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Research Paper

Influence of nutrient-management practices on production, profitability and energetics of baby corn (*Zea mays*)–hyacinth bean (*Lablab purpureus* var. *typicus*) cropping system

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ABSTRACT

An experiment was conducted at Horticultural Research Station, during the rainy (*kharif*) and winter (*rabi*) seasons of 2015–16 and 2016–17 at Adilabad, Telangana, to study the effect of nutrient-management practices on productivity, profitability and energetics of baby corn (*Zea mays* L.)–hyacinth bean (*Lablab purpureus* subsp. *Purpureus*) cropping system in a randomized block design, replicated thrice. Treatments comprised 100% recommended dose of fertilizer (RDF), 25% N supplemented through FYM or vermicompost + 75% RDF with or without bio-fertilizers *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each in addition to the control. Each main treatment was divided into 4 sub-plots and the treatments of 100% RDF (20 kg N and 22 kg p/ha) and 75% RDF, both with or without *Bradyrhizobium* @ 500 g/ha (seed treatment) were imposed for hyacinth bean in the winter season and data of the winter season of 2015–16 and 2016–17 were analyzed in split-plot design. Application of 25% N through vermicompost in conjunction with 75% RDF and bio-fertilizer to baby corn during the rainy season and 100% RDF along with seed treatment with *Bradyrhizobium* to hyacinth bean during the winter season resulted in significantly higher system productivity, gross and net returns, benefit: cost ratio, gross energy output, energy efficiency and net energy over rest of the treatments.

Key words : Baby corn, Economics, Energetics, Hyacinth bean, INM, System productivity

Maize is the third most important cereal crop next to rice and wheat and has the highest production potential among the cereals (Babu *et al*., 2014, 2016; Yadav *et al.*, 2015). At present, specialty maize 'baby corn' cultivation is becoming popular in Meghalaya, Western Uttar Pradesh, Haryana, Maharashtra, Karnataka and Andhra Pradesh. Being a very short-duration crop, it can be grown throughout the year and fits well in intensive cropping systems. Thus, baby corn is a profitable crop that allows crop diversification with increased income. Lablab bean or hyacinth bean is another crop among the cultivated legumes which is grown throughout the tropical regions of Asia, Africa and America. It is indigenous to India and grown all over the country. In erratic rainfall pattern, especially the late onset of monsoon, early cessation of rainfall, the long-duration cultivars of hyacinth bean are resulting in poor yields and returns in Telangana region. Likewise, application of heavy doses of chemical fertilizers without organic manures is causing deterioration of soil health, The recent energy crisis and hike in prices of inorganic fertilizers also necessitate judicious combination of organic manures and biofertilizers along with fertilizers to improve the yield, economics, food quality and soil health (Suri *et al.,* 2011; Kumar *et al*., 2016; Ruxanabi *et al*., 2019; Singh *et al.,* 2020). Hence an experiment was conducted to assess the productivity, economics and energetics of baby corn-hyacinth bean cropping system with integrated use of manures, microbial cultures and inorganic fertilizers.

MATERIALS AND METHODS

A field experiment was carried-out during 2015–16 to 2016–17 at Horticultural Research Station, Sri Konda Laxman Telangana State Horticultural University, Adilabad, Telangana (79°56'03"E; 19°08'09" N; 264 m altitude). The experimental soil was sandy clay-loam in texture, neutral in reaction, medium in available N, P and

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K and belonged to the order Alfisols of shallow to medium depth. The experiment was laid out in randomized block design (RBD), replicated thrice, during the rainy (*kharif*) season 2015 with 7 treatments comprising of 100% RDF (150 : 27 : 50 N : P : K kg/ha), 25% N supplemented through farmyard 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 3 replications. Each main treatment was divided into 4 subplots during the winter (*rabi*) season of 2015–16 and 2016–17 for hyacinth bean and the treatments of 100% RDF (20 kg N and 22 kg P/ha) and 75% RDF with or without *Bradyrhizobium* @ 500 g/ha (seed treatment) were imposed in split-plot design.

