Effect of gibberellic acid and growing media on seed germination, growth and vigour of papaya (*Carica papaya* L.) seedling

**Priyanka Paikra, MS Paikra and Anil Netam**

**Abstract**

An experiment entitled “Effect of Gibberellic acid and growing media on seed germination, growth and vigour of papaya (*Carica papaya* L.) Seedling” was conducted during 2020-21 at the Horticulture Research Farm, under Pt. Kishorilal Shukla College of Horticulture & Research Station, Rajnandgaon, Chhattisgarh. The experiment was laid out in factorial completely randomized design (FCRD), which included 28 treatments with 3 replications; there were two factors which comprised seven levels of different growing media and four levels of growth regulators. The treatment combination of soil: sand: vermicompost; in 1:1:1 ratio along with 100 ppm (M$_5$G$_3$) showed better for seed germination, root growth parameters and survival percentage and combination of growing media soil: sand: rice husk: vermicompost; in 1:1:1:1 ratio with GA$_3$ 100 ppm (M$_5$G$_3$) was found better for shoot growth parameters and survival percentage, hence both treatment combination M$_5$G$_3$ and M$_5$G$_3$ was found to be most suitable and may be recommended for raising of quality planting material of papaya.

**Keywords**: Papaya, GA$_3$, vermicompost, FYM, rice husk, germination, seedling

**Introduction**

Papaya (*Carica papaya* L.) is an important fruit crop in tropical and subtropical regions of the world as well as in kitchen gardens due to its quick growth and early bearing habit. It belongs to the family Caricaceae and its native place is Tropical America. India is the largest producer of papaya, contributing 45% of global production. The major growing states of papaya in India are Karnataka, Gujarat, Orissa, West Bengal, Assam, Kerala, Chhattisgarh, Madhya Pradesh, and Maharashtra. The total area of papaya in India is 142 thousand ha, with an annual production of 6011 thousand MT (Anon., 2019a) [2]. In Chhattisgarh, the area under papaya cultivation is 14.40 thousand ha with a production of 26.48 MT/ha (Anon., 2019b) [2]. In Chhattisgarh, it is mainly cultivated in Durg, Raipur, Bilaspur, Mahasamund, and Bemetara.

Papaya is normally propagated by seed (Cheema and Dhani, 1930) [3]. Many papaya growers face the problem of slow, erratic and incomplete germination. The slow and asynchronous germination is attributed due to the presence of inhibitors (mainly phenolic compounds) in the sarcotesta and seed coat (Reyes et al. 1980) [10].

A growing medium can be defined as a substance through which plant roots grow and extract water and nutrients. Selecting a good growing medium is fundamental to good nursery management and is the foundation of a healthy root system (Mishra et al. 2017) [12]. Seed treatment promotes seed germination and minimises the germination time with suitable growing media. Gibberellic acid (GA$_3$) can stimulate rapid stem and root growth, induce mitotic division in the leaves of some plants, and increase seed germination rate. The seeds of papaya are enclosed within a gelatinous sarcotesta (aril, or outer seed coat which is formed from the outer integument.) which can prevent germination (Yahiro, 1979) [20]. Before sowing of seeds is soaking in water or water soluble endogenous hormones has been reported to promote the germination (Desai et al. 2017) [6].

Growing media serves as a growing medium as well as a fertilizer source for plant growth. Vermicompost delivers sufficient oxygen to roots, as well as appropriate water and nutrient retention for plants; certain beneficial compounds improve nutrient availability, affecting plant development, production, and quality. FYM is porous and has a high water holding capacity, allowing for optimum moisture and gas exchange between the growing medium and the embryo.
Cocopeat is a good growth media constituent because of its pH, electrical conductivity, and other chemical properties (Ramteke et al. 2015) \cite{17}. Rice husk is a by-product of the milling industry and is one of the important agricultural waste materials used as a growing medium. It acts as a sorbent for nutrients due to the presence of high silica content (Radha et al. 2018) \cite{10}.

The cost of many gynodioecious cultivars of papaya is very high, that's why proper seed germination and seedling growth are most important considerations in successful production under nursery technique of papaya cultivation. Plant vigour depends on seedling vigour. Hence attention has to be given from nursery stage itself in order to improve the seedling vigour. So increasing germination and producing vigorous seedling is very important for papaya nursery growers. Keeping in view above, the aims of the study was to identify suitable treatment combinations for better seed germination and seedling growth of papaya.

