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Effect of different combinations of PGR's and micronutrients on growth and flowering of papaya (*Carica papaya* L.) cv. pusa Nanha

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Abstract
An investigation was carried out to assess the "Effect of different combinations of PGR's and micronutrients on growth and flowering of papaya (*Carica papaya* L.) cv. Pusa Nanha" during 2013-14 and 2014-15 at Central Research Field, Department of Horticulture, Sam Higginbottom University of Agricultural Technology and Sciences, Allahabad, U.P. The experiment was laid out in Randomized Block Design (RBD) with fifteen treatment combinations replicated thrice. Observations were recorded during both year of successive experiment on growth and flowering characters of papaya like plant height (cm), stem girth (cm), number of leaves and initiation of first flower. The results revealed that all micronutrients and their combinations with PGR's significantly influenced the vegetative growth and flowering of papaya during both experimental years. Among them foliar application of Copper sulphate 0.25% + Manganese sulphate 0.25% + NAA 30 ppm + GA_3 60 ppm (T_{15}) attained maximum pooled value in terms of plant height (cm) (139.99 cm), stem girth (cm) (42.69 cm), number of leaves (29.52) where as minimum days taken for initiation of first flower (103.83) with the spray of Copper sulphate 0.25%+ Manganese sulphate 0.25% (T_5).

Keywords: Papaya, growth, flowering, PGR, copper sulphate and manganese sulphate

1. Introduction
Papaya (*Carica papaya* L.) is a delicious fruit, belonging to family Caricaceae and also known as papita, pawpaw and true melon. It is native to tropical America (Mexico) (Hofmayr, 1938). In India it was introduced in 16th century via Malacca (Kumar and Abraham, 1943) and now become wide spread throughout the country. Papaya is grown in all tropical and subtropical countries of the world (Ram, 1997) [18]. Papaya is now cultivated in most countries with tropical climate like India, South Africa, Sri Lanka, Philippines, Australia, Mexico, Indonesia and Bangladesh.

It has gained tremendous impact on economic and nutritional value. The ripe fruit of papaya is eaten as such throughout the tropics. Ripe fruits also find its extensive uses for several preparations like jam, soft drinks, ice-cream flavouring and crystallized fruit. It is a nutritive fruit containing carbohydrates, protein and minerals mainly iron, calcium and phosphorus. It is rich source of Vitamin 'A' having 2020 I.U./100g of fruit (Akroyd, 1951). The immature papaya fruit contains milky latex, the dried latex is known as papain which is in great demand in the international market particularly in UK and U.S.A. The papain is used in meat tendering, manufacturer of chewing gum and cosmetics, as a drug for digestive, aliments in the tanning industry for bating hides, for degumming materials in silk and to give shrink resistance to wool (Purseglove, 1968) [17].

Naphthalene Acetic Acid (NAA) belongs to synthetic forms of Auxins. Auxins play key role in cell elongation, cell division, vascular tissue, differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting and flowering (Zhang and Davies, 1987) [21] while Gibberellic acid (GA), a plant hormone stimulating plant growth and development. GAs stimulate seed germination, trigger transitions from meristem to shoot growth, juvenile to adult leaf stage, vegetative to flowering and determines sex expression (Gupta and Chakrabarty, 2013) [6].

Foliar application of micronutrients like B, Cu, Mn, Fe and Zn are vital for controlling deficiencies of these elements in fruit crops as well as it advantageous over soil application. These advantages are high effectiveness, rapid plant response, convenience, elimination and reduction of toxic symptoms (Alexander, 1986) [1]. If all these nutrients are applied, it may give additional benefits to the plant.

Copper sulphate plays a vital role in photosynthesis protein carbohydrate formation in agricultural plants. Many horticultural plants show symptoms of necrosis over the young leaves which results in defoliation of the foliage. Gummosis (Exanthema) and dieback occurs due to copper deficiency.

Manganese sulphate is an essential element in plant respiratory system and plays a crucial role in cell division and development. It also involved in destruction of indole-3 acetic acid (IAA). It activates decarboxylase, dehydrogenase, and oxidase enzymes which are important in photosynthesis, nitrogen metabolism and nitrogen assimilation. Deficiency of Manganese sulphate causes necrosis in agricultural crops.

Materials and Methods

An investigation was carried out to assess the "Effect of different combinations of PGR's and micronutrients on growth and flowering of papaya (*Carica papaya* L.) cv. Pusa Nanha" during 2013-14 and 2014-15 at Central Research Field, Department of Horticulture, Sam Higginbottom University of Agricultural Technology and Sciences, Allahabad, U.P. The experiment was laid out in Randomized Block Design (RBD) with fifteen treatment combinations replicated thrice.

