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Original Research Article

Enhancing Productivity and Quality of Fodder through Organic Source of Nutrients in Fodder Cowpea - Maize Cropping System

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A B S T R A C T

The field experiment was conducted to improve the fodder productivity and quality with utilizing the locally available farm waste for conversion of organic manures and to reduce the use of external inputs and to assess the effect of organic source of nutrients on fodder yield and quality in fodder cowpea-maize cropping system. Among organic sources application of 50% recommended nitrogen through farm yard manure and remaining 50% recommended nitrogen through either vermicompost or bio compost or both recorded improvement in green forage, dry matter and crude protein yield. Fodder quality was not influenced by source of organic nutrients and not much variation in soil available nutrients; electrical conductivity and organic carbon content was noticed. However, improvement in microbial biomass was observed. Application of 50% recommended nitrogen through farm yard manure and remaining 50% recommended nitrogen through bio compost found remunerative compared to other source of organic nutrients.

Keywords

Crude protein, Green forage, Dry matter, Microbial biomass and economics

Introduction

Livestock is the backbone of Indian agriculture and play a pivotal role in Indian economy with contribution of 25.6 per cent to agricultural gross domestic product & 4 per cent of the total gross domestic product of the country (Anon, 2017) and providing employment especially in rural area. The fodder supply situation in India is extremely precarious and the gap is very wide. The chronic shortage of feed and fodder resources during the last few decades indicate that, most of the livestock were underfed. The current agricultural system is largely affect due to unsustainability in food and fodder production due to over use of toxic chemicals, pesticides, fertilizers, that have resulted deterioration of soil health and pollution of ground water resources and excess erosion which leads to leaching of mobile nutrients resulted in low soil productivity and decreased income. Therefore, there is a need to gradual decrease in usage of inorganic fertilizers and in turn enhanced the use of different organic manures as a source of nutrients leads to sustainable production (Abubakar and Ali. 2018). Apart from these organically grown products fetches more value than normal once. Presently organic dairy products are on high demand in the market and moreover farmers can utilize easily available waste in

his form converted into manures and it can use it for cultivation of fodder, which is cost effective and sustainable. The research information on fodder cultivation with use of organic source of nutrients is very meagre. Keeping these things in view, the present investigation was under taken to study the organic source of nutrients on forage yield and quality of fodder cowpea & Maize in fodder cowpea-maize cropping system.

Materials and Methods

A field experiment was conducted during *kharif and rabi* seasons of 2019 at Zonal Agriculture Research Station Vishweshwaraiah canal Farm, Mandya, University of Agricultural Sciences, Bangalore, Karnataka, to study the effect of organic sources of nutrients on fodder maize and cowpea in fodder cowpea-maize cropping system. The experiment was laid out in randomized complete block design comprising of 12 treatments *viz.*, T_1-100% RDN through inorganic fertilizers, T_2-100% RDN through farm yard manure, T_3-75% RDN through farm yard manure + 25% RDN through vermicompost, T_4-75% RDN through farm yard manure + 25% RDN through bio-compost, T_5-50% RDN through farm yard manure + 50% RDN through vermicompost, T_6-50% RDN through farm yard manure + 50% RDN through bio-compost, T_7-75% RDN through farm yard manure, T_8-75% RDN of T_3 (56 % RDN through farm yard manure + 19% RDN through vermicompost), T_9-75% RDN of T_4 (56% RDN through farm yard manure + 19% RDN through bio-compost), T_{10}-75% of T_5 (37.5% RDN through farm yard manure + 37.5% RDN through vermicompost), T_{11}-75% of T_6 (37.5% RDN through farm yard manure + 37.5% RDN through vermicompost) and T_{12}-50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS. The trial was laid out in Randomized block design with replicated thrice. The soil of experimental site is sandy loam texture with neutral in reaction (7.1), medium in available nitrogen (318.5 kg ha^{-1}), phosphorus (54.1 kg ha^{-1}) and potassium (238.5 kg ha^{-1}). The organic carbon content was medium (0.65 %).

