EFFECT OF PHOSPHORUS LEVELS AND BIO-ORGANIC SOURCES ON GROWTH ATTRIBUTES AND YIELD OF RICE

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INTRODUCTION

Rice (Oryza sativa L.) is the premier food crop for south-eastern Asia, where 90% of the world rice is grown and consumed. India is the second largest producer covering 44.01 million ha area with 105.30 million tons production and an average productivity of 23.93 q ha⁻¹. The average productivity of rice in Uttar Pradesh is 23.56 quintals ha⁻¹ (Anonymous, 2011). However, country needs further higher production to feed ever-increasing population.

Phosphorus is one of the major essential plant nutrients essential for photosynthesis, energy transformations, protein synthesis etc. in plants. Low availability of native soil phosphorus and poor recovery of applied fertilizer phosphorus occurs primarily due to phosphorus fixation by soil. Phosphatic fertilizers occupy an important place, its insufficient supply, slow mobility of applied phosphorus and its marked fixation results in low crop recoveries (around 20%), which calls for ways and means for its judicious use (Kanwar and Reddy, 2003).

In view of the escalating cost of fertilizers and environmental pollution due to irrational use of fertilizers, there is need to develop integrated nutrient management, using locally available organic resources like FYM and biofertilizers. Indiscriminate use of inorganic fertilizers leads to nutrient imbalance causing ill effect on soil health and micro flora. Hence, there is need to reduce the use of chemical fertilizers and encourage the application of biofertilizers to the maximum possible level. Integrated use of bio-organic sources and chemical fertilizers has been found promising in arresting the decline in productivity and known for their beneficial influence on the physical and biological properties of soil. Improved soil properties such as decrease in bulk density and increase in infiltration rate due to incorporation of organic sources viz. FYM, green manure, BGA in conjunction with inorganic fertilizers (NPK) in kharif rice has been reported (Nayak et al., 2015).

Farmyard manure is most widely used bulky organic manures contain small quantities of major plant nutrients and traces of micronutrients supply organic matter in large quantities, provide food for soil microorganisms. Farmyard manure and use of blue green algae (BGA) in wetland rice are the common practices (Begum et al., 2009). Wetland rice field provides ideal condition for the use of BGA, liberates plant growth promoting substances like vitamins (vit. B₁₂, Folic acid), IAA and amino acids, help in solubilization of insoluble phosphorus and making it available to the crop (Satapathy, 1999). Phosphate solubilizing bacteria (PSB) is a biofertilizer, the capacity to solubilize and mineralize the residual or fixed phosphorus, increases the availability of phosphorus in soil, produces growth promoting substances, and increases the overall phosphate use efficiency (Chhonkar and Tilak, 1997; Gull et al., 2004). It is hypothesized that bio-organic sources such as FYM, PSB and BGA may influence the dissolution of the soil fixed phosphate and also increase the efficiency of the applied Phosphatic fertilizer under wetland rice condition. Hence, the objective of the study was to evaluate

ABSTRACT

A field experiment conducted during rainy season of 2013 to evaluate the effect of phosphorus levels and bio-organic sources on wetland rice at Varanasi. Result shows significant increase in growth attributes, grain and straw yield and harvest index up to application of 75% RDP (45 kg P₂O₅ ha⁻¹). Highest grain yield (50.97 q ha⁻¹), straw yield (62.93 q ha⁻¹) and harvest index (44.32%) noted with the use of 60 kg P₂O₅ ha⁻¹. Combined application of PSB + BGA + FYM (5 t ha⁻¹) proved significantly superior to BGA + PSB and PSB alone. Combined application of bio-organic sources resulted increase in grain yield (8.59%), straw yield (4.57%) and harvest index (2.77%) over PSB alone. Study suggests saving of twenty five per cent phosphorus by integration of 75% RDP (45 kg P₂O₅ ha⁻¹) in conjunction with combined application of bio-organic sources.

KEY WORDS

BGA
FYM
Phosphorus levels
PSB

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the effect of phosphorus levels and bio-organic sources on growth and yield of rice.

