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Studies on Growth and Yield of Rice as Influenced by Phosphorus Management Practices

M Venkata Lakshmi, Ch Pulla Rao, P V N Prasad, P Prasuna Rani and Y Ashoka Rani
Department of Agronomy, Agricultural College, Bapatla, A.P.

ABSTRACT

A field experiment was conducted during *kharif* 2016-17 and 2017-18 respectively on sandy loam soils at Agricultural College Farm Bapatla to study the yield and growth attributes of rice as influenced by phosphorus management practices. The experiment was laid out in a split plot design in *kharif* rice were replicated thrice. The treatments consisted of four main plots sources of phosphorus and three subplots levels of phosphorus**.** Results of the experiment showed that application of *in-situ* green manuring + PSB showed superior performance in terms of yield and growth characters like plant height, total number of tillers m^{-2}, drymatter accumulation of rice and other parameters studied, but was on a par with that of application of *in-situ* green manuring and significantly superior over inorganic fertilizer through SSP and biofertilizer (PSB) during both the years and pooled data. At all the growth stages, among the phosphorus levels, 150 % RDP showed significantly higher plant height, number of tillers m^{-2}, drymatter accumulation (kg ha^{-1}) and yield over 50 % RDP and it was on a par with 100 % RDP during both years of study and in pooled data.

Key words: *Phosphorus sources and levels, Rice, Yield and Growth characters*

Rice (*Oryza sativa* L.) is one of the most important staple food crops of India in terms of area, production and consumer preference. In India, it is grown in an area of 43.49 M ha with a total production of 104.40 M t and a productivity of 2400 kg ha^{-1} (CMIE, 2016-17). In Andhra Pradesh, rice is grown in an area of 2.16 M ha with an annual production of 7.48 M t and productivity of 3465 kg ha^{-1} (CMIE, 2016-17).

Phosphorus is an essential nutrient. It is involved in the supply and transfer of energy for all biochemical processes in plants and hence, it is called as the "energy currency of living cells". It stimulates early root growth and development, encourages more active tillering, drymatter accumulation and promotes early flowering, maturity and good grain development. Further, optimum response to added nitrogen could be obtained only when adequate amount of P is supplied. Therefore, P availability from soils to the plant is the key to sustain higher yields. Plants utilize less amounts of phosphatic fertilizers that are applied and the remaining portion is rapidly converted into insoluble complexes in the soil. Slow mobility of applied phosphorus and its marked fixation results in low crop recoveries in the order of 20-25%. Phosphate solubilizing bacteria (PSB) solubilize insoluble phosphorus and increase its availability and inturn the overall phosphate use efficiency. Green manures represent a promising approach to maintain sustainable nutrient supply for crop growth. The P in green manure could potentially be delivered to the soil in a form which is readily available to plants and soil microorganisms. The present study was, therefore, designed to find out the response of rice to sources and levels of phosphorus with regard to yield and growth attributes.

MATERIAL AND METHODS

The two years experiment was conducted at the Agricultural College Farm, Bapatla. Initial soil sample analysis revealed that the experimental soil was sandy loam in texture, slightly alkaline in reaction (pH 7.6, 7.8), low in organic carbon (0.42, 0.43 %), low in available nitrogen (226, 230 kg ha^{-1}), low in available phosphorus (18, 20 kg ha^{-1}) and high in available potassium (483, 521 kg ha^{-1}) during 2016-17 and 2017-18 respectively. The experiment was laid out in a split plot design in *kharif* rice and the treatments were replicated thrice. The treatments consisted of four main plots sources of phosphorus S_1 : Inorganic fertilizer phosphorus through SSP, S_2 : Green manuring *in-situ* with dhaincha @ 25 kg seed ha^{-1}, S_3 : Biofertilizer (PSB) @ 750 ml ha^{-1}, S_4 : Green manuring *in-situ* with dhaincha @ 25 kg seed ha^{-1} + Biofertilizer (PSB) @ 750 ml ha^{-1} and three subplots levels of phosphorus L_1 : 50% Recommended dose of P, L_2 : 100% Recommended dose of P and L_3 : 150% Recommended dose of P. A very popular variety, BPT

