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Water productivity and profitability of baby corn in baby corn (*Zea mays* L.): Hyacinth bean (*Lablab purpureus* var. *typicus*) cropping system as influenced by nutrient management

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Abstract
A field experiment was conducted in semi arid tropical region during *kharif* and *rabi* seasons of 2015-16 and 2016-17 to study the effect of integrated nutrient management practices on water productivity and profitability of baby corn 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 150:27:50 N, P and K kg/ha), 25% N supplemented through farm yard manure or vermicompost + 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 for *kharif* 2016 was analyzed in split plot design. Significantly higher water productivity, gross and net returns and higher B: C ratio were noticed with integration of 75% RDF with 25% N through vermicompost in conjunction with the biofertilizers (*Azospirillum and Bacillus megaterium*) during both the years of study over 100% RDF with or without biofertilizers, integration of 75% RDF with 25% N through FYM with or without biofertilizer and un-fertilized control. Integration of 100% RDF with *Bradyrhizobium* for seed treatment of hyacinth bean during *rabi*, 2015-16 resulted in significantly higher water productivity over 75% RDF with or without *Bradyrhizobium* seed treatment, higher gross and net returns of baby corn in the succeeding *kharif* season over 100% RDF alone, 75% RDF with or without *Bradyrhizobium* seed treatment.

Keywords: Baby corn, water productivity, gross returns, net returns, B: C ratio

Introduction
Baby corn is de-husked cob, harvested two or three days after silk emergence. Baby corn proved enormously successful in countries like Thailand, Taiwan, Sri Lanka and Myanmar. Baby corn cultivation is now picking up in Meghalaya, Western Uttar Pradesh, Haryana, Maharashtra, Karnataka and Andhra Pradesh (Kheibari *et al.,* 2012) [7]. Baby corn is the high value crop and quality is the prime factor than quantity, integration of organics and bio fertilizers assumes significance. The recent energy and water 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) [4]. Kler *et al*. (2002) [8] observed better physical, chemical and biological environment in organic manure treatments. Judicious combination of organic manures (Suri *et al.*, 1997) [13], or bio fertilizers *viz., Azospirillum* (Rai and Gaur, 1982) [11] and phospo bacteria (Datta *et al.*, 1992) [6] along with in organic fertilizers not only reduce the quantity of chemical fertilizers but also improved the yield and quality of crop produce. In view of the above a study was conducted to assess the water productivity and economics of baby corn in baby corn-hyacinth bean cropping system with integrated use of manures, microbial cultures and inorganic fertilizers.

Materials and Methods
Field experiment was carried out during *kharif* seasons of 2015 and 2016 at Horticultural Research Station, Adilabad, Telangana State, India which has a semi arid tropical climate.

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 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. During *rabi* season each main treatment was divided into four subplots for hyacinth bean and the treatments of *viz.*, 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.

Effective rainfall was calculated as per the water budgeting method described in the FAO irrigation and drainage paper 25 by Dastane, 1974[5]. The quantity of effective rainfall during *kharif*, 2015 and 2016 was 307.6 mm, 529.4 mm respectively. Amount of water applied to each treatment for irrigation was measured by parshall flume. The total amount of water applied (irrigation water applied + effective rainfall) to baby corn crop during *kharif* 2015 and 2016 was 577.6 and 679.4 mm, respectively.

To find out the economic viability of the system, the cost of cultivation, gross returns, net returns and benefit cost ratio were worked out. The expenditure incurred from field preparation to harvest of baby corn was worked out and expressed as Rs. ha^{-1}.The crop yield was computed ha^{-1} and the total income was worked out based on the market rate which was prevalent during the time of study. The local price of de-husked cob of baby corn and stover was Rs.80 and Rs.2 per kg during *kharif*, 2015-16 and 2016-17 were considered for computing gross monitory returns. Net realization of each treatment was calculated by deducting the total cost of cultivation from the gross returns and is expressed as Rs. ha^{-1}. Benefit: cost ratio (BCR) of each treatment was calculated by using the following formula suggested by Subbareddy and Raghuram (1966) [12].

$$\text{B: C ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

Results and Discussion

Water Productivity

Significantly higher water productivity (3.55 and 2.78 kg mm^{-1}) during *kharif*, 2015 and 2016 respectively, was noticed with integration of 75% RDF with 25% N through VC in conjunction with the biofertilizers (*Azospirillum and Bacillus megaterium*) over 100% RDF with or without biofertilizers, integration of 75% RDF with 25% N through FYM with or without biofertilizer and un-fertilized control (Table 1). Next in the order was biofertilizers integrated with 75% RDF and 25% N through FYM or 100% RDF and integration of 75% RDF with 25% N through VC which resulted in higher water productivity over integration of 75% RDF with 25% N through FYM, 100% RDF and un-fertilized control. Least water productivity was observed in un-fertilized control treatment (1.43 and 1.10 kg mm^{-1}). Use of biofertilizers along with 100% RDF showed significantly higher water productivity over 100% RDF alone (Table 1).

