J Agric Rural Dev Volume15(1&2):19-28, December 2023 *ISSN 1810-1860*

SCHOOL OF AGRICULTURE AND RURAL DEVELOPMENT
কৃষি ও পল্লী উন্নয়ন স্কুল

JARD
Journal of Agriculture & Rural Development

Effect of seed priming and vermicompost on growth and yield of wheat

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ABSTRACT

The aim of this research was to investigate the integrated effect of priming along with vermicompost on growth and yield of wheat. The three priming agents viz. 2% KCl, 1.0% KNO3 and 10% polyethylene glycol (PEG) 6000; and three doses of vermicompost viz. 150, 300 and 500 g/pot were used in this experiment. The hydropriming and without vermicompost were used as their respective controls in the individual experiment of priming and vermicompost, respectively. Seeds were pre-treated with the priming agents for 24 h before being sown in pots amended with varying doses of vermicompost. Data on plant height, leaf area, chlorophyll content, and absolute growth rate (AGR) were recorded at different intervals after sowing. Vermicompost was significantly influenced plant height and leaf area, with 300 and 500 g treatments consistently yielding the highest values across various intervals. Priming agents, particularly 2% KCl, consistently produced taller plants with larger leaf areas. The combined effect of 500 g vermicompost and 2% KCl exhibited superior results in plant height and leaf area. Chlorophyll content varied with different doses of vermicompost, and 2% KCl consistently produced the highest values. The AGR was notably higher in treatments with 500 g vermicompost and 2% KCl priming, indicating enhanced crop development. The combination of 500g vermicompost and 2% KCl proved to be particularly effective, resulting in a high number of spikes and tillers, the highest grain weight, and an improved 100-grain weight. These findings highlighted that the potential of combining 500 g vermicompost and 2% KCl priming as a sustainable strategy to improve wheat growth, productivity, and yield.

Key words: seed priming, vermicompost, wheat, crop growth, yield

INTRODUCTION

An essential cereal crop, wheat is cultivated worldwide and is scientifically known as *Triticum aestivum* L. It is a member of the Poaceae family and ranks second, followed by rice. Increasing agricultural production per acre basis in Bangladesh is becoming the most crucial step to deal with the country's current population growth rate. Wheat can be a valuable additive to rice and is essential for feeding this enormous population. The lack of plant nutrients, uneven germination, weed competition, insect attack, disease infection, and irrigation water are among the most significant factors causing low grain yield in wheat.

Multiple studies have documented its ability to enhance germination speed, promote uniform seedling stands, and stimulate early plant development (Khan *et al*., 2008; Khalil *et al*., 2010). These findings suggest that priming could be a powerful tool for optimizing crop performance, profitability and stress resistance. Rapid emergence and seedling establishment are essential for the production of high-quality grains. Uneven or poor germination followed by inhomogeneous seedling growth can cause significant financial losses by reducing different mechanization possibilities or lower prices for inhomogeneous plant samples (Ghiyasi *et al*. 2008a). Seed priming accelerates the establishment of many crops such as maize, wheat, rice, and canola (Ghiyasi *et al.*, 2008a, b). It is a highly efficient technique that helps optimize the timing and minimize the gap

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between sowing seeds and the emergence of seedlings. The use of various solutions such as potassium pyrophosphate (KH_2PO_4), monobasic, polyethylene glycol (PEG), and potassium chloride (KCL) has shown promising results in improving wheat germination, emergence, growth, and grain production. Good soils should have more than 3.5% organic matter; while the most soils in Bangladesh contain less than 1.7% organic matter, even less than 1% in some cases. Vermicompost is a nutrient-rich organic fertilizer with a balanced blend of nitrogen, potassium, phosphorus, and micronutrients. The most recent research on the role of earthworms in organic waste breakdown has focused on the finished product known as vermicompost.

The large-scale use of compost is an excellent way to increase soil organic matter content, which is essential for long-term fertility (Lal, 2004; Dignac *et al*., 2017). Diverse populations of beneficial microbes in vermicompost produce vitamins, hormones, and antibodies that improve plant growth (Lourduraj, 2006). Soil vermicomposting is an easy method for improving soil properties, such as soil structure, water-holding capacity, nutrient availability, and crop yields (Reddy and Reddi, 2002); therefore, the present research was undertaken to assess the combined effects of seed priming and vermicompost on plant growth, yield and yield attributes of wheat.

