Effect of pre-harvest treatment of GA<sub>3</sub> on physiological behaviour in Mango

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Abstract
Mango (*Mangifera indica* L.) is one of the most important fruit crops of many tropical and sub-tropical countries of world which belongs to the family Anacardiaceae (Nakasone and Paul 1998 and Purseglove 1972). 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<sub>3</sub> 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 physiological traits. The traits such as photosynthetic rate (8.71 μmol/m<sup>2</sup>/sec) and internal CO<sub>2</sub> concentration (283.80 ppm) was recorded with gibberellic acid @ 200 ppm while Stomatal conductance of leaf (0.163 μmol/m<sup>2</sup>/sec) was recorded at the time of stone formation stage. A wide range was observed with application of gibberellic acid on Physiological parameters.

Keywords: Mango tree, variety Langra, GA<sub>3</sub>, photosynthesis and application rate

Introduction
Mango (*Mangifera indica* L.) is one of the best fruit crops of many tropical and sub-tropical countries of world which belongs to the family Anacardiaceae (Nakasone and Paul 1998 and Purseglove 1972)\(^{10,12}\). 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<sub>3</sub> 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)\(^{3,2,5}\). Muarya and Singh (1981)\(^{9}\) and Dutta and Banik (2007)\(^{11}\) 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<sub>3</sub>. The present study was conducted to investigate the effect of GA<sub>3</sub> sprays at the flowering stage to improve mango fruit retention, yield and fruit quality in Keitt cultivar (Nkansah *et al.*, 2012)\(^{11}\).

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\textsubscript{3}) at Pea stage, Marble stage, Stone formation stage, 20 and 10 days before harvest. Control trees were spray with water.

**Results and Discussion**

**Photosynthesis rate (µmol/m\textsuperscript{2}/sec)**

The data related to the photosynthetic rate are presented in Table-1 and represented graphically in Fig.- 1(a). The maximum photosynthetic rate (8.71 µmol/m\textsuperscript{2}/sec) was recorded with gibberellic acid (GA\textsubscript{3}) @ 200 ppm which at par with gibberellic acid (GA\textsubscript{3}) @ 100 ppm. Minimum photosynthetic rate (7.42 µmol/m\textsuperscript{2}/sec) was recorded in gibberellic acid (GA\textsubscript{3}) @ 0 ppm which at par with gibberellic acid (GA\textsubscript{3}) @ 50 ppm.

![Photosynthesis](image1)

**Fig 1(a):** Effect of GA\textsubscript{3} application on different stages on photosynthesis (µmol/m\textsuperscript{2}/sec) in mango cv. Langra

The maximum photosynthetic rate (8.36 µmol/m\textsuperscript{2}/sec) was recorded at the time of 10 days before expected harvest stage which at par with the time of stone formation stage. Minimum photosynthetic rate (7.75 µmol/m\textsuperscript{2}/sec) was recorded at the pea stage which at par with the time of 20 days before expected harvest stage.

The interaction effect was found to be significant effect on the photosynthetic rate shown in Table-2 and represented graphically in Fig.- 1(b). It clearly indicates that the highest photosynthetic rate (9.67 µmol/m\textsuperscript{2}/sec) was recorded with gibberellic acid (GA\textsubscript{3}) @ 200 ppm within stone formation stage followed by (9.13 µmol/m\textsuperscript{2}/sec) with gibberellic acid (GA\textsubscript{3}) @ 100 ppm within pea stage whereas, the lowest photosynthetic rate (6.69 µmol/m\textsuperscript{2}/sec) was found gibberellic acid (GA\textsubscript{3}) @ 0 ppm within 20 days before expected harvest stage. 

(Hayashi, 1961; Little and Louch, 1975; Whiley, 1986; Wieland and Wample, 1985; Khandaker et al., 2013 and Kasambhai, 2015) \[4, 8, 13, 14, 7, 6\].

