Original Research Article

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Response of *rabi* Grain Sorghum to Different form of Biofertilizers

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ABSTRACT

Keywords

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Field studies were conducted during *rabi* season of 2019-20 under All India Coordinated Sorghum Improvement Project (AICSIP) at Nandyal (Andhra Pradesh) to assess the impact of application of different form of biofertilizers on *rabi* grain sorghum. The experiment comprising of six treatments (T₁: Recommended dose of fertilizer (RDF) alone, T₂: RDF + seed treatment with *Azospirillum* (Azo.) @ 50g+PSB @ 50g/kg seed, T₃: RDF + seed treatment with Azo. @ 2ml+PSB @ 2ml/kg seed, T₄: RDF + seed treatment with Azo. @ 2ml + PSB @ 4ml/kg seed, T₅: RDF + seed treatment with Azo. @ 4ml + PSB @ 2ml/kg seed and T₆: RDF + seed treatment with Azo. @ 4ml + PSB @ 4ml/kg seed) were laid out in Randomized Block Design (RBD) with four replications. The results of the study revealed that seed treatment with *Azospirillum* and PSB fertilizers were promising to RDF alone from grain yield and net income point of view. Seed treatment with *Azospirillum* + PSB (2 ml + 4 ml/kg seed) in addition to RDF have enhanced grain and stover yields by 6.22 % and 1.52 % over RDF that together have improved net income by 18.9 %. Further with use of the above inoculants in liquid form (Azo. 2 ml + PSB @ 4 ml/kg seed) enhancing grain and stover yields by 12.45 % and 0.42 % over powder form of inoculants and have registered Rs. 8014 ha⁻¹ higher net income. Liquid form of *Azospirillum* 2 ml + PSB 4 ml/kg seed have at par performance as that of Azo. 4 ml + PSB @ 4 ml/kg seed.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is fifth most important cereal of globe (Taylor, 2019) produced in arid and semi-arid regions that are characterised by soil and climate constraints to which major cereals including maize are less well adapted. In India, sorghum grown in *rabi* season is preferred for human consumption thus has gained prominence to

its *kharif* season. This is evident from the fact that *rabi* season accounted for 52.7% of total sorghum grain production of 3.76 m t (2018-19). Low productivity was ascribed to moisture stress that aggravates mineral nutrient stress. 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 source of nutrients and chemical fertilizers. In respect of organic sources of nutrients, biofertilizers form an integral part of nutrient supply system (Sivamurugan *et al.*, 2018). Among bio fertilizers, *Azospirillum* and phosphate solubilizing bacteria (PSB) are commonly used in crops like sorghum. However, these carriers based powder form inoculants with lower shelf life, low temperature tolerance, low moisture retention capacity and reduced survival, contamination problems etc. were found to result in their reduced effectiveness. In this context, liquid biofertilizers formulation (LBF) was evolved addressing all these concerns (Mahdi *et al.*, 2010). *Azospirillum* species is known to fix considerable quantity of nitrogen in non-leguminous plants such as cereals, millets, oilseeds, cotton etc. with an estimated 25-30% chemical nitrogen fertilizer savings. Phosphorus solubilizing bacteria (PSB) was reported to 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 disease 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 (Pavan and Satyanarayana, 2012). *Azospirillum* alone and

in combination with PSB were reported to increase yield of sorghum substantially (Patidar and Mali, 2004). Keeping in view the above facts, the present experiment was conducted to study the effect of liquid biofertilizers on growth and yield of *rabi* grain sorghum when compared to its powder form and no biofertilizer inoculation.

Materials and Methods

A field experiment was conducted during *rabi* season of 2019-20 at Regional Agricultural Research Station, Nandyal (Andhra Pradesh). The experiment consisting of six treatments (T₁: Recommended dose of fertilizer (RDF) alone (Control), T₂: RDF + seed treatment with *Azospirillum* @ 50g + PSB @ 50g/kg seed, T₃: RDF + seed treatment with *Azospirillum* @ 2ml + PSB @ 2ml/kg seed, T₄: RDF + seed treatment with *Azospirillum* @ 2ml + PSB @ 4ml/kg seed, T₅: RDF + seed treatment with *Azospirillum* @ 4ml + PSB @ 2ml/kg seed and T₆: RDF + seed treatment with *Azospirillum* @ 4ml + PSB @ 4ml/kg seed) were evaluated in Randomized Block Design (RBD) with four replications. Sorghum cv.CSV-29R was sown with spacing of 45 cm x 15 cm and recommended dose of fertilizers was applied to soil in each treatment and seeds were treated with both powder and liquid form of biofertilizers (*Azospirillum* and PSB) at the time of sowing as per treatment. Sorghum growth, yield attributes, grain and stover yields were recorded and economics were worked and all the data was analyzed statistically as outlined by Panse and Sukhatme (1967).