MATERIALS & METHODS

The pot experiment was conducted at Agricultural Laboratory in the School of Agriculture and Rural Development (SARD), Bangladesh Open University, Gazipur, from November 2020 to March 2021. The wheat variety ‘BARI Gom-28’ was used in this experiment. The wheat seeds were collected from the Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The experiment was conducted using a 16 L plastic pot containing 12 kg of soil. The soil texture consisted of 11.28% clay, 26.72% silt, and 62% sand. The physicochemical properties of the surface soil (0–20 cm) were as follows: total N, 0.119 g/kg; total P, 0.26 g/kg; total K, 0.92 g/kg; total Ca, 5.22 g/kg; total Mg, 1.49 g/kg, total CEC 21.13 cmol/kg. Soil was fertilized at the rate of 26-7-10 gm/12kg soil/pot of Urea, TSP (Triple Super Phosphate), and MP (Muriate of Potash), respectively. All of the TSP, MP and half of the Urea were used as a basal dose during pot preparation. The remaining Urea was applied as top dressing at 35 days after sowing. Six seeds were sown in each pot. One week after germination, the plants were thinned to three plants per pot. The pots were perforated at the base to allow excess water to drain out. The experimental seeds were treated with hydropriming (P_0), 2% KCl (P_1), 1.0% KNO_3 (P_2), and 10% PEG 6000 (P_3) for 24 h. The rate of vermicompost was divided into four groups as control (V_1), 150 g/pot (V_2), 300 g/pot (V_3), and 500 g/pot (V_4). The design of the experiment was RCBD (randomized complete block design) with four replications in two factorials (priming media and vermicompost). Throughout the growing season, the experiment was conducted using regular agronomic and cultural practices.

Data Collection

Plant growth

To assess different growth and development parameters, they were measured. These included plant height, leaf area, AGR and chlorophyll content. The measurements of plant height, leaf area, and chlorophyll content were taken three times before flowering, with a 20-day interval between each measurement, from 30 days after sowing (DAS) to 70 DAS. Three plants were randomly chosen for each treatment from the experimental pots. Plant height was measured in cm from the base of the stem (at the soil surface) to the highest point of the plant or the top of the canopy. Leaf area of single wheat leaf were measured by portable Leaf Area Meter (Model: YMJ-A; Camas, WA, USA). Chlorophyll content were measured by the SPAD-502 Plus (Konica Minolta Inc., Japan). By measuring the leaf absorbance in the red and near-infrared wavelengths, the instrument assessed the concentration of chlorophyll. AGR was performed using the formula outlined by Radford (1967).

$$AGR = \frac{W2-W1}{T2-T1} \text{-----------------------(1)}$$

W1and W2 refers to the mean plant height (cm) at the time T1 and T2, respectively. It was expressed in cm/day in case of plant height and g/day in case of dry matter production per plant.

Yield

The study recorded the following parameters: the number of spikes, the number of tillers, the 100-grain weight (g), the grain yield (g/pot), the fresh weight (g), and the harvest index (%). The number of spikes and tillers per plant were counted manually on a randomly selected subset of plants from each pot within each treatment. Fresh weight of each plant was also measured manually. One hundred seeds were randomly selected from the grain harvested from each plant within each pot. These seeds were weighed with a portable automatic electronic balance at approximately 14% moisture content.

Data analysis

The collected data were organized and prepared for statistical analysis. The analysis of variance (ANOVA) and means of the parameters were compared using Statistix 10.0. The mean differences among the treatments were adjudged by least significant differences (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Vermicompost showed a significant role in the growth and yield of different plants, especially when compared to typical plants. Vermicompost enhances the microbial activity in the soil, promotes better oxygen availability, regulates soil temperature, improves soil porosity and water infiltration, enhances nutrient content, and ultimately leads to improved plant growth, higher yields and better-quality production (Rekha *et al*., 2018). On the other hand, using seed priming before sowing is a highly effective approach that can significantly improve the yield and quality of valuable crops. The compatible impact of a combination of vermicompost and priming approaches on crops can potentially enhance their growth, yield, and quality, increasing their ability to adapt to environmental stresses.

