



RESEARCH

A Comprehensive Study on the Effects of Organic Fertilizers on Growth and Yield of Broad Leaf Mustard (*Brassica juncea* var. *rugosa*) cv. Manakamana Rayo

Kapil Prasad Marasini^{1,*} , Jyotish Joshi¹ , Bipana Yogi¹ ,
Desire Rana Chhetri¹ , Aarati Ghimire¹  and Gopal Prasad Shrestha²

¹ Department of Agriculture, Himalayan College of Agricultural Sciences and Technology (HICAST), Kirtipur, Kathmandu 44600, Nepal

² Nepal Horticulture Society, Khumaltar, Lalitpur 44600, Nepal

* Author responsible for correspondence; Email: kapilmarasini03@gmail.com.



ARTICLE HISTORY

Received: 28 January 2024
Revised: 26 February 2024
Accepted: 27 February 2024
Published: 25 March 2024

KEYWORDS

black wonder
broad leaf mustard
organic fertilizer
vermicompost

EDITOR

Sami Abou Fayssal

COPYRIGHT

© 2024 Author(s)
eISSN 2583-942X

LICENCE



This is an Open Access Article published under a Creative Commons Attribution-NonCommercial 4.0 International License

Abstract

Broad Leaf Mustard (BLM) is one of the extensively cultivated vegetable crops in Nepal. In our study, we conducted a thorough analysis to explore how organic fertilizers impact the growth and yield of Broad Leaf Mustard (*Brassica juncea* var. *rugosa*) cv. Manakamana Rayo in Tarakeshwor Municipality, Nepal. To carry out this investigation, we employed a Randomized Complete Block Design, incorporating seven distinct treatments, labeled as T₁ (FYM), T₂ (Poultry Manure), T₃ (Compost), T₄ (Vermicompost), T₅ (Black Wonder), T₆ (Black Wonder Double), and T₇ (Control), each replicated three times. Each treatment plot, measuring 1.2 m², accommodated 60 plants. The application of organic fertilizers was done during the initial phase of field preparation. Our results highlighted the effectiveness of Vermicompost applied at a rate of 20 tons per hectare. This treatment produced the tallest plants (34.83 cm), longest leaves (32.37 cm), widest leaves (17.73 cm), and increased yields, specifically 61.1g/plant and 2.10 kg per plot. Furthermore, Farm-Yard Manure (FYM) at 28.4 tons per hectare and Black Wonder at 0.96 tons per hectare resulted in the maximum number of leaves (11.67). These findings offer practical insights for farmers and researchers keen on optimizing Broad Leaf Mustard cultivation through the judicious use of organic fertilizers.

Citation: Marasini, K P., Joshi, J., Yogi, B., Chhetri, D. R., Ghimire, A., & Shrestha, G. P. (2024). A Comprehensive Study on the Effects of Organic Fertilizers on Growth and Yield of Broad Leaf Mustard (*Brassica juncea* var. *rugosa*) cv. Manakamana Rayo. *AgroEnvironmental Sustainability*, 2(1), 11-18. <https://doi.org/10.59983/s2024020102>

Statement of Sustainability: This research was conducted to assess the effects of various organic fertilizers on growth and the effects of Broad Leaf Mustard. The growing use of chemical fertilizers has severe effects on the physical and chemical properties of soil. So, this research intends to find out the best source of nutrients for the cultivation of Broad Leaf Mustard. Moreover, the use of organic fertilizers also improves the properties of soil and maintains good soil health. Organic fertilizers do not cause any type of harm to nature, so it is nature nature-friendly as well.

1. Introduction

Vegetables are essential for global food security, providing sustenance, resilience, and sustainability (Ghimire et al., 2023). Mustard greens, formally identified as *Brassica juncea* var. *rugosa*, are a type of leafy vegetable with broad leaves that belong to the *Brassica* genus. The *rugosa* variety is known for its distinctive wrinkled or crinkled leaf texture. The plant, commonly known as 'Rayo' in Nepal, is prevalent in Central and Eastern Asia. It is renowned for its nutritional value and serves as a significant source of various vitamins and minerals. Optimal growth conditions are cooler climates, with cultivation in the winter preferred in the Terai region and in the summer in higher altitudes. Notably, the quality of its leaves tends to be superior in cooler conditions compared to warmer ones. Although adaptable to various soil types, the successful growth of this plant is favored by loamy soil with ample organic content and water retention capability (Parajuli, 2015). Broad Leaf Mustard can grow in various soil types if they have good drainage and water retention. However, the crop thrives best in soils rich in organic matter, particularly loam soil with efficient drainage. It is advisable to avoid cultivating Broad Leaf Mustard in dry sand or excessively dry soils. For the germination process, an ideal

