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Research article

Effects of Different Levels of Vermicompost on Black Rice (*Oryza sativa* L.) Cultivation

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Abstract: Given the growing need to address the challenges of black rice cultivation and the environmental impacts of synthetic fertilizers, this study seeks to evaluate the response of a black rice variety to different levels of vermicompost application. The development of organic farming would bring a healthier environment, safe for humans, and result in increased food production that addresses Sustainable Development Goals (SDGs) such as Life on Land (SDG 15) and Zero Hunger (SDG 2). The experiment was conducted using a Randomized Complete Block Design (RCBD) with four treatments, each replicated three times. The treatments were as follows: A–20 tons of vermicompost per hectare, B – 25 tons of vermicompost per hectare, C–30 tons of vermicompost per hectare, and D – inorganic fertilizer applied at a rate of 90-30-30 kg NPK per hectare. The results revealed no significant differences among the treatment means at all stages of plant growth, including growth indicators such as the number of tillers and plant height, as well as yield components, including panicle length, fresh and dry grain weight, and the number of filled and unfilled grains. These findings suggest that applying 20, 25, or 30 tons of vermicompost per hectare produces similar effects to using synthetic fertilizer. The study highlights the potential of vermicompost as a sustainable and environmentally friendly alternative to synthetic fertilizers for black rice cultivation, thereby reducing reliance on synthetic fertilizers that may have long-term adverse effects on soil health.

Keywords: Fertilizer management; nutrient management; organic fertilizer; vermiculture; sustainable farming

1. Introduction

Black rice (*Oryza sativa* L.), often referred to as "forbidden rice" due to its historical association with royalty in ancient China [1], has gained significance as a crop due to its exceptional nutritional and health benefits. Black rice is rich in anthocyanins, which possess a potent antioxidant property and are linked to a reduced risk of chronic illnesses, such as diabetes, heart disease, and cancer [2]. Its nutrient-dense profile, which includes essential amino acids, dietary fiber, vitamins, and minerals [3], makes it a popular choice among health-conscious consumers and a versatile ingredient in various food products. However, despite its increasing demand, black rice faces unique agronomic challenges that hinder its cultivation and productivity.

Black rice typically exhibits a tall phenotype and a long vegetative stage, which increases the risk of lodging and reduces productivity compared to white rice [4]. Furthermore, limited agronomic research has left farmers without optimal cultivation practices, further restricting their adoption and profitability [5]. The development of sustainable and effective practices to enhance black rice cultivation is imperative, not only to address these challenges but also to conserve its genetic and cultural heritage, which is at risk of erosion due to the dominance of high-yielding commercial varieties [6]. Current agricultural practices heavily rely on synthetic fertilizers to boost crop yields. While synthetic fertilizers may be effective in the short term, they contribute to numerous environmental and health issues, including soil degradation [7], water pollution [8], greenhouse gas emissions [9], and loss of biodiversity [10]. Additionally, these fertilizers often lead to soil acidification [11] and nutrient imbalances [12], diminishing long-term soil fertility. In the Philippines, where rice is a staple crop, the overuse of synthetic inputs poses serious risks to agricultural sustainability and food security [13].

In contrast, vermicompost offers a promising and sustainable alternative. Produced through the decomposition of organic matter by earthworms and microorganisms, vermicompost is rich in essential macro- and micronutrients, plant growth hormones, and beneficial microbes [14]. It enhances soil texture, aeration, and water retention while promoting plant growth and suppressing pests and diseases [15]. Studies in the Philippines have demonstrated the cost-effectiveness and productivity benefits of vermicompost [16], particularly in reducing reliance on synthetic fertilizers [16]and improving soil health [17]. Given the growing need to address the challenges of black rice cultivation and the environmental impacts of synthetic fertilizers, this study seeks to evaluate the response of a black rice variety to different levels of vermicompost application. The findings aim to provide evidence-based recommendations for sustainable cultivation practices that enhance black rice productivity while promoting environmental stewardship. This research contributes to the development of sustainable agricultural systems and supports the broader goals of food security, environmental conservation, and the preservation of traditional rice varieties.

This study was conducted to investigate the effects of varying vermicompost levels on black rice (Oryza sativa L.) cultivation, specifically in terms of growth and yield. Specifically, it aimed to determine the growth in terms of the number of tillers and height, as well as yield in terms of the length of the panicle, fresh and dry weight, and the number of filled and unfilled grains of black rice applied with different levels of vermicompost.

