Effect of phosphorus and biofertilizers on growth and yield of soybean (Glycine max (L.) Merill) under rainfed condition

SD Pawar, PN Karanjikar and VG Takankhar

Abstract
The experiment entitled “Effect of phosphorus and biofertilizers on growth and yield of Soybean (Glycine max (L.) Merill) under rainfed condition” was conducted on research farm of College of Agriculture Latur (M.S.) during kharif season of 2015. The experimental field was leveled and well drained. The soil was clayey loam in texture, low in available nitrogen (118.86 kg ha⁻¹), medium in available phosphorus (20.42 kg ha⁻¹), high in potassium (385.89 kg ha⁻¹) and slightly alkaline (pH 8.5) in reaction. The experiment was laid out in randomized block design. There were ten treatments which were replicated thrice. The treatments mainly comprised of T1- No phosphorus application, T2- 45 kg P₂O₅/ha through SSP, T3- 60 kg P₂O₅/ha through SSP, T4- 45 kg P₂O₅/ha through SSP + PSB, T5- 45 kg P₂O₅/ha through SSP + Rhizobium (R.I.), T6- 45 kg P₂O₅/ha through SSP+ VAM, T7- 45 kg P₂O₅/ha through SSP+PSB+R.I., T8- 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM, T9=45kg P₂O₅/ha through SSP+PSB+R.I.+ VAM. Rainfed soybean responded positively to different phosphorus application treatments. Application of 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM (T6) performed the best amongst the various phosphorus treatments evaluated with regards to growth, yield attributing characters and yield of soybean. Maximum seed yield, straw yield and biological yield was produced by application of 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM (T6) which was followed application of 45 kg P₂O₅/ha through SSP+R.I.+VAM (T9) and 45 kg P₂O₅/ha through SSP+PSB+R.I. (T7) and was found significantly superior over rest of the treatments

Keywords: Soybean, phosphorus, biofertilizer, rainfed, growth, yield

Introduction
Soybean (Glycine max (L.) Merill) is a leguminous crop and belongs to family Fabaceae with sub family Faboideae. Soybean is a important crop in human and animal nutrition, because it is a major source of edible vegetable oil and high protein feed as well as food in the world. It is an excellent health food and contains about 40 per cent quality protein, 23 per cent carbohydrates and 20 per cent cholesterol free oil. Soybean protein is rich in valuable amino acid, lysine (5%) which is deficient in most of the cereals. It also contain 60 per cent polyunsaturated fatty acids (52.8% linolenic acid + 7.2 % linoleic acid). It has high caloric value releasing 432 calories from 100 gm edible protein as compared to 350 calories from cereals of same quantity. Soybean is the cheapest source of proteins and it is called “Poor man’s meat”. In India area soown under soybean was 108.34 lakh ha, productivity 959 kg/ha and production was 104.36 lakh MT. In Maharashtra area was 38 lakh ha, productivity 808 kg/ha and production was 30.72 lakh MT. In Marathwada region area was 12.36 lakh ha, productivity 826 kg/ha and production was 10.21 lakh MT (Anonymous, 2013). [1] Now a days, there is vast scope for soybean production due to high nutritional quality, more production and short duration (90-110 days), tolerate long dry spell and being leguminous crop helps in improving the fertility and productivity of soil. But prices of fertilizers are increasing day by day and therefore, it is necessary to reduce the cost of fertilizers by using Rhizobium, PSB and VAM inoculation to increase yield of legume crops. Biofertilizers cannot replace chemical fertilizers, but certainly are capable of reducing their input. Seed inoculation with effective Rhizobium inoculants is recommended to ensure adequate nodulation and N₂ fixation for maximum growth and yield of pulse crop. Farmers are facing severe problem on availability of chemical fertilizers for soybean production. Growers generally use chemical fertilizers to increase soybean production. However, it gives hazardous effect as soil and water pollution. Use of biofertilizer (Rhizobium, PSB & VAM) compared with chemical fertilizers are an attractive and environmental safety method of soybean production. Biofertilizers helps to minimize the use of chemical fertilizer and proved environmental safe and eco-friendly. Phosphorus is an essential major nutrient for the development of plants as it stimulates early
development and promotes healthy growth of seedlings. It also enhances the formation of nodules and nitrogen fixation in legumes. Many scientists used various selected strains of phosphate solubilizers which increase the dry matter, grain yield and ‘P’ uptake (Bothe et al., 2000) [3]. Seed treatment with biofertilizers had their significant effect on microbial population in conjunction with P application in soybean field. Hence an attempt was made to study the effect of phosphorus and biofertilizers on growth and yield of Soybean (*Glycine max* (L.) Merill) under rainfed condition.

