Research Article

Effect of Liquid Biofertilizers on Growth and Yield of *Rabi* Sorghum (*Sorghum bicolor* L.)

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Abstract

A field experiment was conducted at Agricultural Research Station, Tandur, PJTSAU for three consecutive years *viz.* 2016-17, 2017-18 and 2018-19 to study the effect of liquid bio-fertilizers on growth, yield and economics of *Rabi* Sorghum. The following six treatments were considered for the study *i.e.* 1. Seed treatment with Azospirillum @ 50g+PSB @ 50g/kg seed, 2. Seed treatment with Azospirillum @ 2ml+PSB @ 2ml/kg seed, 3. Seed treatment with Azospirillum @ 2ml+PSB @ 4ml/kg seed, 4. Seed treatment with Azospirillum @ 4ml+PSB @ 2ml/kg seed, 5. Seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed and 6. Control. The treatments were evaluated in Randomized Block Design (RBD) with four replications. The pooled results of the study revealed that seed treatment with Azospirillum @ 4ml + PSB @ 4ml/kg seed significantly recorded highest plant height (195.3 cm), number of plants m^{-2} (14 plants m^{-2}), biomass (8.1 t ha^{-1}) and test weight (3.8 g). The highest grain yield (2.33 t ha^{-1}), straw yield (5.79 t ha^{-1}), net returns (Rs. 51,217 ha^{-1}) and B:C (2.10) ratio were recorded in seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed.

Keywords: Biofertilizers; Economics; *Rabi* Sorghum and Yield

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Introduction

Rabi Sorghum is valued mainly as staple food of humans and fodder for livestock in rainfed ecosystem. It is predominantly grown in Maharashtra followed by Karnataka, Tamilnadu, Gujarat, Andhra Pradesh and Telangana. In India, *Rabi* Sorghum is cultivated in an area of 35.65 L ha with a production of 26.04 L tones and productivity of 730 kg ha^{-1}. In Telangana, it is grown in occupies an area of 0.28 L ha with a production 0.33 L tones and an average yield of 1179 kg ha^{-1} [1].

The escalating cost of inorganic fertilizers, environmental hazards associated with them and failure in sustaining yields have given way for integrated use of organic and inorganic sources of nutrients, which will help to mitigate the abeyance state of soil thus improving biological power of the soil. Sustainable yield levels could be achieved only by the usage of organic sources of nutrients and chemical fertilizers. In respect of organic sources of nutrients, biofertilizers form an integral part of nutrient supply system [2].

Liquid biofertilizers formulation (LBF) is a promising and updated technology of the conventional carrier based production technology which inspite of many advantages over the agrochemicals, left a considerable dispute among the farming community in terms of several reasons, major being the viability of the organism. Shelf life is the first and foremost problem of the carrier based biofertilizers which is up to 3 months and it does not retain throughout the crop cycle, LBF on the other hand facilitates the long term survival of the organism by providing the suitable medium which is sufficient for the entire crop cycle. Carrier based bio fertilizers (CBBF) are not so tolerant to temperature which is mostly unpredictable and uncertain in the crop fields while temperature tolerance is the other advantage of the liquid biofertilizers. The range of possible contamination is very high as bulk sterilization does not provide desirable results in case of CBBF, whereas the contamination can be controlled constructively by means of proper sterilization techniques and maintenance of intensive hygiene conditions by appropriate quality control measures in the case of LBF. Moisture retaining capacity of the CBBF is very low which does not allow the organism to be viable for longer period and the LBF facilitates the enhanced viability of the organism [3].

