International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM February 2025, 16(2): 01-06 **Article** AR5804

Research Article *Stress Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2025.5804

Comparative Study of Different Growing Media and Bioagent Applications on Growth and Survival of Mango Grafts (*Mangifera indica* L.) cv. Kesar

Ambrish S.[1], A. S. Lohakare[2] and P. A. Sasane[1]

[1]Dept. of Fruit Science, College of Agriculture, Parbhani, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (431 402), India

[2]Dept. of Fruit Science, College of Horticulture, Parbhani, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (431 402), India

Open Access

Corresponding sambrishs1999@gmail.com

0009-0003-6627-8224

ABSTRACT

An investigation was carried out during the period from June, 2021 to February, 2022 at the College of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (431 402), India, to study the effect of different growing media and bioagent applications on the growth and survival of mango grafts (*Mangifera indica* L.) cv. Kesar. The experiment was laid out in a Randomized Block Design (RBD) with thirteen treatments replicated thrice. The treatment combination of Orchard soil, Farm Yard Manure (FYM), and Vermicompost (1:1:1) with Biomix 1% showed a significant increase in the height of grafts (24.24 cm, 28.25 cm, 31.38 cm, and 34.33 cm), length of scion (16.75 cm, 20.16 cm, 23.39 cm, and 24.58 cm), number of leaves (7.33, 10.72, 13.78, and 15.69), and leaf area (13.36 cm², 19.75 cm², 23.56 cm², and 28.79 cm²) at 30, 60, 90, and 120 days after grafting (DAG), respectively. The same treatment also recorded the highest survival percentages (87.06%, 83.17%, 78.33%, and 74.31%) at 30, 60, 90, and 120 DAG, respectively. Moreover, it resulted in the minimum number of days required for sprouting (10.52 days) and the highest success percentage (74.31%), as well as the maximum root length (24.60 cm), fresh and dry weights of roots (14.38 g and 8.78 g, respectively), and fresh and dry weights of shoots (24.53 g and 17.25 g, respectively) at 120 DAG. This indicates that the media combination of orchard soil, FYM, vermicompost (1:1:1) with Biomix 1% is highly effective in promoting the growth and survival of mango grafts.

KEYWORDS: Biomix, grafting, kesar, mango, media, vermicompost

***Citation* (VANCOUVER):** Ambrish et al., Comparative Study of Different Growing Media and Bioagent Applications on Growth and Survival of Mango Grafts (*Mangifera indica* L.) cv. Kesar. *International Journal of Bio-resource and Stress Management,* 2025; 16(2), 01-06. HTTPS://DOI.ORG/10.23910/1.2025.5804.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 22nd September 2024 RECEIVED in revised form on 24th January 2025 ACCEPTED in final form on 06th February 2025 PUBLISHED on 19th February 2025

