Effects of different Qualities of Light and Phytohormones on Seed Germination, Seedling Growth and Establishment of Papaya (*Carica papaya*) cv. Pusa Nanha.

ABSTRACT

The present study was undertaken to study the effects of different qualities of light and phytohormones (GA3 @ 200ppm) on papaya seed germination, seedling growth, and establishment. The experiment was laid in Randomized Block Design. The experiment comprises of eight treatments viz. T0 {Natural Light (95000 lux)}, T1{Shade Net/Green House (Light 21500 lux)}, T2 {Polyhouse (light 7750 lux)}, T3 {Partially shaded area (light 2800 lux)}, T4 {Fully shaded area (light 880 lux)}, T5 {Incandescent Light (290 lux)}, T6 {Fluorescent Light (3000 lux)}, T7 {Growth Chamber Light (light 2500 lux)}. Among different treatments T6 performed best in terms of Seed germination, Seedling growth and Establishment of Papaya. The findings revealed that treatment T6 {Fluorescent Light (3000 lux)} + GA3 (200 ppm) performed best in term of Days to Germination (8 Days), Germination percentage (94.44%), Number of leaves (9.6), Plant height (16.23 cm), stem vigour index (1444.93), Leaf area (394.4 cm^2), Chlorophyll content (41.47 SPAD value) and stem girth (0.37 cm), Establishment Percentage (93.33%). The highest B:C ratio was found in the same Treatment, T6 {Fluorescent Light (3000 lux)} + GA3 (200 ppm), with 3.5.

Keywords: papaya, light intensities, GA_3 200ppm, growth, germination

1. INTRODUCTION

The germination and growth of papaya seeds and seedlings are influenced by a variety of environmental factors, including light intensity and phytohormones. Environmental factors such as light, wind, edaphic characteristics, temperature, relative humidity and biotic factors such as mycorrhizal fungi and genotype significantly affect the productivity and physiology of papaya (Nakasone and Paul). Pusa Nanha is a dioecious dwarf mutant having 130cm height, bearing fruit at 75cm height suited for high density planting (6,400 plants per hectare) and tolerant to water logging. Fruits are medium sized, round to ovate in shape with thin, yellow pulp having around 10° Brix TSS and low cavity it yields about 63 tonnes/ Hectare and about 10.1 kg / plant approximately. The papaya has a complicated reproductive system (Marler et al., 1994). The propagation is practiced only by seeds. But Seed germination in papaya is very slow, erratic and also incomplete. Cost of papaya seed is also high so increasing germination percentage and producing more vigour seedling is a challenge for papaya grower.

Light intensity is an important factor that affects papaya seed germination, seedling growth, and establishment. Different light intensities can have varying effects on the germination rate and growth of papaya seedlings. For example, low light intensity can lead to slower germination rates and weaker seedlings, while high light intensity can lead to faster germination rates and stronger seedlings. However, too much light intensity can also have negative effects on seedling growth, such as leaf burn and dehydration.

Papaya is a light-demanding plant and prolonged low light intensity can cause significant alterations in the seed anatomy and morphology (Buisson and Lee, 1993). Thus, knowing how papaya responds to light is important to develop management strategies to optimize seed germination and seedling growth (Silva *et al.,* 2019). This research aims to present the current research knowledge related to the effects of light intensity on seed germination and seedling growth of papaya. Understanding the interaction between light and physiological processes is extremely important for a sustainable profitable production under either greenhouse or field conditions (Compostrini *et al.,* 2019). By using improved light science-based management, growers may optimize germination of papaya seed.

Phytohormones are also important for papaya seed germination and seedling growth. As they play crucial roles in seed germination and seedling growth, including cell division, elongation, and differentiation. For example, gibberellins stimulate seed germination and stem elongation. Papaya seeds may exhibit dormancy, a natural mechanism that prevents seeds from germinating under unfavourable conditions. Gibberellic acid can break seed dormancy by stimulating the production of enzymes that promote germination. Applying GA3 to papaya seeds can lead to a higher germination rate by promoting the growth of the embryonic root (radicle) and shoot (plumule) structures. Beyond germination, GA3 can also influence the early growth stages of papaya seedlings by promoting elongation of stems and enhancement of root growth. The promising effect of GA_3 as pre-sowing treatment to the seeds replaced the dormancy mechanism of the seeds resulting in early germination (Khan 1981). The maximum seed germination of papaya was obtained under GA_3 200ppm (Ramteke et al., 2015). In this study, singular rate of GA_3 200ppm is used as pre-soaking seed treatment due to such its superior effect on gemination rate.

