Productivity and profitability of frenchbean (Phaseolus vulgaris) as influenced by nutrient management in cold desert region of north-western Himalaya

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ABSTRACT

A field experiment was conducted during the summer seasons of 2012 and 2013 at Kukumseri, Lahaul and Spiti, Himachal Pradesh, to study the effect of nutrient management on productivity and profitability of frenchbean (Phaseolus vulgaris L.). Combined application of chemical fertilizers and biofertilizers increased growth, yield and economics of frenchbean. Application of 40 kg N/ha with and without Rhizobium and phosphate -solubilizing bacteria (PSB) produced the tallest plants. Application of 20 kg N/ha followed by combined application of biofertilizers with 20, 40 and 60 kg N/ha resulted in the highest dry-matter production. Dry-matter efficiency was significantly higher in N₂₀ + biofertilizers followed by N₄₀, while unit area efficiency was also in N₂₀ + biofertilizers followed by N₄₀ and combined application of biofertilizers with 20, 40 and 60 kg N/ha. Significantly higher seed weight was recorded in N₆₀ + Rhizobium and PSB followed by N₆₀, N₄₀ and N₄₀ + Rhizobium and PSB treatments. Seeds/pod were significantly higher in N₂₀ + Rhizobium and PSB followed by combined application of biofertilizers with N₄₀ and N₆₀. The highest seed yield (3.27 t/ha), productivity (34.42 kg/ha/day), net returns (¥258.49 × 10³/ha) and profitability (¥2721/ha/day) were recorded in N₂₀ + Rhizobium and PSB. Hence, application of 20 kg N/ha with Rhizobium and PSB proved beneficial for enhancing productivity and profitability of frenchbean in cold desert region of North-western Himalaya.

Key words : Biofertilizers, Frenchbean, Growth, Nitrogen, Productivity, Profitability

The cold desert region of North-western Himalaya is a vast stretch of harsh, inaccessible and arid temperate area. It constitutes 79,278 km² of area and spread over Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Sikkim. Himachal Pradesh consists of about 42% cold desert region of its total geographical area. In the region, the climate is extremely cold and heavy snowfall occurs during winter. The temperature at some places remains several degrees below zero level. Single cropping season prevails in the region where both rainy (kharif) and winter (rabi) crops are grown simultaneously due to short favourable growing conditions starting from end of April to end of September or first week of October. The entire population of the region is rural and mainly illiterate, and economically backward.

Frenchbean (Phaseolus vulgaris L.) is also known as rajmash as grain legume and common bean, snap bean and green bean as vegetable (Singh et al., 2014). It is a nutritive legume crop containing 20.69 to 25.81% crude protein, 1.72% fats and 72.42% carbohydrates (Sood et al., 2003) in addition to dietary fibre, potassium, selenium, molybdenum, thiamine, vitamin B₆ and folic acid (Turuko and Mohammed, 2014). It is a major source of income for the cold desert farmers, as there is a great demand of the frenchbean seed in the other parts of the country owing to its better quality and taste.

In the cold desert region, the productivity of frenchbean is deteriorating due to a number of production factors. Inappropriate use of chemical fertilizers is one of the major factors. Farmers are not economically rich to afford chemical fertilizers for their crops due to their increasing prices. There is also acute scarcity of organic manures in the region. Inappropriate application of nutrients in crop causes poor growth and productivity, even if all other practices are adopted in appropriate manner (Kumar et al., 2006). Biofertilizers are cost effective, ecofriendly and renewable source of plant nutrients to supplement chemical fertilizers in agricultural ecosystem (Mohammad and Sohrabi,
Integrated use of inorganic fertilizers and biofertilizers may lead to reduce the dose of chemical fertilizers to a level that is within the reach of small and marginal farmers of the area. Since very little information on this aspect is available for frenchbean being grown in cold desert region of North-western Himalaya, the present investigation was undertaken to study the effect of nutrient management on productivity and profitability of frenchbean.

