*Original Research Article*

Impact of different organic manures on growth of Strawberry (*Fragaria × ananassa*) under polyhouse condition.

ABSTRACT

|  |
| --- |
| The research was conducted to investigate the impact of different organic manures on the growth of strawberry (*Fragaria × ananassa*) under polyhouse conditions at the Department of Horticulture, CoA, UAS, GKVK, Bengaluru during 2022-2023. The experiment was laid out using a Randomized complete block design (RCBD) of nine treatments replicated thrice. Treatments included combining Farm yard manure, Vermicompost, Poultry manure and Sheep manure. There was a significant difference among the treatments in all growth attributes like highest plant height (41.63 cm), number of leaves (25.53), leaf area (105.79 cm2), plant spread (N-S- 44.41 cm and E-W- 42.60 cm) and total dry matter at harvest (34.00 g) recorded in T6. T6 is the combination of vermicompost and poultry manure given at fifty per cent each of Nitrogen equivalent to satisfy the recommended dose of N to strawberry. T9 was on par with T6 which is the combination of vermicompost and sheep manure given at fifty per cent each of Nitrogen equivalent. This demonstrated the most favourable growth characteristics among all treatments when grown in a controlled polyhouse condition. |

*Keywords: Farm yard manure, Vermicompost, Poultry manure, Sheep manure, Plant height, Leaf area, Number of leaves, Dry matter.*

1. INTRODUCTION

Strawberry (*Fragaria × ananassa*) is a popular hybrid fruit, is renowned for its sweet and tangy flavour. It is a member of the Rosaceae family, belonging to the Fragaria genus, which includes 23 species (Rousseau-Gueutin *et al*., 2009) [25]. The modern strawberry cultivar is an octoploid hybrid (2n = 8x = 56) created by crossbreeding of two American species *Fragaria chiloensis* of western America and *Fragaria virginiana* of eastern north America (Vishal *et al.* 2016) [28]. It is native to North America and originated in France, early in 17th century. It was introduced to India, in early sixties at NBPGR regional station, Shimla from where it has spread to other states of India. The fruit is appreciated for its bright reddish, glossy, juicy texture, characteristic aroma, sweetness and for its pleasing tangy flavour. Rich in Vitamin C, manganese, folates, potassium and fibre. The flavour of strawberry is due to the esters, mainly ethyl butyrate. It is loaded with antioxidants such as Pelargonidin, Ellagic acid, Ellagitannins and Procyanidins. Bright red colour of strawberry fruit is due to the anthocyanins, particularly pelargonidin. Ellagic acid content in strawberry is one of the most important antioxidants having anti-bacterial and anti-cancerous properties. Fruits are largely consumed as a fresh and also processed into fruit juices, preserves, pies, ice-cream, milkshakes and other deserts.

Strawberries are herbaceous plants characterized by a fibrous root system and a crown that supports basal leaves. Leaves are compounds in which the leaf blade is divided into three separate leaflets known as “trifoliate”. Inflorescence is known as “Truss”. Flowers are white, consisting of five sepals with axil bearing. Runners, extending from the base of the plant, touch the ground and develop roots, leading to the growth of new plants. Main crown produces side stems known as branch crown. Each branch crowns are similar to mother crown and adds to the yield of the plant. Fruit cluster consists of primary, secondary, tertiary and quaternary berries. Primary berries are the largest and ripens first, while quaternary berries are smallest and ripens last. It is vegetatively propagated; nowadays tissue cultured plants are commercialized due to its advantages. To reduce disease infestation and loss.

