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Effect of fertility levels and bio-fertilizers on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract

In Rabi 2023-24, a field trial titled "Influence of Fertility Levels and Biofertilizers on the Growth and Yield of Wheat (*Triticum aestivum* L.)" took place at the Instructional Farm of Agriculture, Career Point University, Kota. This experiment tested 16 treatment combinations, varying in fertility levels (ranging from Control to 120% RDF) and liquid biofertilizers (including Azotobacter, PSB, and Azotobacter + PSB), using a factorial randomized block design replicated three times. The wheat variety Lok-1 was employed as the test crop, with the recommended dose of fertilizer (RDF) set at 100:60:40 kg ha-1 of N: P_2O_5: K_2O. Notably, the combination of 100% RDF and Azotobacter + PSB significantly enhanced plant height, total tillers per meter of row length, effective tillers per meter of row length, test weight, grain, straw, and biological yield.

Key Words: Fertilizer, Bio-fertilizer, Wheat

Introduction

Wheat, a key cereal crop in India, holds a prominent position in the country's agricultural landscape. It serves as a vital source of energy during the winter season and constitutes a significant portion, accounting for 35%, of the nation's grain production. While India has transitioned from a state of wheat scarcity during its independence to one of surplus today, there remains a pressing need for continued efforts to ensure sustained growth in production. This is essential to meet the nutritional demands of the ever-expanding population, maintain sufficient buffer stocks for food security, and cater to the requirements of wheat-based food processing industries. Wheat plays a crucial role in the dietary intake, contributing approximately 55% of the carbohydrates and 20% of the calories consumed. Globally, it holds the largest cultivated area, spanning around 215 million hectares, and yields a staggering 765.4 million tonnes of produce.

The Integrated Nutrient Management (INM) approach aims to optimize crop yields while preserving the agro-ecosystem through efficient and economical utilization of various plant nutrient sources. Organic sources supplement chemical fertilizers by providing essential trace elements that enhance soil fertility. Combining organic materials with inorganic fertilizers ensures proper nutrition and soil fertility maintenance in wheat cultivation. Comparative studies between different combinations of organic and chemical inputs are necessary to determine the most effective approach. Additionally, integrating farmyard manure (FYM) with inorganic nitrogen sources has been shown to boost wheat productivity, increase monetary returns, and enhance soil fertility.

Material and Method

The experiment took place at the Instructional Farm of Agriculture, Career Point University, Kota, located in the hadouti region of Rajasthan at coordinates 24°85' N latitude and 73°42' E longitude, with an altitude of 582.17 meters above sea level. This area falls within agro-climatic zone V of Rajasthan. During the wheat cropping period in the Rabi season of 2019, the weekly temperature ranged from 20.8 °C to 37.3 °C, while the maximum and minimum relative humidity ranged from 86.7% to 16.7%, respectively. The total rainfall recorded during the crop season was 42.6 mm, with a maximum evaporation of 9.9 mm. Soil analysis revealed that the experimental field's soil is sandy loam, with a neutral alkaline pH, medium levels of available nitrogen and phosphorus, and high levels of available potassium.

The experiment comprised 16 treatment combinations, including four fertility levels (Control, 60%, 90%, and 120% RDF) and four liquid biofertilizer levels (Control, Azotobacter, PSB, and Azotobacter + PSB). It was arranged in a factorial randomized block design with three replications. For the wheat crop, the required nitrogen dose was calculated by subtracting the nitrogen supplied through DAP from the total, with the remaining nitrogen supplied through urea. P2O5 from DAP and K2O from MOP were applied at sowing, with half the nitrogen, full phosphorus, and potassium doses applied before sowing and the remaining nitrogen split into two equal doses during the first and third irrigation. Seed treatment with liquid biofertilizers involved placing 1 kg of seeds in a plastic bag and adding the required amount of biofertilizers (5 to 10 ml kg-1 seed for each biofertilizer). The bag

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was closed and squeezed to ensure even coating of the seeds, then opened and left to dry in the shade for 20 to 30 minutes. Some plots received treatment with Azotobacter and PSB individually, while others received treatment with both.

Result and discussion

The growth parameters of wheat, particularly plant height at 30 days after sowing (DAS), 60 DAS, and at harvest, were significantly influenced by the inoculation of seeds with various liquid biofertilizers, including Azotobacter, PSB, and a combination of Azotobacter + PSB, as compared to the control group. The combined inoculation of Azotobacter + PSB resulted in the highest plant heights across all observed stages compared to both the control and single inoculation treatments. The enhanced growth attributed to biofertilizers may stem from their role in increasing the availability of essential plant nutrients. Inoculating seeds with nitrogen-fixing bacteria, such as Azotobacter, led to an increase in their concentration in the rhizosphere, where they fix atmospheric and organic nitrogen, subsequently converting it into nitrate form. This process, in turn, promotes root development and overall plant growth, potentially facilitated by the secretion of vitamins, auxins, and amino acids by Azotobacter. Additionally, PSB was found to produce organic acids that enhance the mineralization of insoluble organic phosphorus into soluble phosphorus, thus increasing its availability in the soil. Previous studies have also highlighted the beneficial effects of Azotobacter and PSB on wheat, attributed to their nitrogen-fixing ability, phosphate solubilization, and secretion of plant growth hormones. The combined inoculation of Azotobacter and PSB further promoted lateral root proliferation and the development of root hairs, facilitating increased nutrient and water absorption due to the expanded surface area. Consequently, the observed increase in plant height can be attributed to enhanced photosynthesis and assimilate production resulting from the stimulated growth. These findings align with previous research by Bai*et al.* (2003) and Wu *et al.* (2005).

