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Phosphate solubilising inoculants on (Jump start) growth parameters of rice (*Oryza sativa* L.)

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Abstract

Phosphorus plays a significant role in several physiological and biochemical activities in plants. Phosphorus in soils is immobilized due to formation of insoluble complexes such as iron and aluminium hydrous oxides and calcium carbonate. Phosphate-solubilizing microorganisms (PSM) play an important role in insoluble phosphates into soluble forms involves processes of acidulation, ion chelation and exchange reactions. Present study, a field experiment was carried out to study the Growth parameters of phosphate solubilising inoculants (JumpStart) on rice variety CO 47 in rice crop. The present study revealed that the treatment P_3S_3 (100% P + JumpStart 10E5) was recorded increased Seedling Growth will be increase in P_3S_3 treatment. The Plant Height will be increased at grain filling (111.67 cm), Root/ Shoot ratio (0.494 mg g^{-1}) and Root Volume will be increased at Active tillering and 50% flowering stage. The uptake of phosphorus by plants was found higher in P_3S_3 treatment observed at all stages of crop growth. At 50% flowering stage, phosphorus (69.26 kg ha^{-1}), uptake were observed higher in P_3S_3 treatment than control. This might be due to the significant increment of major Growth Parameters such as Root and Shoot ratio by the application of 100% recommended phosphorus with seed treatment of JumpStart 10E5.

Keywords: Phosphorus, rice, growth parameters

Introduction

Phosphorus is an important nutrient required by rice (Kim *et al*., 1998) [13] and it has a defined role in part of the plants, Meiosis, Phospholipids and reproductive parts, metabolisms such as root development, photosynthesis, nutrient transport within the plant, (Rasipour and Asgharzadeh, 2007) [20]. The judicious and proper use of phosphorous in rice markedly increases the yield and quality of rice. Without adequate supply of plant with phosphorous, plant cannot attain its maximum yield. In the world low level of P is one of the major constraints for rice production. This is particularly apparent under upland conditions commonly characterized by poorly fertile, erodible, badly leached, highly acidic, and P-fixing soils, normally with little or no fertilizer applied (IRRI, 1997) [11]. P deficiency is identified as under lowland conditions it's a main factor for limiting the performance of modern rice varieties to approach their optimum yields. P deficiency quick remedy for rice field application of P fertilizers. However, inorganic fertilizers are not always available for rice farmers. Besides, some rice soils having low level of P can also fix it into a highly less soluble mineral. Dobermann *et al*., (1998) [4] resulted that more than 90% of the P fertilizer are not easily available to plants. The microorganisms perform an important role in agriculture by supplying nutrients to plants and reduce the demand of chemical fertilizers (Cakmakci *et al*., 2006) [2].

The use of P solubilizing microorganisms improves the soil fertility and increase the crop production to fulfil the requirement. *Penicillium bilaii* (a phosphorus solubilising fungus) is a newly isolated soil fungus that has profound effect on solubilisation of phosphorus. The efficacy of *Penicillium bilaii* has been test verified in various crops such as wheat, canola, chick pea, mustard and lentil elsewhere. However, the usefulness of *Penicillium bilaii* has not been tested in rice crop under machine transplanting system. The present study was conducted at field level to evaluate the performance of different inoculation of *Penicillium bilaii* in combination with three levels of phosphatic fertilizer on rice crop.

Materials and Methods

The Present investigation was carried out in the field no. H7a of Department of Rice, TNAU, Coimbatore during Kharif season of 2015. Rice variety CO 47 seed material collected from Department of Rice. Before sowing, three bags (1 kg each) of rice seeds were soaked for 24 hours. Seeds are treated with three different population of Phosphate solubilising inoculants – *Penicillium bilaii* (Jump Start) at the rate of 160 mg per Kg of seeds and 6 ml of water was added and wait for one minute as per the treatments and compared with the recommended seed treatment of Azophos at the rate of 20 g kg^{-1} of seeds and control (No seed treatment). The experiment was conducted at field condition.