Manures and fertilizers were applied as per the treatment. Farmyard manure (0.5% N, 0.21% P, 0.53% K, 2000 ppm Fe and 61 ppm Zn during 2015 and 0.5% N, 0.3% P, 0.48% K, 739 ppm Fe and 66 ppm Zn during 2016) @ 7.5 t/ha and vermicompost (2.0% N, 1.2% P, 0.6% K, 1,800 ppm Fe and 50 ppm Zn during 2015 and 2.01% N, 1.3% P, 0.6% K, 1,650 ppm Fe and 82 ppm Zn during 2016) @ 1.875 t/ha were incorporated into the soil before sowing as per the treatments. Nitrogen was applied in 3 equal splits in the form of urea at (4, 8 and 12-leaf stage) 10, 25 and 40 days after sowing (DAS). Entire P and K were applied basal through single superphosphate and muriate of potash, respectively, during both the years. *Azospirillum* (nitrogen-fixing bacterial formulation) and *Bacillus megaterium* (PSB formulation) purchased from Bio-fertilizer Lab, ARI, Rajendranagar, Hyderabad, was applied @ 5 kg/ha to baby corn during the rainy season as per the treatments. 'G 5414' variety of baby corn released by Syngenta which matures within 50–55 days was used. The baby corn crop was sown on 22 July and 3 July in 2015 and 2016 respectively. Two seeds were dibbled per hill at a depth of 3-4 cm with a spacing of 60 cm × 15 cm. Gap-filling was done on day 7 after sowing and thinning was done on day 14 after sowing. The field was irrigated immediately after sowing. Subsequent need-based irrigations were given based on IW : CPE ratio of 1. The data on CPE were obtained from metrological observatory, Agricultural Research Station, Adilabad. At each irrigation, 5 cm water was applied. The water was quantified by using parshall flume. Atrazine @1.0 kg a.i./ha was applied at 2 DAS to control the weeds. The field was maintained weed-free by hand-weeding at 15 and 30 DAS. Neem oil was sprayed @ 5 ml/litre at 10 and 12 DAS in rainy season of 2015 and 2016, respectively to control the incidence of aphids and chloropyriphos was applied @ 2 ml/litre at 29 and 37 DAS during rainy season of 2015; 35 and 43 DAS during rainy season of 2016, respectively, for control of stem-borer.

For hyacinth bean, the nitrogen was applied through urea in 2 splits–basal and 20 DAS, and entire P was applied basal through single superphosphate during both the years. *Bradyrhizobium* (nitrogen-fixing bacterial formulation) collected from Agricultural Research Station, Amaravathi, Andhra Pradeshm was utilized for seed dressing of hyacinth bean @ 500 g/ha as per the treatments. 'Arka Jaya' variety released by the ICAR-Indian Institute of Horticultural Research, Bengaluru was sown on 6 and 10 October of 2015 and 2016 respectively. Two seeds were dibbled/hill at a depth of 3–4 cm with a spacing of 45 cm × 20 cm, and gap filling was done at 7 DAS and thinning was done at 14 DAS. Pendimethalin @ 1.0 kg a.i./ha applied at 2 DAS and hand-weeding was done at 15 and 30 DAS to maintain the fields under weed-free condition. Need-based plant-protection measures were taken up.

Cost of cultivation was computed, based on the prevailing market prices of the inputs during the respective crop season. Gross returns were computed based on the cob or pod and straw yields and their prevailing market prices during the respective crop season. Net returns were computed by subtracting cost of cultivation from gross returns. Benefit: cost (B :C) ratio was computed by dividing gross returns with cost of cultivation.

The input energy consists of diesel, human power, electricity, seed, FYM, vermicompost, fertilizers, biofertilizers, pesticides, herbicides and machinery. Total gross output referred to both cob or pod or seed and by product yields. Quantity of all inputs used in the farm of labour, seed and manures were considered. The energy-conversion factors adopted for the study are presented in Table 1. To calculate the input energy, it was converted to energy equivalents by multiplying their per unit energy equivalents. The farm produce (cob yield, pod yield and straw yield) was also converted into energy in terms of energy output (MJ) using 2 years average crop yield multiplied by their energy equivalents per unit. Based on the energy equivalents of the inputs and output, energy-use efficiency, energy productivity, energy intensity in economic terms and net energy were calculated. The energy input was calculated as the summation of energy requirement for labour, farm machineries, seed, fertilizers and irrigation used in system and expressed in GJ/ha. Output energy from the main product (cob/pod) and byproduct (straw) was calculated by multiplying the amount of production and its corresponding energy equivalent and is expressed as GJ/ha. Energetic indices were calculated by using standard formulae (Rana *et al.,* 2014).

