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RESEARCH PAPER

Response of Bt cotton (*Gossypium hirsutum*) to liquid bio-fertilizer consortia with varied levels of major nutrients

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Abstract: Field experiments were conducted at Agriculture Research Station, Dharwad, Karnataka, India during *kharif* 2018 and 2019 to study the effect of nutrient levels and liquid bio fertilizer consortia on growth, yield and economics of Bt cotton. Experiment was laid out with three main plots comprising nutrient levels and five sub plots comprising bio fertilizer consortia in split plot design with recommended practice as check and replicated thrice. Application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) recorded higher number of bolls per plant (38.04) and sympodial branches per plant at final picking (21.58) as compared to application of 80% and 60 % recommended nutrients. Rhizosphere consortia-II + Phyllosphere consortia at 50, 70 and 90 DAS recorded higher plant height (114.8 cm), sympodial branches per plant (19.77). Significantly higher seed cotton yield to an extent of 16.4 per cent higher gross returns, net returns and benefit cost ratio were (₹ 1,29,579 ha^{-1}, ₹ 67,365 ha^{-1} and 2.08, respectively) were recorded with the application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) along with Rhizosphere consortia-II + Phyllosphere consortia at 50, 70 and 90 DAS.

Key words: Consortia, Cotton yield, Nutrient, Phyllosphere, Rhizosphere

Introduction

Cotton is one of the major fibre crops of global significance and provides the main raw material for textile industry and employment to several million people involved in cultivation, trade, processing, manufacturing and marketing. India has unique place among the cotton growing countries of the world where in all the four lint bearing *Gossypium* spp. *viz*.,

G. hirsutum, G. harbaceum, G. arboreum and *G. barbadense* are grown under diverse agro climatic conditions and contributes nearly 65 per cent of total raw material needs of textile industry. The area under cotton in India is about 122.38 lakh ha accounting 33 per cent of the world cotton area and stands second in production (361 lakh bales), next to China with average productivity of 501 kg lint per hectare. Among the cotton growing states, Karnataka ranks sixth both in area and production 5.75 lakh ha and 18.80 lakh bales of lint, respectively with an average productivity of 532 kg lint per ha (Anon., 2019).

Indiscriminate use of chemical fertilizers in intensive cotton production systems has deteriorated the soil fertility, resulting in lower production and productivity of cotton. The growing concern over the problems in cotton belts *vis-à-vis* increased awareness regarding use of bio fertilzers in cotton has made to search for an alternative to intensive chemical based cotton production systems. Bio fertilizers are cost effective, eco-friendly and renewable source of plant nutrients in sustainable cotton production. Microbial consortia are the association of organisms, which perform the basic biochemical functions *viz.,* toxic substance detoxification, organic matter decomposition and nutrient transformations (solubilizing and mobilizing) improving the soil properties and crop performance (Pindi and Satyanarayana, 2012). Research on the application of liquid rhizosphere and phyllosphere biofertilizer consortiaeither soil or foliar or in combination to cotton crop (Bt or Non Bt) is meagre in most of the cotton growing region of the country and the state. Hence, field trials were initiated to find out the effect of liquid biofertilizer consortia on growth and yield of Bt cotton variety/hybrid.

Material and methods

Field experiments were conducted during *kharif* 2018 and 2019 in Agronomy field unit at Agricultural Research Station, Dharwad (Block B and D) which is situated in the Northern transition zone (Zone-8) of Karnataka on Latitude 15°07' North, Longitude of 76°06' East and at an Altitude of 678 m above the mean sea level. Experimental site consisted medium black soil and available N, P_2O_5 and K_2O were 224.09, 26.67 and 374.55 kg ha^{-1}, respectively during 2018 and 235.30, 28.90 and 379.85 kg ha^{-1}, respectively during 2019. Experiment was laid out with three main plots and five sub plots in split plot design with recommended practice as check and replicated thrice. Main plot comprising nutrient levels *viz.,* M_1-100 % recommended nutrients (100:50:50 $NP_2O_5K_2O$kg ha^{-1}), M_2 - 80 % recommended nutrients (80:40:40 $NP_2O_5K_2O$ kg ha^{-1})and M_3-60 % recommended nutrients (60:30:30 $NP_2O_5K_2O$kg ha^{-1}) and sub plot comprising liquid bio fertilizer consortia *viz.,* S_1 - Rhizosphere Biofertilizer consortia-I, S_2-Rhizosphere Biofertilizer consortia-II, S_3- Phyllosphere consortia at 50, 70 and 90 DAS, S_4- Rhizosphere Bio fertilizer consortia-I + Phyllosphere consortia at 50, 70 and 90 DAS and S_5- Rhizosphere Biofertilizer consortia-II + Phyllosphere consortia at 50, 70 and 90 DAS and recommended practice was taken as check (Seed treatment with *Azospirillum* and PSB each @ 200 g kg^{-1} seed + 100:50:50 NPK kg ha^{-1}). Farm yard manure of FYM @5 t ha^{-1} was applied commonly to all treatments three weeks prior to sowing with common seed treatment with *Azospirillum* and PSB each @ 200 g kg^{-1} seed in all treatments. Ajeet- 199 (BG-II) Bt hybrid cotton was sown on