temperature is around 27 °C, while a temperature range of 18 to 25 °C is suitable for overall growth. Additionally, it is important to maintain a lower humidity level, which is preferred by BLM. To optimize yields, it is recommended to apply 20 metric tons of well-rotted farmyard manure (FYM) or compost, along with 120 kg of nitrogen, 80 kg of phosphorus, and 60 kg of potassium. It is important to mix the complete amounts of phosphorus, potassium, and FYM thoroughly during soil preparation. For Nitrogen, half of the necessary amount is applied as a top dressing in multiple stages: approximately 25–30 days, 45–50 days, and the final dose at 70–80 days after transplanting the seedlings. It is worth noting that higher quantities of organic manure in the soil are associated with increased production of green leaves (Singh and Bhandari, 2019).

Mustard seeds are native to central and eastern Asia. In 2019, worldwide production of mustard seeds reached 654,112 MT, which was a 22.46% increase compared to the 2015 production volume. The top five mustard seed-producing countries in 2019 were Nepal, Russia, Canada, Myanmar, and Ukraine, which respectively produced 209,745 MT (32.07%), 164,857 MT (25.20%), 134,600 MT (20.58%), 39,640 MT (6.06%), and 39,530 MT (6.04%) (FAO, 2021). In Nepal, Broad Leaf Mustard is commonly known as “Rayo”. The crop known as Broad Leaf Mustard is produced on approximately 10,851 hectares of land in Nepal. Its average annual production is 146,756 MT, with a yield of 13.52 MT per hectare. Broad Leaf Mustard is primarily produced in the districts of Illam, Kavre, Chitwan, Sindhuli, Kathmandu, and Rukum (MoALD, 2020/21). The National Seed Board (NSB) has released four varieties of Broad Leaf Mustard in Nepal: 'Khumal Chauda Pat', 'Khumal Rato Pat', 'Marpha Chauda Pat', and 'Tangkuwa Rayo', which have been cultivated for a long time (SQCC, 2020). A new variety called 'Manakamana Rayo' has recently been registered in the NCB and recommended for the mid-hills of the western region (Adhikari et al., 2021). Producing enough nutritious and healthy food for a growing global population while securing environmental, social, and economic sustainability is one of humanity's greatest challenges. The solution to this challenge is the transformation of the agro sector to organic farming (FAO, 2018). Organic agriculture prioritizes soil, ecosystems, and people's health by relying on natural processes and local conditions while avoiding harmful inputs. According to IFOAM (2008), the organization combines tradition, innovation, and science to promote a better environment, fair relationships, and improved quality of life for all. Organic farming results in lower environmental impacts, including reduced energy use, greenhouse gas emissions, and nutrient pollution per unit of land (Tuomisto et al., 2012). It also leads to better soil quality (Meemken and Qaim, 2018), improved animal welfare (Vaarst and Alrøe, 2012), reduced chemical use (Pekala, 2020), and greater profitability for farmers (Reganold and Wachter, 2016).

Although organic farming holds promise, uncertainties remain regarding the effectiveness of organic fertilizers on the growth and yield of broad-leaf mustard. This research aims to address these gaps by investigating the effects of various organic fertilizers on growth and yield. The findings will provide essential insights for guiding farmers and policymakers toward sustainable agricultural practices.

2. Material and Methods

2.1 Site Selection

The study was conducted in Lolang Height, located in Tarakeswor Municipality-4, from July to August 2023. Tarakeswor Municipality is situated in the northwest part of the Kathmandu district, with geographical coordinates of Latitude: 27°47'12" N and Longitude: 85°18'11" E (Figure 1).

2.2. Soil Testing

The soil used for research purposes was analyzed at the HICAST soil laboratory before Broad Leaf Mustard cultivation to determine its general properties. Random soil samples were collected from different spots in the experimental field at a depth of 15cm, and a composite sample was prepared and analyzed for various physio-chemical properties. Table 1 summarizes the physical and chemical characteristics of the soil in the experimental area.

2.3. Experimental Design and Layout

The experiment was conducted using a Randomized Complete Block Design (RCBD) with seven treatments, each replicated three times to ensure consistency of results (Table 2). The treatments included FYM, Poultry Manure, Compost, Vermicompost, and Black Wonder. The experiment was conducted under a plastic tunnel with a spacing of 1 m between replications and 0.5 m between treatments. The total length of the tunnel was 15 m and the breadth was 6.5 m. Twenty-

one plots were prepared, each with a length of 1.2 m and a breadth of 1 m, maintaining an area of 1.2 m² per plot. The plant-to-plant spacing was 10 cm, and the row-to-row spacing was 20 cm. The experiment layout is shown in Figure 2.

