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Effects of vermicompost on growth and yield of Japonica rice (Koshihikari Var.) in Thailand

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Abstract Significant differences were observed in plant height, number of tillers, and chlorophyll content. The 10% vermicompost treatment resulted in the tallest plants at 88 days. The combined vermicompost and chemical fertilizer treatment (T8) produced the highest number of tillers, though it did not differ significantly from the 20% vermicompost treatment (T4). Over time, vermicompost-amended treatments outperformed chemical fertilizer alone in most growth and yield parameters. Treatment 5 yielded the highest total seed count, while T4 resulted in the healthiest seeds and the greatest total fresh and dry seed weights. T4 also had the widest, longest, and thickest seeds, with a fivefold increase in total dry seed weight compared to the control. These findings strongly supported the application of vermicompost particularly at 10–30% for improved Japonica rice growth and yield, highlighting its potential for organic production systems.

Keywords: Japanese rice, Rice yield, Vermicompost, Organic farming

Introduction

Rice is the staple food for over half of the global population, with more than 90% of the world's rice production and consumption occurring in Asia (Duwayri *et al.,* 2024). Thailand and Vietnam are consistently ranked among the top three (IRRI, 2024). By 2025, global demand for paddy rice is expected to reach 760 million tons, representing a 35% increase over the 1996 baseline. In response, many farmers have resorted to using high amounts of chemical fertilizers and pesticides to maximize productivity. However, this intensive use of chemical inputs has led to numerous ecological and health concerns. Runoff of fertilizers into water bodies contributes to water pollution and eutrophication, while excessive pesticide use threatens biodiversity and affects the health of both producers and consumers (Benchamaporn *et al*., 2021). These challenges call for more sustainable and environmentally friendly agricultural practices. Thailand, a leading rice exporter, is also seeing growing domestic and international demand

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for high-quality rice, including Japonica rice. This short-grain variety is particularly favored by Japanese consumers for its taste and texture. Due to the increasing number of Japanese restaurants across Thailand, over 2,000 nationwide, with two-thirds located in Bangkok, the demand for Japonica rice has grown rapidly (Miyamoto, 2017). In fact, Thailand ranks fifth globally in the number of Japanese restaurants (Nakwilai *et al.,* 2020), which confirms the increasing preference for this rice type. Among the Japonica varieties, Koshihikari is one of the most desirable due to its superior grain quality and taste. While the demand for Japonica rice is growing, research on its cultivation under Thai conditions especially under organic or low-input systems remains limited. Most Japonica rice in Thailand is produced using conventional farming methods that rely on chemical fertilizers. However, the Thai government is increasingly promoting Good Agricultural Practices (GAP) to enhance food safety, reduce non-tariff trade barriers, and safeguard farmer livelihoods. Nonetheless, the adoption of GAP is still inconsistent across regions (Jourdain *et al*., 2017). One promising strategy for sustainable rice cultivation is the use of vermicompost a nutrient-rich organic fertilizer derived from the decomposition of organic waste by earthworms, particularly *Eisenia fetida*. Vermicomposting is not only an efficient waste management solution but also enhances soil fertility, microbial activity, and water retention capacity. Vermicompost is known to improve plant germination, growth, and yield while also providing natural plant hormones and enzymes that promote plant health (Manaig, 2016). Unlike chemical fertilizers, vermicompost does not degrade soil structure and can even suppress certain soil-borne diseases (Edwards and Arancon, 2004). Studies have reported that the use of vermicompost can boost plant growth by 50–100% compared to traditional compost and by 30–40% compared to chemical fertilizers. Previous research supports the benefits of vermicompost across various crops. For instance, Kumari and Kumari (2002) found that vermicompost enriched with rock phosphate significantly improved yield parameters in cowpea. Similarly, Tak (2003) reported yield enhancement in green gram when treated with vermicompost. Although such benefits are widely recognized, few studies have been conducted specifically on Japonica rice grown in Thailand, and even fewer under organic or vermicompost-based systems. A study by Nabheerong *et al.* (2005) demonstrated that Japonica rice grown in Uttaradit Province produced higher yields than in other regions of Thailand, suggesting this region is suitable for its cultivation. Furthermore, Nakwilia *et al.* (2020) highlighted the adaptability of Japonica varieties across multiple Thai locations, with minor differences in yield based on genotype and location. However, these studies focused on varietal adaptation and did not evaluate the impact of organic fertilizers. Given the growing demand for Japonica rice and the urgent need for environmentally sustainable production methods, there is a clear gap in research addressing how vermicompost application influences the growth and yield of Japonica rice under Thai agroecological conditions. By integrating organic waste recycling with rice cultivation, vermicompost use could support both environmental sustainability and agricultural productivity. Therefore, the objective was to evaluate the effects of various vermicompost application rates on the growth characteristics and yield components of Japonica rice in Uttaradit, Thailand.