Commercial cultivation often relies on heavy applications of inorganic fertilizers to increase strawberry yields and meet rising consumer demand. Inorganic fertilizers have high nutrient content and are rapidly taken up by plants. However, the use of excess fertilizer can result in a number of problems, such as nutrient loss, surface water and ground water pollution, soil acidification or basification, reductions in useful microbial communities and increased sensitivity to harmful insects. In addition, usage of inorganic fertilizer causes health hazard to the person who handle it. Additionally, synthetic fertilizers can be cost-prohibitive for small and marginal farmers. The most cost-effective plant nutrient alternative to chemical fertilizers, which have high production and environmental costs, is a sustainable option. This approach not only supports agricultural production, which significantly impacts nature, but also helps protect the environment while ensuring efficiency and economic sustainability (Sayğı, H., 2022) [27]. To mitigate the negative impacts of chemical fertilizers, innovative agricultural techniques have emerged under the umbrella of organic, ecological, or sustainable agriculture. Sustainable waste management lies at the core of the circular economy, emphasizing waste reduction, resource efficiency, and the continual reuse of materials (Kotyal., 2023) [16]. Turning crop residue and making it as a manure saves cost to a farmer and leads to a circular economy and also use of manure improves the soil health contrary to the chemical fertilizers. The contemporary global context underscores the importance of adopting environmentally friendly farming practices for sustainable food production.

The use of organic manures in this context is a financially viable option. Organic manures enhance soil structure and promote the growth of beneficial microorganisms. Soil health is essential for sustainable agriculture, as it affects plant growth, nutrient availability, and ecosystem stability (Beleri *et al.,*2023) [5]. Organic agriculture has experienced significant expansion over the past decade, driven by consumer concerns about the detrimental effects of commercial cultivation methods on human health and the environment. Manures play direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improving physical and chemical properties of soils (Chaterjee *et al*. 2005) [7]. The fruit quality and yield can be increased by using manures, which are helpful to reduce fruit drop and increased yield, quality, shelf life and improved the physico-chemical properties of fruits and also increase the marketability as well as demand of fruits (Rajbir *et al*., 2008) [22]

To mitigate the adverse effects of commercial cultivation practices, this study explored the potential of various organic fertilizers, including farm yard manure, vermicompost, poultry manure and sheep manure, to enhance the growth of strawberries.

2. material and methods

The Experiment was carried out in a low-cost polyhouse at Department of Horticulture, College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru. This location is situated in the Eastern Dry Zone (Zone-5) of Karnataka state, at 13° 05' N latitude and 77° 34' E longitude with an elevation of about 924 meters above mean sea level.

Meteorological data were collected throughout the experimental period, spanning November 2022 to March 2023. During this time, maximum and minimum temperatures fluctuated between 25°C and 33°C and 13°C to 20°C, respectively. Average relative humidity exhibited a considerable range, varying from 36 per cent to 89 per cent. These environmental conditions provided a diverse dataset for analyzing the impact on the experimental outcomes.

Tissue culture plants of variety “Winter dawn” were used in the experiment. The experiment incorporated four distinct organic fertilizers (Farm yard manures, vermicompost, poultry manure and sheep manure) arranged in nine separate treatments with three replications in a randomized complete block design. Treatments included combination of organic manures (Table.1)

Table.1 Treatment details

|  |  |
| --- | --- |
| T1 | Absolute Control |
| T2 | 100 % N Equivalent through FYM |
| T3 | 100 % N Equivalent through Poultry Manure |
| T4 | 100 % N Equivalent through Vermicompost |
| T5 | 100 % N Equivalent through Sheep manure |
| T6 | 50 % N Equivalent through Vermicompost + 50 % N Equivalent through Poultry Manure |
| T7 | 50 % N Equivalent through Vermicompost + 50 % N Equivalent through FYM |
| T8 | 50 % N Equivalent through FYM + 50 % N Equivalent through Poultry Manure |
| T9 | 50 % N Equivalent Vermicompost + 50 % N Equivalent through Sheep manure |

\*Note: Manures were calculated on the basis of N equivalent of RDF.

The experimental area was tilled to a fine consistency and divided into plots. of 1.8 m × 1.2 m size with three replications and nine treatments. Manures were applied four weeks before planting according to the treatment combination. Transplanting of tissue cultured plants was carried out during early morning hours. Matted row system was followed with spacing of 60 cm between the rows and 30 cm between the plants within the rows. Paddy straw is used for mulching in strawberry. Appropriate pest management strategies were implemented to mitigate infestations of leaf hoppers, aphids, white fly, Spodoptera as needed. Organic measures were adopted to control pests using Neem oil, *Beauveria bassiana, Lecanicillium lecanii, Trichoderma viride, Pseudomonas fluorescens*.