1. INTRODUCTION

Mango, an ancient fruit in India that has been cultivated for 4000–6000 years, is associated with the heritage and culture of the nation (Sankaran et al., 2021). This fruit is intimately connected with the history of Indian agriculture and civilization, enjoying royal status in the country (Dinesh et al., 2015). Mango is a nutrient-rich fruit, providing about 60% of the daily vitamin C requirement per serving. It is a good source of beta-carotene, supporting skin health and vision, and dietary fiber, which aids digestion and lowers the risk of diabetes and heart disease. Mango also contains essential minerals like potassium, magnesium, and calcium, along with bioactive compounds such as polyphenols and flavonoids, offering antioxidant and anti-inflammatory benefits (Bautista-Ortín et al., 2016; Imran et al., 2019; Liu et al., 2019). The mango genus originated in Burma, Thailand, Indo-China, and the Malaysian peninsula (Hussain et al., 2021). India leads global mango production, contributing over 55% of total output with 2.29 mha yielding 20.8 million mt (Anonymous, 2019). Major cultivation states include Punjab, Haryana, Uttar Pradesh, Gujarat, Rajasthan, West Bengal, Maharashtra, Orissa, Andhra Pradesh, Karnataka, and Tamil Nadu (Yadav and Pandey, 2016). Successful orchard establishment hinges on the availability of high-quality and healthy planting materials, as these are fundamental to achieving optimal growth and productivity in fruit crops. The production of quality seedlings is influenced by multiple factors, including the choice of rootstock and scion, as well as the growing conditions under which the plants are cultivated (Mauro et al., 2020). One of the critical components in seedling production, especially in containerized systems, is the potting medium. The potting medium plays a pivotal role in ensuring the healthy and uniform growth of seedlings. It is crucial not only for promoting initial root development but also for facilitating better establishment and growth of the seedlings once transplanted into the main field (Kiran et al., 2022). The ideal potting medium should be lightweight, friable, and possess good water-holding capacity, proper drainage, porosity, and low bulk density (Chakrabarti et al., 1998). These traits ensure moisture retention and aeration, preventing root rot and supporting vigorous root growth. Maintaining porosity is essential for unrestricted root growth and oxygen availability for metabolic functions (Srivastava et al., 1998). The ideal potting medium should be lightweight, friable, and possess good water-holding capacity, proper drainage, porosity, and low bulk density (Chakrabarti et al., 1998). These traits ensure moisture retention and aeration, preventing root rot and supporting vigorous root growth. Maintaining porosity is essential for unrestricted root growth and oxygen availability for metabolic functions (Srivastava et al., 1998). Additionally, the use of farmyard manure (FYM) as a soil amendment has been shown to have beneficial effects on various growth parameters, such as seed germination, seedling vigor index, shoot length, root length, as well as fresh and dry weight of the plants (Thongney et al., 2018). Cocopeat, an agricultural by-product obtained from coconut husks, is another widely used component of potting media. Cocopeat, with its favorable pH, electrical conductivity, and chemical properties, is ideal for supporting seedling growth. It offers excellent moisture retention, proper aeration, and maintains a balanced water-nutrient environment in the root zone (Mariyappillai and Arumugam, 2021; Abad et al., 2002). Biomix, a blend of selected microbial species, is a promising innovation in seedling production. These microbial inoculants enhance plant growth by improving soil health, boosting nutrient availability, and promoting disease resistance. Considering the future opportunity for soilless nurseries, the present study was undertaken to understand the influence of different growing media and bioagents on the growth and survival of mango grafts.

2. MATERIALS AND METHODS

The study was conducted at the College of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra state (19.2608° N, 76.7748° E) from June, 2021 to February, 2022. The average rainfall in this region during the experimental period is 1710.7 mm with a relative humidity of 79%. The trial was laid out in a randomized block design with thirteen treatments and three replications. The 13 treatments consist of: Control-orchard soil (T_1), Orchard soil+FYM (2:1)+Biomix 1% (T_2), Orchard soil+Biomix 1% (T_3), Orchard soil+FYM+Sand (2:1:1)+Biomix 1% (T_4), Laterite soil+Cocopeat+Vermicompost (1:1:1)+Biomix 1% (T_5), Clay soil+FYM (1:1)+Biomix 1% (T_6), Orchard soil+FYM+Vermicompost (1:1:1)+Biomix 1% (T_7), Orchard soil+Sand (1:1)+Biomix 1% (T_8), Orchard soil+Vermicompost (1:1)+Biomix 1% (T_9), Cocopeat+FYM (1:1)+Biomix (T_{10}), Orchard soil+FYM (2:1)+PSB (0.5%) (T_{11}), Orchard soil+FYM (2:1)+PSB 1% (T_{12}), Cocopeat+FYM (1:1) (T_{13}). The experiment began with the sowing of fresh healthy mango cv. Kesar stones in polybags containing different media mixtures. At the end of September, the raised seedlings were grafted (Softwood grafting) with a healthy scion of cv. Kesar, and observations were recorded every 30 days for up to 120 days. Morphological parameters such as graft height, scion length, number of leaves, leaf area, length of taproot, fresh and dry weight of root, fresh and dry weight of shoot, and graft success parameters such as the minimum number of days required for sprouting, highest success percentage, and highest survival percentage were recorded. Statistical

analysis of the data was carried out by the standard method of analysis of variance as given by Panse and Sukhatme (1995).