The first crop of fodder cowpea variety MFC-09-1 was sown during the first fortnight of July with recommended spacing of 30 cm between the rows, the recommended dose of phosphorous 60 Kg ha^{-1} and potassium 0 Kg ha^{-1} was applied at the time of sowing. The crop was harvested fifty per cent flowering, which has taken 55-60 days after sowing. The second crop of maize was sown during fist fortnight of October with recommended spacing of 30 cm between the rows, the recommended dose of phosphorous 60 Kg ha^{-1} and potassium 40 Kg ha^{-1} was applied at the time of sowing. The crop was harvested at dough stage, which has taken 70-75 days after sowing. The cultural practices were followed as per the recommended package of practices for the establishment of crops. Totally 110 Kg nitrogen recommended for cropping system applied in two equal splits, 50% RDN for *Kharif* crop of fodder cowpea (55 N Kg ha^{-1}) and remaining 50% RDN (55 N Kg ha^{-1}) was applied to fodder maize through different source of organic manures based on N equivalent three weeks prior to sowing with available phosphorous and potassium and no inorganic fertilizers were applied to meet the phosphorous and potassium equivalent. Immediately after harvest of the crop green fodder yield was recorded. The known quantity of sample was taken and oven dried at 70 $\pm$ 2 □ C temperature for the estimation of dry matter content and as well as other quality parameters. Economics was calculated with prevailing market price for output and input costs. The data was statistically analyzed by

adopting Fishers methods of analysis of variance as outlined by Gomez and Gomez (1984) for interpretation of results and draw conclusion (Table 1–7).

$$\text{Dry matter yield (q/ha)} = \frac{\text{Dry matter \% x Green forage yield (q/ha)}}{100}$$

$$\text{Crude protein yield (q/ha)} = \frac{\text{Crude protein \% x Dry matter yield (q/ha)}}{100}$$

$$\text{Gross returns (Rs ha}^{-1}\text{)} = \text{Green fodder yield x market price}$$

$$\text{Net returns (Rs ha}^{-1}\text{)} = \text{Gross returns} - \text{Total cost of cultivation}$$

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

Results and Discussions

Green forage yield

The green forage yield of fodder cowpea and maize as influenced by organic source of nutrients recorded at harvest as presented in table 2. The green forage yield of fodder cowpea was significantly influenced by organic source of nutrients. Among organic source of nutrients higher green forage yield was recorded with 50% RDN through farm yard manure + 50% RDN through Bio-compost (231.6 q ha^{-1}) which was on par with 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS (218.4 q ha^{-1}), While, lower green forage yield was recorded with 75% of T_5 i.e 37.5% RDN through farm yard manure + 37.5% RDN through vermicompost (150.1 q ha^{-1}).

In fodder maize significantly higher green forage yield was noticed with 50% RDN through farm yard manure + 50% RDN through bio-compost (352.0 q ha^{-1}) which was on par with the 100% RDN through farm yard manure (351.2 q ha^{-1}), 50% RDN through + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS (350.3 q ha^{-1}), 75% RDN through farm yard manure + 25% RDN through bio-compost (325.4 q ha^{-1}) and 75% RDN through farm yard manure+ 25% RDN through vermicompost (303.8 q ha^{-1}).

Whereas, 75% RDN through farm yard manure recorded lower green forage yield (238.3 q ha^{-1}). The increase in green forage yield is mainly due to higher plant height and leaf stem ratio and quick release of nutrient from bio-compost resulted better growth of plant which led to more green biomass. This is in conformity with the findings of Uwah *et al.,* (2014) and Thavaprakah *et al.,* (2005).

Among organic source of nutrients application of 50% RDN through farm yard manure + 50% RDN through bio-compost recorded higher system productivity (583.6 q ha^{-1}) which was on par with 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS (568.8 q ha^{-1}) and 50% RDN through farm yard manure + 50% RDN through vermicompost (565.3 q ha^{-1}). Whereas, lower system productivity was observed with 75% RDN through farm yard manure (370.8 q ha^{-1}).

Dry matter yield

The dry matter production of fodder cowpea and maize was significantly influenced by organic source of nutrients and data is presented in Table-2.

In Fodder cowpea among organic sources application of 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS recorded significantly higher dry matter yield (45.0 q ha^{-1}), which was on par with 50% RDN through farm yard manure + 50% RDN through bio-compost (43.9 q ha^{-1}), 50% RDN through farm yard manure + 50% RDN through vermicompost (42.1 q ha^{-1}) & 75% RDN through farm yard manure+ 25% RDN through vermicompost (36.7 q ha^{-1}). In fodder maize 50% RDN through farm yard manure + 50% RDN through bio-compost recorded significantly higher dry matter yield (87.6 q ha^{-1}) which was on par with 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS (84.7 q ha^{-1}) and 50% RDN through farm yard manure + 50% RDN through vermicompost (84.6 q ha^{-1}), 100% RDN through farm yard manure (77.4 q ha^{-1}) and 75% RDN through FYM + 25% RDN through bio-compost (76.4 q ha^{-1}). Whereas, lower dry matter yield was recorded with 75% RDN of T_3 (56% RDN through farm yard manure + 19% RDN through vermicompost) (51.5 q ha^{-1}). Among organic sources, application of 50% RDN through farm yard manure + 50% RDN through bio-compost recorded significantly higher system dry matter yield (131.5 q ha^{-1}), which was on par with 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS (129.8 q ha^{-1}) and 50% RDN through farm yard manure + 50% RDN through vermicompost (126.7 q ha^{-1}). The increase in dry matter yiled is mainly due to increasing in green biomass and dry matter content. Apart from this better partitioning and photosynthetic rate, which was evidenced by better nutrient uptake, led to vigorous growth of plant and resulted more interception, absorption and utilization of solar radiation leading to higher photosynthetic rate and better portioning and finally more accumulation and production of dry matter. This is in accordance with the findings of Singh *et al.,* (2011) and Joshi *et al.,* (2016).

