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Effect of integrated nutrition on productivity, profitability and quality of French bean (*Phaseolus vulgaris)*

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ABSTRACT

A field experiment was conducted to investigate the effect of integrated nutrition along with application of micronutrient and biofertilizers on productivity and profitability of french bean (*Phaseolus vulgaris* L.) at the ICAR-RC for NEH Region, Nagaland Centre, Jharnapani, during *rabi* 2013–15. Treatment consisted of four nutrition levels, viz. control, 100% RDF (80-60-30-20 kg NPKS/ha), 100% RDN (RDN:80 kg/ha through 16 t/ha of FYM), 75% RDF + 25% RDN and 100% RDF + 25% RDN in main-plot and five levels of biofertilizers + micronutrient, viz. control, PGPR (*Rhizobimum* + *Bacillus* + *Pseudomonas*), PGPR + 5 kg Zn/ha, PGPR + 1.5 kg Mo/ha and PGPR + 5 kg Zn + 1.5 kg Mo/ha in sub-plot. Experiment was laid out in split-plot design and replicated thrice. Significantly higher seed yield (1630 kg/ha) was recorded with application of 100% RDF + 25% RDN, which was 30% higher over 100% RDN. Maximum net returns (₹ 21399/ha), B:C ratio (1.31), production efficiency (15.8 kg/ha/day) and economic efficiency (₹ 305/ha/day) were noted with 100% RDF + 25% RDN. Maximum grain yield (1551 kg/ha) had recorded with PGPR +5 kg Zn ha+1.5 kg Mo/ha. Maximum net returns (₹ 29941/ha), B:C ratio (1.30), production efficiency (15.1 kg/ha/day) and economic efficiency (₹ 210/ha/day) were also noted with PGPR+5 kg Zn ha + 1.5 kg Mo/ha. Thus, to achieve the higher productivity and profitability, french bean could be grown with 100% RDF+25% RDN through organic manures (FYM) and seed inoculation with PGPRs + micronutrient in foot hill condition of Eastern Himalayas.

Key words: French bean, Micronutrient, PGPRs, Productivity, Profitability, Quality

French bean (*Phaseolus vulgaris* L.) commonly known as rajmash, common bean, dry bean, pinto bean, field bean, navy bean and kidney bean and grown as premier pulse crop in the worldwide. It is newly introduced as non-traditional winter pulse crop in India with high yield potential of 2.5–3.5 t/ha. This crop is gaining importance in country for its dual uses both for green pods and dried grain, and spreading to north eastern hilly (NEH) states of India like Nagaland. The lower productivity of french bean has been found mainly due to inadequate nutrition management in NEH region. Modern agriculture requires intensive use of chemical fertilizers, but price of inorganic fertilizers has gone up considerably, which in turn increased the production cost and decreased markedly fertility status of the soil (Kumawat *et al*. 2009a, b, c). In view to maintaining the agro-ecosystem, it has become necessary to minimize the uses of chemical fertilizers by adding organic sources more, mainly biofertilizers (PGPRs) and organic manures (Kumar 2015).Thus, optimum fertilization along with farm yard manures (FYM), biofertilizers and micronutrient to crop has to be standardized, which enables as to meet the entire nutrient requirement during cropping and to obtain a better crop yield (Kumar *et al*. 2014, Kumar *et al*. 2015a). Supplying of nutrition through, PGPRs (plant-growth rhizobacteria) and micronutrients sources has found the best option for increasing the crop productivity (Kumar *et al*. 2010). There is ample scope of increasing productivity through combined use of nutrition sources that reduce load of chemical fertilizers within reach of small and marginal farmers (Saikia *et al*. 2018). Combined nutrition of NPKS and micronutrient is always beneficial for enhancing the crop yield. Most of the micronutrients are highly essential for plant growth and development and increase bacterial activity of nodule in pulses (Kumar *et al*. 2010). Therefore, an optimum supply of nutrients in balanced modes is foremost important to achieve the higher productivity in foot hill condition of Eastern Himalayas. Keeping these things in view, the present study was undertaken.

