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Impact of Front-Line Demonstrations of Azotobacter in Wheat in Karji Village, District of Kaimur, Bihar, 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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Short Communication

ABSTRACT

Wheat is the world's most widely cultivated food crop after rice, and it is utilised in various forms by more than a billion people in the world, being a staple food for a large population, contributing about 20% of humans' daily dietary calories and protein intake. Front Line Demonstration is one of the most powerful tools for the transfer of technology. The study aims to impact of front-line demonstrations of azotobacter in wheat. The effect of foliar application by *Azotobacter* regarding biofertilizer on the growth and yield of wheat (*Triticum aestivum)* was studied in Karji village, Chainpur Block, District Kaimur, during the rabi season of 2023-24. The field trial consisted foliar spray of *Azotobacter* at the booting stage under Front Line Demonstration. Results showed that plant height, number of tillers/plant, number of spikes/ plant, spike length, no. of grains/spike, grain yield (kg/ha) and straw yield (kg/ha) were significantly higher in plants with RDF along with foliar application of *Azotobacter* at the booting stage. The interaction effect of foliar application of *Azotobacter* with the recommended dose of fertilisers was a good combination to enhance nitrogen

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content in the plant. However, the maximum grain yield was recorded with the application of *Azotobacter* followed byfarmers' practice. The soil fertility status of organic carbon was recorded in the initial soil, 0.39% after the post-harvest wheat demo plot was 0.42% and the local check plot 0.40.% maximum organic carbon recorded in post harvestpost-harvest demo plot, which was 7% and 5% increased over initial soil and local check after post harvestpost-harvest wheat. The highest gross return (Rs. 84,964/ha) and net return (Rs.. 43,764/ha) were obtained from RDF with foliar application of *Azotobacter*. It can be concluded that millions of farmers in developing countries require adequate resources to boost crop productivity and soil fertility. To keep soil fertility and productivity at a sustainable level for a long period of time, the concept of reducing chemical fertilisers and seed treatment, inoculation and foliar application of biofertilizers (*Azotobacter, Azospirillum*, PSB, etc.) must be implemented.

Keywords: RDF (Recommended Dose of Fertilizer); Azotobacter; yield; wheat; Indo-Gangetic Plains.

1. INTRODUCTION

“Wheat (*Triticum aestivum L.*) holds a prominent status as a staple crop and stands as the second most significant agricultural product, following rice, within the nation. This crop constitutes approximately one-third of the overall production of food grains” (Tiwari *et al*., 2023; Hashmi *et al*., 2023). “It is a second important staple food crop, which has been grown ancient centuries in the world and is known as ‘king of cereal’ and belongs to the family ‘Poaceae’. It is the first important and strategic cereal crop for the majority of the world’s population” (Akhtar et al., 2018). It is the most staple food of about two billion people (36% of the world’s population). Wheat is the world's most widely cultivated food crop after rice, and it is utilised in various forms by more than a billion people in the world, being a staple food for a large population, contributing about 20% of humans' daily dietary calories and protein intake reported by Shiferaw et al. (2013). “In India, wheat is cultivated on 29.6 m ha area with 93.5 million tonnes of production and 31.5 q/ha of average productivity,” reported by FAO, (2013,2015). Low and variable yields of wheat in the rice--wheat cropping systems of lower Indo-Gangetic Plains (IGP) of South Asia, covering Bihar and Eastern Uttar Pradesh (EUP) in India and the Terai region of Nepal, are a matter of significant concern for this densely populated region is as reported in Kisor and Singh 2021. Farmers in Bihar cultivate wheat on more than 2 million ha of land and produce 5-6 million tonnes of it every year” (Jackson, 1967).

Wheat occupies 28% of the gross cropped area of Bihar and 70% of the sown area in the Rabi season. The best regions for wheat cultivation in terms of soil are areas with a high amount of humus, enough aeration, and sufficient nutrients Kishor and Singh, (2021). “Deterioration in soil health due to imbalanced application of chemical fertilisers necessitates us to use biological inputs like biofertilizers (*Azotobacter*, *Azospirillum, PSB* etc*)* and organic manures (vermicompost, sewage sludge), which have been sought as one of the best options to restore the soil health apart from solving the nutrition problem of soil. *Azotobacter* contains living cells of microorganisms, are eco-friendly with the capacity to improve the soil fertility status and promote plant growth by converting major nutrients from unavailable to available form as reported” (Prasad et al., 2016).

