GAU Res. J. 2001 & 02. 27 (1 & 2) : 13-17

Response of Kharif Maize to Inoculation with Azotobacter and Azospirillum at Varying Levels of Nitrogen

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ABSTRACT

A field experiment was conducted at the Main Maize Research Station, Godhra, Gujarat during 1998 to 2000 on sandy loam soil to asses the effect of *Azotobactor chroococcum* and *Azospirillum lipoferum* seed inoculation along with graded levels of nitrogen on grain and straw yield of *kharif* maize cv. GM-1. The results revealed that seed inoculation either with *Azotobactor chroococcum* or *Azospirillum lipoferum* gave significantly highest grain and straw yield 2558 and 2464 kg/ha and 3370 and 3252 kg/ha respectively. Application of nitrogen @ 80 kg/ha gave significantly highest net return of Rs. 17,520/-. The results revealed a saving of 20 kg N/ha when maize seed was inoculated with *A. chroococcum* and *Azospirillum lipoferum*.

(Received on 8th Oct. 2001)

INTRODUCTION

Maize *(Zea maize* L.) is an important cereal crop mostly cultivated in low fertile soils of tribal belt of Gujarat in *kharif* and *rabi* seasons. Though maize is highly responsive to nitrogen and other inputs, their high cost limits their full use. It is, therefore necessary to explore alternative sources of fertilizers, especially nitrogen to fulfil the nitrogen requirement. It is proved in many cereal crops that the seed inoculated with Azotobactor and Azosprillium helps to fix the atmospheric nitrogen in the available form to plants and augments the nitrogen requirement. To assess their effect on grain and straw yield in maize, an experiment was conducted using *Azotobactor chroococcum* and *Azospirillum lipoferum* along with graded levels of nitrogen.

MATERIALS AND METHODS

Field experiment

A field experiment was conducted on sandy loam soil at Main Maize Research Station, Gujarat Agricultural University, Godhra (Gujarat) during *kharif* seasons of 1998, 1999 and 2000. The experiment was laid out in randomised block design with two biofertilizer seed inoculants i.e. *Azotobactor chroococcum* (ABA-1) and *Azospirillum lipoferum* (ASA-1) with untreated control along with five levels of nitrogen viz. 0, 20, 40, 60 and 80 kg/ha alone and in combination with biofertilizer seed inoculation. Nitrogen was applied in the form of urea in a split application, one half being at sowing time and the remaining as a top dressing at knee height and tasselling

Abbreviations :
1. ABA-1 : *Azotobacter chroococcum*, Anand -1.
2. ASA-1 : *Azospirillum lipoferum*, Anand-1.
3. I.C.B.R. : Incrimental Cost Benefit Ratio.

stage in equal splits. A uniform basal dose of 30 kg P_2O_5/ ha was applied in the form of single super phosphate.

Seed Inoculation

The maize seeds of cv. Gujarat Maize -1 were inoculated with bio cultures viz. *Azotobactor chroococum* and *Azospirillum lipoferum* @ 25 gm/ kg seeds containing 10^8 CFU/gram carrier prior to one hour of sowing.

RESULTS AND DISCUSSION

Data presented in Table 1 revealed that effect of seed inuculation treatments has significantly increased the grain yield in all the three years. Among the two seed inoculation treatment ABA-1 gave significantly higher yield in two out of three years and in the pooled data. In case of dry fodder yield treatment ABA-1 was at par with ASA-1 in two years. However the pooled data ABA-1 was significantly superior over the other two treatments. Pooled analysis also revealed that seed inoculation with ABA-1 (2558 kg/ha) could increase the grain yield to the tune of 4 and 26% over ASA-1 (2464 kg/ha) and control (2038 kg/ ha), respectively. Studies carried out by Cavallet *et al.* (2000) revealed that maize seed inoculation with *Azospirillum Spp* along with 70 kg N/ha increased the maize productivity by 17% (from 5211 to 6067 kg/ha) while cob length increased from 13.6 to 14.4 cm. Reddy *et al.* (1977) reported that Azotobacter seed inoculation significantly raised the grain yield of maize by 9-14%.

TABLE 1

Response of kharif maize to inoculation with *Azospirillum* and *Azotobactor* at varying levels of nitrogen (*kharif* 1998-2000).

Treatment	*Grain yield (kg/ha)*				*Dry fodder yield (kg/ha)*			
	1998	*1999*	*2000*	*Pooled*	*1998*	*1999*	*2000*	*Pooled*
(A) Bio-fertilizer								
B_1 Control	2227	2128	1760	2038	2783	2746	2254	2594
B_2 ABA-1	2696	2607	2372	2558	3370	3248	3138	3252
B_3 ASA-1	2633	2532	2228	2464	3292	3317	2973	3194
(B) Nitrogen levels								
N_1-0 kg/ha	1501	1444	1156	1367	1876	1835	1499	1737
N_2-20 kg/ha	2126	1948	1713	1929	2657	2709	2230	2532
N_3-40 kg/ha	2583	2481	2093	2385	3228	3019	2745	2997
N_4-60 kg/ha	2982	2959	2611	29\851	3727	3694	3454	3625
N_5-80 kg/ha	3403	3278	3028	3236	4254	3259	4012	4175
lsd B	107	50	171	67	134	121	217	ns
lsd N	138	64	220	87	173	156	280	ns
lsd B x N	ns	111	ns	ns	ns	270	ns	ns
lsd Y x B				ns				ns
lsd Y x N				ns				ns
lsd Y x B x N				ns				ns
C.V. %	5.7	2.7	10.8	6.8	5.7	5.2	10.4	2.1

Among the nitrogen doses, application of N @ 80 kg/ha was found to be significantly superior in increasing the grain as well as fodder yield in all the three years as well as in pooled analysis. No significant interaction between biofertilizer and nitrogen in two out of three years as well as in pooled analysis was absent. Hegazi *et al.* (1983) advocated that the maize seed inoculation with Azospirillum and straw amendment increase plant height, leaf-area index, shelling percentage, total yields of grain (180-270%), straw (150-170%) and nitrogen content (120-130%).