Material and Methods

The experiment was conducted at the Horticulture Research Farm, under Pt. Kishorilal Shukla College of Horticulture & Research Station, Rajnandgaon (C.G.). The experiment was framed out in factorial completely randomized design (FCRD), which included 28 treatments with 3 replications, there were two factors which comprised seven levels having equal ratios of different growing media viz. control; soil (M₀), soil: sand: FYM (M₁), soil: sand: vermicompost (M₂), soil: sand: rice husk (M₃), soil: sand: cocopeat (M₄), soil: sand: rice husk: vermicompost (M₅), and soil: sand: rice husk: vermicompost: rice husk: cocopeat (M₆). The four levels of growth regulators viz. control; water (G₀), 100 ppm (G₁), 200 ppm (G₂) and 300 ppm (G₃). The seeds of papaya cv. Red Lady were soaked for 10 minutes in shade after soaking. The dried seeds were kept for 12 hrs in beaker. The seeds were dried at 10°C for 75 days after sowing, and the others were recorded at 75 DAS. The height of plant was measured by using meter scale and above 1 cm height of seedling.

\[
\text{Germination Percentage} = \frac{\text{Total no. of seeds germinated}}{\text{Total no. of seeds sown}} \times 100
\]

\[
\text{Vigour Index} - I = \text{Germination \%} \times \text{Total length of seedling}
\]

\[
\text{Vigour Index} - II = \text{Germination \%} \times \text{Dry weight of seedling}
\]

\[
\text{Survival percentage} = \frac{\text{No. of survived seedlings}}{\text{Total no. of seedlings}} \times 100
\]

Result & Discussion

Effect of Growing Media

Germination parameters

Among various growing medium, soil: sand: vermicompost; in 1:1:1 ratio (M₄), took the minimum time for germination (15.39 days), followed by soil: sand: rice husk: vermicompost; in 1:1:1:1 ratio (M₅), soil: sand: cocopeat; 1:1:1 ratio (M₃), while the maximum time (17.00 days) was observed in control; soil (M₀). The higher germination percentage (97.50\%) was noted in media M₃ followed by soil: rice husk: vermicompost; 1:1:1:1 ratio (M₅), soil: sand: rice husk: cocopeat; in 1:1:1:1 ratio (M₄), and soil: FYM; in 1:1:1 ratio (M₁). While the minimum germination percentage (83.33\%) was recorded in control; soil (M₀). The most probable reason for minimizing the germination time and higher germination in the use of media soil: sand: vermicompost, 1:1:1 (M₂) is the presence of greater organic manures in this media, which contain organic acid with high accessible moisture and certain acids, which may increases the availability of nutrients and water holding capacity in media, which favor the germination. Similar findings were reported by Mishra et al. (2017) \cite{12} in papaya and Parasana et al. (2014) \cite{14} in mango.

Seedling parameters

The seedling parameters like height of seedling (18.11 cm), stem girth (7.43 cm) and no. of leaves (24.83) were found maximum in media soil: sand: rice husk: vermicompost; 1:1:1:1 (M₅). The higher plant height, stem girth and no. of leaves were observed in media containing vermicompost and rice husk because they included nutrients that improved nutritional status, pH levels, and organic carbon content. The worm casts increase the density of microbes, which also provide the required nutrients to plants and contain plant growth-promoting substances such as NAA, cytokinins, and gibberellins, which help in the development of plants. A possible reason behind this might be that adding of vermicompost improves physical and biological conditions and maintain proper aeration and permeability, resulting in a good environment for plant growth and biomass. This result was in conformity of Prajapati et al. (2017) \cite{5} in jackfruit.

Largest area of leaf (35.97 cm²) was recorded in media soil: sand: FYM; in 1:1:1 ratio (M₁). The possible reason might be that the FYM contains sufficient nutritional content and creates conducive environment in terms of soil physical characteristics like aeration and porosity, allowing for improved root and shoot development, confirming similar results noted by Ramteke et al. (2015) \cite{15} in papaya.

