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IMPACT OF NITROGEN FIXING BACTERIA ON YIELD AND ECONOMICS OF MAIZE UNDER VARIED NITROGEN MANAGEMENT REGIMES

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ABSTRACT:
Maize being an important cereal crop shows the need for proper nitrogen management for the plant's optimum growth and yield. There is potential to use biofertilizers to enhance nutrient use and crop performance. The present study was carried out at the Research Farm of the Faculty of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana Ambala, Haryana in *Kharif* season of 2025. The experiment was laid in split plot design with three replications. Four levels of Nitrogen and four biofertilizer treatments were applied. The results revealed that application of 100% RDN showed better yield attributes, yield parameters and economic returns. On the other hand, among all the bio-fertilizers Azotobacter reported higher grain yield (5.15t/ha), stover yield (10.91t/ha) and biological yield (16.06t/ha) which are statistically at par with Azospirillum. Under the condition of Haryana, the study revealed that, proper application of nitrogen by the biofertilizer can increase the productivity of maize and farm returns.

KEYWORDS: Biofertilizers, Maize, Yield, Profitability, Azospirillum, Azotobacter, Acetobacter

INTRODUCTION

Maize (Zea mays L.) is one of the most important cereal crops in the world. It is grown in many countries because it can grow well in different weather and soil conditions. Maize is also called as “Queen of Cereals” due to its high yield potential (Bhandari et al., 2021). Maize is used as food for people, feed for animals, and raw material for many industries. Along with rice and wheat, maize provides a large part of the world's food supply. In Haryana, maize is grown over an area of 0.07 lakh ha with production of 0.20 lakh tons having productivity of 3026 kg/ha in 2020-21(Kumar et al., 2024). In current studies which was carried out in Haryana, that maize is sown during the Kharif season. Where rice is the main crop of the season which requires a lot of water. According to the Haryana Statistical Abstract 2022–2023, the area under rice in Haryana has grown significantly over the past three decades, from 661.2 (thousand hectares) in 1990 to 1525 (thousand hectares) in 2020. As a result, water resources especially state groundwater are at risk due to increased cultivated area of rice. To deal with this problem several alternatives were explored to substitute the rice crop in the state. Maize is viewed as a worthwhile substitute for rice that could boost farmers' profits while preserving water resources (Kumar et al., 2025). One of the most important nutrients for maize is Nitrogen. It aids in the development of leaves, formation of chlorophyll, protein and grain. But, heavy application of chemical fertilizer may have an impact on the soil health and may raise production costs. Thus, there is a need for improvement in nutrient management. Biofertilizers are microorganisms which could be useful in improving nutrient availability and plant growth. Some biofertilizers like Azospirillum and Azotobacter are used in cereal crops. They will enhance root development and nutrient utilization. The positive effect of nitrogen and biofertilizers on maize growth and yield was also reported in previous studies. Hence, the present study was carried out to examine the effect of various rates of nitrogen and biofertilizers on growth, yield, soil properties, nutrient content and economics of maize.

MATERIALS AND METHODS

A field experiment was conducted at the Research farm of the Faculty of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala during *kharif* 2025. Geographically the experiment site lies at 30°17′0” North latitude, 77°3′0” East longitude and at an altitude of 264 meter above the mean sea level. The experiment area is Sub-Tropical of Haryana. The region receives 750 mm of rain on an average each year. The soil of experimental field was sandy loam in texture with near neutral in reaction. The

