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Influence of PSB Biofertilizer on Biomass Production in Maize and Soil Microbial Biomass Carbon

S. Vinod Babu[1*], S. Triveni[1], R. Subhash Reddy[1] and J. Sathyanarayana[2]

[1]Department of Agricultural Microbiology and Bioenergy, [2]Department of Entomology, College of Agriculture, Professor Jayashankar Telangana State Agriculture University, Rajendranagar, Telangana, India
**Corresponding author*

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A B S T R A C T

Maize is one of the most important cereal crops of the world and contributes to food security in most of the developing countries. In India, maize is emerging as third most important crop after rice and wheat in recent years. The efficient PSB isolates of 24 phospahte solubilizing bacteria isolated from Maize Research Station and College Farm, Rajendranagar, PJTSAU, Telangana, was used in this study. In this study Soil microbial biomass carbon and Maize plant biomass production of was recorded at different growth stages *viz.*, vegetative, flowering and harvesting stages of crop in response to different formulation of PSB and their combination. There was an increasing trend soil microbial biomass was noticed from vegetative to flowering stages and a gradual decrease was observed from flowering stage towards harvesting stage in all the treatments studied. However significant by higher soil biomass carbon was recorded in the treatment T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer at vegetative (102.06µg kg^{-1} of soil microbial biomass carbon and 5.10 g of Plant dry wt), flowering (140.33 µg kg^{-1} of soil microbial biomass carbon and 15.97 gof Plant dry wt) and at harvesting (121.73µg kg^{-1} of soil microbial biomass carbon and 32.14 g of Plant dry wt) respectively compared to all other treatments. The major outcome of this study was the Carrier + Liquid + Biofilmed PSB biofertilizer treated Maize (*Zea mays*) plants produces highest biomass than other treatments.

Introduction

In the soil, Phosphorus is one of the major plant nutrients that is least available. Phosphorus is essential for morphological, physiological and biochemical development of plants. It plays an important role in root development which in turn enhance plant growth. It is an essential nutrient for plants which is required synthesis of nucleosides, nucleotides, phospholipids etc. Nitrogen fixation and P solubilization (Zaidi *et al.*, 2006) production of antibiotics (Zahir *et al.*, 2004) are the principal mechanism for the PGPR.

Biofilms developed using a combination of two organisms with useful Plant Growth Promoting Rhizobacteria (PGPR) traits may provide a definite advantage. *Trichoderma-Bacillus* and *Trichoderm*a - *Pseudomonas* biofilms exhibited enhanced antifungal activity, ammonia, Indole Acetic Acid (IAA) and siderophore production. *Trichoderma-*

Azotobacter biofilm recorded the highest nitrogenase activity and 1-aminocyclopropane-1- carboxylic (ACC) deaminase activity. The synergism in terms of the PGP traits in the biofilms revealed their promise as superior PGP inoculants (Triveni *et al.*, 2013).

The present investigation involves the testing of commercial PSB inoculants of different formulation (carrier, liquid and biofilmed) with Maize crop.

Materials and Methods

A pot culture experiment was carried out in glass ware of the Dept. of Agricultural Microbiology and Bioenergy, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad.

The soil from the college farm was collected and used for the pot culture studies. Each pot was filled with 8 kgs red soil. Each pot measured 25 cm x 25 cm. The experiment was conducted by following Complete Randomized Block Design (CRD) with 8 treatments replicated thrice.

Details of the pot culture experiment are given below

Crop: Maize
Variety: DHM – 117
Season: Rabi – 2015
Treatments: 8
Replications: 3
Design: CRD (Complete Randomized Block Design)

Treatments

$T_{0:}$ RDF (240: 80: 80 @ kg/ ha)
$T_{1:}$ Carrier based PSB biofertilizer
$T_{2:}$ Liquid PSB biofertilizer
$T_{3:}$ Biofilmed PSB biofertilizer
$T_{4:}$ Carrier based PSB biofertilizer + Liquid PSB biofertilizer
$T_{5:}$ Carrier based PSB + Biofilmed PSB biofertilizer
$T_{6:}$ Liquid PSB biofertilizer + Biofilmed PSB biofertilizer
$T_{7:}$ Carrier + liquid + Biofilmed PSB biofertilizer

Estimation of soil microbial biomass carbon (30, 60, 90 DAS)

Microbial biomass carbon was estimated by the method of Nunan *et al.*, (1998), using aliquots of K_2SO_4 extracts through dichromate digestion. In chloroform fumigation extraction method, a direct measurement of carbon and other nutrients contained therein microbial biomass was carried. The soil samples were fumigated with chloroform and incubated for 24 h in dark at room temperature.

Later on the organic carbon in fumigated and non-fumigated samples thus extracted by mixing with 70 ml of 0.5M K_2SO_4 for half an hour and filtered. Then 5 ml of 0.2 M $K_2Cr_2O_7$, 10 ml of H_2SO_4 were added and after 10 min H_3PO_4 is added. To cool the solutions about 100 ml of distilled water was added.