**Materials and Methods**

The experiment was conducted during kharif season of 2015 on the Farm of College of Agriculture, Latur (M.S.). The topography of experimental field was uniform and leveled. The soil of experimental plots was clayey in texture. The chemical composition of experimental plots indicated that the soil was low in available nitrogen (118.86 kg ha⁻¹), medium in available phosphorus (20.42 kg ha⁻¹), very high in available potassium (385.89 kg ha⁻¹) content and alkaline in reaction having pH 8.5. The experiment was laid out by using randomized block design with three replications. The treatments were consisting of *Rhizobium*, PSB and VAM viz T₁- No phosphorous application, T₂- 45 kg P₂O₅/ha through SSP T₃- 60 kg P₂O₅/ha through SSP T₄- 45 kg P₂O₅/ha through SSP + PSB T₅- 45 kg P₂O₅/ha through SSP + Rhizobium (R.I.) T₆- 45 kg P₂O₅/ha through SSP+ VAM T₇- 45 kg P₂O₅/ha through SSP+PSB+R.I. T₈- 45 kg P₂O₅/ha through SSP+PSB+R.I.+VAM

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Height Plant ¹</th>
<th>No. of leaves plant ¹</th>
<th>No. of branches plant ¹</th>
<th>Total dry matter plant ¹</th>
<th>No. of nodules plant ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁- No phosphorous application</td>
<td>12.89</td>
<td>7.13</td>
<td>8.30</td>
<td>6.43</td>
<td>22.00</td>
</tr>
<tr>
<td>T₂- 45 kg P₂O₅/ha through SSP</td>
<td>13.59</td>
<td>7.23</td>
<td>8.30</td>
<td>7.21</td>
<td>24.00</td>
</tr>
<tr>
<td>T₃- 60 kg P₂O₅/ha through SSP</td>
<td>14.65</td>
<td>7.33</td>
<td>8.87</td>
<td>6.47</td>
<td>25.00</td>
</tr>
<tr>
<td>T₄- 45 kg P₂O₅/ha through SSP + PSB</td>
<td>15.02</td>
<td>7.43</td>
<td>8.77</td>
<td>6.10</td>
<td>23.33</td>
</tr>
<tr>
<td>T₅- 45 kg P₂O₅/ha through SSP + Rhizobium (R.I.)</td>
<td>17.83</td>
<td>8.83</td>
<td>9.03</td>
<td>6.44</td>
<td>27.00</td>
</tr>
<tr>
<td>T₆- 45 kg P₂O₅/ha through SSP+ VAM</td>
<td>16.09</td>
<td>7.83</td>
<td>9.37</td>
<td>6.49</td>
<td>25.33</td>
</tr>
<tr>
<td>T₇- 45 kg P₂O₅/ha through SSP+PSB+R.I.</td>
<td>18.86</td>
<td>9.28</td>
<td>10.53</td>
<td>6.43</td>
<td>27.00</td>
</tr>
<tr>
<td>T₈- 45 kg P₂O₅/ha through SSP+PSB+R.I.+VAM</td>
<td>17.62</td>
<td>8.40</td>
<td>9.37</td>
<td>5.91</td>
<td>25.33</td>
</tr>
<tr>
<td>T₉- 45 kg P₂O₅/ha through SSP+R.I.+VAM</td>
<td>21.20</td>
<td>9.70</td>
<td>9.93</td>
<td>6.55</td>
<td>27.33</td>
</tr>
<tr>
<td>T₁₀- 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM</td>
<td>19.50</td>
<td>10.90</td>
<td>10.53</td>
<td>7.82</td>
<td>28.33</td>
</tr>
<tr>
<td>SE ±c</td>
<td>0.77</td>
<td>0.47</td>
<td>0.32</td>
<td>0.25</td>
<td>1.17</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>2.29</td>
<td>1.40</td>
<td>0.97</td>
<td>0.73</td>
<td>3.49</td>
</tr>
<tr>
<td>General Mean</td>
<td>27.15</td>
<td>8.40</td>
<td>9.20</td>
<td>6.58</td>
<td>25.47</td>
</tr>
</tbody>
</table>

