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Effect of Nutrient Management on Dry Matter Production and Nutrient Uptake of Hyacinth bean in Baby corn (*Zea mays* L.) – Hyacinth bean (*Lablab purpureus* var. *typicus*) Cropping System

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Abstract

The field experiments were conducted at Horticultural Research Station, SKLTSHU, Adilabad, Telangana State, India during *rabi* seasons (October-February) of 2015-16 and 2016-17 to study the effect of Integrated Nutrient Management practices on dry matter production and nutrient uptake of hyacinth bean in baby corn–hyacinth bean 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 150:60:60 N, P_2O_5 and K_2O kg ha^{-1}), 25 % N supplemented through farm yard manure or vermicompost+75% RDF with or without bio-fertilizers *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each in addition to control and replicated thrice. Each main treatment was divided into four subplots and the treatments of 100% RDF (20-50 N, P_2O_5 kg ha^{-1}) and 75% RDF with or without *Bradyrhizobium* @ 500 g ha^{-1} (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. Application of 25% N through FYM in conjunction with 75% RDF and bio-fertilizer to baby corn during *kharif* and 100% RDF along with seed treatment with *Bradyrhizobium* to hyacinth bean during *rabi* resulted in significantly higher dry matter production at various growth stages and nutrient uptake (nitrogen, phosphorus and potassium) over rest of the treatments.

Keywords: Baby corn, DMP, hyacinth bean, INM, nutrient uptake

1. Introduction

Baby corn is a profitable crop that allows a diversification of production, aggregation of value and increased income. Being a very short duration crop, it can be grown throughout the year and it also fits well in intensive cropping systems. Application of organic manures like farm yard manure and vermicompost proved to be a better alternative to inorganic fertilizers in enhancing growth and yield of the plant (Arora and Maini, 2011; Aleem et al., 2014). Baby corn is a nutrient exhaustive crop (Kotru et al., 2012) and application of chemical fertilizer persist several pros and cons, although their application assist in obtaining maximum production, but keeping in mind the hazardous effect on environmental health as well as growing production cost due to its being expensive, the judicious

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use of fertilizers from different sources to crop will maintain the environmental sustainability for generations without affecting the environmental health (Ranjan et al., 2013); Dadarwal et al. (2009); Kumar et al. (2014). Dadarwal et al. (2009) advocated that integration of 75% NPK accompanied by 2.25 t ha^{-1} of vermicompost amplified the available N, P and K status of the soil. Kannan et al. (2013) stated that integrated use of vermicompost and RDF of NPK significantly influenced the soil organic carbon. Kler et al. (2002) observed better physical, chemical and biological environment in organic manure treatments. The recent energy crisis and hike in prices of inorganic fertilizers necessitates balanced use of nutrients through organic sources like farm yard manure, poultry manure, vermicompost, green manuring, neem cake and bio fertilizers are prerequisites for sustaining soil fertility and producing maximal crop yields with optimum input levels (Dahiphale et al., 2003). Organic carbon build up is appreciable and significant in the case of organic matter applied to soil and organic manures leave behind sufficient quantities of residues for the next crop in sequence (Singh et al., 1996); Baruah et al. (1999). Judicious combination of organic manures (Suri et al., 1997) or bio fertilizers viz., *Azospirillum* (Rai and Gaur, 1982) and phospo bacteria (Dutta et al., 1992) along with in organic fertilizers not only reduce the quantity of chemical fertilizers but also improve the yield and quality of crop produce.

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. It has been cultivated in India since earliest times (Purseglore, 1997). It is indigenous to India and grown all over the country. The dwarf, bushy types of hyacinth bean plants are determinate and are photo insensitive and can be cultivated throughout the year. 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. The potential uses of bio fertilizer in agriculture play an important role of providing an economically viable level for achieving the ultimate goal to enhance productivity. *Bradyrhizobium* inoculation to various legume crops significantly improved nodulation and dry matter production (Mahdi and Mustafa, 2005).

Erratic behavior of rainfall pattern, especially the late onset of monsoon, early cessation of rainfall, long duration cultivars of hyacinth bean are resulting in poor yield and returns in Telangana region. In view of the above the field experiments were conducted during *rabi* seasons (October-February) 2015-16 and 2016-17 to evaluate the efficacy of 100% RDF in-conjunction with *Bradyrhizobium* seed treatment to hyacinth bean and FYM and vermicompost in-conjunction with microbial cultures and inorganic fertilizers to preceding baby corn on dry matter production and nutrient uptake of hyacinth bean in baby corn – hyacinth bean cropping system.

