Asian Journal of Advances in Agricultural Research

Volume 24, Issue 7, Page 53-60, 2024; Article no.AJAAR.118191
ISSN: 2456-8864

Effect of Gibbrellic Acid, Kinetin and Potassium Nitrate on Seed Germination of Papaya (*Carica papaya* L.) cv. Red Lady

Mahak Rani [a*], Gurdeep Singh [a], Navdeep Singh [a] and Dinesh Kumar [a]

[a] Department of Horticulture, Faculty of Agriculture, Guru Kashi University, Talwandi Sabo, Bathinda, Punjab-151302, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajaar/2024/v24i7522

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/118191

Original Research Article

Received: 02/04/2024
Accepted: 07/06/2024
Published: 12/06/2024

ABSTRACT

Seed germination is the most important aspect for raising the nursery for successful seedling production of papaya. The research was carried out at the Faculty of Agriculture, Guru Kashi University, Talwandi Sabo, Bathinda (Punjab) during 2023 to evaluate the impact of different pre-soaking chemicals on seed germination and vigour of papaya seedling. The experiment was laid out Randomized block design with three replications and included ten different treatments., namely T1 (Control- double distilled water), T2 (GA3 @ 50 ppm), T3 (GA3 @ 100 ppm), T4 (GA3 @ 200 ppm), T5 (Kinetin @ 25 ppm), T6 (Kinetin @ 50 ppm), T7 (Kinetin @ 75 ppm), T8 (KNO3 @ 500 ppm), T9 (KNO3 @ 1000 ppm), T10 (KNO3 @ 1500 ppm), were soaked for 24 hours. The seeds were sown

---

**Corresponding author: Email: mahakdawra18@gmail.com;*

Cite as: *Rani, Mahak, Gurdeep Singh, Navdeep Singh, and Dinesh Kumar. 2024. "Effect of Gibbrellic Acid, Kinetin and Potassium Nitrate on Seed Germination of Papaya (Carica Papaya L.) Cv. Red Lady". Asian Journal of Advances in Agricultural Research 24 (7):53-60. https://doi.org/10.9734/ajaar/2024/v24i7522.*

in a blend of sand, soil and vermiculite with a ratio of 2:1:1 and maintained under controlled polyhouse condition. Among the treatments, T3 (GA3 @100 ppm) demonstrated the most rapid seed germination, highest percentage of germination (56.20) and maximum survival percentage (53.44) and the T4 (GA3 @ 200 ppm) resulted in the lowest days to first emergence of seedling (3.66), maximum plant height (32.33), maximum number of leaves (8.66) and highest girth of seedling (5.86) at 60 days after sowing. In Conclusion, the most effective approach for enhancing seed germination in papaya involved pre-treating the seeds with GA_3 @ 200 ppm in var. Red lady.

Keywords: Gibberellic acid; papaya (Carica papaya); red lady; randomized block design; seed germination.

1. INTRODUCTION

Papaya, scientifically known as *Carica papaya* L., is a crucial tropical fruit plant belonging to the Caricaceae family. It is a notable member of the *Carica* genus, the Carica genus includes 22 species and is the only member of the Caricaceae family that is specifically cultivated as a fruit tree, while the other three genera are mainly grown for their ornamental appeal [1]. Papayas originated in the Caribbean coastal region of Central America, spanning from Argentina and Chile to southern Mexico [2]. This is believed to have occurred through natural crossbreeding between *Carica peltata* and another wild species [3]. The introduction of papaya to India dates back to the 16th century, and it has since emerged as a vital crop in numerous tropical and subtropical areas across the globe. Widely consumed as a fresh fruit, papaya also finds diverse applications in culinary preparations, including desserts, preserves, baked goods, beverages, and even as an ingredient in winemaking [4,5,6]. Moreover, unripe green papaya fruits can be prepared and consumed as a vegetable [7]. Papain, a white milky fluid with proteolytic properties, is present in the fruits and other parts of the plant. It is effective in addressing dyspepsia and can also be utilized to tenderize meat and clarify beer (Wilson, 1974). Papaya seeds are employed for managing jaundice and urinary issues, while the leaves are utilized for their helminthic, antibacterial, and anti-amoebic properties [8,9].

Internationally, India is recognized as the leading producer of papaya, with the largest cultivation area and highest production output. Papaya cultivation in India covers an expansive area of 97.7 thousand hectares, resulting in a significant production of 5.95 million MT [10]. While Andhra Pradesh takes the lead in papaya production, the cultivation of papaya is also widespread in various other states including Karnataka, Gujarat, Orissa, West Bengal, Assam, Kerala, Maharashtra, and Madhya Pradesh.