soil had low organic carbon (0.30%), low available nitrogen (169.34 kg/ha) and medium available phosphorus (13.45) and
potassium (238.65). The experiment was in split plot design with three replications. Four levels of nitrogen (control, 60% RDN, 80% RDN and 100% RDN) in main plots and different nitrogenous biofertilizers (control, Azospirillum, Acetobacter, Azotobacter) in sub plots were applied. The recommended dose of nitrogen was applied at the rate of 150 kg/ha uniformly in the form of urea and as per treatment requirement. A level of 60 kg of both phosphorus and potassium per hectare was recommended. The nitrogen (N), phosphorus (P), and potassium (K) were supplied as urea, SSP and MOP, respectively. All the fertilizers were applied as basal application at the time of sowing of crop.
Seeds were sown using ridge and furrow method where seeds were placed at the top of the ridge with the depth of 3–4 cm and having spacing 67.5 cm × 18 cm using 25 kg/ha seed rate. The seeds were treated with Azotobacter, Acetobacter and Azospirillum just before sowing. Slurry of inoculant and jaggery solution was prepared and the seeds were mixed with it so that they are uniformly coated on seeds and the seeds were dried for 30 minutes under the shade and were sown immediately. Five plants selected randomly from each plot were tagged to take periodic observations. Five tagged plants were picked from the net plot and the yield attributes namely number of cobs/plants, number of grains/cob and 100 grain weight were determined. Harvesting of crop was done from net plot and sun dried and threshed to obtain seed yield. Cost of cultivation of each treatment was calculated with current market prices and the benefit cost ratio was calculated as ratio of gross returns to cost of cultivation. The crop data collected in the field encompasses various parameters underwent statical analysis using standard methodology as prescribed by Cochran & Cox (1957).

RESULTS AND DISCUSSION

Number of cobs per plant: It is evident from the data (Table 1) that number of cobs per plant increased significantly with increasing level of nitrogen upto 100% RDN. Adequate nitrogen helped in better plant growth, which finally resulted in well-developed cobs. Among biofertilizer treatments, Azotobacter (S4) recorded significantly higher value (1.31) which was statistically at par with Azospirillum (S2). Better root growth and improved nutrient uptake due to biofertilizers may have helped the plants produce higher cobs per plant. Similar findings have been reported by Meena et al. (2013), Kumar et al. (2024), who observed that integrated use of nitrogen and biofertilizers improved number of cobs per plant of maize.

Number of grains per cob: Significant increase in number of grains per cob was recorded with increasing dose of nitrogen upto 100% RDN (367.97), which might be due to nitrogen application which enhanced plant biomass production traits of plant and ultimately reflecting higher number of grains per cob. Same effect on number of grains per cob was reported by Luikham et al., (2018), karki et al., (2020) and Adhikari et al., (2018). Among bio-fertilizers Acetobacter (291.17), resulted in lower number of grains per cob when compared to Azotobacter (303.79) which was statically at par with Azospirillum (291.17). Similar, results were also shown by Luikham et al., (2018) and Kumar et al., (2023).

100-grain weight: 100-grain weight was significantly enhanced with increasing level of nitrogen application upto 100% RDN. Application of 100% RDN recorded significantly highest's value 24.19 g. Such similar report was also showed by Bastakoti et al., (2025), Karki et al. (2020), Luikham et al. (2018) and Ahamad et al. (2018). However, biofertilizers application recorded non-significant effect on 100-grain weight of maize.

Table 1: Effect of nitrogen and biofertilizers on yield attribute of maize

Treatment	No. of cobs/plant	No. of grains/cob	100-grain weight(g)
Main-plot			
M1: Control	1.02	194.23	22.24
M2: 60% RDN	1.31	232.05	23.70
M3: 80% RDN	1.32	303.89	23.04
M4: 100% RDN	1.37	367.97	24.19
SE(m)±	0.03	6.42	0.48
C.D. at 5%	0.07	15.70	1.19
Sub-plot			
S1: Control	1.17	241.92	22.66
S2: Azospirillum	1.29	291.17	23.57
S3: Acetobacter	1.25	261.27	22.99
S4: Azotobacter	1.31	303.79	23.95
SE(m)±	0.03	7.84	0.56
C.D. at 5%	0.05	16.19	NS
Interaction			
M*S	NS	NS	NS

