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Effect of various combinations of organic and inorganic sources on yield and quality of lablab bean in Konkan region of Maharashtra

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Abstract
A field trial was conducted during *rabi* seasons of 2015-16 and 2016-17 with an objectives to assess the effect of different INM treatments on yield and quality of lablab bean (cv. Konkan Wal-2). The treatments comprised of three sources of N at RDF (urea, FYM and urea + FYM), three levels of P (0, 75 and 100 per cent P of RDF) along with PSB and VAM inoculations (no inoculation and inoculation) and a control making in all nineteen (18+1) treatment combinations. Each treatment was replicated thrice in a randomized block design. Application of 100 per cent N through an equal integration of urea and FYM when super imposed with 75 per cent P of RDF along with PSB and VAM inoculations resulted in maximum seed yield and protein content of lablab bean during both the years of investigation. It was closely followed by the treatment T_{19} receiving similar doses of fertilizers/manure as in case of T_{18} with extra addition of 25 per cent P of RDF without PSB inoculation. Thus, a saving of 25 per cent P of RDF for lablab bean crop is possible under INM on Alfisols of Maharashtra.

Keywords: Organic, inorganic, yield, quality, lablab bean

Introduction
Maharashtra ranks first in acreage and production of pulses followed by Madhya Pradesh, Uttar Pradesh, Rajasthan, Orissa, Haryana, Gujrat, Karnataka, Tamilnadu and Andra Pradesh. In Maharashtra, the total pulse production was 34.46 lakh tons, which was produced from 38.26 lakh ha with an average production of 900 kg/ha in the year 2015-2016 while in *Konkan* region total pulse area was 27.2 thousand ha which produced 16.70 thousand tons (Anonymous, 2016) [1]. In India, Lablab bean is grown as a field crop in Madhya Pradesh, Maharashtra, Andhra Pradesh and Tamil Nadu. It is popularly known as 'Wal' in *Konkan* region accounting 80 per cent of total area under lablab bean in Maharashtra and is about 60,000 ha (Davari *et al.*, 2018) [2]. Lablab bean is grown in all the districts of *Konkan* region of Maharashtra *viz*. Thane, Palghar, Raigad, Ratnagiri and Sindhudurg with gram, lentil, horse gram with an average productivity of 537 kg ha^{-1} (Anonymous, 2016) [1]. The proximate and mineral composition of lablab bean shows that the protein content ranged from 20.46 to 25.47 per cent, crude lipid 2.69 to 4.17 per cent, ash 3.97 to 4.48 per cent and carbohydrates 60.63 to 66.32 per cent (Davari *et al.*, 2018) [2]. For achieving high level of production, crop should be supplied with adequate quantities of manures and fertilizers. Now-a-days chemical fertilizers are quite expensive input and their usage over a long period may deplete the soil fertility it is also considered that their indiscriminate usage may also cause environmental pollution problems, soil sickness, reduce the microbial activities and availability of essential nutrients and deteriorate the quality of crops. In developing countries such as India, the most important challenge is to provide sufficient food for the growing population at affordable prices from inelastic land areas. The application of agro-chemicals resulted in a many-fold increase in agriculture production but at the cost of soil health. For the present level of production, the estimated nitrogen– phosphorus–potassium removal is about 28 metric tons, resulting in a negative balance of about 10 metric tons. To fulfill such a negative balance of fertilizers, there is an urgent need to identify suitable integrated plant nutrient systems for different crops and cropping systems.

The concept of Integrated Nutrient Management (INM) is aimed to continuous improvement of soil productivity on long term basis through appropriate use of inorganic fertilizers, organic manures, biofertilizers, green manures, crop residues and legume inter-cropping and their scientific management for optimum growth, yield and quality of different crops and cropping systems in specific agro-ecological situations and ensuring environmental safety. Keeping these facts in view, a study entitled "Effect of different organic and inorganic sources on yield

and quality of lablab bean in konkan region of Maharashtra has been undertaken to investigate the efficiency of integrated nutrient management on improving productivity and quality of lablab bean in konkan region of Maharashtra.

