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Effect of pre seed treatment on seed germination and seedling growth 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. The research trail was carried on papaya crop cv. red lady. The application of fertilizers and manures in different form and combinations T1-Control, T2-Coconut water @ 25%, T3-Coconut water @ 50%, T4-Gibberellic Acids @ 50 ppm, T5- Gibberellic Acids @ 100 ppm, T6-Naphthalene Acetic Acid @ 50 ppm, T7-Naphthalene Acetic Acid @ 100 ppm, T8-Cow urine @ 20%, T9- Thiourea @ 100 ppm, T10- Thiourea @ 200 ppm, T11-Potassium nitrate (KNO₃) @ 0.25% and T12-Potassium nitrate (KNO₃) @ 0.5% was used for the experiment for observed the growth 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), the result revealed that the earliest initiation of seed germination was achieved in T5 (GA₃ @ 100 ppm), which required only 8.21 days, followed by T4 (GA₃ @ 50 ppm) and T7 (NAA @ 100 ppm). In contrast, the untreated control (T1) recorded the most delayed germination, taking 17.30 days. The T5 (GA₃ @ 100 ppm) consistently recorded the maximum seedling height (20.78 cm), stem girth (1.44 mm), root length (7.10 cm), number of leaves per seedling (8.71), and fresh shoot weight (9.10 g). These values were significantly higher than the control, which exhibited poor growth performance in all traits. Treatments T4 (GA₃ @ 50 ppm) and T7 (NAA @ 100 ppm) also demonstrated substantial improvements, though slightly lower than T5, and were statistically at par in some parameters, while the minimum value of all the treatments was observed under the treatment of Control.

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

Introduction

The papaya (*Carica papaya* L.) is a tropical fruit crop belonging to the family Caricaceae. It is primarily propagated through seeds, which are enveloped in a gelatinous sarcotesta and typically require three to five weeks to germinate. However, papaya seeds exhibit slow and often incomplete germination (Sharma *et al.*, 2021) [8]. Several environmental factors such as oxygen availability, temperature, water, light, and substrate type influence the germination potential of these seeds. For growers, enhancing germination rates is crucial to ensure the production of vigorous seedlings, especially given the high cost of quality seeds (Nguyen *et al.*, 2022) [5]. Plant growth regulators like Gibberellic Acid (GA) and Naphthalene Acetic Acid (NAA) have been widely used to enhance germination and plant development. GA promotes stem elongation, seed dormancy breaking, and flowering induction (Voruganti *et al.*, 2022) [11], while NAA supports root formation, lateral root development, and fruit growth, ultimately improving water and nutrient uptake and fruit yield.

Seed pretreatment methods are increasingly used to overcome dormancy, enhance germination, and promote healthy seedling establishment. Techniques such as mechanical scarification, chemical treatment, and priming are employed to improve seed performance across plant species. In papaya, pretreatments like 50% coconut water, 200 ppm gibberellic acid (GA₃), 200 ppm NAA, 20% cow urine, 200 ppm thiourea, 0.5% potassium nitrate (KNO₃), and cow dung slurry have shown significant benefits. Coconut water, rich in natural growth regulators and nutrients, supports rapid germination and seedling vigor. GA₃ and NAA enhance cell division and elongation, promoting uniform growth.

Cow urine contributes essential nutrients and bioactive compounds, while thiourea improves stress tolerance and biomass accumulation. KNO_3 boosts shoot and root development by supplying key macronutrients, and cow dung slurry enriches the soil with organic matter and beneficial microbes. Collectively, these pretreatments improve germination rates, seedling vigor, and plant health, contributing to better field establishment and higher crop productivity in papaya.

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. The research trail was carried on papaya crop cv. red lady. The application of fertilizers and manures in different form and combinations T1-Control, T2-Coconut water @ 25%, T3-Coconut water @ 50%, T4-Gibberellic Acids @ 50 ppm, T5- Gibberellic Acids @ 100 ppm, T6-Naphthalene Acetic Acid @ 50 ppm, T7-Naphthalene Acetic Acid @ 100 ppm, T8-Cow urine @ 20%, T9- Thiourea @ 100 ppm, T10- Thiourea @ 200 ppm, T11-Potassium nitrate (KNO_3) @ 0.25% and T12-Potassium nitrate (KNO_3) @ 0.5% was used for the experiment for observed the growth *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).

- **Height of Seedling (cm):** The average height of the seedling from the base to the tip of the apical bud, recorded in centimeters.
- **Girth of Stem (mm):** The thickness or diameter of the seedling stem measured at the collar region, recorded in millimeters using a digital caliper.
- **Length of Root (cm):** The total length of the primary root from the base of the shoot to the root tip, recorded in centimeters.
- **Number of Secondary Roots per Seedling:** The count of lateral or secondary roots emerging from the primary root

Results and Discussion

Initiation of seed germination days

The data revealed that the minimum days to initiation of seed germination was recorded in treatment T5 (Gibberellic Acid @ 100 ppm) with 8.21 days, followed by T4 (GA_3 @ 50 ppm) with 9.22 days, and T7 (NAA @ 100 ppm) with 9.78 days. In contrast, the maximum or delayed germination initiation was observed under the control treatment (T1), which took 17.30 days.