Quality parameters

Application of organic source of nutrients had significant influence on crude protein yield and content in fodder cowpea - maize cropping system and data is presented in table 3 & 4. Application of 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS significantly recorded higher crude protein yield (17.0 q ha^{-1}), which was on par with 50% RDN through farm yard manure + 50% RDN through bio-compost (15.7 q ha^{-1}), whereas, lower crude protein yield (9.4 q ha^{-1}) was recorded with 75% RDN of T_3 (56% RDN through farm yard manure + 19% RDN through vermicompost). This is due to enhanced dry matter yield and higher crude protein content with higher dose of nitrogen. This assumption as well reasonable treatment greater nutrient content of plants with bio-compost and other organic nutrients, led higher translocation within the plant system. The similar results were reported by Dabhi *et al.,* (2017), Neelar (2011) and Patel *et al.,* (2018)

Application of 100% RDF through inorganic fertilizers recorded significantly recorded higher content of fibre (28.7% and 27.9%), Ether extract (3.2% and 3.3%), Ash (10.6% and 9.1%) and carbohydrates (30.6% and 32.3%) in fodder cowpea and maize respectively. The non significant influence of

organic sources of nutrients was observed on quality of forage both in fodder cowpea and maize. However, application of 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS recorded numerically higher crude fibre (30.5% and 29.9%), Ether extract (2.9% and 3.0%), Ash (9.1% and 8.3%) and carbohydrates (29.1% and 30.3%) in fodder cowpea and maize respectively.

The significant decrease in crude fibre content with increased nitrogen content in herbage is due to synthesized carbohydrates is transformed into proteins and only a minor proteins are available for cell wall leads to more protoplasm. The plant rich in nitrogen content is relatively high proportion of water, low in dry matter content and leaves are more succulent and low in crude fiber content. The increased nitrogen content correspondingly increases the meristematic activity due to which, absorption of mineral salts increase which leads to rapid respiration process and conversion of most of carbohydrates into fat and apart from this nitrogen plays a major role in protein synthesis and nitrogen free extract is a part of carbohydrates (Fig. 1 and 2). This is in conformity with the findings of Joshi *et al.,* (2016) and Singh *et al.,* (2011)

Soil properties:

The organic source of nutrients had no significant influence on organic carbon content in soil (Table 5). However, numerically higher carbon content of soil after completion of cropping sequence was observed with combined application of 50% or 75% or 100% RDN through farm yard manure and 25% through either of vermicompost or bio-compost (0.73%). The significantly lower electrical conductivity was observed with application of 50% RDN through farm yard manure + 50% RDN through vermicompost (0.18 ds m^{-1}), which was on par with 50% RDN through farm yard manure + 50% RDN through bio-compost (0.21 ds m^{-1}) and 75% RDN through farm yard manure and 25% RDN through vermicompost (0.19 ds m^{-1}), whereas, application of 100% RDF through Inorganic fertilizer recorded higher electrical conductivity (0.27 ds m^{-1}).

The soil available nitrogen was significantly higher with 100% RDN through farm yard manure (317.9 Kg ha^{-1}), which was on par with 75% RDN through farm yard manure + 25% RDN through vermicompost (313.5 Kg ha^{-1}) and 50% RDN through farm yard manure + 50% RDN through vermicompost (293.5 Kg ha^{-1}). The lower soil available nitrogen was observed with 75% of T_6 (37.5% RDN through farm yard manure + 37.5% RDN through vermicompost)) (196.1 Kg ha^{-1}).

