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Evaluation of Effect of Inoculation of *Azospirillum* Strains for Sustainable Cotton Production in Vertisols

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Abstract

A field experiment was conducted in 2004-05 to study the effect of different *Azospirillum* strains and graded dose of fertilizers on sustainable and cost effective production of cotton. The Khandwa-2 cotton variety was taken in the experiment. Four main treatments were taken comprising three different fertility levels viz. 100, 75 and 50% recommended dose fertilizer of N and P and control (no N and P). The sub-plot treatments comprised three different strains of *Azospirillum* viz. *Azospirillum* TNAU, *Azospirillum* HAU, *Azospirillum* Surat. The TNAU PSB was common with all the *Azospirillum* strains. All the seeds were duly treated with both *Azospirillum* and PSB and soil application was also done. The experiment was conducted in split plot design with three replications. Application of 75% RDF of N and P was found to be better in yield, yield attributes (boll number, boll weight and seed cotton yield/plant), and B : C Ratio over rest fertilizer doses. However, 100% RDF of N and P exhibited maximum nitrogen and phosphorus uptake with better growth parameters. The seed treatment and soil application of *Azospirillum* strains recorded on an average 145 to 84 kg numerically higher yield over control. The difference in increase among the strain was not significant but the increase was significant over control. The study concluded that application of 75% RDF of N and P was found to be optimum for sustainable cotton production and the *Azospirillum* strain of TNAU was found to be suitable strain for the region.

Key words : Cotton production, *Azospirillum*, Inoculation, Seed treatment, Soil application.

Cotton is a premier commercial crop of the country. It has enormous potential in sustaining rural and urban employment generation, economic and trade activity both within and outside the country. About 60 m people depend on cotton cultivation, trade and processing. Indian cotton meets diverse requirements of mills, power looms, handlooms. India stands first in area, third in production and has got lower rank in productivity among the major cotton growing countries (1). To increase the productivity of cotton, various measures are being taken. The use of biofertilizer is one of the important measures is being practiced and popularized for sustainable cotton production. The application of *Azospirillum* for the cotton crop is gaining momentum among the farmers mainly due to its beneficial effects besides the escalating cost of chemical fertilizers and also due to the ill effects caused by chemical fertilizers. High atmospheric nitrogen fixation capacity with low energy requirements and abundant establishments in roots and tolerance to high soil temperature (30—40 C) have contributed to its sustainability under tropical conditions (2). The isolation of *Azospirillum* was made for the first time in Indian soils by Lakshmi Kumari et al. (3). After this several *Azospirillum* strains were isolated and identified in various of the country. The performance of these strains depends mainly on soil and climatic conditions of the region. Keeping this in consideration, present study was undertaken to find out the suitable strain for soils of the Indore region. Besides the present investigation was also carried out to evaluate rescheduling of fertilizer recommendations and set an INM module based on the utilization of efficient strains of bioinoculants.

Methods

The experiment was conducted in 2004-05 *kharif* season, under TMC at College of Agriculture. The soil of the experimental field was a representative of medium black cotton soils of *malwa* region. The soil of the experimental area is non-saline, non-alkaline with the pH value of 7.6, electrical conductivity of 0.30 dS/m, low in available nitrogen (218 kg/ha),

Table 1. Plant height and dry biomass as influenced by different treatments.

Treatments	Plant height on DAS (CM) 45	90	135	Dry biomass production on DAS (g/plant) 45	90	135
M_0 : Control	29.00	43.04	90.25	9.00	36.00	86.00
M_1 : 50% RDF of N & P	33.15	46.11	105.12	12.74	38.00	101.00
M_2 : 75% RDF of N & P	32.89	51.86	109.88	13.98	39.23	106.45
M_3 : 100% RDF of N & P	35.92	53.98	111.96	16.95	45.65	111.23
SE ±	1.551	2.10	2.14	1.16	1.89	2.02
CD at 0.5%	3.80	5.15	5.25	2.85	4.65	4.95
S_0 : Control	33.00	45.11	100.21	11.13	35.32	92.23
S_1 : Azospirillum TNAU + PSB	34.12	51.12	111.12	14.65	41.94	111.00
S_2 : Azospirillum HAU + PSB	33.14	49.21	104.78	13.32	41.22	103.22
S_3 : Azospirillum SURAT + PSB	32.04	47.02	100.22	13.54	41.05	98.00
SE ±	1.511	1.86	2.25	1.40	2.35	2.96
CD at 0.5%	NS	NS	4.65	NS	NS	6.10

medium in available phosphorus (16.80 kg/ha) and high in available potassium (610 kg/ha).