The earlier initiation of germination in GA_3 -treated seeds is attributed to the hormone's role in breaking seed dormancy and promoting enzymatic activity that facilitates mobilization of stored food reserves (Bewley *et al.*, 2013) [1]. GA_3 stimulates the synthesis of hydrolytic enzymes such as α -amylase, which degrade starch into sugars that are readily used during early seedling growth (Taiz *et al.*, 2015) [10]. Similarly, NAA (T7) also enhanced germination, albeit slightly less effectively than GA_3 . NAA, a synthetic auxin, is known to stimulate root initiation and cell elongation, thereby supporting faster germination by improving cellular metabolism and water uptake (Singh *et al.*, 2014) [9]. The delayed germination in the control (T1) treatment was likely due to the absence of any growth-promoting stimulus, leading to slower enzymatic activation and prolonged dormancy breaking.

Height of seedling (cm)

The experimental results indicated that the maximum seedling height was recorded in treatment T5 (Gibberellic Acid @ 100 ppm) at 20.78 cm, followed by T4 (GA_3 @ 50 ppm) at 19.41 cm, and T7 (Naphthalene Acetic Acid @ 100 ppm) at 18.44 cm. The lowest seedling height was observed in the control treatment (T1) at 9.74 cm, clearly indicating the positive impact of plant growth regulators on seedling elongation.

The superior seedling height in GA_3 -treated seeds can be attributed to the well-documented role of Gibberellic Acid in promoting cell elongation and division, especially in the stem and shoot regions. GA_3 enhances endogenous auxin levels and activates enzymes like expansins and cell wall-loosening proteins, which contribute to increased cell wall plasticity and internodal elongation (Taiz *et al.*, 2015; Bewley *et al.*, 2013) [10, 11]. Additionally, GA_3 accelerates metabolic activities and increases the mobilization of food reserves, resulting in more vigorous seedling growth. Higher concentration (100 ppm) showed a more pronounced effect compared to 50 ppm, indicating a dose-responsive relationship up to an optimum level. NAA (T7), a synthetic auxin, also contributed to enhanced seedling height by promoting cell elongation and tissue differentiation, particularly in meristematic regions. It also improves nutrient uptake and water absorption, indirectly supporting shoot elongation (Singh *et al.*, 2014) [9]. The lowest seedling height in the control (T1) suggests that natural endogenous hormone levels alone were insufficient to maximize vegetative growth under nursery conditions, reaffirming the benefit of exogenous application of growth regulators.

Girth of stem (mm)

The results demonstrated that the maximum girth of stem was observed under T5 (Gibberellic Acid @ 100 ppm) with 1.44 mm, followed by T4 (GA_3 @ 50 ppm) at 1.33 mm, and T7 (NAA @ 100 ppm) at 1.22 mm. The minimum stem girth was recorded in the control (T1) with only 0.22 mm, indicating a significant difference due to growth regulator treatments.

GA_3 significantly enhances stem girth by promoting cell division in the cambial region and facilitating greater radial expansion of tissues. It stimulates the synthesis of enzymes and structural components that lead to increased thickness of vascular tissues (Rai *et al.*, 2011). In seedlings, this results in stronger, more vigorous plants capable of better survival during transplanting. NAA (T7), as a synthetic auxin, also contributes to stem girth improvement by enhancing vascular differentiation and cell expansion, particularly in xylem and phloem tissues. This auxin-induced growth leads to improved translocation and support structure within the seedling stem. The minimal girth observed in the untreated control (T1) is a consequence of the absence of exogenous growth regulators, which limited metabolic activity and structural development during early seedling growth.

Length of root (cm)

The maximum root length was observed in treatment T5 (Gibberellic Acid @ 100 ppm) at 7.10 cm, followed by T4 (GA_3 @ 50 ppm) at 6.45 cm, and T7 (Naphthalene Acetic Acid @ 100 ppm) at 6.15 cm. The minimum root length was recorded under T1 (Control), with only 3.14 cm.

The enhanced root elongation in GA_3 -treated seedlings is primarily due to its ability to stimulate cell elongation in the root meristematic region. Gibberellic Acid promotes the activity of hydrolytic enzymes, such as α -amylase, which enhances the mobilization of food reserves toward growing root tips, thereby supporting vigorous root development (Kumar *et al.*, 2017) [14].