2. Materials and Methods

2.1 Vermicompost Production

For the preparation of vermicompost, a 30:1 ratio of carbon to nitrogenous sources was followed [24]. Carbon sources included rice straw, paper, and dried banana leaves, while nitrogenous sources comprised dried goat and cattle manure and leaves from nitrogen-fixing plants. These materials were shredded and allowed to decompose for 30 days. After this initial composting period, the material was fed to African Night Crawlers. Vermicompost was harvested after an additional 30 days of processing by the worms.

2.2 Black Rice Seedling Production and Research Design

Rice seedlings were produced using the "Dapog Method". The 12-day-old seedlings were then transplanted into the rice paddies at a spacing of 20 cm x 20 cm [19]. The experimental area, measuring 330 square meters (27.5 meters long and 12 meters wide), was laid out using a Randomized Complete Block Design (RCBD) with four treatments replicated three times. Each plot had dimensions of 2 meters x 5 meters with a 0.5-meter distance between plots. The treatments were as follows:

Treatment A: 20 tons of vermicompost per hectare
Treatment B: 25 tons of vermicompost per hectare
Treatment C: 30 tons of vermicompost per hectare
Treatment D: Commercial fertilizer (urea and T-14 at 90–30–30 kg NPK per hectare)

2.3 Data collection

Data were collected from ten representative samples marked 20 days after transplanting, except for the fresh and dry weight of grains, which were measured from all plants within the plot. *Growth Indicators*: Plant height was measured at 30, 60, and 110 days after transplanting, from the base of the plant to the tip of its tallest leaf [20]. The number of tillers was also counted at 30, 60, and 110 days after transplanting, based on the ten representative samples [21]. *Yield Components:* The length of the panicle was determined by measuring from its base to the tip and was recorded from ten representative samples [22]. Filled and unfilled grains were counted separately per panicle, using the same representative samples [23].

2.4 Statistical Analysis

All gathered data were recorded, tabulated, and analyzed using Analysis of Variance (ANOVA) for Randomized Complete Block Design through the Statistical Tool for Agricultural Research (STAR) version 2.0.1 [18].

3. Results and Discussion

3.1 Height of black rice at different stages of growth applied with different levels of vermicompost

The average height of black rice at 30, 60, and 110 days after transplanting is presented in Figure 1. Treatment A recorded mean heights of 46.98 cm, 100.80 cm, and 113.73 cm, respectively. Treatment B showed mean heights of 49.50 cm, 96.48 cm, and 112.43 cm. Treatment C had mean heights of 47.05 cm, 100.43 cm, and 113.43 cm. Finally, Treatment D achieved mean heights of 47.95 cm, 107.91 cm, and 122.27 cm. The height of black rice increased as the number of days lapsed, and it varied with the application of different rates of vermicompost and inorganic fertilizer. There was a rapid increase in plant growth from 30 days to 60 days after transplanting at all levels of vermicompost; the increase was more pronounced, as indicated by the overlapping of the lines. The range of increase in the height of the plants applied with inorganic fertilizer was wide, from 47.95 cm to 107.91 cm, from 30 to 60 days after transplanting, respectively, as evidenced by the wider gap between Treatment D (yellow line) and the rest of the treatments A, B, and C (blue, orange, and gray). From 60 to 110 days after transplanting, the rate of plant growth was already slow, as observed in all treatments. However, statistical analysis using analysis of variance for the Randomized Complete Block Design revealed that the differences among treatment means in terms of height at all stages of plant growth did not vary significantly at the 5% level of significance for black rice height. This means that the effects of 20, 25, and 30 tons of vermicompost are comparable to those of synthetic fertilizer at a rate of 90-30-30 kg NPK per hectare. Similar findings were observed, showing that vermicompost significantly enhanced rice seedling biomass, photosynthesis, and chlorophyll content, thereby promoting vigorous early-stage growth [25]. Likewise, vermicompost improves nutrient uptake and microbial activity, which are critical for vegetative development and plant height [26], [27]. Studies on combined applications further showed that vermicompost used with reduced chemical fertilizers can sustain strong vegetative growth while reducing chemical input [28], [29]. Evidence from other crops also aligns with these results. For instance, vermicompost has been shown to improve chlorophyll content and photosynthetic efficiency in spinach [30], while a similar study reported enhanced vegetative biomass in beans, even under water stress [31]. Additionally, vermicompost is beneficial in improving soil structure and root development, which supports plant height gains [32].

