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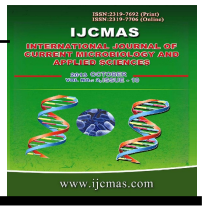

Original Research Article

Seed bacterization with *Azotobacter, PSB* and foliar application of urea on drought affected cotton

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K e y w o r d s

Acetobacter; *Azotobacter;* Seedling Drought; Urea

A B S T R A C T

Azotobacter chrococcum strain AC-1, *Pseudomonas sp.* and *A. chrococcum* AC-2 alongwith *Bacillus megatherium var. phosphaticum* as seed treatment could tolerate 18-23 days seedling drought alongwith 50% RDF when sprayed with 2% urea twice at 60 and 80 days significantly improved seed cotton yields by 0.24 and 0.19 t ha^{-1} or 24 and 14% respectively with a profitability of 4.0 in AHH 468 hybrid cotton at Central Institute for Cotton Research, Nagpur.

Introduction

Nutrient based price fixation in India is going to cost Rs. 21, 19, 18 and 1.7 kg^{-1} NPK and S fertilizers respectively to farmers in 2014 (Kashelkar, 2013). It will be uneconomical for farmers to follow fertilizer recommendations made for normal seasons in drought and wet famine years (Ambati Ravinder Raju and Soniya K. Thakare, 2012). *Azotobacter chrococcum, Azospirillum brasiliense, Pseudomonas and Bacillus megatherium var. Phosphaticum* fixes atmospheric N, solubilises fixed phosphorous, produces phyto hormones as PGPRs by contributing 20-30%of NP requirement in cotton (Bonde and Raju, 1998; Egamberdieva, 2008; Kumar *et al.,* 2001; Kumar *et al.,* 2007; Raju *et al.,* 2008; Ravinder Raju *et al.,* 2009; Ravinder Raju *et al.,* 2006). Applying soil N at 2/3 the recommended rate followed by foliar N applications uses N more efficiently than applying the full recommended rate to the soil, provides at least as much net revenue, and has the added flexibility of correcting N deficiencies during a critical stage of boll development (Ambati Ravinder Raju and Soniya K. Thakare, 2012; Roberts *et al.,* 2006). Urea alongwith K foliar application significantly improved Bt hybrid cotton yield by 25% (Sekhon and Singh, 2013). Field trials were conducted to identify the bio-inoculant strains suitable for advance planted hybrid cotton in *Vertisols* of central India.

Materials and Methods

Field experiments were conducted with AHH-468 hybrid cotton during the monsoon seasons of 2000, 2001 and 2002

at Central Institute for Cotton Research, Nagpur in medium deep Vertisols. Azotobacter chrococcum 4 heat tolerant strains, 5 analogue resistant mutants, 4 isolates and one strain each of Acetobacter diazotrophicus, Azospirillum brasiliense and N fixing Pseudomonas sp. were procured from Dept. of Microbiology, Chaudhary Charan Singh University of Agriculture Sciences, Hissar, Haryana. These were evaluated in RBD design with four replications. Seed bacterization was made with charcoal carrier based biofertilisers produced in laboratory with 50% recommended N: P_2O_5 and K_2O ha^{-1}. Two sprays of urea 2% at 60 and 80 days was applied to meet N demand a peak flowering stage. AHH 468 hybrid cotton seeds were planted as advance sowing on 23rd. June after coating with biofertilisers and followed normal recommended package of practices during field experimentation. The recommended dose of fertilizers were also applied for rainfed hybrid cotton @ 90:45:45 N, P_2O_5 and K_2O ha^{-1}. Cost: benefit ratio was calculated using the prevailing prices input costs and output prices.

Results and Discussion

Weather conditions

Two years 2000, 2002 years faced a seedling drought of 18, 23 days immediately after sowing adversely affected the survival and multiplication of microflora in the rhizosphere with 48 and 0 mm rainfall compared to 103 mm in the year 2001(Fig.1).

2000: *A. chrococcum* MSX-9, HT-541, 542, AC-1, IS-16, *Azospirillum* FS, and *Pseudomonas sp.* with average of 0.34 t ha^{-1} (0.28-0.39) performed well despite of 18 days seedling drought after sowing. *A. chrococcum* HT-54, Ala-27 and *Acetobacter diazotrophicus* did not perform well the problem was suspected and in subsequent years 2001 and 2002, pure culture slants were procured and multiplied by the author himself in the CICR, laboratory and tested them (Table2).

