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Nitrogen and Azotobacter's Impact on Soil characteristics and Nutrient availability

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ABSTRACT: An experiment conducted during the Rabi season of 2016-17 at the Instructional Farm of Acharya Narendra Deva University of Agriculture & Technology, located in Narendra Nagar, Kumarganj, Ayodhya (U.P.), aimed to assess the impact of various nutrient management practices on soil properties and nutrient availability. The experiment featured ten different treatments, including a control (T1: N-0, P-60, K-40 kg/ha^{-1}) and variations involving Azotobacter inoculation, varying levels of nitrogen (N) application, and combinations thereof. These treatments were replicated in a randomized block design (RBD) with triplicate plots, and wheat variety PBW-343 was chosen as the test crop. The findings indicated significant changes in soil parameters. Notably, there was a decrease in soil pH (8.13), electrical conductivity (0.29), and bulk density (1.39) across various treatments. The highest improvements in nutrient availability, including nitrogen (178 kg ha^{-1}), phosphorus (20.5 kg ha^{-1}), and potassium (267.6 kg ha^{-1}), were observed in treatments applying chemical fertilizers at a rate of 100 kg of nitrogen per hectare combined with Azotobacter (T_{10}). This was closely followed by treatment T9, which involved the application of 120 kg of nitrogen per hectare. These results highlight the potential benefits of integrating Azotobacter with chemical fertilizers to enhance soil properties and nutrient availability in wheat cultivation. The study's significant contributions lie in its findings that emphasize the potential benefits of integrating Azotobacter with chemical fertilizers to improve soil properties and nutrient availability. This information can guide agricultural practices, helping farmers optimize their nutrient management strategies to enhance crop yields and promote sustainable agriculture in the Rabi season.

Keywords: Azotobacter, Nitrogen, Phosphorus, Potassium, Soil pH, Bulk density.

INTRODUCTION

A staple meal throughout the world, wheat (*Triticum aestivum* L.) is a member of the Gramineae (Poaceae) family. The most significant cereal crop and a crucial part of many countries' systems for ensuring their food security is wheat. Due to its great productivity and large acreage, it has been dubbed the "King of Cereals" and holds a significant place in the global trade in food grains. Wheat contributes almost 78% of the diet's carbs, 14% of the protein, 2% of the fat, 2.5% of the minerals, 2.5% of the minerals are minerals like zinc and iron, selenium, and magnesium, and 2.5% of the minerals are vitamins like thiamine and vitamin B. Contrary to other cereals, wheat has a high concentration of gluten, a protein that gives the elasticity required for baking good bread. In terms of area (219.42 million hectares) and production (758.38 million metric tonnes), wheat is the most productive cereal in the world, yielding 3.46 tonnes per hectare. According to the Ministry of Agriculture's 2017–18 report, it is grown in India on an area of 30.79 million hectares, producing 98.51 million metric tonnes at a productivity of 3.20 tonnes per hectare. N-fixation, nutrient supplementation, or the production of phytohormones like auxins, gibberellins, and cytokinins, which are all advantageous to the plant, can all drive plant development (El-Naggar *et al.*, 2020; Ahmad *et al.*, 2008; Joseph *et al.*, 2007). Bacteria such Pseudomonas azotobacter and azospirillum can also create plant hormones (Rueda *et al.*, 2016, Hanafy *et al.*, 2002). Azotobacter, a Gamma proteobacteria that belongs to the "PGPR" group of rhizobacteria that promote plant growth, can fix nitrogen from the environment and flourish in N-free situations. They create biological proteins using atmospheric N. N availability is related to cell mortality after the mineralization of the cellular protein (Arough *et al.*, 2016). Additionally, it has been demonstrated that azotobacter strains increase plant output, growth, and N use efficiency for horticultural crops (Sudhakar *et al.*, 2000). When the plants were treated with biofertilizers such Azotobacter chroococcum and Azospirillum lipoferum, the plants' height, number of leaves, and fresh weight significantly increased (Razmjooei *et al.*, 2022), Because it is a component of nucleic acid, protein, and chlorophyll, nitrogen is essential to the growth processes that occur in living things. The most crucial plant nutrient, nitrogen affects plant development and productivity. It is a part of the cell's structural makeup. It is a necessary component of alkaloids, nucleotides, flavin nucleotides enzymes, prophyrins, flavins, purines, and pyrimidine ne. Consequently, it is a fundamental part of life. The transmission of genetic information to the progeny is made possible by nitrogen. It raises the standard of feed and green crops. Additionally, nitrogen gives plants their robust vegetative development and deep green colour. It leads in both early growth and a delay in the maturity of plants. Nitrogen availability and carbohydrate fertilizers are connected. When conditions are ideal for growth and nitrogen supplies are at their highest levels, protein is created from the processed carbs. Because of its function in the synthesis of substances, it is regarded as the primary element. It makes about 1.5 to 5% of higher plant's dry weight. Additionally, it plays a prominent role in plant metabolism. Protein, of which nitrogen is a crucial component, is linked to all key functions in plants. Consequently, nitrogen application in the form of artificial fertilizer is necessary to increase crop productivity. We therefore sought to investigate the impact of both individual and combination applications of N and azotobacter on the physiochemical properties and nutrient availability of soil.

