Original Research Article

Influence of Biofertilizers and Foliar application of Seaweed (*Kappaphycus alvarezii*) Extract on Growth of Sorghum (*Sorghum bicolor* L.)

Abstract

The field trial was carried out in *kharif* season, 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (UP). The experiment was conducted in Randomized Block Design with ten treatments including control. The aim of the experiment is to reduce the impact of harmful chemical amendments used in agro-ecosystem. The experiment was repeated thrice in RBD with different biofertilizers *viz*., *Azospirillum* sps. 25 g/kg seeds + 5% seaweed, *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. 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, significantly increased the growth parameters of sorghum *viz*., plant height (164.07 cm), number of leaves (12.47) dry matter accumulation (116.59 g), absolute growth rate (1.21 g/plant/day), crop growth rate (40.33 g/m^2/day) and leaf area (332.33 cm^2).

Keywords: Sorghum, Seaweed, *Azospirillum* sps., Phosphate solubilizing bacteria, Growth.

Abbreviations: sps.: species, DAS: days after sowing, ha: hectare, m^2: square meter, g: gram, kg: kilogram, PSB: phosphate solubilizing bacteria, NPK: nitrogen phosphorous potassium, SEd ±: standard error of difference, SE(m) ±: standard error of mean

1. INTRODUCTION

Sorghum is generally cultivated as a rainfed crop in India, both during *kharif* and *rabi* seasons (92% of area). Maharashtra is the state where the most sorghum is cultivated and produced in India. It is the fifth most important cereal crop. Sorghum has been found to be high in vitamins as well as having a high protein content and accounting for a significant portion of dietary fiber intake. The 100 g of grains contains 10.4 g proteins, 1.9 g fats, 72.6 g carbohydrates, 1.6 g crude fiber, and 25 g calcium, as well as 3.5 g fat, only 0.6 g of which is

saturated fat. Sorghum is a drought tolerant crop that is ideal for dry climates. Use of chemical fertilizers is inevitable in agriculture as a result of to fulfil the demand for growing population however the priority to supply food in an eco-friendly manner we will have to lessen the impact of chemical fertilizers in the agro ecosystem. Use of biofertilizer can be effective for farmers in this situation to increase productivity. Biofertilizers enhance plant development by adding nutrients through natural biological processes. "It has been claimed that extracts of *Kappaphycus alvarezii* and *Gracilaria edulis* can improve nutrient absorption. This might be due to the presence of organic compounds and natural chelating agents in sap, such as mannitol, which mobilize and fixed nutrients to the plant in effective form" [7].

2. MATERIALS AND METHODS

The trail was conducted at Crop Research Farm, during *kharif* season of 2021, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P). which is situated at 25^{o} 39' 42" N latitude, 81^{o} 67' 56" E longitude and 98 m altitude above the mean sea level. The soil of the experiential plot was sandy loam, nearly neutral in pH (7.7), low in organic carbon (0.57%), available nitrogen (230 kg/ha), available phosphorous (32.10 kg/ha) and available potassium (346 kg/ha). The crop was sown on 20th July 2021 using variety NTJ-5. The trail was carried out in randomized block design which includes three replications and total ten treatments *viz*., T_1: Control 80:40:40 kg NPK/ha (Farmer's Practice), T_2: *Azospirillum* sps. 25 g/kg seeds + 5% seaweed, T_3: *Azospirillum* sps. 25 g/kg seeds + 10% seaweed, T_4: *Azospirillum* sps. 25 g/kg seeds + 15% seaweed, T_5: PSB 25 g/kg seeds + 5% seaweed, T_6 PSB 25 g/kg seeds + 10% seaweed, T_7: PSB 25 g/kg seeds + 15% seaweed T_8: *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 5% seaweed, T_9: *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 10% seaweed, T_{10}: *Azospirillum* sps., PSB: 25, 25 g/kg seeds + 15% seaweed. The details of treatment combinations are mentioned in table 1. The nutrients which were applied to all treatments are urea, single super phosphate (SSP), and muriate of potash (MOP) by the soil. For each plot, full doses of phosphorous and potassium were administered basal, half doses of nitrogen (urea) was also applied as basal dose, and the remaining half dose of N was top dressed at 30-35 DAS. The growth parameters were recorded from randomly selected five tagged plants in each treatment at intervals of 20,40,60,80 DAS and at harvest stage. A statistical analysis was performed, and the mean was compared at a 5% probability level of significance.

