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

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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 phosphater 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 T7 - 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 g of 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.

Keywords
Maize, Soil biomass carbon, Plant biomass and Biofilm.

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 Trichoderma - 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

T₀: RDF (240: 80: 80 @ kg/ ha)

T₁: Carrier based PSB biofertilizer

T₂: Liquid PSB biofertilizer

T₃: Biofilmed PSB biofertilizer

T₄: Carrier based PSB biofertilizer + Liquid PSB biofertilizer

T₅: Carrier based PSB biofertilizer + Biofilmed PSB biofertilizer

T₆: Liquid PSB biofertilizer + Biofilmed PSB biofertilizer

T₇: 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 K₂SO₄ 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 K₂SO₄ for half an hour and filtered. Then 5 ml of 0.2 M K₂Cr₂O₇, 10 ml of H₂SO₄ were added and after 10 min H₃PO₄ 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°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 T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (102.06 µg kg⁻¹) & lowest activity was in T1 - Carrier based PSB biofertilizer (63.50 µg kg⁻¹).

At 60 DAS maximum soil microbial biomass carbon was recorded in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (140.33 µg kg⁻¹). The lowest activity was recorded in T1 - Carrier based PSB biofertilizer i.e., 95.50 µg kg⁻¹.

At 90 DAS maximum soil microbial biomass carbon was recorded in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (121.73 µg kg⁻¹). The lowest activity was recorded in T1 - 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.

At 60 DAS the highest plant height was recorded in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (162.14 cm). Lowest height was recorded in the T4 - Carrier based PSB biofertilizer + Liquid PSB biofertilizer (176.67 cm).

At 90 DAS the highest plant height was observed in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (204.23 cm) and lowest in the T4 - Carrier based PSB biofertilizer + Liquid PSB biofertilizer (176.67 cm).

Significantly highest plant height at 30 to 90 DAS in T7 - 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 carbon at 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  |
| T₁         | 63.50  | 95.50  | 81.40  |
| T₂         | 66.50  | 97.86  | 84.73  |
| T₃         | 76.20  | 112.26 | 98.33  |
| T₄         | 70.20  | 101.66 | 95.50  |
| T₅         | 72.83  | 117.66 | 101.93 |
| T₆         | 79.80  | 124.50 | 109.13 |
| T₇         | 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.
T₁: Carrier based PSB biofertilizer.
T₂: Liquid PSB biofertilizer.
T₃: Biofilmed PSB biofertilizer.
T₄: Carrier based PSB biofertilizer + Liquid PSB biofertilizer.
T₅: Carrier based PSB biofertilizer + Biofilmed PSB biofertilizer.
T₆: Liquid PSB biofertilizer + Biofilmed PSB biofertilizer.
T₇: 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<sub>1</sub> | 64.43   | 136.72  | 177.21  | 8.57    | 21.43   | 52.43   | 2.14    | 9.13    | 24.49   |
| T<sub>2</sub> | 68.36   | 138.64  | 179.87  | 9.43    | 20.63   | 50.14   | 2.31    | 9.27    | 22.16   |
| T<sub>3</sub> | 72.37   | 142.71  | 181.45  | 10.63   | 24.26   | 64.31   | 3.13    | 11.18   | 30.37   |
| T<sub>4</sub> | 70.26   | 140.40  | 176.67  | 10.43   | 22.86   | 58.39   | 3.11    | 10.43   | 29.52   |
| T<sub>5</sub> | 74.49   | 153.62  | 198.98  | 12.14   | 26.28   | 64.48   | 4.05    | 12.70   | 30.84   |
| T<sub>6</sub> | 76.81   | 149.34  | 193.45  | 13.73   | 29.64   | 68.34   | 4.66    | 13.89   | 31.70   |
| T<sub>7</sub> | 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<sub>1</sub>: Carrier based PSB biofertilizer, T<sub>2</sub>: Liquid PSB biofertilizer, T<sub>3</sub>: Biofilmed PSB biofertilizer, T<sub>4</sub>: Carrier based PSB biofertilizer + Liquid PSB biofertilizer, T<sub>5</sub>: Carrier based PSB biofertilizer + Biofilmed PSB biofertilizer, T<sub>6</sub>: Liquid PSB biofertilizer + Biofilmed PSB biofertilizer, T<sub>7</sub>: Carrier + Liquid + Biofilmed PSB biofertilizer.
Plate.1 Maize crop at different growth stages

Plant biomass

Total fresh weight (g)

The plant fresh weight, at 30 DAS was highest in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (15.82 g). Lowest height was found in the T1 - Carrier based PSB biofertilizer (8.56 g).

At 60 DAS the highest plant fresh weight was recorded in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (32.14 g) and least in the T2 - Liquid PSB biofertilizer (20.63 g). At 90 DAS the highest plant fresh weight was recorded in T7 - Carrier + Liquid + Biofilmed PSB biofertilizer (69.14 g) and least in the T1 - Carrier based PSB biofertilizer (8.56 g) depicted in Table 2.

Total dry weight (g)

At 30 DAS, plant dry weight was highest in T7 - Carrier + Liquid + Biofilmed PSB
biofertilizer (5.10 g). Lowest height was recorded in the T₁ - Carrier based PSB biofertilizer (2.14 g).

At 60 DAS the highest plant dry weight was recorded in T₇ - Carrier + Liquid + Biofilmed PSB biofertilizer (15.97 g). Lowest weight was recorded in the T₁ - Carrier based PSB biofertilizer (9.13 g).

At 90 DAS the highest plant dry weight was recorded in T₇ - Carrier + Liquid + Biofilmed PSB biofertilizer (32.14 g). Lowest weight was recorded in the T₂ - 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 carbon 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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