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Effect of *Azotobacter* and *Azospirillum* inoculation under graded levels of nitrogen on growth and yield of sugarcane (*Saccharum officinarum*)

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ABSTRACT

A field experiment conducted during 1990–91 to 1992–93 with sugarcane (*Saccharum officinarum* L.) indicated that application of graded levels of nitrogen along with inoculation of 2 cultures increased the cane and sugar yields to the extent of 7.30 and 0.78 m tons/ha respectively compared with the uninoculated control. The germination, tillering, number of millable canes, girth and cane height were also improved due to *Azotobacter* and *Azospirillum* culture combination. Maximum response was observed in *Azotobacter* + *Azospirillum* culture with nitrogen. There was a saving of fertilizer N to the extent of 25–50 kg/ha and improvement in soil properties.

Sugarcane (*Saccharum officinarum* L.) requires high quantity of nitrogenous fertilizer for maximization of cane and sugar yield. *Azotobacter* and *Azospirillum* bacteria fix atmospheric nitrogen in the rhizosphere of sugarcane non-symbiotically to meet the partial nitrogen requirement of crop (Anderson, 1985). They synthesize auxins and vitamins and also stimulate the uptake of other plant nutrients. Seed inoculation with specific bacterial cultures is a low-cost technology, widely recommended to increase the yield of crops. Therefore an experiment was conducted to study effect of integrated use of inorganic fertilizers and biofertilizers in reducing the cost of production of sugarcane cultivation.

MATERIALS AND METHODS

The field experiment was conducted for 3 spring seasons (during 1990–91 to 1992–93) with 'CoM 7125' at Central Sugarcane Research Station, Padegaon. The experiment was laid out in split-plot design, having 3 replications and 16 treatment combinations. The treatments comprised 4 cultures, viz. without culture, *Azotobacter* culture, *Azospirillum* culture and *Azotobacter* + *Azospirillum* culture, as a main plot and 4 nitrogen levels, viz. 175, 200, 225 and 250 kg/ha as subplot. The recommended P_2O_5 and K_2O @ 115 kg/ha each were applied prior to planting, whereas nitrogen was given in 4 split doses. Amongst the biofertilizers, *Azotobacter* culture was isolated and multiplied at this research station, whereas *Azospirillum* culture obtained from the All-India Co-ordinated Biological Nitrogen Fixation Project, Pune. The cultures were used @ 5

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kg/ha of which 100 litres suspension was prepared. The sugarcane setts (3-eye budded) were dipped in suspension for 5 min. before planting. The soil analysis before planting and after harvest of crop was done for different parameters, following standard analytical procedure (Jackson, 1973). Soil had initial pH 7.78, electrical conductivity 0.20 dS/m, available N 288 kg/ha, P_2O_5 28 kg/ha and K_2O 492 kg/ha. The growth parameters, viz. millable canes, girth, height, cane yield and commercial cane sugar (CSS), were recorded at harvest of crop.

RESULTS AND DISCUSSION

The germination percentage could be enhanced due to inoculation of *Azotobacter* and *Azospirillum* culture in alone or in combination at all graded levels of nitrogen (Table 1). However, maximum germination (67.32%) was noticed in the treatment of combined inoculation of both cultures at 250 kg N/ha and more or less same with 225 kg, 200 kg and 175 kg N/ha. It indicates that the effect of cultures seems to be pronounced, but graded dose of nitrogen did not affect the germination in general. The tillering recorded at 24th week, millable cane, girth and height of cane at harvest were found increased due to inoculation of all cultures and the maximum in combined inoculation treatment. These growth parameters increased with increasing levels of nitrogen with cultures, but were at par with each other. This effect could be attributed to the increase in nitrogen level (higher N in soil) as a result of *Azotobacter* and *Azospirillum*

Table 1. Effect of *Azotobacter* and *Azospirillum* inoculation under graded levels of nitrogen on growth parameters of sugarcane (average data of 3 seasons)