MBC was calculated after back titration with 0.05 N Ferrous Ammonium Sulfate. The end point of the titration was determined by using the diphenylamine indicator. The MBC was calculated using the equation: Biomass C = 2.64 × CE where CE = (organic C from fumigated soil) - (organic C from unfumigated soil). MBC was expressed as µg C kg^{-1} soil.

Plant biomass attributing parameters

Plant height, Fresh weight and Dry weight were recorded at different intervals. Biometric observations were recorded on three competitive plants selected at random from

each treatment and mean per plant was worked out.

Plant height

The plant height was measured with meter scale from the cotyledonary node up to the growing tip of the stem at 30, 60 and 90 DAS.

Mean of three values were worked out from three plants, which were selected at random in each treatment and expressed in centimetres.

Fresh and dry matter accumulation

Three plants per treatment were collected from the sampling rows selected next to border rows were harvested and fresh weight recorded. For dry weight the plant samples were dried at 60 - 65^0 C in hot air oven till constant weights were obtained and weight was recorded.

Results and Discussion

Soil microbial biomass carbon

The soil microbial biomass carbon at different growth stages are presented in Table 1.

At 30 DAS, highest soil microbial biomass carbon was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer(102.06µg kg^{-1}) &lowest activity was in T_1 - Carrier based PSB biofertilizer (63.50µg kg^{-1}).
At 60 DAS maximum soil microbial biomass carbon was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (140.33 µg kg^{-1}). The lowest activity was recorded in T_1 - Carrier based PSB biofertilizer *i.e.,* 95.50 µg kg^{-1}.

At 90 DAS maximum soil microbial biomass carbon was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (121.73 µg kg^{-1}). The lowest activity was recorded in T_1- Carrier based PSB biofertilizer(81.40 µg kg^{-1}).At flowering stage (60 DAS) there was a significant increase in the microbial biomass carbon and it decreased towards the harvesting stage (90 DAS). These results are in agreement with findings of Simek *et al.,* (1999).

Influence of different types of PSB biofertilizers on plant height, fresh weight and dry weight at different intervals of crop growth stage

Plant height (cm)

Plant height of Maize at 30, 60 and 90 days after sowing differed significantly as with application of different phosphate solubilizing biofertilizers formulations are presented in Table 2.

Plant height at 30 DAS was highest in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (81.36 cm). Least was in the T_1 - Carrier based PSB biofertilizer (64.20 cm).

At 60 DAS the highest plant height was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (162.14 cm). Lowest height was recorded in the T_1 - Carrier based PSB biofertilizer (136.72 cm).

At 90 DAS the highest plant height was observed in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (204.23 cm) and lowest in theT_4 - Carrier based PSB biofertilizer + Liquid PSB biofertilizer (176.67 cm).

Significantly highest plant height at 30 to 90 DAS in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer was might be due to nutrients supply throughout its growth stage. Leaching loss of nutrients might have been minimised by the use of biofilmed biofertilizers.

Table.1 Estimation of soil microbial biomass carbonat 30, 60, 90 DAS

Treatments	Soil microbial biomass carbon (µg kg^{-1} of soil)		
	30 DAS	**60 DAS**	**90 DAS**
Control	59.23	87.00	68.66
T_1	63.50	95.50	81.40
T_2	66.50	97.86	84.73
T_3	76.20	112.26	98.33
T_4	70.20	101.66	95.50
T_5	72.83	117.66	101.93
T_6	79.80	124.50	109.13
T_7	102.06	140.33	121.73
CD	**2.623**	**1.874**	**3.311**
SE(d)	**1.227**	**0.876**	**1.548**
SE(m)	**0.867**	**0.620**	**1.095**
CV	**2.036**	**0.979**	**1.992**

Treatments:

Control: RDF.
T_1: Carrier based PSB biofertilizer.
T_2: Liquid PSB biofertilizer.
T_3: Biofilmed PSB biofertilizer.
T_4: Carrier based PSB biofertilizer+ Liquid PSB biofertilizer.
T_5: Carrier based PSB biofertilizer + Biofilmed PSB biofertilizer.
T_6: Liquid PSB biofertilizer + Biofilmed PSB biofertilizer.
T_7: Carrier + Liquid + Biofilmed PSB biofertilizer.

