International Journal of Plant & Soil Science

Volume 38, Issue 10, Page 418-423, 2026; Article no.IJPSS.164119
ISSN: 2320-7035

Influence of Different Pre-sowing Seed Treatments on Germination and Seedling Growth of Papaya (*Carica papaya* L.) cv. Red Lady

Devansh Prakash Saxena [a++], Shiwanand Pandey [a#*], Himanshu Trivedi [a] and Vinay Kumar [a]

[a] *School of Advanced Agricultural Sciences and Technology (SAAST), Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh, 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/ijpss/2026/v38i106360

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://pr.sdiarticle5.com/review-history/164119

Original Research Article

Received: 14/06/2026
Accepted: 11/08/2026
Published: 29/09/2026

Abstract

Papaya (*Carica papaya* L.) seed germination is often slow and uneven, which can limit uniform nursery establishment. The present investigation evaluated the influence of different pre-sowing seed treatments on germination and early seedling growth of papaya cv. Red Lady during 2025 at Chhatrapati Shahu Ji Maharaj University, Kanpur. The experiment was arranged in a Completely Randomized Design with nine treatments and three replications. Seeds were treated with gibberellic acid (GA_3) or naphthalene acetic acid (NAA) at 50 or 100 ppm for 6 or 12 hours and were raised in a vermicompost + cocopeat + soil medium (1:1:1), with an untreated control. Significant treatment effects were observed for all evaluated germination and growth attributes. GA_3 at 100 ppm for 12 hours (T9) produced the earliest first germination (10.00 days), the highest germination percentage (85.47%), Seedling Vigour Index-I (1035) and survival percentage (90.84%). This treatment also recorded the greatest seedling height, number of leaves, girth, leaf area, number of roots and root length at 45 days after sowing, and was closely followed by GA_3 at 100 ppm for 6

[++] *M.Sc. Ag. (Horticulture) Fruit Science;* [#] *Assistant Professor, Horticulture (Fruit Science);*
**Corresponding author: E-mail: pshiwanand@gmail.com;*

Cite as: *Saxena, D. P., Pandey, S., Trivedi, H., & Kumar, V. (2026). Influence of Different Pre-sowing Seed Treatments on Germination and Seedling Growth of Papaya (Carica papaya L.) cv. Red Lady. International Journal of Plant & Soil Science, 38(10), 418–423. https://doi.org/10.9734/ijpss/2026/v38i106360*

hours (T8). The untreated control showed the lowest performance across the measured traits. Under the conditions of this study, pre-sowing treatment with GA_3 at 100 ppm for 12 hours was the most effective treatment for improving germination and early seedling performance of papaya cv. Red Lady.

Keywords: *Carica papaya L.; pre-sowing seed treatment; gibberellic acid; naphthalene acetic acid; seed germination; seedling vigour; nursery establishment.*

1. Introduction

Papaya (*Carica papaya* L.) is one of the most economically and nutritionally important tropical fruit crops in the world, valued for its rapid vegetative growth, short gestation period and year-round fruiting potential. India ranks among the leading papaya-producing nations, having produced over 5.9 million metric tonnes from about 0.13 million hectares (Kumar *et al*., 2026; National Horticulture Board, 2023). The fruit is a rich source of vitamins A and C, dietary fibre, minerals and the proteolytic enzyme papain, while the crop offers small and marginal farmers a reliable livelihood option owing to its low input requirement and short payback period (Kumar *et al*., 2026). Among the papaya cultivars grown commercially, cv. Red Lady is especially preferred for its early-bearing nature, high and uniform yield, attractive deep-red flesh and superior post-harvest life (Rani *et al*., 2024).