The data were analyzed statistically using *F*-test following Gomez and Gomez (1984). The LSD values at P=0.05 were used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Baby corn and hyacinth bean yields

Integration of 75% RDF with 25% recommended dose of nitrogen (RDN) through VC and biofertilizers (*Azospirillum* and *Bacillus megaterium*) resulted in significantly higher cob yields without husk over integration of 75% RDF + 25% N through VC, integration of 75% RDF + 25% N through FYM with or without biofertilizer, 100% RDF, 100% RDF + biofertilizer and the control. The increase in cob yield without husk owing to integration of VC and biofertilizer with 75% RDF was 30.5% and because of biofertilizer integration with 100% RDF was 11.3% over 100% RDF. Integration of 75% RDF with 25% N through FYM showed on par cob yields (without husk) with 100% RDF and significantly superior to the control. Application of FYM or VC along with 75% RDF resulted in improved yield than 100% RDF. Vermicompost proved better in improving the yield than FYM. Synergistic effect of vermicompost along with biofertilizer may be attributed to promoting effect of micronutrient and growth regulators present in it (Ranjan *et al*., 2013).

Application of 100% RDF to hyacinth bean along with seed treatment with *Bradyrhizobium* resulted in significantly higher pod yield (7.65 t/ha) during the winter season 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 than 75% RDF alone and was at par with 100% RDF alone. The yield increase with application of 100% RDF to hyacinth bean along with seed treatment with *Bradyrhizobium* was 3.9% and 13.7% over 100% and 75% RDF alone and 7.1% over 75% RDF along with seed treatment with *Bradyrhizobium.*

System productivity

System productivity was significantly influenced by the treatments given to the rainy season baby corn and succeeding hyacinth bean. Pooled data of 2 years revealed that among different treatments imposed, the highest system productivity of 3.92 t/ha/year was realized owing to application of 75% RDF in conjunction with 25% N substitution through vermicompost and biofertilizer (*Azospirillum* and *Bacillus megaterium*) to baby corn in the rainy season and residual effect on hyacinth bean during the winter season as compared to the other treatments which led to 25.0 and 72.7% increase in productivity over 100% RDF and unfertilized control respectively. This increase in productivity could be owing to higher baby cob, hyacinth bean and straw yields (Table 2). Biofertilizers (*Azospirillum* and *Bacillus megaterium*) when integrated with 25% N through organic manures and 75% RDF or applied along with 100% RDF realized higher system productivity than the treatments in which the biofertilizer was not combined. Among the organic manures, use of vermicompost along with 75% RDF with or without fertilizer realized higher system productivity over FYM along with 75% RDF with or without biofertilizer treatments.

Economics

The cost of cultivation, gross and net returns and B : C

Table 1. Energy equivalents used in the study

Item	Energy equivalent	References
Adult man	1.96 MJ/h	Mittal (1985)
Women	1.57 MJ/h	Mittal (1985)
Farm machinery (Tractor)	64.8 MJ/kg	Devasenapathy *et al*. (2009)
Rotovator	64.8 MJ/kg	Devasenapathy *et al*. (2009)
Diesel	56.31 MJ/lt	Devasenapathy *et al*. (2009)
Petrol	48.23 MJ/lt	Devasenapathy *et al*. (2009)
FYM	0.3 MJ/kg	Devasenapathy *et al*. (2009)
Vermicompost	1.98 MJ/kg	Subhash Babu *et al*. (2014)
N	60.6 MJ/kg	Devasenapathy *et al*. (2009)
P_2O_5	11.1 MJ/kg	Devasenapathy *et al*. (2009)
K_2O	6.7 MJ/kg	Devasenapathy *et al*. (2009)
Zinc sulphate	20.9 MJ/kg	Devasenapathy *et al*. (2009)
Azospirillum, PSB*, Bradyrhizobium*	10 MJ/kg	Devasenapathy *et al*. (2009)
Pesticides, herbicides, neem oil	120 MJ/kg	Devasenapathy *et al*. (2009)
Baby corn, hyacinth bean	14.7 MJ/kg	Devasenapathy *et al*. (2009)
Baby cob	18.0 MJ/kg	Devasenapathy *et al*. (2009)
Baby corn straw dry mass	12.5 MJ/kg	Devasenapathy *et al*. (2009)
Hyacinth bean pod	1.9 MJ/kg	Devasenapathy *et al*. (2009)
Hyacinth bean straw dry mass	10 MJ/kg	Devasenapathy *et al*. (2009)