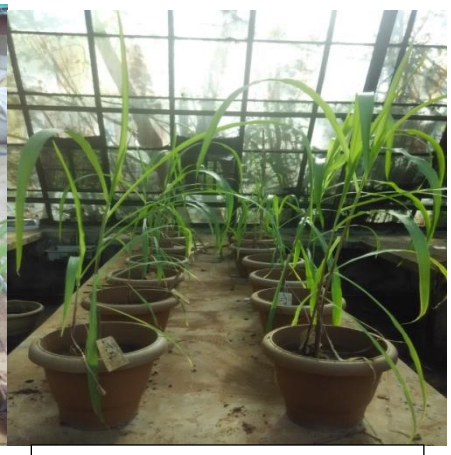
Table.2 Effect of different types of Phosphate solubilizing biofertilizers on Plant height, Fresh weight (g) and Dry weight (g) at different stages of plant growth period

Treatments	Plant height (cm)			Fresh weight (g)			Dry weight (g)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Control	61.88	130.43	170.59	7.47	19.34	50.11	1.73	8.34	20.32
T_1	64.43	136.72	177.21	8.57	21.43	52.43	2.14	9.13	24.49
T_2	68.36	138.64	179.87	9.43	20.63	50.14	2.31	9.27	22.16
T_3	72.37	142.71	181.45	10.63	24.26	64.31	3.13	11.18	30.37
T_4	70.26	140.40	176.67	10.43	22.86	58.39	3.11	10.43	29.52
T_5	74.49	153.62	198.98	12.14	26.28	64.48	4.05	12.70	30.84
T_6	76.81	149.34	193.45	13.73	29.64	68.34	4.66	13.89	31.70
T_7	80.92	162.14	204.23	15.82	32.14	69.14	5.10	15.97	32.14
CD	**1.312**	**1.617**	**1.442**	**2.142**	**1.914**	**2.121**	**1.235**	**1.842**	**2.134**
SE(d)	**0.648**	**0.893**	**0.713**	**1.236**	**0.347**	**1.210**	**0.451**	**0.431**	**1.192**
SE(m)	**0.465**	**0.641**	**0.351**	**0.863**	**0.142**	**0.643**	**0.216**	**0.121**	**0.433**
CV	**1.635**	**1.914**	**1.432**	**1.936**	**1.342**	**1.893**	**1.268**	**1.124**	**1.929**

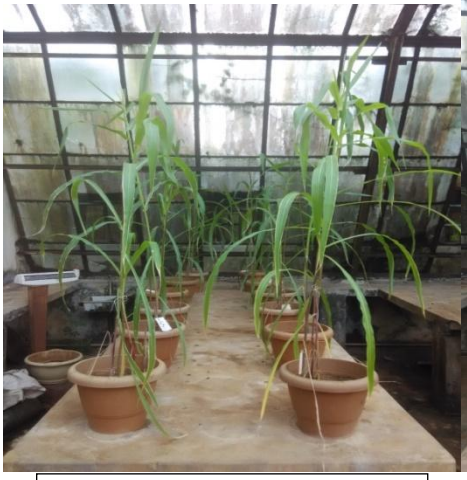
Treatments: Control: RDF, T_1: Carrier based PSB biofertilizer, T_2: Liquid PSB biofertilizer, T_3: Biofilmed PSB biofertilizer, T_4: Carrier based PSB biofertilizer + Liquid PSB biofertilizer, T_5: Carrier based PSB biofertilizer + Biofilmed PSB biofertilizer, $T_{6:}$ Liquid PSB biofertilizer + Biofilmed PSB biofertilizer, T_7: Carrier + Liquid + Biofilmed PSB biofertilizer.

Plate.1 Maize crop at different growth stages

30 days after sowing



60 days after sowing



90 days after sowing

Control and biofilmed biofertilizer treated plant

Plant biomass

Total fresh weight (g)

The plant fresh weight, at 30 DAS was highest in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (15.82 g).Lowest height was found in the T_1 - Carrier based PSB biofertilizer (8.56 g).

At 60 DAS the highest plant fresh weight was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (32.14 g) and least in the T_2 - Liquid PSB biofertilizer (20.63 g). At 90 DAS the highest plant fresh weight was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (69.14 g) and least in the T_1 - Carrier based PSB biofertilizer (8.56 g) depicted in Table 2.

Total dry weight (g)

At 30 DAS, plant dry weight was highest in T_7 - Carrier + Liquid + Biofilmed PSB

biofertilizer (5.10 g).Lowest height was recorded in the T_1 - Carrier based PSB biofertilizer (2.14 g).

At 60 DAS the highest plant dry weight was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (15.97 g).Lowest weight was recorded in the T_1 - Carrier based PSB biofertilizer (9.13 g).

At 90 DAS the highest plant dry weight was recorded in T_7 - Carrier + Liquid + Biofilmed PSB biofertilizer (32.14 g). Lowest weight was recorded in the T_2 - Liquid PSB biofertilizer (22.16 g) given in Table 2.

At 90 DAS more dry matter production (32.14 g) might be due to maximum leaf area which contributed to more photosynthesis and thus yielded maximum total dry matter production at harvest. The increase in the total dry matter production might be due to the supply of phosphorus by phosphate solubilizing bacteria. Biofilm of *Aspergillus sps* and phosphate solubilizing bacteria improved the plant biomass production.

Based on the results obtained in the present study indicated that the biofilmed biofertilizers produced more soil microbial biomass carbo and plant biomass compared to individual cultures and control. The results of this study clearly indicates the possibility of improvement of quality of biofertilizers by use of biofilms.

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