3. RESULTS AND DISCUSSION

The data depicted in Table 1 shows that, grafts raised in media combination of treatment T_7 (10.52 days) showed the significantly early sprouting as compared to other media combination. Earliness in sprouting might be due to utilizing of stored food material present in rootstock, nitrogen and other factors with the aid of growth hormones present in the vermicompost (Aslam et al., 2019; Blouin et al., 2019). Use of media like vermicompost and FYM help for increasing porosity, water holding capacity, low shrinkage, low bulk density and slow biodegradation of the medium which resulted in better growth of root system and root stock which ultimately makes grafted scion to sprout early (Kumar et al., 2016). Treatment T_7 exhibited the highest success percentage in mango grafts after four months (73.57%), likely due to superior media performance, providing ample nutrients, moisture, and aeration for robust root system development. Well–established root systems facilitate better plant growth by efficiently absorbing nutrients from the media (Li et al., 2016). This phenomenon is supported by similar findings in walnut by Sharma and Dhuria (1981) and in mango by Savani (2006). Microorganism inoculants present in the biomix contribute to biological nitrogen fixation, solubilization of insoluble phosphates, and enhanced mobilization of plant nutrients, leading to increased nitrogen, phosphorus, and potassium content in inoculated plants at various growth stages (Shahwar et al., 2023). These factors collectively result in significant plant growth improvement, as documented by Salisbury and Ross (1985). Treatment T_7 led to significant increases in fresh weight (24.53 g) and dry weight (17.25 g) of shoots, attributed to the biomix enhancing nitrogen fixation and nutrient absorption, as well as promoting secretion of growth substances. This is consistent with findings by Umar et al. (2009). Higher concentrations of growth-promoting nutrients, proper aeration, and the addition of FYM improved moisture supply capacity, resulting in increased vegetative growth of grafted seedlings, including taller plant height, more leaves, and thicker stems, ultimately leading to higher shoot weights. In terms of root attributes, the highest length of taproot was 24.60. T_7 exhibited the maximum number of primary roots per grafts (2.64) and secondary roots per grafts (43.38). Additionally, it displayed the highest fresh weight (14.28 g) and dry weight

Table 1: Effect of different growing media and biomix application on days required for sprouting, success percentage of grafts, fresh and dry weight of shoot, Length of tap root, number of primary and secondary roots per grafts, fresh and dry weight of roots

Treatments	Days required for sprouting	Success percentage of grafts	Fresh weight of shoot (g)	Dry weight of shoot (g)	Length of tap root (cm)	No. of primary roots grafts^{-1}	No. of secondary roots grafts^{-1}	Fresh weight of root (g)	Dry weight of root (g)
T_1	13.68	54.96	16.42	8.55	16.93	1.48	29.20	6.58	3.96
T_2	12.67	61.27	17.37	11.16	19.00	1.55	35.00	7.59	4.94
T_3	13.13	56.24	16.73	9.44	17.87	1.57	31.67	6.99	4.49
T_4	11.04	72.64	22.72	16.22	22.96	2.01	40.83	13.34	8.13
T_5	10.82	73.57	23.77	16.81	22.60	1.97	39.73	12.71	7.36
T_6	12.90	58.18	17.19	10.39	18.44	1.48	32.07	7.52	4.66
T_7	10.52	74.31	24.53	17.25	24.60	2.64	43.38	14.38	8.77
T_8	12.28	64.66	18.58	12.21	19.69	1.57	35.70	9.45	5.59
T_9	11.61	70.15	21.23	14.45	21.61	1.98	37.67	10.68	6.46
T_{10}	12.45	63.95	18.56	11.34	19.20	1.59	35.20	8.63	5.91
T_{11}	11.87	64.67	19.60	12.65	20.96	1.67	35.97	10.24	6.03
T_{12}	11.26	71.17	22.35	15.49	22.20	1.74	37.91	11.47	7.04
T_{13}	12.94	59.89	17.35	10.49	20.15	1.62	36.67	10.47	6.19
SEm±	0.66	3.02	1.10	0.71	1.16	0.10	1.94	0.53	0.31
CD (p=0.05)	1.99	8.81	3.21	2.08	3.38	0.29	5.65	1.55	0.92