Observations were recorded at 30 DAT, 60 DAT, 90 DAT and 120 DAT (days after transplanting). Observations on growth parameters viz., plant height, number of leaves, leaf area, plant spread were recorded at the interval of 30, 60, 90 and 120 DAT. While plant dry weight was recorded at harvest stage.

The experimental data collected on various growth attributes was statistically analysed using randomised block design. The significance of the treatment mean was tested using f-test at 5 per cent level of significance, critical difference (C.D.) among the treatment means and standard errors of means.

Statistical analyses were conducted on various characteristics using ANOVA. Data were processed with OPSTAT, INDOSTAT version 8.0 and SPSS version 24.0.

3. results and discussion

The comprehensive data on various growth characteristics of strawberry plants, were meticulously collected and analyzed. These characteristics included plant height(cm), number of leaves, plant spread (N-S, E-W cm), leaf area(cm2) and total dry matter at harvest (g). The researchers diligently tracked and documented these growth metrics at predetermined time points, particularly at 30 DAT, 60 DAT, 90 DAT and 120 DAT (days after transplanting). Total dry matter at harvest was calculated following the harvesting process.

Treatment T6 (50 per cent N equivalent through Vermicompost + 50 per cent N equivalent through Poultry manure) exhibited superior performance compared to the control and all other treatments. At 30 days after transplanting plant height of T6 was 10.47 cm followed by T9 10.03 cm. At 60 days after transplanting T6 has 19.37 cm followed by T9 1.97 cm. At 90 days after transplanting T6 has 28.97 cm followed by T9 28.90 cm. At 120 days after transplanting T6 has 41.63 cm followed by T9 38.18 cm (Table.2). The superior plant height attained by the T6 treatment can be attributed to the positive influence of poultry manure, which stimulates vegetative development in strawberries. These findings align with previous research by Rashid (2018) [24] and Kumar *et al*. (2013) [17]. The growth and development of plants are influenced by the presence of humic acids (Arancon *et al*. 2005a) [2] and essential micro- and macronutrients (Atiyeh *et al.* 2002 [4]; Fernández-Luqueño *et al*. 2010) [12] in vermicompost. The application of vermicompost likely contributed to enhanced plant growth by improving soil conditions, increasing enzymatic activity, fostering microbial proliferation and stimulating the production of plant growth regulators (Albanell *et al.,* 1998) [1].

**Table 2. Impact of different organic manures on plant height (cm) of strawberry at different days after transplanting (DAT).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **30 DAT****(cm)** | **60 DAT****(cm)** | **90 DAT****(cm)** | **120 DAT****(cm)** |
| T1  | 8.03 | 12.43 | 20.67 | 23.42 |
| T2  | 8.80 | 15.97 | 24.13 | 28.26 |
| T3  | 9.33 | 17.53 | 27.33 | 32.94 |
| T4  | 8.87 | 16.57 | 26.23 | 30.00 |
| T5  | 9.57 | 17.90 | 28.03 | 33.01 |
| T6  | 10. 47 | 19.37 | 28.37 | 41.63 |
| T7  | 9.17 | 17.10 | 26.90 | 33.73 |
| T8  | 9.87 | 18.60 | 28.17 | 36.13 |
| T9  | 10.03 | 18.97 | 28.40 | 38.18 |
| **‘F’ test** | \* | \* | \* | \* |
| **S. E. m±** | **0.14** | **0.24** | **0.51** | **0.68** |
| **C. D at 5 %** | **0.41** | **0.72** | **1.54** | **2.04** |

The number of leaves was recorded and found to be as follows (Fig. 1), at 30 DAT, T6 had 7.47 leaves, at 60 DAT it had 12.80 leaves, at 90 DAT it had 15.03 leaves, at 120 DAT it had 25.53 leaves. It was on par with T9, at 30 DAT T6 has 7.20 leaves, at 60 DAT it has 12.53 leaves, at 90 DAT it has 14.77 leaves, at 120 DAT it has 25.27 leaves. The absolute control exhibited the least number of leaves at 30 DAT, 60 DAT, 90 DAT and 120 DAT having 5.60, 10.93, 13.17 and 23.67 leaves respectively. This increase in vegetative growth and number of leaves in strawberry might be attributed to the presence of the plant growth regulators like cytokinin in the vermicompost (Odongo *et al*.,2008) [21] and other phytohormones (Nogales *et al*., 2005) [20].