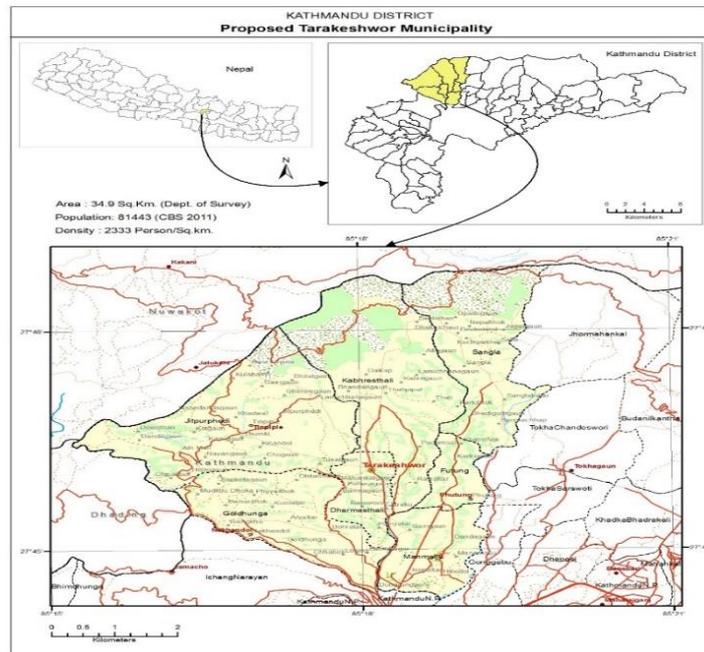


Figure 1. Map of study area used for crop cultivation.

Table 1. Soil status before Broad-leaf mustard cultivation

| Soil Parameters | Value | Method of Determination |
|------------------------------|------------|-------------------------|
| pH | 5.90 | pH meter |
| Texture | Sandy Loam | Hydrometer |
| Available nitrogen (kg/ha) | 22.21 | Kjeldahl Distillation |
| Available phosphorus (kg/ha) | 43.98 | Olsen's Bicarbonate |
| Available potassium (kg/ha) | 285.28 | Flame photometer |
| Organic matter (%) | 2.19 | Walkey and Black |

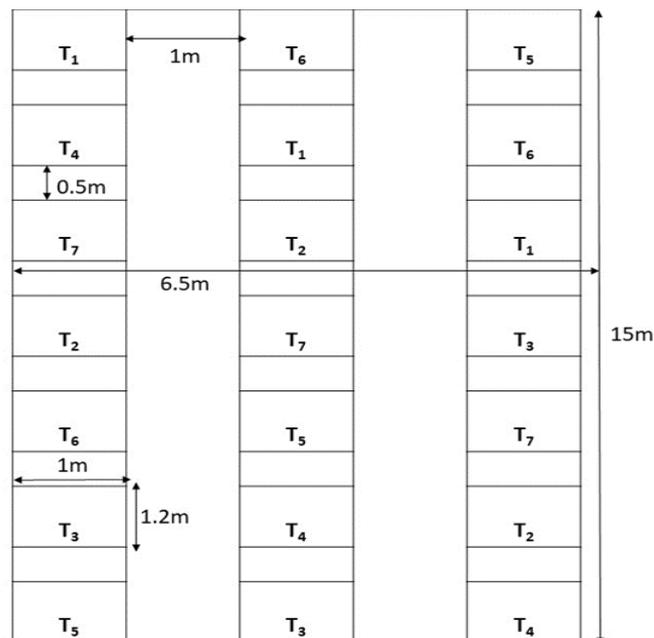


Figure 2. Layout of experiment used for crop cultivation.

2.4 Field Preparation, Sowing, Manure Application, Intercultural Operations and Harvesting

For field preparation, debris was removed, and the land was plowed twice using a mini tiller to achieve a fine tilth. Leveling was also carried out. For field preparation, debris was removed, and the land was plowed twice using a mini tiller to achieve a fine tilth. A total of twenty-one plots of equal size were prepared, and treatments were selected randomly. The spacing between replications was maintained at 1 m, while that between treatments was 0.5 m. Each plot, measuring 1.2 m², was created within the experimental field according to the experimental design. Line sowing was performed using direct sowing instead of transplanting seedlings due to off-season cultivation. The spacing between plants was maintained at 10 cm and 20 cm between rows. Sowing was done in the evening and followed by immediate watering. All necessary irrigation and fertilizers were applied during field preparation. The research utilized five different types of organic fertilizer. In the experiment, Black Wonder was used as two different treatments: one as RDF and another as a double dose. Other organic fertilizers used included Cow Manure, Poultry Manure, Compost, and Vermicompost.