The field experiment was laid out in split plot design with three replications. The treatments are as follows three main plot of three different P levels P_1- 0% (0 kg P ha^{-1}), P_2- 50% P (25 kg P ha^{-1}) and P_3-100%P (50 kg P ha^{-1}) (Recommended dose). Sub plot of five different seed treatments S_1- No Seed Treatment, S_2- JumpStart 10E4 (0.00967 mg kg^{-1} of seeds), S_3-JumpStart 10E5 (0.0967 mg $kg^{-1}$of seeds), S_4- JumpStart 10E6 (9.667 mg kg^{-1} of seeds) and S_5- Azophos at the 20g kg^{-1} of seeds. Five plants were selected at different growth stages for recording observation.

Results and Discussion

Seedling Growth Parameters

Seedling parameters i.e., root length, shoot length, root volume, number of roots, root shoot ratio, dry weight of seedling and vigour index acid were observed with different seed inoculations of *Pencillium bilaii* in our study (Table.1). All the parameters were increased with higher P levels and *Pencillium bilaii* (JumpStart 10E5). *Pencillium bilaii* released maximum amount of Pi and produced highest amount of IAA and GA results in increase in all parameters. Reported increased root length, shoot length and vigor index in maize when treated with bacterial strains. However, this study identifies the effects of *P. bilaii* on gross root morphology (i.e., root length and specific root length) under field conditions in rice crop. In contrary, specific root length of rice seedling was higher in P_3S_3, in line with the findings of Molla *et al* (2001) that seed treatment with co-inoculation of *Azospirillum* and *Bradyrhizobium* increase the SRL of soybean.

The influence of seed inoculants on seedling growth parameters like Shoot length S_3 (18.4 cm), Root length S_3 (14.2 cm), Root Volume S_3 (20.0 cc), No of roots seedling S_3 (18.0), Root/ Shoot ratio S_3 (0.92), Total Dry Weight S_3 (0.37 mg), Specific Root Length (401.4), Vigour Index (7.40), are presented in (Table.1) and found to be influenced by different seed inoculants. Among the different seed inoculants, (*Penicillium bilaii*) recorded higher values followed by S_2, S_4, S_5 and S_1.

Plant height

Plant height is considered as an important trait related to growth and development of a plant. The crop length was significantly increased at different crop stages when the seed was inoculated with *Pencillium bilaii* (JumpStart), a phosphours solubilizing fungus. 100% P fertilizer in combination with S_3 (JumpStart 10E5) have recorded increase in plant height of 20.95% at grain filling stage compared to control. The increase in plant height might be due to the increase activity of meristematic cells when phosphorus application is increased. Increase in shoot and root length may also be attributed to the production of plant growth promoting substances like IAA, GA and cytokine like substances by solubilizing microorganism. Increased cell elongation and multiplication due to enhanced nutrient uptake by plants following inoculation of P solubilizing microorganisms might have caused the increase in plant height. Richa *et al.* (2007) reported positive correlation with phosphorus and plant height. The co-inoculation of *Azospirillum* and PSB significantly increased the shoot height of foxtail millet over the control. In contrary, Mehrvarz (2008) [15] reported that there is no effect of chemical fertilizer and phosphorus soluble microorganism in plant height.

Root parameters

Root characteristics such as root/shoot ratio and root volume, of rice plant at different growth stage had revealed the effect of different P levels and seed inoculation. Mehrvarz *et al.* (2008) [15] reported that phosphorus solubilizing bacteria increase root morphological characters like root length, and root volume in aerobic rice plants. On the present study among the different treatments, P_3S_3 (100% P + JumpStart 10E5) recorded large influence on root characteristics, which may be due to interaction effect of *Penicillium bilaii* with phosphorus levels. In this study related to maximum root volume was reported in P_3S_3 over control treatment (Fig.1). These results are in line with the findings rice in chickpea. The neutral or negative response on root-hair frequency with increasing P concentration reported in spinach, rape, tomato and Arabidopsis. These result are supported with the findings. Showed that P starvation, rather than its provision, increased root to shoot dry weight ratios in corn *(Zea mays* L.) found that root to shoot ratio decreased with increasing P fertilization levels in celery. Treatment P_1S_1 (0.706%) recorded higher root shoot ratio at Active tillering stage (Table 3). Higher root-shoot ratio is often reported for P stressed plants as compared with P sufficient plants. In our study similar to Wissuwa *et al.* (2005) reported that under P deficiency condition root – shoot ratio 20- 30% increase in rice crop. The root growth and development would be more susceptible to declines in soil moisture, nutrients and temperature because of the shallow distribution of the root system in rice (Zhang and Cai, 2005) [26]. Kaymak *et al.* (2008) reported that phosphorus solubilizing bacteria (Bacillus megaterium) increased root parameters like rooting performances, like root length, dry matter content of root in mint plant. Under low - Phosphorus condition lateral root width will be increase in maize crop (Yonghong Xie *et al.*, 2003).

