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Research Article

Impact of Nitrogen and Organic Sources with and without Beneficial Microbes on Wheat Crop

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Abstract | Cereal crops have been the backbone of national agriculture for decades, as they are major staple food crops. Crop nutrients major sources are organic, inorganic and bio-fertilizers. Supplementation of beneficial microbes with organic and inorganic fertilizers is a feasible technology to improve wheat productivity. A field experiment was conducted to evaluate the impact of organic sources (OS) and inorganic N fertilizer (Urea) along with the application of bio-aab (beneficial microbes) on the wheat crop at the Agronomy Research Farm, The University of Agriculture Peshawar Pakistan, during 2020-2021. Two separate experiments were conducted (with and without bio-aab) in Randomized Complete Block Design each consisted of 10 treatments. Bio-aab treatments are T_1: Poultry manure (PM) + 80 kg N + bioabb, T_2: PM + 120 kg N + bio-aab, T_3: PM + 160 kg N + bio-aab, T_4: Farm yard manure (FYM) + 80 kg N + bioabb, T_5: FYM + 120 kg N + bio-aab, T_6: FYM + 160 kg N + bio-aab, T_7: Maize residues (MR) + 80 kg N + bioabb, T_8: MR + 120 kg N + bio-aab, T_9: MR + 160 kg N + bio-aab, T_{10}: Control), same treatments followed for without bio-aab. OS have applied accordingly to the plots one month before sowing, bio-aab solution (60 litres ha^{-1}) was applied with first irrigation to one experiment before sowing to encourage microbial action necessary for manure decomposition, while half N was applied at sowing time and half after seven days of sowing with first irrigation. Statistical analysis was done combined over bio-aab. The principle beneficial microorganisms (BM) in bio-aab contain photosynthetic bacteria, lactic acid bacteria and yeast. These BM produced useful substances such as amino acids, nucleic acids, lactic acid, bioactive substances, hormones, enzymes and sugars. All these substances promote active cell and root division, plant growth, productivity, suppress harmful microorganisms, and enhance the decomposition of organic matter. Results showed that integrated use of PM and N (120 or 160 kg ha^{-1}) along with the application of bio-aab significantly ($P \leq 0.05$) improved tillers m^{-2} (12%), grains spike^{-1} (15%), biological yield (31%) and grain yield (39%) as compared to control plots. Results of the bio-aab treated plots were found (8%) superior yield than without bio-aab.

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Keywords | Bio-aab, Crop residues, Farmyard manure, Poultry manure, Wheat crop

Introduction

Cereal crops have been the backbone of national agriculture for decades, as they are major staple food crops with more area under cultivation than other crops (Farhad *et al*., 2009). The agricultural policy's main goal is to increase wheat crop production by applying beneficial microbes (BM) (Radwan *et al*., 2021). Wheat was chosen as the experimental crop because it is the most widely grown cereal grain crop on the planet earth (Muhamed *et al*., 2022; Jagshoran *et al*., 2004) and is an important major staple food crop in the world (Achari *et al*., 2021). Inorganic fertilizer use has grown to fulfil the increasing demand for grain yield (Achari *et al*., 2021) and the imbalance use of inorganic fertilizer can't preserve soil health which is very important for sustainable farming (Khan *et al*., 2020). Nitrogen (N) is an important plant yield-limiting macronutrient (Achari *et al*., 2021). Plants absorb nitrogen in the form of NH^{+}_{4} and NO^{-}_{3} (Atkinson *et al*., 2007). It is an imperative element for proper growth and development of the plant enhance yield and improve quality by playing a key role in the physiochemical functions of the plant (Radwan *et al*., 2021), but excessive use of chemical fertilizers in agricultural systems can have a detrimental impact on surface water, ground water, and the atmosphere due to nitrogen (N) leaching, runoff, and volatilization (Achari *et al*., 2021; Galloway *et al*., 2008). Organic manures are key to enhancing soil quality and crop yield since they perform numerous functions in agro-ecosystems (Achari *et al*., 2021; Jones *et al*., 2007). Organic sources include farmyard manure (FM), poultry manure (PM), green manures, sewage sludge, and press mud (Iqbal *et al*., 2014). Organic fertilizer application and residue management improve soil microbiological characteristics (Naeem *et al*., 2009). The rise in wheat output per hectare is noteworthy because our country's average yield is quite low, particularly in Khyber Pakhtunkhwa. Farm management strategies and introducing new technologies are important factors in enhancing wheat yield (Tariq *et al*., 2014). EM-technology or beneficial microbes improve crop health and productivity by increasing photosynthesis rate, producing enzymes and hormones, speeding up decomposition, reducing soil pathogens, and improving soil quality (Khan *et al*., 2020; Kurepin *et al*., 2014). Applying BM and organic materials promotes nutrient digestion (Khan *et al*., 2020) and it is more beneficial when used with fresh organic matter (Fatunbi and Ncube, 2009). Organic materials like farmyard manure and poultry litter are used for increasing crop production, but pure organic farming cannot meet the demand for nutrient supply, as large quantities of organic amendments are unavailable (Radwan *et al*., 2021). So, integrating EM/BM and organic/inorganic fertilizer is one of the alternatives for nutrient supply (Khan *et al*., 2020). Therefore, the current experiment evaluated the effect of organic sources and nitrogen with and without beneficial microbes (bio-aab) on wheat yield.