Papaya is propagated almost exclusively through seed, making germination a foundational stage of the entire production cycle (Hartmann *et al*., 2011). Papaya seeds, however, frequently show delayed and erratic germination on account of a hard, water-resistant seed coat (testa) and inhibitory biochemical compounds such as abscisic acid present within the seed (Bewley & Black, 2013). Pre-sowing seed treatments are widely recognised as an effective means of overcoming this dormancy, improving water uptake and promoting uniform germination (Pandit *et al*., 2001). Among plant growth regulators, gibberellic acid (GA3) breaks dormancy by stimulating hydrolytic enzymes, particularly α-amylase, which mobilise stored starch, protein and lipid reserves in the endosperm to support embryo growth (Lay *et al*., 2015). Naphthalene acetic acid (NAA), a synthetic auxin, promotes cell division and elongation in the radicle and encourages a more robust root system during the early post-germination phase (Choudhary *et al*., 2018). Several workers have reported marked improvement in papaya germination and seedling vigour with GA3 and NAA seed treatments (Dayeswari *et al*., 2018; Lay *et al*., 2015; Rani *et al*., 2024). A recent papaya study comparing GA3, NAA and IAA also reported differential germination and seedling responses across PGR treatments, supporting the need to evaluate treatment-specific effects rather than treating all regulators as equivalent (Pandey & Bahadur, 2024). In cv. Red Lady, recent work has further shown that pre-sowing treatments can alter germination and seedling performance, with GA3 among the evaluated treatments producing strong responses under the tested conditions (Aboryia *et al*., 2024).

The physical and chemical environment of the growing medium is equally important for germination success and early seedling development. Incorporation of organic amendments such as vermicompost and cocopeat improves medium porosity, aeration and moisture retention while enhancing nutrient availability. The combination of an appropriate pre-sowing PGR treatment with an enriched organic growing medium has been shown to outperform either intervention applied alone (Choudhary *et al*., 2018). A study in papaya similarly found that combinations of organic growing media and plant growth regulators influenced germination, seed vigour and seedling establishment under protected nursery conditions (Krishnanayak *et al*., 2024). Evidence from a recent pro-tray nursery study in tomato also showed that microbial-consortium-amended cocopeat improved germination and seedling vigour relative to the farmers' practice, illustrating the responsiveness of nursery seedlings to growing-medium management (Kumari *et al*., 2026). Despite the considerable body of work on pre-sowing treatments in papaya, the comparative performance of GA3 and NAA at varying concentrations and soaking durations, in combination with an organic growing medium, remains insufficiently characterised for cv. Red Lady under the agro-climatic conditions of Kanpur, Uttar Pradesh. The present investigation was therefore undertaken to (i) study the effect of different pre-sowing seed treatments on the germination percentage and days to germination of papaya seeds and (ii) evaluate their impact on early seedling growth parameters such as plant height, number of leaves and root length.

2. Materials and Methods

The experiment was conducted during 2025 in the nursery of the Biodiversity Park, Department of Horticulture, School of Advanced Agricultural Sciences and Technology (SAAST), Chhatrapati Shahu Ji Maharaj University, Kanpur (26.46° N, 80.33° E; 126 m above mean sea level), Uttar Pradesh, India. The site falls in the subtropical agro-climatic region of Uttar Pradesh, with a mean annual rainfall of 750-850 mm (about 80% received during the south-west monsoon), winter minimum temperatures of 4-10°C, summer maxima of 42-46°C and relative humidity ranging from 40-85%. Seedlings were raised under shade nets and polytunnels to maintain uniform temperature, humidity and light conditions. The experimental soil was an alluvial sandy loam, with the physico-chemical properties given in Table 1.

Table 1. Physico-chemical properties of the experimental soil

Soil property	Value	Method
pH (1:2.5, soil:water)	7.2-7.6	pH meter
Electrical conductivity (dS/m)	0.42	EC meter
Organic carbon (%)	0.45	Walkley-Black method
Available nitrogen (kg/ha)	172	Alkaline $KMnO_4$ method
Available phosphorus (kg/ha)	18.4	Olsen's method
Available potassium (kg/ha)	215	Flame photometer
Field capacity (%)	24.8	Pressure plate apparatus

Seeds of papaya cv. Red Lady (a gynodioecious F1 hybrid) with more than 85% initial germination, uniform size and freedom from damage or disease were used as the planting material. The growing medium was prepared by mixing garden soil, cocopeat and vermicompost in equal volumes (1:1:1 v/v) and filling it into polythene bags (15 cm × 10 cm, 200 gauge) to a depth of 12 cm; 27 such bags constituted the 27 experimental units. Analytical-grade gibberellic acid (GA3) and naphthalene acetic acid (NAA), with purities of ≥90% and ≥98%, respectively (Hi-Media/Sigma-Aldrich), were used to prepare aqueous stock solutions of 50 and 100 ppm. The experiment comprised nine treatments - an untreated control and eight combinations of GA3/NAA × concentration (50, 100 ppm) × soaking duration (6, 12 hours) - as detailed in Table 2.