Material and Methods:

The present investigation was conducted at College of Horticulture, Mulde, Tal. Kudal. Dist. Sindhudurg in the jurisdiction of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri Maharashtra (India) during *rabi* seasons of 2015-16 and 2016-17. It comprises of nineteen treatments and three replications. Each treatment was replicated thrice in a Randomized Block Design (RBD). The treatment details are given below.

Table 1: Details of the treatments

Notations	Treatment
T_1	Control
T_2	100 % N of RDF through Urea
T_3	T_2 + 75 % P of RDF through SSP+PSB
T_4	T_2 + 100 %P of RDF through SSP
T_5	100 % N of RDF through FYM
T_6	T_5 + 75 % P of RDF through SSP+PSB
T_7	T_5 + 100 %P of RDF through SSP
T_8	50 % N of RDF through Urea + 50 % N of RDF through FYM
T_9	T_8 + 75 % P of RDF through SSP+PSB
T_{10}	T_8 + 100 % P of RDF through SSP
T_{11}	T_2 + VAM
T_{12}	T_3 + VAM
T_{13}	T_4 + VAM
T_{14}	T_5 + VAM
T_{15}	T_6 + VAM
T_{16}	T_7 + VAM
T_{17}	T_8 + VAM
T_{18}	T_9 + VAM
T_{19}	T_{10} + VAM

Urea was applied in single dose before sowing deep placement method as per the treatment plan. SSP as per the treatment plan and KCl (muriate of potash) applied as a basal dose by deep placement in single dose before sowing of lablab bean. FYM was applied through broadcasting in single dose as per the treatment plan 30 days before sowing of lablab bean. In addition to this PSB and VAM culture was also applied to lablab bean seed before sowing.

The harvested material from each net plot was sundried and threshed. The threshed material (seed) was air dried and weighed plot wise and the yield was computed and expressed in q ha^{-1}. Stover yield of lablab bean was derived by subtracting seed yield from respective biological yield of individual net plot of each treatment and computed to express it in q ha^{-1}. Weight of sun dried produce of net plot was recorded and the biological yield was computed in q ha^{-1} for individual treatment plot. Harvest index was worked out using following equation.

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

The protein content will be calculated by multiplying per cent nitrogen content (seed) by 6.25. The data were statistically analyzed as per the method described by Panse and Sukhatme (1967) [5].

Experimental Results

Seed yield of lablab bean (q ha^{-1})

A critical look on the data further, indicated that the highest seed yield of lablab bean to the tune of 13.69 and 14.50 q ha^{-1}was recorded in the treatment (T_{18}) involving application 100 per cent N of RDF through an equal integration of urea and FYM in conjunction with 75 per cent P of RDF along with PSB and VAM inoculations. While the lowest seed yield values (6.85 and 7.66 q ha^{-1}) were observed in the control treatment (T_1) during the year 2015-16 and 2016-17, respectively. When 100 per cent N of RDF was supplied solely through FYM along with 100 per cent P of RDF (T_7), a significant increase in seed yield of lablab bean to the extent of 0.03 q ha^{-1} (2015-16) and 0.31 q ha^{-1} (2016-17) was recorded as compared with the treatment receiving application of 100 per cent N of RDF only through FYM (T_5). Furthermore, when 100 per cent N was supplied through equal integration of chemical fertilizer (urea) and organic source (FYM) with superimposition of 75 per cent and 100 per cent P of RDF (T_9 and T_{10}) caused significant increase in seed yield of lablab bean over the treatment receiving application of only 100 % N of RDF through equal integration of urea and FYM (T_8) during both the years of investigation. Similarly, application of phosphorus @ 75% P of RDF along with 100 per cent N through urea (T_3) resulted in significant increase in seed yield of lablab bean over the application of 100 per cent N through urea alone (T_2). Either PSB and VAM seed inoculations alone or in combinations (T_9,T_{11}, T_{12}, T_{13}, T_{14}, T_{15}, T_{16}, T_{17}, T_{18} and T_{19}) showed significant increase in seed yield of lablab bean over the treatments receiving same doses of fertilizers without inoculations of PSB or VAM (T_1, T_2, T_4, T_5, T_7, $T_8$and T_{10}). Thus, in general, either sole or combined seed inoculation of PSB and VAM along with different doses of fertilizers showed it's statistical significance on seed yield of lablab bean in all the treatments over respective treatments without seed inoculations of PSB and VAM treatments during the year 2015-16 with exception of the treatment T_{10} during the year 2016-17.