Results and Discussion

The growth parameters *viz.*, final plant population, plant height and dry matter production at harvest were recorded (Table 1). Higher plant height (316.4 cm) was recorded by seed treatment with *Azospirillum* @ 2ml +

PSB @ 4ml/kg seed which was on par with all other treatments. This might be due to prolonged vegetative growth which increased the plant height. Application of liquid Azospirillum and PSB improve the total biomass significantly over control plot. Significantly higher dry matter production

was recorded in seed treatment with Azospirillum @ 2ml + PSB @ 4ml/kg seed (9173 kg ha^{-1}) and it was statistically on par with use of liquid biofertilizers at higher dose (Azo. @ 4 ml + PSB @ 4 ml) and the lowest dry matter production was observed in control (8880 kg ha^{-1}).

Table.1 Growth parameters of *rabi* grain sorghum as influenced by form of biofertilizers

Treatments	Final pl popu (No. m^{-2})	Plant height (cm) at harvest	DMP (kg ha^{-1}) at harvest	Days to 50 % flowering	Days to maturity
T ₁ - 100 % RDF (80:40:40 NPK kg ha^{-1})	13.2	308.9	8880	67.7	110.2
T ₂ -RDF + Seed treatment with Azospirillum + PSB @ 50 g each/kg seed	13.7	310.6	9038	68.2	110.7
T ₃ - RDF + Seed treatment with Azospirillum @ 2 ml + PSB @ 2 ml/kg seed	14.0	314.3	9087	67.2	110.7
T ₄ - RDF + Seed treatment with Azospirillum @ 2 ml + PSB @ 4 ml/kg seed	14.0	316.4	9173	68.0	111.5
T ₅ - RDF + Seed treatment with Azospirillum @ 4 ml + PSB @ 2 ml/kg seed	13.5	314.7	9125	67.7	112.5
T ₆ - RDF + Seed treatment with Azospirillum @ 4 ml + PSB @ 4 ml/kg seed	13.7	314.2	9147	67.2	111.2
SEm _±	0.26	2.96	56.77	0.39	0.71
CD (P=0.05)	NS	NS	172.69	NS	NS
C.V (%)	6.82	12.89	14.25	9.16	8.28

Table.2 Yield attributes and yield of *rabi* grain sorghum as influenced by form of biofertilizers

Treatments	Panicle length (cm)	Panicle weight (g)	1000 seed weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T ₁ - 100 % RDF (80:40:40 NPK kg ha^{-1})	19.4	58.9	34.67	3171	8662	26.78
T ₂ -RDF + Seed treatment with Azospirillum + PSB @ 50 g each/kg seed	19.7	60.1	35.20	3314	8759	27.43
T ₃ - RDF + Seed treatment with Azospirillum @ 2 ml + PSB @ 2 ml/kg seed	20.3	64.1	35.45	3407	8717	28.09
T ₄ -RDF + Seed treatment with Azospirillum @ 2 ml + PSB @ 4 ml/kg seed	20.7	71.9	35.70	3774	8796	28.70
T ₅ - RDF + Seed treatment with Azospirillum @ 4 ml + PSB @ 2 ml/kg seed	19.7	67.4	34.95	3544	8737	29.46
T ₆ - RDF + Seed treatment with Azospirillum @ 4 ml + PSB @ 4 ml/kg seed	19.4	68.3	35.15	3653	8788	30.04
SEm _±	0.62	0.76	0.20	43.53	67.19	0.25
CD (P=0.05)	NS	2.32	0.63	132.4	NS	0.76
C.V (%)	6.30	9.34	10.18	12.50	15.35	11.78

Table.3 Economics of *rabi* sorghum as influenced by levels of liquid and powder form of biofertilizers