In India's mild sub-tropical regions, papaya thrives in temperatures ranging from 22 to 26 ºC and is suitable for cultivation up to 1,000 m above mean sea level. Prolonged exposure to nighttime temperatures below 12–14 ºC during winter adversely affects plant growth and productivity. Frost, strong winds, and waterlogging also have significant detrimental effects. Crucial to its growth are a well-developed root system with root ramifications and a primary napiform root, as noted by Costa and Pacova [11].

Traditionally, papayas are generally propagated through seeds [12]. The germination process of papaya seeds is commonly described as slow, unpredictable, and incomplete [13]. Various factors, such as seed quality, treatments, substrate type, and weather conditions, impact the vigor of seedlings [14]. The gelatinous sarcotesta of papaya also acts as a germination inhibitor. Papaya growers often face challenges related to slow, irregular, and incomplete germination of seeds, as well as high initial seedling mortality due to these issues. This has prompted researchers to explore the effects of hormones, growing medium, bacteria, and other factors on increasing the percentage of seeds that germinate and produce healthy seedlings.

The impact of chemical treatment using potassium nitrate, sodium thiosulphate, thiourea, and gibberellic acid on plant growth and development, particularly in breaking dormancy and promoting seed germination, has been documented [15]. Pre-treatment or priming of seeds has been proven to boost the germination of papaya. Additionally, a category of seeds with intermediate characteristics has been identified [16]. The role of plant growth regulators in influencing fruit yield and quality, flowering and fruiting, plant development, and seed germination has been extensively researched across various crop species. Gibberellic acid is a plant growth regulator, is recognized for its ability to stimulate rapid stem and root growth and enhance seed germination rates in certain plant species [17].

2. METHODS AND MATERIALS

2.1 Local of Study

The current investigation was carried out in the summer of 2023 at the experimental site of Guru Kashi University research farm in Talwandi Sabo (Bathinda). The farm is positioned at an elevation of 213 meters above sea level, with coordinates of 29°57'N latitude and 75°7'E longitude. Bathinda, located in the southwest region of Punjab, has a climate characterized by extremely hot summers, a brief wet season, and severe winter conditions. The monsoon typically begins in the first half of July.

2.2 Experimental Details

The experiment included ten treatments: T1 (Control- double distilled water), T2 (GA3 @ 50 ppm), T3 (GA3 @ 100 ppm), T4 (GA3 @ 200 ppm), T5 (Kinetin @ 25 ppm), T6 (Kinetin @ 50 ppm), T7 (Kinetin @ 75 ppm), T8 (KNO3 @ 500 ppm), T9 (KNO3 @ 1000 ppm), T10 (KNO3 @ 1500 ppm). Each treatment was replicated three times using a Randomized block design.

2.3 Sowing of Seeds

Seeds were immersed in solutions with varying concentrations of GA3, kinetin, and potassium nitrate for 24 hours. Subsequently, they were washed and transferred onto petri plates with damp filter paper in a laboratory environment.0n August 12, 2023, the treated seeds were placed carefully in rows in the trays Particular focus was placed on avoiding excessive planting depth, with a maximum soil depth of approximately 2 cm. Furthermore, a fine layer of topsoil was delicately added to cover the seeds, reflecting precise care in the sowing procedure.

2.4 Parameter Observed

Following observation was recorded

2.5 Germination Attributes

2.5.1 Days to first emergences of seedling

The number of days taken for the first papaya cv. Red lady seed to germinate was recorded under selected growing conditions.

2.5.2 Days to 50% germination (days)

The number of days taken place for 50% of germination was recorded under selected growing conditions.

2.5.3 Germination percentage (%)

The number of plants was observed from seedling to record the germination percentage. The germination percentage was calculated by counting the number of seeds that sprouted in each treatment and replication until no further germination was observed, and then documented as the percentage of germination.

Germination percentage=(Total number of seed germination/ Total number of seed sown) X100

2.5.4 Survival percentage (%)

The number of seedlings survive was recorded under selected growing conditions.

Survival%=(Total number of surviving seedlings/ Total number of seed germinated) X100

2.6 Growth Attributes

2.6.1 Plant height (cm)

Plant height was gauged using a scale and recorded in centimeters, with measurements taken from the soil surface to the growing tip of the plant. This method was adopted to maintain precision and uniformity in assessing the plants' vertical development. The height of five seedlings from each treatment and replication was measured from ground level to the growing tip. After calculating the mean, the measurements were recorded as the height of the seedlings in centimeters at30, 60 and 90 days after sowing.