Table 2. Treatment details of the experiment

Treatment	Description
T1	Control (untreated, soaked in distilled water for 12 h)
T2	GA3 @ 50 ppm for 6 hours
T3	GA3 @ 50 ppm for 12 hours
T4	NAA @ 50 ppm for 6 hours
T5	NAA @ 50 ppm for 12 hours
T6	NAA @ 100 ppm for 6 hours
T7	NAA @ 100 ppm for 12 hours
T8	GA3 @ 100 ppm for 6 hours
T9	GA3 @ 100 ppm for 12 hours

Surface-sterilised seeds (0.1% Bavistin for 10 minutes) were soaked in the respective hormone solutions at a seed:solution ratio of 1:10 (w/v) in containers wrapped in aluminium foil to exclude light. Control seeds were soaked in distilled water for 12 hours. Treated seeds were sown immediately, two per bag, at a depth of 1.5-2.0 cm. The experiment was laid out in a Completely Randomized Design (CRD) with nine treatments and three replications (27 polythene bags in all) and was maintained for 45 days after sowing (DAS). Observations were recorded on the number of days to first germination, final germination percentage (International Seed Testing Association [ISTA], 2015), speed of emergence/germination index (Maguire, 1962), Seedling Vigour Index-I (Abdul-Baki & Anderson, 1973) and survival percentage, as well as on seedling height, number of leaves and seedling girth at 30 and 45 DAS and leaf area, number of roots and root length at 45 DAS. Data were analysed statistically according to the CRD model following Panse & Sukhatme (1985) and Hotelling (1938), using ANOVA and the F-test, with treatment means compared using the critical difference (CD) at the 5% level of probability; proportion data (germination and survival percentage) were arcsine-transformed prior to analysis.

3. Results and Discussion

3.1 Germination Parameters

Data on the effect of pre-sowing seed treatments on germination attributes are presented in Table 3. Treatment T9 (GA3 @ 100 ppm for 12 hours) recorded the minimum days to first germination (10.00 days), the highest germination percentage (85.47%), the highest speed of emergence (8.85), the highest Seedling Vigour Index-I (1035) and the highest survival percentage (90.84%), and was closely followed by T8 (GA3 @ 100 ppm for 6 hours) and T3 (GA3 @ 50 ppm for 12 hours). The untreated control (T1) recorded the poorest performance for every germination trait (15.00 days to germination, 61.96% germination, a speed of emergence of 5.76, a vigour index of 683 and 76.17% survival). Among the NAA treatments, T5 (NAA @ 50 ppm for 12 hours) generally performed better than the higher-concentration NAA treatments (T6 and T7). The superiority of GA3-treated seeds, especially at the longer 12-hour soaking duration, may be attributed to GA3-mediated stimulation of α-amylase and other hydrolytic enzymes that mobilise stored endosperm reserves and promote water uptake, cell elongation and embryo growth, while the poor performance of the control reflects the hard seed coat and inhibitory compounds inherent to untreated papaya seeds (Bewley & Black, 2013). These results are in close agreement with Lay *et al*. (2015), Dayeswari *et al*. (2018), Choudhary *et al*. (2018) and Rani *et al*. (2024), who similarly reported marked improvement in papaya germination and vigour with GA3 seed treatment.