Treatment	Germination at 8th week (%)	Tillering ratio at 24th week	Millable cane/ha ('000)	Cane girth (cm)	Cane height (cm)
Without culture + 175 kg N/ha	62.47	1.79	88.28	7.8	180
Without culture + 200 kg N/ha	61.81	1.77	89.43	8.0	182
Without culture + 225 kg N/ha	63.50	1.77	90.57	8.0	184
Without culture + 250 kg N/ha	61.22	1.78	93.07	8.2	187
Azotobacter + 175 kg N/ha	65.27	1.83	90.83	7.9	182
Azotobacter + 200 kg N/ha	65.57	2.12	91.74	8.1	186
Azotobacter + 225 kg N/ha	65.90	2.19	93.86	8.3	185
Azotobacter + 250 kg N/ha	66.20	2.54	95.72	8.5	189
Azospirillum + 175 kg N/ha	66.23	2.50	92.26	8.4	189
Azospirillum + 200 kg N/ha	66.28	2.52	93.17	8.4	189
Azospirillum + 225 kg N/ha	66.49	2.57	94.86	8.6	189
Azospirillum + 250 kg N/ha	67.10	2.59	95.17	8.7	189
Azotobacter + *Azospirillum* + 175 kg N/ha	66.07	2.42	92.36	8.1	182
Azotobacter + *Azospirillum* + 200 kg N/ha	66.90	2.57	94.32	8.6	192
Azotobacter + *Azospirillum* + 225 kg N/ha	67.13	2.60	95.47	8.7	191
Azotobacter + *Azospirillum* + 250 kg N/ha	67.32	2.63	96.30	8.8	193
CD (P = 0.05)	NS	NS	2.38	NS	3.07

Table 2. Effect of *Azotobacter* and *Azospirillum* inoculation under graded levels of nitrogen on yield and commercial cane sugar (CCS) of sugarcane

Culture	N (kg/ha)				
	175	200	225	250	Mean
Control	103.50 (12.25)*	105.73 (12.71)	107.03 (13.07)	110.47 (13.23)	106.68 (12.81)
Azotobacter	106.70 (12.58)	108.20 (12.83)	111.97 (13.42)	112.67 (13.50)	109.88 (13.08)
Azospirillum	108.23 (12.59)	109.87 (12.93)	112.63 (13.55)	113.43 (13.69)	111.04 (13.19)
Azotobacter + *Azospirillum*	108.53 (12.59)	110.73 (13.11)	114.33 (13.85)	115.00 (13.95)	112.14 (13.37)
Mean	106.74 (12.50)	108.63 (12.89)	111.49 (13.47)	112.89 (13.59)	
CD (P = 0.05)					
	Yield			*CCS*	
Culture	0.32			0.032	
N levels	1.78			0.102	
Interaction	3.79			0.33	

* Figures in parentheses denote the CCS in metric tons/ha

Table 3. Effect of *Azotobacter* and *Azospirillum* inoculation under graded levels of nitrogen on soil properties at harvest (average data of 3 seasons)

Treatments	pH	EC (mmhos/cm)	Available nutrients (kg/ha)		
			N	P_2O_5	K_2O
Without culture + 175 kg N/ha	7.63	0.21	239	20.8	440
Without culture + 200 kg N/ha	7.63	0.21	235	19.2	460
Without culture + 225 kg N/ha	7.69	0.21	236	19.0	416
Without culture + 250 kg N/ha	7.60	0.19	241	18.5	410
Azotobacter + 175 kg N/ha	7.70	0.17	241	19.2	443
Azotobacter + 200 kg N/ha	7.80	0.20	241	18.9	456
Azotobacter + 225 kg N/ha	7.65	0.21	243	22.4	453
Azotobacter + 250 kg N/ha	7.70	0.19	247	18.9	434
Azospirillum + 175 kg N/ha	7.68	0.19	242	20.6	464
Azospirillum + 200 kg N/ha	7.65	0.19	245	19.8	453
Azospirillum + 225 kg N/ha	7.80	0.19	245	17.2	436
Azospirillum + 250 kg N/ha	7.67	0.20	250	15.5	430
Azotobacter + *Azospirillum* + 175 kg N/ha	7.66	0.20	258	18.9	435
Azotobacter + *Azospirillum* + 200 kg N/ha	7.70	0.20	253	17.2	434
Azotobacter + *Azospirillum* + 225 kg N/ha	7.66	0.21	253	18.9	422
Azotobacter + *Azospirillum* + 250 kg N/ha	7.62	0.19	262	17.8	410
Initial analysis	7.78	0.20	288	28.0	492
CD (P = 0.05)	NS	NS	7.14	2.27	17.2