2.6.2 Number of leaves

The count of leaves per seedling was conducted on 10 selected seedlings from each treatment and replication. Following the computation of the mean, the outcome was recorded as then number of leaves per seedling at 30, 60 and 90 days after sowing.

2.6.3 Seedling girth (cm)

The average polar diameter is measured with the help of scale and measured in centimeters.

2.6.4 Leaf area (cm^2)

Five fully grown leaves were randomly selected from 10 tagged seedlings in each treatment and replication. The leaf area was measured with the help of image analysis software 30, 60 and 90 days after sowing and after calculating the mean, it was recorded as square centimeters per seedling.

2.6.5 Days required for completion of germination

The number of days taken to give 100 % germination was recorded under selected growing conditions. The time taken for germination to complete in each treatment and replication was carefully noted, with observations ending when no additional germination was observed, and the data were recorded as whole numbers.

2.7 Statistical Analysis

The collected data were subjected to statistical analysis using MVM Statistical and MS-Excel methods, following the guidelines outlined by Gomez and Gomez (1983). The treatment averages were compared using the Critical Difference (C.D.) at a significance level of 5%.

3. RESULTS AND DISCUSSION

Seed germination parameters: In the present study the observation (Table 1) of Seed germination parameters of (*Carica papaya)* var. Red lady as influenced by various chemical treatments of GA3, kinetin, potassium nitrate at different concentrations (ppm) resulted in positive and significant changes in seed germination.

The treatments taken minimum time for the initial emergence of seedlings was recorded as 3.66 days with T4: GA_3 at 200 ppm and in contrast, the control group (T1) required 10.66 days for the first emergence of seedlings under the specified polyhouse conditions .Furthermore, Zanotti et al. [18] documented higher germination rates for seeds treated with KNO_3 or KNO_3 in combination with GA_3 after a 14-day observation period. The time taken for 50% germination was the shortest with T4: GA_3 at 200 ppm (6.33 days), followed by T2: GA_3 at 50 ppm (6.66 days) and T3: GA_3 at 100 ppm (7.33 days) respectively. In contrast, the control group (T1) required a longer time for 50% germination under the specified growth conditions. Similarly, Singh et al. [19] found that treating seeds with GA_3 at 100 ppm for 48 hours reduced the time required for 50% germination.

Germination % at 30 DAS was found significantly maximum (56.20%) in T3 (GA_3 @ 100 ppm) and minimum (17.86%) was recorded under T1 Control. Pratibha et al. [20] documented that the lowest duration of seed germination (12.33 days), the highest germination percentage (88.89%), and germination index (2.90) were achieved in seeds treated with gibberellic acid at 300 ppm for 24 hours. The highest survival percentage was observed in T3: GA_3 at 100 ppm (53.44%), followed by T4: GA_3 at 200 ppm (46.10). In comparison, the control group T1 recorded a survival percentage of 8.44% under the specified growth conditions. Chauhan *et al.* (2015) documented that seeds treated with 200 ppm gibberellic acid achieved the maximum survival percentage of 78.78% along with the highest germination percentage of 82.22. Lay et al*.* [21] noted that higher germination rates were achieved in papaya with GA at 300 ppm for 12 hours and KNO3 at 2% for 24 hours (93.00% and 91.00% respectively).

The duration required for complete germination was found to be the shortest in T4: GA_3 @ 200 ppm (32.66 days) Conversely, T1: control (48.00 days) exhibited the longest duration for completing germination under the polyhouse conditions. This aligns with the findings of Chacko and Singh [13] regarding the enhanced germination rate in papaya seeds treated with GA_3.

Growth attributes: Analysis of observation as presented in Table 2 exhibited that the application of chemical GA3, kinetin, potassium nitrate has a substantial effect on the growth. The results demonstrate that chemical treatments of these growth regulators revealed at any concentration which significantly enhanced in the plant height, numbers of leaves, seedling girth, leaf area.

