

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

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Received : December 2015; Revised accepted : February 2016

### 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 N<sub>20</sub> + biofertilizers followed by N<sub>40</sub>, while unit area efficiency was also in N<sub>20</sub> + biofertilizers followed by N<sub>40</sub> and combined application of biofertilizers with 20, 40 and 60 kg N/ha. Significantly higher seed weight was recorded in N<sub>60</sub> + *Rhizobium* and PSB followed by N<sub>60</sub>, N<sub>40</sub> and N<sub>40</sub> + *Rhizobium* and PSB treatments. Seeds/pod were significantly higher in N<sub>20</sub> + *Rhizobium* and PSB followed by combined application of biofertilizers with N<sub>40</sub> and N<sub>60</sub>. The highest seed yield (3.27 t/ha), productivity (34.42 kg/ha/day), net returns (₹258.49 × 10<sup>3</sup>/ha) and profitability (₹2721/ha/day) were recorded in N<sub>20</sub> + *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 km<sup>2</sup> 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 (*khariif*) 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 B<sub>6</sub> 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 Sohrobi,

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2012). 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 prevails 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. N<sub>20</sub>, N<sub>20</sub> + *Rhizobium* and phosphate-solubilizing bacteria (PSB), N<sub>40</sub>, N<sub>40</sub> + *Rhizobium* and PSB, N<sub>60</sub>, N<sub>60</sub> + *Rhizobium* and PSB, N<sub>0</sub> + *Rhizobium* and PSB, N<sub>0</sub> + *Rhizobium* and PSB applied in soil and N<sub>0</sub>BF<sub>0</sub> (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 N<sub>20</sub> + *Rhizobium* and phosphate-solubilizing bacteria (PSB) followed by N<sub>40</sub> + *Rhizobium* and PSB, N<sub>60</sub> and N<sub>60</sub> + *Rhizobium* and PSB, while the shortest plants were in treatment N<sub>0</sub>BF<sub>0</sub>. Soil treated with biofertilizers and the inoculated seeds resulted in similar plant height but plants recorded in these treatments were significantly taller than those under N<sub>0</sub>BF<sub>0</sub> treatment and shorter than other treatments consisting of nitrogen and biofertilizers (Table 1).

Dry-matter production was also increased significantly with application of nitrogen and biofertilizers. The highest dry-matter production was recorded under N<sub>20</sub> followed by N<sub>20</sub> + *Rhizobium* and PSB, N<sub>40</sub> + *Rhizobium* and PSB and N<sub>60</sub> + *Rhizobium* and PSB treatments. Soil treated with biofertilizers and the inoculated seeds produced significantly higher dry matter production than the control and lower than rest of the treatments. The lowest

dry-matter production was recorded under treatment  $N_0BF_0$ . The treatments  $N_{20}$ ,  $N_{20} + Rhizobium$  and PSB,  $N_{40} + Rhizobium$  and PSB and  $N_{60} + Rhizobium$  and PSB produced 79, 75.4, 76 and 75.9% higher dry-matter than  $N_0BF_0$  treatment, respectively.

Dry-matter efficiency was significantly increased owing to combined application of nitrogen and biofertilizers. The highest dry-matter efficiency was recorded under  $N_{20} + Rhizobium$  and phosphate-solubilizing bacteria, followed by  $N_{40}$  and  $N_0 +$  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  $N_0 +$  seeds inoculated with *Rhizobium* and PSB than  $N_0 + Rhizobium$  and PSB applied in soil. The lowest dry-matter efficiency was noted in  $N_{60}$  followed by  $N_0 + Rhizobium$  and PSB applied in soil and  $N_0BF_0$  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  $N_{20} +$  biofertilizers, followed by  $N_{20}$ ,  $N_{40}$ ,  $N_{40} + Rhizobium$  and PSB, and  $N_{60} + Rhizobium$  and PSB, while the lowest was under  $N_0BF_0$  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 nu-

trients 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  $N_{60} + Rhizobium$  and PSB treatments followed by  $N_{60}$ . The shortest pods were observed in the control treatment. Longer pods were recorded in  $N_0 + Rhizobium$  and PSB and  $N_0 + Rhizobium$  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  $N_0 + Rhizo-$