Table 2: Effect of nitrogen and biofertilizers on yield attribute of maize

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Main-plot				
M1: Control	3.29	7.39	10.68	31.11
M2: 60% RDN	4.41	9.22	13.63	32.48
M3: 80% RDN	4.96	10.28	15.24	32.68
M4: 100% RDN	5.99	12.38	18.38	32.80
SE(m)±	0.15	0.31	0.43	0.62
C.D. at 5%	0.37	0.75	1.06	NS
Sub-plot				
S1: Control	4.12	8.30	12.41	33.24
S2: Azospirillum	4.94	10.56	15.51	31.84
S3: Acetobacter	4.45	9.50	13.95	31.80
S4: Azotobacter	5.15	10.91	16.06	32.18
SE(m)±	0.11	0.29	0.29	0.97
C.D. at 5%	0.23	0.60	0.60	NS
Interaction				
M*S	0.46	1.21	1.20	NS

Grain yield: Results showed in (Table 2) is evident that at harvest of crop 100% RDN recorded significantly higher grain yield (5.99 t/ha). Such a positive yield response of nitrogen application is obvious when it is deficient in the growing medium. The soil sample analysed before the start of the experiment also showed that the available nitrogen status of soil in the experimental site was in low range (169.34 kg N/ha). The improvement in yield resulted in significant increase in yield attributes like number of cobs per plant, grains per cob and 100 grain weight which ultimately contributed to higher grain yield with the application of nitrogen. Same findings were reported by Karki et al., (2020) and Ahamad et al., (2018).

The grain yield of maize was significantly higher with (S4) Azotobacter seed inoculation (5.15 t/ha) but (S2) Azospirillum (4.94 t/ha) is statically at par with S4. The increase in grain yield due to bio-fertilizer may be its direct role in nitrogen fixation and also due to production of phytohormones like Indole acetic acid, Gibberellins and Cytokinin. This finding is supported by Marngar et al., (2017), Luikham et al., (2018) and Kumar et al., (2023).

The interaction effect of Nitrogen and bio fertilizers is presented in Table 3 which revealed that 100% RDN along with azotobacter recorded significantly higher grain yield which was statistically at par with 100% RDN with azospirillum. It was also observed that 80% RDN application with azotobacter or azospirillum was statistically at par with sole 100% RDN application. Which might be attributed to biological nitrogen fixation by azotobacter and azospirillum which overcome the 20% deficiency of RDN resulting in statistically at par grain yield with sole 100% RDN application.

Table 3: Interaction effect of nitrogen and biofertilizers on grain yield of maize

Treatments		Nitrogen			
		Control	60% RDN	80% RDN	100% RDN
Bio fertilizers	Control	2.92	3.85	4.61	5.12
	Azospirillum	3.48	4.66	5.20	6.45
	Acetobacter	3.12	4.41	4.71	5.56
	Azotobacter	3.65	4.73	5.32	6.89
	C.D. at 5%	0.46			

Straw yield: It was found that stover yield increased significantly with the varying dose of nitrogen upto 100% RDN (12.38 t/ha). The higher stover yield associated with the application of nitrogen can be attributed to better growth of the plant as expressed in terms of plant height, no. of leaves, dry matter accumulation. This finding confirms the earlier report of Marngar et al., (2017), Luikham et al., (2018) and Ahamad et al., (2018).

The results of the present investigation have clearly indicated that application of bio-fertilizers had remarkably increased the stover yield. Between the bio-fertilizers significantly higher stover yield was recorded with the inoculation of Azotobacter (10.91 t/ha) which was statically at par with Azospirillum (10.56). Higher stover yield with the inoculation of Azotobacter have also been reported by Marngar et al., (2017), Luikham et al., (2018) and Kumar et al., (2023).

Table 4 illustrates the interaction effect of nitrogen and biofertilizers on straw yield of maize. It showed that 100% RDN with Azotobacter recorded significantly higher straw yield which was statically at par with 100% RDN with Azospirillum. Additionally, it was found that 80% RDN along with azotobacter or azospirillum was statically at par with 100% RDN alone. Which might be attributed to higher vegetative growth in 80% RDN treatments with azotobacter and azospirillum which lead to higher photosynthesis resulting in statistically at par straw yield with sole 100% RDN application.