**Fig. 1. Impact of different organic manures on number of leaves per plant of strawberry at different levels planting**

Leaf area was recorded highest in T6 at 30 DAT (56.47 cm2), 60 DAT (73.42 cm2), 90 DAT (86.47 cm2) and 120 DAT (105.79 cm2) followed by T9 at 30 DAT (55.07 cm2), 60 DAT (72.13 cm2), 90 DAT (85.52 cm2) and 120 DAT (100.84 cm2) respectively (Fig.2). This is likely due to the fact that synergy of vermicompost and poultry manure supplies nutrients, fostering robust growth in strawberries. Enhanced soil properties aids root development and nutrient uptake, resulting in increased leaf area (Prashanth *et al.,* 2019) [8]. This combination promotes thriving plants through improved photosynthesis and nutrient utilization (Arancon *et al*., 2004) [3]. The increased leaf area observed with organic manures (VC and PM) could be attributed to higher soil organic matter and enhanced microbial activity, which likely facilitated nutrient availability, particularly nitrogen, over an extended period, thereby promoting greater vegetative growth (Garg *et al.,* 2020) [13].

**Fig. 2. Impact of different organic manures on leaf area (cm2) of strawberry at different levels planting**

Plant spread (N-S) was recorded highest in T6 (12.40 cm, 31.76 cm, 42.31 cm, 44.41 cm) at all intervals (30, 69, 90, 120 DAT) followed by T9 (12.36 cm, 22.36 cm, 32.52 cm, 37.54 cm). Similarly, plant spread (E-W) was recorded highest in T6 (18.38 cm, 23.33 cm, 27.54 cm, 42.60 cm) at all intervals (30, 69, 90, 120 DAT) followed by T9 (17.20 cm, 22.46 cm, 26.52 cm, 35.15 cm) (Table.3). The positive influence of vermicompost on strawberry plant growth can be attributed to the increased availability of plant growth regulators and humic acid (Er *et al*., 2012) [10], which are produced by the enhanced activity of microbes within the vermicompost (Arancon *et al*., 2004) [3]. Similar results were found by Joshi *et al*., 2015 [15]. Soil amendment with vermicompost enhances water-holding capacity, nutrient availability, and the concentration of trace elements ultimately promoting better plant development (Atiyeh *et al*. 2002) [4]. The increase in leaf length, driven by enhanced nutrient uptake, may contribute to greater plant spread in both directions. This aligns with the findings of Kumar and Bikash Das (2013) [17], who reported that applying vermicompost to broccoli improved nutrient absorption, leading to enhanced plant growth characteristics (Irene *et al.,* 2018) [14].

**Table 3. Impact of different organic manures on plant spread (N-S) and (E-W) (cm) of strawberry at different days after transplanting (DAT)**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Plant spread (N-S) (cm)** | **Plant spread (E-W) (cm)** |
| **30 DAT****(cm)** | **60 DAT****(cm)** | **90 DAT****(cm)** | **120 DAT****(cm)** | **30 DAT****(cm)** | **60 DAT****(cm)** | **90 DAT****(cm)** | **120 DAT****(cm)** |
| **Treatments** | 10.95 | 18.90 | 25.86 | 29.53 | 11.21 | 15.36 | 19.82 | 27.56 |
| T1  | 11.07 | 19.85 | 26.96 | 31.23 | 13.74 | 16.25 | 20.65 | 28.96 |
| T2  | 12.00 | 20.63 | 29.68 | 34.33 | 15.08 | 18.25 | 22.81 | 32.02 |
| T3  | 11.53 | 19.90 | 27.27 | 31.43 | 13.87 | 16.59 | 21.49 | 29.39 |
| T4  | 12.17 | 21.17 | 30.68 | 35.94 | 15.59 | 18.79 | 23.41 | 33.62 |
| T5  | 12.40 | 31.76 | 42.31 | 44.41 | 18.38 | 23.33 | 27.54 | 42.60 |
| T6  | 11.84 | 20.31 | 28.64 | 33.16 | 15.01 | 17.55 | 21.66 | 31.04 |
| T7  | 12.27 | 21.60 | 31.41 | 36.71 | 16.82 | 19.15 | 25.76 | 34.67 |
| T8  | 12.36 | 22.36 | 32.52 | 37.54 | 17.20 | 22.46 | 26.52 | 35.15 |
| **‘F’ test** | **\*** | **\*** | **\*** | **\*** | **\*** | **\*** | **\*** | **\*** |
| **S. E. m±** | **0.02** | **0.03** | **0.58** | **0.29** | **0.18** | **0.13** | **0.15** | **0.34** |
| **C. D at 5 %** | **0.07** | **0.08** | **1.74** | **0.87** | **0.53** | **0.38** | **0.44** | **1.02** |