Materials and Methods

Two field experiments were carried out at the Agronomy Research Farm, The University of Agriculture Peshawar, Pakistan, during winter season of 2020-2021 to explore the effects of organic sources (poultry manure, maize residues and farmyard manure each applied at the rate of 10 t ha^{-1}) and nitrogen levels (80, 120,160 kg ha^{-1}) on the yield and yield components of wheat with and without beneficial microbes (bio-aab). The soil samples of the trial plot were collected from soil depth 0-15 cm for examination of NPK and organic carbon. N (%) was assessed by Kjedhal's apparatus (Jackson, 1969), P (%) was assessed by Olsen extractant method (Olsen *et al*., 1954) and K (%) was assessed by AB-DTPA extract method (Soltanpour *et al*., 1977). The trail plot was slightly alkaline in reaction and silt clay loam in texture was nearly neutral in soil reaction (pH 8.2), total organic carbon (12.7 g kg^{-1}), available N (23.7 mg kg^{-1}), available P (3.20 mg kg^{-1}) and available K (85.8 mg kg^{-1}). Each replication comprise of 10 treatments, replicated thrice and was conducted in randomized complete block design which are T_1: Poultry manure (PM) + 80 kg N + bioabb, T_2: PM + 120 kg N + bio-aab, T_3: PM + 160 kg N + bio-aab, T_4: Farm yard manure (FYM) + 80 kg N + bioabb, T_5: FYM + 120 kg N + bio-aab, T_6: FYM + 160 kg N + bio-aab, T_7: Maize residues (MR) + 80 kg N + bioabb, T_8: MR + 120 kg N + bio-aab, T_9: MR + 160 kg N + bio-aab, T_{10}: Control, same treatments followed for without bio-aab. Each Plot size was 3 m x 2.4 m, with 10 rows, each row 2.4 m long and 30 cm apart. Wheat variety Pirsabaq 2015 was sown on November 11th, 2020 with a seed rate of 120 kg ha^{-1}. The field was ploughed one month before sowing, then the layout was drowned, and OS were applied accordingly to the plots. Half N was applied at sowing and half after seven days with the first irrigation. Five irrigations were applied (after 7 days of sowing, tillering, heading, anthesis and grain filling stage). The crop was harvested in May 2021. Standard procedure for bio-aab solution preparation: The 20 litres of water were taken in a drum (30 litre capacity). Then, one liter of basic bio-aab was added with one kg of sugar, shaken well and placed for 7 days under the shade. The lid was opened once a day to release the gas. The prepared extended bio-aab solution (60 litres ha^{-1}) was then applied with the irrigation to one experiment before sowing to encourage microbial action necessary for manure decomposition.

Measurements and procedures of data recording

Tillers (m^{-2}): At the anthesis stage, tillers per m^2 were enumerated using a meter rod at three distinct locations at every plot, and the tillers were then converted to tillers m^{-2} as:

$$Tillers\ per\ m^2 = \frac{Counted\ tillers\ number}{R\ to\ R\ x\ rows\ No.x\ Row\ length} \times 1m^2$$

Grains spike^{-1}: Grains per spike were estimated on ten randomly selected spikes from each plot, and then the average was calculated.