Materials and methods

The experiment was conducted from June to December 2022 at the Faculty of Agriculture, Uttaradit Rajabhat University, located in Uttaradit Province, lower northern Thailand. The influence of vermicompost application rates on the growth and yield of Japonica rice under controlled pot conditions was investigated. A completely randomized design (CRD) was used, comprising eight treatments with three replications each, totaling 24 experimental units. The Japanese rice was cultivated in 12-liter plastic pots, each filled with 10 kg of soil mixed with vermicompost according to the designated treatment. The treatments were as follows, T1: Control (Soil only), T2: Soil + chemical fertilizer (1.5 g/pot of 15-15-15), T3: Soil + 10% vermicompost, T4: Soil + 20% vermicompost, T5: Soil + 30% vermicompost, T6: Soil + 40% vermicompost, T7: Soil + 50% vermicompost, T8: Soil + 25% vermicompost + chemical fertilizer (1.5 g/pot of 15-15-15). The vermicompost used in the study was produced using *Eisenia fetida* earthworms fed with cow dung as the organic substrate. Japonica rice seedlings were raised in a seedbed and transplanted at 20 days of age into pots, one plant per pot. Pots were maintained under flooded conditions with water levels held at 5 cm throughout the cultivation period. Treatments T2 and T8 received chemical fertilizer one week after transplanting. Regular weeding and water management were performed to ensure uniform growth across all pots. No chemical pesticides were applied, in line with the organic nature of the experiment. Data were collected at regular intervals to assess rice growth and yield performance. The following parameters were measured. Plant growth indicators, stem height (cm) measured at 10-day intervals from day 27 to 88. Number of tillers per plant counted at intervals during vegetative and reproductive stages. Leaf length and width measured on the flag leaf. Chlorophyll content measured using a SPAD-502 chlorophyll meter. Yield components including, number of total grains per panicle, number of filled grains, grain dimensions (width, length, and thickness), total seed weight (fresh and dry), 100-seed weight (fresh and dry). Grain samples were oven-dried at 70°C for 72 hours before determining dry weights. The collected data were analyzed using analysis of variance (ANOVA) with SPSS software. Treatment means were compared using Duncan's New Multiple Range Test (DMRT) at a 5% significance level.

Results

Growth of Japonica rice

Significant differences in stem height were observed among treatments throughout the growth stages (Table 1). At 88 days after transplanting, the tallest plants were found in T3 (80.47 cm), followed by T4 (77.83 cm) and T8 (76.90 cm), all of which received vermicompost. The control treatment (T1) produced the shortest plants across all time points. Statistical analysis indicated significant differences ($P < 0.05$ or $P < 0.01$) at multiple intervals, especially on days 27, 32, 53, 81, and 88 (Table 1).

The number of tillers per plant varied significantly among treatments, particularly during the reproductive stages. The highest tiller numbers were observed in T8 (6.67 tillers at day 88), followed by T4 and T5 (6.00). These values were significantly greater than the control (3.33). Treatments with higher vermicompost percentages generally resulted in increased tillering (Table 2).