Table 2. Treatment details used for crop cultivation.

| Treatments | Applications | Dose (t ha ⁻¹) |
|------------|----------------------------|----------------------------|
| T1 | Farmyard manure (FYM) | 28.4 |
| T2 | Poultry Manure | 14.8 |
| T3 | Compost | 40 |
| T4 | Vermicompost (VC) | 20 |
| T5 | Black Wonder (RDF) | 0.48 |
| T6 | Black Wonder (Double Dose) | 0.96 |
| T7 | Control | No fertilizer |

A light irrigation was performed on the day of broadcasting using a watering can. Subsequently, watering was carried out every 2-3 days for the first 15 days, followed by a 5-day interval for the next 20 days. Weeding was performed 10 days after sowing, and light hand weeding was carried out as needed. Amaranthus was found in the field and was removed manually. Thinning out was performed to maintain 60 plants per plot, as line sowing was done. The Broad Leaf Mustard was harvested 42 days after sowing when all the leaves were ready for market. Since it was an off-season cultivation, the plant was uprooted only once for harvesting.

2.5 Data Analysis

In the field, various parameters were observed, including plant height, leaf size, number of leaves, yield per plant, yield per plot, and yield per hectare. The data was systematically arranged and analyzed using Microsoft Excel (2016, Microsoft Corp., USA) and Statistical Tool for Agricultural Research [STAR, 2.0.1, Biometrics and Breeding Informatics (BBI) group, under IRRI's Plant Breeding, Genetics, and Biotechnology (PBGB), Pili Drive, Los Baños, Laguna 4031, Philippines]. The treatments were tested at a 5 percent level of significance.

3. Results and Discussion

3.1. Effect on Plant Height

Plant height was recorded at seven-day intervals after sowing. The investigation found that different fertilizer sources had a statistically significant impact on plant height. The average height of the plant in the third week was 8.286 cm, and in the sixth week, it was 31.63 cm. The maximum height of 34.83 cm was observed in T4, followed by T1 with a value of 34.73 cm. The lowest value was observed in T7, with a height of 28.37 cm. During the third week of observation, the maximum height of 9.9 cm was recorded in T4, followed by T6 with a value of 8.64 cm. The lowest height of 7.11 cm was observed in T7. These results suggest that the incorporation of vermicompost into the soil may enhance the growth of Broad Leaf Mustard (Table 3).

The best result was obtained through the application of Vermicompost. Vermicompost may contain plant hormones such as cytokinin, gibberellins (e.g., GA3), and auxins (e.g., IAA), as well as enzymes like alkaline phosphatase, cellulase, and urease (Ruangjanda et al., 2022). Vermicomposting enhances the decomposition of organic matter, leading to higher concentrations of plant-available nutrients (N, P, and K), as well as stable humic and fulvic acid content (Elissen et al., 2023). Bosekeng (2019) found that the application of vermicompost increases the height of mustard, which is

supported by Raksun et al. (2022) who stated that the treatment of vermicompost significantly increased the plant height of long beans. These results are consistent with the findings of Anandyawati et al. (2023) on Broad Leaf Mustard.

Table 3. Effect of different organic fertilizers on the height of the plant.

| Treatments | Height of Plant (cm) | |
|--------------------------|----------------------|----------|
| | 3rd Week | 6th Week |
| T1 (FYM) | 8.37 ab | 34.73 a |
| T2 (Poultry Manure) | 7 b | 30.07 ab |
| T3 (Compost) | 7.7 b | 29.07 b |
| T4 (Vermicompost) | 9.9 a | 34.83 a |
| T5 (Black Wonder) | 7.73 b | 31 ab |
| T6 (Black Wonder Double) | 8.64 ab | 33.37 ab |
| T7 (Control) | 7.11 b | 28.37 b |
| Mean | 8.07 | 31.63 |
| CV at 5% | 9.27 | 6.27 |
| LSD | 0.71 | 3.52 |
| SD | 0.95 | 2.48 |

Means with the same letter are not significantly different at a 5% level of significance.