Additionally, GA₃ improves water and nutrient uptake by enhancing root surface area and encouraging deeper rooting. The effect of NAA (T7) in increasing root length is related to its role as a root-promoting hormone. NAA stimulates root initiation and elongation by increasing auxin concentration at the root tip, enhancing cell division and elongation in the root apical meristem (Chauhan *et al.*, 2011) [3]. In contrast, the minimum root length in the control (T1) suggests that endogenous hormone levels were insufficient to initiate strong root growth, emphasizing the effectiveness of growth regulator application in seedling development.

Number of leaves/seedling

The results clearly indicated that the maximum number of leaves per seedling was recorded in treatment T5 (Gibberellic Acid @ 100 ppm) at 8.71 leaves, followed by T4 (GA₃ @ 50 ppm) with 7.89 leaves, and T7 (Naphthalene Acetic Acid @ 100 ppm) with 7.45 leaves. The lowest number of leaves was observed in T1 (Control) at 2.99 leaves, highlighting the significant role of plant growth regulators in enhancing vegetative growth.

The superior performance of GA₃-treated seedlings (especially at 100 ppm) is attributed to GA₃'s ability to break dormancy, enhance cell division, and stimulate leaf primordia development in the apical meristem. Gibberellic Acid also enhances photosynthetic efficiency, chlorophyll synthesis, and carbohydrate mobilization, all of which contribute to higher leaf production (Patel *et al.*, 2016) [6]. NAA (T7), as a synthetic auxin, enhances leaf number by promoting cell enlargement and division in leaf meristems and stimulating vascular differentiation, which supports better nutrient transport to growing leaves. Auxins also help maintain apical dominance,

leading to uniform and compact growth. The minimal leaf number in the control (T1) reflects the absence of any exogenous growth stimulus, resulting in slower metabolic activity and limited vegetative development.

Fresh weight of shoot (g)

The results revealed that the maximum fresh weight of shoot was recorded in T5 (Gibberellic Acid @ 100 ppm) at 9.10 g, which was statistically at par with T4 (GA₃ @ 50 ppm) at 8.90 g, and closely followed by T7 (NAA @ 100 ppm) with 8.55 g. In contrast, the minimum shoot fresh weight was observed in the control treatment (T1) with only 2.34 g, indicating the significant impact of plant growth regulators on shoot biomass accumulation.

The increase in fresh shoot weight under GA₃ treatments is attributed to its well-established role in promoting cell division, cell elongation, and enhanced metabolic activity, which leads to vigorous shoot growth and increased tissue hydration (Rai *et al.*, 2011) [7]. GA₃ also facilitates better translocation of assimilates and water uptake, resulting in greater shoot turgidity and biomass accumulation. Similarly, NAA (T7), being an auxin analog, improves shoot weight by stimulating apical meristem activity, vascular differentiation, and chlorophyll content, which increases photosynthetic efficiency and results in higher shoot biomass (Singh *et al.*, 2014) [9]. Auxins are also known to enhance nutrient uptake and water retention, which further contributes to the increase in fresh weight. The lowest shoot fresh weight in the control (T1) reflects the lack of hormonal stimulation, leading to poor cell expansion and reduced shoot growth, underscoring the importance of exogenous PGR application during seedling development.

Table 1: Effect of pre seed treatment on initiation of seed germination days of papaya

Treatments	Initiation of seed germination days	Height of seedling (cm)	Girth of stem (mm)	Length of root (cm)	Number of leaves/seedling	Fresh weight of shoot (g)
T ₁	17.30	9.74	0.22	3.14	2.99	2.34
T ₂	16.50	10.87	0.37	3.80	3.72	2.65
T ₃	10.79	16.85	1.03	5.48	6.40	7.10
T ₄	9.22	19.41	1.33	6.47	7.89	8.90
T ₅	8.21	20.78	1.44	7.10	8.71	9.10
T ₆	10.45	17.28	1.10	5.92	6.73	7.80
T ₇	9.78	18.44	1.22	6.15	7.45	8.55
T ₈	11.56	15.68	0.92	5.10	5.97	6.33
T ₉	12.21	14.30	0.67	4.90	5.43	5.10
T ₁₀	11.87	15.15	0.77	4.94	5.59	5.70
T ₁₁	14.44	11.94	0.47	4.06	3.89	3.77
T ₁₂	13.30	14.06	0.50	4.69	4.68	4.50
S.Em.±	0.081	0.074	0.014	0.040	0.038	0.096
CD at 5% Levels	0.238	0.217	0.040	0.117	0.112	0.281

Conclusion

The present investigation on the effect of various pre-sowing treatments on germination, seedling growth, and economic performance of papaya seedlings revealed that the application of plant growth regulators, particularly Gibberellic Acid (GA₃) and Naphthalene Acetic Acid (NAA), significantly improved all growth-related parameters and profitability over the untreated control.

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