MATERIALS AND METHODS

A field experiment was conducted during summer seasons of 2012 and 2013 at the Research Farm, Highland Agricultural Research and Extension Centre of the CSK Himachal Pradesh Krishi Vishvavidyalaya, Kukumseri (32° 44' 55’ N and 76° 41' 23’ E, and 2,672 m above mean sea-level), Lahaul and Spiti, Himachal Pradesh, India. Single cropping season with 100% cropping intensity prevailed in the region. During this period, the mean minimum and maximum temperatures range between 12°C and 24°C. Average annual rainfall of the region is 250 mm. The soil of the experimental site was sandy loam, acidic in reaction (pH 6.1) with 10.8 g organic carbon/kg soil, 284 kg available N/ha, 31 kg available P/ha and 304 kg available K/ha. The experiment was laid out in a randomized block design. There were 9 treatments, viz. N20, N20 + Rhizobium and phosphate-solubilizing bacteria (PSB), N40, N40 + Rhizobium and PSB, N60, N60 + Rhizobium and PSB, N0 + Rhizobium and PSB, N20 + Rhizobium and PSB applied in soil and N0BF0 (no application of NPK fertilizers and biofertilizers, absolute control), which were allocated randomly in the different experimental plots using random table and were replicated thrice. Frenchbean ‘Contender’, having dwarf and bushy stature, early maturity and dark green pod with bold seeds was used as test crop. Nitrogen, phosphorus and potassium were supplied through chemical fertilizer, namely urea, single superphosphate and muriate of potash, respectively. Nitrogen was applied as per treatments, whereas phosphorus and potassium were applied @ 60 and 30 kg/ha, respectively, in all the plots except absolute control plot. In the region, recommended dose of nitrogen, phosphorus and potassium is 20, 60 and 0 kg/ha, respectively. All the chemical fertilizers were applied as basal. Rhizobium and phosphate-solubilizing bacteria were used as biofertilizers (BF). As per treatments, seeds were inoculated with biofertilizers except 1 treatment where biofertilizers were applied in soil (furrow) before sowing. Seed rate was kept @ 100 kg/ha. The crop was sown at 30-cm-row spacing during the first week of June 2012 and 2013. Seeds were treated with fungicide, bavistin @ 2.5 g/kg seed for the control of seed-borne diseases. Pendimethalin (30 EC) was sprayed @ 4.5 litres/750 litres of water/ha within 48 hours of sowing for the control of weeds. The other crop-management practices were also followed as per standard recommendation for the region.

Growth (plant height, dry-matter production, dry-matter efficiency and unit area efficiency), yield attributes (pod length, seeds/pod and seed weight), seed yield and straw yield, productivity, net returns, benefit: cost ratio and profitability were recorded and computed for interpretation of the results. Dry-matter efficiency is the per cent of total dry-matter production (seed yield and straw yield) accumulated in seed per day. Unit-area efficiency is expressed as the quantum of seed yield produced over a unit land area for a specified crop growth period. These growth analysis parameters were calculated as:

\[
\text{Dry-matter efficiency} = \frac{\text{Seed yield}}{\text{Total dry-matter production}} \times \frac{100}{\text{Duration of crop}}
\]

\[
\text{Unit area efficiency} = \frac{\text{Seed yield}}{\text{Land area}} \times \frac{1}{\text{Duration of crop}}
\]

The field data obtained for 2 years were pooled and statistically analyzed using ‘F’ test (Gomez and Gomez, 1984). Test of significance of the treatment differences were done on the basis of ‘t’ test. The significant difference between mean of treatments were compared with critical differences at 5% level of probability.

