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Influence of biofertilizers and foliar application of seaweed (*Kappaphycus alvarezii*) extract on yield and economics of sorghum (*Sorghum bicolor* L.)

Mohammed Ali Dalwale, Rajesh Singh and Geshu Singh

Abstract
The field experiment was conducted during *kharif* season, 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (UP). The experiment was laid out in Randomized Block Design with ten treatments including control (only RDF), replicated thrice with the different biofertilizers *viz*., *Azospirillum* sps. 25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS/ha, *Azospirillum* sps. 25 g/kg seeds + 10% seaweed, *Azospirillum* sps. 25 g/kg seeds + 15% seaweed, PSB 25 g/kg seeds + 5% seaweed, PSB 25 g/kg seeds + 10% seaweed, PSB 25 g/kg seeds + 15% seaweed, *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 5% seaweed, *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 10% seaweed, *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 15% seaweed including control i.e., application of 80: 40:40 kg NPK/ha (farmer's practice) were replicated thrice. Significantly increased the yield of sorghum *viz*., (6995.79 kg/ha) and stover yield (7685.90 kg/ha) as compared to all the treatment combinations. The maximum Gross returns (₹176965.06/ha), Net returns (₹136835.06 /ha) and B:C ratio (3.41) were also recorded maximum in treatment with dual inoculation *Azospirillum* Sps. 25 g/kg seeds and PSB 25 g/kg seeds along with foliar application of 10% seaweed at 30-50-70 DAS/ha.

Keywords: Sorghum, bio-fertilizers, seaweed, *Azospirillum* Sps., PSB, yield, economics

Introduction
In the semiarid tropics, particularly in India, sorghum is an important food grain crop. It remains dormant through severe drought stress conditions and recovers with rainfall, and its yields are more consistent in stressed climates than maize (Rao *et al*., 2004). Sorghum, a drought-resistant crop, which plays an important role in dryland food, feed, and fodder security, especially with climate change. Sorghum has been discovered to be high in vitamins and minerals, as well as having a high protein content and accounting for a significant amount of dietary fiber intake. 100 g of grain contains 10.4 g of protein, 1.9 g of fat, 72.6 g of carbohydrates, 1.6 g of crude fiber, 25 g of calcium, and 3.5 g of fat out of which only 0.6 g is saturated fat.

The use of chemical fertilizers is unavoidable in agriculture in order to meet the rising population's need, but the objective is to produce food in an eco-friendly manner while minimizing the environmental concerns produced by chemical fertilizers. Relying too much on chemical fertilizers is not a viable strategy. In this case, biofertilizer would be a realistic option for farmers looking to boost productivity. Biofertilizers enhance plant development by adding nutrients through natural biological processes, such as solubilizing phosphorus and production of growth-promoting substances.

The presence of many organic compounds and a natural chelating compound (i.e., manitol) in sap has been reported to improve nutrient uptake (Shah *et al*., 2013). Seaweed products are utilized in a variety of methods in field crops, including foliar spray, soil supplements, seed priming, and so on. It is directly digested by crop leaves within a few hours of administration by foliar spray, and it is also used as green manure, compost, and seed primer. As a seed primer, it helps the establishment of the crop, increasing vigour and germination rate. *Gracilaria edulis* and *Kappaphycus* were also used in the study (Shah *et al*., 2013).

Materials and Methods
The experiment was carried out during *kharif* season of 2021 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P). Which is located at 25º 39' 42" N latitude, 81º 67' 56" E longitude and 98 m altitude above the mean sea level. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.7), low in organic

carbon (0.57%), available N (203.7 kg/ha), available P (17.2 kg/ha) and available K (346.00 kg/ha). The crop was sown on 20th July 2021 using variety NTJ-5. The experiment was laid out in Randomized Block Design comprised of 3 replications and total 10 treatments *viz*., T_1: Control 80:40:40 kg NPK/ha (Farmer's Practice), T_2: *Azospirillum* sps. 25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS/ha, T_3: *Azospirillum* sps. 25 g/kg seeds + 10% seaweed at 30, 50, 70 DAS/ha, T_4: *Azospirillum* sps. 25 g/kg seeds + 15% seaweed at 30, 50, 70 DAS/ha, T_5: PSB 25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS/ha, T_6 PSB 25 g/kg seeds + 10% seaweed at 30, 50, 70 DAS/ha, T_7: PSB 25 g/kg seeds + 15% seaweed at 30, 50, 70 DAS/ha, T_8: *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS/ha, T_9: *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 10% seaweed at 30, 50, 70 DAS/ha, T_{10}: *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 15% seaweed at 30, 50, 70 DAS/ha. All nutrients were applied through soil as urea, single super phosphate (SSP) and muriate of potash (MOP). Full dose of P and K was applied basal for respective plots, half dose of N (as urea) was applied basal the remaining half quantity of nitrogen was top dressed after 30-35 days after sowing. The growth parameters were recorded at periodical intervals of 20,40,60,80 DAS and at harvest stage from the randomly selected five tagged plants in each treatment. Statistical analysis was done and mean compared at 5% probability level of significant results.