3.2. Number of Leaves Per Plant

Various fertilizer sources showed a statistically significant difference in the number of leaves per plant at a 5% level of significance. The maximum number of leaves was recorded in T1 and T6, with a value of 11.67, followed by T4 with a value of 11.33. The average number of leaves was 10.57. The minimum number of leaves per plant was found in T7 with a value of 9. This suggests that FYM and Black Wonder are good nutrients for increasing the number of leaves on BLM. The minimum number of leaves per plant was found in T7 with a value of 9. This suggests that FYM and Black Wonder are good nutrients for increasing the number of leaves on Broad Leaf Mustard (Figure 3). The most favorable outcomes were achieved through the application of FYM and Black Wonder. This could be attributed to FYM's ability to enhance soil structure and biomass (Dauda et al., 2008). Additionally, FYM aids in improving soil physical properties and enhances soil chemical properties by increasing soil organic carbon, nitrogen, phosphorus, and potassium content (Bayu et al., 2006). Black Wonder provides essential nutrients to the soil, acts as a supplementary source of nutrition for plants, and helps improve soil structure (Wonder, 2023). Fatahi et al. (2014) also found an increase in the number of leaves of Cowpea by the application of organic fertilizers such as compost, cow manure, and chicken manure. This finding is supported by Maurya et al. (2020), who also observed the highest number of leaves on Mustard with the application of FYM. Adhikari et al. (2023) reported that the application of Black Wonder increased the number of leaves on cabbage.

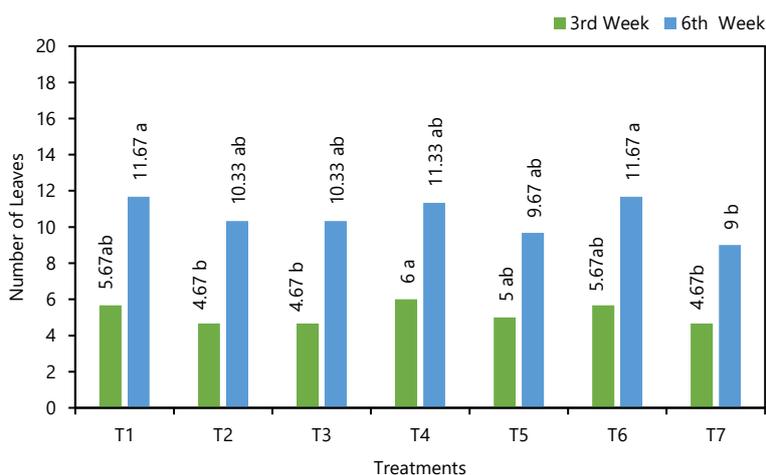


Figure 3. Effect of different organic fertilizers on the number of leaves.

3.3 Effects on Leaf Length and Leaf Breadth

The investigation analyzed the impact of different fertilizer sources on plant leaf length at a 5% level of significance. The results showed that the application of T4 resulted in the maximum leaf length of 32.37 cm, while the minimum leaf

length of 25.93 cm was obtained from T7. The average leaf length was observed to be 29.2 cm. The data is presented in Table 4, and the best result was achieved through the application of Vermicompost. Vermicompost may contain plant hormones such as cytokinin, gibberellins (e.g. GA3), and auxins (Ruangjanda et al., 2022). This finding is consistent with the results of Bosekeng (2019), who also observed increased leaf length with the application of vermicompost. Rauniyar and Bhattarai (2017) also reported similar results. The leaf breadth of the plant showed a statistically significant difference among various fertilizer sources at a 5% level of significance. The maximum breadth of the leaf was observed with the application of T4, which was 17.73 cm. The average leaf length was 15.1 cm. Table 4 shows the minimum leaf length obtained with T7, which was 11 cm. This finding agrees with the results of Devkota et al. (2020) and Rauniyar and Bhattarai (2017), who also found the highest leaf breadth when vermicompost was applied.

Table 4. Effect of different organic fertilizers on length of leaf and breadth of leaf.

| Treatments | Length of Leaf (cm) | Breadth of Leaf (cm) |
|--------------------------|---------------------|----------------------|
| T1 (FYM) | 31.97 a | 17.53 a |
| T2 (Poultry Manure) | 27.90 abc | 13.57 ab |
| T3(Compost) | 26.70 bc | 14.50 ab |
| T4 (Vermicompost) | 32.37 a | 17.53 a |
| T5 (Black Wonder) | 28.93 abc | 15.17 ab |
| T6 (Black Wonder Double) | 30.57 ab | 16.20 ab |
| T7 (Control) | 25.93 c | 11.00 b |
| Mean | 29.20 | 15.10 |
| CV at 5% | 5.50 | 14.26 |
| LSD | 2.85 | 3.83 |
| SD | 2.53 | 2.15 |

Means with the same letter are not significantly different at a 5% level of significance.