Table 1. Plant height (cm) at different stages of *kharif* rice as influenced by phosphorus management practices

Treatments	2016-17				2017-18				Pooled data			
	30 DAT	60 DAT	90 DAT	Maturity	30 DAT	60 DAT	90 DAT	Maturity	30 DAT	60 DAT	90 DAT	Maturity
Source of phosphorus												
S_1 - Inorganic phosphorus	43.0	69.9	85.1	89.1	44.2	72.2	86.2	91.9	43.6	71.1	85.7	90.5
S_2- Green manuring	53.0	83.3	100.7	107.1	54.0	86.7	106.6	108.8	53.5	85.0	103.6	107.9
S_3 - Soil application of PSB	47.8	79.5	92.2	98.6	48.8	80.7	93.7	100.8	48.3	80.1	92.9	99.7
S_4- Green manuring + PSB	55.5	85.4	105.8	110.6	57.4	88.6	109.7	112.8	56.4	87.0	107.7	111.7
S.Em±	1.4	1.8	1.7	2.2	1.2	1.7	2.4	1.9	1.3	1.7	1.7	1.9
CD (p = 0.05)	4.7	6.1	5.9	7.7	4.1	5.7	8.2	6.5	4.4	5.9	5.9	6.5
CV (%)	8.1	6.7	5.3	6.6	6.9	6.0	7.2	5.4	7.5	6.3	5.2	5.4
Levels of phosphorus (P)												
L_1 - 50% RDP	47.1	75.3	92.2	99.0	48.2	78.0	95.5	101.2	47.6	76.6	93.8	100.1
L_2 - 100% RDP	50.4	80.8	95.8	101.3	51.7	82.9	99.8	103.1	51.0	81.8	97.8	102.2
L_3 - 150% RDP	52.1	82.6	99.8	103.8	53.4	85.2	101.8	106.4	52.7	83.9	100.8	105.1
S.Em±	1.1	2.0	1.8	1.2	1.2	1.7	1.5	1.5	1.1	1.8	1.4	1.5
CD (p = 0.05)	3.4	5.9	5.4	3.7	3.5	5.0	4.4	4.4	3.4	5.3	4.3	4.4
CV (%)	7.9	8.5	6.5	4.2	7.9	7	5.1	4.9	7.8	7.6	5.1	4.9
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Total No. of tillers m^{-2} at different stages of *kharif* rice as influenced by phosphorus management practices

Treatments	2016-17				2017-18				Poole			
	30 DAT	60 DAT	90 DAT	Maturity	30 DAT	60 DAT	90 DAT	Maturity	30 DAT	60 DAT	90 DAT	Maturity
Source of phosphorus												
S_1 - Inorganic phosphorus	316.5	337.8	333.3	329.3	323.8	349.8	338.3	332	320.1	343.8	335.8	331.3
S_2- Green manuring	361.1	400.2	381.3	371.3	375.6	421.9	396.3	384.3	368.3	411.1	388.8	377.8
S_3 - Soil application of PSB	335	369.1	352.4	348.3	346.9	384.9	364.3	357.8	340.9	377	359.3	353
S_4- Green manuring + PSB	364.2	410.6	391.8	379.8	378.2	428.9	412.9	393.6	371.4	419.7	402.9	386.7
S.Em±	6.7	8.83	6.73	7.79	7.2	7.9	7.05	7.4	6.92	8.17	6.82	7.28
CD (p = 0.05)	23.2	30.6	23.3	27	24.9	27.3	24.4	25.6	24	28.3	23.6	25.2
CV (%)	5.8	6.9	5.5	6.5	6.1	5.9	5.6	6	5.9	6.3	5.5	6
Levels of phosphorus												
L_1 - 50% RDP	334.3	365.7	351.8	343.8	343.3	383.5	364.3	353.3	338.8	374.6	358	348.5
L_2 - 100% RDP	346.2	383.3	368.5	360.5	360.8	400.2	381	369.3	353.5	391.7	374.8	364.9
L_3 - 150% RDP	352.2	389.3	373.9	367.3	364.3	405.4	388.7	379.2	358.3	397.4	382.4	373.3
S.Em±	4.66	6.24	6.39	6.34	6.29	6.38	6	6.37	3.76	6.1	6	6.03
CD (p = 0.05)	14	18.7	19.2	19	18.9	19.1	18	19.1	11.3	18.3	18	18.1
CV (%)	4.7	5.7	6.1	6.1	6.1	5.6	5.5	6	3.7	5.5	5.6	5.8
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Drymatter accumulation (kg ha^{-1}) at different stages of *kharif* rice as influenced by phosphorus management practices