The dose of NPK fertilizers as recommended by Dr. B.S.K.K.V., Dapoli (M.S.) to lablab bean in Alfisols of Maharashtra is 25: 50: 50 kg ha^{-1} which showed production of seed yield to the tune of 8.80 and 9.76 q ha^{-1} in the treatment T_4in which 100% K was applied as a basal dose in the year 2015-16 and 2016-17, respectively. When recommended dose of N was applied through equal integration of urea and FYM along with 100% P of RDF while 100 % K was applied as a basal dose (T_{10}) it showed significant increase in the seed yield (09.94 and 10.55 q ha^{-1}) of lablab bean over the treatment (T_4) receiving recommended dose of 100 % N and P through chemical fertilizers (8.80 and 9.76 q ha^{-1}) during both the years of investigation, respectively. Application of 100 per cent N of RDF through urea along with 75 per cent P of RDF through SSP with a blend of PSB inoculation (T_3) registered statistically significant higher grain yield of lablab bean (9.89 and 10.09 q ha^{-1}) over the treatment (T_6) receiving application of 100 % N of RDF through FYM + 75 % P of RDF along with PSB inoculation (8.98 and 9.60 q ha^{-1}). A critical examination of data further indicated that statistically significant increase in seed yield of lablab bean was observed in the treatments T_{18} and T_{19} receiving application of 100% N of RDF through conjunctive use of urea and FYM and 75% of P along with VAM and combined PSB and VAM inoculation, respectively over the treatment (T_4) receiving recommended dose of NPK as recommended by Dr. BSKKV, Dapoli (MS). The data of pooled analysis also revealed that the same

treatment (T_{18}) registered significant and the highest yield (14.10 q ha^{-1}) of lablab bean and which was found to be statistically significant over rest of the treatment combinations.

Stover yield of lablab bean (q ha^{-1})

The data on stover yield of lablab bean are presented in table 2. The data when studied revealed that the stover yield of lablab bean varied from 14.48 to 30.55 q $ha^{-1}$and 16.77 to 30.96 q ha^{-1} with an average values of 23.97 and 24.42 q ha^{-1} during the years 2015-16 and 2016-17, respectively.The highest stover yield of lablab bean (30.55 and 30.96 q ha^{-1}) was registered in the treatment (T_{18}) receiving application of 50 per cent N through urea + 50 per cent N through FYM with a superimposition of 75 per cent P of RDF along with PSB and VAM inoculations.

Biological yield of lablab bean (q ha^{-1})

The biological yield of lablab bean ranged from 21.33 to 44.24 q ha^{-1} and 24.43 to 45.46 q $ha^{-1}$with average valuesof 34.62 and 35.68 q ha^{-1}as a consequence of various treatments during the year 2015-16 and 2016-17, respectively. The biological yield of lablab bean followed the similar pattern to that of seed and stover yield of lablab bean. The maximum biological yield of lablab bean was recorded in the treatment T_{18} involving application of 100 per cent N in integration of urea with FYM along with 75 per cent P of RDF + PSB and VAM inoculations during both the years of investigation. It was significantly superior over the biological yield obtained in all other treatment combinations during the year 2015-16. However T_{18} was found to be statistically at par intreatments T_{12} and T_{19}during the year 2016-17. However all the treatment combinations showed it's statistical significance over the control treatment during both the years of investigation and in pooled analysis also.