(8.77 g) of roots. The presence of microorganisms such as *Azospirillum brasilense* in a biomix, when inoculated, can alter root morphology by producing plant growth-regulating substances (Bashan et al., 2004: Khan at al., 2023) and through siderophore production (Sahoo et al., 2014). The organic matter present in FYM acts as a binding agent for soil aggregates and serves as a source of soil nutrients. Vermicompost granules have the potential to contribute to soil aggregation. Enhanced soil aggregation improves permeability and air circulation within polybags, thereby facilitating better tap root growth. Figure 1 illustrates that the survival percentage of grafts in treatment T_7 was higher in the initial days after grafting, reaching 87.06% at 30 days post-grafting. However, it decreased to 74.31% by the end of 120 days. High survival percentage in the media reflected the fact that these combinations of media might have provided physical conditions and sufficient nutrients to grafted seedlings particularly for better metabolic and physiological activities as well as good root system development (Yusnita et al., 2017). The presence of plant growth promoters such as auxins and cytokinins in vermicompost (Wong et al., 2020) is responsible for cell division, cell elongation, and better callus formation in graft union, which leads to better graft survival. In Table 2 shows that maximum number of leaves (7.07, 10.16, 13.20, 15.22) and leaf area (12.59, 19.27, 23.44, 28.09 cm^2) at 30,60,90 and 120 days after grafting

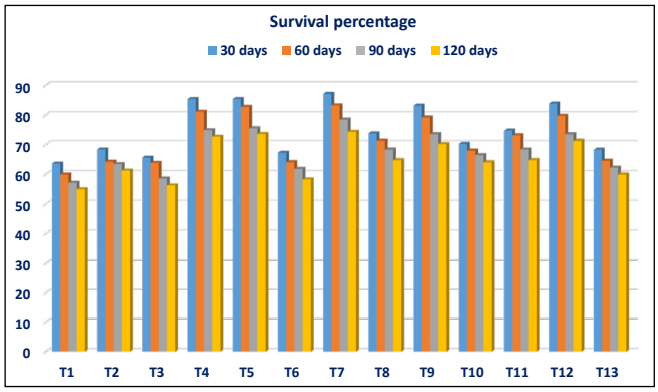

Figure 1: Survival percentage of grafts at 30,60,90 and 120 days after graftin

respectfully was observed in T_7 media combination. This could be attributed to general improvements in the physical and chemical properties of rooting medium, which may have accelerated the process of cell division, differentiation, and better nutrient availability, resulting in higher production of photosynthetically active functional leaves and plant growth by media. The physiological changes observed in vermicompost treated plants could be attributed to the humic substances and nutrients, especially microelements like Zn present in vermicompost. The increase in leaf area might be due to the application of biomix as it is

Table 2: Effect of different growing media and biomix application on leaf area cm^2, number of leaves per graft, height of the grafts (cm), length of scion (cm) at 30, 60, 90 and 120 days after grafting