Treatments	2016-17				2017-18				Pooled data			
	30 DAT	DAT	90 DAT	Maturity	30 DAT	60 DAT	90 DAT	Maturity	30 DAT	60 DAT	90 DAT	Maturity
Source of phosphorus												
S_1 - Inorganic phosphorus	1378	4417	8835	10353	1495	4470	8870	10475	1437	4443	8852	10414
S_2- Green manuring	1872	6386	10390	12169	2002	6772	10807	12582	1937	6579	10598	12375
S_3 - Soil application of PSB	1649	5998	9891	11366	1759	6129	9881	11732	1704	6063	9886	11549
S_4- Green manuring + PSB	1942	6612	10226	12356	2082	6687	10904	12839	2012	6649	10565	12598
S.Em±	35.28	187.4	224.61	252.68	35.28	136.58	227.17	227.17	35.28	153.22	220.75	230.66
CD (p = 0.05)	122.1	648.6	777.3	874.4	122.1	472.6	786.2	786.2	122.1	530.2	763.9	798.2
CV (%)	6.2	9.6	6.9	6.6	5.8	6.8	6.7	5.7	6	7.7	6.6	5.9
Levels of phosphorus												
L_1 - 50% RDP	1623	5466	9416	11141	1743	5656	9703	11494	1683	5561	9559	11318
L_2 - 100% RDP	1740	5843	9793	11519	1860	5950	10086	11877	1800	5897	9940	11698
L_3 - 150% RDP	1768	6250	10297	12022	1901	6437	10558	12349	1834	6343	10427	12186
S.Em±	25.59	177.2	186.71	204.37	25.59	182.64	191.12	191.12	25.59	168.2	170.86	173.99
CD (p = 0.05)	76.7	531.2	559.8	612.7	76.7	547.6	573	573	76.7	504.3	512.3	521.7
CV (%)	5.2	10.5	6.6	6.1	4.8	10.5	6.5	5.6	5	9.8	5.9	5.1
Interaction	NS	S	NS	NS	NS	S	NS	NS	NS	S	NS	NS

Table 3.1a. Interaction effect of drymatter accumulation (kg ha^{-1}) at 60 DAT of rice as influenced by phosphorus management (2016-17)

Sources of phosphorus	Levels of Phosphorus			Mean
	L_1 - 50% RDP	L_2 - 100% RDP	L_3 - 150% RDP	
S_1 - Inorganic phosphorus	4044	4361	4846	4417
S_2- Green manuring	6015	6332	6812	6386
S_3 - Soil application of PSB	5694	6142	6157	5998
S_4- Green manuring + PSB	6110	6539	7186	6612
Mean	5466	5843	6250	5466
	S.Em±	CD (p = 0.05)	CV (%)	
Main Plot	187.42	648.6	9.6	
Sub Plot	177.18	531.2	10.5	
Interaction				
S X L	354.36	1062.4		
LX S	344.73	1080.7		