2001: This was a normal year with well distributed rainfall where 10 cultures such as *A. chrococcum* Ala-27, *Azospirillum* FS *A. chrococcum* AC-1, HT 542, AC-29, IS-16, Ac-2, HT 54, HT 541 and *Acetobacter diazotrophicus* performed above bench mark of 0.25 tha^{-1} with average of 0.35 (0.25-0.53) t ha^{-1}.

2002: A year of 23 days seedling drought with non uniform distribution of rainfall *A. chrococcum* Ala-27**,** AC-1 and Pseudomonas cultures performed above bench mark of 0.25 tha^{-1} with average of 0.25 (0.24-0.27) t ha^{-1}.

Mean: All these odd years most stable culture was *A. chrococcum* AC-1 which produced 0.333 t ha^{-1}, Pseudomonas sp was for 3 years but performed above bench mark only in 2 years with 0.237 t ha^{-1} overage and Ala-27 was only in two years 0.390 t ha^{-1}(Table 2). Hence, it can be concluded that *A. chrococcum* AC-1 alongwith Bacillus megatherium var. phosphaticum as seed treatment could tolerate 23 days seedling drought besides 50% RDF when sprayed with 2% urea twice at 60 and 80 days is most suitable for rainfed hybrid cotton. These results were in agreement with those observed by the previous researchers in cotton (Bonde and Raju, 1998; Raju et al., 2008; Raju et al., 2008; Ravinder Raju et al., 2009 ; Ravinder Raju et al., 2006).

Biomass production t ha^{-1}

Biomass at maturity in all the years were significantly influenced by *A. chrococcum*

Table.1 Rainfall distribution

Month	00	%	01	%	02	%	Normal	%
June	199	77	226	88	350	136	258	27
July	399	181	171	77	93	42	221	23
Aug	245	83	247	84	391	133	294	30
Sept	121	91	142	107	135	102	133	14
October			147	57	21	8	256	6
Total	964	100	933	97	990	103	962	

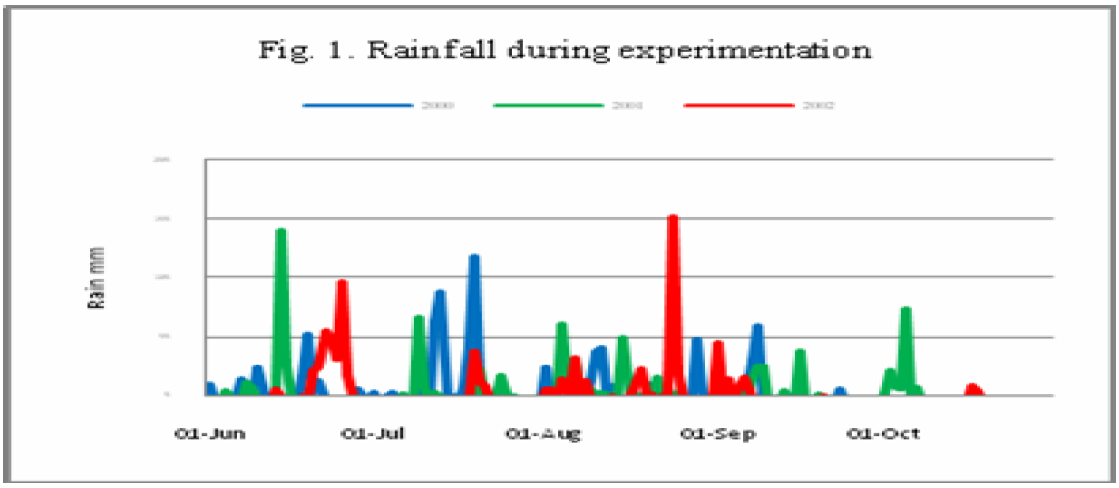

Table.2 Yield contribution t ha^{-1} by bio-inoculants

Strain	**2000**	**%**	**2001**	**%**	**2002**	**%**	**Mean**	**%**
HT54		0.4	0.29	23	0.16	11	0.15	11
HT541	0.28	20	0.28	22		0.3	0.19	14
HT542	0.35	24	0.36	28			0.23	17
MSX-9	0.39	27	0.19	15			0.19	14
AC-1	0.34	20	0.39	32	0.27	24	0.34	25
AC-2	0.17	9.8	0.33	27	0.20	17	023	18
AC-29	0.22	13	035	29	0.03	3	0.20	15
IS-16	0.31	19	0.35	28			0.22	16
ALA-27	0.03	1.5	0.53	44	0.25	22	0.27	22
FS	0.34	20	0.40	32			0.25	18
Aceto	0.02	0.8	0.25	20			0.09	7
Ps	0.36	22	0.11	9	0.24	21	0.24	17