3.4. Effect on Yield

Figure 4 reveals that different treatments had a significant influence on yield. The maximum yield per plant, 61.10 g, was obtained by the application of T4, while the lowest yield, 36.70 g per plant, was obtained from T7. On average, the yield per plant was 49.20 g. These findings are in agreement with Lutt et al. (2020), who also found that the highest yield on Broad Leaf Mustard was achieved by the application of Vermicompost. Ali and Kashem (2018) found that the application of Vermicompost increased the yield of cabbage. Similarly, Ahirwar and Hussain (2015) found similar results in different vegetables through Vermicomposting. The data shows that various treatments had a significant impact on the yield per pot. The highest yield per plot was achieved with the application of T4, which yielded 2.10 kg per plot. This was followed by T6, which yielded 1.93 kg per plot. The lowest yield was obtained from T7 (Control), which yielded 1.26 kg per plot. On average, the yield per plot was 1.66 kg. The data shows that there were significant differences in computed yield among the different treatments. The highest yield per hectare, 17.47 tons, was obtained from T4, while the lowest yield, 10.52 tons, was obtained from T7. On average, the yield per hectare was 13.84 tons. These results suggest that the application of Vermicompost increases the yield of Broad Leaf Mustard (Table 5).

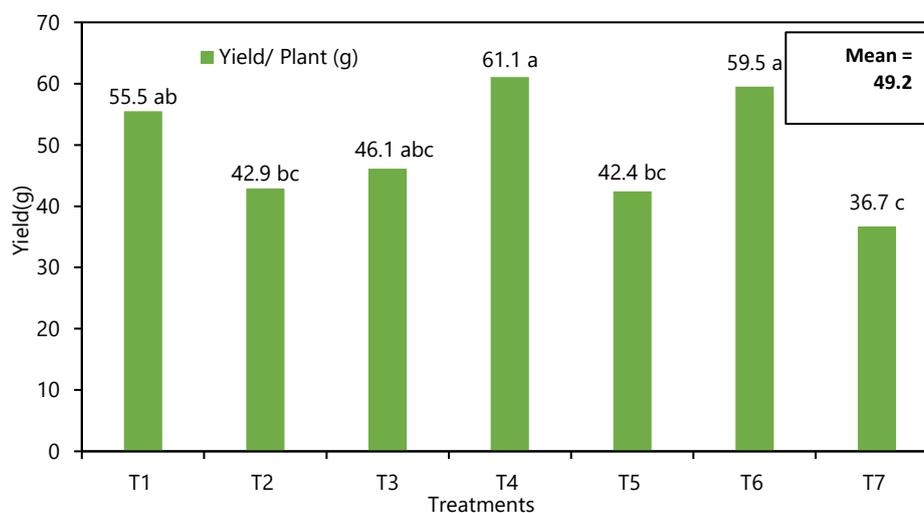


Figure 4. Effect of different organic fertilizers on yield.

Table 5. Effect of different organic fertilizers on yield per plot and per ha.

| Treatments | Yield (kg plot ⁻¹) | Yield (ton ha ⁻¹) |
|--------------------------|--------------------------------|-------------------------------|
| T1 (FYM) | 1.76 abc | 14.66 abc |
| T2 (Poultry Manure) | 1.49 bc | 12.41 bc |
| T3 (Compost) | 1.53 abc | 12.72 abc |
| T4 (Vermicompost) | 2.10 a | 17.46 a |
| T5 (Black Wonder) | 1.56 abc | 13.03 abc |
| T6 (Black Wonder Double) | 1.93 ab | 16.11 ab |
| T7 (Control) | 1.26 c | 10.53 c |
| Mean | 1.66 | 13.85 |
| CV at 5% | 12.38 | 12.38 |
| LSD | 0.36 | 3.05 |
| SD | 0.25 | 2.19 |

Means with the same letter are not significantly different at a 5% level of significance.

4. Conclusion

The study's findings showed significant effects of various organic fertilizers on the growth and yield of Broad Leaf Mustard cv. Manakamana Rayo. Specifically, plants treated with vermicompost at a rate of 20 t ha⁻¹ exhibited the greatest height, maximum leaf length, and breadth among all treatments. The application of farmyard manure at 28.4 t ha⁻¹ and Black Wonder at 0.96 t ha⁻¹ resulted in an equal number of leaves, which was the highest observed among all treatments. The study found that the highest yield of Broad Leaf Mustard per plant, per plot, and per hectare was achieved with the application of vermicompost at 20 t ha⁻¹. Therefore, it is recommended to use vermicompost at 20 t ha⁻¹, FYM at 28.4 t ha⁻¹, and Black Wonder at 0.96 t ha⁻¹ as optimal fertilizers for organic Broad Leaf Mustard cultivation.