RESULTS AND DISCUSSION

Growth

Growth parameters, viz. plant height, dry-matter production, dry-matter efficiency and unit area efficiency, were significantly influenced by different treatments. Plant height increased significantly up to 40 kg N/ha with or without biofertilizers. The tallest plants were recorded in the treatment N20 + Rhizobium and phosphate-solubilizing bacteria (PSB) followed by N40 + Rhizobium and PSB, N60 + Rhizobium and PSB, N20 + Rhizobium and PSB, N0 + Rhizobium and PSB applied in soil, N0BF0 (no application of NPK fertilizers and biofertilizers, absolute control), which were allocated randomly in the different experimental plots using random table and were replicated thrice. Frenchbean ‘Contender’, having dwarf and bushy stature, early maturity and dark green pod with bold seeds was used as test crop. Nitrogen, phosphorus and potassium were supplied through chemical fertilizer, namely urea, single superphosphate and muriate of potash, respectively. Nitrogen was applied as per treatments, whereas phosphorus and potassium were applied @ 60 and 30 kg/ha, respectively, in all the plots except absolute control plot. In the region, recommended dose of nitrogen, phosphorus and potassium is 20, 60 and 0 kg/ha, respectively. All the chemical fertilizers were applied as basal. Rhizobium and phosphate-solubilizing bacteria were used as biofertilizers (BF). As per treatments, seeds were inoculated with biofertilizers except 1 treatment where biofertilizers were applied in soil (furrow) before sowing. Seed rate was kept @ 100 kg/ha. The crop was sown at 30-cm-row spacing during the first week of June 2012 and 2013. Seeds were treated with fungicide, bavistin @ 2.5 g/kg seed for the control of seed-borne diseases. Pendimethalin (30 EC) was sprayed @ 4.5 litres/750
Dry-matter production was recorded under treatment N₀BF₀. The treatments N₂₀, N₂₀ + *Rhizobium* and PSB, N₄₀ + *Rhizobium* and PSB and N₆₀ + *Rhizobium* and PSB produced 79, 75.4, 76 and 75.9% higher dry-matter than N₀BF₀ treatment, respectively.

Dry-matter efficiency was significantly increased owing to combined application of nitrogen and biofertilizers. The highest dry-matter efficiency was recorded under N₂₀ + *Rhizobium* and phosphate-solubilizing bacteria, followed by N₄₀ and N₀ + seed inoculated with *Rhizobium* and PSB. Soil treated with biofertilizers and the inoculated seeds differed significantly in respect of dry-matter efficiency. Higher dry-matter efficiency was recorded under N₀ + seeds inoculated with *Rhizobium* and PSB than N₀ + *Rhizobium* and PSB applied in soil. The lowest dry-matter efficiency was noted in N₀ followed by N₀ + *Rhizobium* and PSB applied in soil and N₀BF₀ treatment. Like dry-matter efficiency, unit area efficiency was also significantly increased with the integrated use of nitrogen and biofertilizers. The highest unit area efficiency was observed under N₂₀ + biofertilizers, followed by N₂₀, N₄₀, N₄₀ + *Rhizobium* and PSB, and N₆₀ + *Rhizobium* and PSB, while the lowest was under N₀BF₀ treatment. Soil treated with biofertilizers and the inoculated seeds were found to be at par but resulted in significantly higher unit area efficiency than the control treatment and lower than combined application of nitrogen, *Rhizobium* and phosphate-solubilizing bacteria (Table 1).

The higher values of growth attributes, *viz.* plant height, dry-matter production, dry-matter efficiency and unit area efficiency, were recorded with combined application of chemical fertilizers, *Rhizobium* and phosphate solubilizing bacteria, might be owing to supply of all the essential nutrients in balanced amount resulted in better growth and development (Thirumelai *et al.*, 1993). Integrated use of chemical fertilizers and biofertilizers also improves physical, chemical and biological properties of the soil which favour better nutrition to crops resulting in better growth of the crops. Inoculation of seeds with biofertilizers enhances nutrient supply to plants. Nitrogen plays an important role in increasing vegetative growth, while phosphorus and potassium improve root growth and grain quality, respectively. Potassium enhances availability of N and P. Increase in growth might be owing to better availability of macro and micronutrients at critical growth stages (Chandra *et al.*, 1987; Thakur *et al.*, 1999). Parmar *et al.* (1999) and Kumar *et al.* (2009) also reported significant effect of combined use of chemical fertilizers and biofertilizers on growth and yield of the crop.

### Yield-attributing characters

Yield attributes, namely pod length, seeds/pod and 100-seed weight, were significantly affected by different treatments. Pod length significantly increased with combined application of chemical fertilizers and biofertilizers over the control treatment. It increased with increase in the level of N with or without biofertilizers. The longest pods were recorded under N₆₀ + *Rhizobium* and PSB treatments followed by N₆₀. The shortest pods were observed in the control treatment. Longer pods were recorded in N₀ + *Rhizobium* and PSB and N₀ + *Rhizobium* and PSB applied in soil over the control treatment but shorter than the rest of the treatments (Table 2). Like pod length, seeds/pod also increased significantly with integrated use of nitrogen and biofertilizers. Significantly higher number of seeds/pod was noted under all the treatments except N₀ + *Rhizobium*

