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Study the Effect of Organic Nutrient Management on Soil Physical Properties, Economics and Energy Budgeting in Rice (*Oryza sativa* L.)

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A B S T R A C T

Organic agriculture is a low cost and effective way to help many of the world's poorest people to have good levels of nutrition and a better quality of life. Present experiment was carried out at BCKV, Kalyani, Nadia, West Bengal during the *Kharif* season of 2013 and 2014 with the objective to study the effect of organic nutrient and plant protection management practices on soil physical properties, economics and to frame the energy budgeting of organic rice cultivation. Based on the economics, energy productivity and soil physical properties it has been concluded that organic package @ 60 kg N equivalent containing *Sesbania* green manuring + vermicompost + mustard cake each @ 20 kg N equivalent along with combination of seed treatment with brahmastra followed by foliar spray of brahmastra (at 15, 30, 45, 60, 75 DAT) and *Trichoderma harzianum* soil mixture (1:40) application@ 130 kg ha^{-1} was found highly profitable by gaining the highest gross returns (Rs. 64973.85), net returns (Rs. 32501.35), B:C ratio (2.00), highest total output energy (126537.75 MJ ha^{-1}) and net energy gain (120994.43 MJ ha^{-1}).

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple foods for the people of southeast Asia including India. About 60% of the world population are dependent on this crop. It occupies about 23.3% of gross cropped area, 43% of the total food grain production and 46% of the cereal production of the country (Anonymous, 2015). After the introduction of high yielding varieties of crops, chemical fertilizers undoubtedly play a significant role in enhancing global food production.

In the quest of more food, the soils have been constantly afflicted with much damaged, steadily degraded and destroyed with profound economic costs (Srinivasa Rao *et al.*, 2016). The organic carbon content of the

Indian soil, which has been traditionally low, has declined further during the post green revolution era from 1.2% to 0.6% (Ramasamy, 2005). While decline in soil fertility and productivity due to nutritional imbalance has been recognized as one of the most important factors limiting crop yields. Organic matter prevents nutrient loss and environmental pollution and above all, helps to maintain resilience of soil nutrient balance, which is the basic attribute for sustainability. Status of soil organic matter, together with the soil physical properties, has been proposed as indicator of soil quality (Doran and Parkin, 1994).

Organic agriculture is a low cost and effective way to help many of the world's poorest people to have good levels of nutrition and a better quality of life. Organic manure works as inducer in nature and generally determined in terms of physical, chemical and biological properties of soil and crop growth. Uptake of organic practices is growing worldwide, particularly among smallholders in low and middle-income countries. India plays an important role in this development, hosting 8,35,000 of a global total of 2.7 million certified organic farms in 2016 (Willer and Lernoud, 2018). Documental evidences are necessary to understand the role of organic farming on soil health, production and profitability of rice, which is a key holder of India's food security (Upendra Rao *et. al*, 2014). Keeping above factors in view an experiment was carried out with the broader objective of assessing the effect of organic nutrients and plant protection management practices on soil physical properties and to study the economics and energy budgeting of rice crop.

Materials and Methods

The field experiment was conducted in the model organic farm at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, under new alluvial zone of West Bengal during the period of *Kharif* 2013 and *Kharif* 2014. The field is maintained as completely organic since 2007. The soil of the experimental field was gangetic alluvium (Entisol) type with sandy clay loam in texture having good water holding capacity and moderate soil fertility status. The experimental site belongs to sub-tropical humid climate with an average annual rainfall of 1460 mm, mostly precipitated during June to September and the mean temperature ranges from 9.24^0C to 38.04^0C. The treatments includes N_1: Vermi compost @ 60 kg N equivalent ha^{-1} (Basal & Top dressing), N_2: Mustard cake @ 60 kg N equivalent ha^{-1} (Basal & Top dressing), N_3: Vermi compost @ 30 kg N equivalent ha^{-1} (Basal) + Mustard cake @ 30 kg N equivalent ha^{-1} (Top dressing), N_4: Sesbania green manure @ 20 kg N ha^{-1} + Vermicompost (Top dressing) @ 40 kg N ha^{-1} N_5: Sesbania green manure @ 20 kg N ha^{-1} + Mustard cake @ 40 kg N ha^{-1} (top dressing), N_6: Sesbania green manure @ 20 kg N ha^{-1} + Vermicompost @ 20 kg N ha^{-1} + Mustard cake @ 20 kg N ha^{-1} and plant protection treatments includes P_1: Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75 DAT), P_2: Seed treatment with Brahmastra + *Trichoderma harzianum* application @ 130 kg ha^{-1}, P_3: P_1 + P_2 (Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75 DAT) + *Trichoderma harzianum* soil application @ 130 kg ha^{-1}) & P_4: Control.