Treatments	Leaf area (cm^2)				No. of leaves $graft^{-1}$				Height of the grafts (cm)				Length of scion (cm)			
	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days
T_1	8.71	15.22	17.93	22.44	3.47	6.33	8.03	9.36	19.66	21.85	24.00	26.39	14.29	15.82	18.06	19.09
T_2	9.77	16.48	20.56	24.10	5.40	7.29	9.33	11.89	22.18	24.04	26.09	28.5	15.5	16.67	18.90	20.06
T_3	8.98	15.94	18.61	23.00	4.93	6.98	8.64	9.98	21.47	22.93	25.04	27.48	14.57	16.10	18.25	19.38
T_4	10.85	17.14	21.46	25.43	5.53	8.68	10.45	12.91	23.82	27.11	29.24	31.67	16.45	19.62	22.57	23.66
T_5	13.36	19.75	23.56	28.79	7.33	10.72	13.78	15.69	23.53	26.55	28.68	31.04	16.25	18.78	21.59	22.61
T_6	10.33	16.79	20.78	24.61	5.47	7.77	9.88	12.32	21.42	23.53	25.63	27.99	14.92	16.49	18.65	19.76
T_7	12.59	19.27	23.44	28.09	7.07	10.16	13.20	15.22	24.24	28.25	31.38	34.33	16.75	20.16	23.39	24.58
T_8	9.11	16.10	19.42	23.65	5.27	7.41	8.98	11.21	22.64	24.79	26.94	29.26	15.63	17.33	19.71	20.84
T_9	9.56	16.45	20.12	23.26	5.33	7.52	9.11	11.45	22.92	25.65	27.76	30.22	16.01	17.78	20.29	21.45
T_{10}	12.10	18.82	23.1	27.68	6.40	9.83	12.94	14.96	22.61	24.04	26.17	28.6	15.47	16.77	19.10	20.22
T_{11}	11.43	17.89	22.12	26.16	6.07	9.13	12.12	13.84	22.64	25.15	27.26	29.7	15.88	17.54	19.94	20.98
T_{12}	11.26	17.68	21.95	25.88	5.93	8.98	10.89	13.28	22.94	26.02	28.28	30.7	16.11	17.98	20.48	21.59
T_{13}	11.94	18.44	22.54	26.38	6.27	9.56	12.65	14.38	21.62	23.71	25.92	28.33	15.14	16.64	18.94	20.08
SEm±	0.57	0.92	1.18	1.36	0.31	0.49	0.61	0.69	1.09	1.21	1.31	1.4	0.75	0.88	1.11	1.08
CD*	1.67	2.68	3.45	3.98	0.91	1.44	1.78	2.02	NS	3.52	3.83	4.09	NS	2.57	3.23	3.17

CD (p=0.05)

mixture of nitrogen fixer bacteria, phosphorous solubilising bacteria and potassium solubilising bacteria which helps for increasing growth of the leaves. The growth attribute such as graft height (24.24 cm, 28.25 cm, 31.38 cm, 34.33 cm) and length of scion (16.75 cm, 20.16 cm, 23.39 cm, 24.58 cm) at 30, 60, 90 and 120 days after grafting respectfully was observed in T_7. Higher levels of auxin activity result from humic-containing vermicompost, which leads to more cell division and growth in terms of height. The results are in line with those obtained by Mirza et al. (2015) in karonda and Singh and Verma (2015) in stevia. Vermicompost improve the soil physical condition and promotes organic matter, which in turn, produce organic acids, which inhibits particularly IAA oxidase enzyme, resulting in enhancing the promotive effect of auxin-IAA, which has direct effect on plant growth, herbage yield. In addition, such media enhanced apical meristematic activity and also triggered cambial division.

In summing up the present investigation based on obtained results it may concluded that, the different growing media and bioagent application positively influenced on growth, success and survival of mango grafts as compared to control treatment. The growing media combination of Orchard soil+FYM+Vermicompost (1:1:1) with Biomix 1% found to be at par with treatments (T_5) Laterite soil +Cocopeat+Vermicompost (1:1:1)+Biomix 1% and (T4) Orchard soil+FYM+Sand (2:1:1)+Biomix 1% for obtaining highest growth, success and survival percentage in mango grafts cv. Kesar. Therefore, it may be advisable for large scale use in the nurseries. Hence in nutshell it can be concluded based on the research findings of present investigation that, use of growing media combination of orchard soil, FYM, vermicompost with the application of bioagent (Biomix) for vigorous growth and better success of mango grafts. However, before commercial application, we must be caution enough not to rely solely in a single study. As a result, a few more trials to be conducted in order to reach a proper conclusion.