Table.3 Biomass production t ha^{-1}

	Peak flowering			Maturity			
Treatment	**00**	**01**	**Mean**	**00**	**01**	**02**	**Mean**
RDF	2.1	2.2	2.2	4.7	4.1	3.5	4.1
1/2 RDF	1.6	1.9	1.7	4.1	4.1	2.7	3.6
Mac-27	1.4	1.9	1.6	4.1	4.3	3.1	3.8
E-12	2.4	1.8	2.1	4.3	4.1	3.3	3.9
Mac-68	2.1	1.8	1.9	4.0	4.4	3.0	3.8
HT-54	2.0	1.6	1.8	4.6	4.6	3.0	4.1
HT-541	1.8	2.1	1.9	4.1	3.6	2.7	3.5
HT-542	2.0	1.7	1.9	4.9	4.3	2.5	3.9
HT-57	1.6	1.9	1.7	4.1	4.0	3.0	3.7
MSX-9	2.3	1.7	2.0	5.5	4.8	3.7	4.4
SED±5%	0.5	0.3	0.0	0.3	1.0	S	0.5
CD±5%	NS	NS		NS	NS	0.7	NS
RDF	2.3	2.3	2.3	3.9	4.8	3.8	4.1
1/2 RDF	1.9	1.7	1.8	3.2	4.0	2.3	3.2
AC-1	2.2	2.7	2.4	3.5	3.6	3.0	3.4
AC-2	1.9	2.1	2.0	3.5	3.2	2.8	3.2
AC-29	1.3	2.1	1.7	3.3	2.7	2.5	2.9
IS-16	1.0	2.4	1.7	4.0	3.7	2.8	3.5
Ala-27	1.9	2.4	2.1	3.2	3.3	2.9	3.1
FS	1.8	1.5	1.6	2.4	5.3	3.4	4.0
35-47	2.8	2.2	2.5	3.5	2.8	2.4	2.9
Ps	1.6	2.0	1.8	3.9	2.9	3.7	3.5
SED±5%	0.1	0.5		S	S	S	S
CD ±5%	NS	NS		0.6	1.3	0.5	0.8

Table.4 Bio-inoculants on yield and bolls plant^{-1}

Treatment	Seed cotton yield g plant $^{-1}$				Boll No plant^{-1-1}			
	2000	**2001**	**2002**	**Mean**	**2000**	**2001**	**2002**	**Mean**
RDF	80	52	43	58	27.3	26.6	18	24
1/2 RDF	55	46	39	47	21.4	19.9	19	20.1
Mac-27	72	43	48	54	25.5	22.2	16	21.2
E-12	69	45	38	51	24	20.8	16	20.3
Mac-68	63	43	39	48	23	25.9	17	22
HT-54	67	48	43	53	26	23.5	17	22.2
HT-541	58	60	43	54	23	25.3	21	23.1
HT-542	78	39	38	52	28	21.2	18	22.4
HT-57	56	51	44	50	23.3	25.9	19	22.7
MSX-9	72	53	41	56	29	25.3	17	23.8
SED±5%	Sig	11.4	8.6	8.47	3.7	Sig	4.1	2.52
CD ±5%	21	NS	NS	NS	NS	4.6	NS	NS
RDF	78	61	32	57	30	20	18	22
1/2 RDF	72	49	28	50	29	19	17	22
AC-1	67	70	59	66	28	21	26	25
AC-2	65	69	49	61	24	23	23	23
AC-29	73	51	52	59	28	16	24	23
IS-16	69	71	32	57	27	22	16	21
Ala-27	58	63	42	54	30	21	24	25
FS	67	66	41	58	29	21	20	23
35-47	67	56	42	55	25	19	16	20
Ps	75	75	28	59	30	19	23	24
SED±5%	10.2	S	S	10	3.8	3.8	S	2.9
CD ±5%		19.6	11.3				4.9	

Table.5 Bio-inoculants on seed cotton yield t ha^{-1} and profitability.