“Biofertilizer, the microbial inoculant, is an eco-friendly alternative to chemical fertiliser, protects the lithosphere, improves the biosphere by protecting air, water, soil, pollution and eutrophication and enhances yields of agricultural produce. It helps to enrich the soil with macro- and micro-nutrients and also releases plant growth regulators. The main nutrients required by plants are nitrogen, phosphorus, and potassium” (Chakraborty & Akhtar, 2021). “Biofertilizers are microorganisms which are capable of mobilising nutrients from unusable form to usable form through biological processes. They are a cost-effective and inexpensive source of plant nutrients, do not require a non-renewable source of energy during their production, improve crop growth and quality of the product by producing plant hormones and help in sustainable crop production through maintenance of soil productivity. Biofertilizer is useful as a biocontrol agent, since they control many plant pathogens”, as reported by Pathak et al. (2017). *“Azotobacter* contains microscopic microorganisms which are used as fertilisers for the growth of plants due to its renewable, cheap and eco-friendly nature has gained increasing popularity in the past decade in the field of agriculture and food production. Application of Azotobacter alone or in combination with yeast resulted in a positive response on growth and yield of wheat" (Sreethu et al., 2023). "Nitrogen is one of the most important mineral nutrients for Poaceae plants, influencing growth, development, yield, and protein content of grains. Wheat yields in the semiarid regions are not only limited by inadequate water supply, but also by nitrogen shortage late in the cropping season. Nitrogen comprises 7% of the total dry matter of plants and is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments. Generally, nitrogen (N) fertilisation at sowing increases wheat grain yield, and late fertilisation enhances grain" (Olsen, 1954). "Nitrogen is one of the most important mineral nutrients for Poaceae plants, influencing growth, development, yield, and protein content of grains. Wheat yields in the semiarid regions are not only limited by inadequate water supply, but also by nitrogen shortage late in the cropping season" (Achari et al., 2021). Nitrogen plays a vital role in all living tissues of the plant. No other element has such an effect on promoting vigorous plant growth.

2. MATERIALS AND METHODS

The present study was carried out by Krishi Vigyan Kendra, Kaimur, for 2023-24 to evaluate the Farmers Practice and RDF along with foliar spray of *Azotobacter* on the yield and economics of wheat" [9]. A total 10 front-line demonstrations were conducted in Karji village, Chainpur block, district Kaimur 10 farmers on 4.0 ha of land. Each frontline demonstration was laid out on 0.4 ha area, while the adjacent 0.4 ha was considered as a control for comparison (farmer's practice). The selection of farmers was done on the basis of a survey by KVK, and special training was organised for selected farmers on rice ,wheat cultivation only. N through RDF along with foliar spray of *Azotobacter*. The experiment consists of one farmer, one replication. Physico-chemical characteristics of soil of the experimental field of Organic Carbon (0.39%), available N (196.8 kg/ha), available P (17.8 kg/ha), available K (119.3 kg/ha) and available S (8.59 mg/kg). The soil sample was taken before sowing and analysed with the standard procedures. Soil pH was determined in soil water suspension of 1:2.5: Soil: Water, after stirring for 30 min using a Systronic pH meter as described by Jackson (1973). organic carbon (Walkley and Black 1934); available N (Subbiah & Asija 1956); NaHCO3 extractable-P (Olsen et al., 1954), ammonium acetate extractable K (Hanway and Heidel 1952) and 0.15% $CaCl_2$ extractable S by developing turbidity using $BaSO_4$ (Chesnin and Yien 1951).