Application of 50% RDN through farm yard manure + 50% RDN through vermicompost recorded significantly higher soil available phosphorous (53.6 Kg ha^{-1}). Whereas lower (28.5 Kg ha^{-1}) with 75% of T_6 (37.5% RDN through farm yard manure + 37.5% RDN through vermicompost) and 75% RDN of T_4 (56% RDN through farm yard manure + 19% RDN through bio-compost) (28.7 Kg ha^{-1}). Application 75% RDN through farm yard manure + 25% RDN through vermicompost recorded significantly higher available potassium (203.8 Kg ha^{-1}), which was on par with 100% RDN through farm yard manure (185.0 Kg ha^{-1}), 50% RDN through farm yard manure + 50% RDN through vermicompost (189.8 Kg ha^{-1}) and 75% RDN through farm yard manure + 25% RDN through bio-compost (182.5 Kg ha^{-1}). The lower soil available potassium (113.4 Kg ha^{-1}) was noticed with 75% of T_5 (37.5% RDN through farm yard manure + 37.5% RDN through vermicompost).

Table.1 Growth Attributers of fodder cowpea and maize as influenced by organic source of nutrients in fodder cowpea-maize system

Sl No	Treatments	Plant height (cm)		Leaf stem ratio	
		Cowpea	Maize	Cowpea	Maize
T_1	100% RDF through inorganic fertilizers	84.7	235.4	0.68	0.46
T_2	100% RDN through farm yard manure	60.0	206.8	0.59	0.36
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	70.5	216.8	0.52	0.30
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	69.4	213.5	0.50	0.33
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	71.6	221.7	0.53	0.36
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	79.3	232.7	0.56	0.35
T_7	75% RDN through farm yard manure	59.6	214.7	0.55	0.30
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	61.6	210.7	0.50	0.28
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	59.2	210.4	0.49	0.29
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	57.0	205.1	0.47	0.27
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	57.9	209.6	0.46	0.26
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	68.7	217.4	0.61	0.38
	S. Em±	**3.1**	**5.9**	**0.14**	**0.13**
	CD @ 5%	**9.2**	**17.5**	**0.39**	**0.37**

Table.2 Green forage & dry matter yield of fodder cowpea and maize as influenced by organic source of nutrients

Sl No	Treatments	Green forage yield (q/ha)			Dry matter yield (q/ha)		
		Cowpea	Maize	System	Cowpea	Maize	System
T_1	100% RDF through inorganic fertilizers	250.7	409.0	659.7	54.2	107.7	161.9
T_2	100% RDN through farm yard manure	163.3	351.2	514.5	30.4	77.4	107.7
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	184.1	303.8	487.9	36.7	69.8	106.5
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	177.4	325.4	502.8	33.8	76.4	110.2
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	217.3	348.0	565.3	42.1	84.6	126.7
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	231.6	352.0	583.6	43.9	87.6	131.5
T_7	75% RDN through farm yard manure	132.4	238.4	370.8	24.9	53.3	78.2
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	150.7	253.3	404.0	25.5	51.5	77.0
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	146.6	264.9	411.5	24.5	54.5	78.9
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	150.1	284.8	434.9	25.0	70.7	95.6
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	165.1	276.1	441.2	29.4	61.3	90.6
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	218.4	350.4	568.8	45.0	84.7	129.8
	S. Em±	**12.64**	**16.50**	**18.26**	**2.74**	**4.76**	**4.34**
	C. D @5%	**17.87**	**48.70**	**53.89**	**8.07**	**14.05**	**12.81**

Table.3 Dry matter and crude protein content (%) of fodder cowpea and maize as influenced by organic source of nutrients

Sl No	Treatments	Dry matter content (%)		Crude protein content (%)		Crude protein yield (q/ha)		
		Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	System total
T_1	100% RDF through inorganic fertilizers	21.6	26.3	18.9	10.8	10.3	11.6	21.9
T_2	100% RDN through farm yard manure	18.7	22.0	16.8	9.1	5.4	7.0	12.4
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	19.9	23.1	17.2	8.9	6.3	6.2	12.5
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	19.1	23.4	17.9	8.6	6.1	6.6	12.6
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	19.4	24.4	16.5	9.1	6.9	7.7	14.6
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	18.9	25.0	18.4	8.7	8.1	7.6	15.7
T_7	75% RDN through farm yard manure	18.6	22.3	17.4	8.9	5.0	4.7	9.7
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	16.9	20.5	17.3	9.0	4.7	4.7	9.4
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	16.8	20.6	17.7	9.3	4.9	5.1	10.0
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	16.7	24.2	17.6	9.5	4.7	6.8	11.5
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	17.8	22.1	17.5	9.6	5.3	5.9	11.2
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	20.6	22.0	18.2	10.4	8.2	8.8	17.0
	S. Em±	**0.67**	**0.88**	**0.31**	**0.41**	**0.4**	**0.4**	**0.5**
	CD @ 5%	**1.98**	**2.59**	**0.93**	**1.20**	**1.2**	**1.3**	**1.4**

Table.4 Effect of organic source of nutrients on quality of fodder cowpea and maize in fodder cowpea-maize system