MATERIALS AND METHODS

The field experiment was carried out during rainy season of 2013 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, to evaluate the effect of phosphorus levels and bio-organic sources on growth and yield of rice (Oryza sativa L.) under eastern Uttar Pradesh conditions. The soil samples collected from experimental site were analyzed for mechanical and physico-chemical properties. The soil was sandy clay loam in texture with pH 7.35, electrical conductivity 0.15 dS/m, organic carbon 0.39% (Jackson, 1973), low in available nitrogen 198.03 kg ha⁻¹ (Subbiah and Asija,1956), medium in available phosphorus 23.7 kg ha⁻¹ (Olsen et al., 1954) and potassium 188.32 kg ha⁻¹ (Jackson,1973). Factorial experiment was laid out in Randomized Complete Block Design with four levels of phosphorus viz. control, 50% RDP, 75% RDP and 100% RDP and three bio-organic sources i.e. PSB, PSB + BGA and PSB + BGA + FYM (5 t ha⁻¹) replicated thrice. Recommended dose of fertilizers (RDF) used was N₃ P₅ O₁₀ K₅ (120-60-60 kg ha⁻¹). The N, P and K were supplied through urea, diammonium phosphate (DAP) and muriate of potash, respectively. Half of the recommended dose of nitrogen and full dose of potassium were applied as basal application and remaining half nitrogen was applied in two equal splits at active tillering and panicle initiation stages uniformly to all the treatments. Variable rates of phosphorus were applied as per treatment. Four week old seedlings of rice cv. HUR-105 were transplanted on the puddled field during second week of July keeping two seedlings hill⁻¹ at a spacing of 20 cm × 15 cm. After 10 days of transplanting, dried and powdered composite algal culture of BGA was applied at the rate of 10 kg ha⁻¹ in their respective treatments. Phosphate solubilizing bacteria, Bacillus polymyxa was obtained from the department of Soil Science and Agricultural chemistry, BHU, Varanasi before transplanting, inoculants suspension was prepared with water in ratio of 1:10 and seedling roots were dipped for 30 minutes followed by transplanting immediately. Well decomposed FYM was applied basally as per treatment. Throughout the crop period, experimental crop received 825.0 mm rainfall and about ± 5 cm water level was continuously maintained till flowering then after field was kept under saturated condition. The other agronomic practices were followed as per recommendations. The crop was harvested at proper physiological maturity. The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height (cm)

Increasing levels of phosphorus up to 100% RDP significantly enhanced the plant height at 30 and 60 DAT. However at 90 DAT, 50%, 75% and 100% RDP were found at par with each other but observed significantly superior over control treatment. At harvest stage, plant height increased significantly up to 75% RDP and further increment of phosphorus (100% RDP) though increased the plant height but could not reach to the level of significance. At harvest stage, 100% RDP recorded maximum plant height (107.63 cm). Plants supplied with adequate amount of phosphorus produces more leaves and greater accumulation of photosynthates, resulting more height. Biofertilizers enhance plant growth by production of organic acid and growth substances and make available the complex phosphorus to the plant, which may cause an appreciable reduction in consumption of inorganic fertilizers. Similar results were also reported by Choudhary et al. (2015).

Among bio-organic sources, at 30 and 60 DAT the maximum plant height was observed with combined use of PSB + BGA + FYM (5 t ha⁻¹) which was significantly higher than other bio-organic treatments (PSB + BGA and PSB). However, at 90 DAT, significant increase in plant height was registered with PSB + BGA application over alone use of PSB. Further addition of FYM (5 t ha⁻¹) to PSB + BGA did not turn significant variation in plant height. At harvest, combined application of PSB + BGA + FYM (5 t ha⁻¹) produced significantly greater plant height (106.47 cm) as compare to PSB + BGA and PSB alone which were at par with each other. These findings are similar to the result of Singh (2013).