29th June 2018 and 19th June 2019 with the spacing of 90 × 60 cm. Thinning was under taken after 15 DAS retaining one healthy seedling per hill. Rhizosphere consortia-I and II were applied @ 6.25 lit ha^{-1} was mixed with 400 kg well decomposed FYM and the mixture was spot applied at the time of sowing. The Phyllosphere Consortium @ 4 ml per lit of water was sprayed with the present recommendation of foliar spray of 1 % $MgSO_4$ and 1% water soluble all 19 fertilizer (19:19:19). The source of nitrogen, phosphorus and potassium were conventional fertilizers *viz.,* urea, diammonium phosphate and muriate of potash. Entire dose (100 %) of phosphorus and 50 % nitrogen and potassium were applied as basal and remaining 50% of nitrogen and potassium applied into 3 equal splits at 30, 60 and 90 DAS. Rhizosphere biofertilizer consortia-I consisted *Gluconoacetobacter,* P- Solubilising Bacteria *(*PSB), K- Solubilising Bacteria *(*KSB), Zn- Solubilising Bacteria (Zn SB), JK-16, Pink Pigmented Facultative Microorganism (PPFM-33) and *Lactobacillus* (LAB 75). Rhizosphere biofertilizer consortia-II consisted *Azospirillum,* P- Solubilising Bacteria *(*PSB), K- Solubilising Bacteria *(*KSB), Zn- Solubilising Bacteria (ZnSB), Silicon Solubilising Bacteria (Si SB), JK-16, Pink Pigmented Facultative Microorganism (PPFM-33) and *Lactobacillus* (LAB 75). Phyllosphere bioertilizer consortia consisted *Actinomycetes* strains 502, 248, A-34, PSA-5, PSA-7 and UPM-3, PPFM strains PPFM-33 and PPFM-58, *Lactobacillus* strains LAB-75, LABLS-36 and LAB-82. Seed cotton (Kapas) picking from the net plot and border rows was done separately in two pickings. The data collected from the experiment was subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used in 'F' and't' test was p = 0.05. Critical difference (CD) values were calculated wherever the 'F' test was found significant.

Results and discussion

Effect on growth parameters

The pooled data of growth parameters revealed that the increase in nutrient levels from 60 % recommended nutrients to 100 % recommended nutrients increased the plant height, monopodial, sympodial and dry matter production

Table 1. Growth parameters of Bt cotton as influenced by nutrient levels and liquid biofertilizer consortia