2. Materials and Methods

2.1. Experimental site

Field experiments were carried out during two consecutive *rabi* seasons (October-February) 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 79^0 56′ 03″ E longitude and 19^0 8′ 09″ N latitude. The experimental soil was sandy clay loam in texture, neutral in reaction, medium in available nitrogen, phosphorus 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, 150:60:60 N, P_2O_5, and K_2O kg ha^{-1}), 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^{-1} 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, 50 Kg P_2O_5 ha^{-1}) and 75 % RDF with or without *Bradyrhizobium* @ 500 g ha^{-1} (seed treatment) were imposed in split plot design. Nitrogen was applied to hyacinth bean in the form of urea in two splits at basal and 20 days after sowing (DAS), and entire phosphorus was applied as basal through single super phosphate during both the years. *Bradyrhizobium* (nitrogen fixing bacterial formulation) collected from Agricultural Research Station, Amaravathi, Andhra Pradesh was utilized for seed dressing of hyacinth bean @ 500 g ha^{-1} as per the treatments. "Arka Jaya" variety released by ICAR-Indian Institute of Horticultural Research, Bangalore was sown on 6^{th} and 10^{th} October of 2015 and 2016, respectively. Two seeds were dibbled per hill at a depth of 3-4 cm with a spacing of 45 x 20 cm^2, and gap filling was done at 7 DAS and thinning was done at 14 DAS. Pendimethalin @ 1.0 kg a.i ha^{-1} applied at 2 DAS and hand weeding at 15 and 30 DAS to maintain the fields under weed free condition. Need based plant protection measures were taken up.

2.2. Method of data collection

Five plants used for estimating leaf area were separately sun dried and later oven dried at 65°C till constant weight was obtained and the weights were recorded at 20, 40, 60, 80, 100 DAS and at harvest and expressed as kg ha^{-1}. Pod yield m^{-2} area was recorded from each treatment at each picking from that yield ha^{-1} was calculated. The nitrogen, phosphorus and potassium uptake was calculated using the formula as shown below and is expressed in kg ha^{-1}.

N, P or K uptake (kg ha^{-1})=(N, P or K content (%)×DMP (kg ha^{-1}))÷100

The data was analyzed statistically using *F*-test following

Gomez and Gomez (1984). LSD values at $p<0.05$ were used to determined the significance of difference between treatment means.

3. Results and Discussion

3.1. Variation in the dry matter production (DMP)

Perusal of the pooled data recorded during *rabi,* 2015-16 and 2016-17 revealed that irrespective of the fertilizer treatments imposed during *rabi* to hyacinth bean or INM treatments imposed to preceding *kharif* baby corn, the DMP increased with the advancement of age of the crop up to harvest, and the magnitude of increase was more between 60 and 80 DAS (Table 1). The DMP varied from 510 kg ha^{-1}with 75 % RDF alone to 663 kg ha^{-1} in 100 % RDF+*Bradyrhizobium* seed treatment at 20 DAS to 2300 kg ha^{-1} with 75% RDF alone to 2750 in 100 % RDF+*Bradyrhizobium* seed treatment at harvest. Significantly higher DMP was recorded with application of 100 % RDF along with seed inoculation with *Bradyrhizobium* to hyacinth bean at 20, 40, 60, 80, 100 DAS and harvest over 100% RDF alone, 75% RDF with or without seed inoculation with *Bradyrhizobium* (Table 1). Vijle and Jebaraj (2008) reported similar results of higher DMP with RDF + seed treatment with *Rhizobium* in green gram, Selva kumar et al. (2012) in black gram, Rudresh et al. (2005) in

Table 1: Effect of INM practices on periodic dry matter production (kg ha^{-1}) and yield (kg ha^{-1}) of hyacinth bean in sequence with *kharif* baby corn (pooled data of 2015-16 and 2016-17)