A	Seed cotton yield t ha-1				B:C ratio			
Treatment	**00**	**01**	**02**	**Mean**	**00**	**01**	**02**	**Mean**
RDF	1.92	1.75	1.65	1.78	4.16	4.21	3.44	3.94
50%RDF	1.43	1.28	1.45	1.38	3.62	3.14	3.67	3.48
Mac-27	1.42	1.42	1.87	1.57	3.58	3.6	5.05	4.08
E-12	1.52	1.69	1.4	1.54	3.91	4.48	3.52	3.97
Mac-68	1.51	1.37	1.51	1.46	3.88	3.43	3.88	3.73
HT-54	1.44	1.57	1.59	1.53	3.64	4.08	4.14	3.95
HT-541	1.71	1.55	1.45	1.57	4.52	4.03	3.68	4.08
HT-542	1.73	1.64	1.38	1.6	4.74	4.3	3.45	4.16
HT-57	1.43	1.47	1.38	1.42	3.61	5.16	3.44	4.07
MSX-9	1.82	1.47	1.52	1.6	4.86	3.94	3.92	4.24
SED	0.267	S	0.237	S	S	S	S	S
CD 5%	NS	0.33	NS	0.17	1.1	1.12	1.12	0.49
RDF	1.93	1.75	1.25	1.64	4.41	3.70	2.02	3.29
50%RDF	1.68	1.22	1.14	1.35	4.19	2.96	1.98	3.13
AC-1	2.02	1.62	1.41	1.68	5.51	3.8	3.23	4.18
AC-2	1.84	1.56	1.33	1.58	4.95	3.5	2.12	3.52
AC-29	1.89	1.58	1.17	1.55	5.11	3.28	2.18	3.52
IS-16	1.99	1.57	1.11	1.56	5.42	4.08	1.31	3.6
Ala-27	1.7	1.75	1.39	1.61	4.49	4.68	2.76	3.98
FS	2.02	1.62	1.02	1.55	5.51	4.24	1.42	3.72
35-47	1.69	1.47	1.03	1.4	4.46	3.76	1.33	3.18
Ps	2.03	1.33	1.38	1.58	5.57	3.32	2.50	3.80
SED	0.17	S	S	S	S	S	S	S
CD 5%	NS	0.41	0.16	0.20	0.79	1.4	0.5	1.42

IS-16, AC-1, *A. diazotrophicus* 35-47, N fixing *Pseudomonas* alongwith *B. megatherium var. phosphaticum* as seed treatment with twice foliar spray of urea 2% at 60 and 80 days (Table 3).

Boll number plant^{-1}

A. chrococcum Mac-68, HT-541, HT-57, MSX-9 in 2001, AC-1, AC-29, Ala-27 in 2002 alongwith *B.megatherium var. phosphaticum* as seed treatment with twice foliar spray of urea 2% at 60 and 80 days significantly improved bolls plant^{-1}.

Yield plant^{-1}

A. chrococcum HT-542 in 2000, AC-1, AC-2, *Pseudomonas* in 2001 and AC-1, AC-2, AC-29, Ala-27 *A. diazotrophicus 3*5-47, *A. brasilience* FS, *Pseudomonas* alongwith *B. megatherium as* seed treatment with twice foliar spray of urea 2% at 60 and 80 days in 2002 significantly produced higher seed cotton yield plant^{-1} (Table 2).

Yield and profitability

A. chrococcum AC-1, *Pseudomonas, A. chrococcum* AC-2 and alongwith *B.megatherium* (PSB) as seed treatment alongwith urea 2% as foliar spray at 60 and 80 days improved mean seed cotton yield significantly in drought years of 2000 and 2002 years by 0. 305,0.300, 0.185 t ha^{-1} or 22, 22,14% respectively over 50% RDF, they were at par with 100% RDF (Table 2). Seedling droughts are going to be future due to changing climate (Table 5) where *A. chrococcum* AC-1, AC-2 only could tolerate seedling droughts of 18-23 days alongwith synthetic N application and improved more than 22-14% seed cotton yield with a C:B ratio of 4.0 is therefore, economically justified and less risk prone compared to chemical fertilizers.

A. chrococcum strain AC-1, *Pseudomonas* and *A. chrococcum* strain AC-2 which could resist synthetic nitrogen fertilizers and drought of 18-23 days alongwith *B. megatherium var. phosphaticum* as seed treatment with twice foliar spray of urea 2% at 60 and 80 days significantly improved 0.24 and 0.19 t ha^{-1} seed cotton yield or 22 and 14% respectively yield improvement with a profitability of 4.0 in hybrid cotton.

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