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Research Article

Effect of phosphate solubilizing bacteria and compost mixture on growth parameters in Paddy (*Oryza sativa* L.)

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Abstract

Phosphorus is one of the major essential macronutrients limiting plant growth owing to its low bioavailability in soils. The biofertilizer effect of phosphate solubilizing bacteria on growth parameters of *Oryza sativa* was studied in a field experiment. Maximum plant height was recorded during the harvest and highest plant height (121.98 cm) was recorded in the treatment T_8 (75% NPK + CM+ BS + BM + EA). Maximum dry matter production was recorded during the harvest and more dry matter production (8.12 g $plant^{-1}$) was recorded in the treatment T_8. Maximum Leaf area index was recorded (6.42 cm) was recorded in the treatment T_8.

Keywords: Leaf area index, Dry matter production, Plant height and Paddy.

Introduction

Phosphorus (P) is as an essential mineral nutrient for plant growth and development is the world's second highest chemical input in agriculture. Soluble P is often the limiting mineral nutrient for biomass production in agricultural ecosystems as well (Hameeda *et al*., 2006). Plants utilize fewer amounts of phosphate fertilizers that are applied and the rest is rapidly converted into insoluble complexes in the soil. So, this phenomenon encourages farmers to frequent application of phosphate fertilizers. Modern agriculture is severely modifying and polluting the natural environment, due to the widespread application of chemical fertilizers, herbicides and pesticides. Therefore, thinking about valid alternative for chemical fertilizers is too necessary. Phosphate solubilizing bacteria (PSB) are used as biofertilizer since 1950's (Kudashev, 1956; Krasilinikov, 1957; Saranraj *et al*., 2013; Sivasakthi *et al*., 2013). These microorganisms secrete different types of organic acids e.g., carboxylic acid (Deubel and Merbach, 2005;) thus lowering the pH in the rhizosphere (He and Zhu, 1988) and consequently dissociate the bound forms of phosphate like $Ca_3(PO_4)_2$ in calcareous soils.
Use of these microorganisms as environment friendly biofertilizer helps to reduce the much expensive phosphatic fertilizers. Phosphorus biofertilizers could help increase the availability of accumulated phosphate (by solubilization), efficiency of biological nitrogen fixation and increase the availability of Fe, Zn etc., through production of plant growth promoting substances (Kucey *et al*., 1989; Kanchana *et al*., 2013). Trials with PSB indicated yield increases in rice (Tiwari *et al*., 1989; Usharani *et al*., 2013), maize (Pal, 1999) and other cereals (Ozturk *et al*., 2003; Afzal *et al*., 2005; Sivasakthi *et al*., 2014; Usharani *et al*., 2014; Kanchana *et al*., 2014).

Materials and Methods

Treatment schedule

T_1 – 100% NPK
T_2 – 75% NPK + CM + *Bacillus subtilis* (BS)

T_3 - 75% NPK + CM + *Bacillus megaterium*(BM)
T_4 -75% NPK + CM + *Enterobacter asburiae* EA)
T_5 - 75% NPK + CM + BS + BM
T_6 - 75% NPK + CM + BM + EA
T_7 - 75% NPK + CM + EA + BS
T_8 - 75% CM + BS + BM + EA
T_9 – Control

Determination of growth parameters

Effect of plant height

The height of the plants in each treatment was measured at 30th day after transplantation (DAT). The mean value of the plants from 3 replications was recorded.

Dry matter production

Plant samples were taken at three stages of crop growth viz., maximum tillering, flowering and harvest. The plant samples were dried in hot air oven at 80^{o}C for 48 to 72 hours. The oven dry weight was recorded and Dry matter production was calculated.

Leaf area index

Leaf area index at flowering was calculated without removing the leaves by using the formula given by Yoshida *et al.* (1976).

LA = KxWxL Where,
LA = leaf area in cm
K = a constant factor (0.75)
W = maximum width of the 3rd leaf from the top (in cm)
L = length of the 3 leaf from the top (in cm)

The leaf area of the middle tiller of the sample hill was calculated and was multiplied by the number of tillers in each hill. The: total leaf area arrived by multiplying the leaf area hill^{-1} with number of hill m^{-1} The LAI was computed using the formula given below.

$$LAI = \frac{\text{Total leaf area per unit area (cm}^2\text{)}}{\text{Unit land area (cm}^2\text{)}}$$

Results and Discussion

The field experiment was conducted to study the effect sugar mill waste (pressmud) by phosphate solubilizing bacteria (*Bacillus subtilis, Bacillus megaterium* and *Enterobacter asburiae)* growth parameters of paddy (*Oryza sativa* L.) var BPT- 5804 grown rhizosphere soil. Phosphate solubilizing bacteria triple inoculants recorded maximum plant height. The observations recorded on plant height at 30 DAS, 60 DAS and at harvest are presented in Table – 1. Among the various treatments tested, the highest plant height was recorded in treatment T_8 (75% NPK + CM +BS+BM+EA) (121 .98 cm) and T_1 – 100% NPK (121.52 cm) were on par with each other. The minimum plant height was recorded in T_9 (Control) (89.30 cm).