4. CONCLUSION

The different growing media and bioagent applications significantly improved mango graft growth, success, and survival compared to the control. The combination of Orchard soil+FYM+Vermicompost (1:1:1) with 1% Biomix matched treatments T_5 (Laterite soil+Cocopeat+Vermicompost) and T_4 (Orchard soil+FYM+Sand). These findings suggest the recommended media for large-scale nursery use to enhance mango grafts cv. Kesar growth. Further trials are necessary before widespread adoption for validation.

5. REFRENCES

Abad, M., Noguera, P., Puchades, R., Maquieira, A., Noguera, V., 2002. Physico-chemical and chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental plants. Bioresource technology 82(3), 241–245.

Anonymous, 2019. Indian Horticulture Database 2019. National Horticulture Board, India. Available from http://nhb.gov.in. Accessed on 20th September, 2024.

Aslam, Z., Bashir, S., Hassan, W., Bellitürk, K., Ahmad, N., Niazi, N.K., khan, A., Khan, M.I., Chen, Z., Maitah, M., 2019. Unveiling the efficiency of vermicompost derived from different biowastes on wheat (*Triticum aestivum* L.) plant growth and soil health. Agronomy 9(12), 791.

Bashan, Y., Holguin, G., De-Bashan, L.E., 2004. Azospirillum-plant relationships: physiological, molecular, agricultural and environmental advances. Canadian Journal of Microbiology 50(8), 521–577.

Blouin, M., Barrere, J., Meyer, N., Lartigue, S., Barot, S., Mathieu, J., 2019. Vermicompost significantly affects plant growth: A meta-analysis. Agronomy for Sustainable Development 39(34). https://doi.org/10.1007/s13593-019-0579-x.

Hussain, S.Z., Naseer, B., Qadri, T., Fatima, T., Bhat, T.A., 2021. Mango (*Mangifera indica*)-morphology, taxonomy, composition and health benefits. In Fruits grown in highland regions of the Himalayas: nutritional and health benefits. Cham: Springer International Publishing, pp. 245–255. http://dx.doi.org/10.1007/978-3-030-75502-7_19

Dinesh, M.R., Ravishankar, K.V., Nischita, P., Sandya, B.S., Padmakar, B., Ganeshan, S., Sharma, T.V.R.S., 2015. Exploration, characterization and phylogenetic studies in wild *Mangifera indica* relatives. American Journal of Plant Sciences 6(13), 2151–2160.

Edwards, C.A., Burrows, I., 1988. The potential of earthworm composts as plant growth media.In: Edwards, C.A., Neuhauser, E.F. (Eds.), Earthworms in environmental and waste management. SPB Academic Publishing, The Hague, 2132. Available at: https://www.scirp.org/reference/referencespapers?referenceid=52179.

Kiran, S., Iqbal, J., Iqbal, A., Bukhari, S.I.U.S., Iqbal, M., Mustafa, G., Khan, A.H., Hussain, R., Khan, A., Majeed, T., 2022. Development of sustainable mango pot media nutrition for healthy and clean mango nursery plants. Journal of Global Innovations in Agricultural Sciences 10(4), 267–271. Available at: https://doi.org/10.22194/JGIAS/10.1027

Khan, A., Panthari, D., Sharma, R.S., Punetha, A., Singh, A.V., Upadhayay, V.K., 2023. Biofertilizers: a microbial-assisted strategy to improve plant growth and soil health. In: Advanced microbial techniques in agriculture, environment, and health management.

Academic Press, 97–118. DOI:10.1016/B978-0-323-91643-1.00007-7.

Kiyasudeen, S.K., Ibrahim, M.H., Quaik, S., Ismail, S.A., 2016. Vermicompost, its applications and derivatives. In: Prospects of Organic Waste Management and the Significance of Earthworms, 9–40. Springer, Cham. https://doi.org/10.1007/978-3-319-24708-3_9.

Kumar, R., Shamet, G.S., Alam, N.M., Jana, C., 2016. Influence of growing medium and seed size on germination and seedling growth of Pinus gerardiana wall. Compost Science & Utilization 24(2), 98–104. https://doi.org/10.1080/1065657X.2015.1048906.