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

3. RESULTS AND DISCUSSION

3.1. Influence of biofertilizers and foliar application of seaweed on growth parameters

Influence of biofertilizers and foliar application of seaweed on growth parameters of sorghum are presented in Table 2.

3.1.1. Plant height

The findings resulted that the treatment with dual inoculation of *Azospirillum* sps. and PSB along with foliar spray of 10% seaweed at 30-50-70 DAS/ha recorded maximum plant height (164.07 cm). "Plant height grows as a result of increased biological activity of auxins and cytokinin's, which lengthen internodes and promote cell division" [5].

ANOVA Table 3.1.1. Plant height (cm) of sorghum 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	**9**	828.40	92.04	34.58	S	S
Replication	**2**	2.65	1.32	0.50		
Error	**18**	47.92	2.66			
TOTAL	**29**	878.96				

3.1.2. Number of leaves per plant

The results revealed that highest number of leaves per plant (12.47) was reported with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 10% seaweed at 30-50-70 DAS/ha which was superior over the treatments.

ANOVA Table 3.1.2. Number of leaves in 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	8.32	0.92	2.95	S	NS
Replication	2	1.60	0.80	2.55		
Error	18	5.65	0.31			
TOTAL	29	15.57				

3.1.3. Dry matter accumulation

The results recorded that significantly highest plant dry matter accumulation (116.59 g) was found with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 10% seaweed at 30-50-70 DAS/ha was higher over the treatments. The presence of biologically active cytokinin, which promotes cell division, boosts the physiological response of crop dry matter [11]. “Foliar application of sea weed sap also enhanced nutrient mobilization division and thereby resulted in dry matter production” [10]. It could be because of enhanced nitrogen and phosphorus availability, which promotes greater vegetative growth and result in larger sorghum seed and stover yields. Similar findings were reported in Singh *et al*., [8].

ANOVA Table 3.1.3. Dry matter accumulation (g) of sorghum 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	1390.65	154.52	127077.61	S	S
Replication	2	0.02	0.01	7.91		
Error	18	0.02	0.00			
TOTAL	29	1390.69				

3.1.4. Absolute growth rate

At 80-100 DAS, significantly highest absolute growth rate (1.21 g/plant/day) was observed by dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 10% seaweed at 30-50-70 DAS/ha which was superior over the treatments.

ANOVA Table 3.1.4. Absolute growth rate of sorghum (g/g/day) 80-100 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	0.48	0.05	533.15	S	S
Replication	2	0.00	0.00	2.53	NS	NS
Error	18	0.00	0.00			
TOTAL	29	0.48				

3.1.5. Crop Growth Rate

At 80-100 DAS, significantly highest crop growth rate (40.339 g/m^2/day) has been recorded with dual inoculation by *Azospirillum* sps. and phosphate solubilizing bacteria (PSB) along with foliar application of 10% seaweed at 30-50-70 DAS over control (only RDF). It might be due to better availability of nutrients during the crop growth period by the action of biofertilizers and seaweed [9], [11].

ANOVA Table 3.1.5. Crop growth rate of sorghum (g/m^2/day) 80-100 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	531.34	59.04	533.15	S	S
Replication	2	0.56	0.28	2.53	NS	NS
Error	18	1.99	0.11			
TOTAL	29	533.90				

3.1.6. Leaf Area (cm^2)

At 80 DAS, significantly highest Leaf area (332.33 cm^2) has been recorded with dual inoculation by *Azospirillum* sps. and phosphate solubilizing bacteria (PSB) along with foliar application of 10% seaweed at 30-50-70 DAS over control (only RDF).