Individual effect of vermicompost on plant height and leaf area of wheat

The effect of vermicompost on plant height and wheat leaf area was measured at 30, 50 and 70 DAS (Table 1). The application of vermicompost was significantly affected on plant height and leaf area. The effect of vermicompost on leaf area by 300 g/pot was statistically similar with 500 g/pot at 70 DAS. The application of vermicompost had a positive effect on plant height and leaf area of wheat; with the 300 and 500 g/pot showed the most significant improvement in growth parameters of wheat plants. The highest plant height and leaf area were recorded due to 500 and 300 g/pot of vermicompost; with average mean values of 73.02 cm and 48.69 cm^2, respectively at 70 DAS among the treatments and DAS. The lowest plant height and leaf area were recorded due to control; with average mean values of 6.77 cm and 23.56 cm^2, respectively at 30 DAS among the treatments and DAS. The studies suggest a quiet revolution is taking place beneath the surface. The soil is enriched with beneficial microbes through the use of vermicompost, a powerful substance created by earthworms. Driven by a combination of complex compounds and proteins, these small companions reveal the mysteries of inaccessible nutrients, converting them into valuable resources that can be easily utilized. Plants, fueled by this newfound abundance, thrive with improved absorption and utilization, their roots stretching towards the unlocked treasures. The results were similar to those observed in geranium and Mentha arvensis by Singh (2011) and Rajmanickam *et al*. (2011).

Individual effect of priming agents on plant height and leaf area of wheat

Significant effect of priming agents was also observed on plant height and leaf area of wheat (Table 2). The results revealed that the different priming agents had a significant effect on plant growth and development. Treatment 2% KCl consistently produced the tallest plants with the largest leaf area, while treatment hydroprime consistently produced the shortest plants with the smallest leaf area. The highest plant height and leaf area were observed for the treatment of 2% KCl at 70 DAS with average mean values of 75.12 cm and 49.25 cm^2; respectively among all treatments and intervals (Table 2). These values was the lowest for control having average mean values of 6.53

cm and 22.92 cm^2; respectively among all treatments and intervals (Table 2). The study conducted by Haider and Rehman (2022) revealed that the highest number of leafs, plant height, and leaf area index of *Stevia rebaudiana* were significantly affected by priming with KCl. Seed priming with KCl can trigger specific changes in the amino acids and fatty acids of wheat grain, which can improve growth, yield, and grain biochemical composition (Khaing *et al*., 2020).

Table 1. Individual effects of vermicompost (g) on wheat plant height and leaf area under different intervals- 30, 50 & 70 DAS

Treatment	Effect of vermicompost on plant height and leaf area of wheat under different intervals					
	Plant height (cm)			Leaf area (cm^2)		
	30DAS	50DAS	70DAS	30DAS	50DAS	70DAS
Control	6.77 ± 0.12^b	45.14 ± 0.67^b	70.19 ± 1.00^c	23.56 ± 0.42^b	33.04 ± 0.56^b	37.23 ± 1.26^c
150 g/pot	7.48 ± 0.15^a	49.53 ± 0.15^a	71.77 ± 0.68^b	26.58 ± 1.64^a	38.11 ± 0.44^a	43.69 ± 0.82^b
300 g/pot	7.46 ± 0.07^a	49.58 ± 1.42^a	71.98 ± 0.39^b	24.68 ± 0.13^b	38.32 ± 1.55^a	48.69 ± 1.07^a
500 g/pot	7.55 ± 0.05^a	50.07 ± 1.70^a	73.02 ± 0.67^a	24.57 ± 0.76^b	38.86 ± 0.71^a	48.59 ± 0.51^a

Data points represent the mean of four replicates for each treatment. Error bars indicate standard error (SE). Treatments with unique letters differ significantly ($p < 0.05$) based on least significant differences tests and two-way ANOVA analysis.

Table 2. Individual effects of priming agents on wheat plant height and leaf area under different intervals- 30, 50 & 70 DAS

Treatment	Effect of priming agents on plant height and leaf area of wheat under different intervals					
	Plant height (cm)			Leaf area (cm^2)		
	30DAS	50DAS	70DAS	30DAS	50DAS	70DAS
Control	6.53 ± 0.04^c	46.72 ± 0.88^b	68.60 ± 0.31^c	22.92 ± 0.14^c	33.63 ± 0.5^c	39.11 ± 0.49^c
2% KCL	7.74 ± 0.45^a	51.06 ± 0.68^a	75.12 ± 0.44^a	27.09 ± 0.66^a	40.24 ± 0.99^a	49.25 ± 0.67^a
1% KNO3	7.50 ± 0.15^a	49.09 ± 0.79^a	73.51 ± 0.67^b	25.49 ± 0.73^b	39.16 ± 0.50^a	47.95 ± 0.82^a
10% PEG6000	6.89 ± 0.26^b	46.37 ± 0.92^b	69.60 ± 0.70^c	22.88 ± 0.49^c	35.30 ± 0.57^b	41.42 ± 1.14^b

Data points represent the mean of four replicates for each treatment. Error bars indicate standard error (SE). Treatments with unique letters differ significantly ($p < 0.05$) based on least significant differences tests and two-way ANOVA analysis.