Table 4. Economics of the biofertilizer application in sugarcane

Treatment	Yield (metric tons/ha)	Increase in yield (m tons/ha)	Additional income/ha (Rs)	Cost : benefit ratio
Without culture + 175 kg N/ha	103.50			
Without culture + 200 kg N/ha	105.73			
Without culture + 225 kg N/ha	107.03			
Without culture + 250 kg N/ha	110.47			
Azotobacter + 175 kg N/ha	106.70	3.20	1,155.20	1 : 5.78
Azotobacter + 200 kg N/ha	108.20	2.47	891.67	1 : 4.46
Azotobacter + 225 kg N/ha	111.97	4.94	1,783.34	1 : 8.92
Azotobacter + 250 kg N/ha	112.67	2.20	794.20	1 : 3.97
Azospirillum + 175 kg N/ha	108.23	4.73	1,707.53	1 : 8.54
Azospirillum + 200 kg N/ha	109.87	4.14	1,494.54	1 : 7.47
Azospirillum + 225 kg N/ha	112.63	5.60	2,021.60	1 : 10.10
Azospirillum + 250 kg N/ha	113.43	2.96	1,068.56	1 : 5.34
Azotobacter + *Azospirillum* + 175 kg N/ha	108.53	5.03	1,815.83	1 : 9.08
Azotobacter + *Azospirillum* + 200 kg N/ha	110.73	5.20	1,877.20	1 : 9.38
Azotobacter + *Azospirillum* + 225 kg N/ha	114.33	7.30	2,635.30	1 : 13.18
Azotobacter + *Azospirillum* + 250 kg N/ha	115.00	4.53	1,635.33	1 : 8.17

Treatment cost/ha was Rs 200

inoculation. (Ahmad *et al.,* 1976; Jadhav and Andhale, 1976; Patil and Hapase, 1981).

Inoculation of both cultures alone or in combination increased the cane as well as CCS yields significantly over uninoculated control (Table 2). However, effect of combined inoculation was maximum, followed by *Azospirillum* and *Azotobacter* culture. It was also noticed that the yield values were increased with increasing levels of nitrogen dose. The *Azotobacter* + *Azospirillum* culture inoculation + 250 kg N/ha recorded highest cane and CCS yields, but at par with 225 and 200 kg N/ha treatments. The response of increasing cane and sugar yields as evident from increase in tillering, girth, height and millable canes due to inoculation with cultures. Similar results were also reported by Hazra (1994) in sorghum.

The soil pH and total soluble salts (EC) values after harvest (Table 3) were not affected due to inoculation with cultures and nitrogen levels. The available nitrogen in soil increased with increasing levels of nitrogen fertilizer along with culture inoculation. The maximum available nitrogen in soil after harvest of crop was 262 kg/ha in the treatment of *Azotobacter* + *Azospirillum* + 250 kg N/ha. Available P_2O_5 and K_2O in soil after the harvest remain unchanged.

The results in general indicate that 25–50 kg N/ha could be saved by application of biofertilizer with marginal cost of Rs 200/ha (Table 4). The cane and sugar yields could be increased up to 7.30 tonnes/ha. The soil fertility was also maintained due to application of biofertilizers.

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