ANOVA Table 3.1.6. Leaf area (cm^2) of sorghum 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	**9**	3283.63	364.85	48438.32	S	S
Replication	**2**	0.04	0.02	2.67	NS	NS
Error	**18**	0.14	0.01			
TOTAL	**29**	3283.81				

Table 3.1.7. Influence of biofertilizers and foliar application of seaweed on growth of sorghum

Treatment Combinations	Growth parameters (80DAS)					
	Plant height (cm)	No. of leaves per plant	Dry matter accumulation (g)	Absolute growth rate (g/plant/day) 80-100 DAS	Crop growth rate (g/m^2/day) 80-100 DAS	Leaf area (cm^2)
1. Control (Farmer's Practice)	130.47	10.87	65.27	0.760	25.322	293.36
2. *Azospirillum* sps. 25 g/kg seeds + 5% seaweed	127.20	11.33	81.35	1.049	34.967	302.36
3. *Azospirillum* sps. 25 g/kg seeds + 10% seaweed	138.21	11.20	81.64	1.084	36.139	310.37
4. *Azospirillum* sps. 25 g/kg seeds + 15% seaweed	138.92	11.73	81.37	1.110	36.983	311.47
5. PSB 25 g/kg seeds + 5% seaweed	139.17	11.40	82.69	1.132	37.728	313.56
6. PSB 25 g/kg seeds + 10% seaweed	139.72	11.13	82.58	1.139	37.967	315.52
7. PSB 25 g/kg seeds + 15% seaweed	135.93	12.13	81.55	1.185	39.500	316.38
8. *Azospirillum* sps. + PSB 25+25 g/kg seeds + 5% seaweed	142.61	11.87	90.33	1.196	39.878	325.38
9. *Azospirillum* sps. + PSB 25+25 g/kg seeds +10% seaweed	146.35	12.47	92.39	1.210	40.339	332.33
10. *Azospirillum* sps. + PSB 25+25 g/kg seeds + 15% seaweed	139.64	10.73	84.37	1.199	39.978	320.33
F test	S	S	S	S	S	S
S.Em (±)	0.94	0.32	0.02	0.006	0.192	0.05
S.Ed (±)	1.33	0.46	0.03	0.01	0.27	0.07
CD (P=0.05)	2.80	0.96	0.06	0.017	0.571	0.15

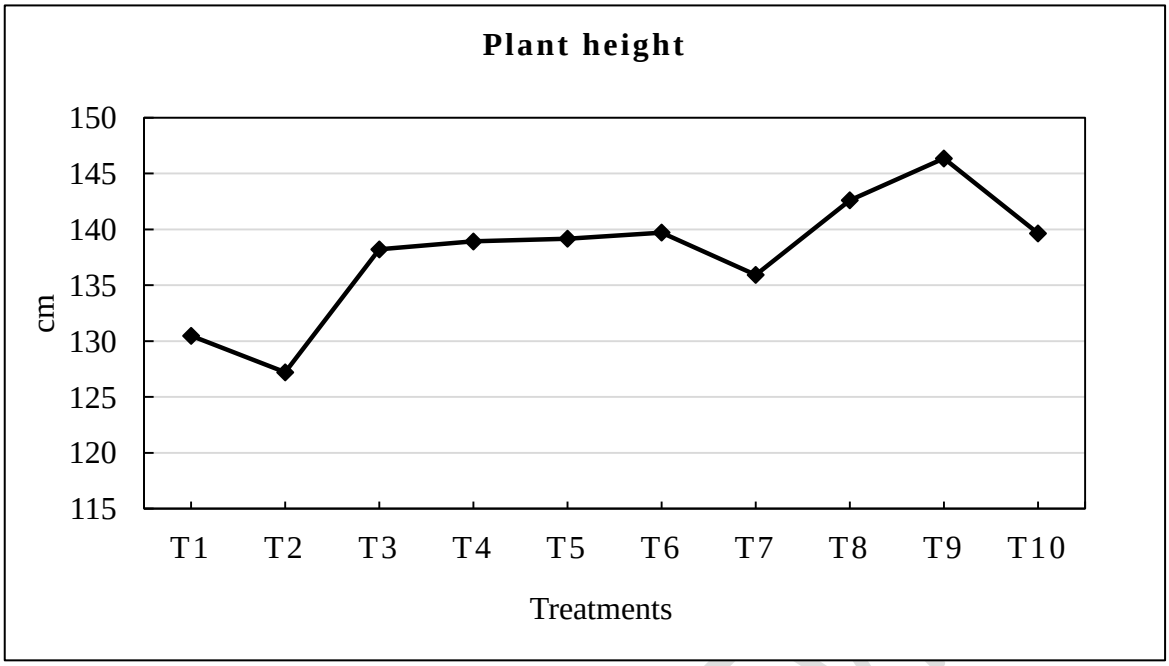

Fig. 1. Influence of biofertilizers and foliar application of seaweed on plant height of sorghum

