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Influence of INM practices on growth and proximate characters of hyacinth bean in baby corn (*Zea mays*. L) – hyacinth bean (*Lablab purpureus* var. *typicus*) cropping system

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Abstract
A field experiment was conducted at Horticultural Research Station, SKLTSHU, Adilabad, Telangana State during *rabi* seasons of 2015-16 and 2016-17 to study the effect of Integrated Nutrient Management practices on growth and proximate characters of hyacinth bean in baby corn (*Zea mays*. L) – hyacinth bean (*Lablab purpureus* var. *typicus*) cropping system. Experiment was laid in Randomized Block Design for baby corn during *kharif* 2015 with seven treatments comprised of 100% recommended dose of fertilizers (RDF 150:27:50 N, P and K kg/ha), 25% N supplemented through farm yard manure or vermicomost + 75% RDF with or without bio-fertilizers *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each in addition to control and replicated thrice. Each main treatment was divided into four subplots and the treatments of 100% RDF (20-22 N, P kg/ha) and 75% RDF with or without *Bradyrhizobium* @ 500 g/ha (seed treatment) were imposed for hyacinth bean in *rabi* season and data of *rabi* 2015-16 and 2016-17 was analyzed in split plot design. Integration of 100% RDF with *Bradyrhizobium* seed treatment to hyacinth bean resulted in significantly higher plant height, LAI, nodule number per plant, higher protein content, less crude fiber of hyacinth bean over application of 75% RDF with or without *Bradyrhizobium* seed treatment and 100% RDF alone. Residual effect due to application of 75% RDF in conjunction with 25% N through FYM and biofertilizers imposed to preceding *kharif* baby corn resulted in significantly higher plant height, LAI, number of root nodules plant^{-1}, protein content in succeeding *rabi* hyacinth bean crop than 100% RDF with or without biofertilizers and unfertilized control and was at par with integration of 75% RDF with 25% N through FYM or VC alone or 25% N through VC in conjunction with biofertilizers. Application of inorganic sources of nutrition integrated with organic manures (FYM or VC) to preceding baby corn crop during *kharif* showed significantly lower crude fibre content of succeeding hyacinth bean.

Keywords: Hyacinth bean, growth attributes, inm, proximate characters

Introduction
Lablab bean or hyacinth bean is one of the most ancient crops among the cultivated legumes and is grown throughout the tropical regions of Asia, Africa and America. The dwarf varieties (determinate bush-type) have a potential for more extensive cultivation of the crop, because of the plants require no support system, the pods mature uniformly and the crop is amenable to mechanical harvesting which will reduce cost and labour. Application of heavy doses of chemical fertilizers without organic manures is causing deterioration of soil health in terms of physical and chemical properties of soil, declining soil microbial activities, reduction in soil humus, increased pollution of soil, water and air. *Bradyrhizobium* inoculation to various legume crops improved nodulation and dry matter production (Mahdi and Mustafa, 2005) [9]. The quality of hyacinth bean is decided by the moisture, protein and fiber content. Hence, a study on the influence of INM practices on growth and proximate characters of hyacinth bean in baby corn (*Zea mays*. L) – hyacinth bean (*Lablab purpureus* var. *typicus*) cropping system was conducted to evaluate the efficacy of microbial culture seed treatment along with inorganic fertilizers to hyacinth bean on growth attributes and quality characters of hyacinth bean, and to evaluate the residual effect of FYM and Vermicompost in conjunction with microbial culture and inorganic fertilizers applied to baby corn on succeeding hyacinth bean.

