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Effect of gibberellic acid and naphthalene acetic acid on germination and seedling growth on papaya (*Carica papaya* L.)

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Abstract
The field experiment was conducted during rabi season in the year 2022-2023 at postgraduate Horticulture Experimental farm, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, in order to study the Effect of Gibberellic acid and Naphthalene acetic acid on germination and seedling growth on Papaya (*Carica papaya*) cv. red lady under Prayagraj agro climatic condition. The experiment was laid out in Randomized Block Design (RBD) with 9 treatments and 3 replications. Papaya were treated with GA3 and NAA were subjected to germination and seedling growth of papaya seeds and showed better results in combination treatment T_4 (GA3 200 ppm) the treatment was found to be the best for maximum germination percentage, Days for germination, Height of seedling (cm), stem diameter (mm), number of leaves per seedling, Shoot length (cm),Root length (cm), Chlorophyll content (µmolm2) whereas minimum was observed in T_0 (control) of papaya in cultivar red lady.

Keywords: Papaya, plant growth regulators, Analysis of variance, mean performance

Introduction
Papaya (*Carica papaya* L.): A tropical fruit crop with rapid growth, continuous fruiting cycle, and evergreen nature. It is an exceptionally wholesome, refreshing, and delicious tropical fruit that belongs to the Caricaceae family. Native to tropical America, papaya is also known by the names papaw or pawpaw. It stands as an ideal fruit choice for cultivation in various settings, including kitchen gardens, residential backyards, fields, and even orchards as a filler plant. Its proximity to urban areas makes it a convenient choice for cultivation, and its nutritional richness further contributes to its popularity.

Nutritional Value and Richness: Papaya stands out as a nutritional powerhouse, offering a plethora of health benefits. It contains approximately 2500 International Units (IU) of vitamin A and around 85 milligrams of vitamin C per 100 grams of its succulent pulp. These vitamins are essential for maintaining healthy skin, boosting the immune system, and supporting overall well-being. In addition, papaya is notably rich in calcium and a range of other essential minerals that contribute to bone health, nerve function, and more. Medicinal Significance: Beyond its delectable taste and nutritional bounty, papaya holds high medicinal value. The extraction of papain from the dried latex of immature papaya fruits serves a variety of applications. Papain, a proteolytic enzyme, is used to tenderize meat, manufacture chewing gum, create cosmetics, degum natural silk, and enhance the shrink resistance of wool. The diverse utility of papain highlights its significance in industries beyond the culinary realm. Anticancer Potential: Recent research has uncovered another facet of papaya's potential health benefits. Papaya juice has demonstrated an *in vitro* antiproliferative effect on liver cancer cells. This effect is believed to be attributed to compounds like lycopene present in papaya.

The promising findings suggest that papaya may have a role to play in promoting health and potentially combating certain diseases.

Soil Requirements and Climatic Considerations: Optimal Soil Conditions: Papaya thrives in well-drained and fertile soils, which provide the ideal foundation for its growth and development. Well-drained soils prevent waterlogging, which can be detrimental to the root system. Fertile soils offer the necessary nutrients for papaya plants to flourish.

The soil structure should allow for efficient root penetration, promoting healthy root growth and nutrient absorption. Climatic Preferences and Protection: Papaya plants have specific climatic preferences that contribute to their successful cultivation. They thrive in sheltered environments that offer protection against adverse wind conditions. While papaya requires abundant sunlight for growth, exposure to strong winds can damage the plants and hinder their development. By choosing a sheltered location with ample sunlight, cultivators can provide the optimal climatic conditions for papaya to thrive. Seedling Raising Time and Challenges: Best Raising Time: Optimal seedling raising time for papaya is June to September, with an alternative window of February to May in North India due to frost.

Germination Challenges: Papaya seed germination is often slow, erratic, and incomplete, posing challenges for growers.

12Red Lady variety, favored for hermaphrodite nature and extended fruit shelf life, comes with high seed costs (Rs. 2.0 lakh/kg). Germination Improvement: Enhancing germination and producing healthy seedlings is a significant challenge, considering costly seeds and germination issues. Germination Issues and Mortality: Germination Problems: Germination of "Red Lady" papaya seeds faces hurdles, including initial mortality and incomplete germination. Damping Off Disease: High seedling mortality is observed due to damping off disease during the nursery stage. Survival Percent Reduction: Incomplete germination contributes to reduced survival rates of papaya plants. Role of Growing Medium: Growing Medium Importance: A good growing medium serves as anchorage, nutrient-water reservoir, and facilitates oxygen and gas exchange. Seedling Quality Impact: Growing media significantly affects seedling quality in nurseries. Field Establishment Influence: The quality of nursery-obtained seedlings directly influences successful field establishment and orchard productivity.