Harvest index of lablab bean (%)

The harvest index of lablab bean which is a ratio of seed and biological yield multiplied by 100 varied from 30.08 to 32.21, 29.80 to 33.04 and 30.32 to 32.51 per cent due to various treatment combinations with an average values of 30.80, 31.60 and 31.20 per cent during the year 2015-16, 2016-17 and in the pooled analysis, respectively.Maximum harvest index was recorded in the treatment T_7, T_2 and T_7 in the year 2015-16, 2016-17 and in pooled analysis, respectively. Whereas the minimum harvest index was recorded in the treatments T_6, T_{16} and T_{16} during the years 2015-16, 2016-17 and in the pooled analysis, respectively. However various treatment combinations during both the years of investigations and in pooled analysis did not reach to the level of significance.

Quality parameter [Protein content (%)] of lablab bean seed

Data when studied revealed that the protein content in lablab bean seed showed variation from 18.73 to 24.43 per cent, 19.03 to 25.71 per cent and 18.88 to 25.07 with average values of 21.62, 22.45 and 22.03 per cent during the years 2015-16, 2016-17 and in pooled analysis, respectively. Data further, indicated that the lowest values of protein (18.73, 19.03 and 18.88%) content ware seen in the control treatment (T_1) while the highest values of protein (24.43, 25.71 and 25.07%) content ware observed in the treatment (T_{18}) receiving 100 % N of RDF through equal integration of urea and FYM when super imposed with 75 per cent P of RDF along with PSB+VAM inoculations. However the treatment T_{18} was found to be statistically significant over all the treatment combinations with exception of the treatment T_{19} only. In addition to this all the treatment combinations showed statistical significance over control treatment (T_1) in the pooled analysis.

Discussion

Yield of Lablab bean:

In general increase in the seed yield in the present investigation was expected because applications of fertilizers are based on recommendations.A significant increase in seed yield of lablab bean (13.69 and 14.50 q ha^{-1}) over control was recorded in the treatment T_{18} receiving application of N through integration of urea with FYM with super imposition of 75 per cent P of RDF along with PSB and VAM inoculations during the years 2015-16 and 2016-17, respectively. Such an improvement in yield of crops under study is attributed to increased supply of nutrients making a congenial environment for growth in the rhizosphere. The yield of lablab bean recorded in the treatment T_{19} receiving same doses of N with VAM as that of T_{18} and 100 per cent P of RDF without PSB inoculation was statistically at par during both years of investigation with exception of yield of lablab bean in the year 2016-17. This suggest that a 25 per cent saving in phosphatic fertilizers of RDF could be possible in case of lablab bean when 100 per cent N of RDF is applied through integration of urea with FYM in equal proportion and super imposition of PSB and VAM inoculation to solubilize native as well as applied phosphorus.

In general various treatment combinations showed significant variations in seed yield of lablab bean during both the years of investigation. Application of 100 per cent N of RDFthrough equal integration of urea and FYM (T_8) recorded higher seed yield of lablab bean over respective application of 100 per cent N solely through urea (T_2) or FYM (T_5) with exception of seed yield of lablab bean in the year 2015-16. The right kind of nutrients required by the crops may not be achieved from a single source. The comparison of 100 per cent N of RDF through different sources with a superimposition of 75 per cent P of RDF along with PSB and VAM inoculations clearly showed added benefits of N through integration of urea with FYM and super imposition of 75per cent P of RDF with (T_{18}) PSB and VAM inoculations or 100 per cent P of RDF without (T_{17}) PSB and VAM inoculations over treatments receiving N through urea alone or solely through FYM even when super imposed with 75 per cent and 100 per cent P of RDF along with (T_{12} and T_{15}) or without (T_4 and T_7) PSB and VAM inoculations, respectively. PSB and VAM inoculations caused an increase in the seed yield of lablab bean during both the years. The results of present investigation are in conformity with the results reported by several researchers (Dhangada, 2015, Mhashelkar, 2015 and Tapkeer*et al*., 2017)[3, 4, 8].