**Fig. 3.** **Impact of different organic manures on total dry matter at harvest (g) of strawberry**

Total dry matter at harvest was highest in T6 (34.00 g), followed by T9 (31.10 g) (Fig.3). The control recorded the least total dry matter at harvest, with only 14.41 g. The increased plant growth may have improved photosynthesis and carbohydrate production, leading to a higher accumulation of dry biomass in various plant parts. Application of vermicompost influences the C:N ratio, the increase in total dry matter observed in soil enriched with vermicompost is attributed to improved nutrient mineralization (Saha *et al*., 2012) {26}. Multiple studies have consistently shown that vermicompost application significantly increases plant dry matter content, as supported by various researchers (Edwards, 1995 [9]; Erdal & Ekinci, 2017 [11]; Nagavallemma *et al*., 2004 [19]). This increase is primarily due to the slow decomposition rate of vermicompost in the soil, which ensures a continuous supply of essential nutrients throughout the plant's growth cycle (Catanzaro *et al*., 1998) [6]. Similar results were found by Mehraj *et al*., 2014 [18] that vermicompost is a valuable source of plant nutrients for sustainable strawberry production and holds great potential for organic strawberry cultivation.

The exceptional performance of T6 and T9 underscores the significant impact of these organic manure combinations on strawberry plant growth parameters, which are likely to correlate directly with yield. The synergistic effect of the combined manures appears to have played a pivotal role in enhancing plant growth. The enzymes and growth regulators present within the manures may have influenced nutrient uptake by the plants, leading to increased growth attributes.

The enzymes present in the fertilizers could have catalyzed various biochemical reactions within the plants, such as the degradation of complex organic molecules into simpler forms that are readily absorbed by the roots. Additionally, the growth hormones contained within the fertilizers may have stimulated cell division, elongation and differentiation, leading to increased plant height, leaf area and root development.

Additionally, the synergistic effect of vermicompost and poultry manure may have positively influenced soil structure and water retention capacity, thereby creating a more favourable environment for root growth and nutrient uptake (Rajneesh *et al*., 2017) [23]. The organic matter content in these fertilizers can also serve as a nutrient source for beneficial soil microorganisms, which can enhance nutrient cycling and promote plant health.

4. Conclusion

In conclusion, the outstanding performance of T6 and T9 demonstrates the effectiveness of organic manure combinations in promoting strawberry plant growth. The synergistic effects of the enzymes and growth regulators present in the manures, coupled with their positive impact on soil health, appear to be key factors driving the observed improvements in plant growth parameters.