MATERIALS AND METHODS

An experiment was conducted during the *Rabi* season 2016-17 at the Instructional Farm of Acharya Narendra, Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) to evaluate the effect of different nutrient management practices on growth and yield attributes of wheat. The soil was partially reclaimed sodic soil with silt loam texture slightly alkaline in reaction (pH 8.90) with low available nitrogen (159.0 kg ha^{-1}), medium in available phosphorus (12.60 kg ha^{-1}), and high in available potassium (245.80 kg ha^{-1}). The experiment consisted of 10 treatments, T_1 Control (N-0, P-60, K-40Kg/ha^{-1}); T_2 (Azotobacter); T_3 (60 kg Nitrogen ha^{-1}); T_4 (40 kg Nitrogen ha^{-1} + Azotobacter); T_5 (80 kg Nitrogen ha^{-1}); T_6 (60 kg Nitrogen + Azotobacter); T_7 (100 kg Nitrogen ha^{-1}); T_8 (80 kg Nitrogen ha^{-1} + Azotobacter); T_9 (120 kg Nitrogen ha^{-1}); T_{10} (100 kg Nitrogen ha^{-1}+ Azotobacter) were laid down in triplicate plots in Randomized block design (RBD). Wheat variety PBW-343 was taken as a test crop. At the time of sowing, the soil was again mixed thoroughly. Nitrogen was applied as urea. Uniform doses of Phosphorus and Potassium at the rate of 60 and 40 kg ha $^{-1}$, respectively, were applied in all the plots for wheat and rice. The fertilizers were applied in rows alongside the seed at the time of sowing of wheat. Nitrogen was applied in three splits. The seed rate of wheat used was 100 kg ha $^{-1}$, whereas, rice seedlings were transplanted at a spacing of 22.5 cm. To determine the soil's physical and chemical properties, the soil samples were collected after the harvest of the crop at a depth of 15 cm. The samples were air-dried at room temperature and stored at 4°C. Soil sub-samples before chemical analysis were screened through a 2 mm sieve and homogenated. The pH of soil samples was measured in distilled water [soil: water, 1:2.5 (v/v) ratio] after shaking the solution for 30 min by means of a pH Meter (CD 510, WPA) fitted with a glass electrode. The EC was measured in a sutured solution extract of soil samples using an EC Meter (Sension 7, HACH). The organic carbon was determined by the dichromate oxidation method and subsequent titration with ferrous ammonium sulphate (Walkley and Black 1934). An available nitrogen was estimated by the alkaline potassium permanganate method of Subbiah and Asija (1956), and available phosphorus was measured by the method of Olsen *et al.* (1954). Also, soil K was measured by the neutral normal ammonium acetate method of Standford and English (1949). Bulk density was determined using the core method by weighing the undisturbed soil samples of a volume of 250 m^3 (Blake and Hartge 1986). The Gas Pycnometer method was used to determine the total porosity of the soil. Data obtained from this experiment were subjected to analyses of variance by statically software of SAS (SAS (2002) Institute Inc., Cary, NC, USA), in one-way ANOVA with a general linear model. The least significant difference (LSD; P = 0.05) values were used for comparisons of treatment means.