Table 1. Stem height (cm) of Japonica rice at different days after planting

	day27	day32	day46	day53	day60	day67	day74	day81	day88
T1	24.73 ± 1.87^{abc}	39.83 ± 1.39^{a}	46.60 ± 0.36	47.17 ± 1.76^{a}	50.90 ± 0.70	52.93 ± 2.76	56.23 ± 1.94	59.90 ± 1.85^{c}	66.23 ± 1.80^{c}
T2	29.57 ± 1.72^{ab}	43.40 ± 1.13^{a}	48.63 ± 2.73	47.73 ± 3.67^{a}	53.73 ± 7.21	57.33 ± 2.52	60.67 ± 4.31	64.57 ± 4.02^{bc}	71.50 ± 2.29^{bc}
T3	22.80 ± 1.65^{c}	33.17 ± 0.84^{b}	42.03 ± 2.83	44.53 ± 1.34^{ab}	50.27 ± 2.27	58.17 ± 2.28	62.60 ± 2.46	73.00 ± 1.73^{a}	80.47 ± 1.29^{a}
T4	25.47 ± 3.93^{abc}	40.90 ± 7.09^{a}	43.07 ± 7.27	44.90 ± 4.07^{ab}	50.87 ± 0.31	58.07 ± 1.84	60.20 ± 0.26	70.07 ± 2.34^{ab}	77.83 ± 4.19^{ab}
T5	30.30 ± 6.90^{a}	42.00 ± 4.55^{a}	47.23 ± 3.68	45.87 ± 2.37^{a}	53.37 ± 0.42	60.40 ± 1.93	64.83 ± 6.71	67.53 ± 5.82^{ab}	75.03 ± 5.74^{ab}
T6	21.00 ± 0.78^{c}	32.83 ± 3.84^{b}	39.33 ± 4.57	40.47 ± 2.59^{b}	51.40 ± 2.62	54.27 ± 4.53	57.63 ± 10.6	67.90 ± 5.81^{ab}	73.93 ± 8.41^{ab}
T7	21.77 ± 0.71^{c}	32.30 ± 2.43^{b}	44.80 ± 4.63	43.57 ± 1.40^{ab}	53.37 ± 0.78	60.10 ± 1.90	60.73 ± 1.62	65.97 ± 1.97^{bc}	75.43 ± 1.90^{ab}
T8	23.77 ± 2.76^{bc}	32.80 ± 2.05^{b}	41.53 ± 1.55	42.97 ± 0.84^{ab}	55.27 ± 1.72	58.10 ± 3.42	62.27 ± 0.64	67.63 ± 1.46^{ab}	76.90 ± 0.66^{ab}
F-test	*	**	ns	*	ns	ns	ns	*	*
CV(%)	12.77	9.50	9.01	5.59	5.57	4.85	8.01	5.31	5.51

1/ Data in the table were averaged ± standard error (n=3), ns,*, **, =non-significant, significant at $P< 0.05$, significant at $P< 0.01$, respectively. Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Table 2. Number of tillers per plant at different days after planting