References

1. Albanell, E., Plaixats, J. & Cabrero, T. Chemical changes during vermicomposting (*Eisenia fetida*) of sheep manure mixed with cotton industrial wastes. *Biol Fert Soils* **6**, 266–269 (1988). <https://doi.org/10.1007/BF00260823>
2. Arancon NQ, Edwards CA, Bierman P, Metzger JD, Lucht C (2005a) Effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field. Pedobiologia 49(4):297–306. <https://doi.org/10.1016/j.pedobi.2005.02.001>
3. Arancon, N. Q., Edwards, C. A., Bierman, P., Welch, C., & Metzger, J. D. (2004). Influences of vermicomposts on field strawberries: 1. Effects on growth and yields. *Bioresource technology*, *93*(2), 145-153. <https://doi.org/10.1016/j.biortech.2003.10.014>
4. Atiyeh RM, Edwards CA, Metzer JD, Lee S, Arancon NQ (2002) The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresour Technol 84:7–14. <https://doi.org/10.1016/j.envpol.2006.01.022>
5. Beleri, Pooja. (2023). Microbial Solutions to Soil Health: The Role of Biofertilizers in Sustainable Agriculture. Environmental Reports. 5. 6-9. <http://dx.doi.org/10.51470/ER.2023.5.2.06>
6. Catanzaro, C. J., Williams, K. A., & Sauve, R. J. (1998). Slow release versus water soluble fertilization affects nutrient leaching and growth of potted chrysanthemum. *Journal of Plant Nutrition*, *21*(5), 1025–1036. <https://doi.org/10.1080/01904169809365461>
7. Chaterjee, B., Ghanti, P., Thapa, U., & Tripathy, P. (2005). Effect of organic nutrition in sprouting broccoli (*Brassica oleracea* L. *var. italica* Plenck). *Vegetable science*, *33*(1), 51-54. [https:// org/doi/full/10.5555/20063131351](https://www.cabidigitallibrary.org/doi/full/10.5555/20063131351)
8. D. V. Prashanth., Krishnamurthy, R., & Naveen, D. V. (2019). Long-term Effect of Integrated Nutrient Management on Soil Nutrient Status, Content and Uptake by Finger Millet Crop in a *Typic Kandiustalf* of Eastern Dry Zone of Karnataka. *Communications in Soil Science and Plant Analysis*, *51*(2), 161–174. <https://doi.org/10.1080/00103624.2019.1695829>
9. Edwards, C. A. (1995). Historical overview of vermicomposting. *Historical Overview of Vermicomposting*, *36*(6), 56–58. <https://www.cabidigitallibrary.org/doi/full/10.5555/19951303443>
10. Er, L. K., Aziz, N. A. A., Yin, K. H., Mustafa, M., Ismail, I. S., & Zainudin, N. A. I. M. (2012). Potential of neem leaf-empty fruit bunch-based vermicompost as biofertiliser-cum-biopesticide: Chemical properties, humic acid content and enzymes (protease and phosphatase) activity in vermicompost (Part I). *Scientific Research and Essays*, *7*(42), 3657-3664. <https://doi.org/10.5897/SRE12.391>
11. Erdal, I., & Ekinci, K. (2017). Effects of vermicomposts obtained from rose oil processing wastes, dairy manure, municipal open market wastes and straw on plant growth, mineral nutrition, and nutrient uptake of corn. *Journal of Plant Nutrition, 40*, 2200 – 2208. [https://api.semanticscholar.org/CorpusID:102827562](https://api.semanticscholar.org/CorpusID%3A102827562)
12. Fernández-Luqueño F, Reyes-Varela V, Martínez-Suárez C, Salomón-Hernández G, Yáñez-Meneses J, Ceballos-Ramírez JM, Dendooven L (2010) Effect of different nitrogen sources on plant characteristics and yield of common bean (*Phaseolus* *vulgaris* L.) Bioresour Technol 101(1):396–403. <https://doi.org/10.1016/j.biortech.2009.07.058>
13. Garg, Ashok K., Rajesh Kaushal, and Vishal S. Rana. 2020. “Impact of Vermicompost, Poultry Manure and Jeevaamrit on Growth Parameters of Kiwifruit (Actinidia Deliciosa) Cv. Allison”. *International Journal of Plant & Soil Science* 32 (18):31-40. <https://doi.org/10.9734/ijpss/2020/v32i1830389>.
14. Irene Vethamoni, P. and Syama S. Thampi. 2018. Effect of Organic Manuring Practices on Growth and Yield of Palak (*Beta vulgaris* var. *bengalensis* Hort.). *Int.J.Curr.Microbiol.App.Sci.* 7(8): 1855-1863. doi: <https://doi.org/10.20546/ijcmas.2018.708.213>
