



Above and below Ground Dried Biomass of Wheat and Biomass Derived Indices as Influenced by Bio Priming Levels and Nitrogen Management Practices under Agro-climatic Conditions of Eastern Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted to study the effect of bio priming levels and nitrogen management practices on dry biomass accumulation of wheat and crop growth indices during two consecutive *rabi* seasons of year 2020-21 and 2021-22. The experiment was laid out in randomized block design (Factorial) consisting of factor I bio priming with two levels viz. P₀ (without bio priming) and P₁ (with bio priming) and factor II nitrogen management with seven levels viz. N₀ (Control), N₁ (90 kg N ha⁻¹ through urea), N₂ (63 kg N ha⁻¹ through urea + 27 kg N ha⁻¹ through FYM), N₃ (120 kg N ha⁻¹ through urea), N₄ (84 kg N ha⁻¹ through urea + 36 kg N ha⁻¹ through FYM), N₅ (150 kg N ha⁻¹ through urea) and N₆ (105 kg N ha⁻¹ through urea + 45 kg N ha⁻¹ through FYM). The results showed that level P₁ recorded significantly higher shoot dry matter accumulation (280.15 and 295.07 g running m⁻¹) and root dry matter accumulation (186.77 and 196.71 g running m⁻¹) during both the years of study at harvest stage while crop growth rate was found significant for second experimental year only in the growth period of 90 days after sowing- At harvest (9.49 g m⁻² day⁻¹). As for relative growth rate during interval of 90 DAS- At harvest, P₀ recorded higher value (0.00688 and 0.00728 g g⁻¹ day⁻¹) although found at par with level P₁ during both the years of study. Application of N₆ proved superiority in shoot dry matter accumulation (284.26 and 302.24 g running m⁻¹) and root dry matter accumulation (189.51 and 201.49 g m⁻¹ row length) during both the years and was statistically at par with level N₅ during both the experimental years except for crop growth rate which was found significant (9.68 g m⁻² day⁻¹) only in the second year of experiment in the growth stage interval of 90 DAS- At harvest. The relative growth rate for 90 DAS- At harvest interval got the highest significant maximum value with N₀ (0.00732 and 0.00735 g g⁻¹ day⁻¹) although found at par with other levels of nitrogen management during both the years.

Keywords: Above ground mass; below ground mass; crop growth indices; bio priming; nitrogen management.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the top food crops in global agriculture and is prominent among cultivated grains (Waines & Hegde, 2003). In rural areas, wheat accounts for up to 70% of the daily caloric intake and serves as a crucial source of essential nutrients in developing countries (Cakmak, 2008). It has been pivotal in human civilization, enhancing food security both globally and regionally. For a significant portion of the Indian population, wheat is the primary source of protein and calories and plays a vital role in ensuring food and nutritional security across the nation. Wheat productivity varies greatly across India's different agro-ecological zones owing to diverse climatic conditions, moisture stress, genetic variations, imbalanced fertilizer use, and differences in seeding times and management practices (Kantwa et al., 2015). Additionally, wheat is predominantly cultivated in light-textured soils with low water retention and poor nitrogen, phosphorus, and organic matter contents, which leads to suboptimal growth and yield. A relatively recent method known as "seed bio priming" facilitates the adherence and growth of microorganisms on seeds. Bio priming involves a biological seed treatment process that combines seed hydration with the inoculation of seeds using beneficial biological agents. This

approach aims to protect seeds, enhance germination, improve seedling establishment, and promote vegetative growth (Rakshit et al., 2014; Babu et al., 2014; Kumar et al., 2017). In the context of wheat cultivation, bio priming has emerged as a revolutionary agricultural technique that has transformed traditional crop cultivation methods. The outcomes of bio-priming in wheat are remarkable, showing increased germination rates, enhanced seedling vigor, and a greater ability to endure environmental stress. By leveraging naturally occurring microorganisms, bio priming not only strengthens the plant's defense systems, but also supports sustainable farming by reducing dependence on chemical inputs. Farmers who have adopted bio-priming reported higher yields and healthier crops, highlighting it as a promising and eco-friendly strategy to optimize wheat production while minimizing the ecological impact of agriculture. Effective nitrogen management is essential to maximize the yield and quality of wheat crops. The proper application of nitrogen is vital for enhancing plant growth, grain development, and overall productivity. Achieving the right balance in nitrogen management not only ensures optimal wheat yields but also addresses environmental sustainability and resource management concerns, making it a crucial aspect of contemporary wheat farming

