Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1501-1505
Received: 27-10-2020
Accepted: 25-12-2020

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Study on physiological changes in mango cv. Langra under the influence of GA_3

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Abstract
The experiment was carried out in Horticulture Garden of Bihar Agricultural College, Sabour during Rabi season with the objectives focused in this direction on the effect of GA_3 application on physiological regulation of flowering and maturity in mango [*Mangifera indica* L.] cv. Langra. A critical analysis of data revealed that wide range of observation was observed on fruit set percentage (17.98%) was recorded with gibberellic acid @ 50 ppm within pea stage and fruit retention percentage (0.67%) and fruit drop percentage (99.01%) was recorded with gibberellic acid @ 0 ppm within stone formation stage. The other traits like yield (288.73 Kg/ plant) and length of fruit (97.47 mm) were recorded with spray of gibberellic acid @ 100 ppm respectively. The other traits like pulp weight (210.00 g), edible: non edible ratio (2.69) and Pulp and stone ratio (6.11) was recorded with gibberellic acid @ 50 ppm; however, maximum stone weight (37.95 g) and peal weight (59.91 g) was recorded at the time of 20 days before expected harvest stage.

Keywords: mango tree, variety Langra, GA_3, fruit yield

Introduction
Mango (*Mangifera indica* Linn) is the most important fruit of India and is known as "King of fruits". Mango is popular and favorite in our country and is relished by people of all the ages because of its attractive appearance, enticing fragrance, rich aromatic flavor and attractive colour. It is found in North-East India, North-Burma and foot hills of the Himalayas and is said to have originated in the Indo-Burma region. India has vast germplasm and varietal diversity with about 1100 named varieties and no other country surpass but in India only few are grown on a commercial scale. Especially in Bihar, there is immense scope of mango crop because the agro-climatic conditions of Bihar are very congenial for mango production and the state has enormous wealth of mango genotypes.

Mango cv. Langra is predominant variety of Bihar which constitutes about 60 percent area under mango. The availability period of cv. Langra is very short hence it makes glut in the market. The farmers growing cv. Langra are not able to get good remuneration due to short availability. Moreover, the post harvest life of cv. Langra is very poor that make further problem in market. The use of plant growth regulators such as GA_3 by many researchers have shown reduced flower drop, high flower retention, increased yield and fruit quality in mango and other fruit species such as citrus, apple and guava (Hairdry *et al*., 1997; El-Shaikh, 1999; Iqbal *et al*., 2009). Muarya and Singh (1981) and Dutta and Banik (2007) [6, 4, 8, 14, 2] observed that foliar applications of GA significantly increased fruit length, diameter and fruit weight. Recent investigation has been conducted to increase the retention of flowers and fruits using plant growth regulators like GA_3. The present study was conducted to investigate the effect of GA_3 sprays at the flowering stage to improve mango fruit retention, yield and fruit quality in Keitt cultivar (Nkansah *et al*., 2012) [15].

Materials and Methods
The field experiment was conducted in AICRP (Fruits) Sabour, in the permanent experimental site under the Department of Horticulture (Fruit & Fruit Tech.), Bihar Agricultural College, Sabour, Bhagalpur, Bihar. The experimental plot had well drained sandy loam soil of good fertility with leveled surface. The experiment was carried out on plants those were planted in 1980 (33 year) at AICRP-fruit trial area of Bihar Agriculture College, Sabour. All the trees were maintained under uniform cultural practices during the course of investigation. Trees of mango cv. Langra were sprayed with 50, 100 and 200 ppm Gibberellic acid (GA_3) at Pea stage. Marble stage, Stone formation stage, 20 and 10 days before harvest. Control trees were spray with water.

Results and Discussion

Fruit Set and Fruit Retention Percentage

It clearly indicates that in Table-1, there is no significant effect on fruit set percentage with the application of gibberellic acid (GA_3) and time of application. However, range varies of fruit set percentage from (15.74%) to (16.87%) Whereas, the application effect of time ranged from (15.90%) to (16.58%). The highest fruit set percentage (17.98%) was recorded with gibberellic acid (GA_3) @ 50 ppm within pea stage.

The application of gibberellic acid (GA_3) and time of application was non-significant effect of fruit retention percentage (Table-1). However, different levels of gibberellic acid (GA_3) range of fruit retention percentage vary from (0.52%) to (0.59%) Whereas the application of time range varied from (0.54%) to (0.60%). The highest fruit retention percentage (0.67%) was recorded with gibberellic acid (GA_3) @ 0 ppm within stone formation stage (Kerdchoechuen and Matta, 2008; Singh *et.al*, 2007; Khan *et al.*, 1976; Barua and Mohan, 1984; Rani and Brahmachari, 2002; Kumar *et al*., 2009 and El-Shabasi *et.al*., 2009) [9, 20, 10, 1, 16, 11, 3] obtained best results by the application of GA_3 on fruit set and retention.