Observations were recorded during both years of successive experiment on growth and flowering characters of papaya like plant height (cm), stem girth (cm), number of leaves, total leaf area (m^2), plant height at flower initiation stage (cm), fruiting zone (cm), initiation of flowering (days taken to first flowering) and number of fruit per plant. Vegetative parameters were recorded at 30 days interval. The leaves were collected from all the five tagged plants and leaf area was measured with the laser leaf area meter. Average was calculated and recorded. It was recorded in number of days from date of planting to first flowering, and was expressed as days taken to first flowering.

Statistical analyses of the data obtained in the different sets of experiment were calculated, as suggested by Panse and Sukhatme (1989).

Results and Discussion

Plant growth attributes

Plant height

The data presented in Table 1 clearly revealed that all the treatments showed significant differences for plant height at 180, 270 and 360 days after planting in first year and second year and their pooled data. From the pooled data it is clear that maximum plant height during 2013-14 was recorded 139.99 cm was with foliar application of Copper sulphate 0.25% + Manganese sulphate 0.25% + NAA 30 ppm + GA_3 60 ppm (T_{15}) followed by 139.08 cm with the spray of Copper sulphate 0.25% + Manganese sulphate 0.25% + GA_3 60 ppm (T_{14}), 138.82 cm with the spray of Manganese sulphate 0.25% + NAA 30 ppm +GA_3 60 ppm (T_{13}) and 138.14 with the spray of Copper sulphate 0.25% + NAA 30 ppm + GA3 60 ppm (T_{12}) which were at par with each other. Whereas, minimum value 114.12 cm was obtained in control (T_0). Similar trend was observed in 2014-15 and their pooled data. It might be due to application of proper dose of micronutrients, because they play important role in chlorophyll synthesis and development of cells in meristemetic tissues. These results due to micronutrients effect are in close conformity with the findings of Harnandes-Medina, 1969 in banana and Singh and Ram, 1984 [20] in guava. The result due to PGR effect is in Conformity with the earlier report by Bhogave and Raut (2014) [3] in papaya, Saima *et al*., (2014) [16] in strawberry and Digrase *et al*., (2016) [5] in pomegranate.

Table 1: Effect of different combination of Plant Growth Regulators and micronutrients on Plant height of papaya at different days after transplanting in papaya cv. Pusa Nanha

Treatments	180 DAP		Pooled	270 DAP		Pooled	360 DAP		Pooled
	2013-14	2014-15		2013-14	2014-15		2013-14	2014-15	
T_0	73.17	71.98	72.58	110.60	108.71	109.66	115.75	112.49	114.12
T_1	74.70	73.51	74.11	112.13	110.24	111.19	117.28	113.89	115.59
T_2	77.23	76.04	76.64	114.66	112.77	113.72	119.81	116.42	118.11
T_3	79.76	78.57	79.17	117.19	115.30	116.25	122.34	118.95	120.65
T_4	88.86	87.67	88.27	128.76	126.87	127.82	128.26	124.87	126.57
T_5	78.49	77.30	77.90	131.24	129.35	130.30	140.59	137.20	138.90
T_6	93.22	92.03	92.63	132.38	130.49	131.44	137.93	134.54	136.24
T_7	94.42	93.23	93.83	124.94	123.05	124.00	139.29	135.90	136.92
T_8	90.76	89.57	90.17	114.68	112.79	113.74	121.60	118.21	119.91
T_9	94.55	93.36	93.96	133.62	131.73	132.68	136.03	132.64	134.34
T_{10}	80.33	79.14	79.74	129.33	115.87	116.82	122.91	119.52	121.22
T_{11}	89.43	88.24	88.84	131.81	127.44	128.39	141.16	125.44	133.30
T_{12}	79.06	77.87	78.47	132.95	129.92	130.87	138.50	137.77	138.14
T_{13}	93.79	92.60	93.20	125.51	131.06	132.01	139.86	135.11	138.82
T_{14}	94.99	93.80	94.40	139.02	123.62	124.57	141.68	136.47	139.08
T_{15}	101.89	100.70	101.30	139.02	137.13	138.08	141.68	138.29	139.99
F-test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	1.489	1.700	1.593	2.087	2.336	2.211	2.289	2.539	2.414
C.D. (P = 0.05)	3.073	3.508	3.287	4.307	4.821	4.564	4.725	5.241	4.983