Azospirillum is known to fix considerable quantity of nitrogen in range of 20-40 kg ha^{-1} in the rhizosphere in non-leguminous plants such as cereals, millets, oilseeds, cotton etc. *Azospirillum* is considered as efficient biofertilizer because of its ability of inducing abundant roots in several plants like rice, millets and oilseeds even in upland conditions. An estimated amount of 25- 30% chemical nitrogen fertilizer can be saved by the appropriate use of *Azospirillum* inoculants. Phosphorus solubilizing bacteria (PSB) play a vital role in persuading the insoluble phosphatic compound such as rock phosphate, bone meal, basic slag and particularly the chemically fixed soil

phosphorus into available form, PSB encourages early root development, produce organic acids like malic, succinic, fumaric, citric, tartaric and alpha ketoglutaric acid which hastens the maturity and thereby increases the ratio of grain to straw as well as the total yield, helps in rapid cell development in plants and consequently enhance diseases resistance towards pathogens, increase micro nutrient content in soil like Mn, Mg, Fe, Mo, B, Zn, Cu etc., and make them available to the plant parts; stimulates formation of fats, convertible starches and healthy seeds. Inoculants of phosphate solubilizing bacteria as fertilizer increases P uptake by the plant and enhance crop yield [4]. Among the several bio-agents, Azospirillum alone and in combination with PSB increases the yield of Sorghum [5]. Keeping in view the above facts, the present experiment was conducted to study the effect of liquid biofertilizers on growth and yield of *Rabi* Sorghum.

Materials and Methods

A field experiment was conducted at Agriculture Research Station, Tandur, Professor Jayashankar Telangana State Agricultural University for three consecutive years 2016-17, 2017-18 and 2018-19. The soil of the experimental field was clayey in texture, low in organic carbon (0.24 %), low in available nitrogen (151 kg ha^{-1}), high in available phosphorus (32 kg ha^{-1}), high in available potassium (414 kg ha^{-1}) and slightly alkaline in reaction (pH 7.39). The treatments include 1. Seed treatment with Azospirillum @ 50g+PSB @ 50g/kg seed, 2. Seed treatment with Azospirillum @ 2ml+PSB @ 2ml/kg seed, 3. Seed treatment with Azospirillum @ 2ml+PSB @ 4ml/kg seed, 4. Seed treatment with Azospirillum @ 4ml+PSB @ 2ml/kg seed, 5. Seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed and 6. Control. The treatments were evaluated in Randomized Block Design (RBD) with four replications. Sorghum cv. CSV-15 R was sown with spacing of 45 cm x 10 cm in the second fortnight of October and harvested in second fortnight of February during three years. RDF (60:30 NP Kg ha^{-1}) was applied to soil in each treatment and seed treated with biofertilizers (Azospirillum and PSB) at the time of sowing. Net plot yields were used for calculating yield per hectare. The results were analyzed using standard statistical procedure [6].

Results and Discussion

Growth and Yield Parameters

The pooled analysis of results revealed that, there is a significant difference between carrier and liquid biofertilizers on growth and yield parameters of *Rabi* Sorghum.

Significantly higher plant height (195.3 cm) was recorded by seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed and on par with the all liquid biofertilizers treated plots and lowest plant height was recorded in control (160.4 cm) plots followed by seed treatment with Azospirillum @ 50g+PSB @ 50g/kg seed (178.6 cm). This might be due to prolonged vegetative growth which increased the plant height [2]. Significantly highest plant population (14 plants m^{-2}) was recorded in seed treatment with liquid biofertilizers than powder formulation. Number of days to 50% flowering significantly differed with the use of biofertilizers in *Rabi* Sorghum (**Table 1**). This was ascribed to increased microbial activity in the rhizosphere which resulted in solubilization of bound form of soil minerals and enhanced availability of nutrients in the soil for plant growth and development by the liquid biofertilizers leading to improved seedling germination, vigour, emergence and productivity [7] [8] and [9].

Application of liquid Azospirillum and PSB improve the total biomass significantly over control plot. The significantly highest biomass was recorded in seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed (8.11 t ha^{-1}) and it was superior over all the other treatments and lowest was observed in control (6.05 t ha^{-1}). Seed inoculation with liquid biofertilizers fixes nitrogen and solubilizes insoluble phosphate in soil and make available to plants due to which plant grows vigorously producing more biomass [10]. Seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed recorded highest test weight (3.76 g) than other treatments and lowest was recorded in control plot (3.4 g) (**Table 2**) [3] and [11].