Combined effect of vermicompost and priming agents on plant height and leaf area of wheat

A significant combined effect of vermicompost and priming on wheat plant height and leaf area were found at three different intervals of 30, 50 and 70 DAS (Table 3). The highest plant height and leaf area were observed for combined effect of 300 g/pot vermicompost along with 2% KCL and 150 g/pot vermicompost along with 2% KCL having average mean values of 75.31 cm and 54.02 cm^2, respectively at 70 DAS; while the lowest plant height and leaf area were observed for combined effect of 0 g/pot vermicompost along with hydro priming (control) at 30 DAS and 0 g/pot vermicompost along with 10% PEG6000 at 50 DAS having average mean values of 6.18 cm and 30.62 cm^2, respectively among all treatments and intervals (Table 3). Overall, the results of the experiment suggest that the application of vermicompost and priming had a significant impact on wheat plant height and leaf area. However, further statistical analysis is required to validate the observed differences between the treatments. The findings of this study could provide insights into the potential use of vermicompost and priming to enhance wheat growth and productivity.

Individual effect of vermicompost and priming agents on chlorophyll content of wheat

The Figure 1 presents the results of the impact of different doses of vermicompost on chlorophyll content in plants at three sampling dates. Significantly higher chlorophyll content was investigated for the treatment of 300 g/pot of vermicompost at 50 DAS and 2% KCL at 70 DAS, respectively (Fig. 2). Statistically there was no significant difference among the treatment of 0, 150 and 500 g/pot of vermicompost at 30 DAS on chlorophyll content of wheat. A similar phenomenon was also observed on chlorophyll content among the treatment of 0, 150 and 300 g/pot of vermicompost at

70 DAS. The 150g and 300g vermicompost treatments showed intermediate chlorophyll levels. At 70 DAS, all treatments except the highest treatment exhibited similar chlorophyll content. The 500g vermicompost treatment had the highest chlorophyll content. The results suggest that the chlorophyll content at different doses of vermicompost varies across the different days.

Table 3. Combined effects of vermicompost and priming agents on plant height and leaf area of wheat under different intervals

Treatment	Plant height (cm)			Leaf area (cm^2)		
	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS
V_0P_1	6.18 ± 0.25^{f}	43.50 ± 0.70^{fg}	65.63 ± 0.98^{f}	23.05 ± 0.74^{cde}	31.35 ± 0.56^{ef}	34.67 ± 1.18^{g}
V_0P_2	7.27 ± 0.13^{bcde}	47.92 ± 1.07^{cde}	72.80 ± 0.83^{ab}	25.46 ± 0.54^{bcd}	35.27 ± 0.87^{d}	41.49 ± 1.44^{ef}
V_0P_3	$6.95 \pm 0.10d^{e}$	46.92 ± 0.34^{ef}	72.95 ± 1.47^{ab}	24.27 ± 0.73^{cde}	34.92 ± 0.87^{d}	38.41 ± 1.18^{f}
V_0P_4	6.68 ± 0.38^{ef}	42.22 ± 1.28^{g}	67.37 ± 1.36^{ef}	21.46 ± 0.29^{e}	30.62 ± 0.43^{f}	34.36 ± 1.46^{g}
V_1P_1	$7.00 \pm 0.04d^{e}$	$47.45 \pm 1.59d^{e}$	$68.98 \pm 0.89d^{e}$	23.12 ± 0.65^{cde}	34.10 ± 0.29^{de}	38.03 ± 0.87^{fg}
V_1P_2	8.05 ± 0.17^{a}	51.99 ± 1.00^{ab}	73.25 ± 0.55^{ab}	31.21 ± 2.59^{a}	42.86 ± 0.49^{a}	48.95 ± 0.88^{bc}
V_1P_3	7.74 ± 0.25^{abc}	50.85 ± 0.97^{abcd}	73.65 ± 0.39^{ab}	27.87 ± 2.47^{b}	40.06 ± 1.10^{ab}	47.03 ± 1.57^{cd}
V_1P_4	7.15 ± 0.62^{cde}	47.82 ± 1.31^{cde}	69.21 ± 1.34^{de}	24.10 ± 1.63^{cde}	35.41 ± 0.25^{d}	40.73 ± 1.14^{ef}
V_2P_1	6.78 ± 0.16^{ef}	46.95 ± 1.03^{ef}	69.31 ± 0.26^{de}	22.30 ± 0.57^{de}	35.75 ± 1.73^{cd}	42.69 ± 0.85^{c}
V_2P_2	7.68 ± 0.10^{abc}	52.63 ± 1.74^{a}	75.11 ± 0.37^{a}	25.50 ± 0.58^{bcd}	40.63 ± 1.68^{ab}	54.02 ± 0.91^{a}
V_2P_3	7.45 ± 0.08^{abcd}	50.78 ± 1.52^{abcd}	73.20 ± 0.74^{ab}	24.52 ± 0.14^{cde}	40.52 ± 1.58^{ab}	53.53 ± 0.54^{a}
V_2P_4	6.78 ± 0.04^{ef}	46.90 ± 1.67^{ef}	69.21 ± 0.72^{de}	22.40 ± 0.24^{de}	36.39 ± 1.69^{cd}	44.13 ± 2.15^{de}
V_3P_1	6.20 ± 0.24^{f}	48.97 ± 1.02^{bcde}	70.48 ± 1.47^{cd}	23.20 ± 0.37^{cde}	33.34 ± 0.96^{def}	41.08 ± 1.91^{ef}
V_3P_2	7.97 ± 0.31^{a}	52.71 ± 1.80^{a}	75.31 ± 0.42^{a}	26.21 ± 0.75^{bc}	42.19 ± 1.93^{a}	52.84 ± 1.55^{a}
V_3P_3	7.87 ± 0.16^{ab}	51.05 ± 2.37^{abc}	74.24 ± 0.48^{ab}	25.30 ± 1.13^{bcd}	41.13 ± 3.93^{ab}	52.52 ± 0.57^{ab}
V_3P_4	6.97 ± 0.25^{de}	44.53 ± 1.25^{bcde}	72.02 ± 1.33^{bc}	23.57 ± 1.29^{cde}	38.80 ± 1.62^{bc}	46.44 ± 2.53^{cd}