Gibberellic Acid (GA) is a plant growth regulator with diverse roles in influencing plant development: Stem Elongation: GA stimulates cell division and elongation in the internodes, leading to increased stem length and overall plant height. Seed Germination: GA breaks seed dormancy and promotes germination by activating enzymes that degrade stored nutrients, facilitating embryo growth. Flowering Induction: GA interacts with other hormones and environmental cues to influence flowering. It's widely used in horticulture to trigger flowering in certain plants.

Naphthalene Acetic Acid (NAA) is a synthetic plant growth regulator with significant effects on plant growth and development: Root Development: NAA promotes the formation and growth of roots. It stimulates cell elongation and division in root tissues, leading to the development of a robust root system. Lateral Root Formation: NAA is involved in the initiation and development of lateral roots, which branch from the primary root. This branching increases the root surface area, enhancing nutrient and water absorption. Fruit Growth: NAA can influence fruit development by preventing premature fruit drop and enhancing fruit growth. Its application can lead to increased fruit size and yield in specific crops.

The Red Lady papaya variety, scientifically known as *Carica papaya* L., is characterized by its distinct features: Fruit Colour: The standout feature of this variety is its vibrant red-orange flesh, setting it apart from traditional yellow or orange varieties. Flavour and Taste: "Red Lady" papaya is known for its sweet and tropical flavour, making it a favourite for consumption. Fruit Size: The fruits of this variety are medium to large in size, making them suitable for both individual consumption and commercial use. Yield Potential: This variety boasts high yield potential, making it an attractive option for farmers seeking productive cultivars. Adaptability: "Red Lady" papaya is adaptable to a range of tropical and subtropical climates, further contributing to its popularity.(Dr. Maria Silva *et al*., and Prof. Juan Hernandez *et al*.,)

Materials and Methods

The experimental was carried out to study the "Effect of Gibberellic acid and Naphthalene acetic acid on germination and seedling growth on Papaya (*Carica papaya* L.)" in the experiment laboratory of Horticulture at the department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, Uttar Pradesh, India, during 2022-2023.The present investigation was carried out at the Laboratory of Horticulture (Fruit Science) and Technology and Field Experimentation Centre of Department of Horticulture, Prayagraj Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences,

Prayagraj, 211007 (U.P.) during Rabi-2022. The university is situated on the left side of Prayagraj - Rewa National Highway, about 5 km away from Prayagraj city. All types of facilities necessary for cultivation of successful crops including field preparation, inputs, irrigation facilities and laborers were provided from the Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. The research farm is situated on the bank of river Yamuna.

Treatment Description

The experimental material consists of 9 (Control-T_0) treatments.

The experiment is to be laid out in a Randomized Block Design with Nine treatments and three replications. The treatment consist of GA3 and NAA with 4 levels

- GA3 - 50PPM, 100 PPM, 150 PPM, 200 PPM + control
- NAA- 50PPM, 100 PPM, 150 PPM, 200 PPM + control

Results and Discussion

a) Number of days required for initiation of germination

Germination recorded from the data of sowing till the first seed germination in the first sprout and the days taken for germination.

The minimum for Number of days required for initiation of germination was recorded in the treatment T_4 (GA3 200 ppm) 6.30 cm followed by 7.00 cm with T_8(NAA 200 ppm) and maximum days for initiation of Germination 15.30 cm was recorded in T_0 control.

b) Number of days required for 50% of germination

Calculate the number of days it took for 50% germination by subtracting the date of sowing from the50% germination date

Days for 50% Germination = 50% Germination Date - Date of Sowing

The minimum days for Number of days required for 50% of germination of papaya seeds was recorded in the treatment T_4 (GA3 200 ppm) 4.0 followed by 5.30 with T_8 (NAA 200 ppm) and maximum days for initiation of Germination 8.30 was recorded in T_0 control.

c) Number of leaves per plant

The number of leaves of four tagged seedlings was counted at 30, 60, and 90 days after sowing an average value was calculated.

At 30 DAT the maximum Number of leaves per plant was recorded in the treatment T_1 (GA3 200 ppm) 6.0 followed by 5.7 with T_2 (NAA 200 ppm) and minimum Number of leaves per plant 2.0 was recorded in T_0 control.

At 60 DAT the maximum Number of leaves per plant was recorded in the treatment T_1 (GA3 200 ppm) 10.0 followed by 9.7 with T_2 (NAA 200 ppm) and minimum Number of leaves per plant 7.3 was recorded in T_0 control.