Treatments	Plant height (cm)			Sympodial plant^{-1}			Dry matter accumulation (g plant^{-1})		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
M_1	118.0	123.5	120.8	20.89	22.27	21.58	266.6	276.6	271.6
M_2	111.7	110.1	110.9	17.97	19.27	18.62	236.2	248.0	242.1
M_3	100.7	99.6	100.2	14.45	17.04	15.74	200.7	214.1	207.4
S.Em.±	0.96	0.83	0.88	0.32	0.59	0.39	1.11	2.71	1.73
C.D. (P=0.05)	3.77	3.24	3.46	1.25	2.33	1.53	4.36	10.65	6.79
S_1	108.1	109.6	108.8	17.19	19.07	18.13	230.5	240.8	235.6
S_2	108.9	111.1	110.0	17.69	19.51	18.60	234.7	246.7	240.7
S_3	106.6	106.6	106.6	16.68	18.42	17.55	224.1	234.5	229.3
S_4	112.8	112.9	112.8	18.05	20.33	19.19	239.3	251.7	245.5
S_5	114.5	115.1	114.8	19.24	20.30	19.77	243.9	257.5	250.7
S.Em.±	1.99	1.91	1.38	0.57	0.47	0.47	1.01	2.44	1.18
C.D. (P=0.05)	5.81	5.57	4.03	1.66	1.38	1.38	2.95	7.11	3.44
M_1S_1	114.9	122.0	118.5	19.94	21.51	20.73	260.2	268.0	264.1
M_1S_2	116.1	123.7	119.9	20.32	22.17	21.25	264.7	275.0	269.9
M_1S_3	113.8	117.8	115.8	19.91	21.57	20.74	256.9	266.3	261.6
M_1S_4	121.5	125.5	123.5	21.05	23.30	22.18	272.8	281.0	276.9
M_1S_5	123.7	128.6	126.2	23.24	22.82	23.03	278.6	292.7	285.7
M_2S_1	110.0	108.9	109.5	17.80	19.03	18.41	233.5	243.8	238.6
M_2S_2	110.9	110.1	110.5	18.18	19.21	18.70	236.5	248.0	242.3
M_2S_3	108.4	106.6	107.5	16.50	18.33	17.42	227.5	235.4	231.5
M_2S_4	113.7	111.3	112.5	18.26	19.63	18.95	239.6	255.2	247.4
M_2S_5	115.7	113.4	114.5	19.13	20.16	19.64	244.0	257.4	250.7
M_3S_1	99.3	97.9	98.6	13.84	16.68	15.26	197.8	210.6	204.2
M_3S_2	99.6	99.6	99.6	14.56	17.16	15.86	202.9	217.0	209.9
M_3S_3	97.5	95.3	96.4	13.64	15.37	14.50	187.9	201.7	194.8
M_3S_4	103.1	101.8	102.4	14.83	18.06	16.44	205.7	218.9	212.3
M_3S_5	104.1	103.2	103.7	15.36	17.93	16.65	209.1	222.4	215.8
S.Em.±	3.23	3.07	2.31	0.94	0.94	0.83	1.92	4.65	2.52
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Check	115.9	115.1	115.5	18.98	21.10	20.04	250.3	262.1	256.1
S.Em.±	3.32	3.27	2.50	0.94	0.89	0.81	1.94	4.52	2.35
C.D. (P=0.05)	10.02	9.87	7.54	2.85	2.68	2.45	5.86	13.64	7.07

M_1: 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) M_2: 80 % recommended nutrients (80:40:40 NPK kg ha^{-1})
M_3: 60 % recommended nutrients (60:30:30 NPK kg ha^{-1})
S_1 : Rhizosphere biofertilzer consortia-I S_2: Rhizosphere biofertilzer consortia-II S_3: Phyllosphere consortia @ 50, 70 and 90 DAS
S_4 : S_1+S_3 S_5: S_2+S_3

Table 2. Seed cotton yield and its parameters as influenced by nutrient levels and liquid bio-fertilizer consortia