Integration of 75% RDF with 25% N through VC was significantly superior to 100% RDF, integration of 75% RDF with 25% N through FYM and un-fertilized control during both the years and was at par with 100% RDF along with use of biofertilizer and integration of 75% RDF with 25% N through FYM in conjunction with biofertilizers during *kharif*, 2015.

Residual effect of 100% RDF applied with *Bradyrhizobium* as seed treatment to hyacinth bean during *rabi*, 2015-16 was significant and resulted in higher water productivity in the succeeding baby corn crop over 75% RDF with or without seed treatment and was at par with 100% RDF alone.

Economics

The cost of cultivation, gross and net returns and B: C ratio varied among the treatments during both the years of study.

Table 1: Effect of integrated nutrient management practices on water productivity (kg mm^{-1}) of baby corn in baby corn- hyacinth bean cropping system.

Treatments	Water Productivity (kg mm^{-1})	
	2015	2016
Main treatments- (*Kharif*-Baby corn)		
T_1- 25% N through FYM + 75% RDF	2.77	2.20
T_2- 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	3.12	2.35
T_3- 25% N through VC + 75% RDF	3.12	2.36
T_4- 25% N through VC + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	3.55	2.78
T_5- 100% RDF	2.67	2.16
T_6- 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	3.13	2.29
T_7- Control (No fertilizer application)	1.43	1.10
S.Em±	0.11	0.02
C.D. (P=0.05)	0.34	0.07
Sub-treatments– (*Rabi*- hyacinth bean)		
S_1-100% RDF		2.28
S_2-75% RDF		2.02
S_3-100% RDF + *Bradyrhizobium* @ 500 g ha^{-1}Seed treatment		2.34
S_4-75% RDF + *Bradyrhizobium* @ 500 g ha^{-1} Seed treatment		2.08
S.Em±		0.02
C.D. (P=0.05)		0.07
Interaction between		
Bean treatment means at same level of baby corn INM treatments		
S.Em±		0.06
C.D. (P=0.05)		NS
INM treatment means of baby corn at same or different level of bean treatments		

S.Em±		0.06
C.D. (P=0.05)		NS

Gross and Net Returns

Significantly higher gross and net returns were recorded with conjunctive use of 75% RDF along with VC (25% N) and biofertilizers (*Azospirillum* and *Bacillus megaterium*) (Rs. 211960 and Rs. 161063 in 2015 and Rs. 193530 and Rs. 145813 ha^{-1} in 2016) respectively over rest of the treatments of 100% RDF, integration of 75% RDF with 25% N through FYM or VC with or without biofertilizers and un-fertilized control during both the years of study (Table 2). Higher gross and net returns are due to higher baby corn cob and stover yields. Significantly lower gross and net returns (Rs. 93482 and Rs. 64547 in 2015 and Rs. 84256 and Rs. 58148 ha^{-1} in 2016, respectively) were recorded with un-fertilized control compared to rest of the treatments.

Biofertilizers in conjunction with 100% RDF resulted in significantly higher gross and net returns (Rs.185356 and Rs.145185 ha^{-1}) in 2015 and (Rs.163502 and Rs.126905 ha^{-1}) in 2016 over 100% RDF and un-fertilized control. Integrated use of biofertilizers and 25% N through FYM and 75% RDF resulted in significantly higher net returns over integration of 75% RDF with 25% N through FYM and un-fertilized control and was on par with 75% RDF + VC (25% N). Vermicompost (25%N) incorporation along with 75% RDF recorded significantly higher gross and net returns over 100% RDF, integration of 75% RDF with 25% N through FYM and un-fertilized control during both the years of study. Highest gross and net returns was realized in baby corn with application of N through chemical fertilizers and VC in the ratio of 75:25% by Ashish Shivran *et al.* (2015) [1]. Similar results of significant increase in net returns and B: C ratio was obtained by application of VC in conjunction with chemical fertilizers over FYM and leaf compost (Barod *et al.*, 2012) [2]. Higher net returns from maize were also reported with the application of VC as compared to farmyard manure (Meena *et al.*, 2011) [10]. Similar results of significantly higher net returns and benefit cost ratio were reported with application of 75% NPK along with 2.25t ha^{-1} VC and bio-fertilizers in baby corn by Dadarwal *et al.* (2009) [3].