Maximum plant height (cm) at 30, 60 and 90 days after sowing was recorded in T4 GA_3 at 200 ppm (14.33, 32.33, 46.33 cm respectively) and the minimum plant height was observed in control (8.00, 16.33 and 22.33 cm). Prasad et al. [22] observed similar outcomes for papaya seeds treated with GA3 and KNO3, resulting in improved plant height. The tallest seedlings and the maximum number of leaves were observed in papaya seeds after an 8-hour treatment with 200 ppm GA3, as reported by Sen et al. in [23]. These results are in line with similar findings in cowpea, as noted by Anitha et al. [24].

Table 1. Effect of Gibbrellic acid, kinetin and potassium nitrate on seed germination of papaya (*Carica papaya* L.) cv. Red lady

Treatments	Days to first emergence of seedling	Days to 50 % germination	Germination% at 30 DAS	Survival percentage (%)	Days required for the completion of germination
T1-control	10.66	14.30	17.87	8.44	48
T2-GA_3 @ 50 ppm	4.66	6.66	47.10	32.66	33
T3-GA_3 @ 100 ppm	5.33	7.33	56.20	53.44	33.66
T4- GA_3 @ 200 ppm	3.66	6.33	51.10	46.10	32.66
T5-kinetin @ 25ppm	7.66	10.00	30.86	24.44	39
T6-kinetin @ 50 ppm	6.33	8.66	41.96	29.99	39.66
T7-kinetin @ 75 ppm	7.33	9.66	34.96	25.66	41
T8-KNO_3 @ 500 ppm	5.66	7.66	50.43	34.44	36.33
T9-KNO_3 @ 1000 ppm	6.66	9.33	38.96	28.33	36
T10-KNO_3 @ 1500 ppm	8.33	12.33	26.10	16.33	44.66
SE(m)	0.32	0.29	0.24	0.24	0.62
C.D. at (5%)	0.98	0.87	0.73	0.74	1.87

Table 2. Effect of Gibbrellic acid, kinetin and potassium nitrate on seed germination of papaya (*Carica papaya* L.) cv. Red lady

Treatments	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at 90 DAS	Number of leaves at 30 DAS	Number of leaves at 60 DAS	Number of leaves at 90 DAS	Leaf area at 30 DAS	Leaf area at 60 DAS	Leaf area at 90 DAS	Girth of seedling (mm) at 60 DAS
T1-control	8	16.33	22.33	2.66	3.66	5.33	11.00	22.2	26.2	2.6
T2-GA_3 @ 50 ppm	12.66	29.66	42.66	7.00	8.00	8.66	22.00	44.26	53	5.54
T3-GA_3 @ 100 ppm	13.66	30.33	45.33	7.33	8.33	9.33	20.00	40	50	5.24
T4- GA_3 @ 200 ppm	14.33	32.33	46.33	7.66	8.66	9.66	26.00	48	56.2	5.86
T5-kinetin @ 25ppm	9.33	24.33	32.33	4.66	5.66	6.33	15.00	32	42.2	4.94
T6-kinetin @ 50 ppm	8.00	26.66	37.66	5.66	7.33	7.66	16.00	34	44.2	3.94
T7-kinetin @ 75 ppm	11.33	24.66	33.66	5.00	6.33	6.66	15.00	30	40	3.84
T8-KNO_3 @ 500 ppm	10.33	28.33	39.66	6.66	7.66	8.33	14.00	28	36.2	4.23
T9-KNO_3 @ 1000 ppm	12.33	25.66	35.66	5.33	6.66	7.33	13.26	26.26	32.4	4.52
T10-KNO_3 @ 1500 ppm	10.66	19.66	26.66	4.33	5.33	6.00	12.26	25.26	30.26	3.44
SE(m)	0.30	0.31	1.57	0.28	0.29	0.30	0.037	0.089	0.091	0.038
C.D. at (5%)	0.89	0.93	0.96	0.86	0.88	0.92	0.11	0.26	0.38	0.11

Maximum Number of leaves per plant at 30, 60, and 90 days after sowing, indicating enhanced vegetative growth followed by T4 with GA_3@ 200 ppm (7.66, 8.66 and 9.66) and minimum number of leaves (2.66, 3.66 and 5.33). Consistent findings regarding the maximum number of leaves with KNO_3 priming on seeds were also documented by Maneesha and Priya [25] and the Similar findings were reported by Anjanawe et al. [26] for papaya seeds treated with 200 ppm of GA_3.