Table 1: Effect of Phosphorus levels and Bio-organics on Plant height, dry matter production and no of tillers hill⁻¹ at successive growth stages of rice

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Dry matter production (g hill⁻¹)</th>
<th>No. of tillers hill⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAT</td>
<td>60 DAT</td>
<td>90 DAT</td>
</tr>
<tr>
<td>P Levels (% RDP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>48.08</td>
<td>77.04</td>
<td>100.07</td>
</tr>
<tr>
<td>50</td>
<td>48.87</td>
<td>79.53</td>
<td>102.50</td>
</tr>
<tr>
<td>75</td>
<td>49.29</td>
<td>81.16</td>
<td>102.62</td>
</tr>
<tr>
<td>100</td>
<td>50.54</td>
<td>84.67</td>
<td>103.80</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.17</td>
<td>0.18</td>
<td>0.59</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.51</td>
<td>0.54</td>
<td>1.72</td>
</tr>
<tr>
<td>Bio-organics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSB</td>
<td>48.30</td>
<td>78.47</td>
<td>100.40</td>
</tr>
<tr>
<td>PSB+BGA</td>
<td>49.24</td>
<td>81.07</td>
<td>102.38</td>
</tr>
<tr>
<td>PSB+BGA+FYM</td>
<td>49.82</td>
<td>82.27</td>
<td>103.96</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.17</td>
<td>0.18</td>
<td>0.54</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.51</td>
<td>0.54</td>
<td>1.72</td>
</tr>
</tbody>
</table>

RDP: Recommended dose of phosphorus (60 kg ha⁻¹), FYM (Farmyard manure) @ 5 tonne ha⁻¹, BGA (Blue Green Algae), PSB (Phosphate Solubilizing Bacteria)
Dry matter production (g hill⁻¹)

Experimental results revealed that a consistent increase in the dry matter production occurred with the advancement of the crop growth stages and reached to maximum at the maturity. The rate of increase in dry matter production enhanced rapidly between 30 to 60 DAT. Application of 100% RDP produced significantly higher dry matter production g hill⁻¹ than lower phosphorus levels at all stages. However, 75% RDP and 100% RDP were statistically at par at 60 and 90 with 30 DAT and harvest stage. Crop plants supplied with adequate quantity of phosphorus resulted greater accumulation of photosynthates which accounted for higher dry matter production. The findings are in close agreement with Sharma et al. (2009).

Among the bio-organic sources significantly higher values were observed with the combined use of PSB + BGA + FYM (5 t ha⁻¹) at 60 and 90 DAT though it could not reach to the level of significance over PSB + BGA use at 30 DAT & at harvest. Improvement in dry matter production is the combined effect of growth parameters due to organic sources was also reported by Kumar and Reddy (2010).

Number of tillers hill⁻¹

The data revealed that number of tillers hill⁻¹ increased gradually between 30 to 60 DAT thereafter a slight decline was observed up to harvest stage. The reduction in number of tillers after 60 DAT was due to the ageing and senescence and seems responsible for dying of the secondary and tertiary tillers which produced at later stage. The highest number of tillers per hill was recorded due to application of 100% RDP at all growth stages. At 30 DAT, control and 50% RDP found at par and also at harvest 50%, 75% and 100% RDP were noted at par. The magnitude of increase over control was 19.83%, 17.6%, 18.12% and 16.13% at 30, 60, 90 DAT and at harvest, respectively.

Combined use of PSB + BGA + FYM (5 t ha⁻¹) significantly increased the number of tillers hill⁻¹ than other treatments of bio-organic sources followed by application of PSB + BGA while significantly lower number of tillers hill⁻¹ observed due to use of PSB alone. The increase in tillers hill⁻¹ was probably because of greater supply of phosphorus with other nutrients due to bio-organic sources with efficient utilization for cell multiplication and enlargement and also for the formation of nucleic acids and other vital important organic compounds in the cell sap (Simons, 1982).

Leaf area index

Leaf area index increased rapidly up to 60 DAT and thereafter with a considerable pace up to 90 DAT due to senescence of leaves after the reproductive phase. Higher leaf area index was observed with the application of maximum phosphorus level (100% RDP) at all growth stages though it was at par with the 75% RDP at all the stages of crop growth except at 30 DAT where it proved significantly superior.