![Interaction effect of GA\textsubscript{3} and time of application](image2)

**Fig 1(b):** Interaction effect of GA\textsubscript{3} and its application time on photosynthesis (µmol/m\textsuperscript{2}/sec) in mango cv. Langra

| GA\textsubscript{3} application | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
|---------------------------------|---------|---------|--------|---------|---------|--------|---------|---------|--------|---------|---------|--------|
| Control                         | 7.03    | 7.81    | 7.42   | 0.153   | 0.161   | 0.157  | 275.30  | 273.90  | 274.60  | 275.30  | 273.90  | 274.60  |
| 50 ppm                          | 8.09    | 7.81    | 7.95   | 0.155   | 0.159   | 0.157  | 282.50  | 280.30  | 281.40  | 282.50  | 280.30  | 281.40  |
| 100 ppm                         | 8.09    | 8.43    | 8.26   | 0.159   | 0.157   | 0.158  | 283.80  | 281.60  | 282.70  | 283.80  | 281.60  | 282.70  |
| 200 ppm                         | 9.03    | 8.39    | 8.71   | 0.163   | 0.158   | 0.163  | 283.80  | 283.80  | 283.80  | 283.80  | 283.80  | 283.80  |
| SE ± mean                       | 0.039   | 0.038   | 0.027  | 0.003   | -       | -      | 1.90    | 2.22    | 1.46    |

Table 1: Effect of GA\textsubscript{3} application on different stages on photosynthesis (µmol/m\textsuperscript{2}/sec), stomatal conductance (µmol/m\textsuperscript{2}/sec) and Internal CO\textsubscript{2} concentration of leaf (ppm) in mango cv. Langra
Table 2: Interaction effect of GA3 and its application time on photosynthesis (µmol/m2/sec), stomatal conductance (µmol/m2/sec) and Internal CO2 concentration of leaf (ppm) in mango cv. Langra

| GA3 application | Time of application | Photosynthesis (µmol/m2/sec) | Stomatal conductance (µmol/m2/sec) | Internal CO2 concentration of leaf (ppm) |
|-----------------|---------------------|------------------------------|-----------------------------------|----------------------------------------|
|                 |                     | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| GA3 @ 0 ppm     | Pea stage           | 6.48    | 7.89    | 7.18   | 0.16    | 0.18    | 0.17   | 274.00  | 267.50  | 270.75 |
|                 | Marble stage        | 7.25    | 7.89    | 7.57   | 0.15    | 0.18    | 0.16   | 273.00  | 282.50  | 277.75 |
|                 | Stone formation stage | 6.89   | 9.55    | 8.22   | 0.16    | 0.17    | 0.16   | 274.00  | 282.50  | 278.25 |
|                 | 20 days before expected harvest | 6.89   | 6.48    | 6.69   | 0.16    | 0.14    | 0.15   | 278.50  | 269.00  | 273.75 |
|                 | 10 days before expected harvest | 7.65   | 7.25    | 7.45   | 0.15    | 0.15    | 0.15   | 277.00  | 268.00  | 272.50 |
| GA3 @ 50 ppm    | Pea stage           | 7.44    | 7.26    | 7.35   | 0.15    | 0.16    | 0.15   | 283.00  | 277.00  | 280.00 |
|                 | Marble stage        | 8.42    | 7.65    | 8.03   | 0.17    | 0.14    | 0.15   | 281.00  | 277.00  | 279.00 |
|                 | Stone formation stage | 7.89   | 8.28    | 8.08   | 0.14    | 0.19    | 0.16   | 282.50  | 283.50  | 283.00 |
|                 | 20 days before expected harvest | 8.28   | 7.44    | 7.86   | 0.19    | 0.16    | 0.17   | 283.50  | 283.00  | 283.25 |
|                 | 10 days before expected harvest | 8.44   | 8.42    | 8.43   | 0.15    | 0.17    | 0.16   | 282.50  | 281.00  | 281.75 |
| GA3 @ 100 ppm   | Pea stage           | 8.51    | 9.74    | 9.13   | 0.16    | 0.18    | 0.17   | 285.00  | 278.00  | 281.50 |
|                 | Marble stage        | 7.85    | 8.44    | 8.14   | 0.15    | 0.15    | 0.15   | 286.50  | 282.50  | 284.50 |
|                 | Stone formation stage | 7.26   | 7.62    | 7.44   | 0.16    | 0.17    | 0.16   | 285.00  | 276.00  | 280.50 |
|                 | 20 days before expected harvest | 7.47   | 8.51    | 7.99   | 0.17    | 0.15    | 0.16   | 276.00  | 285.00  | 280.50 |
|                 | 10 days before expected harvest | 9.35   | 7.85    | 8.60   | 0.18    | 0.16    | 0.17   | 286.50  | 286.50  | 286.50 |
| GA3 @ 200 ppm   | Pea stage           | 7.78    | 6.89    | 7.33   | 0.18    | 0.15    | 0.16   | 283.50  | 279.00  | 281.25 |
|                 | Marble stage        | 8.49    | 9.35    | 8.92   | 0.14    | 0.18    | 0.16   | 282.00  | 286.50  | 284.25 |
|                 | Stone formation stage | 9.79   | 9.55    | 9.67   | 0.18    | 0.17    | 0.17   | 278.00  | 288.00  | 283.00 |
|                 | 20 days before expected harvest | 9.55   | 7.78    | 8.67   | 0.18    | 0.17    | 0.17   | 288.00  | 283.50  | 285.75 |
|                 | 10 days before expected harvest | 9.55   | 8.39    | 8.97   | 0.18    | 0.14    | 0.16   | 287.50  | 282.00  | 284.75 |
|                | SE ± mean           | 0.087   | 0.056   | 0.061  | 0.006   | 0.007   | 0.005  | -       | -       | -       |
|                | CD (P=0.05)         | 0.259   | 0.250   | 0.174  | 0.018   | 0.021   | 0.013  | NS      | NS      | NS      |