Table 1: Effect of GA_3 application on different stages on fruit set percent, fruit retention percent and Fruit drop percent in mango cv. Langra

Treatments	Fruit set (%)			Fruit retention (%)			Fruit drop (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
GA_3 application									
Control	16.84	16.39	16.61	0.64	0.53	0.59	98.95	99.07	99.01
50 ppm	16.80	16.94	16.87	0.58	0.52	0.55	98.95	98.88	98.92
100 ppm	16.15	15.81	15.98	0.67	0.52	0.59	98.98	98.82	98.90
200 ppm	16.40	15.08	15.74	0.52	0.52	0.52	98.96	98.83	98.90
SE ± mean	-	-	-	-	-	-	-	0.05	0.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	0.16	0.08
Time of application									
Pea stage	16.37	16.69	16.53	0.65	0.51	0.58	98.98	98.94	98.96
Marble stage	16.66	15.14	15.90	0.59	0.52	0.55	98.96	98.87	98.92
Stone formation stage	16.06	16.63	16.35	0.67	0.53	0.60	98.96	98.85	98.91
20 days before expected harvest	16.27	16.02	16.14	0.54	0.53	0.54	98.96	98.89	98.92
10 days before expected harvest	17.38	15.78	16.58	0.58	0.51	0.54	98.93	98.96	98.94
SE ± mean	-	-	-	-	-	-	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Fruit drop and cracking percentage

Mango is subject to heavy and continuous fruit drop due to biotic as well as abiotic factors. The maximum number of fruit drop percentage (99.01%) was recorded when gibberellic acid (GA_3) @ 0 ppm while as minimum number of fruit drop percentage (98.90%) was recorded in gibberellic acid (GA_3) @ 100 ppm. There was no significant effect of number of fruit drop percentage with time of application and range varies from 98.91% to 98.96% (Table-1). Fruit drop is the major problem which reduces the quantitative as well as qualitative yield in mango. Khan *et al*., 1976; Veer and Das, 1972 and Singh *et al*., 1986 [10, 22, 21] reported that spray of 2, 4-D (10 ppm) effectively controlled fruit drop in Chausa cultivar of mango. Gupta and Kaur (2007) [5] assessed the growth regulators viz, ethrel, NAA and GA were sprayed at different fruit development stage which prevent the pre harvest fruit drop in plum cv. Satluj Purple.

There is significant data (Table-2) to the maximum fruit cracking percentage (3.53%) was recorded with gibberellic acid (GA_3) @ 0 ppm while the minimum fruit cracking percentage (3.00%) was recorded in gibberellic acid (GA_3) @ 100 ppm. The maximum time of application was recorded of fruit cracking (3.55%) at the time of stone formation stage and Minimum fruit cracking percentage (2.88%) was recorded at the time of marble stage. It clearly indicates that the highest fruit cracking percentage (3.85%) was recorded with gibberellic acid (GA_3) @ 0 ppm within pea stage and the lowest fruit cracking percentage (2.54%) was found in gibberellic acid (GA_3) @ 100 ppm within marble stage. Mishra *et al*., (2012) [13] sprayed GA_3 @ 40 ppm reduced fruit cracking and increased fruit.

Table 2: Effect of GA_3 application on different stages on fruit cracking percent and fruit yield/plant in mango cv. Langra

Treatments	Cracking (%)			Yield/plant (Kg)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
GA_3 application						
Control	0.82	0.75	0.79	184.95	250.28	217.62
50 ppm	0.80	0.80	0.80	231.92	291.24	261.58
100 ppm	0.79	0.84	0.81	267.89	313.20	290.54
200 ppm	0.76	0.81	0.79	231.21	296.24	263.73
SE ± mean	-	-	-	10.19	12.55	8.08
CD (P=0.05)	NS	NS	NS	30.17	37.15	23.15
Time of application						
Pea stage	0.81	0.84	0.82	223.25	270.75	247.00
Marble stage	0.85	0.82	0.84	224.71	277.87	251.29
Stone formation stage	0.77	0.77	0.77	227.67	288.85	258.26
20 days before expected harvest	0.79	0.70	0.74	229.83	293.07	261.45
10 days before expected harvest	0.77	0.86	0.81	239.51	308.16	273.83
SE ± mean	-	-	-	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Yield/plant (Kg)

