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The Effect of Combination of *Azotobacter, Trichoderma* and Chemical Fertilizers on Wheat (*Triticum aestivum* L.) Yield in Gwalior Region, Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study aims to evaluate the influence of *Azotobacter* and *Trichoderma viride*, along with chemical fertilizers, on wheat yield and economics in the Gwalior region of Madhya Pradesh, India.
Study Design: With ten treatment and three replications, the experiment was carried out using RBD (Randomized Block Design).
Place and Duration of Study: During the *Rabi* season of 2023, the field trial was carried out at the experimental field of Crop Research Centre (CRC) of ITM University in Gwalior, Madhya Pradesh.

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Methodology: Different combinations of 50%, 75% and 100% recommended doses fertilisers, *Azotobacter* and *Trichoderma viride*, had been included in the treatments. The wheat variety Raj-4037 has been used and yield parameters were noted. Analysis was also done on economic variables.

Results: The treatment with 100% RDF + *Azotobacter* + *Trichoderma viride* (T_8) produced the highest grain yield (4127.17 kg ha^{-1}), straw yield (4474.35 kg ha^{-1}), and biological yield (9162.91 kg ha^{-1}). This treatment also achieved the highest gross income (₹119,071.87), net income (₹ 78,281.67), and benefit-cost ratio (1.92). The results indicated that combining microbial inoculants with chemical fertilizers significantly enhances wheat yield and economic returns.

Conclusion: The combined application of *Azotobacter*, *Trichoderma viride*, and chemical fertilizers significantly improves wheat yields and economic returns, making it a viable strategy for enhancing wheat productivity in the Gwalior region.

Keywords: Azotobacter; Trichoderma viride; chemical fertilizer NPK; wheat.

1. INTRODUCTION

One of the most important cereal crops in the world, wheat (*Triticum aestivum* Linn.) supplies an important part of the recommended daily caloric and protein requirements for the great majority of the world's population. After China, India is the world's second leading producer of wheat, with an estimated 107.74 million tons produced from 30.450 mha in 2022-23 (FAOSTAT, 2021). According to the office of the Director of the Department of Agriculture Madhya Pradesh, there was a huge jump in the wheat area in MP in the 2019-20 *Rabi* season when it increased by 2.5 million hectares and reached over 10.02 million hectares area. The use of chemical fertilizers has been a crucial factor in enhancing crop yields, but it also raises concerns about soil health and sustainability.

Chemical fertilizers, primarily nitrogen (N), phosphorus (P), and potassium (K), have played a crucial role in enhancing wheat yields since the Green Revolution. However, the exclusive reliance on chemical fertilizers can lead to diminishing returns over time. Studies have shown that while initial applications boost yields, the long-term effects can result in nutrient imbalances and soil degradation. For instance, continuous use of high doses of nitrogen without adequate phosphorus and potassium can lead to nutrient deficiencies, adversely affecting wheat growth and yield stability Lokesh et al. [1] and Sharma et al. [2]. Nitrogen fertilizer consumption has shown a positive growth in recent years Sharma et al. [2].

One of the most demanding nutrients to supply, nitrogen can also have an adverse effect on the environment through nitrate leaching, which can pollute groundwater sources, eutrophication of waterways that contributes to global warming, and nitrous oxide emissions linked to soil bacterial denitrification [3]. To address these issues, the use of microbial inoculants, which contains beneficial microbes, has drawn more attention recently and is seen as a promising part of Integrated Nutrient Management (INM) systems. Among the various biofertilizers available, Azotobacter and Trichoderma have gained significant attention due to their ability to improve soil fertility and plant growth. Azotobacter can fix up to average 20kgN/ha per year. It is able to grow at a pH range of 4.8–8.5 and fixes N at optimum pH of 7.0–7.5 Dilworth et al. [4]. Trichoderma, on the other hand, has the capacity to produce antibiotics, parasitize other fungi, and compete with deleterious microorganisms which were considered to be the basis for how Trichoderma exert beneficial effects on plant growth and development Harman et al. [5]. The combined application of Azotobacter and Trichoderma, along with reduced rates of chemical fertilizers, has the potential to optimize wheat productivity while minimizing the environmental impact and production costs. With this background, the present study aims to evaluate the effects of different biofertilizers including *Trichoderma viride* and Azotobacter applied as seed and soil treatments in conjunction with chemical fertilizers on the performance of wheat crop in Gwalior region of Madhya Pradesh, India.