RESULTS AND DISCUSSION

Soil Physico-chemical Properties

Soil pH, Bulk Density (B.D.), and Electrical Conductivity (EC). The results of the study, as presented in Table 1, The maximum reduction in soil pH, reaching 8.13, as well as bulk density (1.39), and electrical conductivity (0.29), was observed in the treatment involving the application of T_{10} (100 kg Nitrogen ha^{-1}+ Azotobacter). This reduction was closely followed by the treatment T_9 (120 kg Nitrogen ha^{-1}). In both cases, these reductions were significantly higher compared to the treatment involving only Azotobacter inoculation (T_2). Conversely, the minimum reduction was observed in the control treatment (T_1). This decrease in soil pH due to biofertilizer application is consistent with previous research findings. Ramalakshmi *et al.* (2008) also reported a substantial reduction in soil pH when biofertilizers were applied, particularly in cases of combined application. In their study, Gulaiya *et al.* (2023) observed consistent findings in the impact of various nutrient sources, specifically a combination of organic and inorganic inputs. Their research revealed a significant influence of these nutrient sources on soil characteristics, particularly soil bulk density, organic carbon content, and pH levels in post-harvest soils.

Organic Carbon and Porosity: The results of the study, as presented in Table 1. The treatment T_{10} (100 kg Nitrogen ha^{-1}+ Azotobacter) exhibited the maximum increase in organic carbon content (0.53%) and porosity (48.00%). These increments were significantly higher compared to treatments with reduced nitrogen levels (T_3-T_6). Conversely, the control treatment (T_1) showed the minimum increase. These findings align with previous research by Ramalakshmi *et al.* (2008); Solanki *et al.* (2015); Banerjee *et al*. (2011), which also reported increased organic carbon content with the application of fertilizers. Bioinoculants, by proliferating in the soil, produce plant growth-promoting substances that enhance rhizodeposition and root exudation of photosynthetic carbon, leading to increased root biomass and, consequently, organic matter in the soil.

In summary, the nutrient management practices in this study had a substantial impact on soil physiochemical properties. The combined application of biofertilizers and nitrogen significantly reduced soil pH, bulk density, and electrical conductivity while increasing organic carbon content and porosity. These findings emphasize the potential of bioinoculants to enhance soil properties, which can contribute to improved crop growth and overall soil health.

Available Nutrients

The results of the study, as presented in Table 2, indicate that the availability of nutrients in the soil was influenced by various nutrient management practices. Among the different practices evaluated, the highest levels of available nitrogen (178kg ha^{-1}), phosphorus (20.5 kg ha^{-1}), and potassium (267.6 kg ha^{-1}) were observed in the treatment involving the application of 100 kg of nitrogen per hectare combined with Azotobacter (T_{10}). This was closely followed by the treatment with 120 kg of nitrogen per hectare (T_9). These two treatments significantly outperformed the other treatments, including those with a combination of reduced nitrogen levels and bioinoculants or the sole application of bioinoculants. In contrast, the control treatment (T_1) exhibited the lowest levels of nutrient availability.

These findings align with the research conducted by Chand *et al.* (2006), who similarly observed increased nutrient availability when organic materials were applied. The increase in available nitrogen, phosphorus, and potassium can be attributed to the decomposition of organic materials, which released acids that lowered soil pH. This decrease in pH made nutrients more soluble, consequently enhancing their availability for plant uptake. El-Kouny (2007) also reported that the application of organic materials resulted in a substantial increase in total nitrogen and available phosphorus and potassium availability. Khalil *et al.* (2013) further supported these results, demonstrating an increase in the available soil content of nitrogen, phosphorus, and potassium following the application of *Azospirillum brasilense*.

The addition of organic manure, as observed in this study, led to an increase in post-harvest nutrient availability. This effect can be attributed to the enhanced release of nutrients from the soil's native pool, as well as the promotion of the growth of beneficial microorganisms. Additionally, organic acids and chelation effects from organic manure played a role in converting insoluble forms of phosphorus into soluble forms, as noted by Rao (2003). These results are in accordance with the findings of Gulaiya *et al.* (2023).