Grain and Stover Yield

The grain and stover yields were significantly effected due to use of different biofertilizers formulations. Highest grain (2.33 t ha^{-1}) and stover yields (5.79 t ha^{-1}) were recorded in seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed followed by seed treatment with Azospirillum @ 4ml+PSB @ 2ml/kg seed, whereas lowest grain and stover yields (1.47 t ha^{-1} and 4.58 t ha^{-1}) were recorded in control plot (**Table 3**). Highest grain and stover yield in seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed which were 36.90% and 20.89% higher over control plot and 24.46 and 15.54 % higher over Azospirillum @ 50g+PSB @ 50g /kg seed treated plot, respectively. The highest Harvest Index (28.8%) was recorded under seed treatment with Azospirillum @ 4ml+PSB @ 2ml/kg seed. Application of liquid biofertilizers and its seed inoculation significantly increased the respective growth and yield

parameters over control plot [12]. The use of biofertilizers may lead to higher availability of nitrogen and phosphorus that promoted growth and development and ultimately resulting in higher yields [13] [14] and [15].

Maximum net returns of Rs. 51,217 ha^{-1} with BCR of 2.10 was recorded in seed treatment with Azospirillum @ 4ml+PSB @ 4ml/kg seed followed by Azospirillum @ 4ml+PSB @ 2ml/kg seed treatment with a net returns of Rs.43,479 ha^{-1} with BCR of 1.78 over rest of the treatments (**Table 4**). This might be due to higher yield of crop with these treatments. This results were conformity in Sorghum crop [16] and Okra [17].

Table 1 Effect of liquid biofertilizers on growth parameters of *Rabi* Sorghum

Treatments	Plant height (cm)				No. of plants m^{-2}				Days to 50% Flowering			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Seed treatment with Azospirillum@50g + PSB@50g /kg seed	167.5	174.6	193.7	178.6	14	13	11	12	74	75	75	75
Seed treatment with Azospirillum @ 2ml +PSB @ 2ml/kg seed	173.5	182.0	207.5	187.7	14	13	11	13	74	75	75	75
Seed treatment with Azospirillum @ 2ml +PSB @ 4ml/kg seed	179.0	184.2	208.1	190.4	14	14	13	14	75	76	76	75
Seed treatment with Azospirillum @ 4ml +PSB @ 2ml/kg seed	181.8	187.4	208.5	192.5	14	14	13	14	74	76	76	75
Seed treatment with Azospirillum @ 4ml +PSB @ 4ml/kg seed	186.5	189.1	210.3	195.3	14	15	14	14	73	77	76	75
Control	156.0	158.1	167.2	160.4	13	12	11	12	72	74	75	74
SEm±	9.69	19.43	17.73	10.14	0.73	0.94	1.52	0.46	1.49	NS	NS	1.39
CD @5%	3.19	6.39	5.83	3.33	0.24	0.31	0.50	0.15	0.49	0.99	0.84	0.46
CV (%)	3.66	7.13	5.85	3.62	3.39	4.53	8.41	2.31	1.34	2.62	2.24	1.22

Table 2 Effect of liquid biofertilizers on yield parameters of *Rabi* Sorghum

Treatments	Biomass (t ha^{-1})				Test weight (g)			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Seed treatment with Azospirillum @ 50g+ PSB @ 50g /kg seed	6.81	7.14	6.50	6.65	3.6	3.6	3.2	3.5
Seed treatment with Azospirillum @ 2ml+PSB @ 2ml/kg seed	7.07	7.32	6.75	6.88	3.6	3.7	3.3	3.5
Seed treatment with Azospirillum @ 2ml+PSB @ 4ml/kg seed	7.03	7.19	7.45	7.14	3.8	3.7	3.3	3.6
Seed treatment with Azospirillum @ 4ml+PSB @ 2ml/kg seed	7.17	7.36	7.55	7.36	4.0	3.7	3.4	3.7
Seed treatment with Azospirillum @ 4ml +PSB @ 4ml/kg seed	8.67	7.87	7.87	8.11	4.1	3.7	3.4	3.8
Control	6.87	5.90	5.38	6.05	3.6	3.5	3.2	3.4
SEm±	0.61	0.57	0.60	0.42	0.19	NS	NS	0.14
CD @5%	0.20	0.19	0.20	0.14	0.06	0.08	0.12	0.05
CV (%)	5.54	5.22	5.73	3.96	3.33	4.31	7.19	2.51