GA_3 @ 200 ppm (T4) recorded the maximum leaf area (48.00 cm^2) and girth of seedlings (5.86 mm) at 60 days after sowing, suggesting improved photosynthetic capacity and stem robustness. The study's findings align with those reported by Malshe and Parab [27], who similarly noted increased leaf area with GA_3 pre-soaking treatment and similar findings of increased leaf area with pre-sowing GA_3 treatment in papaya, as reported by Ramteke et al. [28]. This effect on stem girth is consistent with the findings of Dhankhar and Singh [29] in Anola, suggesting that GA_3 application stimulates cambium and its immediate cell progeny. Anjanawe et al. [26] and Meena and Jain [30] reported similar outcomes regarding the increased stem girth resulting from GA_3 pre-soaking treatments in papaya [31-34].

4. CONCLUSION

In conclusion, among all the treatments, the application of GA_3, especially at a concentration of 200 ppm (T4) has demonstrated a pronounced positive effect on the germination and early growth parameters of papaya seedlings and significantly influenced the growth and germination attributes in papaya remaining on at par with treatment GA_3 @ 50 ppm (T2), while the control conditions resulted in poor performance of the cultivar.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Burkill IH. A dictionary of the economic products of the malay peninsula (2nd Edn), Malay Ministry of Agriculture and Co-operatives, Kuala Lumpur; 1966.
2. Manshardt RM, Lius S, Sondur S, Wenslaff T, Fitch M, Sanford J, Zee F, Gonsalves D, Stiles J, Ferreira S, Slightom JL. Papaya breeding for PRV resistance. Acta Horticulturae. 1995;370:27-32
3. Purseglove JW. Caricaceae. In: Tropical Crops. Dicotyledons (Vol. I), Longmans, Green and Co., Bristol. 1968;45-51.
4. Guchhait P, Varma S, Banerjee D, Kumar S, Halder R, Dahiya A. Plant growth regulators and rooting media: A viable approach for growth and performance of citrus. Journal of Experimental Agriculture International. 2024;46(5):366–378. Available:https://doi.org/10.9734/jeai/2024/v46i52387
5. Salari H, Kumar SS, Wani OA, Kumar S, Kumar VV. Sowing media and gibberellic acid influences germination and seedling growth of chilgoza pine (*Pinus gerardiana*. Wall). International Journal of Plant & Soil Science. 2023;35(24):84–99. Available:https://doi.org/10.9734/ijpss/2023/v35i244300
6. Furutani SC, Nagao MA. Influence of temperature, KNO3, GA3 and seed drying on emergence of papaya seedlings. Scientia Horticulturae. 1987 Jun 1;32(1-2):67-72.
7. Storck CR, Nunes GL, Oliveira BB, Basso C. Folhas, talos, cascas e sementes de vegetais: Composição nutricional, aproveitamenton aalimentaçãoe análise sensorial de preparações. Ciência Rural. 2013;43(3):537-543. Available:http://dx.doi.org/10.1590/S0103-84782013000300027.
8. Kermanshai R, McCarry BE, Rosenfeld J, Summers PS, WeretilnyEA, Sorger GJ. Benzyl isothiocynate is the sole or chief anthelmintic in papaya seed extracts. Phytochem. 2001;57(3): 427-435.
9. Calzada, Yepez-Mulia. *In vitro* antiprotozoal activity the roots of Geranium mexicanum and its constituents on *Entamoeba histolytica* and Giardia lamblia Journal of Ethnopharmacology; 2005.
10. Anonymous. National horticulture board, Indian Horticulture Database. Ministry of Agriculture & Farmers Welfare, Government of India; 2020.