Table 1: Details of treatment combinations

Treatment No.	Treatment Combinations
T1	Control, 80:40:40 kg NPK/ha (Farmer's Practice)
T2	*Azospirillum* sps. 25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS
T3	*Azospirillum* sps. 25 g/kg seeds + 10% seaweed at 30, 50, 70 DAS
T4	*Azospirillum* sps. 25 g/kg seeds + 15% seaweed at 30, 50, 70 DAS
T5	PSB 25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS
T6	PSB 25 g/kg seeds + 10% seaweed at 30, 50, 70 DAS
T7	PSB 25 g/kg seeds 15% seaweed at 30, 50, 70 DAS
T8	*Azospirillum* sps. + PSB: 25+25 g/kg seeds + 5% seaweed at 30, 50, 70 DAS
T9	*Azospirillum* sps. + PSB: 25+25 g/kg seeds +10% seaweed at 30, 50, 70 DAS
T10	*Azospirillum* sps. + PSB: 25+25 g/kg seeds + 15% seaweed at 30, 50, 70 DAS

Results and Discussion

Influence of biofertilizers and foliar application of seaweed extract on yield of sorghum

Influence of biofertilizers and foliar application of seaweed on yield of sorghum are presented in Table 2. In the results revealed that dual inoculation by *Azospirillum* sps. 25 g/kg seeds and PSB 25 g/kg seeds along with foliar application of 10% seaweed at 30-50-70 DAS/ha significantly increased the yield attributing parameters *viz*., grain yield (6995.79 kg/ha), stover yield (7685.90 kg/ha), over control. Higher grain yield and stover yield was due to the foliar application of seaweed and the action of biofertilizers. As biofertilizers it may be due to increased nitrogen and phosphorus supply, which contributes to better vegetative growth resulting into higher seed and stover yield of sorghum. These results are in close conformity with the findings of (Singh *et al.*, 2015) [14]. In rice application of seaweed extract at lower concentration (25%) enhanced biochemical constituents like carotenoids, amino acids, reducing sugar content and α and β-amylase activity of shoot and root (Bai *et al.*, 2011). Seaweed extract is a bio stimulant, which provides micro and macro nutrients in significant amount and presence of cytokinin, auxins ultimately increasing the chlorophyll content by boosting the photosynthesis process, thereby stimulating vegetative growth and resulted in higher productivity. Similarly in soybean, foliar application of 15% *Kappaphycus alvarezii* extract increased grain yield by 57% as compared to control (Rathore *et al.*, 2009)

Influence of biofertilizer and foliar application of seaweed extract on economics

Influence of biofertilizer and foliar application of seaweed on economics are presented in Table 3. The highest gross returns (₹ 176965.06/ha), net returns (₹ 136835.06/ha) and B:C ratio (3.41) were recorded in dual seed inoculation of *Azospirillum* sps. 25 g/kg seeds and PSB 25 g/kg seeds along with foliar application of 10% seaweed at 30-50-70/ha DAS over control (only RDF). This was mainly due to higher seed and stover yields compared to other treatment combinations. Similar findings were supported by (Pramanick *et al.*, 2014) [10] and (Singh *et al.*, 2015) [14]

Table 2: Influence of biofertilizers and foliar application of seaweed extract on yield of sorghum

Treatment Combinations	Grain yield (kg/ha)	Stover yield (kg/ha)
1. Control 80:40:40 kg NPK/ha (Farmer's Practice)	4085.67	4710.67
2. *Azospirillum* sps. 25 g/kg seeds + 5% seaweed	5414.83	6548.91
3. *Azospirillum* sps. 25 g/kg seeds + 10% seaweed	5519.13	6517.80
4. *Azospirillum* sps. 25 g/kg seeds + 15% seaweed	5562.67	6522.77
5. PSB 25 g/kg seeds + 5% seaweed	5524.31	6421.67
6. PSB 25 g/kg seeds + 10% seaweed	5689.03	6588.97
7. PSB 25 g/kg seeds + 15% seaweed	5656.73	6454.37
8. *Azospirillum* sps. + PSB 25+25 g/kg seeds + 5% seaweed	5617.34	6522.13
9. *Azospirillum* sps. + PSB 25+25 g/kg seeds +10% seaweed	6995.79	7685.90
10. *Azospirillum* sps. + PSB 25+25 g/kg seeds + 15% seaweed	5637.37	6736.80
F test	S	S
S.Em(±)	11.48	3.07
CD (p=0.05)	34.11	9.12

Table 3: Influence of biofertilizers and foliar application of seaweed extract on economics of sorghum

Treatment Combinations	Total cost of cultivation	Gross return	Net return	B:C ratio
1. Control 80:40:40 kg NPK/ha (Farmer's Practice)	33630.00	104016.67	70386.67	2.09
2. *Azospirillum* sps. 25 g/kg seeds + 5% seaweed	36880.00	138773.06	101893.06	2.76
3. *Azospirillum* sps. 25 g/kg seeds + 10% seaweed	39880.00	140974.33	101094.33	2.53
4. *Azospirillum* sps. 25 g/kg seeds + 15% seaweed	42880.00	141946.97	99066.97	2.31
5. PSB 25 g/kg seeds + 5% seaweed	36880.00	140799.84	103919.84	2.82
6. PSB 25 g/kg seeds + 10% seaweed	39880.00	144925.63	105045.63	2.63
7. PSB 25 g/kg seeds + 15% seaweed	42880.00	143811.23	100931.23	2.35
8. *Azospirillum* sps. + PSB 25+25 g/kg seeds + 5% seaweed	37130.00	143147.98	106017.98	2.86
9. *Azospirillum* sps. + PSB 25+25 g/kg seeds +10% seaweed	40130.00	176965.06	136835.06	3.41
10. *Azospirillum* sps. + PSB 25+25 g/kg seeds + 15% seaweed	43130.00	144232.47	101102.47	2.34

Conclusion

In conclusion, it is inferred from the present investigation that sorghum should be sown with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 10% seaweed at 30-50-70 DAS/ha was recommended for receiving higher yield and economic benefits of sorghum.

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