**Results and Discussion**

**Effect on growth characters**

Data revealed that the number of pods per plant were observed more with the application of 45kg P₂O₅/ha through SSP+PSB+R.I.+ VAM (T₁₀) which was significantly superior overall other treatments and at par with the treatment 45 kg P₂O₅/ha through SSP+R.I.+ VAM (T₅) and 45 kg P₂O₅/ha through SSP+PSB+R.I. (T₇). The application of 45kg P₂O₅/ha through SSP+PSB+R.I. + VAM (T₁₀) recorded significantly higher pod weight plant ¹ (5.09 g). Statistically similar results were recorded for application of 45 kg P₂O₅/ha through SSP+R.I. + VAM (T₅) (4.81 g). Similarly application of 45 kg P₂O₅/ha through SSP+PSB+R.I. + VAM (T₁₀) also recorded significantly higher number of seeds plant ¹ and seed yield plant ¹. More number of seeds plant ¹ was due to better growth of plant and pod bearing capacity which was enhanced due to different treatment as reported by Oad et al., (2002) [8]. The application of 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM (T₁₀) recorded higher mean seed yield (1108 kg ha⁻¹) and it was followed by application 45 kg P₂O₅/ha through SSP+R.I.+VAM (T₅) (1014 kg ha⁻¹) and 45 kg P₂O₅/ha through SSP+PSB+R.I. (T₇) (979 kg ha⁻¹). In case of straw yield also the application of 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM (T₁₀) recorded significantly higher mean straw yield (1495 kg ha⁻¹) followed by the application of 45 kg P₂O₅/ha through SSP+R.I.+VAM (T₅) (1355 kg ha⁻¹). This might because of the cumulative effect in increasing growth contributing characters which have been clearly exhibited on the final produce i.e. seed and straw yield ha⁻¹. Similar kind of results was reported by Ingle et al., (2001). [4]
Table 2: Number of pods plant⁻¹, weight of pods plant⁻¹, seed yield plant⁻¹, number of seeds plant⁻¹ and seed yield kg ha⁻¹ and straw yield kg ha⁻¹ of soybean as influenced by various treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of pods plant⁻¹</th>
<th>Weight of pods (g)</th>
<th>No. of seeds plant⁻¹</th>
<th>Seed yield plant⁻¹</th>
<th>Seed yield kg ha⁻¹</th>
<th>Straw yield Kg ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ - No phosphorous application</td>
<td>12.46</td>
<td>3.03</td>
<td>25.67</td>
<td>2.23</td>
<td>808</td>
<td>954</td>
</tr>
<tr>
<td>T₂ - 45 kg P₂O₅/ha through SSP</td>
<td>14.02</td>
<td>3.08</td>
<td>26.47</td>
<td>2.47</td>
<td>884</td>
<td>1084</td>
</tr>
<tr>
<td>T₃ - 60 kg P₂O₅/ha through SSP</td>
<td>14.25</td>
<td>3.37</td>
<td>27.67</td>
<td>2.50</td>
<td>917</td>
<td>1108</td>
</tr>
<tr>
<td>T₄ - 45 kg P₂O₅/ha through SSP + PSB</td>
<td>14.75</td>
<td>3.65</td>
<td>28.33</td>
<td>2.62</td>
<td>920</td>
<td>1144</td>
</tr>
<tr>
<td>T₅ - 45 kg P₂O₅/ha through SSP + Rhizobium (R.I.)</td>
<td>17.29</td>
<td>4.20</td>
<td>29.00</td>
<td>3.00</td>
<td>959</td>
<td>1189</td>
</tr>
<tr>
<td>T₆ - 45 kg P₂O₅/ha through SSP + VAM</td>
<td>15.35</td>
<td>3.85</td>
<td>28.67</td>
<td>2.73</td>
<td>929</td>
<td>1168</td>
</tr>
<tr>
<td>T₇ - 45 kg P₂O₅/ha through SSP+PSB+R.I.</td>
<td>18.11</td>
<td>4.30</td>
<td>31.83</td>
<td>3.20</td>
<td>979</td>
<td>1284</td>
</tr>
<tr>
<td>T₈ - 45 kg P₂O₅/ha through SSP+PSB+R.I.+VAM</td>
<td>16.38</td>
<td>3.90</td>
<td>28.67</td>
<td>2.78</td>
<td>939</td>
<td>1196</td>
</tr>
<tr>
<td>T₉ - 45 kg P₂O₅/ha through SSP+R.I.+VAM</td>
<td>20.18</td>
<td>4.81</td>
<td>32.33</td>
<td>3.33</td>
<td>1014</td>
<td>1355</td>
</tr>
<tr>
<td>T₁₀ - 45 kg P₂O₅/ha through SSP+PSB+R.I.+VAM</td>
<td>21.55</td>
<td>5.09</td>
<td>34.67</td>
<td>3.57</td>
<td>1104</td>
<td>1495</td>
</tr>
<tr>
<td>SE ±</td>
<td>0.74</td>
<td>0.25</td>
<td>1.31</td>
<td>0.14</td>
<td>46</td>
<td>80</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>2.21</td>
<td>0.74</td>
<td>3.88</td>
<td>0.42</td>
<td>136</td>
<td>239</td>
</tr>
<tr>
<td>General Mean</td>
<td>16.43</td>
<td>3.93</td>
<td>29.33</td>
<td>2.84</td>
<td>945</td>
<td>1198</td>
</tr>
</tbody>
</table>

Conclusions

On the basis of present investigation following broad conclusions can be drawn.

1. Rainfed soybean responded positively to different phosphorus application treatments. Application of 45 kg P₂O₅/ha through SSP+PSB+R.I.+ VAM (T₁₀) performed the best amongst the various phosphorus treatments evaluated with regards to growth, yield attributing characters and yield of soybean.

2. Application of 45 kg P₂O₅/ha through SSP+R.I.+VAM (T₉) was the second best treatment in improving growth, yield attributing characters and yield of soybean.

References

1. Fotouhi L, Shahbaazi HR, Fatehi A, Heravi MM. Anonymous. Area and production estimates of soybean in India in kharif monsoon, 2013. w.w.w.sopa.org/crop.po.doc.