Data points represent the mean of four replicates for each treatment, denoted by V_1 (control, 0gm vermicompost), V_2 (150g), V_3 (300g), V_4 (500g), P_1 (control, hydro prime), P_2 (2% KCL), P_3 (1% KNO_3), and P_4 (10% PEG6000). Error bars indicate standard error (SE). Treatments with unique letters differ significantly ($p < 0.05$) based on least significant differences tests and two-way ANOVA analysis.

The study also investigated the impact of various priming agents on chlorophyll content over a three-day period. At 30 DAS, hydroprime treatment had the lowest chlorophyll content, while 2% KCl treatment showed the highest. 1% KNO_3 treatment had comparable chlorophyll content to the 2% KCl, and the 10% PGE6000 treatment had the second-lowest. At 50 DAS, hydroprime treatment exhibited the lowest chlorophyll content, and 2% KCl treatment displayed the highest. 1% KNO_3 treatment had an intermediate chlorophyll content, while 10% PGE6000 treatment had lower chlorophyll content than 2% KCl but higher than hydroprime. Finally, at 70 DAS, hydroprime treatment had the lowest chlorophyll content, while both 2% KCL and 1% KNO_3 treatments showed similar chlorophyll content, which was higher than that of hydroprime. 10% PGE6000 treatment exhibited the highest chlorophyll content. The results indicate that different priming agents had varying effects on chlorophyll content at different days. Primed by 2% KCl treatment consistently resulted in the highest chlorophyll content, while hydroprime treatment consistently resulted in the lowest chlorophyll content. 1% KNO_3 and 10% PGE6000 treatments showed intermediate chlorophyll content compared to the other treatments.

Individual effect of vermicompost on grain yield and yield parameters

According to the data presented in Table 3, the application of vermicompost treatments (150g, 300g, and 500g) resulted in a significant increase in spikes as compared to the control. However, the highest number (9.25) of spikes/plant was observed in the 500g/pot, followed (9.18) closely by the 300g/pot of vermicompost. The vermicompost treatments exhibited the highest number of tillers as compared to the control. Particularly, the treatment with 500g/pot had the highest number of tillers (10.06) among all the treatments. Moreover, the vermicompost treatments resulted in a significant increase in the fresh weight of the harvested plants. The significant differences were observed among the treatment of vermicompost on fresh wt. and 100 grain wt. of wheat as compared with their respective controls (Table 4). The highest fresh wt. and 100 grain wt. were observed for the rates of vermicompost are 300 and 500 g/pot with average mean values of 65.02

g and 6.04 g, respectively (Table 4). Among all the treatments, the 500g treatment exhibited the highest value (20.84 cm) in grain weight per plant. The vermicompost treatments also often led to a higher harvest index, indicating improved resource allocation for grain production. Applying 500 g of vermicompost treatment resulted in the highest harvest index of 37.05%, while the control produced a harvest index of 31.50% (Table 4).