Light, can control photosynthetic processes and affect papaya plant growth (Compostrini *et al.,* 2019). Thus, regardless of whether papaya is grown under either field or protected cultivation, understanding this important environmental factor on different qualities of light is extremely important for commercial papaya production. Information included in this study could greatly aid in future papaya breeding efforts. Therefore, this study aimed to access the effects of different qualities of light and phytohormones on seed germination, seedling growth and establishment of Papaya var. Pusa Nanha. By understanding the effects of different qualities of light and phytohormones, we can contribute to development of sustainable agriculture practices that helps us to improve the germination parameters, growth parameters and better establishment to produce good quality of Papaya.

2. Materials and Methods

Papaya, Pusa Nanha was used in the present research. The experiment was treated with different qualities of light and phytohormones GA_3 @ 200 ppm, consisting eight treatment combination viz. T0 {Natural Light (95000 lux)}, T1{Shade Net/Green House (Light 21500 lux)}, T2 {Polyhouse (light 7750 lux)}, T3 {Partially shaded area (light 2800 lux)}, T4 {Fully shaded area (light 880 lux)}, T5 {Incandescent Light (290 lux)}, T6 {Fluorescent Light (3000 lux)}, T7 {Growth Chamber Light (light 2500 lux)}, and all the seeds were maintained under uniform culture schedule during the entire experiment period.

2.1 Locale of Study

The study was conducted at, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, located in Prayagraj, Uttar Pradesh, India. Prayagraj is located in the south-east part of Uttar Pradesh India. Prayagraj falls under agroclimatic zone IV which is named as “trans Jamuna plains” the site of experiment is located at 25.57º N latitude 81.51º E longitude and 98 meter above the sea level the temperature falls down as low as 4-5ºc during winter, the average rainfall in this area is around 798.900 mm annually with maximum concentration during July to September with few showers and drizzles in winter also. The portray with seeds were kept according to their light requirement at different places with controlled light, and seeds pre-treated with GA_3 200ppm were used in the experiment.

2.2 Experimental Design

A randomized block design was employed, with three replications in each treatment, the control group (T0) receiving Natural light. The remaining seven treatment groups (T1-T7) received different qualities of light.

2.3 Observations Recorded

Various parameters which were observed are as follows Days to germination, Germination %, Seedling Height, Number of Leaves, Seed Vigor Index, Leaf Area, Chlorophyll Content (SPAD Value), Stem Girth, Establishment % and Economics.

3. Result and Discussion

The result of investigation and experiment are summarized below:

Present study revealed that treatment T6 {Fluorescent Light (3000 lux)} with the pre-soaking seed treatment with GA_3 (200 ppm), performed better in terms of seed germination, seedling growth and establishment of papaya and also the development and growth under this treatment showed superior morphological and physiological characters, as compared to other treatments.

Light is an extremely important factor for releasing seeds from dormancy. Almost all light-requiring seeds have coat-imposed dormancy. Seeds of many species are affected by exposure to white light for just a few minutes or seconds (e.g., lettuce) or even milliseconds, whereas others require intermittent illumination for some times prolonged periods of time. And, GA in particular have a profound influence on the dormancy and germination of seeds and appearance of plumule and appearance of first true leaves were also found significantly higher, plant height, diameter of the stem and primary roots per plant were also noticed significantly more. The rapid and early germination might have helped in producing vigorous growth of seedlings during subsequent period of growth. The combination of both Light and GA^3 in this research creates a supreme impact on various germination parameters, growth parameters leading to better establishment, production and economics as well, ultimately leading to sustainability.

3.1 Germination %, Days to Germination

Among different qualities of lights treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) is recorded with maximum germination percentage i.e. 94.44% and the earliest to germinate with 8 days, whereas the minimum germination percentage was recorded in T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 77.78% and the sprouting also came last with 12 days. The interacting data showed that the fluorescent light have the most positive impact on the days to germination and germination %, although the results were non-significant, the fluorescent light showed most promising results and also caused the seedling to elongate more in comparison to other treatments. Similar results were reported by, Li *et al.*, (2010) in his study, that LEDs are considerable as an interesting alternative light source for plant growth, especially for in vitro propagation of cotton. LEDs were the best ratio for the growth of upland cotton (Gossypium hirsutum L.) plantlets in vitro. Giang *et al*. (2011) Seeds were germinated under different light conditions, with some interesting results: although germination percentage was close to 100% in all light conditions and for both cultivars, although LEDs led to elongation of shoots.