Table 1: Effect of P levels and *Penicillium bilaii* inoculants on seedling growth characters of rice

Treatments	Shoot length (cm)	Root length (cm)	Root volume (cc)	No. of roots	Root shoot ratio	Specific root length (cm)	Dry weight per seedling (g)	Vigour index
S_1	15.3	8.8	12	13.0	0.56	1.7	0.24	4.56
S_2	17.2	13.3	18	17.0	0.81	2.6	0.33	6.60
S_3	18.4	14.2	20	18.0	0.92	2.8	0.37	7.40
S_4	17.1	12.8	17	16.0	0.78	2.4	0.29	5.80
S_5	16.4	12.7	15	15.0	0.72	2.3	0.27	5.40

Mean	16.88	12.36	16.4	15.8	0.758	2.36	0.3	5.952
SEd	0.024	0.034	0.050	0.033	0.0038	0.0072	0.0021	0.001
CD (P= 0.05)	0.054	0.079	0.116	0.075	0.0088	0.0167	0.0049	0.002

S_1 - No seed treatment, S_2 - JumpStart 10E4 (0.097 g/kg of seed), S_3 - JumpStart 10E5 (0.966 g/kg of seed)
S_4 - JumpStart 10E6 (9.662 g/kg of seed), S_5 - Azophos (20 g/kg of seed)

Table 2: Effect of P levels and *Penicillium bilaii* inoculants on plant height (cm plant^{-1}) at different growth stages of rice

Treatments	AT (40 DAS)	PI (55 DAS)	F (85 DAS)	GF (105 DAS)	Mean
P_1S_1	42.63	62.12	85.67	92.33	70.69
P_1S_2	46.30	68.60	90.33	100.00	76.31
P_1S_3	48.59	70.72	96.33	104.67	80.08
P_1S_4	45.83	65.55	87.33	96.67	73.85
P_1S_5	44.55	63.55	86.00	94.67	72.19
P_2S_1	45.90	63.00	87.67	96.00	73.14
P_2S_2	49.90	68.53	92.00	103.33	78.44
P_2S_3	52.53	71.10	99.50	107.33	82.62
P_2S_4	47.10	66.27	90.00	97.67	75.26
P_2S_5	46.14	64.97	89.00	95.00	73.78
P_3S_1	47.06	66.13	92.00	98.33	75.88
P_3S_2	51.00	70.93	98.00	106.00	81.48
P_3S_3	53.55	74.47	103.33	111.67	85.76
P_3S_4	49.35	68.37	97.00	100.33	78.76
P_3S_5	48.64	66.55	96.33	99.67	77.80
Mean	47.94	67.39	92.70	100.24	
S at P SEd	0.969	1.415	1.094	1.601	
CD (P= 0.05)	1.999	2.920	2.257	3.304	

P_1 - 0% Phosphorus, P_2 -50% Phosphorus, P_3 - 100% Phosphorus
S_1-No seed treatment, S_2 - JumpStart 10E4 (0.097 g/kg of seed), S_3 - JumpStart 10E5 (0.966 g/kg of seed)
S_4 - JumpStart 10E6 (9.662 g/kg of seed), S_5 - Azophos (20 g/kg of seed)