In summary, the results of this study indicate that the combination of nitrogen application and Azotobacter inoculation (T_{10}) and higher nitrogen application alone (T_9) were effective in improving nutrient availability in the soil, particularly for nitrogen, phosphorus, and potassium. These findings emphasize the importance of nutrient management practices in enhancing soil fertility and nutrient accessibility for crop growth and development.

Table 1: Effect of different nutrient management practices on soil physiochemical properties.

Sr. No.	Treatments	Bulk density (g. c.c.$^{-1}$)	Porosity (%)	EC (dS m^{-1})	pH (1:2.5)	OC (%)
T_1	Control (N-0, P-60, K-40Kg ha^{-1})	1.43	45.00	0.34	8.87	0.31
T_2	*Azotobacter*	1.42	46.33	0.32	8.77	0.33
T_3	60 kg Nitrogen ha^{-1}	1.41	46.33	0.32	8.67	0.43
T_4	40 kg Nitrogen ha^{-1} + *Azotobacter*	1.40	46.33	0.33	8.57	0.44
T_5	80 kg Nitrogen ha-	1.41	36.67	0.32	8.47	0.45
T_6	60 kg Nitrogen + *Azotobacter*	1.41	47.0	0.31	8.37	0.46
T_7	100 kg Nitrogen ha^{-1}	1.42	46.33	0.32	8.33	0.47
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	1.41	46.67	0.30	8.27	0.48
T_9	120 kg Nitrogen ha^{-1}	1.40	47.00	0.30	8.17	0.48
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	1.39	48.00	0.29	8.13	0.53
SEm±		0.01	0.43	0.01	0.16	0.01
C.D. at 5%		0.02	1.27	0.02	0.46	0.02

Table 2: Effect of different nutrient management practices on availability of nutrients.

Sr. No.	Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1	Control (N-0, P-60, K-40 Kg ha^{-1})	158	11.9	242.4
T_2	*Azotobacter*	163	13.0	245.7
T_3	60 kg Nitrogen ha^{-1}	162	13.9	245.9
T_4	40 kg Nitrogen ha^{-1} + *Azotobacter*	167	14.8	248.6
T_5	80 kg Nitrogen ha^{-1}	165	16.6	252.3
T_6	60 kg Nitrogen ha^{-1}+ *Azotobacter*	167	17.2	254.5
T_7	100 kg Nitrogen ha^{-1}	169	17.5	256.2
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	170	18.3	260.7
T_9	120 kg Nitrogen ha^{-1}	174	19.0	261.4
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	178	20.5	267.6
SEm±		2.17	0.87	2.13
C.D. at 5%		6.86	2.57	6.31

CONCLUSIONS

From the above it may be concluded that, the application of 100 kg ha^{-1} + nitrogen in combination with Azotobacter has shown significant positive effects on soil physicochemical properties and nutrient availability. This synergistic approach has improved soil fertility, enhanced nutrient retention, and holds promise for sustainable agricultural practices, contributing to increased crop productivity.

FUTURE SCOPE

Future research could explore the long-term impacts of Azotobacter and nitrogen combinations on diverse crop types, addressing sustainability, soil health, and nutrient management strategies for optimized agricultural productivity.

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Conflict of Interest. None.

REFERENCES

Ahmad, F., Ahmad, I. & Khan, M. (2008). Screening of free-living rhizospheric bacteria for their multiple plant growth-promoting activities. *Microbiological Research, 163*, 173–181.

Arough, Y. K., Sharifi, R. S., Sedghi, M. & Barmaki, M. (2016). Effect of zinc and biofertilizers on antioxidant enzyme activity, chlorophyll content, soluble sugars, and proline in triticale under salinity conditions. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 44*, 116–124.

Banerjee, A., Datta, J. K., Mondal, N. K. & Chanda, T. (2011). Influence of integrated nutrient management on soil properties of old alluvial soil under mustard cropping system. *Communications in Soil Science and Plant Analysis, 42*(14), 2473–2492.

Blake, G. F. & Hartge, K. H. (1986). Bulk density. In A. Klute (Ed.), *Methods of soil analysis. Part 1* (2nd ed., pp. 363-382). American Society of Agronomy.