Materials and Methods

Field experiment was carried out during *rabi* seasons of 2015-16 and 2016-17 at Horticultural Research Station, Adilabad, Telangana State, India which is at an altitude of 264 meters above mean sea level and at 79º 56' 03" E longitude and 19º08' 09" N latitude. The experimental soil was sandy clay loam in texture, neutral in reaction, medium in available nitrogen, phosphorous and potassium and belongs to the order Alfisol of shallow to medium depth. The experiment was laid out in randomized block design (RBD) replicated thrice during *kharif*, 2015 with seven treatments comprised of 100% Recommended dose of fertilizer (RDF, 150:27:50 N, P, and K kg/ha), 25% N supplemented through Farm Yard Manure (FYM) or vermicompost (VC) + 75% RDF with or without soil application of *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each and unfertilized control with three replications. Each main treatment was divided into four subplots during *rabi* season of 2015-16 and 2016-17 for hyacinth bean and the treatments of 100% RDF (20 kg N, 22 Kg P/ha) and 75% RDF with or without *Bradyrhizobium* @ 500 g/ha (seed treatment) were imposed in split plot design.

Plant height was measured with scale from the base to tip of the plant at harvest. Leaf area (cm^2) was determined from all the leaves collected from the selected plants with the help of graph paper and the leaf area $plant^{-1}$ was calculated. Leaf area index was calculated by using the formula as suggested by Williams (1946) [15]. Five randomly selected plants were uprooted at 100 DAS along with roots carefully. Number of nodules was counted and the average number of nodules $plant^{-1}$ was calculated. Total protein content of hyacinth bean pod was estimated by combustion method by using Leco F-528 Nitrogen Analyzer as advocated in AOAC (2005) [1]. Crude fibre content of hyacinth bean pod was estimated by filter bag technique as advocated in AOAC (2005) [1]. Moisture content of hyacinth bean pod was estimated by drying a test portion at a temperature of 130ºC $\pm$ 3ºC under conditions which enable a result to be obtained which is in agreement with that obtained by the basic reference method. The data was analyzed statistically using *F*-test following Gomez and Gomez (1984) [5]. LSD values at *P*=0.05 were used to determined the significance of difference between treatment means.

Results and Discussion

Growth Parameters

Plant height (cm)

Application of 100% RDF with *Bradyrhizobium* seed treatment to hyacinth bean resulted in significantly higher plant height over application of 75% RDF with or without seed treatment during *rabi*, 2015-16 and 2016-17 and was at par with 100% RDF alone at harvest (Table-1). Integration of 75% RDF along with *Bradyrhizobium* seed treatment showed at par plant height with 100% RDF alone at harvest during both the years of study. Significant effect on the increase of plant height of hyacinth bean with inorganic fertilizer might be attributed to the fact that nitrogen being an essential constituent of plant tissue favoured rapid cell division and enlargement which together with adequate quantity of phosphorous helped in rapid cell division and better development of cell size. Application of biofertilizers for seed treatment might have improved physical, chemical and biological properties of the soil, which helped in improved root nodulation (Table 1) thereby enhancing plant growth in terms of plant height. Significant increase in plant height was noticed in bush bean by Abdulkadir *et al.* (2014) [2] with integration of RDF and biofertilizers. Suma *et al.* (2011) [13]; Hernandez and Cuevas (2003) [6] and Islam *et al.* (2016) [7] also reported significantly higher plant height with integration of organic and inorganic sources of nutrition.

Significantly higher plant height of hyacinth bean was noticed in the succeeding *rabi*, 2015-16 and 2016-17 due to residual effect of 75% RDF integrated with 25% N through FYM in conjunction with biofertilizers (*Azospirillum* and *Bacillus megaterium)* applied to preceding baby corn crop in *kharif*, 2015 and 2016 over 100% RDF with or without biofertilizer and un-fertilized control and was at par with other organic treatments. The residual effect of FYM to preceding *kharif* baby corn along with 100% RDF to succeeding hyacinth bean in conjunction with the use of *Bradyrhizobium* seed inoculation might have helped in improving the physical, chemical and biological environment in soil thereby higher nutrient availability and uptake, making conducive to better plant growth of hyacinth bean (Suma, 2007 [12] and Katyal, 1986 [8]).

Combined application of 75% RDF with 25% N through VC with or without biofertilizers to preceding *kharif* baby corn resulted in significantly higher plant height of succeeding hyacinth bean during *rabi* over 100% RDF with or without the biofertilizers and un-fertilized control and was at par with integration of 75% RDF with 25% N through FYM during both the years of study.