The effect of sugar mill waste, Compost mixture (Pressmud + *Bacillus subtilis* + *Bacillus megaterium* + *Enterobacter asburiae*) chlorophyll content of paddy var BPT - 5804 (*Oryza sativa* L.) was investigated and the results were furnished in Table – 2. Among the nine treatments tested, the dry matter production was maximum in treatment T_8 (75% NPK + CM + BS + BM + EA) (8.12 t ha^{-1}) and T_1 – 100% NPK (7.93 t ha^{-1}) was on par with each other. The minimum plant height was recorded in T_9 (Control) (4.00 t ha^{-1}).

The effect of sugar mill waste, Compost mixture (Pressmud + *Bacillus subtilis* + *Bacillus megaterium* + *Enterobacter asburiae*) Leaf area index at flowering of paddy var BPT - 5804 (*Oryza sativa* L.) was investigated and the results were furnished in Table – 3. Among the nine treatments tested, the Leaf area index at flowering was maximum in treatment T_8 (75% NPK + CM+BS+BM+EA) (6.42 cm) and T_1 – 100% NPK (6.02cm) was on par with each other. The minimum plant height was recorded in T_9 (Control) (3.98 cm).

Enhancement of seedling growth due to seed treatment with phosphate solubilizing bacteria like *B. subtilis* and *B. megaterium* may be due to release of plant growth promoting substances. Plant growth promoting microbes are an important contributor to biofertilization of agricultural crops. Production of growth regulators by phosphate solubilizing bacteria has been studied by Ponmurugan and Gopi (2006).There is increasing evidence that phosphobacteria improve plant growth due to biosynthesis of plant growth substances rather than their action in releasing available phosphorus. Chaykovskaya *et al*. (2001) reported that treatment

Table – 1: Plant height of paddy (*Oryza sativa L.*) cv –BPT 5804

Treatments	Plant height (cm)		
	30 DAS	60 DAS	Harvest
T_1 – 100% NPK	55.37	82.02	121.52
T_2 – 75% NPK + CM + *Bacillus subtilis* (BS)	50.12	72.60	110.20
T_3 - 75% NPK + CM + *Bacillus megaterium* (BM)	50.83	73.99	112.86
T_4 -75% NPK + CM + *Enterobacter asburiae (*EA)	49.93	70.02	109.07
T_5 - 75% NPK + CM+BS+BM	54.81	78.12	119.83
T_6 - 75% NPK + CM+BM+EA	53.78	76.91	119.71
T_7 - 75% NPK + CM+EA+BS	52.91	75.80	118.36
T_8 - 75% + CM+BS+BM+EA	56.13	82.70	121.98
T_9 - Control	27.80	50.55	89.30
SE_D	0.41	0.35	0.24
CD (P=0.05)	0.83	0.71	0.48

Table – 2: Dry matter production of Paddy (*Oryza sativa L.*) var BPT 5804

Treatments	Dry matter production (t ha^{-1})
T_1 – 100% NPK	7.93
T_2 – 75% NPK + CM + *Bacillus subtilis* (BS)	6.43
T_3 - 75% NPK + CM + *Bacillus megaterium* (BM)	6.93
T_4 -75% NPK + CM + *Enterobacter asburiae (*EA)	6.00
T_5 - 75% NPK + CM+BS+BM	7.68
T_6 - 75% NPK + CM+BM+EA	7.45
T_7 - 75% NPK + CM+EA+BS	7.12
T_8 - 75%CM+BS+BM+EA	8.12
T_9 - Control	4.00
SE_D	0.51
CD (P=0.05)	1.03

Table – 3: Leaf area index at flowering (*Oryza sativa L.*) cv –BPT 5804

Treatments	Leaf area index at flowering (cm)
T_1 – 100% NPK	6.02
T_2 – 75% NPK + CM + *Bacillus subtilis* (BS)	5.00
T_3 - 75% NPK + CM + *Bacillus megaterium* (BM)	5.12
T_4 -75% NPK + CM + *Enterobacter asburiae (*EA)	4.89
T_5 - 75% NPK + CM+BS+BM	5.98
T_6 - 75% NPK + CM+BM+EA	5.77
T_7 - 75% NPK + CM+EA+BS	5.32
T_8 - 75%CM+BS+BM+EA	6.42
T_9 - Control	3.98
SE_D	0.4
CD (P=0.05)	0.8

with phosphate solubilizing bacteria resulted in increased yield of pea and barley. Several results suggest that phosphate-solubilizing bacteria have the ability to solubilize phosphate thereby increasing its availability to plants. Goenadi *et al*. (2000) suggested that the inoculation of PSB could enhance the maximum growth as well as result increased productivity. Among the PSB, will be more effective in increasing growth with inoculation of PSB will give better results as compared to control (Kanchana *et al*., 2014). Hence, use of these phosphate-solubilizing bacteria, as biofertilizer should be promoted (Sivasakthivelan and Saranraj, 2013; Kanchana *et al*., 2013; Usharani *et al*., 2014).

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