However, PSB and VAM inoculation showed it's significance on seed yield of lablab bean, which may be attributed to it's phosphate solubilizing ability. PSB and VAM solubilize the fixed native P in soil by production of organic acids in micro environment around the root. Organic acids solubilize more P than inorganic acids at same pH due to chelating effect of the former. Further, production of CO_2 by soil micro organisms and plant roots leads to formation of carbonic acid which also encourages solubilization of insoluble P (Somani, 2002)[7].

Protein content of lablab bean

Protein content in seed of lablab bean (Table 3) was influenced significantly due to various integrated nutrient management treatment combinations.Protein content of seed of lablab bean followed the similar trend as observed in the nitrogen content of seed, because protein content was computed by multiplying N content with the factor of 6.25. Significant and the highest protein content in seed of lablab bean was recorded in the treatment (T_{18}) receiving application of 100 per cent N of RDF through equal integration of urea and FYM with superimposition of 75 per cent P of RDF with a blend of PSB and VAM inoculations during both the years of investigation.Sodavadiya*et al.* (2017)[6] reported that the application of 50% RDF + 5t BC/ha + bio fertilizer (PSB + Rhizobium) recorded significantly highest protein content in seed of Indian bean this might be due to an increase in the N uptake which might have proportional increase in the protein content. Since protein content is function of nitrogen accumulation, higher nitrogen content resulting in the higher protein content.These results are in close conformity with the results reported by Dhangada (2015) Mhashelkar (2015) and Tapkeer*et al.* (2017)[3, 4, 8].

Table 2: Effect of various combinations of organic and inorganic sourceson seed, stover, biological yields (q/ha) and harvest index (%) of lablab bean