Application of 100% RDF with the use of *Bradyrhizobium* for seed treatment of hyacinth bean during *rabi*, 2015-16 resulted in significantly higher gross and net returns of baby corn in the succeeding *kharif* season over 100% RDF alone, 75% RDF with or without *Bradyrhizobium* seed treatment. Use of *Bradyrhizobium* for seed treatment of hyacinth bean crop during *rabi*, 2015-16 with 75% RDF did not show any significant improvement in the net returns of baby corn in the succeeding *kharif* season over application of 75% RDF alone to hyacinth bean.

Table 2: Effect of integrated nutrient management practices on economics (gross returns, COC, net returns and B: C ratio) of baby corn in baby corn- hyacinth bean cropping system.

Treatments	*Kharif*, 2015			*Kharif*, 2016			B: C	
	Gross Returns (Rs. ha^{-1})	COC (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	Gross Returns (Rs. ha^{-1})	COC (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	2015	2016
Main treatments- (*Kharif*-Baby corn)								
T_1- 25% N through FYM + 75% RDF	166848	46562	120286	157438	43598	113840	3.58	3.61
T_2- 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	185970	47796	138174	167096	44417	122679	3.89	3.76
T_3- 25% N through VC + 75% RDF	187030	49468	137562	167604	46118	121486	3.78	3.63
T_4- 25% N through VC + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	211960	50897	161063	193530	47718	145813	4.16	4.06
T_5- 100% RDF	161480	38671	122809	156408	35857	120551	4.18	4.36
T_6- 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	185356	40171	145185	163502	36597	126905	4.61	4.47
T_7- Control (No fertilizer application)	93482	28935	64547	84256	26108	58148	3.23	3.23
S.Em±	5119		5119	1546		1546		
C.D. (P=0.05)	15774		15774	4763		4763		
Sub-treatments– (*Rabi*- hyacinth bean)								
S_1-100% RDF				161852	40059	121793		4.04
S_2-75% RDF				145186	40059	105127		3.62
S_3-100% RDF + *Bradyrhizobium* @ 500 g ha^{-1}Seed treatment				166020	40059	125961		4.14
S_4-75% RDF + *Bradyrhizobium* @ 500 g ha^{-1} Seed treatment				149610	40059	109551		3.73
S.Em±				1442		1442		
C.D. (P=0.05)				4115		4115		
Interaction between								
Bean treatment means at same level of baby corn INM treatments								
S.Em±				3814		3814		
C.D. (P=0.05)				NS		NS		
INM treatment means of baby corn at same or different level of bean treatments								
S.Em±				3647		3647		
C.D. (P=0.05)				NS		NS		

B: C Ratio

The least benefit cost ratio was recorded with un-fertilized control (3.23 and 3.23) during *kharif*, 2015 and 2016 respectively, compared to rest of the treatments (Table 2). Maximum B: C ratio (4.61 and 4.47) in 2015 and 2016 respectively, was noticed with 100% RDF along with the use of biofertilizers which was significantly higher than rest of the treatments. This might be due to low cost of bio-fertilizer when compared to organic manures. It was followed by 100% RDF, integration of 75% RDF with 25% N through VC in conjunction with biofertilizers, integration of 75% RDF with 25% N through FYM in conjunction with biofertilizers, integration of 75% RDF with 25% N through VC, integration of 75% RDF with 25% N through FYM and un-fertilizer control during *kharif*, 2015. During *kharif*, 2016 next in the order were 100% RDF with B: C ratio of 4.36 and integration of 75% RDF with 25%N through VC or FYM with or without biofertilizers and were significantly higher than un-fertilized control though the B: C ratio recorded with VC (25% N) applied along with 75% RDF was at par with conjunctive use of FYM (25%N) along with biofertilizers and 75% RDF. Significantly higher B: C ratio of baby corn were also obtained with recommended dose of nitrogen application over 75 or 50 kg N in combination with neem cake @ 25 or 50% N substitution (Leela Rani *et al.*, 2011) [9]. Residual effect with application of 100% RDF along with seed treatment with *Bradyrhizobium* to hyacinth bean crop in *rabi*, 2015-16 resulted in significantly higher B: C of baby corn (4.14) in the succeeding *kharif*, 2016 which was followed by 100% RDF (4.04) and were significantly higher than 75% RDF with *Bradyrhizobium* seed treatment and 75% RDF alone.

Conclusion

Higher gross and net monetary returns, higher water productivity and profitability of baby corn in baby corn-hyacinth bean cropping system was realized with integration of 25 per cent nitrogen through vermicompost with 75 per cent recommended dose of fertilizer and biofertilizers during *kharif* season and 100 per cent recommended dose of fertilizer along with *Bradyrhizobium* seed treatment to hyacinth bean during *rabi* season.

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