Treatments	Dry matter production (kg ha^{-1}) at various growth stages*						Pod Yield* (kg ha^{-1})
	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	At Harvest	
Main treatments- (*Kharif*-Baby corn)							
T_1	619	805	1164	1717	1852	2723	7816
T_2	625	817	1232	1805	1953	2849	7986
T_3	608	787	1167	1711	1845	2703	7682
T_4	626	808	1173	1725	1861	2731	7793
T_5	567	713	966	1428	1548	2269	6516
T_6	583	738	995	1476	1599	2348	6790
T_7	419	579	789	1200	1292	1940	5944
SEm±	13	11	36	40	46	51	106
CD (p=0.05)	39	35	110	123	141	158	326
Sub-treatments– (Rabi- Hyacinth bean)							
S_1-100% RDF	581	768	1096	1617	1747	2567	7364
S_2-75% RDF	510	683	969	1442	1557	2300	6731
S_3-100% RDF+Bradyrhizobium @ 500 g ha^{-1} Seed treatment	663	832	1195	1745	1888	2750	7647
S_4-75% RDF+Bradyrhizobium @ 500 g ha^{-1} Seed treatment	558	716	1018	1517	1636	2421	7135
SEm±	10	8	24	27	30	36	86
CD (p=0.05)	28	22	68	77	86	101	244
Interaction between							
Bean treatment means at same level of baby corn INM treatments							
SEm±	25	20	63	72	82	94	226
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS
INM treatment means of baby corn at same or different level of bean treatments							
SEm±	25	21	66	74	84	96	223
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

T_1: 25% N through FYM+75% RDF; T_2: 25% N through FYM+75% RDF+*Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each; T_3: 25% N through VC+75% RDF; T_4: 25% N through VC+75% RDF+*Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each; T_5: 100% RDF chick pea and Jayashri and Kushwah (2017) in French bean. Application of 100% RDF alone to hyacinth bean resulted in significantly higher DMP over 75% RDF with or without *Bradyrhizobium* seed treatment at 20, 40, 60, 80, 100 DAS and harvest (Table 1). Significant variations were noticed in the DMP of hyacinth bean crop in *rabi* due to residual effect of treatments imposed to baby corn in the preceding *kharif* season. Application of 75% RDF+25% N through FYM in conjunction with bio fertilizer to preceding baby corn crop in *kharif* season resulted in significantly higher DMP of hyacinth bean at 20, 40, 60, 80, 100 DAS and at harvest over rest of the treatments of 100% RDF with or without biofertilizers and control and was at par with integration of 75% RDF with 25% N through FYM, integration of 75% RDF with 25% N through VC in conjunction with or without use of biofertilizers at 20, 40, 60, 80, 100 DAS and harvest.

Use of phosphorus solubilizing bio fertilizer (*Bacillus megaterium* bio-var *phosphaticum*) in *kharif* and the use of nitrogen fixing bacteria (*Bradyrhizobium*) to *rabi* crop might have helped in solubilization of insoluble phosphorus, stimulating growth (DMP) by providing hormones, vitamins and other growth factors as opined by Bhattacharya and Jain (2000).

3.1.1. Variation in yield

Pooled data on yield of hyacinth bean revealed that application of 100% RDF to hyacinth bean along with seed treatment with *Bradyrhizobium* resulted in significantly higher pod yield (7647 kg ha^{-1}) during *rabi* over 100% RDF alone, 75% RDF with or without seed treatment. Application of 75% RDF in conjunction with seed treatment to hyacinth bean resulted in significantly higher pod yields over 75% RDF alone and was at par with 100% RDF alone. Significantly lower pod yields of hyacinth bean were recorded with the application of 75% RDF alone than rest of the treatments. The yield increase with 100% RDF along with *Bradyrhizobium* treatment was 3.8%, 7.18% and 13.61% over treatments of 100% RDF, 75% RDF+*Bradyrhizobium* and 75% RDF alone (Table 1). Similar results of higher yields with RDF in conjunction with biofertilizer seed treatment were reported by Hunter (1994) in soybean, Ahmed (1998); Abdallah (2001); Rughheim and Abdelgani (2009) in faba bean, Rudresh *et al.*(2005) and Bhuiyan *et al.* (2008) in chick pea, Shehata and Khawas (2003) in sunflower. Significant higher yields in *Bradyrhizobium* inoculated treatment may be due to higher plant uptake of nutrients (Table 2), which in turn might have resulted in higher plant growth in terms of DMP (Table 1) and ultimately resulted in higher yield.

