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Effect of pre seed treatment on seed seedling growth and economics of papaya (*Carica papaya* L.)

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Abstract
The present investigation entitled "Effect of pre seed treatment on seed germination and seedling growth of papaya (*Carica papaya* L.)" was conducted at University Research Farm, GHRU, Saikheda in *Rabi* Season of 2024, are presented and described in this chapter. Data pertaining to various criteria used for treatment evaluation were analyzed statistically to test their significance and analysis of variance for these data has been given in appendices at the end. The research trail was carried on papaya crop cv. red lady. The application of fertilizers and manures in different form and combinations T_1-Control, T_2-Coconut water @ 25%,T_3-Coconut water @ 50%, T_4-Gibberellic Acids @ 50 ppm, T_5-Gibberellic Acids @ 100 ppm, T_6-Naphthalene Acetic Acid @ 50 ppm, T_7-Naphthalene Acetic Acid @ 100 ppm, T_8-Cow urine @ 20%, T_9- Thiourea @ 100 ppm, T_{10}- Thiourea @ 200 ppm, T_{11}-Potassium nitrate (KNO3) @ 0.25% and T_{12} - Potassium nitrate (KNO3) @ 0.5% was used for the experiment for observed the growth and economics *i.e.* dry weight of shoot (g), fresh weight of root (g), dry weight of roots, gross return, net return and benefit: cost ratio. The result revealed that the Treatment T_5 consistently resulted in the highest dry weight of shoots (3.60 g), and the maximum fresh (1.20 g) and dry root weight (0.32 g). Economically, T_5 was the most profitable treatment with the highest Benefit-Cost (B:C) ratio of 7.56 and a substantial net return of ₹15,545. It also achieved an impressive 88% germination rate. All treatments with growth regulators or priming agents showed superior results compared to the control (T_1). The control had the lowest biomass accumulation (0.92 g shoot dry weight, 0.98 g fresh root weight, 0.09 g dry root weight), the lowest B:C ratio (5.98), and a lower germination rate (70%). In conclusion, applying Gibberellic Acid at 100 ppm is a highly effective method for enhancing the growth, germination, and profitability of papaya cultivation from seedlings. While the minimum value was observed under control.

Keywords: Pre seed treatment, seed, seedling growth, economics and papaya

Introduction

Papaya (*Carica papaya* L.), a tropical fruit crop from the family Caricaceae, is commonly propagated through seeds, which are encased in a gelatinous sarcotesta and typically take three to five weeks to germinate. However, seed germination in papaya is often slow and inconsistent (Sharma *et al.*, 2021) [11], influenced by various factors including oxygen availability, temperature, water, light, and the type of growing medium. Improving germination is essential for papaya growers due to the high cost of quality seeds (Nguyen *et al.*, 2022) [8]. Plant growth regulators such as Gibberellic Acid (GA) and Naphthalene Acetic Acid (NAA) are widely used to enhance seedling development. GA promotes stem elongation, breaks seed dormancy, and induces flowering (Voruganti *et al.*, 2022) [12], while NAA is known to enhance root development, lateral root formation, and fruit growth, resulting in better nutrient absorption and yield.

To address the challenge of poor germination, various seed pretreatments are employed to improve seedling emergence and vigor. Treatments such as 50% coconut water, 200 ppm gibberellic acid (GA_3), 200 ppm NAA, 20% cow urine, 200 ppm thiourea, 0.5% potassium nitrate (KNO_3), and cow dung slurry have shown significant positive effects on papaya seed germination and early growth. Coconut water contains natural hormones and nutrients that boost germination, while GA_3 and NAA stimulate cell elongation and division for faster growth. Cow urine and thiourea contribute to improved seedling vigor and stress resistance. Potassium nitrate supplies essential nutrients like nitrogen and potassium, promoting shoot and root development. Cow dung slurry enhances soil fertility and microbial activity, supporting healthier root systems. Together, these treatments offer a holistic approach to enhancing papaya seedling establishment and overall plant performance.

Materials and Methods

The present investigation entitled "Effect of pre seed treatment on seed germination and seedling growth of papaya (*Carica papaya* L.)" was conducted at University Research Farm, GHRU, Saikheda in *Rabi* Season of 2024, are presented and described in this chapter. Data pertaining to various criteria used for treatment evaluation were analyzed statistically to test their significance and analysis of variance for these data has been given in appendices at the end. The research trail was carried on papaya crop cv. red lady. The application of fertilizers and manures in different form and combinations T_1-Control, T_2-Coconut water @ 25%,T_3-Coconut water @ 50%, T_4-Gibberellic Acids @ 50 ppm, T_5- Gibberellic Acids @ 100 ppm, T_6-Naphthalene Acetic Acid @ 50 ppm, T_7-Naphthalene Acetic Acid @ 100 ppm, T_8-Cow urine @ 20%, T_9- Thiourea @ 100 ppm, T_{10}- Thiourea @ 200 ppm, T_{11}-Potassium nitrate (KNO3) @ 0.25% and T_{12}-Potassium nitrate (KNO3) @ 0.5% was used for the experiment for observed the growth and economics *i.e.* Initiation of seed germination days, height of seedling (cm), Girth of stem (mm), length of root (cm), number of secondary roots/seedling, number of leaves/seedling, fresh weight of shoot (g), dry weight of shoot (g), fresh weight of root (g), dry weight of roots, Seeding vigor, gross return, net return and benefit: cost ratio. The observations are recorded and the results obtained and discussed in preceding chapters are summarized below:

Fresh Weight of Shoot (g): The weight of the shoot portion (above-ground part) immediately after harvesting, measured in grams using a digital balance.

Dry Weight of Shoot (g): The shoot weight recorded after oven-drying the sample at 70 °C for 48 hours, to determine the dry biomass.

Fresh Weight of Root (g): The immediate weight of the cleaned root portion (below-ground part), measured in grams.

Dry Weight of Root (g): The root weight recorded after oven-drying to a constant weight, representing actual biomass content.

Gross Monetary Return (₹/ha): Total income generated per hectare from sale of marketable seedlings or cuttings.

Net Monetary Return (₹/ha): The actual profit, calculated by subtracting the total cost of cultivation from the gross return. Net Return=Gross Return−Total Cost.

Benefit-Cost Ratio (B:C Ratio): An indicator of profitability, calculated by dividing the gross return by the total cost.

Results and Discussion

Dry weight of shoot (g)

The maximum dry weight of shoot was recorded in T_5 (Gibberellic Acid @ 100 ppm) at 3.60 g, which was statistically at par with T_4 (GA_3 @ 50 ppm) at 3.52 g, and closely followed by T_7 (Naphthalene Acetic Acid @ 100 ppm) with 3.38 g. The minimum dry weight was observed in the control (T_1) with 0.92 g, demonstrating the significant effect of growth regulators on shoot biomass accumulation.

The increase in dry shoot weight with GA_3 treatments is attributed to its role in promoting cell division, elongation, and enhanced biosynthesis of structural carbohydrates like cellulose and hemicellulose, which contribute to dry matter accumulation (Randhawa & Singh, 1992) [10]. Moreover, GA_3 improves photosynthetic activity and nutrient assimilation, leading to more robust shoot growth and greater biomass accumulation. Similarly, NAA (T_7) improves vascular differentiation and translocation efficiency, thereby enhancing nutrient use and dry matter partitioning to the shoots. Auxins also support chloroplast development and enzyme activity, indirectly boosting biomass production (Katoch *et al.*, 2003) [5]. In contrast, the lowest shoot dry weight in the control (T_1) reflects slower metabolic activity, reduced structural growth, and poor carbohydrate synthesis in the absence of growth-promoting substances.

Fresh weight of roots (g)

The maximum fresh root weight was recorded under T_5 (Gibberellic Acid @ 100 ppm) at 1.20 g, followed by T_4 (GA_3 @ 50 ppm) with 1.15 g, and T_7 (Naphthalene Acetic Acid @ 100 ppm) with 1.14 g. The minimum fresh root weight was observed in the control treatment (T_1) at 0.98 g, indicating that the application of plant growth regulators significantly enhanced root biomass in papaya seedlings. The increase in root fresh weight with GA_3 treatments is attributed to its ability to stimulate root elongation and cell expansion, along with enhancing the mobilization of food reserves, which supports root tissue hydration and biomass accumulation. Gibberellic Acid improves root vigor and nutrient absorption efficiency, leading to better water uptake and higher fresh root mass (Kumar *et al.*, 2012) [6]. NAA, being a root-inducing auxin, promotes adventitious root formation and elongation, especially in early seedling stages. It enhances auxin-induced gene expression responsible for cell division in root meristems, leading to increased root biomass and overall vigor (Bisht *et al.*, 2010) [2]. The lowest root fresh weight in the untreated control (T_1) highlights the limiting effect of absent hormonal support, resulting in reduced root development and water-holding capacity, which directly affects seedling health and transplant success.