The rice cultivar used in the experiment is IET 4786 (Satabdi). This is a semi dwarf, high yielding cultivar, developed at Central Rice Research Institute (CRRI). Seed rate was 50 kg ha^{-1}. About 26 days old seedlings were transplanted in 20 cm apart rows maintaining hills at a distance of 15 cm apart in the rows on the 3^{rd} week of July in both the years. 2-3 seedlings per hill were transplanted. The recommended dose of fertilizer for rice was 60: 30: 30 kg N, P_20_5 and K_20 ha^{-1} respectively. The green manure was sown and incorporated in their respective treatment plots at the time of puddling and the remaining organic nutrient sources *i.e*., mustard cake and vermicompost were divided in to two parts and applied as basal and top dressing in their respective plots according to treatment combination. Brahmastra is a product preparing from various natural sources, it can be used as organic source as plant protection measure against pest and disease attack.

Ingredients: Water, Cow dung, Cow urine, Neem leaves, Castor leaves, Calotropis leaves, Custard apple leaves, Pongamia leaves, Bitter gourd leaves, Parthenium leaves. All these mentioned plant and animal products collected in a container mix it and boiled for 20 - 30 minutes time after that cool it and kept it for 30 days for fermentation. After 30 days filtered solution can be used as seed treatment or foliar spray @ 2 ml lit^{-1} water (Anand, 2006). The plant protection inputs *i.e., Trichoderma harzianum* mixed with soil as 1:40 ratio according to treatment, and applied in their respective plots after land preparation. The brahmastra product was used as seed treatment and foliar spraying according to their respective treatment plots.

Soil sampling and analysis was done by collecting field moist soil samples in triplicate from each of the treatment plot at a depth of 0-15 cm with a bucket auger. They are pooled together to make a composite sample. Bulk samples were taken to the laboratory in bags. The samples were then allowed to air dry for 72 hr before chemical and physical analysis. The air-dried soil samples of each sample were then hand crushed, passed through 2 mm sieve and was stored for determination of various physical and chemical analyses. Additionally, sieved samples were taken that passed through 5.0 mm sieve but retained on the 2.0 mm sieve. Particle size distributions of the soils were determined following the Boyoucous hydrometer method (Gee and Bauder, 1986). From the percentage contents of sand, silt and clay, the textural class of the soil was ascertained with the help of the triangular textural diagram.

Undisturbed soil cores, collected in stainless steel core samplers (5cm diameter and 5 cm length) were used for collection of core samples, from the treated plots for determination of bulk density following the method of Blake and Hartge (1986). The Water holding capacity (WHC) of the soil was measured with the help of Keen-Rackzowski Box as described by Baruah and Barthakur (1997). Water stable aggregate and their distribution in soil were determined by wet sieving method as described by Yoder (1936).

The cost of cultivation (expenditure on land preparation, seed materials, sowing, weeding, thinning and gap filling, plant protection, irrigation and harvesting etc.) of the rice crop under different treatments were taken into consideration. The variable costs included the cost of manures and plant protection inputs depending upon the particulars of treatments. The total cost of cultivation, consisted as the cost of cultivation plus input cost. Gross return was estimated by adding the return from main product and by product of each crop in sequence. Profit was calculated by deducting total cost of cultivation from total product value. The net production value was, calculated by dividing net profit with total cost of cultivation.

The energy budget of the treatments considering both main and by products for the rice crop was determined by using the conversion factors for each and every input, output and cultural activities as suggested by

Mittal *et al.*, (1985). Energy co-efficient used for different inputs has been depicted in Table 1. The energetic of the rice crop cultivation was estimated by using the following energy calculations.