Stem Girth

The data presented in Table 2 revealed that all the treatments showed significant differences at 180, 270 and 360 days after planting in first year and second year and their pooled data. From the pooled data it was observed that the maximum plant girth 42.69 cm was obtained with foliar application of Copper sulphate 0.25% + Manganese sulphate 0.25% + NAA 30 ppm + GA_3 60 ppm (T_{15}) followed by 41.51 cm with the foliar spray of Manganese sulphate 0.25% + GA_3 60 ppm (T_9) and 40.88 cm with foliar spray of Copper sulphate 0.25% + Manganese sulphate 0.25% +GA_3 60 ppm (T_{14}) at 360 days, which were at par with each other. Whereas, minimum plant stem girth 29.31 cm was obtained in control (T_0). Similar trends were also observed in first and second year. These

results due to micronutrients effect are in close conformity with the findings of Harnandes–Medina, 1969 in banana, Bhogave and Raut, 2014 [3] in papaya and Singh and Ram, 1984 [20] in guava. Similar observations due to PGR effect have been reported by Jadhav *et al*., (2006) [9] and Kaur and Kaur (2015) [11].

Table 2: Effect of different combination of Plant Growth Regulators and micronutrients on stem girth of papaya at after transplanting in papaya cv. Pusa Nanha.

Treatments	180 DAP		Pooled	270 DAP		Pooled	360 DAP		Pooled
	2013-14	2014-15		2013-14	2014-15		2013-14	2014-15	
T_0	12.24	11.05	11.65	25.51	23.62	24.57	30.94	27.68	29.31
T_1	13.57	12.38	12.98	26.84	24.95	25.90	32.27	28.88	30.58
T_2	14.10	12.91	13.51	27.37	25.48	26.43	32.80	29.41	31.11
T_3	16.63	15.44	16.04	29.90	28.01	28.96	35.33	31.94	33.64
T_4	19.72	18.53	19.13	35.45	33.56	34.51	38.64	35.25	36.95
T_5	16.91	15.72	16.32	34.71	32.82	33.77	37.87	34.48	36.18
T_6	20.32	19.13	19.73	36.98	35.09	36.04	40.03	36.64	38.34
T_7	21.04	19.85	20.45	37.07	35.18	36.13	41.45	38.06	39.76
T_8	17.93	16.74	17.34	32.31	30.42	31.37	37.08	33.69	35.39
T_9	23.38	22.19	22.79	37.75	35.86	36.81	44.38	38.63	41.51
T_{10}	17.20	16.01	16.61	36.02	28.58	29.53	35.90	32.51	34.21
T_{11}	20.29	19.10	19.70	35.28	34.13	35.08	38.44	35.82	37.13
T_{12}	17.48	16.29	16.89	37.55	33.39	34.34	40.60	35.05	37.83
T_{13}	20.89	19.70	20.30	37.64	35.66	36.61	42.02	37.21	39.62
T_{14}	21.61	20.42	21.02	38.84	35.75	36.70	42.57	39.18	40.88
T_{15}	23.98	22.79	23.39	38.84	36.95	37.90	44.38	40.99	42.69
F-test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	1.180	1.364	1.269	1.480	1.728	1.604	2.574	2.752	2.414
C.D. (P = 0.05)	2.435	2.814	2.619	3.056	3.567	3.311	5.313	5.680	4.983

Number of leaves of per plant

The data presented in Table 3 revealed that all the treatments showed significant differences at 180, 270 and 360 days after planting in first year and second year and their pooled data. From the pooled data it was observed that the maximum number of leaves of per plant 29.52 was obtained with foliar application of Copper sulphate 0.25% + Manganese sulphate 0.25% + NAA 30 ppm + GA_3 60 ppm (T_{15}) followed by 28.90 with the foliar spray of Copper sulphate 0.25% + Manganese sulphate 0.25% + GA_3 60 ppm (T_{14}) at 360 days, which were at par with each other. Whereas, minimum plant stem girth 20.91 was obtained in control (T_0). Similar trends were also observed in first and second year. The increase in production of more number of leaves might be attributed towards PGR since PGR like gibberellins stimulates the activity of auxin resulting in production of more number of leaves. These findings are in close conformity with the findings of Singh and Singh (2009) [16], who also reported an increase in leaf number in strawberry plants with BA application. Manjunath, 2012 also observed similar finding due to the effect of micronutrient in papaya.