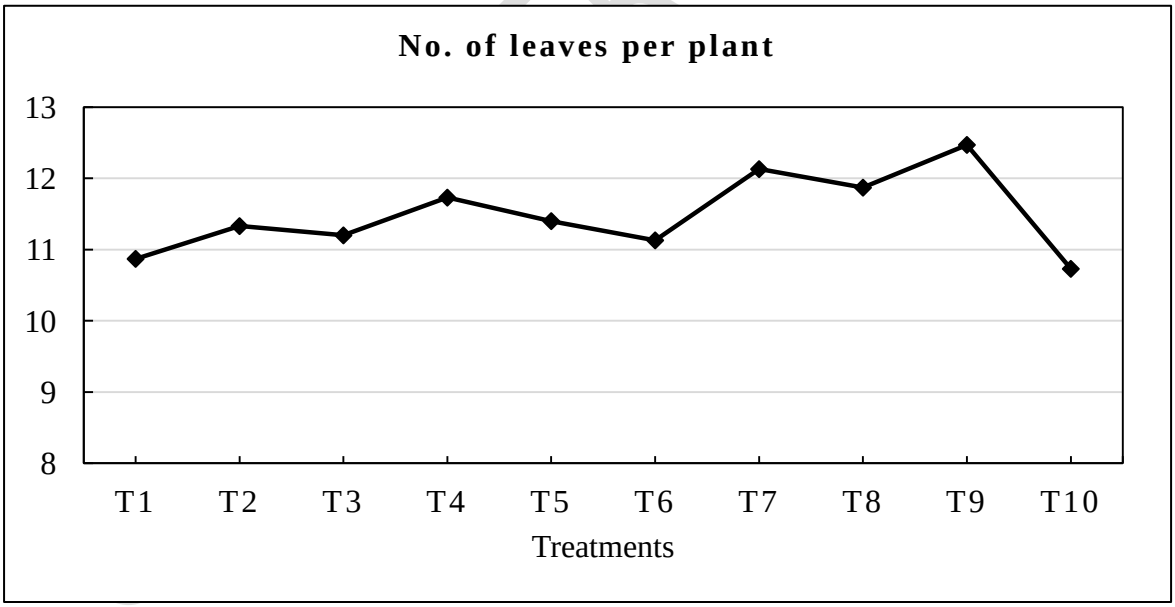

Fig. 2. Influence of biofertilizers and foliar application of seaweed on No. of leaves per plant of sorghum