Net energy gain (MJha^{-1}) = output energy - input energy (Azarpour *et al.*, 2012)

Energy ratio = Energy output (MJ ha^{-1}) (Kalbande and More, 2008)

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}^{-1}\text{)}}{\text{Grain output (kg ha}^{-1}\text{)}}$$

(Kalbande and More, 2008)

$$\text{Energy productivity} = \frac{\text{Grain yield [Kg ha}^{-1}\text{]}}{\text{Input energy [MJ ha}^{-1}\text{]}}$$

(Kalbande and More, 2008)

Results and Discussion

Soil physical properties includes bulk density (Mg m^{-3}), porosity and water holding capacity (%) and percentage of soil aggregates were calculated after harvest of rice crop in both the years of experimentation and depicted in Table 1. The experimental site is organically maintained since 2007. Therefore, bulk density and particle density has almost stabilized. Bulk density of soil was not influenced significantly with diversified organic nutrient during 1st year, however it was influenced significantly during 2nd year with diversified organic nutrient management treatments.

Whereas, bulk density of soil was not influenced significantly with the organic plant protection treatments and interaction of organic nutrient and plant protection management treatments in both the years of study (Table 1). During 2nd year among the organic nutrient treatments, the minimum bulk density value (1.22 Mg m^{-3}) was recorded under the treatment N_3 and the maximum value (1.26 Mg m^{-3}) was recorded under N_6. Similarly from the pooled data of both the years the minimum bulk density value was recorded under the treatment N_3 (1.24 Mg m^{-3}) and the maximum value (1.26 Mg m^{-3}) was recorded under the treatment N_6. Among the organic plant protection management treatments the bulk density values ranges from 1.24 Mg m^{-3} under the treatment P_2 to 1.26 Mg m^{-3} under the treatment P_4.

Whereas, with interaction effect of organic nutrient and plant protection management treatments, the soil bulk density values were ranged from 1.23 under the treatment N_2P_3 to 1.27 under N_6P_4. Porosity of the soil after rice harvest was not significantly influenced with organic nutrient and plant protection management treatments in both the years of study (Table 2). The porosity values of the soil were increased during 2nd year than 1st year. Among organic nutrient management treatments, by the pooled data of both the years the porosity values ranges from 52.15 % under the treatment N_1 to 54.02 % under the treatments N_6.

Whereas, the organic plant protection management treatments the soil porosity values ranges from 51.26 % under the treatments P_4 to 54.89 % under the treatment P_3. In case of the combined application of both organic nutrient and plant protection management treatments, by the pooled data of both the years the soil porosity values ranges from 50.55 % under the treatments N_1P_4 to 55.81% under the treatments N_6P_3.

The water holding capacity of soil changed significantly with organic nutrient management treatments in both the years of study. Among organic nutrient treatments significantly the maximum water holding capacity (50.81) was observed with the treatment N_3 and it was followed by N_1

(46.04) and N_2 (44.28) during the 1st year of experimentation. Similarly in 2nd year also the water holding capacity was maximum (55.21) under the treatment N_3 and it was followed by N_2 (43.98) and N_1 (43.15). In both the years of investigation, the least water holding capacity was noted in the treatment N_4 (34.58 & 34.07 during 1st and 2nd years respectively). Percentage of soil aggregates after harvest of rice varied significantly with organic nutrient management treatments in both the years of study (Table 1). The maximum values of percentage of soil aggregate were recorded during 2nd year. Among the organic nutrient treatments, by the pooled data of both the years of the experimentation, the highest percentage of soil aggregates (45.97) was recorded with the treatment N_6 and the least percentage of soil aggregates (42.23) were observed under N_2. The trend was follows as $N_6 \geq N_5 \geq N_4 > N_3 > N_1 > N_2$.

Whereas, the water holding capacity and percentage of soil aggregates was not influenced significantly by organic plant protection management treatments as well as with combined application of both organic nutrient and plant protection management treatments. The soil physical parameters like water holding capacity and percentage of aggregate stability were influenced significantly by organic nutrient management treatments only, whereas the porosity of soil was not influenced significantly.

Similar results also found by Kenchaiah, 1997; Liu, 2005), who reported that addition of organic inputs could have favored microbial activity and enhanced the soil microbial biomass because of supply of organic carbon and improved soil physical properties (soil moisture and structural stability). The increased soil organic carbon content with the long-term application of organic manures resulted in decreased soil bulk density increased total porosity as well as water holding capacity and improved soil aggregation was also reported by Rasool *et al.*, (2008).