Leaf Area Index (LAI)

Combined use of 100% RDF along with seed treatment to hyacinth bean, recorded significantly higher LAI over 75% RDF with or without *Bradyrhizobium* seed treatment during both the years of study at harvest and 100% RDF alone during *rabi* 2016-17 but was at par with 100% RDF alone during *rabi* 2015-16 (Table 1). Leaf area index recorded with organic treatments (FYM or VC) along with inorganic fertilizers with or without the biofertilizers in the preceding baby corn crop showed significantly higher values over inorganic fertilizers with or without biofertilizers and unfertilized control. This may be attributed to the enhanced availability and uptake of nutrients by the plants might have favoured better cell division, cell elongation, amino acid synthesis and assimilation in producing more LAI compared to unfertilized control.

Application of 75% RDF integrated with 25% N through FYM and biofertilizer (*Azospirillum* and *Bacillus megaterium*) to preceding baby corn during *kharif*, 2015 and 2016 resulted in significantly higher LAI values of hyacinth bean due to residual effect over 100% RDF with or without biofertilizers and unfertilized control at harvest in the succeeding *rabi*, 2015-16 and 2016-17 and it was at par with integration of 75% RDF with 25% N through FYM or VC alone or 25% N through VC in conjunction with biofertilizers. Significantly higher LAI values were registered due to residual effect of 100% RDF applied in conjunction with biofertilizers to preceding baby corn during *kharif*, 2015 and 2016 in the succeeding *rabi* hyacinth bean at harvest during *rabi* 2015-16 and 2016-17 over unfertilized control and was at par with 100% RDF alone.

Root nodules $plant^{-1}$

The nodule number per plant was higher in *rabi*, 2016-17 over *rabi*, 2015-16. Least number of nodules $plant^{-1}$ was recorded with 75% RDF alone and highest was with integration of 100% RDF with *Bradyrhizobium* seed treatment at 100 DAS during both the years of study.

Application of 75% RDF along with *Bradyrhizobium* seed treatment resulted in significantly higher nodules plant^{-1} over 75% or 100% RDF alone at 100 DAS during *rabi*, 2015-16 and over 75% RDF alone at 100 DAS during *rabi*, 2016-17 and was at par with 100% RDF at 100 DAS during *rabi*, 2016-17. Observations of increased nodule number plant^{-1} with RDF combined with biofertilizers seed treatment have been recorded by Barea *et al*. (2005) [3] and Bhuiyan *et al*. (2008) [4] in chick pea, Rughheim and Abdelgani (2009) [10] in faba bean and Selvakumar *et al*. (2012) [11] in green gram.

Among the different INM treatments imposed to preceding *kharif* baby corn, application of 75% RDF in conjunction with 25% N through FYM and biofertilizers (*Azospirillum* and *Bacillus megaterium*) recorded significantly higher number of root nodules plant^{-1} in succeeding *rabi* hyacinth bean crop at 100 DAS during both the years of study due to residual effect over rest of the treatments of 100% RDF with or without biofertilizers and unfertilized control and was at par with integration of 75% RDF with 25% N through FYM or VC alone or 25% N through VC in conjunction with biofertilizers (Table 1).

Residual effect of 100% RDF applied with or without biofertilizers during *kharif*, 2015 and 2016 to preceding baby corn has resulted in significantly higher nodules plant^{-1}in succeeding hyacinth bean over un-fertilized control at 100 DAS during *rabi*, 2015-16 and 2016-17.

The increase in nodulation might be due to synergistic effect of two types of microorganisms (*Bacillus megaterium* bio-var *phosphaticum* in *kharif* and *Bradyrhizobium* in *rabi*) for biological nitrogen fixation. Phosphate solubilizing bacteria by virtue of their property of producing organic acids solubilizes the insoluble or fixed form of phosphorus in the rhizosphere and makes it available to the growing plants, which might have promoted better nodulation (Tagore *et al*., 2013) [14].