### Table 1: Effect of nitrogen and biofertilizers on plant height, dry-matter production, dry-matter efficiency and unit area efficiency of frenchbean (pooled data of 2 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Dry-matter production (t/ha)</th>
<th>Dry-matter efficiency (%/day)</th>
<th>Unit area efficiency (kg/ha/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₀BF₀</td>
<td>29.9</td>
<td>5.29</td>
<td>0.36</td>
<td>19.1</td>
</tr>
<tr>
<td>N₀BF₀*</td>
<td>28.0</td>
<td>4.99</td>
<td>0.35</td>
<td>18.1</td>
</tr>
<tr>
<td>N₀BF₀*</td>
<td>0.9</td>
<td>0.06</td>
<td>0.003</td>
<td>0.5</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>2.7</td>
<td>0.19</td>
<td>0.01</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*Biofertilizers were applied in soil; PSB, phosphate-solubilizing bacteria
60 kg P and 30 kg K/ha were applied in all the treatments except N₀BF₀
bium and PSB and N₀ + Rhizobium and PSB applied in soil, while the lowest was in treatment N₀BF₀. Seeds/pod recorded under N₀ + seeds inoculated with Rhizobium and PSB and N₀ + Rhizobium and PSB applied in soil were statistically similar but lower than rest of the treatments except N₂₀, N₂₀ + Rhizobium and phosphate-solubilizing bacteria and N₀BF₀ treatment. Seed weight was an important yield-contributing character which increased with the increase in level of N up to 60 kg/ha with or without biofertilizers. The highest seed weight was recorded in N₀ + Rhizobium and PSB and N₀ + Rhizobium and PSB applied in soil, but higher than the control and lower than rest of the treatments. The lowest seed weight was noted in the control. Kushwaha (1994), Thakur et al. (1999), Turuko and Mohammed (2004), Kumar et al. (2006, 2009) and Girma (2009) also observed significant effect of chemical fertilizers and biofertilizers on yield attributes. The higher values of these yield-contributing characters may be attributed to increased nutrients availability, improved nodulation, nitrogen fixation and production of secondary metabolites by nitrogen fixing and phosphate-solubilizing bacteria. Insufficient availability of nutrients in the control treatment resulted in poor yield attributes.

Yield

Yields were also significantly influenced by different treatments. Significantly higher seed yield was recorded with integrated use of nitrogen and biofertilizers over the control as well as N₀ + biofertilizers. The highest seed yield was recorded under treatment N₂₀ + biofertilizers, while the lowest in treatment N₀BF₀. An increase of 80% in seed yield was noted in N₂₀ + Rhizobium and phosphate-solubilizing bacteria as compared to the control. Similar seed yield was recorded in the treatments, soil treated with biofertilizers and the inoculated seeds but higher than the control treatment and lower than the rest of the treatments. Like seed yield, straw yield also increased significantly with combined application of nitrogen and biofertilizers over the control and N₀ + biofertilizers. The highest straw yield was recorded in N₂₀ followed by N₂₀ + Rhizobium and phosphate-solubilizing bacteria, while the lowest was in the control treatment. The N₀ + biofertilizers resulted in higher straw yield than control treatment but lower than rest of the treatments. Soil treated with biofertilizers and the inoculated seeds produced statistically similar straw yield (Table 2). The highest productivity was recorded under N₂₀ + Rhizobium and phosphate-solubilizing bacteria which was 80.68, 49.33 and 44.68% higher than N₀BF₀, N₀ + seeds inoculated with Rhizobium and phosphate solubilizing bacteria and N₀ + Rhizobium and phosphate-solubilizing bacteria applied in soil (Table 2). In the cold desert region, only single crop is grown in a year and thus, the fields remain fallow or covered with snow for 7 to 8 months. This results in enhancing and restoring soil fertility. Due to the higher soil fertility, frenchbean could respond to 20 kg N/ha with biofertilizers. Srinivas and Rao (1984), Singh (1987), Verma and Saxena (1995), Kumar et al. (2006, 2009) and Hussainmdar et al. (2014) also observed significant response of common bean to in-