The fresh weight of seedling (10.96 g) and dry weight of seedling (2.78 g), vigour index-Ⅱ (160.77 g) and survival percentage (97.50\%) were noted maximum in media soil: sand: vermicompost; in 1:1:1 ratio (M₂), similarly highest vigour index-I (4451.91 cm) was noted in M₃, which was statistically equal to soil: sand: rice husk: vermicompost; 1:1:1:1 ratio (M₅). A possible reason behind this might be that addition of vermicompost improves physical and biological conditions and maintain proper aeration and permeability, resulting in a good environment for plant growth and biomass. This result was in conformity of Prajapati et al. (2017) \cite{5} in acid lime and Chaudhary et al. (2018) in papaya.

Whereas the minimum seedling height (7.51 cm), stem girth (3.99 mm), leaf area (14.17 cm²), fresh weight of seedling (2.78 g), dry weight of seedling (0.54 g), length of root (20.68 cm), vigour index-Ⅰ (2335.18 cm) and vigour index-Ⅱ (45.31 g) were noted in control; soil (M₀). The minimum no. of leaves (12.60) and survival percentage (69.63\%) were noted in media soil: sand: cocopeat; 1:1:1 ratio (M₄).

Effect of GA₃

Germination parameters

Early germination (15.70 days) was recorded in seeds treated with 200 ppm GA₃ (G₂) followed by GA₃ 100 ppm (G₁) and
GA$_3$ 300 ppm (G$_3$). Similarly higher germination percentage (95.71%) was recorded in seeds treated with 200 ppm GA$_3$ (G$_2$) followed by G$_3$ and G$_1$. While the maximum time for germination (16.49 days) and minimum germination percentage (87.14%) were recorded in control; water (G$_0$). The increased germination percentage in seeds treated with GA$_3$ 200 ppm might be because of GA$_3$ involvement in activation of cytological enzymes and also increases cell wall plasticity and water absorption. This helps to loosen the seed coat and increases the germination. GA$_3$ is involved in two phases of germination: initial enzyme induction and activation of the reserve food mobilization mechanism, both of which boost germination. The mentioned result is in accordance with Lay et al. (2013) [11], Parab et al. (2017) [13], Chaudhary et al. (2018) and Rana et al. (2020) [18] in papaya.

**Seedling parameters**

In case of growth regulator GA$_3$ 100 ppm (G$_1$) was found to be most effective for most of the seedling parameters like seedling height (12.46 cm), stem girth (5.71 mm), no. of leaves (18.22), leaf area (27.46 cm$^2$), fresh weight of seedling (7.69 g), dry weight of seedling (1.32 g), root length (30.25 cm), vigour index I (4005.03 cm), vigour index II (125.98 g). The maximum survival percentage (94.76%) was noted in G$_1$, which was at par with G$_2$ and G$_3$. While the minimum value of all seedling parameters were recorded in control; water (G$_0$) viz. seedling height (10.66 cm), stem girth (5.16 mm), no. of leaves (16.39), leaf area (17.86 cm$^2$), fresh weight of seedling (4.65 g), dry weight of seedling (0.77 g), root length (22.44 cm), vigour index I (2909.78 cm), vigour index II (67.95 g), and survival percentage (82.22%). The positive effect of GA$_3$ emphasised by the fact that the papaya seedling’s endogenous levels of GA$_3$ were insufficient, and external treatment of GA$_3$ improved growth by promoting cell multiplication and cell elongation, leading to greater plant development GA$_3$ may have aided in the invigoration of plant physiological processes and the stimulatory action of chemicals to develop new leaves at a faster rate, resulting in an increase in the number of leaves. The influence of GA$_3$ on different plant parts leads to an increase in the fresh weight of shoots, which might be owing to its effect on promoting cell division, cellular and auxin metabolism, cell wall plasticity, and cell membrane permeability, all of which contribute to increased growth. A similar finding was reported by Ramteke et al. (2015) [17] and Hota et al. (2018) [18] in Jamun.

**Effect of GA$_3$ and Growing Media**

**Germination parameters**

Among different combinations of growing media and GA$_3$, the minimum time required for germination (13.98 days) was noted in soil: sand; vermicompost; 1:1:1 ratio with GA$_3$ 300 ppm (M$_{G_0}$). While the maximum time required for germination (18.43 days) was noted in soil: sand; rice husk; 1:1:1 ratio along with GA$_3$ 100 ppm (M$_{G_1}$). In the case of germination percentage the interaction between growing media and GA$_3$ was observed to be non-significant.