Treatments	Gross income (Rs. ha ⁻¹)	Net income (Rs. ha ⁻¹)	B:C ratio
T ₁ - 100 % RDF (80:40:40 NPK kg ha ⁻¹)	75826/-	47723/-	2.70
T ₂ —RDF + Seed treatment with Azospirillum + PSB @ 50 g each/kg seed	79039/-	50833/-	2.80
T ₃ — RDF + Seed treatment with Azospirillum @ 2 ml + PSB @ 2 ml/kg seed	81062/-	52919/-	2.88
T ₄ — RDF + Seed treatment with Azospirillum @ 2 ml + PSB @ 4 ml/kg seed	86996/-	58847/-	3.09
T ₅ — RDF + Seed treatment with Azospirillum @ 4 ml + PSB @ 2 ml/kg seed	84090/-	55913/-	2.98
T ₆ — RDF + Seed treatment with Azospirillum @ 4 ml + PSB @ 4 ml/kg seed	86518/-	58335/-	3.07

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 (Sandhyarani *et al*, 2019). Days to 50 % flowering and days to maturity were not significantly influenced by form of bio fertilizers. Grain, stover yield and economics of *rabi* grain sorghum varied significantly among the bio fertilizer treatments (Table 2 & 3). Maximum panicle weight (71.9 g), 1000 seed weight (35.7 g) and harvest index (28.9%) were recorded under seed treatment with Azospirillum @ 2ml + PSB @ 4 ml/kg seed. Application of liquid biofertilizers and its seed inoculation significantly increased the respective yield parameters over control plot. The use of biofertilizers may lead to higher availability of nitrogen and phosphorus that promoted growth and development and ultimately resulting in higher yield parameters and yield (Baghchand and Gautam, 2000).

Seed treatment with *Azospirillum* @ 50g + PSB @ 50g /kg seed significantly improved stover yields (8759 kg ha⁻¹) over no bio-fertilizer control (RDF) treatment (8662 kg/ha). Grain yields too showed increasing trend due to seed treatment with powder form

of bio fertilizers, the increase was statistically insignificant over control (3171 kg/ha). Use of liquid biofertilizer inoculants (Azo. @ 2 ml + PSB @ 4 ml) being at par with its other three rates (Azo. @ 2 ml + PSB @ 2 ml; Azo. @ 4 ml + PSB @ 2 ml and Azo. @ 4 ml + PSB @ 4 ml) have brought significant improvement in grain yield (3774 kg ha⁻¹) over powder form inoculants i.e. *Azospirillum* @ 50g + PSB @ 50g/kg (3314 kg ha⁻¹). Stover yields remained unaltered statistically with use of liquid form of biofertilizers as compared to its powder form. Liquid biofertilizers treated sorghum (mean over 4 rates) has 12.45 % and 0.42 % higher grain and stover yields than its powder form (*Azospirillum* @ 50g+PSB @ 50g /kg) treatment. Grain (3774 kg ha⁻¹) and stover yields (8759 kg ha⁻¹) were maximum with *Azospirillum* @ 2 ml + PSB @ 4 ml/kg seed treatment (Table 2). Higher yields of powder and liquid form of *Azospirillum* and PSB biofertilizer inoculated sorghum crop of present were supported findings of Jat *et al.*, (2013) and Raja and Takankharb (2017). Increased availability of nitrogen and phosphorus with liquid biofertilizers has enhanced the efficacy that might have promoted growth, yield attributes formation and thus higher yields.

Seed treatment with biofertilizers irrespective of its form (powder or liquid) have brought marked improvements in net income (Table 3). Seed treatment with *Azospirillum* @ 50 g + PSB @ 50g /kg seed has improved net income by Rs. 3110/- as compared to RDF i.e. no bio fertilizer control (Rs.47723 ha⁻¹). The net income of sorghum crop were further improved by Rs. 6735 with use of liquid form *Azospirillum* and PSB for seed treatment. Among liquid bio fertilizer inoculant levels, *Azospirillum* @ 2 ml + PSB @ 4 ml/kg seed being at par with *Azospirillum* @ 4 ml + PSB @ 4ml/kg seed has recorded highest net income (Rs. 58847 ha⁻¹) and B:C ratio (3.09). These results are in conformity with the findings of Patel (2015). Higher net income and BC ratio in liquid bio fertilizer inoculation (*Azospirillum* @ 2 ml + PSB @ 4 ml/kg seed) was ascribed to higher grain and stover yields.

Based on the present study it was recommended that for *rabi* grain sorghum seed treatment with *Azospirillum* + PSB irrespective of its form (liquid or powder) is promising to the existing use of recommended dose of fertilizers (RDF) alone. Liquid form bioinoculants i.e. *Azospirillum* 2 ml + PSB @ 4 ml/kg seed is promising to its powder form of inoculation from grain, stover yield and net returns point of view and are recommended for adoption in *lieu* of current practice of use of RDF alone.

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