3.2 Number of Leaves

Among different qualities of light treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) recorded the maximum number of leaves with an average of 2.53 at (20 days after sowing), 4.20 at (30 days after sowing), 6.30 at (40 days after sowing) and 9.60 at (60 days after sowing);

whereas the minimum number of leaves was recorded in T7 {Growth Chamber Light (light 2500 lux)} + GA_3 (200 ppm) with 2.07 at (20 days after sowing) and 3.07 at (30 days after sowing) and 5.0 at (40 days after sowing) and lastly in treatment T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 7.43 at (60 days after sowing). The interacting data showed that the treatment 6 have the most significant impact on number of leaves and studied have also shown that the use of fluorescent light makes a positive impact on plant and leads to production of more leaves. Silva (2014) studied that, in the case of 100% R LEDs, slightly more leaves were produced relative to the control lighting conditions. GA_3 200 ppm has also has a profound effect on number of leaves as it helps in invigoration of physiological process of plant and stimulatory effect of chemicals to form new leaves faster rate. The results are in conformity of Sen et al. (1990) in papaya seeds and Kalalbandi et al. (2003) in kagzi lime.

3.3 Seedling Height

Among different qualities of light treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) recorded the maximum seedling height of 4.17 cm at (20 days after sowing), 6.83cm at (30 days after sowing), 7.47cm at (40 days after sowing) and 16.2cm at (60 days after sowing); whereas the minimum seedling height was recorded in T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 2.93cm at (20 days after sowing) and 4.37cm at (30 days after sowing) followed by T0 {Natural Light (95000 lux)} + GA_3 (200 ppm) with 5.93cm at (40 days after sowing) and lastly in treatment T7 {Growth Chamber Light (light 2500 lux)} + GA_3 (200 ppm) with 12.13cm at (60 days after sowing). The result pertaining the significant improvement was shown by fluorescent light in seedling height development were seen in this study and Giang *et al.* (2011) reported that LEDs led to elongation of shoots. GA_3 200 ppm has also played a vital role in maximising plant height due to cell division and cell elongation, which in turn would have increased the internodal length. The observations are in agreement with the findings of Deb et al. (2010) in papaya seeds.

3.4 Seed Vigour Index

Among different qualities of lights treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) is recorded with maximum seed vigour index i.e. 1444.93; whereas the minimum seed vigour index was recorded in T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 1055.22. The interacting data showed that the fluorescent light have the most positive impact on vigour caused due to better PAR and improved physiology of Papaya. Similar results were reported by (Parab *et al.* 2017) in the effect of phytohormones and light intensities improves seed germination, seedling growth and seedling vigour of papaya.

3.5 Leaf Area

Among different qualities of lights treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) is recorded with maximum Leaf Area (cm^2) i.e. 394.40 cm^2; whereas the minimum Leaf Area was recorded in T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 166.77cm^2. The interacting data showed that the fluorescent light have the most significant effect on the leaf area as it leads to most superior growth, similar results were found by Wang *et al.* (2014) studied and concluded that the Leaf age and light intensity substantially affect photosynthesis within the canopy of papaya. Mature leaves in the upper canopy were the major contributors to papaya photosynthesis. The first study of LAI and extinction coefficient was estimated in the papaya canopy.

3.6 Chlorophyll content (SPAD value)

Among different qualities of lights treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) is recorded with maximum Chlorophyll content (SPAD value) i.e. 41.47; whereas the minimum Chlorophyll content (SPAD value) was recorded in T7 {Growth Chamber Light (light 2500 lux)} + GA_3 (200 ppm) with 32.60. The interacting data showed that the fluorescent light showed most promising results as it has most effect on leaf area which will lead to larger surface area leading to better photosynthesis and more chlorophyll content, similar results were found by

Silva *et al*. (2019) investigated and found that compared to plants cultivated in full sunlight, light treatments caused increased chlorophyll content per unit leaf area and the amount of air, space into the leaf mesophyll.

3.7 Stem Girth

Among different qualities of lights treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) is recorded with maximum Stem Girth (cm) i.e. 0.37 cm; whereas the minimum Stem Girth (cm) was recorded in T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 0.29cm. The result pertaining that treatment 6 showed most effective impact on stem girth and similar results were shown by Baiyeri (2005) in Pawpaw seedlings grown under different nursery light shades responded strongly to colour effects. There was progressive increase in seedling height, stem girths and vigour index.