Table 3.1b. Interaction effect of drymatter accumulation (kg ha^{-1}) at 60 DAT of rice as influenced by phosphorus management (2017-18)

Sources of phosphorus	Levels of Phosphorus			Mean
	L_1 - 50% RDP	L_2 - 100% RDP	L_3 - 150% RDP	
S_1 - Inorganic phosphorus	4135	4458	4817	4470
S_2- Green manuring	6324	6641	7349	6772
S_3 - Soil application of PSB	5992	6081	6314	6129
S_4- Green manuring + PSB	6174	6620	7267	6687
Mean	5656	5950	6437	
	S.Em±	CD (p = 0.05)	CV (%)	
Main Plot	136.58	472.6	6.8	
Sub Plot	182.64	547.6	10.5	
Interaction				
S X L	365.27	1095.1		
LX S	328.03	1009.8		

Table 3.1c. Interaction effect of drymatter accumulation (kg ha^{-1}) at 60 DAT of rice as influenced by phosphorus management (Pooled data)

Sources of phosphorus	Levels of Phosphorus			Mean
	L_1 - 50% RDP	L_2 - 100% RDP	L_3 - 150% RDP	
S_1 - Inorganic phosphorus	4090	4410	4831	4443
S_2- Green manuring	6170	6487	7081	6579
S_3 - Soil application of PSB	5843	6111	6235	6063
S_4- Green manuring + PSB	6142	6579	7226	6649
Mean	5561	5897	6343	
	S.Em±	CD (p = 0.05)	CV (%)	
Main Plot	153.22	530.2	7.7	
Sub Plot	168.2	504.3	9.8	
Interaction				
S X L	336.39	1008.6		
LX S	314.51	977.5		

Table 4. Grain yield (kg ha $^{-1}$) of *kharif* rice as influenced by phosphorus management practices

Treatments	2016-17	2017-18	Pooled data
Source of phosphorus			
S_1 - Inorganic phosphorus	4620	4649	4635
S_2- Green manuring	5520	5730	5625
S_3 - Soil application of PSB	5179	5329	5254
S_4- Green manuring + PSB	5656	5896	5776
S.Em±	73.14	79.45	75.81
CD (p = 0.05)	253.1	274.9	262.3
CV (%)	4.2	4.4	4.3
Levels of phosphorus			
L_1 - 50% RDP	5024	5164	5094
L_2 - 100% RDP	5283	5456	5369
L_3 - 150% RDP	5425	5583	5504
S.Em±	55.92	70.28	57.21
CD (p = 0.05)	167.7	210.7	171.5
CV (%)	3.7	4.5	3.7
Interaction	S	S	S

Table 4.1a. Interaction effect of grain yield of *kharif* rice as influenced by phosphorus management practices during First year

Source of phosphorus	Levels of Phosphorus			Mean
	L_1 - 50% RDP	L_2 - 100% RDP	L_3 - 150% RDP	
S_1 - Inorganic phosphorus	4350	4543	4967	4620
S_2- Green manuring	5396	5560	5605	5520
S_3 - Soil application of PSB	5166	5145	5225	5179
S_4- Green manuring + PSB	5183	5886	5901	5656
Mean	5024	5283	5425	
	S.Em±	CD (p = 0.05)	CV (%)	
Main Plot	73.14	253.09	4.2	
Sub Plot	55.92	167.65	3.7	
Interaction				
S X L	111.84	335.3		
L X S	116.99	371.9		

Table 4.1b. Interaction effect of grain yield (kg ha^{-1}) of *kharif* rice as influenced by phosphorus management practices during second year