Treatments	Good opened bolls/ Plant			Total number of bolls/ Plant			Seed cotton yield (kg ha^{-1})		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
M_1	28.75	37.62	33.18	35.69	40.39	38.04	1886	2597	2241
M_2	23.59	32.10	27.85	32.10	36.62	34.36	1605	2154	1880
M_3	16.14	24.33	20.23	25.67	29.57	27.62	1331	1714	1523
S.Em.±	0.49	0.95	0.68	0.53	1.03	0.77	43	58	31
C.D. (P=0.05)	1.92	3.72	2.68	2.10	4.04	3.01	167	227	121
S_1	21.94	29.64	25.79	30.73	33.89	32.31	1564	2064	1814
S_2	22.88	31.90	27.39	31.22	36.01	33.62	1630	2104	1867
S_3	20.40	28.83	24.61	29.06	33.63	31.34	1462	1975	1719
S_4	23.95	32.49	28.22	32.02	36.47	34.25	1668	2264	1966
S_5	24.97	33.89	29.43	32.75	37.64	35.20	1713	2367	2040
S.Em.±	0.98	0.66	0.52	1.10	0.71	0.66	28	44	27
C.D. (P=0.05)	2.86	1.93	1.53	NS	2.06	1.94	81	128	79
M_1S_1	28.32	35.12	31.72	35.79	37.81	36.80	1856	2593	2224
M_1S_2	28.72	37.18	32.95	35.83	40.02	37.92	1848	2618	2233
M_1S_3	26.60	34.40	30.50	33.44	37.79	35.62	1774	2482	2128
M_1S_4	29.48	39.62	34.55	36.31	42.44	39.37	1880	2662	2271
M_1S_5	30.63	41.76	36.19	37.10	43.91	40.50	2070	2706	2388
M_2S_1	22.98	32.18	27.58	32.10	36.79	34.44	1623	2065	1844
M_2S_2	23.33	34.09	28.71	31.93	38.49	35.21	1619	2122	1870
M_2S_3	21.43	30.74	26.09	30.47	35.88	33.17	1378	2010	1694
M_2S_4	24.73	30.60	27.66	32.79	34.71	33.75	1719	2261	1990
M_2S_5	25.48	32.89	29.19	33.23	37.23	35.23	1687	2312	2000
M_3S_1	14.51	21.62	18.07	24.29	27.06	25.67	1213	1534	1373
M_3S_2	16.58	24.43	20.50	25.91	29.53	27.72	1422	1573	1497
M_3S_3	13.17	21.34	17.25	23.26	27.23	25.25	1234	1435	1334
M_3S_4	17.63	27.25	22.44	26.97	32.26	29.62	1405	1947	1676
M_3S_5	18.79	27.03	22.91	27.94	31.78	29.86	1383	2082	1733
S.Em.±	1.60	1.40	1.06	1.79	1.50	1.28	61	89	52
C.D. (P=0.05)	NS	4.72	NS	NS	NS	NS	207	298	170
Check	26.14	32.44	29.29	33.55	35.85	34.70	1705	2394	2050
S.Em.±	1.59	1.31	0.99	1.76	1.38	1.21	56	85	51
C.D. (P=0.05)	4.78	3.94	2.97	5.32	4.16	3.63	168	257	153

M_1: 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) M_2: 80 % recommended nutrients (80:40:40 NPK kg ha^{-1}) M_3: 60 % recommended nutrients (60:30:30 NPK kg ha^{-1})

S_1: Rhizosphere biofertilzer consortia-I S_2: Rhizosphere biofertilzer consortia-II S_3: Phyllosphere consortia @ 50, 70 and 90 DAS S_4: S_1+S_3 S_5: S_2+S_3

progressively. Application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) recorded significantly higher plant height (120.8 cm), sympodial branches per plant (21.58) and dry matter production per plant (271.6 g) at final picking in pooled data. Significantly lower plant height (100.2 cm), sympodial braches per plant (15.74) and dry matter production per plant (207.4 g) was recorded with 60 % recommended nutrient (60:30:30 NPK kg ha^{-1}) (Table 1). This may be due to the fact that higher levels of nutrients might have enhanced the normal metabolic and physiological activities of plant *viz.,* cell division, cell elongation and chlorophyll content. Hargilas and Saini (2018) and Veeraputhiran and Gunasekaran (2018), also reported positive correlation between plant height and number of sympodial branches per plant.

Plant height, sympodial branches per plant and dry matter production differed significantly by application of liquid bio fertilizer consortia during 2018, 2019 and in pooled. Rhizosphere Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS recorded significantly higher plant height for pooled (114.8 cm), sympodial branches per plant (19.77) (Table 1). Higher dry matter production is the pre requisite for higher yield. Among different liquid biofertilizer consortia, significantly higher dry matter was recorded with Rhizosphere Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS (250.7 g plant^{-1}). (Table 1). Higher growth parameters might be due to enhanced beneficial microorganisms in soil *viz., Azospirillum,* P- Solubilising Bacteria (PSB), K- Solubilising Bacteria (KSB), Zn- Solubilising Bacteria (ZnSB), Silicon Solubilising Bacteria which might have helped in increased availability of nutrients to plants and *Lactobacillus*, PPFM and *Actinomycetes* strains in plant, might have produced growth hormones and amino acids and which in turn increased photosynthates production. Arif *et al.* (2018) also reported that application of biofertilizer along with phosphorus enriched compost resulted in higher plant height and sympodial branches.