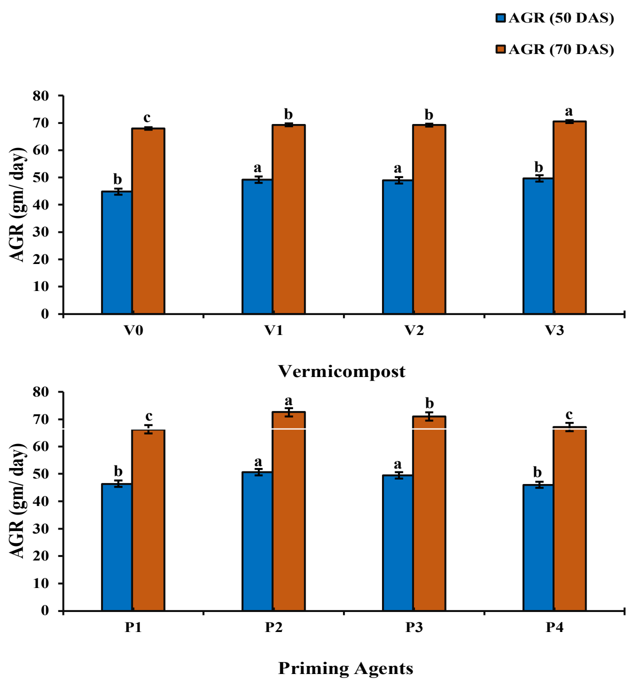

Figure 2. Effect of vermicompost and priming agents on Absolute growth rate (AGR). Data bar represent the mean of four replicates for each treatment, denoted by V_1 (control, 0gm vermicompost), V_2 (150g), V_3 (300g), V_4 (500g), P_1 (control, hydro prime), P_2 (2% KCL), P_3 (1% KNO_3), and P_4 (10% PEG6000). Error bars indicate standard error (SE).

Table 4. Individual effects of vermicompost on yield and yield parameters of wheat

Rate of vermi compost (g/pot)	Effect of vermicompost					
	No. of spike/plant	No. of tiller/plant	Fresh wt./plant (g)	100 grain wt. (g)	Grain wt./plant(g)	Harvest Index (%)
Control	7.75 ± 0.25^{b}	8.37 ±0.47 ^{b}	46.97 ±2.48^{c}	5.19 ± 0.12^{b}	14.43 ±0.49^{c}	31.50 ±3.25^{b}
150	8.68 ± 0.25^{a}	9.68 ± 0.40^{a}	65.02 ± 2.47^{a}	5.23 ± 0.04^{b}	14.54 ± 0.12^{c}	22.85 ± 0.95^{c}
300	9.18 ± 0.25^{a}	9.87 ± 0.25^{a}	53.86 ± 3.48^{b}	5.82 ± 0.17^{a}	16.05 ± 0.25^{b}	30.40 ± 2.75^{b}
500	9.25 ± 0.28^{a}	10.06 ± 0.47^{a}	57.22 ± 1.99^{b}	6.04 ± 0.07^{a}	20.84 ± 0.44^{a}	37.05 ± 1.21^{a}

Error bars indicate standard error (SE). Treatments with unique letters differ significantly ($p < 0.05$) based on least significant differences tests and two-way ANOVA analysis.

Individual effect of priming agents on grain yield and yield parameters

The effect of priming agents on various parameters related to yield and yield parameters revealed interesting findings (Table 5). 2% KCl treatment showed remarkable superiority in multiple aspects. It exhibited the highest number of spikes (10.93) and tillers (11.37), significantly surpassing the other treatments. Additionally, the 2% KCl treatment yielded the highest fresh wt. of harvested plants (64.50 g) and the highest weight of 100 grains (6.01 g), both significantly outperforming the other treatments (Table 5). Moreover, 2% KCl treatment demonstrated the highest grain weight per plant (18.76 cm), indicating exceptional productivity compared to the other treatments. In terms of harvest index, hydroprime and 10% PGE6000 treatments had the highest values (31.38 and 31.63, respectively), with no significant differences observed among the treatments (Table 5). These results emphasized the advantageous effects of 2% KCl as a priming agent, leading to improved spike and tiller production, increased fresh weight, grain weight, and overall productivity.