Economics

By considering the cost of cultivation, gross return, net return and benefit : cost ratio the economic performance was estimated and as elaborated in Table 3. The treatment cost and interest on working capital differed as per different treatment, ultimately the total cost of cultivation change accordingly. By the average of both the years calculated among organic nutrient treatments the cost of cultivation was highest under the treatment N_2 (mustard cake @60 kg ha^{-1}) and the least cost of cultivation was calculated under the treatment N_4 (Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 40 kg N equivalent ha^{-1}). This is due to differences in input cost and other working costs. The highest gross return, net return as well as B:C ratio values were calculated under the treatments N_6 (Sesbania green manure + Vermicompost + Mustard cake each @ 20 kg N equivalent ha^{-1}). This is due to less cost of cultivation and higher yields in the respective treatment, though the treatment sole mustard cake @ 60 kg N equivalent ha^{-1} (N_2) recorded comparable values of gross returns, due to high cost of cultivation it recorded least net returns and B: C ratio values.

Among the plant protection treatments, by the two years average the least cost of cultivation, gross return, net return and B: C ratio were recorded in control (P_4). However, the highest values were recorded under the treatment P_3 (Seed treatment with Brahmastra + Foliar spray with Brahmastra + *Trichoderma harzianum* soil application @ 130 kg ha^{-1}) though the cost of cultivation is high but due to higher grain yields it recorded maximum gross return, net return and B: C ratio values.

Table.1 Effect of organic nutrient and plant protection management treatments on soil physical parameters

Treatments	Bulk Density (g cc^{-1})			Porosity (%)			Water Holding Capacity			Percent aggregate stability		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
N_1	1.27	1.24	1.25	51.21	53.09	52.15	46.04	43.15	44.6	42.34	44.29	43.32
N_2	1.24	1.25	1.25	52.16	54.31	53.24	44.28	43.98	44.1	41.28	43.18	42.23
N_3	1.26	1.22	1.24	51.57	53.69	52.63	50.81	55.22	53.0	43.07	45.05	44.06
N_4	1.27	1.22	1.25	52.15	54.28	53.22	34.58	34.07	34.3	44.69	45.92	45.31
N_5	1.25	1.22	1.24	52.33	54.91	53.62	41.08	38.16	39.6	44.39	46.43	45.41
N_6	1.25	1.26	1.26	52.70	55.34	54.02	42.04	41.60	42.0	44.31	47.63	45.97
SEm (±)	0.01	0.01	0.01	0.40	0.42	0.70	1.38	2.13	2.77	0.16	0.42	0.61
CD at 5%	NS	0.03	0.04	NS	NS	NS	4.12	6.36	8.32	0.48	1.28	1.82

Treatments	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
P_1	1.26	1.24	1.25	51.21	53.30	52.26	37.35	36.08	36.7	43.44	45.21	44.32
P_2	1.25	1.22	1.24	52.86	55.50	54.18	33.64	33.01	33.3	42.97	44.99	43.98
P_3	1.25	1.24	1.24	53.49	56.30	54.89	42.21	44.69	43.5	43.60	45.60	44.60
P_4	1.27	1.24	1.26	50.52	51.99	51.26	34.66	35.30	35.0	43.39	45.87	44.63
SEm (±)	0.01	0.006	0.01	0.25	0.27	0.46	0.35	0.29	0.49	0.27	0.32	0.48
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment details: N_1: Vermi compost @ 60 kg N equivalent ha^{-1}, N_2: Mustard cake @ 60 kg N equivalent ha^{-1}, N_3: Vermi compost @ 30 kg N equivalent ha^{-1} + Mustard cake @ 30 kg N equivalent ha^{-1}, N4: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 40 kg N equivalent ha^{-1}, N_5: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Mustard cake @ 40 kg equivalent N ha^{-1}, N_6: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 20 kg N equivalent ha^{-1}+ Mustard cake @ 20 kg N equivalent ha^{-1}; P_1: Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75DAT), P_2: Seed treatment with Brahmastra + Trichoderma harzianum soil application @ 130 kg ha^{-1} & P_3: P_1 + P_2 & P_4: Control

Table.2 Interaction effect of organic nutrient and plant protection management treatments on soil physical parameters