Proximate Characters

Moisture content

Significant difference was not observed in the moisture content of hyacinth bean due to the treatments imposed during *rabi*, 2015-16 and 2016-17 (Table 2). However significant variations were noticed in the moisture content of succeeding hyacinth bean due to residual effect of the treatments imposed to preceding *kharif* baby corn. Least moisture content in the succeeding hyacinth bean was noticed due to un-fertilized control treatment imposed to baby corn during *kharif*, 2015 and 2016 and was at par with 100% RDF during both the years of study and 100% RDF with biofertilizers during *rabi*, 2015-16.

Residual effect of 75% RDF with 25% N through FYM or VC applied to *kharif* baby corn showed significantly higher moisture content of hyacinth bean during both the years of study over 100% RDF with or without biofertilizer and un-fertilized control and was at par with integration of 75% RDF with 25% N through VC in conjunction with biofertilizer.

Incorporation of 25% N through FYM along with 75% RDF in conjunction with biofertilizers to *kharif* baby corn resulted in significantly higher moisture content of hyacinth bean in the succeeding *rabi*, 2015-16 and 2016-17 due to residual effect over rest of the treatments and was at par with integration of 75% RDF with 25% N through VC in conjunction with use of biofertilizers during *rabi*, 2015-16.

Protein content

Use of bio fertilizer (*Bradyrhizobium* seed treatment) in conjunction with 100% or 75% RDF to hyacinth bean during *rabi*, 2015-16 showed significantly higher protein content of hyacinth bean as compared to use of only inorganic fertilizer (100% RDF and 75% RDF). Similar results of increased protein content were reported with combined use of inorganic fertilizers and biofertilizer seed treatment by Selvakumar *et al.* (2012) [11] in black gram. Application of 75% RDF along with seed treatment with *Bradyrhizobium* resulted in at par protein content of hyacinth bean during *rabi*, 2016-17 with 100% RDF and 75% RDF.

Application of 75% RDF integrated with 25% N through FYM and in conjunction with bio fertilizer (*Azospirillum* and *Bacillus megaterium*) to preceding baby corn crop in *kharif* resulted in the record of maximum protein content of hyacinth bean in the succeeding *rabi* crop during both the years of study. Application of 75% RDF along with 25% N through FYM or VC to *kharif* baby corn and integration of 75% RDF with 25% N through VC and in conjunction with biofertilizer resulted in at par protein content of hyacinth bean in the succeeding *rabi*, 2015-16 and 2016-17 (Table 2). Protein content of hyacinth bean was less in the un-fertilized control treatment followed by 100% RDF (inorganic source of nutrient treatment).

Crude fibre

Application of inorganic sources of nutrition with or without the use of bio fertilizer for seed treatment had no significant effect on the crude fibre content of hyacinth bean during both the years of study (*rabi*, 2015-16 and 2016-17).

Residual effect due to application of inorganic sources of nutrition integrated with organic manures (FYM and VC) to preceding baby corn crop during *kharif* showed significantly lower crude protein content of succeeding hyacinth bean during both the years of study (*rabi*, 2015-16 and 2016-17).

Among the organic sources of nutrition, integration of FYM along with in organic sources in conjunction with biofertilizers resulted in lower crude fibre content than integration of VC with inorganic sources or inorganic sources alone with or without biofertilizers and un-fertilized control (Table 2).

Table 1: Effect of integrated nutrient management practices on plant height (cm), leaf area index (LAI) and nodule number per plant of hyacinth bean in sequence with *kharif* baby corn