3. RESULTS AND DISCUSSION

The wheat crop at Karji village, Kaimur district, Bihar, production was recorded varied from 14.10 to 16.48 q/ha, and productivity was also varied from 35.25 to 41.20 q/ha (Table 1). The plant height maximum (101.3 cm) was observed in the demonstrated plot (RDF along with foliar application of *Azotobacter* at booting stage) compared to the Farmers' practice (98.7 cm). The increase in the number of tillers per plant in response to the application of RDF along with foliar application of *Azotobacter,* is probably due to enhanced availability of nitrogen. The number of spikes per plant was higher (14) in treatment RDF with *Azotobacter* compared with the minimum (11) in farmers' practice (Local check). However, treatment RDF with *Azotobacter* maximum (45) number of grain and minimum (43) in Local check plot (Farmer Practice), which was 5% increased over local check (Table 2). The maturity was recorded in wheat crop matured 138 days after sowing in demonstration plot and 140 days after sowing wheat crop matured in farmers' practice. Application of RDF with foliar application of *Azotobacter* biofertilizer demo plot recorded the maximum (38.62 q/ha) average yield and minimum (34.10 q/ha) in local check (FP), which was13% increased grain yield over the local check plot (Fig. 1). A Similar trend was recorded in straw yield. The adequate supply of Nitrogen allowed the plant tissue to grow large and increase the chlorophyll formation and stimulated a rapid rate of photosynthetic activity, consequently recording more dry matter accumulation in comparison to its lower level as stated by Raghuvanshi et al., (2018). Inoculation of biofertilizers stimulates activation of hormones, which helps in shoot and root elongation and high dry matter production. Similar results were observed by Akhthar et al. (2018).

The soil pH was recorded in the initial soil sample and post-harvest wheat demo and local check 7.86, 7.85, 7.34 and electrical conductivity was also recorded 0.126, 0.132, 0.129 dS^{-m}. The soil fertility status of organic carbon was recorded in the initial soil, 0.39% after post post-harvest wheat demo plot was 0.42% and the local check plot 0.40.% maximum organic carbon recorded in post-harvest demo plot, which was 7% and 5% increased over initial soil and local check after post-harvest wheat. Biofertilizers with radical hyphae and bacterial population in the inoculated plot contribute to the increased organic carbon in soil Prasad et al., 2016. Available Phosphorus was recorded as maximum (18.2 Kg/ha) in post harvest soil of wheat in the demo plot, followed by (17.4 Kg/ha) in the local check plot after post-harvest wheat and (17.2 Kg/ha) in the initial soil sample, which was 5 and 6% increased over the local check plot and initial soil samples. Maximum potassium (123.4 Kg/ha) was recorded in RDF with foliar application of *Azotobacter* demo plot followed by local check plot (119.6 Kg/ha) and 119.3 Kg/ha in the initial soil sample. Increased availability of macro nutrients might be due to the soil community, which is able to influence soil fertility through processes, viz. decomposition, mineralisation, and release of nutrients and combined application of biofertilizers is found to have a beneficial effect on enhancing N, P and K nutrients (Prasad et al., 2016). The sulphur content in the soil sample was recorded as maximum (8.59 mg/kg) in the initial soil sample, followed by 7.54 and 7.24 mg/kg, which were 14 and 19% decreased over the initial soil sample.

The cost of cultivation of wheat was observed to be Rs. 41,200/ha in the demo plot and Rs. 39,100/ha in the local check plot.In general, the gross returns, net returns and B: C were higher in the wheat crop when RDF, along with foliar application of *Azotobacter,* was compared to the Local check (FP). An increase in gross returns with the application of *Azotobacter* might be due to a higher yield in the demonstration plot. In the wheat demo plot, maximum gross returns (Rs. 84,964/ha) were recorded in the application of RDF with *Azotobacter,* and minimum gross returns (Rs. 75,020/ha) were recorded in the local check plot. In the demo plot, maximum net returns (Rs. 43,764/ha) were recorded with the application of *Azotobacter,* and minimum net returns (Rs. 35,920/ha) were recorded in the local check plot. In the demo plot, the maximum benefit cost ratio (2.06) and minimum (1.92) in the demo and local check plot (Fig. 2). Higher net return and benefit: cost ratio in wheat cultivation were achieved from the use of the recommended N dose with foliar application of *Azotobacter* when compared with the local check plot.

Table 1. Effect of Azotobacter foliar spray on production and productivity in wheat

Sl. No.	Production (q/ha)	Productivity (q/ha)
1.	15.40	38.50
2.	14.88	37.20
3.	16.40	41.00
4.	16.20	40.50
5.	16.48	41.20
6.	16.35	40.88
7.	15.64	39.10
8.	14.15	35.38
9.	14.88	37.20
10.	14.10	35.25

Table 2. Effect of Azotobacter on yield and yield attribute character and post harvest soil in wheat