The reason behind minimum time required for papaya seed germination in sand: soil; vermicompost; 1:1:1 along with GA$_3$ 300 ppm (M$_{G_0}$) might be that vermicompost contains a high amount of organic matter, which provides the media with a sufficient amount of water and nutrients. It also contains bioactive principles which are beneficial for root growth, root initiation, germination and plant growth (Kaur, 2017) [9]. Gibberellic acid weakens the mechanical barriers of the endosperm cells and helps in radical protrusion. This facilitates the early germination. The results are in conformity with the findings of Desai et al. (2017) [6] in papaya.

**Seedling parameters**

The combination of the growing media and GA$_3$ resulted in a significant increase in seedling parameters. The greater values in respect to seedling height (21.85 cm), stem girth (8.16 mm), no. of leaves (28.13), fresh weight of seedling (14.79 g) and dry weight of seedling (2.09 g), were noted in soil: sand; rice husk: vermicompost; 1:1:1:1 ratio with GA$_3$ 100 ppm (M$_{G_0}$). M$_{G_1}$ was statistically at par with M$_{G_3}$ (soil: sand: rice husk: vermicompost; 1:1:1:1 ratio with GA$_3$ 100 ppm) in case of stem girth, and in case of the dry weight of shoot it was statistically equal to M$_{G_3}$ (soil: sand: FYM; 1:1:1 ratio with GA$_3$ 100 ppm).

Increase in seedling parameters might be due to the combination containing many macro and micro nutrients, humic acid, which maintaining proper aeration and porosity and GA$_3$, which increases cell division and uptake of nutrients, thus increasing the growth of seedling. The increase in fresh weight and dry weight might be because the combination of GA$_3$ and media increases the water and nutrient transportation to aerial parts, which leads to production of photosynthetic product and translocation of various plant parts, resulting in a higher fresh and dry weight of shoot. Similar findings were obtained by Kumawat et al. (2014) [19] and Dayeswari et al. (2017) [20] in papaya.

Soil: sand; vermicompost; in 1:1:1 ratio with GA$_3$ 100 ppm (M$_{G_1}$) interaction recorded the maximum mean root length (37.49 cm), vigour index I (5441.17 cm) and vigour index II (223.26 g). In case of root length M$_{G_1}$ was at par with M$_{G_3}$, M$_{G_0}$, M$_{G_1}$ and M$_{G_2}$. The increased root growth is attributed to the fact that the combination of GA$_3$ and media provides a better root environment for the plant, resulting in better nutrient availability to the photo synthetically functional leaves and it also increases the translocation of food into the root zone, which leads to the production of root biomass. A similar result was recorded by Ramteke et al. (2015) [17] in papaya, Kaur (2017) [20] in mango, Parab et al. (2017) [18] in papaya.

The interaction of soil: sand; FYM; 1:1:1 ratio with GA$_3$ 100 ppm (M$_{G_1}$) was found to be superior in terms of leaf area (51.86 cm$^2$). The interaction of M$_{G_0}$, M$_{G_1}$, M$_{G_2}$, M$_{G_3}$, M$_{G_4}$, M$_{G_5}$, M$_{G_6}$ and M$_{G_7}$ noted 100% survival percentage, which was statistically equal to M$_{G_2}$, M$_{G_3}$, M$_{G_4}$, M$_{G_5}$, M$_{G_6}$, M$_{G_7}$, M$_{G_8}$, M$_{G_9}$, M$_{G_10}$, M$_{G_11}$ and M$_{G_12}$. Treatment combination of soil: sand; vermicompost; in 1:1:1 ratio with control; water (M$_{G_0}$), recorded the minimum survival percentage (50%). The combination of control; soil with control; water (M$_{G_0}$) noted minimum values in case of height (7.25 cm), stem girth (3.70 mm), no. of leaves (11.73), petiole length (3.30 cm), fresh weight of seedling (2.07 g), dry weight of seedling (0.44 g), vigour index I (1913.72 cm) and vigour index II (33.96 g). The combination of soil: sand; rice husk; 1:1:1 ratio with control; water (M$_{G_0}$) recorded minimum leaf area (8.90 cm$^2$). Root length (13.51) was noted as minimum in control (soil) with GA$_3$ 300 ppm (M$_{G_3}$).

**Conclusion**

According to the research findings, it may be concluded that among the different growing media, the minimum time for germination and maximum germination percentage were...
noted in soil: sand: vermicompost; 1:1:1 ratio (M3). Shoot growth parameters like seedling height, stem girth and no. of leaves were recorded maximum in M4 and other parameters like fresh weight of seedling, dry weight of seedling, vigour index - I, vigour index - II and survival percentage were noted maximum in soil: sand: vermicompost; 1:1:1 ratio (M4) media.