Sl No	Treatments	Fodder Cowpea				Fodder Maize			
		Crude fibre (%)	Ether extract (%)	Ash (%)	Carbohy drates (%)	Crude fibre (%)	Ether extract (%)	Ash (%)	Carbohy drates (%)
T_1	100% RDF through inorganic fertilizers	28.7	3.2	10.6	30.6	27.9	3.3	9.1	32.3
T_2	100% RDN through farm yard manure	29.5	2.7	9.3	28.3	29.3	2.8	7.9	29.6
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	29.6	2.4	8.4	27.1	27.5	2.7	7.6	29.0
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	28.1	2.3	8.8	27.5	27.9	2.6	7.6	28.6
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	28.7	2.6	8.5	27.1	28.7	2.8	7.5	27.6
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	28.0	2.6	8.5	28.0	28.0	2.8	8.0	27.1
T_7	75% RDN through farm yard manure	27.6	2.4	8.3	28.1	28.1	2.6	7.1	29.6
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	26.5	2.2	7.6	27.0	27.0	2.7	7.3	25.9
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	26.9	2.3	7.5	26.9	26.9	2.6	6.6	26.9
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	26.5	2.3	7.7	26.5	27.1	2.7	6.9	26.7
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	26.6	2.2	7.7	26.7	26.6	2.6	6.9	27.0
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	30.5	2.9	9.1	29.1	29.9	3.0	8.3	30.3
	S. Em+	**1.42**	**0.25**	**1.65**	**0.89**	**1.02**	**0.13**	**0.7**	**1.53**
	CD @ 5%	**4.01**	**0.73**	**4.87**	**2.63**	**2.99**	**0.37**	**2.06**	**4.42**

Table.5 Soil properties as influenced by organic source of nutrients in fodder cowpea – maize cropping system

Sl No	Treatments	OC (%)	EC (ds m^{-1})	Soil Available Nutrients (Kg/ha)		
				N	P	K
T_1	100% RDF through inorganic fertilizers	0.67	0.27	358.3	50.3	217.3
T_2	100% RDN through farm yard manure	0.73	0.23	317.9	43.0	185.0
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	0.73	0.19	313.5	42.1	203.8
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	0.73	0.23	281.5	46.3	182.5
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	0.73	0.18	293.5	53.6	189.8
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	0.67	0.21	249.1	48.2	155.8
T_7	75% RDN through farm yard manure	0.68	0.25	232.0	36.7	133.7
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	0.70	0.23	216.7	36.6	127.4
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	0.67	0.25	205.1	28.7	115.5
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	0.70	0.25	205.2	29.9	113.4
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	0.65	0.24	196.1	28.5	115.1
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	0.70	0.23	230.2	31.3	137.6
	S. Em±	**0.02**	**0.01**	**8.91**	**1.56**	**5.98**
	CD @ 5%	**NS**	**0.03**	**26.14**	**4.57**	**17.54**
	Initial Soil Values	**0.65**	**0.26**	**318.5**	**54.1**	**238.5**

Table.6 Effect of organic source of nutrients on microbial biomass in fodder cowpea – maize cropping system

Sl No	Treatments	After harvest of Cowpea			After harvest of Maize		
		Bacteria (cfu x 10^5 g^{-1} of Soil)	Fungi (cfu x 10^3 g^{-1} of Soil)	Actinomycetes (cfu x 10^3 g^{-1} of Soil)	Bacteria (cfu x 10^5 g^{-1} of Soil)	Fungi (cfu x 10^3 g^{-1} of Soil)	Actinomycetes (cfu x 10^3 g^{-1} of Soil)
T_1	100% RDF through inorganic fertilizers	28.6	15.4	8.4	26.6	13.3	7.7
T_2	100% RDN through farm yard manure	40.4	22.0	13.0	42.0	23.7	14.6
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	41.8	22.9	13.3	43.1	24.6	15.0
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	40.8	20.8	13.6	43.1	21.8	14.7
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	43.1	24.7	14.6	45.5	25.9	12.3
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	38.7	22.1	11.6	41.0	23.9	13.7
T_7	75% RDN through farm yard manure	41.1	24.5	12.5	42.4	25.0	14.3
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	38.7	23.1	12.6	40.4	23.5	14.5
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	36.3	21.5	12.4	38.4	22.8	12.8
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	39.0	22.3	10.7	41.1	24.0	13.8
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	35.7	21.8	12.5	37.6	22.5	13.9
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	36.1	21.2	12.6	38.3	22.8	13.7
	S. Em±	**1.15**	**0.67**	**0.48**	**1.40**	**0.87**	**0.50**
	CD @ 5%	**3.37**	**1.97**	**1.42**	**4.10**	**2.55**	**1.45**
	Initial Soil Values	**31.3**	**11.2**	**9.5**	**-**	**-**	**-**