Maximum leaf area index was found associated with combined use of PSB + BGA + FYM (5 t ha⁻¹) which was observed at par with the PSB + BGA though both were significantly higher over application of PSB alone at 60 & 90 however, integration of PSB + BGA + FYM (5 t ha⁻¹) produced significantly higher leaf area index than other bio-organic sources only at 30 DAT. These results are in close conformity with Kumar and Reddy (2010).

Grain and straw yield

The highest grain yield (50.97 q ha⁻¹) was recorded with the application of 100% RDP which exhibited a superiority of 19.67, 13.11, and 2.12 per cent over 0, 50 and 75% RDP, respectively. Addition of 100% RDP and 75% RDP recorded grain yield at par to each other but both were significantly superior over 50% RDP and control treatment. Similarly, maximum straw yield (62.93 q ha⁻¹) was registered under application of highest phosphorus level (100% RDP) closely followed by 75% RDP and 50% RDP respectively. However, increase in level of phosphorus from 50% RDP to 100% RDP could not exhibit significant effect on straw yield and the above treatments were observed significantly superior only to control treatment. Application of 100% RDP recorded (8.36%) higher straw yield than control.

Combined application of PSB + BGA + FYM (5 t ha⁻¹) recorded the maximum grain yield (49.27 q ha⁻¹) which was significantly superior to PSB + BGA and PSB alone. However, difference between PSB + BGA and PSB alone was not significant. Maximum straw yield was noted with the combined use of PSB + BGA + FYM (5 t ha⁻¹) which proved significantly

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### Table 2: Effect of Phosphorus levels and Bio-organics on leaf area index, yield and harvest index of rice

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Leaf area index</th>
<th>Yield (q ha⁻¹)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAT</td>
<td>60 DAT</td>
<td>90 DAT</td>
</tr>
<tr>
<td>P Levels (% RDP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.92</td>
<td>1.89</td>
<td>2.55</td>
</tr>
<tr>
<td>50</td>
<td>1.10</td>
<td>1.99</td>
<td>2.84</td>
</tr>
<tr>
<td>75</td>
<td>1.21</td>
<td>2.44</td>
<td>3.10</td>
</tr>
<tr>
<td>100</td>
<td>1.31</td>
<td>2.64</td>
<td>3.30</td>
</tr>
<tr>
<td>SEm ±</td>
<td>0.01</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>CD (p = 0.05)</td>
<td>0.04</td>
<td>0.26</td>
<td>0.22</td>
</tr>
<tr>
<td>Bio-organics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSB</td>
<td>1.01</td>
<td>2.04</td>
<td>2.72</td>
</tr>
<tr>
<td>PSB + BGA</td>
<td>1.13</td>
<td>2.38</td>
<td>3.02</td>
</tr>
<tr>
<td>PSB + BGA + FYM</td>
<td>1.27</td>
<td>2.30</td>
<td>3.11</td>
</tr>
<tr>
<td>SEm ±</td>
<td>0.01</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>CD (p = 0.05)</td>
<td>0.03</td>
<td>0.22</td>
<td>0.19</td>
</tr>
<tr>
<td>Interaction</td>
<td>S</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

RDP: Recommended dose of phosphorus (60 kg ha⁻¹), FYM (Farmyard manure) @ 5 tonne ha⁻¹, BGA (Blue Green Algae), PSB (Phosphate Solubilizing Bacteria)
superior to application of PSB alone but found statistically at
par with PSB + BGA. Increase in grain and straw yield might
be due to higher photosynthetic activity because of increased
leaf area index, which ultimately promoted dry matter
production resulting higher grain and straw yield (Quyen and
Sharma, 2003; Singh et al, 2013) also reported similar results.

Harvest index
Data revealed that maximum harvest index recorded with the
application of highest phosphorus level (100% RDP) observed
at par with 75% RDP but significantly superior than control
and 50% RDP. Minimum harvest index was noted under
control treatment noted at par with 50% RDP. The harvest
index did not showed significant variation due to bio-organic
sources.

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