3.2 Number of Tillers of Black Rice at Different Levels of Vermicompost

The results showed that at 30 days after transplanting, the highest average number of tillers (4.00) was observed in black rice applied with 90-30-30 kg NPK per hectare. This was followed by those treated with 25 tons of vermicompost per hectare (3.47), 20 tons of vermicompost per hectare (3.37), and 30 tons of vermicompost per hectare (3.27). At 60 days after transplanting, black rice treated with 20 tons of vermicompost per hectare produced the highest average number of tillers (7.70), followed by 90-30-30 kg NPK per hectare (7.37), 30 tons of vermicompost per hectare (7.23), and 25 tons of vermicompost per hectare (6.60). 110 days after transplanting, the highest average number of productive tillers was recorded in black rice treated with 20 tons vermicompost per hectare (8.10), followed by 90-30-30 kg NPK per hectare (7.73), 30 tons vermicompost per hectare (7.43), and 25 tons vermicompost per hectare (6.90) (**Table 1**). Statistical analysis using Analysis of Variance (ANOVA) revealed no significant differences among treatment means at the 0.05 level of significance in the three-observation period. This means that the effects of 20, 25, and 30 tons of vermicompost are comparable to those of synthetic fertilizer at a rate of 90-30-30 kg NPK per hectare. These findings are consistent with the reports of other studies that observed vermicompost application in rice significantly enhanced the number of tillers per hill, particularly when used with reduced chemical fertilizer input [29], [33]. A similar study highlighted the role of vermicompost in promoting microbial activity and nutrient availability, resulting in improved shoot development and tiller production [26]. Additionally, improvements in chlorophyll content and photosynthesis under vermicompost treatment contribute to higher tillering capacity [25]. Moreover, the improvement in tiller number may also be attributed to better soil physical and chemical properties brought about by vermicompost [27], [32]. The increased availability of NPK and enhanced soil structure favor root branching and subsequent tiller initiation. This suggests that vermicompost can provide a sustainable alternative to inorganic fertilizers for maintaining tiller production in rice cultivation.

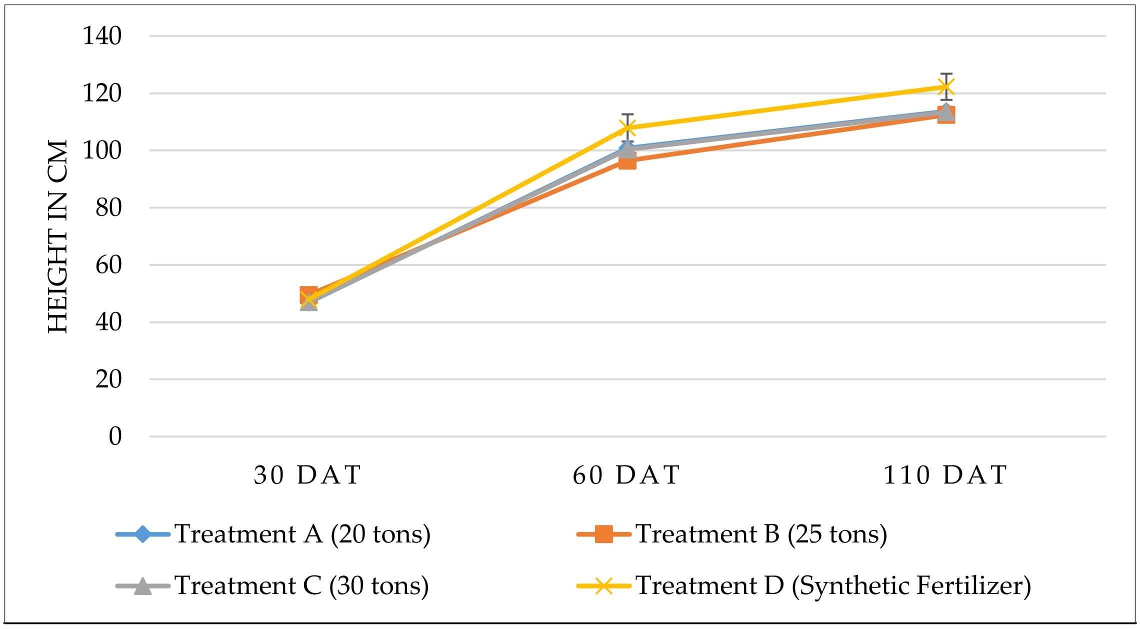

Figure 1. Height of the black rice at different stages of growth applied with different levels of vermicompost

Table 1. Number of tillers of black rice 30, 60, and 110 days after transplanting applied with different levels of vermicompost

Treatments	30 DAT	60 DAT	110 DAT
A – 20 t vermicompost/ha.	3.37 ± 0.41^{ns}	7.70 ± 0.85^{ns}	8.10 ± 1.71^{ns}
B – 25 t vermicompost/ha.	3.47 ± 0.25	6.60 ± 1.60	6.90 ± 1.99
C – 30 t vermicompost/ha.	3.27 ± 1.23	7.23 ± 0.81	7.43 ± 2.02
D – 90-30-30 kg NPK/ha.	4.00 ± 1.17	7.37 ± 1.76	7.73 ± 0.75