Table.7 Economics of organic source of nutrients in fodder cowpea - maize cropping system

Sl No	Treatments	Gross Returns (Rs./ha)			Net Returns (Rs./ha)			C:B ratio		
		Cowpea	Maize	System	Cowpea	Maize	System	Cowpea	Maize	System
T_1	100% RDF through inorganic fertilizers	50138	61351	111489	33617	36816	70433	3.0	2.5	2.8
T_2	100% RDN through farm yard manure	32657	52677	85334	8682	22752	31434	1.4	1.8	1.6
T_3	75% RDN through farm yard manure + 25% RDN through vermicompost	36824	45572	82397	12832	15629	28461	1.5	1.5	1.5
T_4	75% RDN through farm yard manure + 25% RDN through bio-compost	35479	48816	84295	13422	20809	3423	1.6	1.7	1.7
T_5	50% RDN through farm yard manure + 50% RDN through vermicompost	43458	52196	95655	19433	22221	41654	1.8	1.7	1.8
T_6	50% RDN through farm yard manure + 50% RDN through bio-compost	46324	52799	99124	26166	26690	52856	2.3	2.0	2.1
T_7	75% RDN through farm yard manure	26478	35759	62237	5215	8546	13761	1.2	1.3	1.3
T_8	75% RDN of T_3 (56% through farm yard manure + 19% through vermicompost)	30132	38001	68133	8837	10756	19593	1.4	1.4	1.4
T_9	75% RDN of T_4 (56% through farm yard manure + 19% through bio-compost)	29320	39733	69054	9482	13944	23426	1.5	1.5	1.5
T_{10}	75% of T_5 (37.5% through farm yard manure + 37.5% through vermicompost))	30026	42718	72744	8701	15443	24144	1.4	1.6	1.5
T_{11}	75% of T_6 (37.5% through farm yard manure + 37.5% through vermicompost))	33020	41413	74433	14607	17050	31657	1.8	1.7	1.7
T_{12}	50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through biocompost at 30 DAS	43683	52556	96239	21584	24507	46091	2.0	1.9	1.9

Fig.1 Relationship between crude protein and ether extract in fodder cowpea as influenced by organic source of nutrients

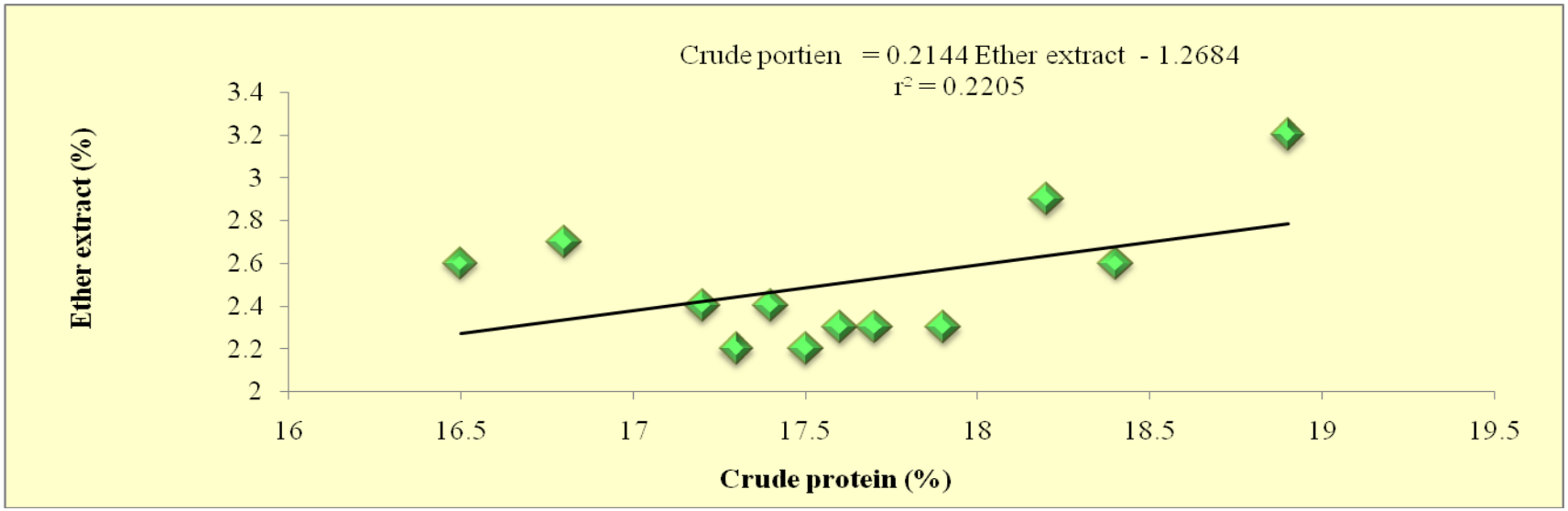


Fig.2 Relationship between crude protein and ether extract in fodder maize as influenced by organic source of nutrients