Imposition of various treatments to preceding *kharif* baby corn resulted in significant variations on the yields of succeeding hyacinth bean during *rabi* due to residual effect. Integration of 75% RDF with 25% N through FYM or VC with or without biofertilizers during *kharif* resulted in significantly higher pod yields of succeeding *rabi* hyacinth bean over 100% RDF with or without biofertilizers and un-fertilized control (Table 1). Residual effect due to application of 100% RDF with biofertilizers during *kharif* to baby corn showed significantly higher pod yields of hyacinth bean in the succeeding *rabi* over 100% RDF alone and un-fertilized control though these were significantly lower than the treatments having organic manures. Reducing 25% of inorganic fertilizers resulted in significant reduction in yield of hyacinth bean; however seed treatment with *Bradyrhizobium* compensated the loss of yield and was at par with 100% RDF. Residual effect of FYM applied to baby corn was higher compared to VC on the succeeding hyacinth bean. Presence of persistent material, *i.e.,* cellulose in FYM which required longer time for complete decomposition, thus nutrients released from FYM for longer periods might had notable benefits on succeeding hyacinth bean. Soil application of microbes during *kharif* has shown residual effect on *rabi* hyacinth bean compared to RDF alone or in combination with organics. Organic manures (FYM and VC), apart from serving as source of nutrients (Macro and micro) to a certain extent, their decomposition produces ligands capable of complex ion nutrient elements. Such complexes remain more available to plant roots as complex shields than against immobilization in soil. In addition several indirect effects of organic matter on improvement of soil fertility have been well documented like increased availability of phosphorus (Stevenson, 1982), acceleration in the availability of several micro nutrients like iron, manganese etc., (Katyal, 1986) and improvement in soil microorganisms (Chitesh, 2005 and Nandani, 2006). All these factors might have helped in better growth and yield of hyacinth bean.

3.2. *Variation in nutrient uptake*

3.2.1. Nitrogen uptake (kg ha^{-1})

The N uptake varied from 66.5 kg ha^{-1}and 72.8 kg ha^{-1} in 75 % RDF alone treatment to 81.3 kg ha^{-1} and 89.8 kg ha^{-1} in 100% RDF in conjunction with *Bradyrhizobium* seed treatment during 2015-16 and 2016-17 respectively. In both the years of study (*rabi,* 2015-16 and 2016-17), uptake of N recorded by hyacinth bean was significantly higher with 100% RDF in conjunction with *Bradyrhizobium* seed treatment over 100% RDF alone, 75% RDF with or without seed treatment (Table-2). Higher nitrogen uptake was reported by Patel et al., (2010) with 100% RDF and *Rhizobium* seed treatment in cluster bean over only in organic fertilizer application. Similar results of higher nitrogen uptake, was also reported in soybean, mung bean and cow pea by Aung et al. (2019). Significantly higher N uptake of succeeding hyacinth bean in *rabi,* 2015-16 and 2016-17 were recorded due to residual effect of 75% RDF integrated with 25% N through FYM in conjunction with bio-fertilizer to preceding baby corn. Similar results of higher N uptake were reported by Srinivasan et al. (2014) in baby corn due to residual effect of organic manure applied to preceding cabbage crop. The use of biofertilizers (*Azospirillum* in *kharif* and *Bradyrhizobium* in *rabi*) might have fixed nitrogen from the atmosphere and released plant

Table 2: Effect of INM practices on nitrogen, phosphorus and potassium uptake (kg ha^{-1}) of hyacinth bean at harvest in sequence with *kharif* baby corn