	day39	day46	day53	day60	day67	day74	day81	day88
T1	1.67±0.58	3.33±0.58	4.33±1.15^{cd}	4.67±0.58^{bc}	3.67±0.58^{c}	3.67±1.15	3.67±0.58^{c}	3.33±0.58
T2	1.67±1.15	3.33±0.58	5.00±1.00^{bcd}	6.00±2.00^{ab}	5.67±1.53^{ab}	5.00±1.00	4.67±0.58^{bc}	4.33±0.58
T3	1.33±0.58	3.67±0.58	5.33±0.58^{abc}	5.33±0.58^{abc}	5.33±0.58^{abc}	6.33±1.15	5.33±0.58^{abc}	5.33±0.58
T4	2.33±0.58	4.00±0.00	6.00±1.00^{ab}	5.67±1.15^{abc}	5.67±0.58^{ab}	5.67±0.58	6.00±1.00^{ab}	6.00±1.00
T5	1.00±0.00	3.00±0.00	4.33±0.58^{cd}	4.33±0.58^{bc}	5.00±1.73^{bc}	5.00±1.73	5.67±1.15^{ab}	6.00±1.73
T6	1.00±0.00	2.67±0.58	4.33±0.58^{cd}	4.33±0.58^{bc}	4.33±0.58^{bc}	4.67±0.58	5.33±1.53^{abc}	6.00±2.65
T7	1.00±0.00	3.33±0.58	3.67±0.58^{d}	4.00±0.00^{c}	5.00±0.00^{bc}	5.00±0.00	5.00±0.00^{bc}	5.33±0.58
T8	1.67±0.58	3.33±0.58	6.67±0.58^{a}	7.00±1.00^{a}	7.00±1.00^{a}	6.33±1.15	7.00±1.00^{a}	6.67±0.58
F-test	ns	ns	**	*	*	ns	*	ns
CV(%)	39.57	15.00	15.94	18.94	18.79	19.98	17.11	23.41

[1/] Data in the table were averaged ± standard error (n=3), ns,*, **, =non-significant, significant at P< 0.05, significant at P< 0.01, respectively. Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Leaf dimensions

The length and width of leaves were significantly influenced by the treatments. T3 (10% vermicompost) produced the longest leaves during the early stages (days 39–53), while T8 (vermicompost + chemical fertilizer) produced the longest leaves on day 81. Leaf width at day 88 was highest in treatments with vermicompost, particularly T5, T4, and T6, all significantly greater than the control (Tables 3 and 4).

Table 3. Effect of treatments on leaf length of Japonica rice (cm) at different growth stages

	day32	day39	day46	day53	day60	day67	day74	day81	day88
T1	14.80±0.75	31.53±2.59^{ab}	28.60±2.55^{bc}	28.37±2.76^{a}	19.50±1.04	28.40±3.34	32.40±0.79	33.67±2.02^{cd}	34.20±2.78
T2	17.83±2.83	33.67±1.76^{a}	34.80±2.52^{a}	21.87±4.51^{bc}	29.00±1.71	30.57±2.77	33.70±6.76	34.90±2.72^{bcd}	34.87±2.51
T3	14.43±1.66	19.37±1.21^{d}	23.70±2.43^{c}	20.87±2.50^{bcd}	28.17±2.20	29.17±1.76	34.07±3.00	36.73±2.53^{abc}	38.33±1.22
T4	16.70±5.51	25.60±3.44^{abcd}	25.13±2.57^{bc}	24.67±2.47^{ab}	22.53±4.20	29.53±0.93	35.20±1.31	36.53±1.36^{abc}	36.10±0.66
T5	18.90±4.33	32.13±1.86^{ab}	30.43±2.67^{ab}	17.57±2.69^{cde}	23.90±5.00	29.53±1.38	36.23±4.53	38.30±1.18^{a}	37.10±2.19
T6	12.07±2.07	25.07±5.97^{bcd}	24.47±3.56^{c}	16.67±1.04^{de}	24.37±2.85	29.07±3.64	33.67±3.01	37.07±0.60^{ab}	34.90±3.26
T7	14.60±1.15	29.70±7.69^{abc}	24.33±5.39^{c}	16.17±0.29^{e}	25.63±0.91	28.73±3.76	39.43±6.26	36.53±0.61^{abc}	38.30±1.57
T8	14.80±1.00	23.10±5.96^{cd}	24.03±1.17^{c}	15.93±0.60^{e}	25.63±1.86	33.20±2.43	32.33±1.04	32.50±1.42^{d}	34.97±3.35
F-test	ns	**	**	**	ns	ns	ns	**	ns
CV(%)	18.67	16.09	11.41	12.21	11.38	9.04	11.50	4.83	6.58