Author Contributions: Conceptualization: Kapil Prasad Marasini, Gopal Prasad Shrestha; Data curation: Bipana Yogi; Funding acquisition: Jyotish Joshi; Investigation: Kapil Prasad Marasini, Jyotish Joshi, Bipana Yogi, Desire Rana Chhetri, Aarati Ghimire; Methodology: Kapil Prasad Marasini; Software: Kapil Prasad Marasini; Supervision: Gopal Prasad Shrestha; Validation: Gopal Prasad Shrestha; Writing – original draft: Aarati Ghimire, Kapil Prasad Marasini; Writing – review & editing: Kapil Prasad Marasini, Aarati Ghimire. All authors have read and agreed to the published version of the manuscript.

Funding: Partial funding was provided by the Himalayan College of Agricultural Sciences and Technology (HICAST), Kirtipur, Kathmandu, Nepal.

Acknowledgment: Dr. Binayak Prasad Rajbhandari, College Chief, Himalayan College of Agricultural Sciences and Technology (HICAST), and all the faculty members and staff of HICAST College.

Conflicts of Interest: The authors declare no conflict of interest.

Institutional/Ethical Approval: Not applicable.

Data/Supplementary Information Availability: Supplementary data of this article is available online at: <https://doi.org/10.59983/s2024020102>.

References

- Adhikari, R., Katel, S., Chhetri, P. K., Simkhada, P., Chaudhari, P., & Yadav, S. P. (2023). Effect of different sources of organic fertilizers on crop growth and yield of Cabbage. *Journal of Agriculture and Applied Biology*, 4(1), 83-94.
- Adhikari, S., Bhusal, Y., Paudel, S., Lohani, S., & Aryal, L. (2021). Performance evaluation of broadleaf mustard varieties in the mid-hill condition of Kaski district, Nepal. Proceedings of the Tenth National Horticulture Workshop, pp. 195-198.
- Ahirwar, C. S., & Hussain, A. (2015). Effect of vermicompost on growth, yield and quality of vegetable crops. *International Journal of Applied and Pure Science and Agriculture*, 1(8), 49-56.
- Ali, S., & Kashem, M. A. (2018). Effect of Vermicompost on the Growth and Yield of Cabbage. *Journal of Agricultural Engineering and Food Technology*, 5(1), 45-49.
- Anandiyawati, A., Murcitra, B. G., Herman, W., & Prameswari, W. (2023). Effect of Vermicompost Chicken, Goat and Cow Manure on Growth Response and Yield of Brassica juncea L. on Ultisols. *TERRA Journal of Land Restoration*, 6(1), 1-10.
- Bayu, W., Rethman, N. F., Hammes, P. S., & Alemu, G. (2006). Application of Farmyard Manure Improved the Chemical and Physical Properties of the Soil in a Semi-Arid Area in Ethiopia. *Biological Agriculture & Horticulture*, 24(3), 293-300.
- Bosekeng, G. (2019). Response of Ethiopian Mustard (*Brassica carinata* A. Braun) to Different Levels of Vermicompost in North East, Botswana. *World Journal of Agricultural Research*, 7(3), 112-118