Table 5. Individual effects of priming agents on yield and yield parameters of wheat

Priming agent	Effect of Priming agents					
	No. of spike/plant	No. of tiller/plant	Fresh wt./plant (g)	100 grain wt. (g)	Grain wt./plant (g)	Harvest Index (%)
Control	6.56 ±0.25 ^{d}	7.18 ± 0.47^{d}	45.10 ±3.12^{c}	4.95 ±0.03^{c}	13.51 ±0.15^{d}	31.38 ±2.88^{a}
2% KCL	10.93 ±0.27^{a}	11.37 ±0.68^{a}	64.50 ± 3.61^{a}	6.01 ±0.06^{a}	18.76 ±0.32 ^{a}	29.58 ±1.47^{a}
1% KNO_3	9.50 ± 0.22^{b}	10.62 ±0.29^{b}	62.65 ± 1.72^{a}	5.95 ± 0.03^{a}	17.96 ± 0.30^{b}	29.20 ± 0.56^{a}
10% PEG6000	7.87 ± 0.07^{c}	8.81 ± 0.06^{c}	50.81 ± 2.50^{b}	5.36 ± 0.40^{b}	15.64 ± 0.33^{c}	31.63 ± 1.51^{a}

Error bars indicate standard error (SE). Treatments with unique letters differ significantly ($p < 0.05$) based on least significant differences tests and two-way ANOVA analysis.

Combined effect of vermicompost and priming agents on grain yield and yield parameters

The combined effects of vermicompost and priming agents significantly affected on wheat yield and yield characteristics (Table 6). Among the treatments, 300 g of vermicompost mixed with 2% KCl produced the most spikes (11.75) and tillers (12.5). The combined treatment of300 g vermicompost with 10% PGE exhibited the highest grain weight (24.25 g) and 100 grain wt. (6.82 g), suggesting improved productivity and grain quality (Table 6). Conversely, the treatment with 0 g vermicompost and hydroprime had the lowest number of spikes (4.50) and tillers (5.09), as well as the lowest 100 grain wt. (4.80 g) and grain wt. (12.37 g/plant) (Table 6). These results demonstrated the importance of combining vermicompost and priming agents to increase wheat production and yield characteristics. The vermicomposted organic waste mixtures had a more positive impact on wheat yield and yield components as compared to the non-vermicomposted organic waste mixtures (Kizilkayaa *et al*., 2012). Seed priming with KCl can enhance various growth parameters of different crops, including germination percentage, shoot length, root length, and fresh and dry biomass (Youssef *et al*. 2021). This improvement is particularly significant when the crops are subjected to salinity stress. Kalpana *et al*. (2013) found that the application of 1% KCl and 3% KNO_3 can significantly increase yield and the most growth traits in wheat and accumulate other nutrients in yield and straw. These findings are supported by Farooq *et al*. (2008) in wheat and Farooq *et al*. (2006) in rice. Overall, the combined effect of vermicompost and priming agents can be a useful tool for promoting the growth and productivity of wheat. By improving soil health, nutrient availability, and photosynthetic activity, this technique can help increase the number of spikes and tillers of wheat, leading to higher yields and better-quality agricultural products.

Table 6. Combined effects of vermicompost and priming agents on yield and yield parameters of wheat.