[1/] Data in the table were averaged ± standard error (n=3), ns,*, **, =non-significant, significant at P< 0.05, significant at P< 0.01, respectively. Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Table 4. Effect of treatments on leaf width of Japonica rice (cm) at different growth stages

	day27	day32	day39	day46	day53	day60	day67	day74	day81	day88
T1	0.33±.06	0.57±.06	0.80±.17	0.97±.06	0.93±.06	0.90±.10	0.97±.06	1.03±.06	1.07±.06	0.97±.06^{b}
T2	0.37±.06	0.67±.12	0.87±.12	0.97±.06	1.00±.00	1.00±.00	1.00±.10	1.07±.06	1.13±.12	1.10±.10^{a}
T3	0.33±.06	0.50±.00	0.67±.06	0.90±.10	0.93±.06	1.00±.00	0.97±.06	1.10±.10	1.17±.06	1.13±.06^{a}
T4	0.43±.23	0.53±.21	0.77±.15	1.00±.20	0.97±.06	1.03±.06	1.03±.06	1.07±.06	1.10±.10	1.13±.06^{a}
T5	0.40±.10	0.63±.15	0.93±.23	1.00±.10	0.97±.06	1.00±.00	1.03±.06	1.10±.00	1.13±.06	1.10±.00^{a}
T6	0.37±.12	0.40±.10	0.63±.15	0.80±.10	0.87±.12	0.97±.06	1.00±.00	1.07±.06	1.13±.06	1.13±.06^{a}
T7	0.50±.10	0.53±.06	0.73±.12	0.93±.12	0.87±.06	0.97±.06	1.03±.06	1.17±.06	1.17±.06	1.17±.06^{a}
T8	0.33±.06	0.53±.06	0.73±.12	0.97±.06	1.00±.00	1.07±.06	1.10±.00	1.17±.06	1.13±.06	1.13±.06^{a}
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
CV(%)	28.58	20.07	19.35	11.63	6.72	5.52	5.39	5.77	6.26	5.71

[1/] Data in the table were averaged ± standard error (n=3), ns,*, **, =non-significant, significant at P< 0.05, significant at P< 0.01, respectively Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Chlorophyll content

Chlorophyll content, measured in SPAD units, varied significantly across treatments and growth stages of Japanese rice. The results found that significant differences among treatments at multiple growth stages (days 32, 46, 53, 74, 81, and 88), while days 39, 60, and 67 showed no significant variation. At the early growth stage (Day 32–Day 46): On day 32, T4 recorded the highest SPAD value (33.77 ± 0.6), significantly greater than T3 and T8 (both < 27 SPAD units). By day 46, T8 showed a marked increase (42.87 ± 0.5), significantly outperforming other treatments, while T2 and T7 remained below 34 SPAD units. Significant differences were observed on days 32 and 46 ($P < 0.01$), indicating early-stage sensitivity to treatment effects. At middle growth stage (Day 53–Day 67): T8 continued to show superior chlorophyll content on day 53 (47.10 ± 1.5), followed closely by T3 and T4. From day 60 to day 67, SPAD values across treatments converged, with no significant differences detected, suggesting a plateau in chlorophyll accumulation. At the late growth stage (Day 74–Day 88): On day 74, T5 recorded the highest SPAD value (39.13 ± 1.5), while T8 dropped sharply to 29.50 ± 1.1, indicating a potential decline in chlorophyll retention. By day 88, T5 and T8 rebounded to peak values above 42 SPAD units, significantly higher than T1 (31.30 ± 2.8). Significant treatment effects were observed on days 74, 81, and 88 ($P < 0.01$ and $P < 0.05$), highlighting late-stage variability (Table 5).