Table 3: Effect of different combination of Plant Growth Regulators and micronutrients on Number of leaves per plant of papaya after transplanting in papaya cv. Pusa Nanha.

Treatments	180 DAP		Pooled	270 DAP		Pooled	360 DAP		Pooled
	2013-14	2014-15		2013-14	2014-15		2013-14	2014-15	
T_0	10.86	9.67	10.27	16.43	14.54	15.49	22.54	19.28	20.91
T_1	11.82	10.63	11.23	18.96	17.07	18.02	23.87	20.48	22.18
T_2	11.97	10.78	11.38	21.50	19.61	20.56	24.40	21.01	22.71
T_3	13.00	11.81	12.41	22.53	20.64	21.59	25.43	22.04	23.74
T_4	15.80	14.61	15.21	24.26	22.37	23.32	27.91	24.52	26.22
T_5	14.53	13.34	13.94	24.50	22.61	23.56	28.15	24.76	26.69
T_6	16.13	14.94	15.54	24.96	23.07	24.02	28.61	25.22	26.92
T_7	16.93	15.74	16.34	25.76	23.87	24.82	29.41	26.02	27.72
T_8	15.86	14.67	15.27	24.40	22.51	23.46	28.05	24.66	26.36
T_9	18.96	17.77	18.37	27.30	25.41	26.36	30.95	27.56	29.26
T_{10}	13.57	12.38	12.98	24.83	21.21	22.16	26.00	22.61	24.31
T_{11}	16.37	15.18	15.78	25.07	22.94	23.89	28.72	25.09	26.91
T_{12}	15.10	13.91	14.51	25.53	23.18	24.13	29.18	25.33	27.26
T_{13}	16.70	15.51	16.11	26.33	23.64	24.59	29.98	25.79	27.89
T_{14}	17.50	16.31	16.91	27.56	24.44	25.39	31.21	26.59	28.90
T_{15}	19.03	17.84	18.44	27.56	25.67	26.62	31.21	27.82	29.52
F-test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	1.180	1.364	1.269	1.182	1.366	1.272	0.915	1.102	2.414
C.D. (P = 0.05)	2.435	2.814	2.619	2.441	2.820	2.624	1.888	2.274	4.983

Flowering

Initiation of first flower

The data presented in Table 5 revealed that all the treatments showed significant differences at after planting in first year and second year and their pooled data. The minimum days to initiation of first flower 103.83 was obtained with foliar

application of Copper sulphate 0.25% + Manganese sulphate 0.25% (T_5) followed by 104.40 days with the spray of Copper sulphate 0.25% + NAA 30 ppm + GA_3 60 ppm (T_{12}), which were at par with each other. Whereas, the maximum days to initiation of first flower 126.25 days was obtained in control. The result on earliness in flowering due to PGR in this experiment goes with the reports by Kannan *et al*., (2009) [10] in paprika and Bhujbal *et al*., (2013) [4] in sapota who reported that the application of NAA produced significantly minimum number of days for flower initiation. Kundu and Mitra (1999) [13] they found that spraying with Cu+B+Zn, Cu+B, Cu.+Zn and Cu alone brought about earlier flower bud initiation.

Table 4: Effect of different combination of Plant Growth Regulators and micronutrients on Initiation of flowering of papaya.

Treatments	2013-14	2014-15	Pooled
T_0	126.63	125.87	126.25
T_1	126.10	125.34	125.72
T_2	108.04	103.61	105.83
T_3	125.57	124.28	124.93
T_4	125.04	124.81	124.93
T_5	104.38	103.28	103.83
T_6	113.38	111.61	112.50
T_7	107.04	106.05	106.55
T_8	117.04	115.50	116.27
T_9	111.38	107.83	109.61
T_{10}	126.14	124.85	125.50
T_{11}	125.61	125.38	125.50
T_{12}	104.95	103.85	104.40
T_{13}	113.95	112.18	113.07
T_{14}	107.61	106.62	107.12
T_{15}	109.04	106.61	107.83
F- test	S	S	S
S. Ed. (±)	3.411	3.690	3.550
C. D. (P = 0.05)	7.040	7.615	7.328

Conclusion

From the above experiment it can be concluded that with the application of foliar spray of Copper sulphate 0.25% + Manganese sulphate 0.25% + NAA 30 ppm + GA_3 60 ppm (T_{15}) growth parameters in papaya can be improved significantly however for early flowering application of foliar spray of Copper sulphate 0.25% + Manganese sulphate 0.25% (T_5) can be employed.

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