Treatment	No. of spike/plant	No. of tiller/plant	Fresh wt./plant(g)	100 grain wt. (g)	Grain wt./plant(g)	Harvest Index (%)
V_0P_1	4.50 ± 0.28^{f}	5.09 ± 0.40^{g}	35.35 ± 3.48^{g}	4.80 ± 0.27^{ef}	12.37 ± 0.27^{g}	36.20 ± 4.20^{ab}
V_0P_2	10.25 ± 0.47^{bc}	11.00 ± 0.91^{bc}	$56.27 \pm 4.0b^{c}$	5.57 ± 0.19^{bcd}	16.27 ± 0.64^{de}	29.35 ± 1.18^{cde}
V_0P_3	8.75 ± 0.62^{ef}	9.50 ± 0.28^{de}	51.72 ± 1.83^{ef}	5.52 ± 0.14^{cd}	15.22 ± 0.58^{e}	29.48 ± 0.42^{cde}
V_0P_4	7.50 ± 0.40^{gh}	8.00 ± 1.94^{f}	44.54 ± 0.14^{f}	4.87 ± 0.58^{ef}	13.75 ± 0.82^{f}	30.97 ± 0.07^{bc}
V_1P_1	5.75 ± 0.47^{i}	6.25 ± 0.25^{g}	54.45 ± 3.88^{de}	4.52 ± 0.15^{f}	13.10 ± 0.59^{fg}	24.50 ± 2.35^{ef}
V_1P_2	10.54 ± 0.64^{bc}	10.75 ± 0.94^{bcd}	67.90 ± 2.51^{ab}	5.67 ± 0.13^{bc}	16.24 ± 0.39^{e}	32.07 ± 1.28^{f}
V_1P_3	10.00 ± 0.00^{c}	11.50 ± 0.64^{ab}	75.10 ± 3.50^{a}	5.65 ± 0.06^{bc}	15.38 ± 0.07^{e}	20.62 ± 0.97^{f}
V_1P_4	7.25 ± 0.25^{h}	8.50 ± 0.28^{ef}	56.23 ± 3.93^{de}	5.07 ± 0.10^{ac}	13.45 ± 0.16^{fg}	24.21 ± 1.43^{ef}
V_2P_1	7.75 ± 0.25^{fgh}	8.50 ± 0.64^{ef}	46.37 ± 3.66^{f}	5.52 ± 0.28^{cd}	13.07 ± 0.64^{fg}	29.05 ± 3.77^{de}
V_2P_2	11.25 ± 0.25^{ab}	11.25 ± 0.47^{ab}	59.53 ± 4.08^{cd}	6.02 ± 0.16^{bc}	18.22 ± 0.29^{c}	31.22 ± 2.56^{f}
V_2P_3	9.50 ± 0.28^{cde}	10.75 ± 0.47^{bcd}	58.03 ± 3.36^{de}	6.05 ± 0.15^{b}	17.72 ± 0.24^{cd}	30.84 ± 1.75^{bc}
V_2P_4	8.25 ± 0.47^{fgh}	9.0 ± 0.57^{ef}	51.50 ± 5.65^{ef}	5.70 ± 0.17^{bc}	15.13 ± 0.29^{e}	30.47 ± 3.34^{bcd}
V_3P_1	8.25 ± 0.47^{fgh}	9.0 ± 0.40^{ef}	44.25 ± 3.29^{f}	4.97 ± 0.28^{ef}	15.52 ± 0.63^{e}	35.78 ± 3.46^{ab}
V_3P_2	11.75 ± 0.47^{a}	12.5 ± 0.01^{a}	74.32 ± 4.49^{a}	6.80 ± 0.07^{a}	24.15 ± 0.65^{a}	35.69 ± 1.40^{ab}
V_3P_3	9.75 ± 0.75^{cd}	10.75 ± 0.25^{bcd}	65.77 ± 2.58^{bc}	6.57 ± 0.07^{a}	23.45 ± 0.71^{a}	35.85 ± 1.98^{ab}
V_3P_4	8.50 ± 0.28^{efg}	9.75 ± 0.47^{cde}	66.97 ± 4.90^{ab}	6.82 ± 0.19^{a}	24.25 ± 0.39^{a}	40.88 ± 4.05^{a}

Treatments that do not have the same letters are significantly different ($p < 0.05$) as determined by least significant differences tests. Each point represents the mean of four replicates [were, V_1= 0gm (as control), V_2= 150g, V_3= 300g, V_4= 500g of vermicompost and P_1= hydro prime (as control), P_2= 2%KCl, P_3= 1% KNO_3, P_4= 10% PEG6000]. The values presented are the mean ± standard error (SE). Significant differences among treatments were determined using a two-way analysis of variance (ANOVA).

CONCLUSIONS

The experiment measured plant height and leaf area at 30, 50, and 70 days after sowing (DAS), as well as chlorophyll content and absolute growth rate (AGR) at 50 and 70 DAS. Results showed that vermicompost significantly improved plant height and leaf area, with the 500 g vermicompost treatments consistently yielding the highest values across all three DAS. This indicates that vermicompost enhances soil fertility, thereby improving nutrient uptake and plant utilization. Priming agents also impacted plant height and leaf area. The 2% KCl treatment consistently produced the tallest plants with the largest leaf area, while the hydroprime treatment resulted in the shortest plants with the smallest leaf area. Furthermore, combining 500 g of vermicompost with 2% KCl priming consistently yielded the highest plant height and leaf area. The 2% KCl treatment consistently achieving the highest chlorophyll content and AGR, while the hydroprime treatment remained the lowest. The 500 g treatment resulted in the highest number of spikes and tillers, fresh weight, 100-grain weight, grain weight, and harvest index per plant. Among the priming agents, the 2% KCl treatment was particularly effective, enhancing spikes and tillers, fresh weight, 100-grain weight, and grain weight per plant. Conversely, hydroprime and 10% PEG6000 treatments did not significantly improve growth and yield parameters. Overall, this study highlights the effectiveness of combining 500g of vermicompost with 2% KCL priming to enhance wheat growth and yield. It demonstrates the significant benefits of using both vermicompost and priming agents to improve wheat production and yield characteristics.

ACKNOWLEDGEMENT

My sincere gratitude goes to Bangladesh Open University, Gazipur, for providing the essential funding that made this research possible.

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