MJ = 0.001 GJ

ratio varied among the treatments. Pooled data of 2 years revealed that, the highest cost of cultivation was incurred with 25% N through vermicompost in conjunction with 75% RDF and biofertilizer (88.3 × 10^3/ha) (Table 2). It may be due to high cost of vermicompost. Higher gross and net returns and B : C ratio were recorded with incorporation of 25% N through vermicompost along with 75% RDF and biofertilizer. This was owing to higher system productivity as compared to other treatments.

Energetics

Pooled data of 2 years on energetics of baby corn–hyacinth bean system revealed that, there was marked variation in the input energy used, output energy, energy efficiency, energy productivity, energy intensity in economic terms and net energy due to imposition of various nutrient management practices (Table 3). The input energy utilized was more in the vermicompost applied treatments along with 75% RDF with or without bio-fertilizers followed by 100% RDF treatments with or without bio-fertilizer and integration of 25% N through FYM + inorganic form with or without biofertilizer. The least input energy was used in unfertilized control. The maximum gross output energy was recorded with integration of vermicompost (25% N) with 75% RDF and biofertilizer (145.33 GJ/ha) followed by integration of 25% N through FYM along with 75% RDF and biofertilizers (130.95 GJ/ha) (Table 3). The highest energy efficiency was observed with integration of 25% RDN through vermicompost with 75% RDF and biofertilizers to baby corn during the rainy season and 100% RDF along with seed treatment with *Bradyrhizobium* to hyacinth bean during the winter season.

Table 2. Effect of integrated nutrient managment practices on system productivity and economics of baby corn-hyacinth bean cropping system (pooled data of 2 years)

Treatment	Baby corn yield (t/ha)	Hyacinth bean yield (t/ha)	BEY (t/ha)	System productivity (t/ ha)	System productivity (kg/ha/day)	Cost of cultivation (×10^3 ₹/ha)	Goss returns (×10^3₹/ha)	Net returns (×10^3₹/ha)	Benefit: cost ratio
Main treatments-(Rainy season-Baby corn)									
T_1—, 25% N through FYM + 75% RDF	1.55	7.82	1.95	3.50	9.6	84.1	318.5	234.3	3.80
T_2, 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each	1.70	7.99	2.00	3.70	10.1	85.1	336.2	251.1	3.96
T_3, 25% N through VC + 75% RDF	1.70	7.68	1.92	3.62	9.9	86.8	331.0	244.1	3.82
T_4, 25% N through VC + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each	1.97	7.79	1.95	3.92	10.7	88.3	358.6	270.3	4.05
T_5, 100% RDF	1.51	6.52	1.63	3.14	8.6	76.3	289.3	213.0	3.80
T_6, 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each	1.68	6.79	1.70	3.38	9.3	77.4	310.2	232.8	4.01
T_7, Control (No fertilizer application)	0.79	5.94	1.49	2.27	6.2	66.6	207.8	141.2	3.14
SEm ±	0.04	0.11	0.03	0.04	0.12	—	5.45	5.45	—
CD (P=0.05)	0.12	0.33	0.08	0.13	0.37	—	16.8	16.8	—
Sub-treatments: (Winter season-hyacinth bean)									
S_1, 100% RDF	1.59	7.36	1.84	3.43	9.40	80.9	319.2	232.5	3.83
S_2, 75% RDF	1.50	6.73	1.68	3.18	8.72	80.3	306.7	212.0	3.52
S_3, 100% RDF + *Bradyrhizobium* @ 500 g/ha seed treatment	1.61	7.65	1.91	3.52	9.66	81.1	324.7	240.0	3.95
S_4, 75% RDF + *Bradyrhizobium* @ 500 g/ha seed treatment	1.52	7.14	1.78	3.31	9.06	80.4	315.2	222.2	3.70
SEm±	0.03	0.09	0.02	0.02	0.06	—	1.8	1.8	—
CD (P=0.05)	0.09	0.24	0.06	0.06	0.17	—	5.2	5.2	—