Table 5. Effect of different treatments on chlorophyll content (SPAD Units) of Japonica rice across growth stages

	day32	day39	day46	day53	day60	day67	day74	day81	day88
T1	31.10±2.6^{ab}	33.73±1.9	37.40±1.2^{bc}	35.97±1.7^{d}	38.37±2.9	35.23±1.6	30.93±0.6^{bc}	28.43±1.8^{e}	31.30±2.8^{b}
T2	32.97±2.3^{ab}	33.73±1.7	34.07±0.6^{c}	41.37±1.6^{b}	39.93±1.8	39.33±0.8	32.43±1.1^{b}	31.73±2.9^{cde}	37.10±3.9^{a}
T3	26.67±2.6^{c}	32.60±0.9	39.70±5.9^{ab}	41.87±0.70^{b}	41.83±3.5	39.83±2.3	36.93±2.1^{a}	38.17±3.0^{ab}	39.17±3.7^{a}
T4	33.77±0.6^{a}	34.20±1.7	40.93±0.8^{ab}	41.03±0.9^{bc}	42.20±1.3	41.77±5.7	36.70±0.7^{a}	34.97±1.7^{bcd}	41.93±1.8^{a}
T5	29.17±1.2^{bc}	33.77±2.3	37.30±1.6^{bc}	39.00±0.9^{c}	41.87±0.6	41.50±0.2	39.13±1.5^{a}	35.50±2.9^{bc}	42.20±1.6^{a}
T6	29.90±2.2^{abc}	31.43±1.2	39.30±2.2^{ab}	40.20±1.3^{bc}	42.10±1.5	41.33±3.9	37.50±1.6^{a}	39.63±0.4^{a}	40.10±0.9^{a}
T7	29.33±1.2^{bc}	32.27±1.8	33.83±2.4^{c}	38.77±1.1^{c}	41.57±0.8	41.50±1.7	37.23±1.7^{a}	36.13±1.1^{ab}	40.20±4.6^{a}
T8	26.93±3.1^{c}	34.70±1.9	42.87±0.5^{a}	47.10±1.5^{a}	43.10±0.7	38.20±0.3	29.50±1.1^{c}	31.37±1.9^{de}	40.23±4.6^{a}
F-test	**	ns	**	**	ns	ns	**	**	*
CV(%)	7.13	5.08	6.64	3.09	4.65	6.76	3.92	6.26	8.43

[1/] Data in the table were averaged ± standard error (n=3), ns,*, **, =non-significant, significant at P< 0.05, significant at P< 0.01, respectively. Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Yield components of japonica rice

Grain characteristics, grain width, length, and thickness varied significantly among treatments. The highest seed width was recorded in T4 (3.99 mm), followed by T5 and T6. T4 also had the longest seeds (7.34 mm), while the thickest seeds were observed in T2 (2.43 mm), followed by T4 (2.33 mm). The control (T1) produced the smallest grains in all dimensions. Grain count and quality, the total number of seeds per plant was highest in T5 (191.50), followed by T4 (172.00) and T6 (162.66). The number of filled seeds followed a similar trend, with T4 (151.66) outperforming all other treatments, indicating improved seed development (Table 6).

Table 6. Grain morphology and seed quality of Japonica rice under different treatments