3.8 Establishment %

Among different qualities of lights treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) is recorded with maximum Establishment % i.e. 93.33 %; whereas the minimum Establishment % was recorded in T2{Polyhouse (light 7750 lux)} + GA_3 (200 ppm) with 78.33%. The interacting data showed better development with relation to see germination, seedling growth and superior morphology and physiology ultimately leading to better establishment %, however the observations were non-significant and none of the values were at par and the most impactful observations were recorded in treatment 6 i.e. Fluorescent Light.

Table 1 Effects of different qualities of light and phytohormones (GA_3 @ 200ppm) on Germination %, Number of leaves, Seedling Height.

Notion	Treatment	Germination %.	Number of Leaves	Seedling Height
			60 Days	60 Days
T_0	Natural Light (Light 95000 Lux)	83.33	8.33	14.1
T_1	Shade net (Green House) (Light 21500 Lux)	88.89	8.67	15.67
T_2	Polyhouse (Light 7750 Lux)	77.78	7.43	13.57
T_3	Partially Shaded Area (Light 2800 Lux)	88.89	8.6	15.3
T_4	Fully Shaded Area (Light 880 Lux)	83.33	8.4	12.73
T_5	Incandescent Light (Light 290 Lux)	88.89	9.37	14.23
T_6	Fluorescent Light (Light 3000 Lux)	94.44	9.6	16.23
T_7	Growth Chamber Light (Light 2500 Lux)	83.33	8.33	12.13
	F Test	NS	S	S
	S.Ed(±)	6.56	0.29	0.84
	CV	9.33	4.19	7.2
	CD (5%)	14.7	0.63	1.8

Table 2 Effects of different qualities of light and phytohormones (GA_3 @ 200ppm) on Seed Vigour Index, Leaf Area (cm^2), Chlorophyll Content (SPAD Value), Stem Girth (cm), Establishment %.

Notion	Treatments	Seed Vigour Index	Leaf Area (cm^2).	SPAD value.	Stem Girth (cm).	Establishment %.
T_0	Natural Light (Light 95000 Lux)	1174.95	312.67	38.57	0.33	83.33
T_1	Shade net (Green House) (Light 21500 Lux)	1392.61	176.23	40.43	0.36	88.89
T_2	Polyhouse (Light 7750 Lux)	1055.22	166.77	33.97	0.29	78.33
T_3	Partially Shaded Area (Light 2800 Lux)	1442.98	294.7	37.57	0.34	86.11
T_4	Fully Shaded Area (Light 880 Lux)	1061.07	334.43	36.97	0.34	86.11
T_5	Incandescent Light (Light 290 Lux)	1265.20	267.7	33.07	0.33	88.89
T_6	Fluorescent Light (Light 3000 Lux)	1444.93	394.4	41.47	0.37	93.33
T_7	Growth Chamber Light (Light 2500 Lux)	1011.07	224.53	32.6	0.36	83.33
	F Test	S	S	S	S	NS
	S.Ed(±)	70.58	36.1	1.78	0.01	12.05
	CV	7.02	16.29	5.93	3.71	17.15
	CD (5%)	151.38	77.42	3.82	0.02	25.83

Table 3 Total cost of cultivation, Gross return, Net return and Benefit: Cost Ratio of Papaya (*Carica papaya L*) cv Pusa Nanha.

Notion	Fixed Cost (Rs.)	Variable Cost (Rs.)	Total Cost Cultivation (Rs.)	No. of seedling/100 m sq. (Rs.)	Selling Prise/Seedling (Rs.)	Gross Return (Rs.)	Net Return (Rs.)	B:C Ratio.
T0	7,350	0	7,350	1,562	15	23,430	16,080	3.1
T1	7,350	70	7,420	1,667	15	25,005	17,585	3.3
T2	7,350	100	7,450	1,468	15	22,020	14,570	2.9
T3	7,350	50	7,400	1,614	15	24,210	16,810	3.2
T4	7,350	50	7,400	1,614	15	24,210	16,810	3.2
T5	7,350	100	7,450	1,667	15	25,005	17,555	3.3
T6	7,350	110	7,460	1,749	15	26,235	18,775	3.5
T7	7,350	210	7,560	1,562	15	23,430	15,870	3

4. Conclusion

On the basis of present experimental findings, it is concluded that treatment T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm) performed best in term of Days to Germination, Germination percentage, Number of leaves, Plant height, Leaf area, Chlorophyll content and stem girth, Establishment Percentage.

The highest B:C ratio was found in the same Treatment, T6 {Fluorescent Light (3000 lux)} + GA_3 (200 ppm), with **3.5.**

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