Li, X., Zeng, R., Liao, H., 2016. Improving crop nutrient efficiency through root architecture modifications. Journal of Integrative Plant Biology 58(3), 193–202. https://doi.org/10.1111/jipb.12434.

Maheswarappa, H.P., Nanjappa, H.V., Hegde, M.R., 1999. Influence of organic manures in yield of arrow root, soil. Physico-chemical and biological properties when grown as intercrop in coconut garden. Annals of Agricultural Research 20(3), 318–323.

Mariyappillai, A., Arumugam, G., 2021. Physico-chemical and hydrological properties of soilless substrates. Journal of Environmental Biology 42(3), 700–704.

Mirza, S., Sharma, T.R., Bisen, B.P., Upadhay, A., Kushwaha, K.S., 2015. Influence of soil media and seed storage period on germination and seedling vigour of karonda (*Carissa carandas* L.). Indian Horticulture Journal 5(1–2), 11–15. http://dx.doi.org/153-14-IHJ-3012-2014-03.

Mauro, R. P., Agnello, M., Onofri, A., Leonardi, C., Giuffrida, F., 2020. Scion and rootstock differently influence growth, yield, and quality characteristics of cherry tomato. Plants 9(12), 1725.

Panse, V.G., Sukhatme, P.V., 1964. Statistical methods for agricultural research workers. ICAR, New Delhi, 381.

Wong, W.S., Zhong, H.T., Cross, A.T., Yong, J.W.H., 2020. Plant biostimulants in vermicomposts: Characteristics and plausible mechanisms. In: The chemical biology of plant biostimulants, 155–180. https://doi.org/10.1002/9781119357254.ch6

Sahoo, R.K., Ansari, M.W., Pradhan, M., Dangar, T.K., Mohanty, S., Tuteja, N., 2014. Phenotypic and molecular characterization of native Azospirillum strains from rice fields to improve crop productivity. Protoplasma 251(4), 943–953.

Salisbury, F.B., Ross, C.W., 1985. Plant physiology, (3rd Edn.). Belmont: Wadsworth publishing co.

Sankaran, M., Dinesh, M.R., Abirami, K., Murugan, C., 2021. Botany of mango. In: Kole, C. (Ed.), The mango genome. Compendium of Plant Genomes. Springer, Cham. https://doi.org/10.1007/978-3-030-47829-2_2.

Shahwar, D., Mushtaq, Z., Mushtaq, H., Alqarawi, A. A., Park, Y., Alshahrani, T.S., Faizan, S., 2023. Role of microbial inoculants as bio fertilizers for improving crop productivity: a review. Heliyon 9(6), e16134.

Sharma, S.D., Dhuria, H.S., 1981. Standardization of suitable media and the interval for walnut propagation under controlled conditions. Progressive Horticulture 13(3–4), 43–46. cabidigitallibrary.org/doi/full/10.5555/19840318203.

Singh, A., Verma, P.P.S., 2015. Survival and growth performance of stevia cutting under different growing media. Journal of Medicinal Plants Studies 3(2), 111–113.

Srivastava, R., Nanhorya, R., Upadhyay, J.K., 1998. Selection of proper potting mixture for root trainer of eucalyptus hybrid. Indian Forester 124(7), 503–510.

Thongney, P.L., Khare, N., Rout, S., Debbarma, R., 2020. Effect of different level of vermicompost and FYM organic manure on growth and yield of cucumber intercropped with citrus based agroforestry system. Advances in Bioresearch 11(2), 11–20.

Yadav, A.S., Pandey, D.C., 2016. Geographical perspectives of mango production in India. Imperial Journal of Interdisciplinary Research 2(4), 257–265.

Yusnita, E., Puspitasari, Y., Susanto, D., 2017. Growth of shoots cuttings agarwood (*Aquilaria malacensis lamk*.) on some media and application synthetic plant growth regulator. International Journal of Scientific & Technology Research 6(7), 73–77.