	width (mm)	length(mm)	thickness(mm)	total seed(no.)	filled seed(no.)
T1	3.40±.16^{b}	6.34±0.23^{c}	2.29±0.13^{b}	111.44±27.92^{c}	75.11±16.33^{bc}
T2	3.66±.10^{ab}	6.61±0.34^{bc}	2.43±0.07^{a}	109.66±24.19^{c}	70.66±18.50^{c}
T3	3.67±.16^{ab}	7.02±0.19^{ab}	2.22±0.06^{b}	143.00±9.00^{abc}	117.33±6.42^{ab}
T4	3.99±.13^{a}	7.34±0.59^{a}	2.33±0.02^{ab}	172.00±22.11^{ab}	151.66±18.44^{a}
T5	3.71±.07^{ab}	7.14±0.09^{ab}	2.23±0.07^{b}	191.50±0.70^{a}	144.5±17.67^{a}
T6	3.74±.13^{ab}	6.97±0.17^{ab}	2.24±0.06^{b}	162.66±50.06^{abc}	142.66±41.42^{a}
T7	3.68±.25^{ab}	7.13±0.42^{ab}	2.28±0.05^{b}	155.33±7.76^{abc}	127.66±12.22^{a}
T8	3.40±.16^{a}	7.14±0.22^{ab}	2.26±0.05^{b}	126±34.00^{bc}	116.00±34.00^{ab}
f-test	**	*	*	*	**
CV(%)	16.78	22.95	11.29	72.97	78.00

[1/] Data in the table were average ± standard error (n=3), ns,*, **, =non-significant, significant at P< 0.05, significant at P< 0.01, respectively Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Seed weight, significant differences were found in total fresh and dry seed weights among treatments. The highest total dry weight was obtained from T4 (21.36 g), followed by T3 and T5. Similarly, 100-seed dry weights were highest in T4 (2.53 g), T3 (2.48 g), and T8 (2.47 g). The control treatment yielded the lowest values for all seed weight parameters (Table 7).

Table 7. Comparative analysis of fresh and dry weights in Japonica rice seeds

	total fresh weight(g)	total dry weight(g)	100 seeds fresh weight(g)	100 seeds dry weight(g)
T1	3.61+1.5^{d}	3.58+1.5^{d}	2.08+0.2^{b}	2.17+0.16^{c}
T2	8.88+3.31^{c}	8.74+3.32^{c}	2.41+0.13^{a}	2.38+0.12^{ab}
T3	16.05+3.01^{b}	15.84+3.02^{b}	2.47+0.04^{a}	2.48+0.08^{ab}
T4	21.61+3.39^{a}	21.36+3.28^{a}	2.42+0.05^{a}	2.53+0.05^{a}
T5	14.27+4.31^{bc}	14.08+4.27^{b}	2.27+0.11^{ab}	2.29+0.09^{bc}
T6	13.48+2.77^{bc}	13.37+2.75^{bc}	2.35+0.13^{a}	2.41+0.12^{ab}
T7	12.99+1.6^{bc}	12.81+1.57^{bc}	2.41+0.2^{a}	2.48+0.01^{ab}
T8	14.1+2.02^{bc}	13.93+2.04^{bc}	2.49+0.05^{a}	2.47+0.01^{ab}
f-test	**	**	*	**
CV(%)	82.03	82.37	21.81	15.85

[1/] Data in the table were averaged ± standard error (n=3), ns,*, **, =non-significant, significant at P< 0.05, significant at P< 0.01, respectively. Mean in the columns followed by different letter are significantly different at P = 0.05(DMRT)