practices. Excessive use and sole reliance on inorganic fertilizers can negatively impact soil, leading to issues such as alkalization, pH reduction, water pollution, leaching, and reduced availability of trace elements. In contrast to chemical fertilizers, agricultural productivity has been boosted by the use of organic manure derived from animal dung. Organic manure offers several benefits, owing to its balanced supply of macro-and micronutrients. It can enhance the physical and chemical properties of the soil by boosting soil microbial activity, thereby increasing soil nutrients. Organic manure has an advantage over chemical fertilizers in terms of improving nutrient use efficiency and grain production because of its gradual and sustained nitrogen release. Additionally, manure fertilization not only contributes to soil organic carbon (SOC) but also enhances the availability of soil nutrients for crop growth and development. However, the exclusive use of manure cannot support the typical intensity of agricultural production, as organic fertilizers have relatively low nutrient content and a limited capacity to release nutrients quickly enough to meet crop demands. It has been shown that combining organic manure with synthetic fertilizers is a more effective strategy for maintaining and enhancing soil fertility and crop yield than using mineral or organic manure alone (Iqbal et al., 2019).

2. MATERIALS AND METHODS

A field study was conducted at the Agricultural Research farm (25°18' North latitude and 83°03' E) of Banaras Hindu University, Varanasi, using a Randomized Block Design (Factorial). The study included two factors: factor I involved bio priming with two levels, P0 (no bio priming) and P1 (bio priming with *Trichoderma harzianum*), while factor II focused on nitrogen management with seven levels: N0 (Control), N1 (90 kg N ha⁻¹ through urea), N2 (63 kg N ha⁻¹ through urea + 27 kg N ha⁻¹ through FYM), N3 (120 kg N ha⁻¹ through urea), N4 (84 kg N ha⁻¹ through urea + 36 kg N ha⁻¹ through FYM), N5 (150 kg N ha⁻¹ through urea), and N6 (105 kg N ha⁻¹ through urea + 45 kg N ha⁻¹ through FYM). Nitrogen from urea was applied in four equal split doses (25% each at basal, Z₂₁, Z₃₁, and Z₅₁; Z= Zadoks scale; Z₂₁= main shoot and one tiller; Z₃₁= 1st node detectable; Z₅₁= tip of inflorescence emerged). In total, 14 treatment combinations were evaluated and each was replicated three times. The soil in the experimental field was sandy clay loam, slightly alkaline, and low in organic carbon and available nitrogen, but medium in available

phosphorus and potassium during both years. The recommended phosphorus and potassium doses (60 and 40 kg ha⁻¹) were applied as basal doses using the SSP and MOP, respectively, in both years. Nitrogen was applied according to the treatment plan. The crop growth season experienced less rainfall in 2020-21 compared than in 2021-22. The wheat variety HD 2967 was used for sowing. Both factors were managed according to the treatment specifications. Weather conditions were more favorable for wheat growth in the second year, leading to better crop development than in the first year. The observations on crop growth characters viz. shoot dry matter accumulation (g m⁻¹ row length) and root dry matter accumulation (g m⁻¹ row length) were recorded at harvest through standard procedure. Crop growth rate (g m⁻² day⁻¹) and relative growth rate (g g⁻¹ day⁻¹) were calculated at various growth interval as per standard formulae. The crop growth rate was calculated as per the formula given by Radford (1967) and was expressed as g.m⁻².day⁻¹.

$$\text{Crop growth rate (g.m-2.day-1)} = \frac{(W_2 - W_1)}{(t_2 - t_1) \times \text{Ground Area}}$$

Where,

W₁ = Total dry biomass of crop plant at time interval t₁

W₂ = Total dry biomass of crop plant at time interval t₂

Formula suggested by Radford (1967) used to work out the RGR is given below:

$$\text{Relative growth rate (g.g-1.day-1)} = \frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$$

Where,

W₁ = Total dry biomass of crop plant at time interval t₁

W₂ = Total dry biomass of crop plant at time interval t₂

The recorded data were subjected to statistical analysis as prescribed by Gomez and Gomez (1984). The interpretation of the treatment effects were made on the basis of Fisher's critical difference at p=0.05 level.