Source of phosphorus	Levels of Phosphorus			Mean
	L_1 - 50% RDP	L_2 - 100% RDP	L_3 - 150% RDP	
S_1 - Inorganic phosphorus	4316	4632	4999	4649
S_2- Green manuring	5606	5770	5815	5730
S_3 - Soil application of PSB	5310	5295	5375	5327
S_4- Green manuring + PSB	5423	6126	6141	5896
Mean	5164	5456	5583	
	S.Em±	CD (p = 0.05)	CV (%)	
Main Plot	79.45	274.9	4.4	
Sub Plot	70.28	210.7	4.5	
Interaction				
S X L	140.55	421.4		
L X S	139.58	439.4		

Table 4.1c. Interaction effect of grain yield (kg ha^{-1}) of *kharif* rice as influenced by phosphorus management practices during pooled data

Source of phosphorus	Levels of Phosphorus			Mean
	L_1 - 50% RDP	L_2 - 100% RDP	L_3 - 150% RDP	
S_1 - Inorganic phosphorus	4333	4588	4983	4635
S_2- Green manuring	5501	5665	5710	5625
S_3 - Soil application of PSB	5241	5220	5300	5254
S_4- Green manuring + PSB	5303	6006	6021	5776
Mean	5094	5369	5504	
	S.Em±	CD (p = 0.05)	CV (%)	
Main Plot	74.31	257.1	4.2	
Sub Plot	58	173.9	3.8	
Interaction				
S X L	116	347.8		
L X S	120.38	382.1		

5204 (Samba Mahsuri) was used for the study. The experimental field was ploughed twice by a tractor drawn cultivator, followed by a rotovator to obtain required tilth. The levelled field was then divided into the required number of main plots as per the layout plan. Dhaincha seed was broadcasted in the main plots namely S_2 (Green manuring @ 25 kg ha^{-1}) and S_4 (Green manuring *in situ* + biofertilizer (PSB) @750 ml ha^{-1}) in all the three replications as per the layout plans and the seeds were covered by dragging a spike toothed harrow. These main plots (Green manure plots) were divided into sub plots after incorporation of green manure by making strong bunds and irrigation was given for better decomposition before transplanting of rice crop during both the years of experimentation.

A common dose of nitrogen @120 kg ha^{1}was applied in the form of urea in three splits, half at basal, one fourth at active tillering and remaining at panicle initiation stage. Phosphorus in the form of single super phosphate was applied basal as per the treatments. A common dose of 40 kg K_2O ha^{-1} was applied as basal just before transplanting through muriate of potash by taking the plot size into consideration.

RESULTS AND DISCUSSION

Plant Height (cm)

Data on plant height (Table 1) revealed that it was significantly influenced by different treatments at all the growth stages *i.e.* 30, 60, 90 DAT and at maturity of the crop during both years. Interaction between sources and levels of phosphorus was non significant at all growth stages of observation during both the years and also in pooled data of the study.

Plant height increased with advancement in age of the crop. At 30 DAT, among the (main plots) sources of phosphorus significantly taller plants were recorded with the combination of green manuring + PSB (55.5 cm), which was on par with the green manuring alone treatment (53 cm) and found significantly superior to inorganic phosphorus and PSB alone application. Similar trend was noticed at 60, 90 DAT and at maturity during both the years and also in pooled data. This could be due to integration of organic manure and biofertilizer, which resulted in better mineralization of plant nutrients *In-situ* green manuring provides greater availability and steady release of nutrients, which helps in cell enlargement and multiplication leading to increase in plant height. Similar results of taller plants with *insitu* green manuring was reported by Rao *et al*. (2004) and Indrani *et al*. (2008). PSB containing living cells of microorganism like bacteria, fungi and actinomycetes are capable of solubilizing calcium, aluminium and iron phosphorus present in the soil available to the crops. The biofertilizer might have helped in stimulating the solubilization of insoluble P and the plant growth by providing vitamins, hormones and other growth promoting substances, which might have enhanced cell division and cell elongation resulting in taller plants. Similar findings were reported by Mohammad *et al.* (2003) and Gurkirpal *et al*. (2006).