	Plant height (cm)	No. of Tillers/ Plant	No. of spikes/ Plant (80-90 days)	Spike length (cm)	No. of grains/ spike	Maturity (Days)	Average Grain Yield (q/ha)	Average Straw Yield (q/ha)
Demo	101.3	16	14	12.6	45	138	38.62	52.4
Local	98.7	14	11	11.8	43	140	34.10	51.7
		pH	**EC (dS^{-m})**	**OC (%)**	**Available N (Kg/ha)**	**Available P (Kg/ha)**	**Available K (Kg/ha)**	**Available S (mg/kg)**
Initial Soil		7.86	0.126	0.39	196.8	17.8	119.3	8.59
Post Harvest Wheat	Demo	7.85	0.132	0.42	198.7	18.2	123.4	7.54
	Local	7.34	0.129	0.40	195.4	17.4	119.6	7.24

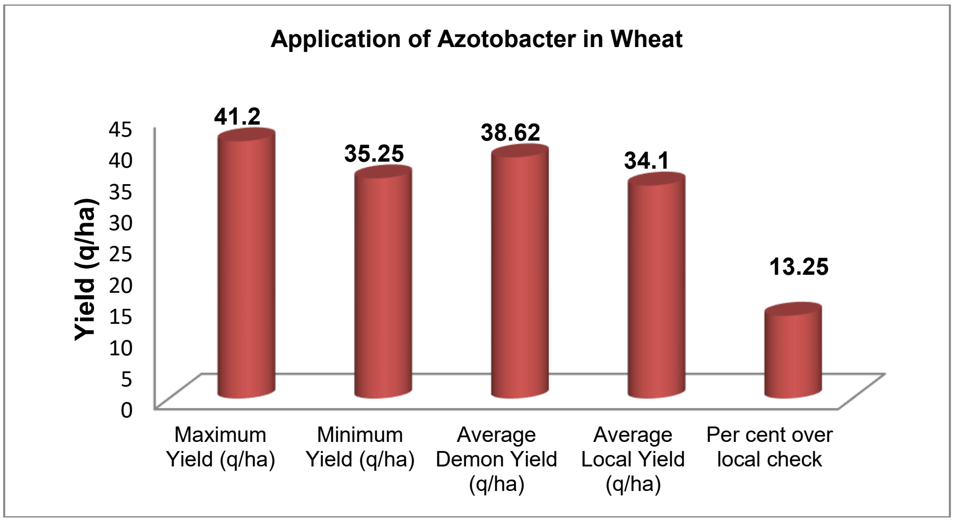

Fig. 1. Maximum, minimum and per cent increase yield over local check in wheat

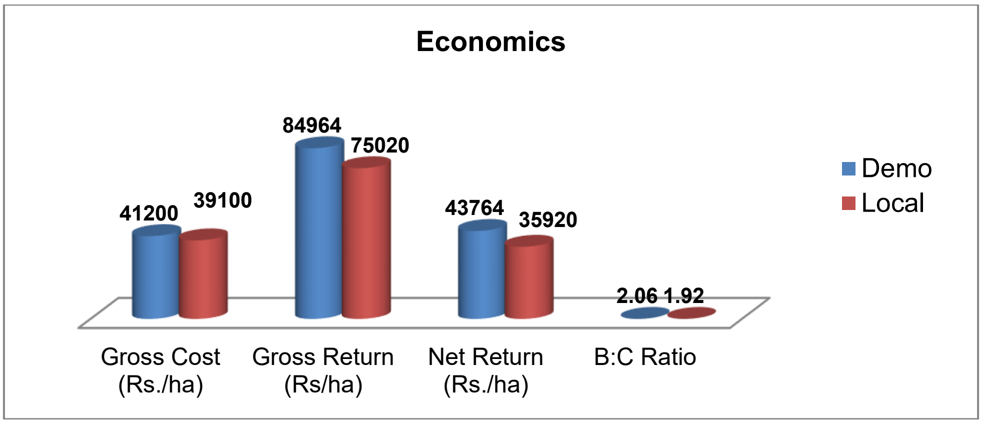

Fig. 2. Economics of Wheat

4. CONCLUSIONS

It can be concluded that millions of farmers in developing countries require adequate resources to boost crop productivity and soil fertility. To keep soil fertility and productivity at a sustainable level for a long period of time, the concept of reducing chemical fertilisers and seed treatment, inoculation and foliar application of biofertilizers (*Azotobacter, Azospirillum, PSB,* etc.) must be implemented.

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 this manuscript.

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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