Yield of fruits varies considerably according to the variety, climatic conditions, plant population etc. It clearly indicates in Table-2 that there is no significant effect of fruit yield per plant. However, the maximum yield (288.73 Kg/plant) was recorded when spray of gibberellic acid (GA_3) @ 100 ppm while as minimum yield (264.52 Kg/plant) was recorded in gibberellic acid (GA_3) @ 200 ppm. Ruby- Rani and Brahmachari (2004) [17] evaluated the efficacy of pre-harvest sprays of GA_3 @ 100 ppm which produced highest yield.

Length and Breadth of fruit (mm)

The maximum length of fruit (97.47 mm) was recorded with gibberellic acid (GA_3) @ 100 ppm while as minimum length of fruit (92.49 mm) was recorded in gibberellic acid (GA_3) @ 0 ppm (Table-3). Hegazi (2011) reported that the fruit length (5.83 cm) @ 100 ppm and (7.03 cm) @ 150 ppm of GA_3 was maximum in "Leconte" cultivar of pear.

Table-3 showed that the maximum fruit breadth (73.63 mm) was recorded with gibberellic acid (GA_3) @ 200 ppm while as the minimum fruit breadth (69.78 mm) was recorded in gibberellic acid (GA_3) @ 0 ppm. Ruby- Rani and Brahmachari (2004) [17] evaluated the efficacy of pre-harvest sprays of GA_3 @ 200 ppm which produced fruits of the greatest diameter in mango fruit.

Table 3: Effect of GA_3 application on different stages on length of fruit, breadth of fruit and volume of fruit in mango cv. Langra

Treatments	Length of fruit (mm)			Breadth of fruit (mm)			Volume of fruit (ml)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
GA_3 application									
Control	92.79	92.18	92.49	68.04	71.51	69.78	247.62	251.99	249.81
50 ppm	96.43	95.73	96.08	71.71	73.10	72.40	265.84	266.17	266.00
100 ppm	95.68	99.27	97.47	72.93	74.12	73.52	271.41	276.82	274.12
200 ppm	95.86	96.89	96.37	71.76	75.50	73.63	257.77	270.18	263.97
SE ± mean	-	1.52	1.08	1.00	0.86	0.66	5.19	5.57	3.81
CD (P=0.05)	NS	4.49	3.08	2.95	2.56	1.89	15.37	16.48	10.90
Time of application									
Pea stage	93.68	96.38	95.03	70.49	73.31	71.90	255.20	253.42	254.31
Marble stage	91.78	93.91	92.85	66.20	68.22	67.21	255.21	262.70	258.96
Stone formation stage	94.63	94.13	94.38	71.33	74.54	72.93	251.75	257.68	254.71
20 days before expected harvest	99.51	98.88	99.19	75.13	75.71	75.42	283.00	290.81	286.91
10 days before expected harvest	96.34	96.77	96.56	72.40	76.02	74.21	258.13	266.84	262.49
SE ± mean	1.71	-	1.20	1.11	0.97	0.74	5.80	6.22	4.26
CD (P=0.05)	5.05	NS	3.45	3.30	2.86	2.11	17.18	18.42	12.18

Volume of fruit (ml)

The maximum fruit volume (295.93 ml.) was recorded at the time of 20 days before expected harvest stage while as minimum fruit volume (230.71 ml.) was recorded at the marble stage (Table-3). Mandal *et al*., (2012) [12] reported that maximum fruit volume (226.09 cc) it means volume of cylindrical container) with GA_3 @ 100 ppm was found.

Weight of Pulp, Stone and Peel (g)

The effect of gibberellic acid (GA_3) and time of application has significant effect on pulp weight (Table-4). The maximum pulp weight (210.00 g) was recorded with gibberellic acid (GA_3) @ 50 ppm and lowest pulp weight (189.81 g) was recorded in gibberellic acid (GA_3) @ 200 ppm. The time of application in pulp weight (232.23 g) was recorded at the time of 20 days before expected harvest stage. The minimum pulp weight (180.77 g) was recorded at the stone formation stage. Ruby- Rani and Brahmachari (2004) [17] evaluated the efficacy of pre-harvest sprays the greatest pulp weight per fruit was recorded for GA_3 at 100 ppm.