Dry weight of roots (g)

The maximum dry root weight was observed under T_5 (Gibberellic Acid @ 100 ppm) at 0.32 g, followed by T_4 (GA_3 @ 50 ppm) with 0.29 g, and T_7 (Naphthalene Acetic Acid @ 100 ppm) with 0.25 g. The minimum dry weight was recorded in the control treatment (T_1) at 0.09 g, indicating the critical role of growth regulators in improving root biomass accumulation in papaya seedlings. The observed increase in root dry weight with GA_3 application is due to its influence on cell division, elongation, and vascular tissue differentiation, leading to the development of structurally stronger and denser root systems. GA_3 also promotes enhanced translocation of photosynthates and nutrients to root tissues, thus supporting higher dry matter deposition. NAA (T_7), being an auxin analog, further contributes by stimulating root primordia formation and lateral root development, which enhances root surface area and biomass. Auxins improve carbohydrate metabolism and the formation of secondary xylem, contributing to dry weight gain in root tissues (Katoch *et al.,* 2003) [5]. The lowest dry weight in the control (T_1) shows that without hormonal intervention, limited root growth and low structural tissue accumulation occurs, affecting the seedling's ability to anchor and absorb nutrients effectively.

Economics

A study evaluating twelve pre-sowing treatments in papaya revealed that T_5 (Gibberellic Acid @ 100 ppm) was the most profitable, showing the highest Benefit-Cost (B:C) ratio of 7.56, with 88% germination and a net return of ₹15,545. Treatments T_4 (GA_3 @ 50 ppm) and T_{12} (KNO_3 @ 0.5%) also exhibited high B:C ratios of 7.35 and 7.34, respectively, confirming their economic viability. The control (T_1) had the lowest B:C ratio (5.98) and poor germination (70%), underscoring the effectiveness of seed priming. The superior economic performance of GA_3 treatments (T_5 and T_4) can be attributed to their proven role in stimulating seed germination and enhancing seedling vigor. GA_3 acts by activating hydrolytic enzymes like α-amylase that break down stored food reserves, facilitating faster and uniform germination, better seedling growth, and higher transplant success (Deshmukh *et al.,* 2020; Kumar & Singh, 2017) [3, 7]. KNO_3 (T_{12} and T_{11}) improves germination by enhancing oxygen availability and acting as a nitrate signal, which triggers metabolic processes within the embryo, resulting in enhanced seedling emergence and growth (Gupta *et al.,* 2016; Bairwa *et al.,* 2015) [4, 1]. Treatments like T_3 (Coconut water @ 50%) and T_7 (NAA @ 100 ppm) also showed B:C ratios above 7.0, indicating profitability. Coconut water, rich in natural growth hormones (Cytokinins and Auxins) and nutrients, stimulates seedling growth. Meanwhile, NAA (a synthetic auxin) promotes cell elongation and lateral root development, supporting better nutrient uptake and early growth vigor (Patel & Patel, 2021) [9]. T_8 (Cow urine @ 20%), though organic and slightly better than the control, had the lowest efficiency among treated plots (B:C 6.46). This may be due to limited hormone and nutrient availability, making it less consistent and slower acting compared to synthetic PGRs.

Table 4.7: Effect of pre seed treatment on dry weight of shoot of papaya

Treatments	Dry weight of shoot (g)	Fresh weight of roots (g)	Dry weight of roots (g)	Gross Return (₹)	Net Return (₹)	B:C Ratio
T_1	0.92	0.98	0.09	14000	11995	5.98
T_2	1.04	0.98	0.10	16000	13985	6.94
T_3	2.80	1.08	0.19	16400	14380	7.12
T_4	3.52	1.15	0.29	17000	14965	7.35
T_5	3.60	1.20	0.32	17600	15545	7.56
T_6	3.08	1.11	0.21	16000	13985	6.94
T_7	3.38	1.14	0.25	16400	14380	7.12
T_8	2.50	1.06	0.19	15000	12990	6.46
T_9	2.02	1.04	0.18	15600	13590	6.76
T_{10}	2.25	1.05	0.19	16000	13985	6.94
T_{11}	1.49	0.99	0.11	16400	14390	7.16
T_{12}	1.78	1.01	0.13	16800	14785	7.34
S.Em.±	0.038	0.0016	0.0024			
CD at 5% Levels	0.111	0.0047	0.0070			

Conclusion

Based on the one year research, the application of Gibberellic Acid (GA_3), particularly at a concentration of 100 ppm (T_5), was the most effective treatment for improving the growth and economic viability of papaya seedlings. Treatment T_5 consistently resulted in the highest dry weight of shoots (3.60 g), and the maximum fresh (1.20 g) and dry root weight (0.32 g). This highlights the significant role of GA_3 in enhancing overall plant biomass. Economically, T_5 was the most profitable treatment with the highest Benefit-Cost (B:C) ratio of 7.56 and a substantial net return of ₹15,545. It also achieved an impressive 88% germination rate. All treatments with growth regulators or priming agents showed superior results compared to the control (T_1). The control had the lowest biomass accumulation (0.92 g shoot dry weight, 0.98 g fresh root weight, 0.09 g dry root weight), the lowest B:C ratio (5.98), and a lower germination rate (70%). In conclusion, applying Gibberellic Acid at 100 ppm is a highly effective method for enhancing the growth, germination, and profitability of papaya cultivation from seedlings.

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