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MATERIALS AND METHODS

The field experiment was conducted on french bean during two consecutive *rabi* season of 2013–14 and

2014–15 at the ICAR-RC-NEH Region, Nagaland Centre, Jharnapani, Medziphema on a sandy loam soil (sand : 80%, slit:9%, clay: 11%, Inceptisol) having *p*H (1:2) 5.74, EC (1:2) 0.125 d/Sm and soil organic carbon of 0.72%. Soil of the experimental site was low in available nitrogen (150 kg N/ha), potassium (174.3 kg K_2O/ha) and moderate in phosphorus (18.7 kg P_2O_5/ha) and sulphur (15.7 kg S/ha), respectively. Initial status of the available Zn in soil was 0.49 mg/kg. Experiment was laid out in split-plot design and replicated thrice. Four fertility levels, viz. control, 100% RDF (RDF : 80-60-30-20 kg NPKS/ha), 100% RDN (80 kg N/ha through 16 t/ha of FYM), 75% RDF+25% RDN and 100% RDF+25% RDN were allotted to main-plot. Five different combinations of PGPR (*Rhizobium+Bacillus+Pseudomonas*) with micronutrients (control, PGPR, PGPR + 5 kg Zn/ha, PGPR + 1.5 kg Mo/ha and PGPR+5 kg Zn +1.5 kg Mo/ha) were allotted to sub-plot. All the treatments were applied at crop planting as basal. Farm yard manures (FYM) was applied on basis of N content. A uniform dose of lime was applied @0.5 t/ha in soil furrow at crop sowing. French bean cv. Anupama was sown after proper seed inoculation with *Rhizobium* (*Rhizobium phaseoli*), PSB (*Bacillus polymixa*) and PGPR (*Pseudomonas fluorescence*) @200 g culture/10 kg seed. Crop was sown using seed rate of @120 kg/ha at spacing of 40 cm × 15 cm. During both season 2013-14, crop was sown on October 24 and 20th and harvested on 3rd March in 2014 and 6th March in 2015, respectively. Total rainfall was received during cropping was 203.8 mm in 2013–14, whereas 176.7 mm in 2014–15, respectively. Maximum and minimum temperature of 2013–14 and 2014–15 was 29.4°C, 30.7°C and 9.2°C, 10.9°C, respectively. The yield attributes (pods/plant, pod length, grains/pod and 100-grain weight of french bean) were recorded from randomly selected 10-plant at crop harvesting. Grain yield from net plot was recorded after drying bundles under sun to a standard moisture condition (12%) and converted into yield kg/ha. Plant samples were collected at harvest for chemical analysis for NPKSZn content in grain and straw following standard procedures. Data on yield attributes, nutrient content and uptake of french bean were statistically analyzed using the standard statistical procedures (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on yield attributes and yields: Among yield attributes, maximum pods/plant (12.3), pod length (12.3 cm), grains/pod (8.7) and 100-grain weight (53.9) were found with100% RDF + 25% RDN followed by 75% RDF + 25% RDN (Table 1). Highest grain yield (1630 kg/ha) was obtained with 100% RDF + 25% RDN an increase of 30% in grain yield of french bean compared to 100% RDN. Higher crop productivity might be attributed to the beneficial effect of recommended dose of fertilizers (RDF) along with organic manure (FYM), which assured better crop establishment. Balanced supplied of beneficial nutrients during cropping period that helps increase in efficiency of micro-organisms in rhizoshphere results in better crop productivity. The present results are in agreement with findings of Kumari *et al*. (2012), Kumawat *et al*. (2015). Application of PGPR + 5.0 kg Zn + 1.5 kg Mo/ha increased pods/plant, pod length, grains/pod and 100-grain weight by 29.4, 32.1, 15.9, 11.9%, respectively, than control. Increase in grain yield with application of PGPR + 5.0 kg Zn + 1.5 kg Mo/ha was 16.3%, respectively, compared to control. Combined application of PGPR and Zn+Mo might have a synergistic effect, which enhanced nitrogenase activity and in turn availability of more N fixation and produced better crop yield. Application of Zn/Mo increased yield probably

Table 1 Growth and yield attributes of French bean as influenced by integrated nutrition (Pooled data of 2 years)