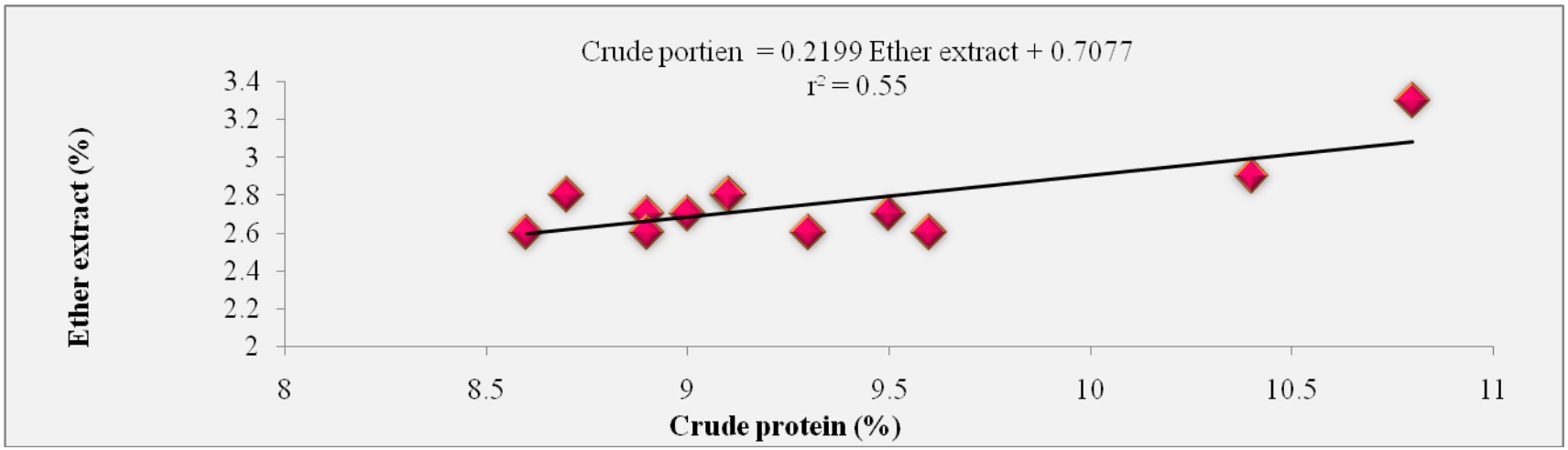
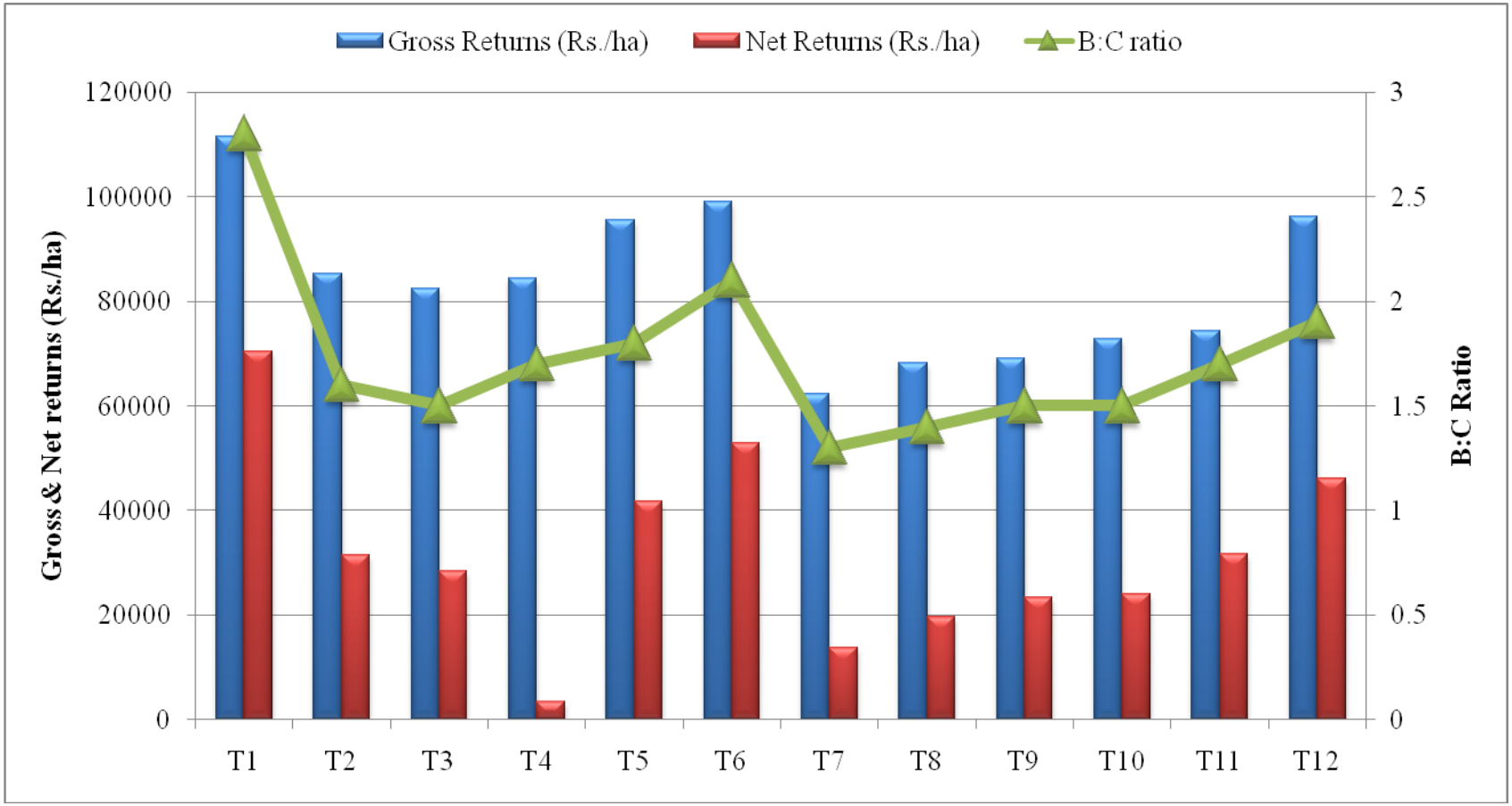


