}, T_3 & T_9 and T_2, T_8, T_{10}, T_1 & T_9 and T_{14}, T_{13} & T_7 with average days to first fruiting of 75.10, 75.71 & 76.47 and 79.96, 81.22, & 81.44 and 82.72, 82.46, 82.27, 81.97 & 81.44 and 86.71, 86.08, & 85.17, respectively were detected non-significant differences between each other at 5 per cent level of significance. The maximum days to first fruiting (87.77) was reported under (control) T_0. The minimum days to first fruiting in GA_3 treated plants may be due to GA_3 promotes the formation and translocation of flowering stimuli as hormone from the leaf to axil of the leaves and thus produces only flowering and fruiting. The present findings are accordance with the results obtained by Ghanta and Mitra (1998) [3] and Syamal *et al.* (2010) [13] in papaya and Kumar *et al.* (2012) [9] in strawberry.

Fruit set percentage

On the basis of pooled data, the maximum fruit set per cent (83.89) was recognized the under the application of GA_3 @ 200 ppm (T_6) which was seen significantly higher from rest of the treatments under the study. The statistically similar fruit set per cent was notified between the treatments T_{14} & T_{15} and T_7, T_{10} & T_{15} and T_8, T_{11}, T_7 & T_1 and T_{12} & T_1 and T_3 & T_2 and T_4 & T_5 having the respective fruit set percentages of 73.02 & 73.88 and 74.42, 74.32 & 73.38 and 75.11, 74.64, 74.42 & 74.32 and 76.73 & 77.70 and 79.60 & 78.55 and 81.42 & 82.05, However, the fruit set per cent was recorded minimum (61.95) under control (T_0). The maximum fruit set per cent in papaya might be due to the GA_3 resulted in the production of a larger number of flower with rapid elongation of the peduncles, leading to full development of flower buds exhibiting all functional reproductive parts, which increased fruit set tremendously compared with the control. Similar increased in fruit set percentage with GA_3 were also reported by Kumar and Prasad (1997) [10] and Ghanta & Mitra (1998) [3] and Syamal (2010) [13] and Dubey *et al.* 2020 [2] in papaya and Voyiatzis and Paroyssi (2002) [16] in strawberry.

Days to flowering to maturity

The findings obtained based on pooled mean showed, the supremacy of treatment T_6: GA_3 @ 200 ppm (189.38 days) registered minimum days to flowering to fruit maturity which was noted at par with T_5: GA_3@ 150 ppm having days to flowering to maturity of 190.57 days. Furthermore the non-significant differences were also noticed among the treatment T_7 & T_8 and T_{12} & T_{11} and T_{10}, T_{13} & T_{14} and T_1, T_{14} & T_{13} and T_{15}, T_2, T_1 & T_{14} and T_3, T_{15} & T_2 having average days to flowering to fruit maturity of 196.59 & 197.75 and 200.73 & 202.02 and 202.36, 202.42 & 203.92 and 206.40, 205.14 & 204.98 respectively. However, the treatment T_0 (control) took maximum days to flowering to maturity (211.62) during the present study. The minimum flowering to fruit maturity promotes the exogenous application of GA_3 provides ethylene to the plant, which effect on the growth, development and flowering in many fruit crops. In addition the GA_3 treated plants promotes the formation and translocation of flowering stimuli as hormone from leaves and axil of leaves and thus produces early flowering which might have resulted in early maturity in GA_3 treated plants. The present results are in close agreements with the findings observed by Ghanta and Mitra (1998) [3] and Syamal *et al.* (2010) [13] in papaya. Kumar *et al.* (2012) [9] in strawberry. also started the early flowering in GA_3 treated plants during their experiment, which supported the present study.

Table 1: Flowering, fruiting, fruit setting and maturity characters as influenced by different plant growth regulator

Notations	Treatments	Days to first flowering (Pooled mean)	Days to first fruiting (Pooled mean)	Fruit set per cent (Pooled mean)	Days to flowering to maturity (Pooled mean)
T_0	Control- water spray	83.04^{j}	87.77^{g}	61.95^{a}	211.62^{j}
T_1	Naphthalene acetic acid 100 ppm	79.08^{h}	81.97^{d}	77.70^{gh}	203.93^{gh}
T_2	Naphthalene acetic acid 150 ppm	78.19^{g}	82.72^{d}	78.55^{hi}	204.98^{hi}
T_3	Naphthalene acetic acid 200 ppm	77.06^{ef}	81.22^{cd}	79.60^{i}	206.40^{i}
T_4	Gibberellic acid 100 ppm	76.38^{h}	75.10^{b}	81.42^{j}	192.62^{a}
T_5	Gibberellic acid 150 ppm	73.85^{i}	75.71^{b}	82.05^{j}	190.57^{a}
T_6	Gibberellic acid 200 ppm	71.91^{i}	73.37^{a}	83.99^{k}	189.38^{b}
T_7	Benzyl adinine 100 ppm	78.42^{gh}	85.17^{e}	74.42^{de}	196.59^{c}
T_8	Benzyl adinine 150 ppm	74.88^{de}	82.46^{d}	75.11^{e}	197.75^{c}
T_9	Benzyl adinine 200 ppm	75.84^{cd}	81.44^{cd}	76.42^{f}	200.47^{d}
T_{10}	2,4 –Dichloro phynoxy acetic acid 10 ppm	75.68^{cd}	82.27^{d}	74.32^{de}	202.36^{f}
T_{11}	2,4 –Dichloro phynoxy acetic acid 15 ppm	77.93^{fg}	79.96^{c}	74.64^{e}	202.02^{e}
T_{12}	2,4 –Dichloro phynoxy acetic acid 20 ppm	79.40^{h}	75.10^{b}	76.73^{g}	200.73^{e}
T_{13}	Ethrel 200 ppm	79.50^{a}	86.08^{ef}	67.38^{b}	202.42^{fg}
T_{14}	Ethrel 300 ppm	81.68^{b}	86.71^{ef}	73.02^{c}	203.92^{fg}
T_{15}	Ethrel 400 ppm	81.26^{c}	87.30^{f}	73.38^{cd}	205.14^{hi}
S.E(m)±		0.38	0.56	0.39	0.56
CD at 5%		1.11	1.63	1.14	1.56

Conclusion

It is concluded that application of gibberelic acid @200 ppm (T_6) was found to be significantly minimum days of flowering, fruiting, fruit maturity and maximum fruit setting per cent of papaya cv. Red Lady. Therefore, treatment (T_6) is considered better treatment for the flower parameters of papaya.

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