Table 3. Effect of pre-sowing seed treatments on germination parameters of papaya cv. Red Lady

Treatment	Days to first germination	Germination (%)	Speed of emergence	SVI-I	Survival (%)
T1 Control	15.00	61.96	5.76	683	76.17
T2 GA3 50 ppm, 6 h	11.50	75.11	7.11	875	84.05
T3 GA3 50 ppm, 12 h	10.33	78.00	7.91	981	85.21
T4 NAA 50 ppm, 6 h	12.33	70.88	6.80	831	79.05
T5 NAA 50 ppm, 12 h	12.33	70.43	7.19	852	83.76
T6 NAA 100 ppm, 6 h	13.33	69.09	6.47	784	78.79
T7 NAA 100 ppm, 12 h	13.67	66.76	6.36	742	76.75
T8 GA3 100 ppm, 6 h	11.00	81.90	8.16	967	85.54
T9 GA3 100 ppm, 12 h	10.00	85.47	8.85	1035	90.84
CD (P=0.05)	1.24	3.42	0.48	95	3.20
SEm±	0.42	1.15	0.16	32	1.08

3.2 Seedling Growth Parameters at 30 and 45 DAS

Data on seedling height, number of leaves and seedling girth recorded at 30 and 45 DAS are presented in Table 4. Treatment T9 (GA3 @ 100 ppm for 12 hours) produced the tallest seedlings at both 30 DAS (13.41 cm) and 45 DAS (23.22 cm), the highest number of leaves at 30 DAS (5.60) and 45 DAS (7.67) and the maximum seedling girth at 30 DAS (0.63 cm) and 45 DAS (1.04 cm), followed closely by T8 (GA3 @ 100 ppm for 6 hours). The untreated control (T1) recorded the lowest values for all three traits at both observation dates. NAA treatments also improved seedling growth relative to the control, though to a lesser extent than GA3. Gibberellin-induced cell elongation and enhanced apical meristematic activity account for the taller, thicker and leafier seedlings obtained with GA3 treatment, while the comparatively smaller gains under NAA reflect its greater specificity for root rather than shoot promotion. These findings corroborate the reports of Choudhary *et al*. (2018), Lay *et al*. (2015) and Rani *et al*. (2024) in papaya.

3.3 Leaf Area, Root Number and Root Length at 45 DAS

Leaf area, number of roots and root length recorded at 45 DAS are presented in Table 5. The maximum leaf area (41.37 cm²), the highest number of roots (17.33) and the longest root length (15.64 cm) were recorded in T9 (GA3 @ 100 ppm for 12 hours), followed by T8 (37.99 cm², 16.67 roots, 15.21 cm) and T3 (37.34 cm², 15.67 roots, 13.59 cm). The control (T1) recorded the lowest leaf area (24.42 cm²), fewest roots (12.33) and shortest root length (9.35 cm). Larger leaf area under GA3 treatment reflects enhanced cell enlargement and photosynthetic surface, supporting greater biomass accumulation and seedling vigour, while the improved root number and root length under both GA3 and NAA treatments - the latter acting through auxin-mediated cell division in the root meristem - enable more efficient water and nutrient uptake and contribute to the higher survival percentage recorded in these treatments. These results are consistent with the findings of Rani *et al*. (2024) and Choudhary *et al*. (2018).

Table 4. Effect of pre-sowing seed treatments on seedling height, leaf number and girth of papaya cv. Red Lady at 30 and 45 DAS

Treatment	Height 30 DAS (cm)	Height 45 DAS (cm)	Leaves 30 DAS	Leaves 45 DAS	Girth 30 DAS (cm)	Girth 45 DAS (cm)
T1 Control	8.25	14.83	3.67	5.00	0.41	0.69
T2 GA3 50 ppm, 6 h	10.42	18.64	4.00	6.33	0.51	0.84
T3 GA3 50 ppm, 12 h	11.67	20.08	4.67	7.00	0.56	0.92
T4 NAA 50 ppm, 6 h	9.12	16.79	3.00	5.00	0.48	0.79
T5 NAA 50 ppm, 12 h	10.18	17.74	3.00	5.00	0.49	0.81
T6 NAA 100 ppm, 6 h	9.71	15.38	4.00	6.00	0.46	0.76
T7 NAA 100 ppm, 12 h	8.77	15.37	4.00	5.67	0.44	0.69
T8 GA3 100 ppm, 6 h	12.40	22.35	5.00	7.00	0.58	0.94
T9 GA3 100 ppm, 12 h	13.41	23.22	5.60	7.67	0.63	1.04
CD (P=0.05)	1.12	1.61	0.45	0.63	0.03	0.05
SEm±	0.38	0.54	0.15	0.21	0.01	0.02