2. MATERIALS AND METHODS

At ITM University's Crop Research Centre, Gwalior, Madhya Pradesh, the trial was conducted to evaluate the effects of different microbial inoculants including *Trichoderma viride* and Azotobacter applied as seed and soil treatments in conjunction with chemical fertilizers on the performance of wheat crop. The experimental field was located at the latitude of 26º 14' N, the longitude of 78º 14' E with an altitude of 211 m above the sea level. According to the experimental site's initial soil analysis, the soil has a sandy loam texture with 56.7% sand, 22.2% silt, and 21.1% clay. The soil pH was 7.8, electrical conductivity (EC) was 0.33 dS m^{-1}, organic carbon content was 0.42%, available nitrogen was 159.8 kg ha^{-1}, available phosphorus was 18.9 kg ha^{-1}, and available potassium was 412.9 kg ha^{-1}. The annual rain fall in Gwalior is 800-1000 mm. Temperature varies from 23^0-42^0C in summers and from 4^0-29^0C in winters.

The experiment was laid out in a Randomized Block Design (RBD) with ten treatments and three replications. The treatments were T_1: Control, T_2: Azotobacter, T_3: *Trichoderma viride*, T_4: 100% RDF, T_5: 100% RDF + Azotobacter, T_6: 100% RDF + *Trichoderma viride*, T_7: Azotobacter + *Trichoderma viride*, T_8: 100% RDF + Azotobacter + *Trichoderma viride*, T_9: 75% RDF + Azotobacter + *Trichoderma viride*, and T_{10}: 50% RDF + Azotobacter + *Trichoderma viride*.

The agronomic plant used was high yielding variety of Wheat viz. Raj-4037, sown mid-December, 2023 in rows at 20 cm apart at 4-5 cm by seed drill at a depth of 4-5 cm. Basal dose of recommended P and K, i.e. 60 and 40 kg ha^{-1} in the form of SSP and MOP respectively. applied uniformly across all treatments. Nitrogen was applied as per the treatments. In 100% RDN, nitrogen was applied at the rate of 120 kg ha^{-1}. Half dose of urea (as per treatments) was applied at sowing, while remaining half of urea was applied as top-dressed at 20 and 40 DAS. The control plot (T_1) was not supplemented with urea, and the seeds sown in these plots were not treated with bio-inoculant. The microbiological fertilizers i.e. *Azotobacter* and *Trichoderma viride* were used in both liquid and powder forms respectively for soil treatment. The doses of *Azotobacter* and *Trichoderma viride* were equally fixed for soil treatment in powder & liquid form respectively. For soil inoculation, *Trichoderma viride* powder was directly placed into the soil and for Azotobacter, liquid formulation mixed with FYM was evenly spread on the plots above which the wheat seeds were sown. Second application at 40 DAS was done as soil drench to reinforce the presence of microbial inoculants in the rhizosphere.

The yield parameters recorded grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%). The net returns and cost-benefit ratio were calculated based on the yield data. Statistical analysis was done by the method of analysis of variance (Fisher, 1958) and critical difference (CD) was calculated at 5% level of significance using R software.