Chand, S., Anwar, M. & Patra, D. D. (2006). Influence of long-term application of organic and inorganic fertilizer to build up soil fertility and nutrient uptake in mint-mustard cropping sequence. *Communications in Soil Science and Plant Analysis, 37*, 63-76.

El-Kouny, H. M. (2007). Effect of organic manure and biofertilizers on wheat grown in Lacustrine soil as compared with mineral fertilizers. *Egypt. J. Soil Sci., 3*, 263-280.

El-Naggar, M. E., Abdelsalam, N. R., Fouda, M. M. G., Mackled, M. I., Al-Jaddadi, M. A. M., Ali, H. M., Siddiqui, M. H. & Kandil, E. E. (2020). Soil Application of Nano Silica on Maize Yield and Its Insecticidal Activity Against Some Stored Insects After the Post-Harvest. *Nanomaterials, 10*, 739.

Gulaiya, S., Agrawal, S. B., Kochale, P., Vermam V. & Patel, K. K. (2023). Changes in Soil behaviour under with the use of various Sources of Nutrient and Bio-fertilizer in Chickpea (*Cicer arietinum* L.). *Biological Forum – An International Journal*, *15*(8), 316-319.

Hanafy Ahmed, A., Mishriky, J. & Khalil, M. (2002). Reducing nitrate accumulation in lettuce (*Lactuca sativa* L.) plants by using different biofertilizers. *Annals of Agricultural Sciences, 47*, 27–42.

Joseph, B., Patra, R. R. & Lawrence, R. (2007). Characterization of plant growth-promoting rhizobacteria associated with chickpea (*Cicer arietinum* L.). *International Journal of Plant Production, 1*, 141–152.

Khalil, H. M. A., Afifi, M. M. I., El-Akshar, Y. S. & El-Sayed, G. A. M. (2013). Effect of bio-organic fertilizers on barley plants in saline soil. *Journal of Applied Sciences Research, 9*(8), 5337-5343.

Olsen, S. R., Cole, C. V., Watanabe, F. S. & Dean, L. A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *United States Department of Agriculture, Circular No. 939*.

Ramalakshmi, A., Iniyakumari, M. & Raj, S. A. (2008). Influence of biofertilizers on soil physico-chemical and biological properties during the cropping period. *Asian Journal of Bioscience, 3*, 348-351.

Rao, S. S. (2003). Nutrient balance and economics of integrated nutrient management in groundnut (*Arachis hypogaea* L.) mustard (*Brassica juncea* L.). *Madras Agricultural Journal, 90*, 465-471.

Razmjooei, Z., Etemadi, M., Eshghi, S., Ramezanian, A., Mirazimi Abarghuei, F. & Alizargar, J. (2022). Potential Role of Foliar Application of Azotobacter on

Growth, Nutritional Value, and Quality of Lettuce under Different Nitrogen Levels. *Plants, 11*, 406.

Rueda, D., Valencia, G., Soria, N., Rueda, B. B., Manjunatha, B., Kundapur, R. R. & Selvanayagam, M. (2016). Effect of *Azospirillum* spp. and *Azotobacter* spp. on the growth and yield of strawberry (*Fragaria vesca*) in a hydroponic system under different nitrogen levels. *Applied Pharmaceutical Sciences, 6*, 48–54.

Solanki, R. L., Mahendra, S., Sharma, S. K., Purohit, H. S. & Arvind, V. (2015). Effect of different levels of phosphorus, sulfur, and PSB on the yield of Indian mustard (*Brassica juncea* L.) and soil properties and available macronutrients. *Scholarly Journal of Agricultural Sciences, 5*, 305-310.

Standford, D. & English, L. (1949). Use of flame photometer in rapid soil tests of K and Ca. *Agronomy Journal, 4*, 446-447.

Subbiah, B. V. & Asija, G. L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science, 25*, 259-260.

Sudhakar, P., Chattopadhyay, G., Gangwar, S. & Ghosh, J. (2000). Effect of foliar application of *Azotobacter*, *Azospirillum*, and *Beijerinckia* on leaf yield and quality of mulberry (*Morus alba*). *Journal of Agricultural Science, 134*, 227–234.

Walkley, A. & Black, I. A. (1934). An estimation of degtareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science, 37*, 29-38.

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