Table 5. Effect of pre-sowing seed treatments on leaf area, root number and root length of papaya cv. Red Lady at 45 DAS

Treatment	Leaf area (cm²)	Number of roots	Root length (cm)
T1 Control	24.42	12.33	9.35
T2 GA3 50 ppm, 6 h	32.05	14.67	12.64
T3 GA3 50 ppm, 12 h	37.34	15.67	13.59
T4 NAA 50 ppm, 6 h	28.58	13.33	11.12
T5 NAA 50 ppm, 12 h	30.44	14.00	12.28
T6 NAA 100 ppm, 6 h	26.66	13.33	10.60
T7 NAA 100 ppm, 12 h	25.98	12.67	10.23
T8 GA3 100 ppm, 6 h	37.99	16.67	15.21
T9 GA3 100 ppm, 12 h	41.37	17.33	15.64
CD (P=0.05)	5.52	1.36	1.24
SEm±	1.86	0.46	0.42

Overall, pre-sowing treatment of papaya cv. Red Lady seeds with GA3 consistently outperformed NAA and the untreated control across all germination and growth attributes, with the 12-hour soaking duration proving more effective than 6 hours for both hormones, suggesting a possible dose-time interaction in PGR absorption. The enriched vermicompost + cocopeat + soil growing medium is likely to have contributed to the overall performance recorded across treatments by providing favourable aeration, moisture retention and nutrient availability.

4. Conclusion

The present investigation demonstrates that pre-sowing seed treatment plays an important role in overcoming seed dormancy and improving nursery performance in papaya cv. Red Lady. Among all treatments evaluated, GA3 @ 100 ppm for 12 hours (T9) was the most effective, producing the earliest germination, the highest germination percentage, the maximum Seedling Vigour Index-I and superior seedling height, leaf number, girth, leaf area, root number and root length, closely followed by GA3 @ 100 ppm for 6 hours (T8) and GA3 @ 50 ppm for 12 hours (T3). The untreated control recorded the lowest values for all traits studied. Being simple, inexpensive and readily adoptable, pre-sowing treatment of papaya cv. Red Lady seeds with GA3 @ 100 ppm for 12 hours, sown in a vermicompost + cocopeat + soil medium, is recommended for commercial nursery production as well as for future nursery-management research in papaya.

5. Limitations

The study was conducted during a single year at one location and evaluated seedlings only up to 45 days after sowing under protected nursery conditions. The experiment used one growing-medium composition and a limited range of GA_3 and NAA concentrations and soaking durations. Consequently, the findings are specific to the tested conditions and do not directly establish treatment performance after transplanting, under open-field environments, or across different growing media, seasons and locations. Further validation under broader production conditions would be required before generalising the results.

Acknowledgements

The author expresses sincere gratitude to Dr. Shiwanand Pandey, Assistant Professor, Horticulture (Fruit Science), for his valuable guidance and supervision throughout the course of this investigation. This work forms part of the M.Sc. (Ag.) Horticulture (Fruit Science) thesis of the first author submitted to Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh, India.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abdul-Baki, A. A., & Anderson, J. D. (1973). Vigor determination in soybean seed by multiple criteria. *Crop Science, 13*(6), 630–633. https://doi.org/10.2135/cropsci1973.0011183X001300060013x

Aboryia, M. S., Abo AL-Saoud, A. M., El-Boraie, E. S. A., Abd El-Gawad, H. G., Ismail, S., Alkafafy, M., Aljuaid, B. S., & Abu-Ziada, L. M. (2024). Seed germination, seedling growth performance, genetic stability and biochemical responses of papaya (*Carica papaya* L.) upon pre-sowing seed treatments. *Folia Horticulturae, 36*(4), 533–558. https://doi.org/10.2478/fhort-2024-0036

Bewley, J. D., Bradford, K. J., Hilhorst, H. W. M., & Nonogaki, H. (2013). *Seeds: Physiology of development, germination and dormancy* (3rd ed.). Springer. https://doi.org/10.1007/978-1-4614-4693-4