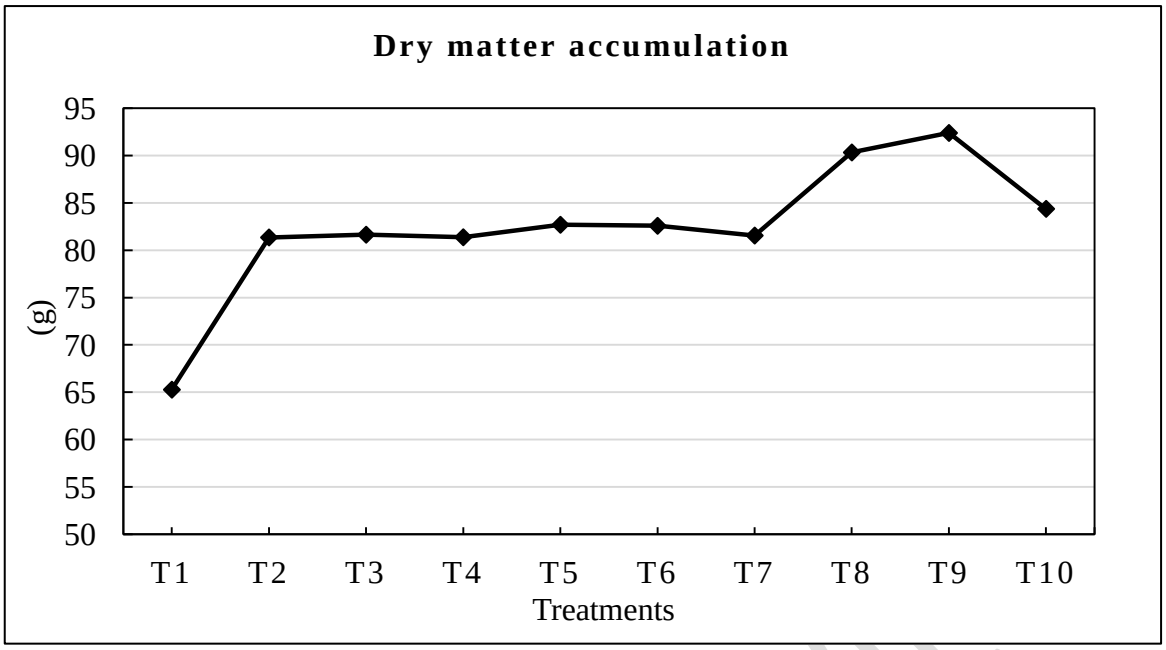

Fig. 3. Influence of biofertilizers and foliar application of seaweed on dry matter accumulation of sorghum

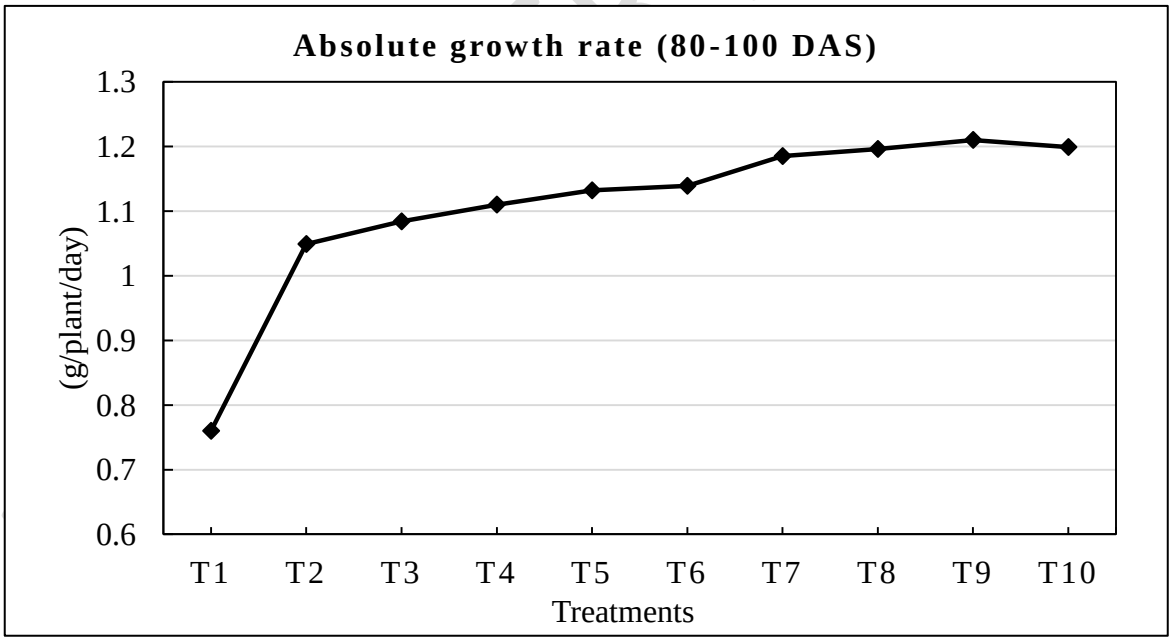

Fig. 4. Influence of biofertilizers and foliar application of seaweed on absolute growth rate of sorghum