Considering the linear trend of nitrogen response and the definite effect of biofertilizer inoculation, an attempt has also been made to estimate the amount of nitrogen replaced by the biofertilizer treatments by fitting three separate equations for each biofertilizer treatments. The results are presented in Table 2.

TABLE 2

Nitrogen response equation fitted for three treatments.

Treatments	*Constant (a)*	*Partial Regression coefficient (b)*	*R^2 (%)*
B_1 (Control)	1189.27	21.2283	99
B_2 (ABA-1)	1568.14	24.7550	99
B_3 (ASA-1)	1507.97	23.9134	99

The result presented in Table 2 clearly suggest that close linear relation exists between the applied nitrogen and yield.

Comparison of regression co efficient of three equations indicated that increase in yield for per unit application of nitrogen was highest in case of ABA-1 (24.7550 kg) followed by ASA-1 (23.9134 kg). This clearly indicated that applied nitrogen efficiency was higher when seed are inoculated with biofertilizers.

In order to estimate the amount of nitrogen being saved due to seed inoculation with biofertilizer for various levels, the expected yields levels were worked out using the above fitted equations corresponding to no biofertilizer (B_1) keeping these expected yield as the targeted yields, the equations corresponding to biofertilizer applied (B_2 and B_3) were used to provide the estimated nitrogen requirement.

The data presented in Table 3 clearly indicated that sizable amount of nitrogen is saved when seed is inoculated with biofertilizer more so in ABA 1 (18 kg/ha) in case of first dose of nitrogen (20 kg/ha) whereas, it was to the tune of approximately 27 kg/ha for highest dose of nitrogen (80 kg/ha). On an average 22 and 20 kg of nitrogen /ha can be saved by inoculating the maize seeds before sowing with *Azotabactor chrococcum* and *Azospirillum lipoferum*.

TABLE 3

Estimated Nitrogen requirement.

'N doses for No bio - fertilizer (kg/ha)	*Expected/ targeted grain yield (kg/ha)*	*Estimated 'N' requirement when seed inoculated with*		*'N' saving (kg/ha)*	
		ABA-1	ASA-1	ABA-1	ASA-1
20	1614	1.85	4.44	18.15	15.56
40	2038	18.97	22.17	21.03	17.83
60	2463	36.10	38.34	23.90	21.66
80	2888	53.30	55.44	26.70	24.56
Mean				22.45	19.90

Economics

TABLE 4

Economics of biofertilizers and Nitrogen levels in Maize.

Treatment	*Fodder yield (kg/ha)*		*Income (Rs.)*			*Cost of cultivation (Rs.)*	*Net realization (Rs.)*	*I.C.B.R.*
	Grain	*Fodder*	*Grain*	*Fodder*	*Total*			
(A) Bio-fertilizers								
B_1 Control	2038	2594	12228	2594	14824	5143	9679	—
B_2 ABA-1	2558	3252	15348	3252	18600	5165	13435	1:173.7
B_3 ASA-1	2464	3194	14784	3194	17978	5165	12813	1:142.5
(B) Nitrogen levels								
N_1-0 kg/ha	1367	1737	8202	1737	9939	5143	4796	—
N_2-20 kg/ha	1929	2532	11574	2532	14106	5435	8671	1:13.3
N_3-40 kg/ha	2385	2997	14310	2997	17307	5647	11660	1:13.6
N_4-60 kg/ha	2851	3625	17106	3625	20731	5859	14872	1:14.1
N_5-80 kg/ha	3236	4175	19416	4175	23591	6071	17520	1:13.7

	Market Price	**Rs.**
1.	1.0 kg Grain	6.00
2.	1.0 kg Fodder	1.00
3.	1.0 kg 'N'	10.60
4.	Per ha seed treatment with biofertilizers including labour.	22.00

The results presented in Table 4 revealed that maximum net realization of Rs. 13,435/- with highest ICBR (1:173.73) was obtained through mere inoculation, the seeds with *Azotobactor chrococcum* followed by *Azospirillum lipoferum* (Rs. 12,813/- ICBR 1 : 142.55). Maximum net realization of Rs. 17,520/- with ICBR value of 13.71 was obtained with 80 kg nitrogen application along with biofertilizer seed inoculation. Mishra *et al.* (1998) reported that maize seed inoculation with Azospirillum produced maximum grain yield (32.6 q/ha) along with application of 50% dose with respective increase in cost of cultivation, yield and net profit of 4.03, 32.5 and 47.4% over the application of 50% recommended dose which was superior (12%) to the application of 100% recommended dose (80, 40 and 40 kg/ha of N, P and K) of crop.

In present study, seed inoculation either with ABA-1 or ASA-1 was economically most efficient at lower doses of nitrogen fertilizer which not only increases yields but resulted in a saving of nitrogen also (22 and 20 kg/ha). Similarly Maskey (1977) obtained significant positive effects of Azospirillum inoculation when combined with low levels of N fertilization of about 45 kg N/ha^{-1} in paddy and wheat crop.

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