Biological yield (kg ha^{-1}): In each plot 4 central rows were harvested then dried in sun up to constant moisture and was weighted. The biological yield kg ha^{-1} was calculated as:

$$Biological\ yield\ (kg\ ha^{-1}) = \frac{Biological\ yield\ of\ four\ rows}{R\ to\ R\ (m)x\ Row\ length\ (m)x\ No.of\ rows} \times 10000m^{-2}$$

Grain yield (kg ha^{-1}): The harvested materials of the four central rows of each plot were threshed, cleaned and weighted. The grain yield kg ha^{-1} was calculated as:

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Grain yield of four rows}}{\text{R to R (m) x Row length (m) x No. of rows}} \times 10000m^{-2}$$

Statistical analysis

Statistical analysis of the data, and the means were compared using the Least Significant Difference (LSD) test (P≤0.05) according to Steel *et al.* (1997).

Results and Discussion

Tillers (m^{-2})

Tiller m^{-2} was significantly (P≤0.05) affected with the supplementation of bio-aab, N, OS and control vs rest, while all interactions had no significant effect on tillers m^{-2} (Table 1). Mean data of bio-aab showed that application of bio-aab produced more tiller m^{-2} (278) than without bio-aab (271). The application of 80 kg Nha^{-1} between N levels resulted in fewer tillers per m^2 (269). However, an upward trend was noted with each increscent of N and maximum number of tillers was recorded with 160 kg N ha^{-1}. These results are similar with (Achari *et al.*, 2021). Using bio-aab in conjunction with organic N fertilizer sources enhances the number of tillers m^{-2} (Lee, 1991). As the level of bio-fertilizer and N increased it directly increased the tillers $plant^{-1}$ (Achari *et al.*, 2021). Among the OS, PM produced more tiller m^{-2} (298), while less tiller m^{-2} (252) was recorded with the application of maize residues. Treated plots produced more tiller m^{-2} (274) than control plots (241). Abbasi and Khaliq (2016) reported similar conclusions, stated that PM-treated plots supplied enough moisture and nitrogen, resulted in good wheat growth conditions. Our results were further backed up by Ibrahim *et al.*, (2008). MeCarty *et al.* (2017) and Maurya *et al.* (2019) revealed that number of tillers increased by the greater availability of nutrient in soil as well as increasing N application prolonged elongation and multiplication of cells leading to increased tillers (m^{-2}).

Grains spike^{-1}

Analysis of the data (Table 1) revealed that treated plots produced more grains $spike^{-1}$(49.5) as compared with the control (41.9). Mean data concerned with bio-aab indicated that application of bio-aab improved grains $spike^{-1}$ (50.7) than without bio-aab (48.3). Highest rate of N (160 and 120 kg ha^{-1}) produced maximum grains $spike^{-1}$ (51.4 and 49.7), respectively. Similar finding was reported by Deghani *et al.* (2013) and Tavanaee *et al.* (2013). Achari *et al.* (2021) and Bhatta *et al.* (2020) reported that grains $spike^{-1}$ increased by increasing N levels by which more spikelets are emerged which increased the rates of spikelets primordial production. Among the applications of OS, more grains $spike^{-1}$ (52.3) was recorded with the application of PM, while MR produced less grains $spike^{-1}$ (46.2). There was no significant effect was noted among all integrations. The likely source of this improvement is because mineral fertilizer and organic manure decomposition provide nutrients throughout the season, preventing nutritional stress in the plant at any phase until harvesting, resulting in highest grains $spike^{-1}$. Our results were backed up by Singh and Agarwal (2001), Iqbal *et al.* (2002), and Arif *et al.* (2006), who stated that the combine organic and inorganic fertilizers boosted wheat grain $spike^{-1}$.

Table 1: *Tiller m^{-2}, grain spike^{-1}, biological and grain yield (kg ha^{-1}) of wheat as affected by nitrogen, organic sources and bio-aab.*

Treatments	Tiller m^{-2}	Grains Spike^{-1}	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Nitrogen (kg ha^{-1})				
80	269 c	47.4 b	10656 b	3346 b
120	274 b	49.7 a	11536 a	3655 a
160	281 a	51.4 a	11776 a	3855 a
LSD value (P≤0.05)	2.3	1.7	532	250
Organic Sources (10 ton ha^{-1})				
Poultry manure	298 a	52.3 a	12158 a	4110 a
Farmyard manure	274 b	49.9 b	11580b	3609b
Crop residues	252 c	46.2 c	10230c	3137c
LSD value (P≤0.05)	2.3	1.7	532	250
Bio-aab (60 L ha^{-1})				
With	278 a	50.7 a	11647 a	112.0 a
Without	271b	48.3 b	10999 b	102.9 b
LSD value (P≤0.05)	2.0	1.3	502	202
Control vs Rest				
Control	241	41.9	7861	2204
Rest	274	49.5	11412	3619
Significance	***	***	***	***
CV (%)	1.26	5.30	7.18	10.64