There is no significant effect on stone weight with application of gibberellic acid (GA_3) which range varies from (35.13 g) to (37.18 g). The time of application has significant effect on stone weight. The maximum stone weight (37.95 g) was recorded at the time of 20 days before expected harvest stage and minimum stone weight (34.94 g) was recorded at the time of pea stage. There is no significant effect on peel weight with application of gibberellic acid (GA_3) which range varies from (45.22 g) to (49.68 g). The time of application has significant effect on peel weight. The maximum peel weight (59.91 g) was recorded at the time of 20 days before expected harvest stage, Sandhu and Subhadrabandhu, 1992 [18].

Table 4: Effect of GA_3 application on different stages on weight of pulp, weight of stone and weight of peal in mango fruit cv. Langra

Treatments	Weight of pulp (g)			Weight of stone (g)			Weight of peal (g)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
GA_3 application									
Control	173.90	175.86	174.88	38.00	37.72	37.86	52.22	50.91	51.56
50 ppm	196.90	198.20	197.55	35.77	35.40	35.58	45.67	45.07	45.37
100 ppm	202.97	211.60	207.28	34.53	35.36	34.95	42.41	42.36	42.39
200 ppm	186.37	196.24	191.31	36.30	37.44	36.87	47.60	48.99	48.29
SE ± mean	5.24	4.17	3.35	0.52	0.67	0.42	1.36	1.94	1.19
CD (P=0.05)	15.52	12.34	9.59	1.52	1.97	1.21	4.04	5.75	3.40
Time of application									
Pea stage	180.50	187.31	183.90	37.75	38.19	37.97	49.45	40.43	44.94
Marble stage	187.58	191.96	189.77	36.29	37.83	37.06	43.84	45.42	44.63
Stone formation stage	184.29	187.25	185.77	36.29	36.71	36.50	43.66	46.22	44.94
20 days before expected harvest	211.08	213.38	212.23	35.04	34.13	34.58	49.38	55.81	52.59
10 days before expected harvest	186.71	197.50	192.10	35.38	35.56	35.47	48.55	46.28	47.42

SE ± mean	5.86	4.66	3.75	0.58	0.75	0.47	1.52	2.17	1.33
CD (P=0.05)	17.36	13.80	10.72	1.70	2.21	1.35	4.51	6.43	3.80

Pulp/stone ratio and Edible/non edible ratio

Table-5 showed that the maximum Pulp and stone ratio (6.11) with GA_3 @ 50 ppm were recorded while as lowest Pulp and stone ratio (5.16) was recorded in gibberellic acid (GA_3) @ 200 ppm. Shrivastava and Jain (2006) [19] reported that maximum pulp and stone ratio (5.20) with GA_3 @ 50 ppm followed by (5.05) GA_3 @ 100 ppm.

The effect of gibberellic acid (GA_3) and time of application has significant effect of edible: non edible ratio. The maximum edible: non edible ratio (2.69) was recorded with gibberellic acid (GA_3) @ 50 ppm and lowest edible: non edible ratio (2.25) was recorded in gibberellic acid (GA_3) @ 200 ppm. The time of application maximum edible: non edible ratio (2.51) was recorded at the time of pea stage and the minimum edible: non edible ratio (2.23) was recorded at the time of stone formation stage. It clearly indicates that the highest edible: non edible ratio (3.61) was recorded with gibberellic acid (GA_3) @ 50 ppm within marble stage whereas, the lowest edible: non edible ratio (1.76) was found gibberellic acid (GA_3) @ 0 ppm within marble stage. Ruby-Rani and Brahmachari (2004) [17] evaluated that the edible/non-ratio was highest with GA_3 at 200 ppm.

Table 5: Effect of GA_3 application on different stages on weight of fruit, pulp: stone ratio and edible: non edible ratio in mango fruit cv. Langra

Treatments	Weight of fruit (g)			Pulp: stone ratio			Edible: non edible ratio		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
GA_3 application									
Control	264.12	264.49	264.31	4.58	4.71	4.65	1.93	1.99	1.96
50 ppm	278.34	278.67	278.50	5.52	5.65	5.59	2.43	2.47	2.45
100 ppm	279.91	289.32	284.62	5.90	6.04	5.97	2.65	2.73	2.69
200 ppm	270.27	282.68	276.47	5.14	5.26	5.20	2.23	2.27	2.25
SE ± mean	-	5.57	4.01	0.140	0.188	0.117	0.067	0.052	0.042
CD (P=0.05)	NS	16.48	11.49	0.414	0.558	0.336	0.197	0.154	0.121
Time of application									
Pea stage	267.70	265.92	266.81	4.78	4.94	4.86	2.07	2.40	2.24
Marble stage	267.71	275.20	271.46	5.19	5.13	5.16	2.37	2.34	2.35
Stone formation stage	264.25	270.18	267.21	5.09	5.12	5.11	2.33	2.27	2.30
20 days before expected harvest	295.50	303.31	299.41	6.05	6.24	6.14	2.52	2.39	2.46
10 days before expected harvest	270.63	279.34	274.99	5.32	5.65	5.48	2.24	2.43	2.34
SE ± mean	6.47	6.22	4.49	0.156	0.211	0.131	0.075	0.058	0.047
CD (P=0.05)	19.15	18.42	12.85	0.463	0.624	0.376	0.221	0.172	0.135