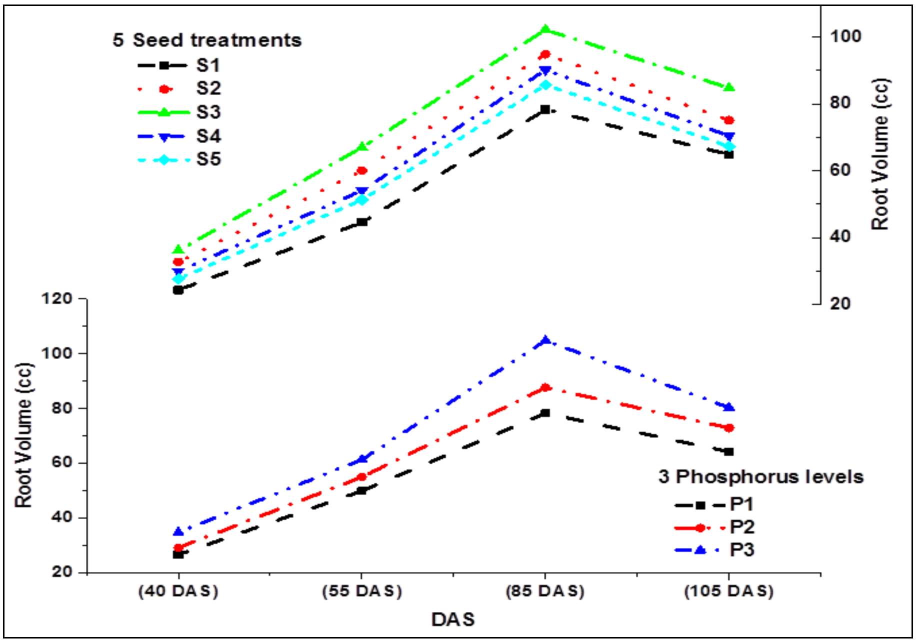

Fig 1: Effect of P levels and *Penicillium bilaii* inoculants on root volume (cc) at different growth stages of rice

Table 3: Effect of P levels and *Penicillium bilaii* inoculants on Root – Shoot (R/S) ratio at different growth stages of rice

Treatments	AT (40 DAS)	PI (55 DAS)	F (85 DAS)	GF (105 DAS)	Mean
P_1S_1	0.706	0.658	0.487	0.434	0.571
P_1S_2	0.577	0.583	0.447	0.415	0.506
P_1S_3	0.562	0.563	0.438	0.393	0.489
P_1S_4	0.591	0.602	0.467	0.400	0.515
P_1S_5	0.668	0.591	0.477	0.422	0.540
P_2S_1	0.650	0.638	0.476	0.421	0.546
P_2S_2	0.576	0.559	0.421	0.400	0.489
P_2S_3	0.531	0.533	0.415	0.381	0.465
P_2S_4	0.605	0.572	0.438	0.415	0.508
P_2S_5	0.638	0.547	0.458	0.428	0.518

P_3S_1	0.618	0.524	0.459	0.395	0.499
P_3S_2	0.528	0.507	0.411	0.371	0.454
P_3S_3	0.494	0.489	0.367	0.359	0.427
P_3S_4	0.551	0.546	0.425	0.404	0.482
P_3S_5	0.583	0.513	0.436	0.403	0.484
Mean	0.592	0.562	0.441	0.403	
S at P SEd	0.0019	0.0017	0.0012	0.00059	
CD (P= 0.05)	0.0026	0.0023	0.0016	0.00121	

P_1 - 0% Phosphorus, P_2 -50% Phosphorus, P_3 - 100% Phosphorus
S_1-No seed treatment, S_2 - JumpStart 10E4 (0.097 g/kg of seed), S_3-JumpStart 10E5 (0.966 g/kg of seed)
S_4-JumpStart 10E6 (9.662 g/kg of seed), S_5 - Azophos (20 g/kg of seed)

Conclusion

I conclude that S_3- (*Penicillium bilaii* JumpStart 10E5) is the best one compare to other treatment from my research experiment in rice crop.

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