Stomatal conductance (µmol/m²/sec)

The data related to the Stomatal conductance of leaf are presented in Table-1 and represented graphically in Fig. 2(a). There are no significant effects of Stomatal conductance of leaf with application of gibberellic acid (GA3) which range from 0.157µmol/m²/sec to 0.163 µmol/m²/sec. The maximum Stomatal conductance of leaf (0.163 µmol/m²/sec) was recorded at the time of stone formation stage which at par with the time of 20 days before expected harvest stage. Minimum Stomatal conductance of leaf (0.154 µmol/m²/sec) was recorded at the marble stage which at par with the time of 10days before expected harvest stage.

The interaction effect was found to be significant effect on the Stomatal conductance of leaf shown in Table-2 and represented graphically in Fig. 2(b). It clearly indicates that the highest Stomatal conductance (0.17 µmol/m²/sec) and lowest Stomatal conductance (0.15 µmol/m²/sec) was found. Similar findings were reported by Khandaker et al., 2013

Fig 2(a): Effect of GA3 application on different stages on stomatal conductance (µmol/m²/sec) in mango cv. Langra

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The data related to the internal CO$_2$ concentration of leaf are presented in Table-1 and represented graphically in Fig.-3(a). There is significant effect of internal CO$_2$ concentration of leaf with application of gibberellic acid (GA$_3$). The maximum internal CO$_2$ concentration of leaf (283.80 ppm) was recorded with gibberellic acid (GA$_3$) @ 200 ppm which at par with gibberellic acid (GA$_3$) @ 100 ppm. Minimum internal CO$_2$ concentration of leaf (274.60 ppm) was recorded with gibberellic acid (GA$_3$) @ 0 ppm which at par with gibberellic acid (GA$_3$) @ 50 ppm. There was no significant effect of internal CO$_2$ concentration on leaf and range varies from 278.38 ppm to 281.38 ppm. The interaction effect did not have any significant effect on the internal CO$_2$ concentration on leaf shown in Table-2 and represented graphically in Fig.-3(b). The highest internal CO$_2$ concentration on leaf (86.50 ppm) was recorded with gibberellic acid (GA$_3$) @ 100 ppm within 10 days before expected harvest stage. However, the lowest internal CO$_2$ concentration of leaf was observed (270.75 ppm) with gibberellic acid (GA$_3$) @ 0 ppm within pea stage. Similar findings were reported by Zaharah et al., 2012 [15].
Conclusion
The maximum photosynthetic rate ($8.71 \, \mu\text{mol/m}^2/\text{sec}$) was recorded with gibberellic acid (GA$_3$) @ 200 ppm and at the time of 10 days before expected harvest stage. There are no significant effects of Stomatal conductance of leaf with application of gibberellic acid (GA$_3$) which ranged from $0.157 \, \mu\text{mol/m}^2/\text{sec}$ to $0.163 \, \mu\text{mol/m}^2/\text{sec}$. The maximum Stomatal conductance of leaf ($0.163 \, \mu\text{mol/m}^2/\text{sec}$) was recorded at the time of stone formation stage. There is significant effect of internal CO$_2$ concentration of leaf with application of gibberellic acid (GA$_3$) while the interaction effect was non-significant to the internal CO$_2$ concentration on leaf. The maximum internal CO$_2$ concentration of leaf (283.80 ppm) was recorded with gibberellic acid (GA$_3$) @ 200 ppm.

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