Table 3 Effect of liquid biofertilizers on yield of *Rabi* Sorghum

Treatments	Grain Yield (t ha^{-1})				Stover Yield (t ha^{-1})				Harvest Index (%)			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Seed treatment with Azospirillum@50g	1.92	1.57	1.79	1.76	4.90	5.06	4.70	4.89	28.2	22.3	27.7	26.5

+ PSB@50g /kg seed												
Seed treatment with Azospirillum @ 2ml +PSB @ 2ml/kg seed	2.09	1.69	1.93	1.90	4.97	5.13	4.82	4.98	29.6	23.6	28.4	27.7
Seed treatment with Azospirillum @ 2ml +PSB @ 4ml/kg seed	2.14	1.83	2.18	2.05	4.89	5.11	5.27	5.09	30.4	25.7	29.3	28.7
Seed treatment with Azospirillum @ 4ml +PSB @ 2ml/kg seed	2.13	2.01	2.22	2.12	5.06	5.32	5.34	5.24	29.7	28.1	29.3	28.8
Seed treatment with Azospirillum @ 4ml +PSB @ 4ml/kg seed	2.55	1.99	2.45	2.33	6.12	5.82	5.43	5.79	29.5	26.1	31.1	28.7
Control	1.91	1.16	1.35	1.47	4.96	4.75	4.03	4.58	27.9	19.7	25.2	24.4
SEm±	0.27	0.27	0.43	0.21	0.48	0.64	0.53	0.37	NS	4.41	NS	2.49
CD @5%	0.09	0.09	0.14	0.07	0.16	0.21	0.17	0.12	0.94	1.45	1.76	0.82
CV (%)	8.46	10.24	14.32	7.27	6.14	7.73	7.08	4.79	6.45	11.96	12.36	5.95

Table 4 Effect of liquid biofertilizers on economics of *Rabi* Sorghum

Treatments	**Gross Returns (Rs ha^{-1})**				**Net Returns (Rs ha^{-1})**				**B:C ratio**			
	2016-17	**2017-18**	**2018-19**	**Pooled**	**2016-17**	**2017-18**	**2018-19**	**Pooled**	**2016-17**	**2017-18**	**2018-19**	**Pooled**
Seed treatment with Azospirillum @ 50g+ PSB @ 50g /kg seed	72191	58669	44790	58550	48891	34369	19990	34417	2.10	1.41	0.81	1.44
Seed treatment with Azospirillum @ 2ml+PSB @ 2ml/kg seed	77659	61991	48165	62605	54159	37491	23165	38272	2.30	1.53	0.93	1.59
Seed treatment with Azospirillum @ 2ml+PSB @ 4ml/kg seed	78886	64616	54530	66011	55286	40016	29430	41577	2.34	1.63	1.17	1.71
Seed treatment with Azospirillum @ 4ml+PSB @ 2ml/kg seed	78905	69683	55450	68013	55205	44983	30250	43479	2.33	1.82	1.20	1.78
Seed treatment with Azospirillum @ 4ml +PSB @ 4ml/kg seed	94861	71561	61130	75850	71061	46761	35830	51217	2.99	1.89	1.42	2.10
Control	72172	45510	33820	50501	49172	21510	9320	26667	2.14	0.90	0.38	1.14

Conclusion

From the experimental results, it can be concluded that seed treatment with Azospirillum @ 4ml + PSB @ 4ml/kg seed is ideal for obtaining higher grain yield (2.33 t ha^{-1}), net returns (Rs. 51,217 ha^{-1}) and B:C ratio (2.10) in *Rabi* Sorghum.

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