11. Costa AFS, Pacova Bev. Caracterização de cultivares, estratégias e perspectivas do melhoramen to genético do mamoeiro. In: Martins DS, Costa AFS (eds) A cultura do mamoeiro: tecnologias de produção. Incaper, Vitória. 2003;59–102.
12. Cheema GS, Dani PG fruits-tropical and sub-tropical, Eds. In Bose TK, Mitra SK, Sanyal D, Naya Prokash, Kolkata. 1990;1:507.
13. Chako EK, Singh RN. Studies on the longevity of papaya, phalsa, guava and mango seeds. International Seed Testing Association. 1966;36:147-158.10.
14. Choudhary J, Wilson D. To study the effect of different growing media on papaya (*Carica papaya*) seedling on germination percentage under protected condition cv. Pusa Nanha. International Journal of Current Microbiology and Applied Sciences. 2020;9(12):1035-1041.
15. Kadam SS, Arumugam R, Balamohan TN. Effect of seed treatment with chemical on germination of papaya seed cv. Washington. National Seminar on Production and Utilization of sPapaya. T.N.A.U., Coimbatore. 6-7 March. 1992;26.
16. Ellis RH. The longevity of seeds. HortScience. 1991;26:1119-1125.
17. Desai A, Panchal B, Trivedi A, Prajapati D. Studies on seed germination and seedling growth of papaya (*Carica papaya* L.) CV. Madhubindu as influenced by media, GA3 and cow urine under net house condition. Journal of Pharmacognosy and Phytochemistry. 2017;6(4):1448-1451.
18. Zanotti RF, Fernandes dos Santos Dias DC, Barros RS, Damatta FM, Oliveira GL. Germination and biochemical changes in 'Formosa" papaya seeds treated with plant hormones. ActaScientiarum. Agronomy, Maringá. 2014;36(4):435-442.
19. Singh M, Das AK, Palei S, Mahali B. Studies on the effect of different concentration of GA3 and KNO3 on germination of papaya seeds cv. PusaNanha. Trends in Biosciences. 2017;10(38): 7979-7982.
20. Pratibha C, Teja T, Krishna PM. Effect of chemical treatments on the germination and subsequent seedling growth of papaya (*Carica papaya* L.) seeds cv. PusaNanha. Journal of Agricultural Engineering and Food Technology. 2015;2:189-191.
21. Lay P, Basvaraju GV, Sarika BG, Amrutha N. Effect of seed treatments to enhance seed quality of papaya (*Carica papaya* L.) cv. Surya. Global Journal of Biology, Agriculture and Health Sciences. 2013;2(3):221-225.
22. Prasad VM, Yeddula N, Topno SE, Srivastava V, Bahadur V, Singh SK. Effect of chemical priming on seed germination and seedling growth in papaya (*Carica papaya* L.). The Pharma Innovation Journal. 2022;11(5):2542-6.
23. Sen SK, Hore JK, Bandyopadhyay A. Per-sowing seed treatment and its role on germination, seedling growth and longevity of papaya. Orissa Journal of Agricultural Research. 1990;2:160-4.
24. Anitha S, Sreenivan E, Purushothaman SM. Response of cowpea (*Vigna unguiculata* L. Walp) to foliar nutrition of zinc and iron in the oxisols of Kerala. Legume Research. 2005;28(4):294-296.
25. ManeeshaSr, priya. Effect of calcium nitrate and potassium nitrate priming on seed germination and seedling vigour of papaya (*Carica papaya* L.). Journal of Horticultural Sciences. 2019;14(2):149-54.
26. Anjanawe SR, Kanpure RN, Kachouli BK, Mandloi DS. Effect of plant growth regulators and growth media on seed germination and growth vigour of papaya. Annals of Plant and Soil Research. 2013;15(1):31-34.
27. Mathad JC, Malshe KV. Parab AM effect of presoaking chemicals on germination and subsequent seedling growth of Papaya (*Carica papaya*) Cv. Solo. IJCS. 2017;5(4):1812-6.
28. Ramteke V, Kurrey VK, Paithankar DH, EktaNingot E. Effect of ga3 and propagation media on germination, growth and vigour of papaya cv. coorg honey dew. The Bioscan. 2015;10(3): 1011-1016.
29. Dhankhar DS, Singh M. Seed germination and seedling growth in aonla (*Phyllanthus emblica* Linn.) as influenced by gibberellic acid and thiourea. Crop Research (Hisar). 1996;12(3):363-366.
30. Meena RR, Jain MC. Effect of seed treatment with gibberellic acid on growth paramerters of papaya seedlings (*Carica papaya* L.). Progressive Horticulture. 2012;44(2):248-50.
31. Lanjhiyana R, Sahu GD, Panigrahi HK, Katiyar P. Role of pre-sowing seed treatment on germination behavior and seedling vigour of papaya (*Carica papaya* L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(5):3039-3042.

32. Silva JD, Rashid Z, Nhut DT, Sivakumar D, Gera A, Souza MT, Tennant P. Papaya (*Carica papaya* L.) biology and biotechnology. Tree and Forestry Science and Biotechnology. 2007;1(1):47-73.
33. Sen SK, Ghunti P. Effect of pre-sowing seed treatments on the germination and seedling growth in papaya. Orissa Journal of Horticulture. 1976;4(1/2):38-43 ref. 7.
34. Sehrawat SK, Kumar P, Rana GS, Dahiya DS, Dahiya OS. Influence of priming treatments on vigour and viability of papaya seeds. In II International Symposium on Papaya 851 2008 Dec 9; 317-330.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/118191