- Dauda, S. N., Ajayi, F., & Ndor, E. (2008). Growth and yield of water melon (*Citrullus lanatus*) as affected by poultry manure application. *Journal of Agriculture, Forestry and the Social Sciences*, 4, 121-127.
- Devkota, C., Bhattarai, B. P., Mishra, S. R., Ghimire, P., & Chaudhari, D. (2020). Effect of Integrated plant nutrient management on growth, yield and leaf nutrient status of broad leaf mustard (*Brassica juncea* var. *rugosa*). *Horticulture International Journal*, 4(3), 81.
- Elissen, H., Weide, R. v., & Gollenbeek, L. (2023). Effects of vermicompost on plant and soil characteristics – a literature overview. *Wageningen Research*, 11(3), 55-63.
- FAO (2018). The future of food and agriculture – Alternative pathways to 2050. Rome. Available online at: <https://www.fao.org/3/I8429EN/i8429en.pdf> (accessed on 5 July, 2023).
- FAO (2021). 2021 Industry Report: Mustard Greens report.
- Fatahi, E., Mobasser, H. R., & Akbarian, M. M. (2014). Effect of organic fertilizer on wet weight, dry weight and number of leaves in cowpea. *Journal of Applied Sciences*, 3(4), 440-443.
- Ghimire, A., Aryal, M., Karki, R., Dhital, D., Dahal M & Poudel A. (2023). Navigating the Economics of Production and Marketing of Tomatoes in Lalitpur, Nepal. *Global Scientific Journal*, 11(9), 160-168
- IFOAM. (2008). Definition of organic agriculture. Available online at: <https://www.ifoam.bio/why-organic/organic-landmarks/definition-organic> (accessed on 5 July, 2023).
- Lautt, B. S., Sulistiyanto, Y., Sakti, P. P., & Antang, E. U. (2020). Effects of Vermicompost and NPK Fertilizer to Growth and Yield of Mustard Plant (*Brassica Juncea* L.) on Tropical Peatlands. *Journal of Tropical Peatland*, 10(2), 1-10.
- Maurya, S., Pandey, M., Padhak, R., Verma, A. K., Ranjan, R., Pal, A., & Rajput, N. (2020). Integrated nutrient management of mustard (*Brassica juncea* L.) alluvial soil of Uttar Pradesh. *International Journal of Chemical Studies*, 8(1), 1386-1389.
- Meemken, E.-M., & Qaim, M. (2018). Annual Review of Resource Economics. *Organic Agriculture, Food Security, and the Environment*, 10, 39-63.
- MoALD (2020/21). Statistical Information on Nepalese agriculture 2077/78 (2020/21). Available online at: <https://moald.gov.np/wp-content/uploads/2022/07/Statistical-Information-on-Nepalese-Agriculture-2077-78.pdf> (accessed on 5 July 2023).
- Parajuli, A. (2015). Cultivation and management practices of leafy Vegetables in Nepal. Available online at: <https://parajulianish.wordpress.com/2015/02/13/cultivation-and-management-practices-of-leafy-vegetables-in-nepal/> (accessed on 5 July, 2023).
- Pekala, A. (2020). Market analysis of organic foods in the Nordic and Baltic countries. Available online at: <https://norden.diva-portal.org/smash/get/diva2:1386343/FULLTEXT01.pdf> (accessed on 5 July 2023).
- Raksun, A., Merta, I. W., Ilhamdi, M. L., & Mertha, G. (2022). The Effect of Vermicompost and NPK Fertilizer on Growth of Long Beans (*Vigna sinensis* L.). *Jurnal Penelitian Pendidikan Ipa*, 8(4), 1-10.
- Rauniyar, K., & Bhattarai, B. P. (2017). Growth, yield and oil nutrient status of broad leaf mustard (*Brassica juncea* var. *rugosa*) under integrated nutrient management. *Nepalese Journal of Agricultural Sciences*, 15, 101-102.
- Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants*, 2, 221-229.
- Ruangjanda, S., Iwai, C. B., Greff, B., Chang, S. W., & Ravindran, B. (2022). Valorization of spent mushroom substrate in combination with agro-residues to improve the nutrient and phytohormone contents of vermicompost. *National Center for Biotechnology Information*, 214(1), 1-10.
- Singh, K. P., & Bhandari, R. R. (2019). Vegetable Crops Production Technology (1st ed.). Samiksha Publication., pp. 1-10.
- SQCC. (2020). Notified and denotified varieties of different crops (1960-2013). Available online at: http://sqcc.gov.np/images/category/Notified_and_Denotified_Varieties_till_2077-04-26.pdf (accessed on 5 July 2023).
- Tuomisto, H., Hodge, I., Riordan, P., & Macdonald, D. (2012). Does organic farming reduce environmental impacts? – A meta-analysis of European research. *Journal Of Environmental Management*, 112, 309-320.
- Vaarst, M., & Alrøe, H. F. (2012). Concepts of Animal Health and Welfare in Organic Livestock Systems. *Journal of Agricultural and Environmental Ethics*, 25, 333-347.
- Wonder, B. (2023). Black Wonder 5000. Available online at: <https://blackwonder5000.com/> (accessed on 5 July 2023).

Publisher's note/Disclaimer: Regarding jurisdictional assertions in published maps and institutional affiliations, SAGENS maintains its neutral position. All publications' statements, opinions, and information are the sole responsibility of their respective author(s) and contributor(s), not SAGENS or the editor(s). SAGENS and/or the editor(s) expressly disclaim liability for any harm to persons or property caused by the use of any ideas, methodologies, suggestions, or products described in the content.