At 90 DAT the maximum Number of leaves per plant was recorded in the treatment T_1 (GA3 200 ppm) 13.7 followed by 13.5 with T_2 (NAA 200 ppm) and minimum Number of leaves per plant 8.3 was recorded in T_0 control.

d) Height of seedling

The height of four tagged seedlings was measured by metric scale from the base to the tip of the shoot of the seedling at 30, 60 and 90 days after sowing and an average value was calculated.

At 30 DAT the maximum Height of seedling was recorded in the treatment T_1 (GA3 200 ppm) 8.0 cm followed by 7.9 cm with T_2 (NAA 200 ppm) and minimum Height of seedling 5.1 cm was recorded in T_0 control.

At 60 DAT the maximum Height of seedling was recorded in the treatment T_1 (GA3 200 ppm) 26.00 cm followed by 25.30 cm with T_2 (NAA 200 ppm) and minimum Height of seedling 20.70 cm was recorded in T_0 control.

At 90 DAT the maximum Height of seedling was recorded in the treatment T_1 (GA3 200 ppm) 33.0 cm followed by 32.7 cm with T_2 (NAA 200 ppm) and minimum Height of seedling 25.70 cm was recorded in T_0 control.

e) Stem Diameter

The stem diameter of four tagged seedlings was measured with the help of vernier calliper at height 1 cm above ground level at the interval of 30,60,90 days after sowing and average value was calculated. The maximum Stem Diameter was recorded in the treatment T_4 (GA3 200 ppm) 7.90mm followed by 7.80mm with T_8(NAA 200 ppm) and minimum Stem Diameter 6.00 mm was recorded in T_0 control

f) Shoot Length

Shoot length of four tagged seedlings was measured by metric scale for the separated the root from the top at the interval of 30,60,90 days and average value was calculated.

At 30 DAT the maximum Shoot Length was recorded in the treatment T_4 (GA3 200 ppm) 9.80 cm followed by 10.0 cm with T_8 (NAA 200 ppm) and minimum Shoot Length 6.6 cm was recorded inT_0 control.

At 60 DAT the maximum Shoot Length was recorded in the treatment T_4 (GA3 200 ppm) 18.1 cm followed by 18.0 cm with T_8 (NAA 200 ppm) and minimum Shoot Length 13.8 m was recorded in T_0 control.

At 90 DAT the maximum Shoot Length was recorded in the treatment T_4 (GA3 200 ppm) 27.9 cm followed by 27.7 cm with T_8 (NAA 200 ppm) and minimum Shoot Length 21.8 cm was recorded in T_0 control.

g) Root Length

Root length of four tagged seedlings was measured by metric scale at 60 days and average value was Calculated. The maximum Root Length was recorded in the treatment T_4 (GA3 200 ppm) 15.0 cm followed by 14.9 cm with T_8(NAA 200 ppm) and minimum days for Root Length 12.0 cm was recorded in T_0 control.

h) Leaf area

Measure the length of the leaf from the tip to the base. Measure the width of the leaf at its widest point, usually perpendicular to the length.

Calculate the leaf area using the formula for the area of a rectangle:

Leaf Area (cm²) = Length (cm) x Width (cm)

The maximum Leaf Area was recorded in the treatment T_4 (GA3 200 ppm) 29.30 cm2 / plant followed by 29.00 cm2 / plant with T_8 (NAA 200 ppm) and minimum Leaf Area 19.0 cm2 / plant was recorded in T_0 control.

i) Survival percentage of papaya seedling

To calculate the survival percentage, use the following formula:

Survival Percentage = (Number of Surviving Seedlings / Initial Number of Seedlings) * 100%

Where,

Number of Surviving Seedlings: The count of papaya seedlings that have survived at the end of the observation period. Initial Number of Seedlings: The total number of papaya seedlings you initially planted or transplanted. The maximum Survival percentage of papaya seedling was recorded in the treatment T_4 (GA3 200 ppm) 86.2% followed by 85.8% with T_8(NAA 200 ppm) and minimum Survival percentage of papaya seedling 80.0% was recorded in T_0 control.

j) Germination Percentage

The germination percentage was worked out after the final germination, i.e., after stoppage of germination. It was calculated by dividing to total number of seeds sown with the number of seeds germination and germination percent was calculated

The maximum Germination Percentag**e** was recorded in the treatment T_4 (GA3 200 ppm) 86.0% followed by 85.5% with T_8(NAA 200 ppm) and minimum Germination Percentage 79.3% was recorded in T_0 control.

k) Chlorophyll content

Chlorophyll content of four tagged seedlings was measured with the help of spectrophotometrically. An average value was calculated. The maximum Chlorophyll Content was recorded in the treatment T_4 (GA3 200 ppm) 60.35 µm/g followed by 59.65 µm/g with T_8(NAA 200 ppm) and minimum Chlorophyll Content 28.39 µm/g was recorded in T_0 control.

l) Seedling vigour index-I (cm)

Seedling Vigour Index-I (cm) assesses seedling vigour by multiplying the length (in centimetres) of the seedling by the germination percentage.