3. RESULTS AND DISCUSSION

3.1 Shoot Dry Matter Accumulation

From Table 1 it can be observed that bio priming (P1) led to much more shoot dry matter (280.15

g per meter of row) than the control group in the first year. The second year showed the same pattern, with the highest amount (295.07 g per meter of row) at level P₁, which was better than level P₀. Bio priming helps plants grow better in both normal and tough conditions. It boosts photosynthetic pigments, osmolytes, and antioxidant enzymes, which help plants grow and build more biomass (Dief et al., 2020). More

efficient photosynthesis and higher chlorophyll levels result in more dry matter. Using *Trichoderma harzianum* strains as bio priming agent, strengthens roots and helps with osmoregulation. It also improves how plants uptake nutrients. Since nutrient build-up is linked to biomass, better nutrient uptake early on helps achieve good crop yield and dry matter (Malhi et al., 2006).

Table 1. Effect of bio priming and nitrogen management on shoot and root dry matter accumulation (g m⁻¹ row length) of wheat at harvest

Treatments	Shoot dry matter accumulation (g m ⁻¹ row length)		Root dry matter accumulation (g m ⁻¹ row length)	
	2020-21	2021-22	2020-21	2021-22
Bio priming (P)				
P ₀	270.75	286.21	180.50	190.81
P ₁	280.15	295.07	186.77	196.71
SEm±	0.72	0.67	0.48	0.45
CD (P = 0.05)	2.18	2.04	1.45	1.36
Nitrogen management (N)				
N ₀	249.46	258.16	166.31	172.11
N ₁	275.09	290.73	183.39	193.82
N ₂	276.83	291.04	184.55	194.03
N ₃	279.57	295.27	186.38	196.85
N ₄	280.43	297.13	186.95	198.09
N ₅	282.51	299.91	188.34	199.94
N ₆	284.26	302.24	189.51	201.49
SEm±	0.85	0.79	0.57	0.53
CD (P = 0.05)	2.61	2.42	1.74	1.61

Treatment details: P₀: Without Bio priming (Control); P₁: With Bio priming N₀: 0 Kg N ha⁻¹ (Control); N₁: 90 kg N ha⁻¹ through urea; N₂: 63 kg N ha⁻¹ through urea + 27 kg N ha⁻¹ through FYM; N₃: 120 kg N ha⁻¹ through urea; N₄: 84 kg N ha⁻¹ through urea + 36 kg N ha⁻¹ through FYM; N₅: 150 kg N ha⁻¹ through urea; N₆: 105 kg N ha⁻¹ through urea + 45 kg N ha⁻¹ through FYM

Table 2. Effect of bio priming and nitrogen management on crop growth rate (CGR) and relative growth rate (RGR) of wheat during 90 DAS-at harvest interval

Treatments	CGR (g m ⁻² day ⁻¹)		RGR (g g ⁻¹ day ⁻¹)	
	2020-21	2021-22	2020-21	2021-22
Bio priming (P)				
P ₀	8.41	9.36	0.00688	0.00728
P ₁	8.32	9.49	0.00654	0.00715
SEm±	0.012	0.012	0.00090	0.00110
CD (P = 0.05)	NS	0.030	0.00260	0.00330
Nitrogen management (N)				
N ₀	8.20	8.51	0.00732	0.00735
N ₁	8.39	9.58	0.00673	0.00734
N ₂	8.53	9.46	0.00681	0.00723
N ₃	8.74	9.57	0.00692	0.00721
N ₄	8.37	9.58	0.00657	0.00716
N ₅	8.18	9.59	0.00636	0.00710
N ₆	8.16	9.68	0.00630	0.00711
SEm±	0.017	0.013	0.00170	0.00210
CD (P = 0.05)	NS	0.045	0.00490	0.00620

Treatment details: P₀: Without Bio priming (Control); P₁: With Bio priming N₀: 0 Kg N ha⁻¹ (Control); N₁: 90 kg N ha⁻¹ through urea; N₂: 63 kg N ha⁻¹ through urea + 27 kg N ha⁻¹ through FYM; N₃: 120 kg N ha⁻¹ through urea; N₄: 84 kg N ha⁻¹ through urea + 36 kg N ha⁻¹ through FYM; N₅: 150 kg N ha⁻¹ through urea; N₆: 105 kg N ha⁻¹ through urea + 45 kg N ha⁻¹ through FYM

In the nitrogen management treatments, using N₆ (105 kg N ha⁻¹ from urea + 45 kg N ha⁻¹ from FYM) led to more shoot dry matter (284.26 g m⁻¹ row length) at harvest in the first year. In the second year, N₆ also had the highest value (302.24 g m⁻¹ row length), better than other levels except N₅ (150 kg N ha⁻¹ from urea) (Table 1). Plants' shoot dry matter comes from photosynthesis. More nitrogen increases plant dry matter at different growth stages, leading to more biomass. This is because plants need more nitrogen then, which helps make chlorophyll and other nitrogen compounds. Kumar et al. (2017) found similar results.