The experiment was laid out in split plot design with three replications. The Khandwa-2 cotton variety was taken in the experiment. Four main treatments were taken comprising three different fertility levels viz. 100% RDF of N and P (M_3), 75% RDF of N and P (M_2), 50% RDF of N and P (M_1) and control (no N and P fertilizer M_0). The RDF was 80 kg N + 40 kg P_2O_5 + 20 kg K_2O. The sub-plot treatments comprised three different strains of *Azospirillum* viz. *Azospirillum* TNAU (S_1), *Azospirillum* HAU (S_2), *Azospirillum* Surat (S_3) and control (no bioinoculant S_0). The TNAU PSB was common with all the *Azospirillum* strains. All the seeds were treated with both Azospirillum and PSB at 20 g/kg seed and soil application at 2 kg/ha. The field observations like growth (plant height and dry matter production) and nutrient uptake were taken at three stages (45, 90 and 135 DAS).

Results and Discussion

Effect on Biometric Parameters

The height of the plant was grew well due to various levels of N and P. The application of 100% RDF of N and P exhibited the maximum plant height while lowest under control at all three stages (Table 1). The similar trend was observed in respect of dry biomass production at 45, 90 and 135 day stages ; whereas the minimum value was recorded in control.

Table 2. Nitrogen and phosphorus plant uptake as influenced by different treatments.

Treatments	Nitrogen on DAS (kg/ha) 45	90	135	Phosphorus on DAS (kg/ha) 45	90	135
M_0 : Control	18.97	20.42	21.23	0.526	0.555	0.623
M_1 : 50% RDF of N & P	20.27	21.70	22.27	0.536	0.560	0.638
M_2 : 75% RDF of N & P	20.79	22.37	23.95	0.551	0.570	0.652
M_3 : 100% RDF of N & P	21.19	23.23	24.56	0.561	0.580	0.663
SE ±	0.444	0.206	0.173	0.008	0.003	0.004
CD at 0.5%	NS	0.505	0.424	NS	0.008	0.010
S_0 : Control	19.02	20.31	21.42	0.522	0.541	0.621
S_1 : Azospirillum TNAU + PSB	21.29	23.07	24.27	0.563	0.591	0.666
S_2 : Azospirillum HAU + PSB	21.69	22.45	23.47	0.547	0.571	0.646
S_3 : Azospirillum SURAT + PSB	21.21	21.89	22.84	0.543	0.561	0.641
SE ±	0.355	0.250	0.327	0.012	0.008	0.006
CD at 0.5%	NS	0.515	0.675	NS	0.018	0.015

Table 3. Yield and yield attributes as influenced by different treatments. The yield levels were recorded low, as the crop did not perform well due to high precipitation recorded in September 2004.

Treatments	Seed cotton yield (kg/ha)	Seed cotton yield (g/plant)	Boll number (per plant)	Boll weight (g)	Ginning percentage (GP)
M_0 : Control	672	47	19	2.72	34.20
M_1 : 50% RDF of N & P	728	53	21	2.61	33.98
M_2 : 75% RDF of N & P	818	59	25	2.48	34.19
M_3 : 100% RDF OF N & P	788	55	23	2.44	33.96
SE ±	11.71	2.08	1.04	0.236	0.530
CD at 0.5%	28.71	5.10	2.57	NS	NS
S_0 : Control	662	50	19	2.61	34.13
S_1 : Azospirillum TNAU + PSB	807	57	25	2.47	34.18
S_2 : Azospirillum HAU + PSB	792	54	23	2.59	33.97
S_3 : Azospirillum SURAT + PSB	746	52	22	2.57	34.05
SE ±	2.93	1.15	1.0	0.218	0.728
CD at 0.5%	6.05	2.37	2.04	NS	NS

Similarly Donald (4) found that plant height continued to increase with application of N up to 112 kg N/ha. The height of plant and dry biomass production remained unaffected by bioinoculants at 45 and 90 DAS stages but reverse was the situation at 135 DAS. All *Azospirillum* strains produced taller plants as compared to control (no bioinoculant). Though TNAU culture responded well in respect of plant height and dry biomass production as compared to all rest strains. Similar results were recorded by Subbarao et al. (5) with *Azospirillum* and by Singh et al. (6) in sorghum crop.