Treatments	2015-16			2016-17		
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Main treatments- (*Kharif*-Baby corn)						
T_1	79.8	13.8	58.2	88.5	15.4	61.5
T_2	85.6	14.8	62.4	93.6	16.3	64.9
T_3	77.9	13.5	56.9	88.4	15.4	61.4
T_4	80.3	13.9	58.6	89.9	15.6	62.5
T_5	66.0	11.5	48.1	71.6	12.5	49.5
T_6	70.1	12.2	51.1	74.8	13.0	51.8
T_7	52.6	9.1	38.4	58.6	10.2	40.9
SEm±	1.1	0.2	0.8	1.4	0.2	0.9
CD (p=0.05)	3.5	0.6	2.5	4.3	0.8	2.8
Sub-treatments– (*Rabi*- Hyacinth bean)						
S_1-100% RDF	74.0	12.8	53.9	82.0	14.3	56.9
S_2-75% RDF	66.5	11.5	48.5	72.8	12.7	50.6
S_3-100% RDF+Bradyrhizobium @ 500 g ha^{-1} Seed treatment	81.3	14.1	59.3	89.8	15.6	62.2
S_4-75% RDF+Bradyrhizobium @ 500 g ha^{-1} Seed treatment	71.0	12.3	51.8	78.5	13.7	54.6
SEm±	1.0	0.2	0.7	1.1	0.2	0.8
CD (p=0.05)	2.9	0.5	2.1	3.3	0.6	2.2
Interaction between						
Bean treatment means at same level of baby corn INM treatments						
SEm±	2.7	0.5	2.0	3.0	0.5	2.1
CD (p=0.05)	NS	NS	NS	NS	NS	NS
INM treatment means of baby corn at same or different level of bean treatments						
SEm±	2.0	0.5	1.9	2.0	0.5	2.0
CD (p=0.05)	NS	NS	NS	NS	NS	NS

T_1:25% N through FYM+75% RDF; T_2:25% N through FYM+75% RDF+*Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each; T_3:25% N through VC+75% RDF; T_4:25% N through VC+75% RDF+*Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each; T^5:100% RDF

available nitrogen.

3.2.2. Phosphorus uptake (kg ha^{-1})

Phosphorus uptake varied from 11.5 kg ha^{-1} and 12.7 kg ha^{-1} in 75% RDF alone treatment to 14.1 kg ha^{-1} and 15.76 kg ha^{-1} in 100% RDF along with *Bradyrhizobium* seed treatment during *rabi,* 2015-16 and 2016-17 respectively. Significantly higher uptake of phosphorus by hyacinth bean during both the years of study was noticed in 100% RDF with seed treatment over 100% RDF alone and 75% RDF with or without seed treatment (Table 2). Tagore et al*.,* 2013 reported maximum uptake of phosphorus by chickpea with inoculation of both *Rhizobium* and PSB integrated with 100% RDF. Application of 75% RDF with seed treatment resulted in on par phosphorus uptake with 100% RDF alone by hyacinth bean during *rabi*, 2015-16 and 2016-17. Residual effect due to application of 75% RDF integrated with 25% N through FYM and biofertilizers to preceding baby corn resulted in significantly higher uptake of phosphorus in the succeeding hyacinth bean crop. Srinivasan et al. (2014) also noticed increased phosphorus uptake of baby corn due to residual effect of application of inorganic fertilizers integrated with organic manures to preceding cabbage crop. The use of *Bacillus megaterium* in *kharif* might have helped in increasing crop productivity (Table 2) by way of helping in solubilization of insoluble phosphorus, stimulating growth in terms of DMP (Table 1) by providing hormones, vitamins and other growth factors.

3.2.3. Potassium uptake (kg ha^{-1})

The potassium uptake varied from 48.5 kg ha^{-1} to 59.3 kg ha^{-1} during *rabi,* 2015-16 and 50.6 kg ha^{-1} to 62.2 kg ha^{-1} during *rabi,* 2016-17. Significantly higher uptake of potassium by hyacinth bean crop during both the years of study was recorded with combined application of 100% RDF and *Bradyrhizobium* seed treatment (Table 2). Similar results of higher uptake of potassium by chickpea with inoculation of both *Rhizobium* and PSB integrated with 100% RDF were reported by Tagore et al. (2013). Application of 75% RDF with 25% N through FYM in conjunction with bio fertilizer to preceding baby corn recorded significant higher uptake of potassium due to residual effect in the succeeding hyacinth bean crop. Srinivasan et al. (2014) noticed similar results of higher potassium uptake in baby corn with application of organic manures to preceding cabbage crop.

4. Conclusion

Application of farm yard manure (25% N) in combination with 75% recommended dose of fertilizer along with bio-fertilizers is recommended for baby corn during *kharif* and 100% recommended dose of fertilizer along with *Bradyrhizobium* seed treatment to hyacinth bean during *rabi* for higher dry matter production, yield and nutrient uptake of hyacinth bean.

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