3.2 Root Dry Matter Accumulation

In the first year, using bio priming (P₁) led to much more root dry matter (186.77 g per meter of row) compared to the control group. The second year showed the same pattern, with the highest amount (196.71 g per meter of row) recorded at harvest with P₁ from Table 1.

Among the nitrogen management treatments shown in Table 1, incorporation of N₆ i.e., 105 kg N ha⁻¹ through urea + 45 kg N ha⁻¹ through FYM achieved higher root dry matter accumulation (189.51 g m⁻¹ row length) than rest of the treatments at harvest during first year of study. The maximum value (201.49 g m⁻¹ row length) was recorded with N₆ at harvest for the second year of experiment as was recorded in the first experimental year and found statistically at par with N₅.

3.3 Crop Growth Rate (CGR)

The data showed (Table 2) that bio priming treatments had a significant effect on crop growth rate between 90 days after sowing (DAS) and harvest time, but only in the second year of the experiment. The highest crop growth rate (9.49 grams per square meter per day) was recorded with treatment P₁ during this time, which was better than treatment P₀.

Different nitrogen management levels also caused significant effect on CGR of 90 DAS- at harvest interval during course of study (Table 2). Application of N₆ achieved higher crop growth rate (9.68 g m⁻² day⁻¹) during 90 DAS- at harvest interval for the second experimental year only and was found statistically superior over the other levels.

3.4 Relative Growth Rate (RGR)

Bio priming treatments had a big effect on the relative growth rate (RGR) from 90 days after

sowing (DAS) to harvest in the first year as shown in Table 2. Among the treatments, P₀ had a higher RGR (0.00688 g g⁻¹ day⁻¹) during this time and was similar to P₁. The same pattern was seen in the second year, with the highest RGR (0.00728 g g⁻¹ day⁻¹) again in P₀, which was also similar to P₁.

The data showed that different nitrogen levels affected the growth rate of wheat from 90 days after sowing (DAS) to harvest in the first year (Table 2). The highest growth rate (0.00732 g g⁻¹ day⁻¹) was seen with no nitrogen (N₀) during this time and was similar to other nitrogen levels. In the second year, N₀ again had the highest growth rate (0.00735 g g⁻¹ day⁻¹) from 90 DAS to harvest, and it was also statistically at par with other nitrogen levels.

4. CONCLUSIONS

From the above overall study, it can be concluded that level P₁ recorded significantly higher shoot dry matter accumulation (280.15 and 295.07 g running m⁻¹) and root dry matter accumulation (186.77 and 196.71 g running m⁻¹) during both the years of study at harvest stage while crop growth rate was found significant for second experimental year only in the growth period of 90 days after sowing- At harvest (9.49 g m⁻² day⁻¹). As for relative growth rate during interval of 90 DAS- At harvest, P₀ recorded higher value (0.00688 and 0.00728 g g⁻¹ day⁻¹) although found at par with level P₁ during both the years of study. Application of N₆ proved superiority in shoot dry matter accumulation (284.26 and 302.24 g running m⁻¹) and root dry matter accumulation (189.51 and 201.49 g m⁻¹ row length) during both the years and was statistically at par with level N₅ during both the experimental years except for crop growth rate which was found significant (9.68 g m⁻² day⁻¹) only in the second year of experiment for the growth stage interval of 90 DAS- At harvest. The relative growth rate for 90 DAS- At harvest interval got the highest significant maximum value with N₀ (0.00732 and 0.00735 g g⁻¹ day⁻¹) although found at par with other levels of nitrogen management during both the years.

Therefore, to obtain higher biomass and biomass based indices, wheat should be grown by following bio priming treatment of seeds (Priming material: *Trichoderma harzianum*) and nitrogen management as application of 105 kg N ha⁻¹ through urea + 45 kg N ha⁻¹ through FYM under agro-climatic conditions of Eastern Uttar Pradesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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