Effect on Nutrient Uptake

Table 2 shows that increasing N and P from 0 to 100% RDF increased uptake of N and P at all stages. The highest uptake of nutrients was recorded when 100% RDF was applied and the lowest uptake was noted under control plots (no N and P fertilizer). Working at Hisar, Verma and Jain (7) reported that by increasing application level of each nutrient, there

Table 4. Seed cotton yield and B : C ratio as influenced by both fertilizer and bioinoculants.

Treatments	Seed cotton yield (kg/ha)			B : C ratio		
M_0 S_0 : 0% N & P + No bioinoculant (Control)	725			1.64		
M_0 S_1 : 0% N & P + AZO TNAU + PSB	710			1.83		
M_0 S_2 : 0% N & P + AZO HAU + PSB	677			1.74		
M_0 S_3 : 0% N & P + AZO Surat + PSB	580			1.70		
M_1S_0 : 50% N & P alone (control)	785			1.76		
M_1S_1 : 50% N & P + AZO TNAU + PSB	770			1.95		
M_1S_2 : 50% N & P + AZO HAU + PSB	720			1.86		
M_1S_3 : 50% N & P + AZO Surat + PSB	640			1.82		
M_2S_0 : 75% N & P alone (control)	860			2.02		
M_2S_1 : 75% N & P + AZO TNAU + PSB	875			2.22		
M_2S_2 : 75% N & P + AZO HAU + PSB	810			2.13		
M_2S_3 : 75% N & P + AZO Surat + PSB	730			2.08		
M_3S_0 : 100% N & P alone (control)	845			1.87		
M_3S_1 : 100% N & P + AZO TNAU + PSB	830			2.07		
M_3S_2 : 100% N & P + AZO HAU + PSB	780			1.98		
M_3S_3 : 100% N & P + AZO Surat + PSU	700			1.93		
	M	S	MS	M	S	MS
SE	11.71	2.93	30.23	0.355	0.019	0.355
CD (0.05)	28.71	6.05	NS	NS	0.040	NS

was corresponding increase in concentration and uptake of N, P, K. The uptake of N and P influenced well at 90 and 135-day stages due to various sources of bioinoculants. The TNAU culture helps more in increasing the N and P uptake by the plants as compared to other treatments at all the three stages. Although other two were also found to be better in respect of nutrient uptake as compared to control (no bioinoculant). Similarly Gadagi et al. (8) observed an improved nutrient uptake in blanket flower *Gaillardia* due to inoculation of *Azospirillum.*

Effect on Yield and Yield Attributing Characters

The significant differences in yield and yield attributes were recorded due to application of various N and P levels. Application of 75% of RDF recorded highest seed cotton yield as compared to 100 and 50% RDF of N & P. Similar trend was recorded in seed cotton yield/plant boll numbers/plant. The various levels of N and P did not have any impact on the size of boll and ginning outturn (GOT) (Table 3). Similarly, Karthikeyan and Jayakumar (9) observed significant effect by graded levels of N and P fertilizers on yield and yield attributes of cotton. The seed cotton yield was influenced well based on the effect of various strains of Azospirillum. The seed treatment and soil application of all bioinoculant recorded higher yield over control although the TNAU culture gave significantly higher yield compared to other two strains. The similar trend was noted in yield/plant and boll/plant while boll weight and ginning outturn remained unaffected due to application of various sources of bioinoculants. Similar results were also obtained with cotton by Fayez and Daw (10) and with pearl millet by Venkateshwarlu and Rao (11).

The interaction effect was found to be non-significant with respect to seed cotton yield and B : C ratio (Table 4). The treatment with 75% N and P + Azospirillum TNAU recorded the highest seed cotton yield. The increase was significantly over the absolute control although the difference in increase among the rest treatment was not significant. In B : C ratio, treatment combination $M_2 S_1$ (75% N and P + AZO TNAU + PSB) showed numerically high benefit cost ratio (2.22) over rest treatment combinations. The lowest B : C Ratio (1.64) was recorded with absolute control (M_0S_0–0% N and P + no bioinoculant). So the treatment M_2S_1 (75% N and P + AZO TNAU + PSB) was found to be an economic integrated nutrient management dose under irrigated cotton based cropping system. Working at Tamilnadu Srinivasan and Sivasamy (12) found treatment with 75% N + Rhizobium + phosphobacterium + 100% P recorded significantly highest seed cotton yield and B : C ratio followed by 100% RDF.

The study concluded that application of 75% RDF of N and P was found to be optimum for sustainable cotton production and the *Azospirillum* strain of TNAU performed better in Malwa region soils.

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