*BEY, Baby corn-equivalent yield
FYM, Farmyard manure; RDF, recommended dose of fertilizer; VC, vermicompost

Table 3. Effect of integrated nutrient-management practices on energetic of baby corn-hyacinth bean cropping system (pooled data of 2 years)

Treatment	Energy input (GJ/ha)	Gross energy output (GJ/ha)	Energy efficiency	Energy productivity (kg/MJ)	Energy intensity ineconomic terms (₹/MJ)	Netenergy (GJ/ha)
Main treatments- (*Rainy season*-Baby corn)						
T_1—, 25% N through FYM + 75% RDF	38.87	123.66	3.18	1.09	1.77	84.79
T_2, 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each	38.90	130.95	3.37	1.14	1.86	92.05
T_3, 25% N through VC + 75% RDF	40.31	130.07	3.23	1.09	1.81	89.76
T_4, 25% N through VC + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each	40.33	145.33	3.61	1.14	2.00	105.00
T_5, 100% RDF	39.23	119.09	3.04	0.95	2.03	79.86
T_6, 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg/ha each	39.42	126.48	3.21	0.99	2.13	87.07
T_7, Control (No fertilizer application)	28.53	76.63	2.69	0.96	1.60	48.10
SEm±	—	1.72	0.07	0.02	0.03	2.27
CD (P=0.05)	—	5.29	0.20	0.07	0.09	6.98
Subtreatments: (*Winter season*- hyacinth bean)						
S_1, 100% RDF	37.75	123.98	3.28	1.05	1.53	85.31
S_2, 75% RDF	37.30	116.81	3.13	0.99	1.45	78.42
S_3, 100% RDF + *Bradyrhizobium* @ 500 g/ha seed treatment	37.75	126.88	3.36	1.11	1.56	88.35
S_4, 75% RDF + *Bradyrhizobium* @ 500 g/ha seed treatment	37.31	119.29	3.20	1.02	1.48	81.11
SEm+	—	1.30	0.03	0.02	0.02	1.95
CD (P=0.05)	—	3.75	0.09	0.04	0.06	5.71

*BEY, Baby corn-equivalent yield
FYM, Farmyard manure; RDF, recommended dose of fertilizer; VC, vermicompost

Higher energy efficiency values were observed because of higher gross output-energy realization. Maximum energy productivity was realized with integration of 25% N through vermicompost or FYM with 75% RDF and biofertilizers (1.14 kg/MJ) during the rainy season and 100 RDF along with seed treatment with *Bradyrhizobium* during the winter season. Highest energy intensity in economic terms was measured with 100% RDF along with bio fertilizers to baby corn followed by 100% RDF and integration of 25% N through vermicompost and 75% RDF with biofertilizers to *kharif* baby corn followed by 100% RDF + *Bradyrhizobium* seed treatment to *rabi* hyacinth bean (Table 3). The maximum net energy was recorded with conjunctive use of 25% N through vermicompost with 75% RDF and biofertilizer during the rainy season followed by 100% RDF with *Bradyrhizobium* seed treatment in the winter season. The least net energy was recorded with unfertilized control treatment during the rainy season and 75% RDF alone during in the winter season.

Based on the study, it was concluded that among different INM practices tested for baby corn-hyacinth bean cropping system, 75% RDF in conjunction with 25% N through vermicompost and biofertilizer to baby corn during the rainy season and 100% RDF along with seed treatment with *Bradyrhizobium* to hyacinth bean during the winter season realized higher system productivity, gross and net returns, higher benefit: cost ratio and higher energy efficiency, energy productivity and net energy.

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