Choudhary, R. C., Kanwar, J., Chouhan, G. S., Singh, P., & Tanwar, D. R. (2018). Effect of GA3 and growing media on seedling growth of papaya (*Carica papaya* L.) cv. Pusa Nanha. *International Journal of Chemical Studies, 6*(6), 1008–1012. https://www.chemijournal.com/archives/?ArticleId=4311&issue=6&si=false&vol=6&year=2018

Dayeswari, D., Auxcilia, J., Vijayakumar, R. M., & Malarkodi, K. (2018). Role of KNO3, KCl, KH2PO4, GA3, halopolymer and PPFM on seed germination, seedling growth and vigour of TNAU papaya CO. 8 (*Carica papaya* L.). *Journal of Biotechnology and Crop Science, 7*(11), 130–136.

Hartmann, H. T., Kester, D. E., Davies, F. T., Jr., & Geneve, R. L. (2011). *Hartmann & Kester's plant propagation: Principles and practices* (8th ed.). Pearson. https://books.google.com/books?id=7nNFYgEACAAJ

Hotelling, H. (1938). [Review of the book *Statistical tables for biological, agricultural and medical research*, by R. A. Fisher & F. Yates]. *Science, 88*(2295), 596–597. https://doi.org/10.1126/science.88.2295.596

International Seed Testing Association. (2015). *International rules for seed testing 2015: Chapter 5—The germination test*. https://doi.org/10.15258/istarules.2015.05

Krishnanayak, L., Kotiyal, A., & Koubouris, G. (2024). Optimized seed germination and adaptation of plantlets to a new environment of papaya cv. 'Red Baby' using organic media and plant growth regulators. *Vegetos, 37*, 355–362. https://doi.org/10.1007/s42535-023-00597-2

Kumar, D., Chhoidub, C., Sharma, M., & Rani, S. (2026). Growth, trends and future projections in India's horticulture sector: Insights from a time series analysis. *Discover Agriculture, 4*, Article 47. https://doi.org/10.1007/s44279-026-00490-x

Kumari, A., Jat, A. S., & Choudhary, M. (2026). Improving tomato seedling performance through Arka Microbial Consortium-enriched coco peat in pro-tray nurseries. *BIONATURE, 46*(2), 84–90. https://doi.org/10.56557/bn/2026/v46i22128

Lay, P., Basvaraju, G. V., Pashte, V. V., & Gowri, M. (2015). Studies on effect of giberellic acid (GA3) and potassium nitrate (KNO3) on breaking of seed dormancy of papaya (*Carica papaya* L.) cv. Surya. *The Ecoscan, 9*(1&2), 109–113.

Maguire, J. D. (1962). Speed of germination—Aid in selection and evaluation for seedling emergence and vigor. *Crop Science, 2*(2), 176–177. https://doi.org/10.2135/cropsci1962.0011183X000200020033x

National Horticulture Board. (2023). *Horticultural statistics at a glance*. Ministry of Agriculture and Farmers Welfare, Government of India.

Pandey, A., & Bahadur, V. (2024). Effects of different plant growth regulators on seed germination, seedling growth and establishment of papaya (*Carica papaya*) cv. Pusa Nanha. *Journal of Advances in Biology & Biotechnology, 27*(6), 717–724. https://doi.org/10.9734/jabb/2024/v27i6932

Pandit, V. K., Nagarajan, S., & Sinha, J. P. (2001). Improving papaya (*Carica papaya*) seed germination and seedling growth by pre-sowing treatments. *The Indian Journal of Agricultural Sciences, 71*(11), 704–706. https://epubs.icar.org.in/index.php/IJAgS/article/view/40433

Panse, V. G., & Sukhatme, P. V. (1985). *Statistical methods for agricultural workers* (4th ed.). Indian Council of Agricultural Research. https://books.google.com/books?id=iAXnzAEACAAJ

Rani, M., Singh, G., Singh, N., & Kumar, D. (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

Peer-review history:
The peer review history for this paper can be accessed here: https://pr.sdiarticle5.com/review-history/164119