3. RESULTS AND DISCUSSION

The study's data presented in Tables 1 and 2 highlight the significant influence of various microbial inoculants combined with chemical fertilizers on grain, straw, and biological yields, as well as economic returns and the benefit-cost ratio. The maximum grain yield of 4127.17 kg ha^{-1} was obtained with the application of 100% RDF + Azotobacter + *Trichoderma viride* (T_8), which was at par to Treatment 100% RDF + Azotobacter (T_5) at 3820.66 kg ha^{-1}, straw yield followed a similar trend, with T_8 producing the highest yield of 4474.35 kg ha^{-1}, again at par to T_5 (4830.95 kg ha^{-1}) and significantly higher than the other treatments. Biological yield was also maximized in T_8 (9162.91 kg ha^{-1}. The harvest index, however, was not significantly influenced by the treatments, with T_8 recording the highest index at 45.05%. In this experiment the increase in yield can also be attributed to the application of *Trichoderma viride* bioformulation along with the RDF which helped increasing the colonies by providing nutrient to crop thereby increasing the plant growth and yield of wheat. According to Millet et al. [6], the maximum yield in T8 might be the result of the roots acting as a catalyst for the microbial population's response, or it could be the result of the microbes offering plant hormones. This could be explained by the way microbiological fertilizer works to promote soil biological activity, which in turn serves to improve the way that nutrients from applied sources are mobilized. Additionally, the rise in nitrogen fixation and the generation of compounds that promote plant growth and stimulate soil microbial activity, which in turn helps plants to access nutrients, may be responsible for the yield and its component increases brought about by the Azotobacter inoculation. As a result, the combination of these three sources of nutrients helped in increasing the grain yield. These outcomes align with the earlier findings of Zaki et al. [7] Badr et al. [8], Bahrani et al. [9], Jala-Abadi et al. [10].

Table 1. Influence of Azotobacter, Trichoderma with Chemical Fertilizers on Wheat Yield Parameters

Treatments		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T1	Control	1656.73	2076.17	3732.89	44.37
T2	*Azotobacter*	2127.30	2698.79	4826.09	44.04
T3	*Trichoderma viride*	2072.15	2685.17	4757.32	43.55
T4	100% RDF	3193.84	3956.01	7149.85	44.66
T5	100% RDF + Azotobacter	3820.66	4830.95	8651.61	44.17
T6	100% RDF + Trichoderma viride	3341.31	2742.38	7564.07	44.17
T7	Azotobacter + Trichoderma viride	2150.74	5035.73	4893.12	43.93
T8	100% RDF + Azotobacter + Trichoderma viride	4127.17	4474.35	9162.91	45.05
T9	75% RDF + Azotobacter + Trichoderma viride	3629.41	3348.35	8103.76	44.78
T10	50% RDF + Azotobacter + Trichoderma viride	2756.44	3348.43	6104.87	45.38
SEm(±)		137.49	192.12	323.33	0.74
CD at 5 %		408.53	570.81	951.77	NS

Table 2. Influence of Azotobacter, Trichoderma with Chemical Fertilizers on Wheat Economics

Treatments		Total cost (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio
T1	Control	37267	48071.39	10804.39	0.29
T2	*Azotobacter*	37767	61890.00	24123.00	0.64
T3	*Trichoderma viride*	37767	60567.36	22800.36	0.60
T4	100% RDF	39790.2	92440.00	52649.80	1.32
T5	100% RDF + *Azotobacter*	40290.2	111074.67	70784.47	1.76
T6	100% RDF + *Trichoderma viride*	40290.2	97128.57	56838.37	1.41
T7	Azotobacter + Trichoderma viride	38267	62641.32	24374.32	0.64
T9	100% RDF + *Azotobacter* + *Trichoderma viride*	40790.2	119071.87	78281.67	1.92
T9	75% RDF + Azotobacter + Trichoderma viride	40159.4	104940.88	64781.48	1.61
T10	50% RDF + Azotobacter + Trichoderma viride	39528.6	79451.25	39922.65	1.01