Values represent the mean ± standard deviation
^{ns}No Significant Difference ($p > 0.05$)

3.3 Yield Components of Black Rice at Different Levels of Vermicompost

The results showed that the average panicle length of black rice was highest in the 90-30-30 kg NPK per hectare treatment (22.17 cm), followed by applications of 20 tons vermicompost per hectare (21.43 cm), 30 tons vermicompost per hectare (21.31 cm), and 25 tons vermicompost per hectare (21.02 cm). The average number of filled grains per panicle was most significant in the treatment with 25 tons of vermicompost per hectare (72.75 grains), followed by 20 tons of vermicompost per hectare (70.28 grains), 30 tons of vermicompost per hectare (68.86 grains), and 90-30-30 kg NPK per hectare (61.55 grains). The average number of unfilled grains per panicle was highest in the 90-30-30 kg NPK per hectare treatment (57.75 grains), followed by 25 tons vermicompost per hectare (46.36 grains), 30 tons vermicompost per hectare (45.60 grains), and 20 tons vermicompost per hectare (44.98 grains). The fresh weight yield of black rice was highest in the 90-30-30 kg

NPK per hectare treatment (7.21 kg), followed by 20 tons vermicompost per hectare (6.92 kg), 30 tons vermicompost per hectare (6.67 kg), and 25 tons vermicompost per hectare (6.66 kg). The dry weight yield of black rice was highest in the treatment with 20 tons vermicompost per hectare (6.12 kg), followed by 90-30-30 kg NPK per hectare (5.71 kg), 30 tons vermicompost per hectare (5.59 kg), and 25 tons vermicompost per hectare (5.59 kg) (**Table 2**). Statistical analysis using the Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD) revealed no significant differences among treatment means at the 0.05 level for all measured components. This indicates that the application of vermicompost at any tested level is comparable to the 90-30-30 kg NPK per hectare treatment in terms of panicle length, filled and unfilled grain count, and both fresh and dry weight yields.

Similar studies reported that vermicompost application significantly improved panicle traits and yield in rice [29], [33]. Similarly, vermicompost enriched with beneficial microbes enhances nutrient uptake and grain filling, contributing to improved productivity [26]. Likewise, the integration of vermicompost with chemical fertilizers resulted in longer panicles and higher grain yield than chemical fertilizers alone [28]. Additionally, improved photosynthetic capacity under vermicompost application supports higher grain filling [25], while organic amendments improve soil conditions and nutrient availability, thereby favoring yield components [27], [32]. Similar yield-enhancing effects of vermicompost have also been reported in non-rice crops. A significant increase in pod number, seed number, and seed biomass was observed in beans treated with vermicompost [31], while potatoes and beets achieved higher yields with vermicompost compared to conventional compost [34]. In vegetables, the application of vermicompost produced substantial increases in both the fresh and dry yields of pepper [35] and resulted in higher tomato yields [36]. Likewise, the combined application of vermicompost enhanced yields in spinach, peas, and radish under reduced chemical fertilizer treatments [37].

4. Conclusions

Based on the results of the study, it is concluded that any level of vermicompost from 20 to 30 tons showed comparable results to black rice in terms of plant growth, both in the growth indicators, such as number of tillers and height and in yield components such as length of panicle, both fresh and dry weight of grains, and the number of filled and unfilled grains with the use of inorganic fertilizer at the rate of 90-30-30 kg NPK per hectare.

Table 2. Yield components of black rice applied with different levels of vermicompost

Treatments	Panicle Length (cm)	Number of Filled Grains per Panicle	Number of Unfilled Grains per Panicle	Fresh Weight (kg)	Dry Weight (kg)
A – 20 t vermicompost/ha.	21.43 ± 0.61^{ns}	70.28 ± 14.57^{ns}	44.98 ± 9.17^{ns}	6.92 ± 1.38^{ns}	6.12 ± 1.33^{ns}
B – 25 t vermicompost/ha.	21.02 ± 0.27	72.75 ± 10.86	46.36 ± 5.79	6.66 ± 0.76	5.5 ± 0.71
C – 30 t vermicompost/ha.	21.31 ± 0.11	68.86 ± 10.66	45.60 ± 3.76	6.67 ± 1.01	5.54 ± 0.3
D – 90-30-30 kg NPK/ha.	22.17 ± 1.04	61.55 ± 4.53	57.75 ± 7.52	7.21 ± 0.76	5.71 ± 1.17

Values represent the mean ± standard deviation

^{ns}No Significant Difference ($p > 0.05$)

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