Interactions of nutrient levels and liquid bio-fertilizer consortia resultednon significant effect on growth parameters. However, significant difference was observed as compared to check. In pooled data application of 100 % recommended nutrients (100:50:50 kg NPK ha^{-1}) along with Rhizosphere

Table 3. Economics of cotton production as influenced by nutrient levels and liquid bio-fertilizer consortia

Treatments	Gross returns (₹ ha^{-1})			Net returns (₹ ha^{-1})			B:C ratio		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
M_1	98054	146276	122165	38091	84918	61504	1.63	2.38	2.01
M_2	83466	120627	102046	25874	62450	44162	1.45	2.07	1.76
M_3	69238	95982	82610	13986	40977	27482	1.25	1.74	1.50
S.Em.±	2214	3282	1713	2214	3282	1713	0.04	0.06	0.03
C.D. (P=0.05)	8695	12887	6726	8695	12887	6726	0.15	0.22	0.12
S_1	81327	115578	98453	23922	57834	40878	1.41	1.99	1.70
S_2	84745	117835	101290	27011	59889	43450	1.46	2.02	1.74
S_3	76031	110625	93328	20835	55022	37929	1.37	1.97	1.67
S_4	86734	128233	107483	28009	68687	48348	1.47	2.15	1.81
S_5	89093	132536	110815	30141	72477	51309	1.50	2.20	1.85
S.Em.±	1445	2441	1466	1445	2441	1466	0.02	0.04	0.03
C.D. (P=0.05)	4219	7125	4278	4219	7125	4278	0.07	0.12	0.07
M_1S_1	96504	145202	120853	36670	83843	60256	1.61	2.37	1.99
M_1S_2	96114	146588	121351	36318	85105	60711	1.61	2.38	2.00
M_1S_3	92266	138965	115616	34540	79863	57201	1.60	2.35	1.97
M_1S_4	97762	149091	123426	37007	86968	61988	1.61	2.40	2.00
M_1S_5	107622	151536	129579	45919	88811	67365	1.74	2.42	2.08
M_2S_1	84384	115648	100016	26684	57896	42290	1.46	2.00	1.73
M_2S_2	84166	118850	101508	26487	60812	43649	1.46	2.05	1.75
M_2S_3	71669	112566	92118	16891	56789	36840	1.31	2.02	1.66
M_2S_4	89373	126590	107982	30393	67061	48727	1.52	2.13	1.82
M_2S_5	87740	129479	108609	28917	69692	49304	1.49	2.17	1.83
M_3S_1	63092	85885	74489	8411	31763	20087	1.15	1.59	1.37
M_3S_2	73954	88067	81011	18229	33750	25989	1.33	1.62	1.47
M_3S_3	64159	80343	72251	11075	28415	19745	1.21	1.55	1.38
M_3S_4	73066	109019	91042	16626	52031	34328	1.29	1.91	1.60
M_3S_5	71918	116594	94256	15588	58929	37259	1.28	2.02	1.65
S.Em.±	3149	5007	2844	3149	5007	2844	0.05	0.09	0.05
C.D. (P=0.05)	10761	16783	9341	10761	16783	9341	NS	0.29	NS
Check	88671	134061	111366	32091	76197	54144	1.57	2.32	1.94
S.Em.±	2901	4779	2774	2901	4779	2774	0.05	0.08	0.05
C.D. (P=0.05)	8745	14406	8361	8745	14406	8361	0.15	0.25	0.14

M_1: 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) M_2: 80 % recommended nutrients (80:40:40 NPK kg ha^{-1})
M_3: 60 % recommended nutrients (60:30:30 NPK kg ha^{-1})
S_1: Rhizosphere bio-fertilzer consortium-I S_2: Rhizosphere bio-fertilzer consortium-II
S_3: Foliar application of Phyllosphere consortium @ 50, 70 and 90 DAS S_4: S_1+S_3 S_5: S_2+S_3

Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS recorded significantly higher plant height (126.2 cm), sympodial branches per plant (23.03) and dry matter production (285.7 g plant^{-1}) (Table 1). Higher level of nutrient might have increased soil nutrient status than lower levels and application of *Azospirillum,* PSB, KSB, ZnSB and PPFM through rhizosphere and phyllosphere consortia might have increased the nutrient availability and mobility to plant throughout the cropping season which resultingin higher growth parameters. Srinivasan (2008), also reported increased plant height and sympodial branches with 100 per cent RDF (60:30:30 NPK kg ha^{-1}) + *Azospririllum*+ *Phosphobacetrium* + PPFM as seed dressing and soil application at Srivilliputhur, Tamilnadu.