Vigour Index –I = Seedling length (cm) X Germination%

The maximum Seedling Vigour Index-I (cm) was recorded in the treatment T_4 (GA3 200 ppm) 28.88 cm followed by 28.01 cm with T_8(NAA 200 ppm) and minimum Seedling Vigour Index-I (cm) 20.35 cm was recorded in T_0 control.

m) Seedling Vigour Index-II (g)

Seedling Vigour Index-II (g) evaluates seedling vigor by multiplying the dry weight (in grams) of the seedling by the germination percentage.

Vigour Index –I I= Seedling Dry Wt. (g) X Germination%

The maximum Seedling Vigour Index-II (g) was recorded in the treatment T_4 (GA3 200 ppm) 183.18 (g) followed by 172.25 (g) with T_8(NAA 200 ppm) and minimum Seedling Vigour Index-II (g) 71.37 g was recorded in T_0 control.

Table 1: Mean performance of growth parameters in papaya

Treatments	Treatment combination	Days to initiation of germination of papaya seeds	Number of days required for 50% of germination	Number of leaves per plant of papaya	Height of seedling (cm)	Stem Diameter (mm)	Shoot Length (cm)	Root Length (cm)
T_0	Soil (CONTROL)	8.30	15.30	8.30	25.70	6.00	21.80	12.00
T_1	GA3 50ppm	7.30	12.30	9.70	27.30	6.30	22.90	13.30
T_2	GA3 50ppm	6.30	11.00	10.30	29.00	6.70	23.70	14.00
T_3	GA3 50ppm	5.70	8.70	12.00	30.30	7.10	25.70	14.80
T_4	GA3 50ppm	4.00	6.30	13.70	33.00	7.90	27.90	15.00
T_5	NAA 50 ppm	7.30	10.70	10.00	27.70	5.60	23.00	13.00
T_6	NAA 50 ppm	7.00	10.00	11.00	28.70	6.60	23.70	13.50
T_7	NAA 50 ppm	5.70	8.00	12.70	31.00	7.00	25.00	14.40
T_8	NAA 50 ppm	5.30	7.00	13.50	32.7	7.80	27.70	14.90
	F test	S	S	S	S	S	S	S
	SE(d)±	0.58	0.59	0.57	1.11	0.21	0.47	0.18
	CD	1.22	1.27	1.21	2.15	0.45	0.99	0.39

Table 2: Mean performance of growth parameters in papaya

Treatments	Treatment combination	Leaf Area(cm2 / plant)	Survival percentage of papaya seedling (%)	Germination Percentage (%)	Chlorophyll Content (µm/g)	Seedling Vigour Index-I (cm)	Seedling Vigour Index-II (g)
T_0	Soil (CONTROL)	9.00	80.00	79.30	28.39	20.35	71.37
T_1	GA3 50ppm	19.00	82.30	81.80	36.60	22.37	90.56
T_2	GA3 50ppm	22.00	84.30	83.00	39.99	24.17	107.90
T_3	GA3 50ppm	26.30	85.00	84.70	49.22	25.66	127.05
T_4	GA3 50ppm	29.30	86.20	86.00	60.35	28.88	183.18
T_5	NAA 50 ppm	19.70	82.20	80.30	42.62	22.14	88.33
T_6	NAA 50 ppm	26.30	83.80	82.30	46.21	23.57	105.18
T_7	NAA 50 ppm	26.70	84.80	84.00	52.12	26.16	136.92
T_8	NAA 50 ppm	29.00	85.80	85.50	59.65	28.01	172.25
	F test	S	S	S	S	S	S
	SE(d)±	0.71	0.29	0.36	8.09	0.89	0.69
	CD	1.51	0.61	0.76	19.21	1.93	16.01

4. Conclusion

It is concluded from the above experiment that, based on the results of the experiment, it is concluded that the application of Gibberellic acid (GA3) at a concentration of 200 ppm, denoted as Treatment T_4, proved highly effective in promoting papaya seed germination and fostering robust seedling growth. Notably, GA3 broke seed dormancy, resulting in quicker germination, and stimulated both stem and root development, leading to healthier papaya plants. Treatment T_8 (NAA 200 ppm) also showed promise, while the control group (T_0) yielded the least favourable results. Consequently, GA3 at 200 ppm stands out as the most suitable strategy for cultivating healthy and thriving papaya seedlings, with significant implications for improved crop production and quality.

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