	Treatment	2015-16				2016-17				Pooled			
		Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T_1	Control	6.85	14.48	21.33	32.11	7.66	16.77	24.43	31.35	7.26	15.63	22.87	31.73
T_2	100 % N of RDF through Urea	8.97	20.13	29.10	30.82	9.07	18.38	27.45	33.04	9.02	19.25	28.25	31.93
T_3	T_2 + 75 % P of RDF through SSP+PSB	9.89	22.55	32.44	30.49	10.09	22.03	32.12	31.41	9.99	22.29	32.27	30.95
T_4	T_2 + 100 %P of RDF through SSP	8.80	19.83	28.63	30.74	9.76	21.07	30.83	31.65	9.28	20.45	29.74	31.20
T_5	100 % N of RDF through FYM	8.96	20.49	29.45	30.42	9.11	19.91	29.02	31.39	9.04	20.20	29.24	30.91
T_6	T_5 + 75 % P of RDF through SSP+PSB	8.98	20.87	29.85	30.08	9.60	20.97	30.57	31.40	9.29	20.92	30.21	30.75
T_7	T_5 + 100 %P of RDF through SSP	8.99	18.92	27.91	32.21	9.42	19.30	28.72	32.80	9.21	19.11	28.32	32.51
T_8	50 % N of RDF through Urea + 50 % N of RDF through FYM	8.88	20.48	29.36	30.24	9.17	20.02	29.19	31.41	9.03	20.25	29.28	30.83
T_9	T_8 + 75 % P of RDF through SSP+PSB	10.77	24.87	35.64	30.22	11.27	23.83	35.10	32.11	11.02	24.35	35.36	31.16
T_{10}	T_8 + 100 % P of RDF through SSP	9.94	22.31	32.25	30.82	10.55	23.26	33.83	31.18	10.26	22.79	33.05	31.04
T_{11}	T_2 + VAM	10.89	24.73	35.62	30.57	11.64	24.27	35.91	32.41	11.27	24.50	35.77	31.50
T_{12}	T_3 + VAM	12.84	28.87	41.71	30.78	13.97	30.73	44.70	31.25	13.41	29.80	43.22	31.02
T_{13}	T_4 + VAM	12.91	28.70	41.61	31.03	13.66	28.82	42.49	32.15	13.29	28.76	42.06	31.59
T_{14}	T_5 + VAM	11.94	27.29	39.23	30.43	12.08	26.58	38.66	31.25	12.01	26.93	38.94	30.84
T_{15}	T_6 + VAM	12.42	28.77	41.19	30.15	13.12	28.86	41.98	31.25	12.77	28.82	41.59	30.70
T_{16}	T_7 + VAM	11.82	26.50	38.32	30.84	12.80	30.15	42.95	29.80	12.31	28.32	40.61	30.32
T_{17}	T_8 + VAM	11.64	25.89	37.53	31.01	12.35	27.17	39.52	31.25	12.00	26.53	38.54	31.13
T_{18}	T_9 + VAM	13.69	30.55	44.24	30.94	14.50	30.96	45.46	31.90	14.10	30.75	44.85	31.43
T_{19}	T_{10} + VAM	13.26	29.20	42.46	31.23	14.04	30.89	44.93	31.25	13.65	30.04	43.69	31.24
	Mean	10.65	23.97	34.62	30.80	11.26	24.42	35.68	31.60	10.96	24.19	31.31	31.20
	SEm ±	0.21	0.46	0.55	0.59	0.12	0.79	0.82	0.82	0.12	0.65	0.78	0.41
	CD (0.05%)	0.59	1.32	1.58	NS	0.35	2.27	2.35	NS	0.34	1.96	2.33	NS

PSB - Phosphate solubilizing bacteria FYM - Farm yard manure N - Nitrogen P - P2O5
VAM- Vesicular Arbuscular Mycorrhiza SSP - Single super phosphate RDF - Recommended dose of fertilizer

Table 3: Effect of various combinations of organic and inorganic sourceson Quality parameter [Protein content (%)] of lablab bean seed

Tr. No.	Treatments	2015	2016	Pooled
T_1	Control	18.73	19.03	18.88
T_2	100 % N of RDF through Urea	19.40	20.12	19.76
T_3	T_2 + 75 % P of RDF through SSP+PSB	21.63	21.66	21.65
T_4	T_2 + 100 %P of RDF through SSP	19.62	20.58	20.10
T_5	100 % N of RDF through FYM	20.42	20.84	20.63
T_6	T_5 + 75 % P of RDF through SSP+PSB	22.28	22.68	22.48
T_7	T_5 + 100 %P of RDF through SSP	20.88	21.74	21.31
T_8	50 % N of RDF through Urea + 50 % N of RDF through FYM	19.51	20.23	19.87
T_9	T_8 + 75 % P of RDF through SSP+PSB	22.33	23.63	22.98
T_{10}	T_8 + 100 % P of RDF through SSP	21.26	22.69	21.98
T_{11}	T_2 + VAM	20.15	20.45	20.30
T_{12}	T_3 + VAM	23.44	24.35	23.89

T_{13}	T_4 + VAM	21.98	23.38	22.68
T_{14}	T_5 + VAM	22.30	23.59	22.94
T_{15}	T_6 + VAM	23.87	24.40	24.13
T_{16}	T_7 + VAM	22.70	23.93	23.32
T_{17}	T_8 + VAM	21.58	22.45	22.02
T_{18}	T_9 + VAM	24.43	25.71	25.07
T_{19}	T_{10} + VAM	24.25	25.11	24.68
	Mean	21.62	22.45	22.03
	SEm ±	1.37	1.28	0.21
	CD (0.05%)	3.92	3.67	0.62

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