At all the stages of observation, plant height was found to increase with increase in levels of phosphorus. Among the phosphorus levels, plant height at 30 DAT was found to increase with increased levels of phosphorus and the tallest plants were produced with the application of 150% RDP (52.1 cm) and found significantly superior to 50% RDP (47.1 cm). However, it was on par with 100 % RDP (50.4 cm) at all the stages of observation. This trend was observed in both years and pooled data of study. This could be attributed to higher amount of phosphorus supply, which might have more leaves and greater accumulation of photosynthates resulting in higher plant height. Similar findings were also reported by Khan *et al*. (2002) and Devideen *et al.* (2015).

Total Number of Tillers m^{-2}

Data on total number of tillers m^{-2} are presented in (Table 2) at different growth intervals of rice, which was significantly affected by different sources and levels of phosphorous but not by their interaction. In general, the number of tillers m^{-2} observed in different treatments was higher during the second year of experimentation which was due to more amount of rainfall (842.9 mm) received during second year of experimentation.

During both the years and pooled data of study, number of tillers m^{-2} increased from 30 DAT to 60 DAT and showed a slight decreasing trend from 90 DAT to maturity which might be due to death of later formed tillers because of competition.

At 30 DAT, the treatment with the combination of green manuring + PSB recorded significantly maximum number of tillers (364.2, 378.2 and 371.4) which was closely followed by *in-situ* green manuring alone (361.1, 375.6 and 368.3) and was significantly superior to inorganic phosphorus through SSP (316.5, 323.8 and 320.1) and Biofertilizer (PSB) (335, 346.9 and 340.9) during 2016-17, 2017-18 and pooled data. The similar trend was noticed for 60, 90 DAT and at maturity during both the years and pooled data of study. This might be due to addition of *in-situ* green manure in combination with PSB reduced susceptibility to fixation or precipitation reactions in soil forming soluble complexes which might have supported higher tillering compared to other treatments. This is in concurrence with the findings of Pramanik *et al*. (2009) and Siva Jyothi *et al*.(2015).

At all the growth stages, among the phosphorus levels, 150 % RDP showed significantly higher number of tillers over 50 % RDP and it was on a par with 100 % RDP during both years and pooled data. Application of phosphorus increased root growth, photosynthetic activity and translocation of photosynthates to the sink and improved growth of the plant might contributed higher number of tillers. These results are in accordance with the findings of Meena *et al*. (2015) and Ashiana Javeed *et al*. (2017).

Drymatter Accumulation (kg ha^{-1})

A perusal of the data on drymatter accumulation (Table 3, 3.1a, 3.1b, 3.1c) indicated that it was significantly influenced by the various treatments under test during two consecutive years and pooled data. Interaction was found to be significant at 60 DAT during 2016-17, 2017-18 and pooled data.

Drymatter accumulation increased progressively with advancement in age of the crop upto harvest. Drymatter accumulation followed the similar trend as in case of plant height and total number of tillers m^{-2}.

At 30 DAT, among the phosphorus sources *in-situ* green manuring + PSB recorded significantly maximum drymatter accumulation and was on par with alone green manuring, which was significantly superior to biofertilizer (PSB) and inorganic fertilizer through SSP. Similar trend was observed in other stages also *i.e.* 60, 90 DAT and at maturity during both the years and pooled data. This might be due to fast decomposition of dhaincha and slow release of nutrients, which enabled increase of leaf area and photosynthetic rate and in turn the highest drymatter accumulation. With regard to PSB resulting in conversion of insoluble form of phosphorus into soluble form and applied nutrient is easily available to crop. Hence, showed the highest drymatter accumulation. This is in mearing with the findings of Prathibha Sree *et.al* (2016) and Premalatha (2017).

At all the growth stages, among the phosphorus levels 150 % RDP recorded significantly highest drymatter accumulation over 50 % RDP and it was on par with 100 % RDP. However, drymatter accumulation in 100 % RDP was on par with 50 % RDP during both the years and pooled data.