Fig.3 Economics of fodder cowpea maize cropping system as influenced by organic source of nutrients



The increase in organic carbon content in soil is attributed to addition of organic manures stimulated growth and activity of micro organisms present in soil and resulted better root growth, which leads to higher biomass production and sequestration of organic carbon. Apart from these, faster decomposition of organic manures might have resulted enhanced carbon content of soil, these helps in balancing of electrical conductivity of soil. These results are in accordance with the findings of Singh *et al.,* (2011), Yilmaz and Alagoz (2010) and Moharana *et al.,* (2012).

Microbial biomass

The organic source of nutrients had significant influence on microbial biomass (Table 6). Application of 50% RDN through farm yard manure + 50% RDN through vermicompost recorded significantly more number of bacteria (43.1 cfu x 10^5 g^1 of soil), fungi (24.7 cfu x 10^5 g^1 of soil) and Actinomycetes (14.6 cfu x 10^5 g^1 of soil) recorded after harvest of first crop of fodder cowpea. The same treatment recorded higher bacterial and fungal biomass (45.5 and 25.9 cfu x 10^5 g^1 of soil respectively). The 75% RDN through farm yard manure + 25% RDN through vermicompost recorded higher Actinomycetes population in soil (15.0 cfu x 10^5 g^1 of soil) after harvest of second crop of fodder maize. This is due to organic manures as a source of energy for soil microbes which resulted enhanced microbial population. This is in accordance with the findings of Mishra *et al.,* (2008) and Thakur *et al.,* (2011)

Economics

Application of 50% RDN through farm yard manure + 50% RDN through bio-compost recorded higher gross returns (99124 Rs.ha^{-1}), net returns (52856 Rs.ha^{-1}) and B:C ratio (2.1) followed by 50% RDN through farm yard manure + 25% RDN through vermicompost + 25% RDN through bio-compost at 30 DAS (Rs.96239, Rs.46091 and 1.9 respectively) (Table 7 and Fig. 3). This is due to higher green biomass resulted higher gross returns and lower cost of bio compost as compared to vermicompost and less quantity required as compared to farm yard manure, because of higher nitrogen content. This is in accordance with the findings of Kumar *et al.,* (2010) and Bama *et al.,* (2013).

Based on the preliminary results it can be inferred that application of 50% RDN through farm yard manure + 50 % RDN through bio compost or 25% RDN through vermicompost + 25% RDN through bio compost found better source of organic nutrients for achieving sustainable and economical fodder yield with quality in fodder cowpea-maize cropping system.

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