Discussion

The results demonstrated that soil amended with vermicompost significantly influenced the growth and yield of Japonica rice. Key growth parameters including stem height, number of tillers, leaf width and length, and chlorophyll content showed statistically significant improvements. Yield components such as seed quantity and seed weight were also positively affected. These findings are consistent with previous research on vermicompost application across various crops. Kumari and Kumari (2002) reported that enriched vermicompost significantly enhanced root-shoot ratios and yield attributes in cowpea, including the number of pods per plant, seeds per pod, and 100-seed weight. Similarly, Todawat *et al.* (2017) found that applying vermicompost at 7.5 t/ha improved both grain and seed yield in green gram compared to control treatments. Chamani *et al.* (2008) and Atiyeh *et al*. (2000) emphasized the potential of vermicompost as a plant growth medium and soil amendment, noting its distinct advantages over traditional composts due to differences in nutrient profiles and microbial communities. In our study, rice grown with varying ratios of vermicompost exhibited significant differences in stem height, tiller number, and leaf morphology. These results align with Jadhav *et al*. (1996), who concluded that vermicompost could substitute up to 50% of urea-N in rice cultivation. Talashikar and Dosani (2008) also highlighted the flexibility of vermicompost application across crops and developmental stages, supporting our observation that rice responded well to different vermicompost levels throughout its growth cycle. Leaf length showed highly significant differences between days 39 to 53 and again at day 81, with the 10% vermicompost treatment producing the longest leaves during early growth. Leaf width was significantly different at day 88. Interestingly, while vermicompost combined with chemical fertilizer yielded the longest leaves, the difference was not statistically significant compared to other treatments, except the control. Chlorophyll content varied across treatments and growth stages. The highest chlorophyll value was recorded at day 40 in the 20% vermicompost treatment (T4). At day 60, chemical fertilizers had the most pronounced effect on chlorophyll content. By day 88, chlorophyll levels across treatments including vermicompost and chemical fertilizer did not differ significantly, except in the control group. These findings are consistent with Sushree and Vikramreddy (2009), who observed a gradual increase in chlorophyll content with higher vermicompost doses. Their study reported chlorophyll levels six times higher in vermicompost-treated plants compared to compost-treated ones, and nine times higher than those grown in untreated soil. Recent studies further support the role of vermicompost in enhancing rice growth. Ruan *et al*. (2021) found that vermicompost significantly improved seedling vigor, chlorophyll content, and antioxidant enzyme activity in fragrant rice. Iqbal *et al.* (2024) demonstrated that vermicompost not only enhanced grain yield but also reduced cadmium uptake in contaminated soils, highlighting its role in stress mitigation. Mindalisma *et al.* (2023) showed that vermicompost improved productive tillers and milled dry weight in upland rice grown on marginal soils. Ghosh *et al.* (1996) attributed improved rice yields to enhanced soil physical and chemical properties facilitated by earthworm activity. Their findings support our result that the 20% vermicompost treatment (T4) produced the highest yield. Subler *et al.* (1998) similarly recommended vermicompost concentrations between 10% and 20% for optimal plant growth, cautioning that higher concentrations may not yield additional benefits. Edwards (2004) further explained that even small amounts of vermicompost can significantly promote plant growth due to bioactive compounds such as humic acids, auxins, gibberellins, and cytokinins. Jianwitchayakul and Somniyam (2021) demonstrated that combining vermicompost (500 kg/rai) with chemical fertilizer (46-0-0 at 25 kg/rai) significantly enhanced tiller number, panicle formation, and rice yield. Our study also observed reduced plant disease incidence in vermicompost-treated plots, with 100% disease occurrence in the control group (data not shown). This supports Edwards and Arancon (2004), who found that certain commercial vermicomposts can suppress plant diseases. Wonglom *et al.* (2024) further developed Trichoderma-bioenriched vermicompost, which reduced sheath blight and enhanced defense responses in Thai rice. Yatoo *et al.* (2021) reviewed mechanisms of disease suppression, including microbial antagonism and induced systemic resistance. Regional suitability also plays a role in Japonica rice performance. Nakwilai *et al*. (2020) found that Japonica rice grows well across different Thai regions, with Phan district outperforming Khampang Saen in terms of yield. Nabheerong *et al*. (2005) reported higher Japonica rice yields in Uttaradit Province, recommending cultivation in the lower northern region using GAP or intensive practices. Chuleemas and Ajcharawadee (2017) applied vermitechnology to rehabilitate salt-affected soils in Northeast Thailand, improving rice growth and soil health. Overall, the T4 treatment (20% vermicompost) consistently produced the highest growth and yield metrics. These findings suggest that organic Japonica rice cultivation using vermicompost is both agronomically effective and economically viable. Vermicompost not only enhances plant growth and yield but also improves soil health, reduces disease incidence, and supports environmentally sustainable farming practices addressing broader concerns related to climate change and ecological resilience.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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