Treatments	Plant height (cm) at harvest		LAI at Harvest		Root nodules per plant at 100DAS	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Main treatments- (*Kharif*-Baby corn)						
T_1- 25% N through FYM + 75% RDF	80.1	77.6	0.72	0.72	26.2	28.6
T_2- 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	82.8	79.8	0.75	0.75	26.9	29.6
T_3- 25% N through VC + 75% RDF	81.4	76.9	0.71	0.70	26.0	28.3
T_4- 25% N through VC + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	82.1	76.8	0.73	0.73	26.3	29.3
T_5- 100% RDF	71.8	71.7	0.64	0.62	21.3	24.5
T_6- 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	72.9	73.1	0.65	0.64	22.2	25.6
T_7- Control (No fertilizer application)	65.7	69.2	0.58	0.56	16.1	19.5
S.Em±	1.7	1.2	0.02	0.02	0.7	0.4
C.D. (P=0.05)	5.4	3.6	0.05	0.05	2.1	1.4
Sub-treatments– (*Rabi*- hyacinth bean)						
S_1-100% RDF	74.8	75.1	0.69	0.67	22.4	25.5
S_2-75% RDF	73.8	72.3	0.65	0.62	21.6	24.5
S_3-100% RDF + *Bradyrhizobium* @ 500 g ha^{-1}Seed treatment	80.5	78.5	0.72	0.75	25.8	29.8
S_4-75% RDF + *Bradyrhizobium* @ 500 g ha^{-1} Seed treatment	77.6	74.1	0.67	0.66	24.4	26.2
S.Em±	1.5	0.9	0.01	0.01	0.4	0.3
C.D. (P=0.05)	4.2	2.5	0.04	0.03	1.1	0.9
Interaction between						
Bean treatment means at same level of baby corn INM treatments						
S.Em±	3.9	2.3	0.03	0.02	1.0	0.8
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
INM treatment means of baby corn at same or different level of bean treatments						
S.Em±	3.8	2.3	0.03	0.03	1.1	0.8
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Effect of integrated nutrient management practices on proximate characters (moisture, crude fibre and total protein content) of hyacinth bean pod in sequence with *kharif* baby corn

Treatments	Moisture (%)		Crude fibre (%)		Total protein (%)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Main treatments- (*Kharif*-Baby corn)						
T_1- 25% N through FYM + 75% RDF	87.5	87.5	10.5	10.5	21.3	21.3
T_2- 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	87.7	87.5	10.5	10.5	21.9	21.6
T_3- 25% N through VC + 75% RDF	87.4	87.4	10.7	10.7	21.2	21.3
T_4- 25% N through VC + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	87.7	87.5	10.5	10.7	21.4	21.6
T_5- 100% RDF	87.4	87.3	11.3	11.1	19.8	20.0
T_6- 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	87.4	87.5	11.2	11.0	20.4	20.2
T_7- Control (No fertilizer application)	87.2	87.3	11.7	11.6	19.3	19.5
S.Em±	0.2	0.1	0.1	0.1	0.2	0.1
C.D. (P=0.05)	NS	NS	0.2	0.3	0.5	0.4
Sub-treatments– (*Rabi*- hyacinth bean)						
S_1-100% RDF	87.6	87.5	11.0	11.1	20.6	20.7
S_2-75% RDF	87.5	87.3	10.9	10.9	20.3	20.5
S_3-100% RDF + *Bradyrhizobium* @ 500 g ha^{-1}Seed treatment	87.4	87.5	10.7	10.8	21.3	21.2
S_4-75% RDF + *Bradyrhizobium* @ 500 g ha^{-1} Seed treatment	87.4	87.4	10.9	10.8	20.8	20.8
S.Em±	0.1	0.1	0.0	0.1	0.12	0.1
C.D. (P=0.05)	NS	NS	0.1	0.2	0.3	0.3
Interaction between						
Bean treatment means at same level of baby corn INM treatments						
S.Em±	0.2	0.2	0.1	0.2	0.3	0.3
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
INM treatment means of baby corn at same or different level of bean treatments						
S.Em±	0.2	0.3	0.1	0.2	0.3	0.3
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

Conclusion

Conjunctive use of 100% recommended dose of fertilizer along with *Bradyrhizobium* seed treatment resulted in improved growth parameters (plant height, leaf area index and nodule number) and superior proximate characters (high protein, less fibre) of hyacinth bean. Application of 25% nitrogen recommendation through farm yard manure or vermicompost along with 75% recommended dose of fertilizer through chemical fertilizers and bio fertilizers to preceding *kharif* season baby corn resulted in significant improvement in growth parameters and proximate characters of succeeding hyacinth bean during *rabi* season than 75% or 100% recommended dose of fertilizer alone and unfertilized control.

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