Treatment	Pods/ plant (no.)	Pod length (cm)	Grains/ pod (no.)	100- grain weight (g)	Grain yield (kg/ha)	Gross returns (₹ha)	Net returns (₹ha)	B: C ratio	Production efficiency (kg/ha/day)	Economic efficiency (₹/ha/day)
Nutrition levels										
Control (100% RDF)	20.8	10.27	7.22	51.15	1468	47205	28117	1.27	14.3	273
100% RDN	19.4	9.54	6.10	49.81	1254	40450	22143	1.03	12.2	215
75% RDF +25% RDN	20.8	10.82	7.82	52.22	1424	45843	26328	1.16	13.8	256
100% RDF + 25% RDN	24.8	12.29	8.68	53.98	1630	52286	31399	1.31	15.8	305
LSD (P=0.05)	1.1	0.62	0.55	3.15	104	3302	3302	0.06	1.0	32.1
Biofertilizers+Micronutrients										
Control	18.53	8.92	6.83	48.52	1334	43009	23999	1.08	13.0	233
PGPR	20.35	10.48	7.23	50.98	1397	44973	25714	1.15	13.5	250
PGPR+5 kg Zn/ha	21.67	11.32	7.67	52.96	1458	46864	27260	1.20	14.2	265
PGPR+1.5 kg Mo/ha	22.62	11.12	7.63	52.21	1481	47591	28069	1.24	14.4	273
PGPR+5 kg Zn ha+1.5 kg Mo/ha	23.98	11.78	7.92	54.29	1551	49794	29941	1.30	15.1	291
LSD (P=0.05)	1.10	0.57	0.23	1.91	48	1480	1480	0.04	0.5	14.4

*100% RDF: 80-60-30-20 kg NPKS/ha along with 0.5 t/ha lime in furrow application.

Table 2 Nutrient content (NPKS) and protein content of French bean as influenced by integrated nutrition (Pooled data of 2 years)

Treatment	Nutrient content in grain (%)					Nutrient content in straw (%)					Protein content (%)
	N	P	K	S	Zn	N	P	K	S	Zn	
Nutrition levels											
Control (100% RDF)	3.45	0.73	1.65	0.050	0.0025	1.05	0.25	1.26	0.081	0.0040	21.59
100% RDN	3.18	0.68	1.45	0.041	0.0023	0.92	0.21	1.20	0.070	0.0036	19.88
75% RDF +25% RDN	3.32	0.72	1.57	0.042	0.0023	0.97	0.23	1.22	0.073	0.0037	20.78
100% RDF + 25% RDN	3.51	0.77	1.70	0.053	0.0028	1.07	0.27	1.32	0.083	0.0042	21.92
LSD (P=0.05)	0.24	0.05	0.10	0.004	0.0002	0.06	0.02	0.06	0.003	0.0003	1.49
Biofertilizers+Micronutrients											
Control	3.24	0.68	1.42	0.040	0.0020	0.93	0.20	1.26	0.072	0.0033	20.27
PGPR	3.29	0.70	1.46	0.043	0.0022	0.97	0.21	1.20	0.073	0.0036	20.54
PGPR+5 kg Zn/ ha	3.36	0.71	1.65	0.048	0.0027	1.00	0.25	1.22	0.077	0.0042	21.02
PGPR+1.5 kg Mo/ha	3.41	0.74	1.68	0.049	0.0024	1.03	0.26	1.32	0.079	0.0039	21.32
PGPR+5 kg Zn ha+1.5 kg Mo/ha	3.53	0.77	1.76	0.051	0.0030	1.07	0.28	0.02	0.083	0.0044	22.06
LSD (P=0.05)	0.11	0.02	0.07	0.003	0.0002	0.04	0.02	0.05	0.003	0.0002	0.68

*100% RDF: 80-60-30-20 kg NPKS/ha along with 0.5 t/ha lime in furrow application

due to its influence on auxin synthesis, nodulation and N fixation in french bean (Rajput *et al*. 2009, Kumar *et al*. 2015b, Singh and Chaudhary 2016).

Effect on nutrients content and uptake: Application of nutrition levels and biofertilizers + micronutrients significantly improved the nutrients content (NPKSZn) in grain as well as straw (Table 2). Highest NPKSZn content in grain and straw were obtained from 100% RDF + 25% RDN, which increased NPKSZn content by 10.4, 13.2, 17.2, 29.3, 21.7% and 16.3, 28.6, 10, 18.6, 16.7%, respectively, compared with control. Highest uptake of NPKSZn by grain and straw were recorded with 100% RDF + 25% RDN, which increased these attributes by 43.2, 47.9, 40.9, 67.3, 55.2% in grain and 39.4, 54.7, 13.1, 42.4, 41.2% in straw, respectively than control (Table 3). Similar trend were followed with total nutrient uptake (Fig 1). Increase in yields might be due to better performance of yield attributes as these attributes influence directly yield and nutrients uptake. Further, organic matter is the storehouse of macronutrient (NPKS), thereby supply of these nutrients to crops help to achieve the better yields (Kumawat *et al*. 2013b).