Effect on yield and yield parameters

Application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) recorded significantly higher yield parameters *viz.,* good opened bolls per plant (33.18), total number of bolls per plant (38.04) and seed cotton yield per hectare (2241 kg) followed by 80 % recommended nutrients (80:40:40 NPK kg ha^{-1}) (27.85, 34.36 and 1880 kg, respectively) and 60 % recommended nutrients (60:30:30 NPK kg ha^{-1}) (20.23, 27.62 and 1523 kg, respectively) in pooled data (Table 2). Higher number of bolls with increased levels of nutrients was also reported by Bharathi *et al.* (2016) and Gadade *et al*. (2015).

Among liquid bio fertilizer consortia, Rhizosphere Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS recorded significantly higher number of good opened and total number of bolls per plant (29.43 and 35.20, respectively) which helped for higher seed cotton yield per hectare (2040 kg). Phyllosphere Consortia @ 50, 70 and 90 DAS recorded significantly lower number of good opened bolls (24.61), total number of bolls (31.34) and seed cotton yield per hectare (1719 kg) (Table 2). Increased plant height and higher dry matter production might have led to higher number bolls and seed cotton yield. Madhaiyan *et al.* (2006) and Jawahar and Suresh (2007) also reported that different biofertilizers combination recorded significantly higher growth, bolls per plant and boll weight over the control.

Interaction effect was significant on seed cotton yield, where in Significant effect was observed on yield parameters when interactions were compared with check in pooled data. Application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) along with Rhizosphere Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS recorded higher good opened bolls per plant (36.19), total number of bolls per plant (40.50), seed cotton yield per hectare (2388 kg) (Table 2). Raju (2013) and Jayakumar *et al.* (2014) also reported higher seed cotton yield with combined application of fertilizers and bio fertilizer.

Economics of application of Bio-fertilizers

Significantly higher gross returns, net returns and benefit cost ratio were recorded with application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) in pooled data (₹ 1,22,165 ha^{-1}, ₹ 61,504 ha^{-1} and 2.01, respectively). Application of 60 % recommended nutrients (60:30:30 NPK kg ha^{-1}) recorded lower gross returns, net returns and benefit cost ratio (₹ 82,610 ha^{-1}, ₹ 27,482 ha^{-1} and 1.50, respectively) (Table 3). Pandagale *et al.* (2015) also reported application of higher levels of nutrients resulted in higher gross and net returns as compared to lower levels of nutrients. Rhizosphere Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS recorded higher economic parameters *viz.,* gross returns (₹ 1,10,815 ha^{-1}), net returns (₹ 51,309 ha^{-1}) and benefit cost ratio (1.85). Significantly lower gross returns (₹ 93,328 ha^{-1}), net returns (₹ 55,022 ha^{-1}) and benefit cost ratio (1.67) was recorded with Phyllosphere consortia at 50, 70 and 90 DAS (Table 3). Srinivasan (2008) also reported higher benefit cost ratio with combined application *Azospirilum* + *Phosphobacterium* + Pink Pigmented Facultative Methylotropic bacteria as compared to control. Significantly higher gross returns and net returns and benefit cost ratio were recorded with application of 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) along with Rhizosphere consortia-II + Phyllosphere consortia at 50, 70 and 90 DAS (₹ 1,29,579 ha^{-1}, ₹ 67,365 ha^{-1} and 2.08, respectively) (Table 3). Nalayini *et al.* (2014) in Coimbatore also reported that application of recommended dose of N and P along with *Azospirillum* + PSB + PPFM recorded higher net returns as compared recommended dose of N and P alone.

Conclusion

Based on the findings of the experiment it was concluded that 100 % recommended nutrients (100:50:50 NPK kg ha^{-1}) along with liquid bio-fertilizers *i.e.* Rhizosphere Consortia-II + Phyllosphere Consortia at 50, 70 and 90 DAS resulted in increased yield to an extent of 16.4 per cent and higher net returns over application of recommended nutrients alone.

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