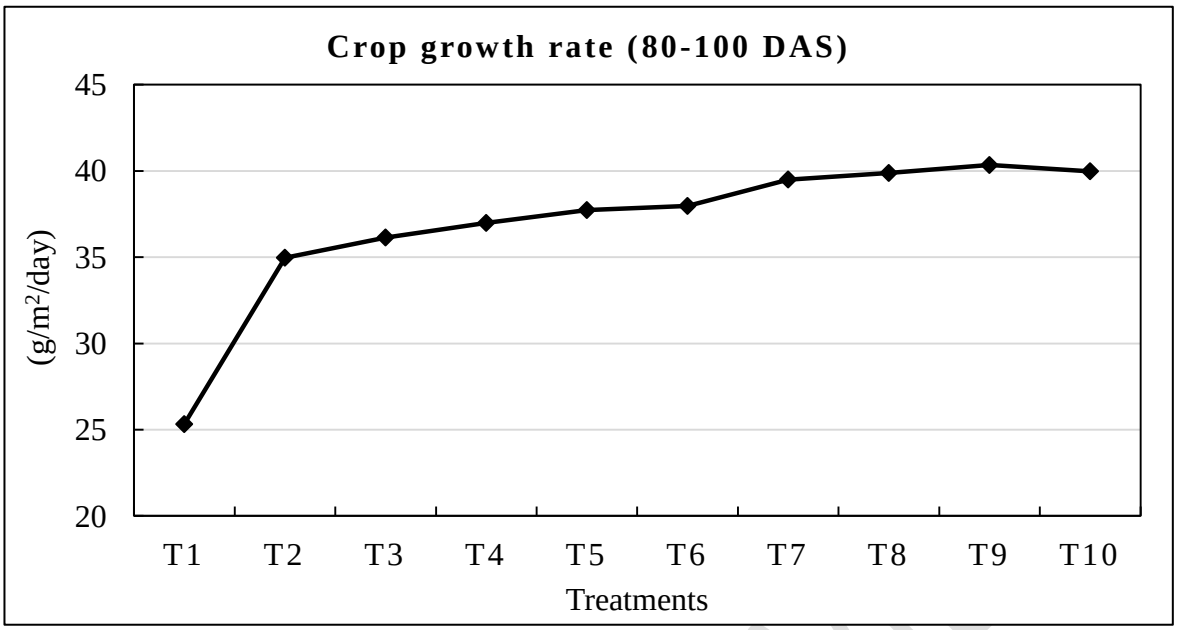

Fig. 5. Influence of biofertilizers and foliar application of seaweed on crop growth rate of sorghum

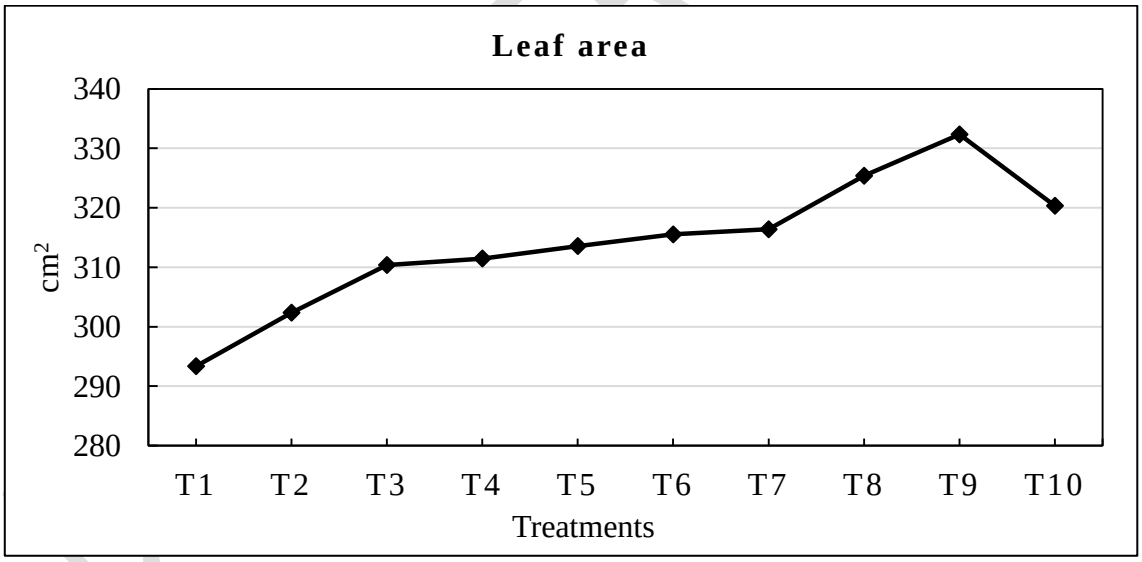

Fig. 6. Influence of biofertilizers and foliar application of seaweed on leaf area of sorghum

Conclusion

Finally, based on the results of this trail it can be proved that sorghum should be sown with dual inoculation of *Azospirillum* sps. and PSB along with of foliar spray of 10%

seaweed at 30-50-70 DAS/ha was recommended for getting higher growth parameters of sorghum.

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