Means sharing the same letter did not significantly differ at P ≤ 0.05

Biological yield (kg ha^{-1})

An improvement was noted in biological yield (11647 kg ha^{-1}) with the supplementation of bio-aab as compared to plots not treated with bio-aab (10999 kg ha^{-1}). This is because BM have enhanced the decomposition rate of OM, released nutrients for the plant uptake, and thus resulted in higher biological yield (Deghani *et al*., 2013; Tavanaee *et al*., 2013). The highest rate of N (160 and 120 kg ha^{-1}) produced maximum biological yield (11776 and 11536 kg ha^{-1}), respectively, while 80 kg N ha^{-1} produced minimum biological yield (10656 kg ha^{-1}). Our results are similar with (Achari *et al*., 2021; Bhatta *et al*., 2020). Increasing the rate of N can ultimately increased plant height, green leaves and dry matter which ultimately increased the biological yield (Bhatta *et al*., 2020). In contrast to lower and higher N doses, appropriate N dosage may generate more fertile tillers per unit area, boosting biomass output (Khalil *et al*., 2011). Among OS, improved biological yield (12158 kgha^{-1}) was achieved with PM, whereas a downward trend was observed with FYM (11580 kg ha^{-1}) and maize residues (10230 kg ha^{-1}). The possible reason for this improvement could be that OS maintain moisture and nutrients release throughout the entire season (Abbas *et al*., 2012). The biological yield of the treated plots was higher (11412 kg ha^{-1}) than control (7861 kg ha^{-1}). No significant effect was detected among all interactions.

Grain yield (kg ha^{-1})

Analysis of the data (Table 1) revealed bio-aab application produced maximum grain yield (3756 kg ha^{-1}) than without bio-aab (3482 kg ha^{-1}). It is due to the effect of BM on organic matter in the soil, which has increased the decomposition rate of organic matter, improved soil physio-chemical properties, and resulted more grain yield (Deghani *et al*., 2013; Tavanaee *et al*., 2013). Among N levels, 160 kg N ha^{-1} and 120 kg N ha^{-1} had resulted statistically similar results for grain yield (3855 and 3655 kg ha^{-1}), respectively, whereas grain yield (3346 kg ha^{-1}) was greatly reduced with 80 kg N ha^{-1}. This might be owing to increased N accessibility to the crop (Belete *et al*., 2018), which could lead to improved growth and leaf area. Pandey *et al*. (2018), Kaur *et al*. (2018) investigated that increasing N application can increase photosynthetic activity, vegetative growth and yield attributes ultimately improving grain yield. An improved grain yield (4110 kg ha^{-1}) was achieved with the supplementation of PM, while a minimum grain yield (3137 kg ha^{-1}) was recorded with the application of maize residues. Our findings correspond to those of Zhang *et al*. (2016), who claimed that increased grain yields might be achieved by boosting nutrient availability eliminating N losses, or raising N absorption over the crop's life cycle. Mean data for control vs. rest showed that rest plots produced higher (3619 kg ha^{-1}) grain yield than control (2204 kg ha^{-1}). All interactions had no significant effect on grain yield.

Conclusions and Recommendations

Based on the findings, it was determined that nitrogen treatment boosted wheat growth, yield, and yield components considerably. PM 10 t ha^{-1} considerably increased wheat growth, yield and yield components among the OS. The application of bio-aab increased the growth and productivity of wheat. Supplementation of bio-aab with OS was found superior. In the light of the current study, it is recommended that nitrogen at a rate of 120 kg ha^{-1} and poultry manure at a rate of 10 t ha^{-1} along with bio-aab application improved wheat yield in the study area.

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Novelty Statement

This research evaluated supplementation of beneficial microbes along-with organic and inorganic fertilizers is a feasible technology to improve wheat productivity.

Author's Contribution

Siddique Ahmad: Principal author, conducted the research and wrote first draft.
Basit Ullah and Saif Ullah: Helped in data analysis.
Sajid Ali and Muhammad Zeeshan: Helped in data collection.
Ali Zaid: Scientific writing.
Zeeshan Ahmad and Muhammad Usaid: Data analysis.

Conflict of interest
The authors have declared no conflict of interest.

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