Table 4: Interaction effect of nitrogen and biofertilizers on straw yield of maize

Treatments		Nitrogen			
		Control	60% RDN	80% RDN	100% RDN
Bio fertilizers	Control	5.84	8.40	8.93	10.09
	Azospirillum	7.91	9.65	11.14	13.54
	Acetobacter	7.73	9.05	9.96	11.25
	Azotobacter	8.07	9.76	11.09	14.73
	C.D. at 5%	1.21			

Biological yield: The present study demonstrates that fertilizer dose had significantly affected the biological yield. Nitrogen dose of 100% RDN had significantly higher biological yield (18.38 t/ha). These results were in similarity with Adhikari et al., (2021). Similarly, (S4) Azotobacter showed higher biological yield (16.06 t/ha) when compared to other biofertilizers. But, (S2) Azospirillum (15.51 t/ha) found at par with Azotobacter. This finding is supported by Marngar et al., (2017), Luikham et al., (2018) and Kumar et al., (2023).
Similarly, in Table 5 interaction effect of Nitrogen and bio fertilizers revealed that 100% RDN along with azotobacter recorded significantly higher biological yield but was statically at par with 100% RDN with Azospirillum. Furthermore, it was observed that 80% RDN plus either Azotobacter or Azospirillum was statically at par to 100% RDN alone. Which can be correlated to superior grain and straw yield in the aforesaid treatments due to azotobacter and azospirillum application with 80% RDN treatments.

Table 5: Effect of nitrogen and biofertilizers on biological yield of maize

Treatments		Nitrogen			
		Control	60% RDN	80% RDN	100% RDN
Bio fertilizers	Control	8.75	12.25	13.54	15.21
	Azospirillum	11.39	14.31	16.34	19.99
	Acetobacter	10.85	13.46	14.68	16.81
	Azotobacter	11.72	14.49	16.41	21.62
	C.D. at 5%	1.20			

Relative economic: Relative economics (Table 6) of maize revealed higher cost of cultivation (Rs 45922 /ha), gross returns (Rs 159956 /ha), net returns (Rs 114034 /ha) and benefit cost ratio (2.48) with application of 100% RDN (M4) and which was followed by the application of 80% RDN (M3). Similarly, in case of nitrogenous bio-fertilizers S4 (Azotobacter) cost of cultivation (Rs 45922), gross returns (Rs 137704 /ha), net returns (Rs 92530 /ha), and benefit cost ratio (2.04) founded higher and which was followed by (S2) Azospirillum.

Table 6: Effect of nitrogen and biofertilizers on relative economic of maize

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C
Main-plot				
M1: Control	43965	88602	44636	1.02
M2: 60% RDN	45139	117865	72725	1.61
M3: 80% RDN	45531	132404	86873	1.91
M4: 100% RDN	45922	159956	114034	2.48
Sub-plot				
S1: Control	45084	109544	64460	1.42

S2: Azospirillum	45174	132394	87220	1.92
S3: Acetobacter	45126	119184	74058	1.63
S4: Azotobacter	45174	137704	92530	2.04

CONCLUSION

Current investigation clearly revealed that significant improvement in all the parameters of maize with each increment in nitrogen dose up to 100% recommended dose of nitrogen. Among biofertilizers, Azotobacter seed treatment recorded significantly higher parameters which were statistically at par with Azospirillum. On the other hand, interaction effect of grain yield revealed statistical superiority of 100% RDN along with Azotobacter which was statistically at par with 100% RDN along with Azospirillum. It was also observed that 80% RDN application with Azotobacter or Azospirillum recorded statistically at par grain yield with 100% RDN alone making these treatments sustainable as well as economical alternative of sole 100% RDN application.

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