Increase in plant height and tillers m^{-2} due to phosphorus application might have resulted in increase in photosynthesis and production of photosynthates, which finally transformed into vegetative part and thereby higher drymatter production. Increased drymatter accumulation with increased phosphorus application was also reported by Dakshina murthy *et al*. (2015) and Santosh Kumar *et al*. (2015).

Grain yield (kg ha^{-1})

Grain yield, was significantly influenced by sources and levels of phosphorus and their interaction too during both the years of study and in pooled data of study. The data pertaining to the grain yield of rice are presented in the (Table 4, 4 a, 4 b, 4 c). The grain yield of various treatments was higher during the second year (2017-18) of study than that of the first year (2016-17), however the influence of different treatments was almost consistent in the both years of study and pooled data as well.

During both the years, significantly higher yields were recorded with the treatment that received *in-situ* green manuring + biofertilizer (PSB) *i.e.* 5656 kg ha^{-1}, 5896 kg ha^{-1} and 5776 kg ha^{-1} during 1st, 2nd years and pooled data respectively, which was statistically on a par with *in-situ* green manuring treatment (5520 kg ha^{-1}, 5730 and 5625 during 1st and 2nd years and pooled data respectively) but proved significantly superior to inorganic fertilizer through SSP and biofertilizer (PSB) alone treatment under test.

Present study results showed that *in-situ* green manuring + biofertilizer (PSB) significantly influenced the grain yield of rice. Application of *in-situ* green manuring + biofertilizer (PSB) was found to be superior in realizing maximum grain yield. It might be due to the fact that green manure biomass is a potential source of major nutrients for lowland rice and showed significant improvement in growth, yield, net returns, soil moisture retension, organic carbon and nutrient status of soil and reduction in bulk density of plough layer (Siva Jyothi *et al*., 2015). The yield increase may be due to increase in growth attributes like drymatter production and yield attributes like panicle length, total number of grains, more number of filled grains per panicle. Similar findings were also reported by Arivukkarasu and Kathiresan (2007) and Deshpande and Devasenapathy (2010). Green manure + Biofertilizer (PSB) promotes improvement in leaf photosynthetic rate, biomass production and sink formation, which increased the grain yield of rice. Besides P solubilisation activity, PSB liberates growth hormone (IAA) that might have influenced on root growth and yield. The extensive root system might have increased nutrient uptake from the surroundings which boosted plant biomass and subsequently more grain yield of rice. These results were alike with the findings of Dass *et al*. (2009) and Panhwar *et al*. (2010).

Data in 4, 4.1a, 4.1b, 4.1c shows that among the levels of phosphorus, 150 % RDP recorded highest grain yield (5425 kg ha^{-1}, 5583 kg ha^{-1} and 5504 kg ha^{-1} over 50 % RDP (5024 kg ha^{-1}, 5164 kg ha^{-1} and 5094 kg ha^{-1}) it was remained on a par with 100 % RDP

(5283 kg ha^{-1}, 5456 kg ha^{-1} and 5369 kg ha^{-1}). Similar trend was observed during first, second and pooled data of study. This might be due to adequate supply of P in soil might have favoured efficient use of P in turn brought higher grain yield. These results are in close conformity with the findings obtained by Dutta and Gogoi (2009) and Ramesh Babu *et al.* (2013).

CONCLUSION

Results of the experiment showed that application of *in-situ* green manuring + PSB showed superior performance in terms of yield and growth characters like plant height, total number of tillers m^{-2}, drymatter accumulation of rice and other parameters studied, but was on a par with that of application of *in-situ* green manuring and significantly superior over inorganic fertilizer through SSP and biofertilizer (PSB) during both the years and pooled data. At all the growth stages, among the phosphorus levels, 150 % RDP showed significantly higher plant height, number of tillers m^{-2}, drymatter accumulation (kg ha^{-1}) and yield over 50 % RDP and it was on a par with 100 % RDP during both years of study and in pooled data.

LITERATURE CITED

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