Significantly higher nutrient content in grain and straw, i.e. N (3.53 and 1.07%), P (0.77 and 0.28%), K (1.76 and 1.32%), S (0.051 and 0.079%) and Zn (0.0030 and 0.0044%), respectively, were recorded with PGPR + 5.0 kg Zn + 1.5 kg Mo/ha (Table 2). Highest uptake of N (55.1 and 23.6 kg/ha), P (12.1 and 6.1 kg/ha), K (27.3 and 29.3 kg/ha), S (0.79 and 1.8 kg/ha) and Zn (0.048 and

Table 3 Nutrient uptake (NPKS) by French bean as influenced by integrated nutrition (Pooled data of 2 years)

Treatment	Grain (kg/ha)					Straw (kg/ha)				
	N	P	K	S	Zn	N	P	K	S	Zn
Nutrition levels										
Control (100% RDF)	50.89	10.84	24.41	0.73	0.037	22.24	5.34	26.75	1.71	0.084
100% RDN	40.02	8.48	19.70	0.52	0.029	17.34	3.95	22.59	1.32	0.068
75% RDF +25% RDN	47.46	10.27	20.88	0.60	0.034	20.08	4.78	25.42	1.53	0.078
100% RDF + 25% RDN	57.30	12.54	27.76	0.87	0.045	24.18	6.11	29.85	1.88	0.096
LSD (P=0.05)	6.73	1.40	2.82	0.09	0.005	2.49	0.65	2.62	0.16	0.011
Biofertilizers+Micronutrients										
Control	43.41	9.13	19.02	0.54	0.027	18.54	4.00	23.59	1.45	0.066
PGPR	46.12	9.90	20.54	0.61	0.032	19.86	4.37	24.89	1.50	0.074
PGPR+5 kg Zn/ ha	49.28	10.38	24.09	0.72	0.039	20.96	5.20	25.85	1.62	0.087
PGPR+1.5 kg Mo/ha	50.70	11.19	25.00	0.74	0.036	21.87	5.58	27.10	1.67	0.083
PGPR+5 kg Zn ha+1.5 kg Mo/ha	55.07	12.06	27.30	0.79	0.048	23.57	6.08	29.32	1.82	0.098
LSD (P=0.05)	3.01	0.62	1.49	0.05	0.002	1.15	0.43	1.29	0.09	0.004

*100% RDF: 80-60-30-20 kg NPKS/ha along with 0.5 t/ha lime in furrow application.