15. Joshi, R., Singh, J. & Vig, A.P. Vermicompost as an effective organic fertilizer and biocontrol agent: effect on growth, yield and quality of plants. *Rev Environ Sci Biotechnol* **14**, 137–159 (2015). <https://doi.org/10.1007/s11157-014-9347-1>
16. Kotyal, Kiran. (2023). Sustainable Waste Management in the Circular Economy: Challenges and Opportunities. Environmental Reports. 5. 1-5. <http://dx.doi.org/10.51470/ER.2023.5.2.01>
17. Kumar, M., Das, B. D., Prasad, K., & Kumar, P. (2013). Effect of integrated nutrient management on growth and yield of broccoli (Brassica oleracea var. italica) under Jharkhand conditions. *Vegetable Science*, *40*(01), 117-120. <https://doi.org/10.61180/>
18. Mehraj, H., Ahsan, M. K., Hussain, M. S., Rahman, M. M., & Jamal Uddin, A. F. M. (2014). Response of different organic matters in strawberry. *Bangladesh Research Publication Journal*, *10*(2), 151-161. <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3592108>
19. Nagavallemma, K. P., Wani, S. P., Lacroix, S., Padmaja, V. V., Vineela, C., Rao, M. B., & Sahrawat, K. L. (2004). *Vermicomposting: Recycling wastes into valuable organic fertilizer.global theme on agroecosystems report no. 8’. monograph*. International Crops Research Institute for the Semi-Arid Tropics. 2004. [https://oar.icrisat.org/3677/(open in a new window)](https://oar.icrisat.org/3677/).
20. Nogales, R., Cifuentes, C., & Benítez, E. (2005). Vermicomposting of Winery Wastes: A Laboratory Study. *Journal of Environmental Science and Health, Part B*, *40*(4), 659–673. <https://doi.org/10.1081/PFC-200061595>
21. Odongo, O., Isutsa, D. K., & Aguyoh, J. N. (2008). Effects of integrated nutrient sources on growth and yield of strawberry grown under tropical high altitude conditions. *African Journal of Horticultural Science*, *1*. <http://www.journal.hakenya.net/index.php/ajhs/article/view/40>
22. Rajbir Singh, R. S., Sharma, R. R., Satyendra Kumar, S. K., Gupta, R. K., & Patil, R. T. (2008). Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (*Fragaria× ananassa* Duch.). <https://10.1016/j.biortech.2008.03.034>
23. Rajneesh, R., Sharma, R. P., Sankhyan, N. K., & Rameshwar Kumar, R. K. (2017). Long-term effect of fertilizers and amendments on depth-wise distribution of available NPK, micronutrient cations, productivity and NPK uptake by maize-wheat system in an acid alfisol of NorthWestern Himalayas. <http://dx.doi.org/10.1080/00103624.2017.1408816> Rashid, M. H. A. (2018). Optimisation of growth yield and quality of Strawberry cultivars through organic farming. *Journal of Environmental Science and Natural Resources*, *11*(1-2), 121-129. <https://doi.org/10.3329/jesnr.v11i1-2.43379>
24. Rousseau-Gueutin, M., Gaston, A., Aïnouche, A., Aïnouche, M. L., Olbricht, K., Staudt, G., & Denoyes-Rothan, B. (2009). Tracking the evolutionary history of polyploidy in *Fragaria* L.(strawberry): new insights from phylogenetic analyses of low-copy nuclear genes. *Molecular phylogenetics and evolution*, *51*(3), 515-530.DOI: <https://doi.org/10.1016/j.ympev.2008.12.024>
25. Saha, S., Dutta, D., Ray, D.P., Karmakar, R. (2012). Vermicompost and Soil Quality. In: Lichtfouse, E. (eds) Farming for Food and Water Security. Sustainable Agriculture Reviews, vol 10. Springer, Dordrecht. <https://doi.org/10.1007/978-94-007-4500-1_10>
26. Sayğı, H. (2022). Effects of organic fertilizer application on strawberry (*Fragaria vesca* L.) cultivation. *Agronomy*, *12*(5), 1233. <https://doi.org/10.3390/agronomy12051233>
27. Vishal, V. C., Thippesha, D., Chethana, K., Maheshgowda, B. M., Veeresha, B. G., & Basavraj, A. K. (2016). Effect of various growth regulators on vegetative parameters of strawberry (*Fragaria x ananassa* Duch.) cv. Sujatha. *Research Journal of Chemical and Environmental Sciences*, *4*(4), 68-71. <https://aelsindia.com/rjcesaugust2016/12f.pdf>