GA4 had a positive effect shown in both germination and seedling parameters. GA4 200 ppm was found to be the most appropriate for germination parameters; however, most of the growth parameters were improved by using GA3 100 ppm. The treatment combinations of soil: sand: vermicompost; in 1:1:1 ratio along with 100 ppm (M4G1) and soil: sand: rice husk: vermicompost; in 1:1:1:1 ratio with GA3 100 ppm (M4G4) showed better results for seed germination, seedling growth parameters and survival percentage. Hence, it can be concluded that both the combination are good for seedling production.

### Table 1: Effect of GA4, growing media and their interaction on different germination and seedling parameters

<table>
<thead>
<tr>
<th>No. of days required for germination (DAS)</th>
<th>Germination percentage</th>
<th>Seedling height (cm)</th>
<th>Stem girth (mm)</th>
<th>No. of leaves</th>
<th>Leaf area (cm²)</th>
<th>Root length (cm)</th>
<th>Fresh weight of seedling (g)</th>
<th>Dry weight of seedling (g)</th>
<th>Vigour Index - I</th>
<th>Vigour Index - II (g)</th>
<th>Survival percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0</td>
<td>17.00</td>
<td>83.33</td>
<td>7.51</td>
<td>3.99</td>
<td>12.75</td>
<td>14.17</td>
<td>20.68</td>
<td>2.78</td>
<td>0.54</td>
<td>2335.18</td>
<td>45.31</td>
</tr>
<tr>
<td>M1</td>
<td>16.44</td>
<td>94.17</td>
<td>15.73</td>
<td>6.93</td>
<td>23.65</td>
<td>35.97</td>
<td>25.76</td>
<td>8.91</td>
<td>1.46</td>
<td>3929.73</td>
<td>138.07</td>
</tr>
<tr>
<td>M2</td>
<td>15.39</td>
<td>97.50</td>
<td>15.98</td>
<td>6.91</td>
<td>23.30</td>
<td>31.32</td>
<td>29.51</td>
<td>10.96</td>
<td>1.65</td>
<td>4451.91</td>
<td>160.77</td>
</tr>
<tr>
<td>M3</td>
<td>16.99</td>
<td>88.33</td>
<td>8.40</td>
<td>4.02</td>
<td>12.88</td>
<td>14.48</td>
<td>32.40</td>
<td>3.63</td>
<td>0.72</td>
<td>3615.49</td>
<td>63.88</td>
</tr>
<tr>
<td>M4</td>
<td>15.81</td>
<td>93.33</td>
<td>7.58</td>
<td>4.29</td>
<td>12.60</td>
<td>14.19</td>
<td>22.40</td>
<td>2.94</td>
<td>0.62</td>
<td>2815.31</td>
<td>57.69</td>
</tr>
<tr>
<td>M5</td>
<td>15.50</td>
<td>96.67</td>
<td>18.11</td>
<td>7.43</td>
<td>24.83</td>
<td>29.57</td>
<td>26.34</td>
<td>10.50</td>
<td>1.23</td>
<td>4293.91</td>
<td>119.03</td>
</tr>
<tr>
<td>M6</td>
<td>15.48</td>
<td>95.00</td>
<td>7.90</td>
<td>4.55</td>
<td>13.58</td>
<td>14.51</td>
<td>27.34</td>
<td>0.72</td>
<td>0.44</td>
<td>3420.90</td>
<td>68.23</td>
</tr>
<tr>
<td>SE(m)</td>
<td>0.274</td>
<td>0.144</td>
<td>0.323</td>
<td>0.06</td>
<td>0.414</td>
<td>0.613</td>
<td>1.029</td>
<td>0.199</td>
<td>0.01</td>
<td>121.995</td>
<td>1.818</td>
</tr>
<tr>
<td>SE(m)</td>
<td>0.207</td>
<td>1.091</td>
<td>0.251</td>
<td>0.049</td>
<td>0.313</td>
<td>0.464</td>
<td>0.778</td>
<td>0.15</td>
<td>0.08</td>
<td>92.219</td>
<td>1.374</td>
</tr>
</tbody>
</table>

Table 1: Effect of GA4, growing media and their interaction on different germination and seedling parameters

References