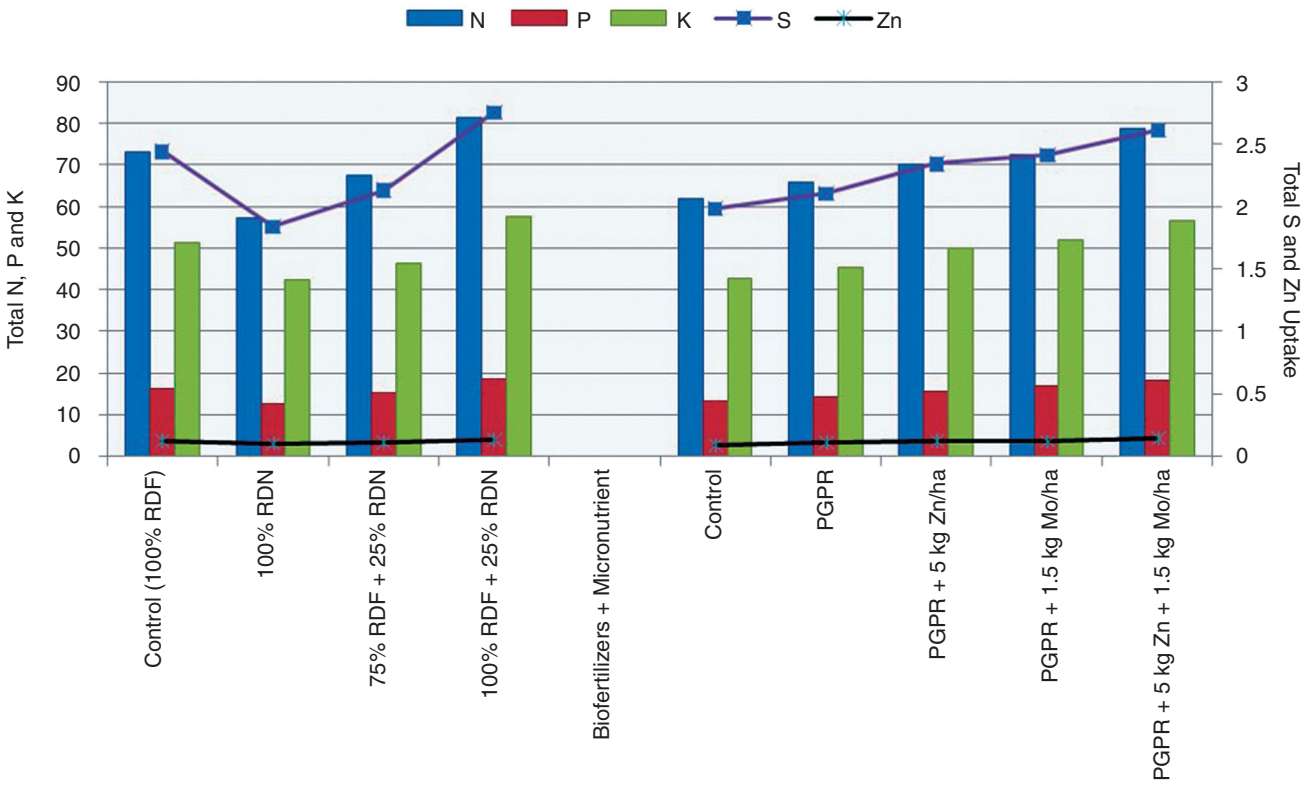

Fig 1 Total nutrient uptake (NPKSZn) by french bean as influenced by integrated nutrition (Pooled data of 2 years).

0.098 kg/ha) by grain and straw were noted with PGPR + 5.0 kg Zn + 1.5 kg Mo/ha and found significantly superior over control. Similar trend was reported in total uptake of nutrients (Fig 1). Increase in nutrient contents in plant might be due to seed inoculation with bio-inoculants (PGPRs) + micronutrients that makes crop roots more efficient to absorb nutrients, which is taken up by crop. Increase in nutrients uptake by grain and stover might be due to higher grain and straw yields as well nutrient content. Increase uptake with applied biofertilizers and micronutrients might be due to enhanced effect of *Rhizobium* in N supply, *Bacillus* in phosphorus solublization and *Pseudomonas* in facilitating availability of nutrients for quite longer periods (Rajput *et al*. 2009, Sharma and Verma 2011). Among nutrition level, application of 100% RDF + 25% RDN improved protein content in grain (21.9%), which was at par with 100% RDF and 75% RDF+25% RDN and significantly superior over 100% RDN (Table 2). Significantly highest protein content (22.1%) was associated with PGPR + 5.0 kg Zn + 1.5 kg Mo/ha. Increase in protein content might be attributed to enzyme substrate involved in amino acid biosynthesis and thereby increased protein content in grain (Kumari *et al*. 2014, Bhamare *et al*. 2018).

Effect on economics: Application of 100% RDF + 25% RDN gave the maximum gross returns (₹ 52286/ha), net returns (₹ 21399/ha), B: C ratio (1.31), production efficiency (15.8 kg/ha/day) and economic efficiency (₹ 305/ha/day) (Table 1). Among biofertilizers + micronutrient treatment, highest gross returns (₹ 49794/ha), net returns (₹ 29941/ha), B: C ratio (1.30), production efficiency (15.1 kg/ha/day) and economic efficiency (₹ 210/ha/day) were noted with PGPR + 5.0 kg Zn + 1.5 kg Mo/ha and significantly superior to rest of the treatment. This might be due to higher grain and straw yield (Kumari *et al*. 2012, Kumawat *et al*. 2013a, b, Singh and Chaudhary 2016).

Hence, it was concluded from above study that higher productivity, profitability and quality of french bean could be achieved with application of 100% RDF (80-60-30-20 kg NPKS/ ha +25% RDN through organic manures (FYM) along with seed inoculation of PGPRs + micronutrients (Zn: Mo @5:1.5 kg/ha) under foot hill condition of Eastern Himalayas.

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