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pod length (cm)</th>
<th>Grams/pod</th>
<th>100-seed weight (g)</th>
<th>Seed yield (t/ha)</th>
<th>Straw yield (t/ha)</th>
<th>Productivity (kg/ha/day)</th>
<th>Net returns (× 10⁴ ₹/ha)</th>
<th>Benefit: cost ratio</th>
<th>Profitability (₹/ha/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₀</td>
<td>13.16</td>
<td>4.25</td>
<td>51.36</td>
<td>3.24</td>
<td>6.24</td>
<td>34.1</td>
<td>256.8</td>
<td>4.47</td>
<td>2704</td>
</tr>
<tr>
<td>N₂₀ + Rhizobium and PSB</td>
<td>13.63</td>
<td>4.45</td>
<td>51.93</td>
<td>3.27</td>
<td>6.02</td>
<td>34.4</td>
<td>258.4</td>
<td>4.47</td>
<td>2721</td>
</tr>
<tr>
<td>N₄₀</td>
<td>14.21</td>
<td>4.78</td>
<td>53.61</td>
<td>3.16</td>
<td>5.82</td>
<td>33.2</td>
<td>247.3</td>
<td>4.33</td>
<td>2604</td>
</tr>
<tr>
<td>N₄₀ + Rhizobium and PSB</td>
<td>14.59</td>
<td>4.72</td>
<td>53.76</td>
<td>3.21</td>
<td>6.13</td>
<td>33.7</td>
<td>253.6</td>
<td>4.40</td>
<td>2670</td>
</tr>
<tr>
<td>N₆₀</td>
<td>15.22</td>
<td>4.84</td>
<td>54.97</td>
<td>3.00</td>
<td>6.24</td>
<td>31.5</td>
<td>234.3</td>
<td>4.15</td>
<td>2466</td>
</tr>
<tr>
<td>N₆₀ + Rhizobium and PSB</td>
<td>15.86</td>
<td>4.85</td>
<td>55.19</td>
<td>3.15</td>
<td>6.17</td>
<td>33.1</td>
<td>247.3</td>
<td>4.30</td>
<td>2604</td>
</tr>
<tr>
<td>N₀BF₀</td>
<td>11.48</td>
<td>3.57</td>
<td>42.39</td>
<td>1.81</td>
<td>3.48</td>
<td>19.0</td>
<td>114.9</td>
<td>2.64</td>
<td>1210</td>
</tr>
<tr>
<td>SEm</td>
<td>0.26</td>
<td>0.18</td>
<td>0.38</td>
<td>0.05</td>
<td>0.06</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.79</td>
<td>0.55</td>
<td>1.13</td>
<td>0.13</td>
<td>0.19</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Biofertilizers were applied in soil; PSB, phosphate-solubilizing bacteria. 60 kg P and 30 kg K/ha were applied in all the treatments except N₀BF₀.
tegrated use of chemical fertilizers and microbial inoculants in terms of seed yield and straw yield. The increased yield might be attributed due to significant influence of nitrogen on translocation of nutrients and dry-matter accumulation during reproductive stage which in turn improved growth and yield attributes, and ultimately seed yield and straw yield (Sharma et al., 2003; Singh et al., 2009).

Economics

The adoption of any technology in modern agriculture can only be feasible and acceptable to farmers if it is economically viable. The highest net returns, benefit: cost ratio and profitability were recorded in N$_{20}$ + Rhizobium and phosphate-solubilizing bacteria, while the lowest in the N$_{0}$BF$_{0}$ (Table 2). Application of nitrogen with biofertilizers resulted in higher values of all economics parameters than sole application of nitrogen. The treatment N$_{0}$ + Rhizobium and PSB applied in soil proved to be superior to N$_{0}$ + seeds inoculated with Rhizobium and PSB. An increase of 124.8% in net returns, 69.9% in benefit: cost ratio and 124.8% in profitability was recorded under N$_{20}$ + Rhizobium and phosphate-solubilizing bacteria as compared to N$_{0}$BF$_{0}$ treatment. The highest net returns, benefit: cost ratio and profitability observed in N$_{20}$ + Rhizobium and phosphate-solubilizing bacteria could be attributed due to increased yield with integrated use of chemical fertilizers and biofertilizers (Sharma et al., 2003; Kumar et al., 2006, 2009; Singh et al., 2009). Poor yield in the control treatment resulted in the lowest profitability.

Based on the results of present study, it was concluded that application of 20 kg N/ha in combination with Rhizobium and phosphate-solubilizing bacteria is the best treatment for increasing the productivity and profitability of frenchbean in cold desert region of North-western Himalaya.

REFERENCES