Economically, T_8 incurred the highest cultivation cost (₹ 40,790.2), 9.46% higher than the Control (T_1, ₹ 37,267) and 7.53% higher than T_4 (100% RDF, ₹. 40,290.2). Despite the higher cost, T_8 achieved the highest gross return (₹ 119,071.87), 28.77% higher than T_4 and 147.75% higher than the Control. Net returns also peaked with T_8 (Rs. 78,281.67), 48.66% higher than T_4 and a substantial 624.64% higher than the Control. Treatments with only Azotobacter, Trichoderma viride, or both showed significant increases in gross and net returns over the Control, though lower than treatments involving 100% RDF. The Benefit-Cost (B-C) ratio was highest in T_8 (1.92), 45.45% higher than T_4 (1.32) and 562.07% higher than the Control (0.29). T_5 also demonstrated a high B-C ratio of 1.76, a 33.33% increase over T4. Treatments with reduced RDF but added bio-fertilizers, such as T_9 (75% RDF + Azotobacter + Trichoderma viride) and T_{10} (50% RDF + Azotobacter + Trichoderma viride), showed moderate B-C ratios of 1.61 and 1.01, respectively. These findings are consistent with the results of Sharma et al. [2] and Singh et al. [11], underscoring the economic and yield benefits of integrating microbial inoculants with RDF.

4. CONCLUSION

The study shows that microbial inoculants, especially Azotobacter and Trichoderma viride, combined with 100% RDF greatly increases wheat yields and financial returns. Despite paying more for cultivation, treatment T8 produced the highest outputs of straw and grains, as well as better net returns and a favorable benefit-cost ratio. The enhanced nitrogen fixation and plant growth-promoting compounds from the microbial inoculants, which enhance nutrient mobilization and soil biological activity, are responsible for the favorable impacts on yield. In general, combining chemical fertilizers and microbial inoculants increases agricultural profitability and production.

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 writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Lokesh Dubey LD, Dwivedi AK, Megha Dubey MD. Long term application of fertilizer and manures on physico-chemical properties and N, P and K uptake in soybean-wheat cropping system; 2015.
2. Sharma N, Pannu RS, Malik DP, Sain V, Kayastha R. Analysis of growth trends of production and consumption of fertilizer nutrients in India; 2022.
3. Cameira MDR, Mota M. Nitrogen related diffuse pollution from horticulture production—mitigation practices and assessment strategies. Horticulturae. 2017;3(1):25.
4. Dilworth MJ, Eady RR, Eldridge ME. The vanadium nitrogenase of Azotobacter chroococcum. Reduction of acetylene and ethylene to ethane. Biochemical Journal. 1988;249(3):745-751.
5. Harman GE, Howell CR, Viterbo A, Chet I, Lorito M. Trichoderma species—opportunistic, avirulent plant symbionts. Nature Reviews Microbiology. 2004;2(1): 43-56.
6. Millet E, Avivi Y, Feldman M. Effects of rhizospheric bacteria on wheat yield under field conditions, Plant Soil. 1985;86:347–355.
7. Zaki NM, Hassanein MS, Gamal El-Din KM. Growth and yield of some wheat cultivars irrigated with saline water in newly cultivated land as affected by bio fertilization, J. Appl. Sci. 2007;3 (10):1121–1126.
8. Badr EA, Ibrahim OM, El-Kramany MF. Interaction effect of biological and or ganic fertilizers on yield and yield components of two wheat cultivars, Egypt. J. Agron. 2009;31(1):17–27.
9. Bahrani A, Pourreza J, Joo MH. Response of winter wheat to co-inoculation with Azotobacter and Arbescular Mycorrhizal Fungi (AMF) under different sources of nitrogen fertilizer, American-Eurasian. J. Agric. & Environ. Sci. 2010;8(1):95–103.

10. Jala-Abadi AL, Siadat SA, Bakhsandeh AM, Fathi G, Saied KHA. Effect of organic and inorganic fertilizers on yield and yield components in wheat (*T. aestivum* and *T. durum*) genotypes, Adv. Environ. Biol. 2012;6 (2):756–762.
11. Singh R, Agarwal SK. Growth and yield of wheat (*Tritium aestivum*) as influenced by level of farm yard manure and nitrogen. Ind. J. Agron. 2001;46:462-467.

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