Yield attributes and Yield

The investigation results presented in Table 2 revealed significant impacts on yield attributes and overall yield, except for the harvest index, when seeds were inoculated with various liquid biofertilizers such as Azotobacter, PSB, and a combination of Azotobacter + PSB, in comparison to the control group. While there was no significant effect observed on the harvest index due to biofertilizer inoculation, prior research by Jnawali*et al.* (2015) indicated that Azotobacter seed inoculation enhances yield by supplying more nitrogen to the crop. The chelating effect of PSB reduces phosphorus fixation, thereby increasing phosphorus uptake and promoting better growth attributes such as total tillers per meter of row length, effective tillers per meter of row length, and test weight. This enhanced uptake of micronutrients and secondary nutrients, facilitated by increased phosphorus availability, likely leads to greater root expansion, enhanced photosynthesis, and improved partitioning of photosynthates among vegetative and reproductive plant parts, ultimately resulting in improved yield attributes and seed yield. Additionally, the combined inoculation of N+P-fixer bacteria may have a synergistic effect on the production of growth-promoting hormones such as auxin, gibberellins, and cytokinins, further enhancing yield attributes and overall yield, as suggested by Kaushik*et al.* (2012). The combination of Azotobacter + PSB notably increased stover yield, possibly due to increased biomass production. Previous studies by Kumawat and Khangarot (2002), Brahmaparkash*et al.* (2004), Ram and Mir (2006), Singh *et al.* (2008), and Bhavya*et al.* (2017) also support the cumulative positive effects of biofertilizer inoculation on growth and yield attributes.

Table 1: Effect of different treatments on plant height of wheat.

Treatments	**Plantheight (cm)**				**Number of grains spike^{-1}**	**Tillers m^{2}at Harvest**
	DAS			**At Harvest**		
	30	**60**	**90**			
Control	24.6	40.3	84.8	85.8	38.00	226
T2: 60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	28.1	48.8	97.2	97.8	45.00	322
T3: 90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	26.7	44.8	91.5	91.9	48.00	351
T4: 120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	26.4	44.6	91.0	91.5	49.67	387
T5: Azatobacter	27.2	44.9	94.2	94.9	48.67	356
T6: PSB	27.3	45.3	93.0	93.2	50.00	388
T7: Azatobacter + PSB	27.5	44.9	94.2	96.8	50.00	405
T8: Azatobacter+60 kg N + 20 kg P_2O_5	26.1	43.2	89.4	89.9	50.67	425

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+ 20 kg K_2O ha^{-1}						
T9: PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	26.1	43.0	87.9	89.0	50.54	424
T10: Azatobacter + PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	26.1	43.2	89.4	89.9	45.00	327
T11: Azatobacter+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	26.4	43.0	87.9	89.0	46.67	333
T12: PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	26.7	43.2	89.9	90.8	50.00	388
T13: Azatobacter + PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	35.5	32.5	71.7	107.6	50.00	405
T14: Azatobacter+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	37.6	32.8	72.9	102.2	50.67	425
T15: PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	38.13	33.6	73.1	103.4	47.00	344
T16: Azatobacter + PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	38.1	34.2	74.2	104.0	47.00	346
S.Em.±	**0.49**	**0.52**	**0.42**	**0.30**	**0.07**	**0.08**
C.D.=(P=0.05)	**NS**	**1.50**	**1.20**	**0.85**	**6.53**	**7.35**

Table 2. Effect of different treatments on yield of wheat.

Treatments	**Biological yield (kg/ha^{-1})**	**Seed yield ($kg\ ha^{-1}$)**	**Straw yield ($kg\ ha^{-1}$)**	**Harvest index (%)**
T1: Control	7754	2499	5254	32.2

T2: 60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	10370	4412	5957	42.6
T3: 90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	9503	3728	5775	39.2
T4: 120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	9595	3742	5853	39.0
T5: Azatobacter	9682	3806	5876	39.3
T6: PSB	9660	3771	5890	39.0
T7: Azatobacter + PSB	10279	4373	5906	42.5
T8: Azatobacter+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	9306	3523	5783	37.9
T9: PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	9301	3490	5811	37.5
T10: Azatobacter + PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	9416	3598	5818	38.2
T11: Azatobacter+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	10541	3460	4078	43.62
T12: PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	10618	4816	4992	48.00
T13: Azatobacter + PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	10661	5034	5391	46.01
T14: Azatobacter+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	10800	5146	5500	45.95
T15: PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	9345	3505	5840	37.5
T16: Azatobacter + PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	9474	3532	5943	37.3
S.Em.±	**34.4**	**26.6**	**38.5**	**0.41**
C.D.=(P=0.05)	**98.7**	**76.5**	**110.6**	**1.16**

Conclusion:

Based on the results, it can be concluded that the use of a combination of 100% Recommended Dose of Fertilizers (RDF), Azotobacter, and Phosphate - Solubilizing Bacteria (PSB) significantly improves various aspects of wheat cultivation. This includes enhanced plant growth, improved yield attributes, and increased overall yield. Therefore, I recommend the application of this treatment regimen comprising 100% RDF, Azotobacter, and PSB to maximize wheat productivity. By adopting this approach, farmers can achieve optimal returns under the current agro-climatic conditions.

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