**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)

Treatment	Plant height (cm)	Dry-matter production (t/ha)	Dry-matter efficiency (%/day)	Unit area efficiency (kg/ha/day)
$N_{20}$	37.2	9.48	0.36	34.1
$N_{20} + Rhizobium$ and PSB	37.1	9.29	0.37	34.4
$N_{40}$	41.9	8.98	0.37	33.2
$N_{40} + Rhizobium$ and PSB	41.6	9.34	0.36	33.8
$N_{60}$	40.5	9.25	0.35	31.6
$N_{60} + Rhizobium$ and PSB	41.2	9.32	0.36	33.2
$N_0 + Rhizobium$ and PSB	31.6	6.24	0.37	23.0
$N_0 + Rhizobium$ and PSB*	32.1	6.74	0.35	23.8
$N_0BF_0$	29.9	5.29	0.36	19.1
SEm±	0.9	0.06	0.003	0.5
CD (P=0.05)	2.7	0.19	0.01	1.4

\*Biofertilizers were applied in soil; PSB, phosphate-solubilizing bacteria 60 kg P and 30 kg K/ha were applied in all the treatments except  $N_0BF_0$

*bium* and PSB and  $N_0 + Rhizobium$  and PSB applied in soil, while the lowest was in treatment  $N_0BF_0$ . Seeds/pod recorded under  $N_0 + seeds$  inoculated with *Rhizobium* and PSB and  $N_0 + Rhizobium$  and PSB applied in soil were statistically similar but lower than rest of the treatments except  $N_{20}$ ,  $N_{20} + Rhizobium$  and phosphate-solubilizing bacteria and  $N_0BF_0$  treatment. Seed weight is 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  $N_{60} + Rhizobium$  and PSB followed by  $N_{40}$ ,  $N_{40} + Rhizobium$  and PSB and  $N_{60}$  seed weight was statistically similar in  $N_0 + seeds$  inoculated with *Rhizobium* and PSB and  $N_0 + Rhizobium$  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  $N_0 +$  biofertilizers. The highest seed yield was recorded under treatment  $N_{20} +$  biofertilizers, while the lowest in treatment  $N_0BF_0$ . An increase of 80% in seed yield was noted in  $N_{20} + Rhizobium$  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  $N_0 +$  biofertilizers. The highest straw yield was recorded in  $N_{20}$  followed by  $N_{20} + Rhizobium$  and phosphate-solubilizing bacteria, while the lowest was in the control treatment. The  $N_0 +$  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  $N_{20} + Rhizobium$  and phosphate-solubilizing bacteria which was 80.68, 49.33 and 44.68% higher than  $N_0BF_0$ ,  $N_0 + seeds$  inoculated with *Rhizobium* and phosphate solubilizing bacteria and  $N_0 + Rhizobium$  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 Hussaindar *et al.* (2014) also observed significant response of common bean to in-

**Table 2.** Effect of nitrogen and biofertilizers on yield attributes, yield, productivity, net returns, benefit: cost ratio and profitability of frenchbean (pooled data of 2 years)

Treatment	Yield attributes			Yield		Productivity (kg/ha/day)	Net returns ( $\times 10^3$ ₹/ha)	Benefit: cost ratio	Profitability (₹/ha/day)
	Pod length (cm)	Grains/pod	100-seed weight (g)	Seed yield (t/ha)	Straw yield (t/ha)				
$N_{20}$	13.16	4.25	51.36	3.24	6.24	34.1	256.8	4.47	2704
$N_{20} + Rhizobium$ and PSB	13.63	4.45	51.93	3.27	6.02	34.4	258.4	4.47	2721
$N_{40}$	14.21	4.78	53.61	3.16	5.82	33.2	247.3	4.33	2604
$N_{40} + Rhizobium$ and PSB	14.59	4.72	53.76	3.21	6.13	33.7	253.6	4.40	2670
$N_{60}$	15.22	4.84	54.97	3.00	6.24	31.5	234.3	4.15	2466
$N_{60} + Rhizobium$ and PSB	15.86	4.85	55.19	3.15	6.17	33.1	247.3	4.30	2604
$N_0 + Rhizobium$ and PSB	12.85	4.08	48.18	2.19	4.05	23.0	148.6	3.00	1565
$N_0 + Rhizobium$ and PSB*	12.78	4.03	47.97	2.26	4.47	23.7	157.6	3.12	1659
$N_0BF_0$	11.48	3.57	42.39	1.81	3.48	19.0	114.9	2.64	1210
SEm $\pm$	0.26	0.18	0.38	0.05	0.06	-	-	-	-
CD (P=0.05)	0.79	0.55	1.13	0.13	0.19	-	-	-	-

\*Biofertilizers were applied in soil; PSB, phosphate-solubilizing bacteria 60 kg P and 30 kg K/ha were applied in all the treatments except  $N_0BF_0$ .

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  $N_0BF_0$  (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  $N_0BF_0$  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.

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