Stone length and Breadth

The effect of gibberellic acid (GA_3) and time of application has significant effect of stone length (Table-6). The maximum stone length (74.12 mm) was recorded with gibberellic acid (GA_3) @ 0 ppm and lowest stone length (68.49 mm) was recorded in gibberellic acid (GA_3) @ 200 ppm. The maximum stone length (73.48 mm) was recorded at the time of 20 days before expected harvest stage and the minimum stone length (69.17 mm) was recorded at the time of marble stage.

The effect of gibberellic acid (GA_3) and time of application has significant effect on stone breadth. The maximum stone breadth (42.87 mm) was recorded with gibberellic acid (GA_3) @ 0 ppm followed by gibberellic acid (GA_3) @ 50 ppm (41.73 mm) and lowest stone breadth (41.30 mm) was recorded in gibberellic acid (GA_3) @ 100 ppm.

Table 6: Effect of GA_3 application on different stages time on length of stone and breadth of stone in mango cv. Langra

Treatments	Length of stone (mm)			Breadth of stone (mm)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
GA_3 application						
Control	73.99	74.25	74.12	42.67	43.08	42.87
50 ppm	70.13	72.60	71.37	41.13	42.34	41.73
100 ppm	69.04	70.70	69.87	41.28	41.32	41.30
200 ppm	67.99	68.99	68.49	42.75	40.27	41.51
SE ± mean	1.02	1.20	0.79	0.47	0.39	0.31
CD (P=0.05)	3.02	3.56	2.26	1.40	1.17	0.88
Time of application						
Pea stage	68.65	70.16	69.41	40.87	40.92	40.89
Marble stage	64.49	73.85	69.17	39.92	40.12	40.02
Stone formation stage	71.85	70.38	71.11	42.66	41.75	42.20
20 days before expected harvest	74.40	72.56	73.48	44.67	43.82	44.24
10 days before expected harvest	72.05	71.23	71.64	41.68	42.14	41.91
SE ± mean	1.14	-	0.88	0.53	0.44	0.34
CD (P=0.05)	3.37	NS	2.52	1.56	1.30	0.98

Conclusion

There is no significant effect on fruit set percentage with the application of gibberellic acid (GA_3) and time of application. However, fruit set percentage range varied from (15.74%) to (16.87%) Whereas, the application effect of time ranged from (15.90%) to (16.58%). Fruit set and fruit retention and yield were unaffected either by the dose of GA_3 application or time of application. The application of gibberellic acid (GA_3) and

time of application was non-significant effect of fruit retention percentage. However, different levels of gibberellic acid (GA_3) of fruit retention percentage varied from (0.52%) to (0.59%) Whereas the application of time range varied from (0.54%) to (0.60%). Mango is subject to heavy and continuous fruit drop due to biotic as well as abiotic factors. The minimum number of fruit drop percentage was recorded in gibberellic acid (GA_3) @ 100 ppm. There was no significant effect of number of fruit drop percentage with time of application and range varied from 98.91% to 98.96%. The minimum fruit cracking percentage (3.00%) was recorded in gibberellic acid (GA_3) @ 100 ppm and Minimum fruit cracking percentage (2.88%) was recorded at the time of marble stage. Yield of fruits varies considerably according to the variety, climatic conditions, plant population etc. It clearly indicates that there is no significant effect of fruit yield per plant. However, the maximum yield (288.73 Kg/ plant) was recorded when spray of gibberellic acid (GA_3) @ 100 ppm while as minimum yield (264.52 Kg/ plant) was recorded in gibberellic acid (GA_3) @ 200 ppm. The effect of gibberellic acid (GA_3) and time of application has significant effect on pulp weight, stone weight, Pulp and stone ratio and edible: non edible ratio. The maximum pulp weight, stone weight, Pulp and stone ratio and edible: non edible ratio was recorded with gibberellic acid (GA_3) @ 50 ppm.

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