Treatments	Bulk Density (g cc^{-1})			Porosity			Water Holding Capacity			Percent aggregate stability		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
N_1P_1	1.28	1.26	1.27	50.37	51.93	51.15	40.23	38.65	39.4	40.25	42.10	41.18
N_1P_2	1.28	1.23	1.25	51.98	54.38	53.18	38.22	42.05	40.1	42.38	44.33	43.35
N_1P_3	1.26	1.22	1.24	52.23	55.29	53.76	31.54	35.61	33.6	45.39	47.48	46.43
N_1P_4	1.29	1.23	1.26	50.26	50.77	50.52	40.88	39.70	40.3	41.35	43.25	42.30
N_2P_1	1.25	1.28	1.26	50.77	52.98	51.87	47.83	44.15	46.0	40.31	42.16	41.24
N_2P_2	1.24	1.26	1.25	53.35	55.68	54.52	38.44	37.55	38.0	41.26	43.16	42.21
N_2P_3	1.22	1.25	1.23	54.22	57.24	55.73	46.97	41.79	44.4	40.31	42.16	41.24
N_2P_4	1.26	1.22	1.24	50.31	51.34	50.82	37.46	45.49	41.5	43.25	45.24	44.24
N_3P_1	1.25	1.20	1.23	50.86	52.98	51.92	35.02	40.68	37.9	41.02	42.91	41.96
N_3P_2	1.26	1.21	1.23	52.20	55.00	53.60	36.15	41.36	38.8	43.25	45.24	44.24
N_3P_3	1.25	1.23	1.24	52.90	55.36	54.13	35.71	47.21	41.5	41.65	43.57	42.61
N_3P_4	1.27	1.23	1.25	50.33	51.44	50.88	36.02	35.06	35.5	46.35	48.48	47.42
N_4P_1	1.27	1.22	1.24	51.80	53.96	52.88	42.92	38.89	40.9	47.31	46.20	46.76
N_4P_2	1.26	1.21	1.24	53.35	55.68	54.52	36.57	39.28	37.9	45.25	47.33	46.29
N_4P_3	1.26	1.22	1.24	53.08	55.56	54.32	40.28	37.95	39.1	42.56	44.52	43.54
N_4P_4	1.29	1.24	1.26	50.37	51.93	51.15	36.94	34.50	35.7	43.64	45.65	44.64
N_5P_1	1.26	1.21	1.23	52.04	54.38	53.21	48.33	46.30	47.3	47.36	49.54	48.45
N_5P_2	1.25	1.20	1.22	52.75	55.29	54.02	37.54	36.66	37.1	41.35	43.25	42.30
N_5P_3	1.26	1.24	1.25	54.11	57.08	55.59	40.68	43.68	40.5	46.31	48.44	47.38
N_5P_4	1.26	1.25	1.25	50.41	52.89	51.65	41.36	59.62	42.5	42.52	44.48	43.50
N_6P_1	1.28	1.26	1.27	51.46	53.60	52.53	47.21	33.56	53.4	44.36	48.37	46.37
N_6P_2	1.24	1.23	1.24	53.54	56.95	55.24	35.06	35.25	34.3	44.31	46.60	45.46
N_6P_3	1.24	1.27	1.26	54.38	57.24	55.81	38.89	40.83	37.1	45.35	47.44	46.39
N_6P_4	1.26	1.29	1.27	51.44	53.58	52.51	39.28	34.80	40.1	43.21	48.10	45.66
SEm (±) NXP	0.017	0.017	0.025	0.69	0.71	1.04	0.69	0.72	0.99	1.08	0.98	1.10
SEm (±) PXN	0.016	0.015	0.023	0.64	0.66	0.93	0.78	0.76	1.02	1.06	1.05	1.14
CD at 5% (NXP)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5% (PXN)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table.3 Effect of organic nutrient and plant protection management treatments on economics of rice

Treatments	2013				2014				Average			
	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
N_1	32111.25	51869.56	19758.31	1.61	34711.25	57026.22	22314.97	1.64	33411.25	54447.89	21036.64	1.63
N_2	38111.25	55163.83	17052.58	1.45	40711.25	60602.60	19891.35	1.49	39411.25	57883.21	18471.96	1.47
N_3	35111.25	52911.91	17800.66	1.51	37711.25	57676.39	19965.14	1.53	36411.25	55294.15	18882.90	1.52
N_4	28511.25	52798.16	24286.91	1.85	31111.25	57706.01	26594.76	1.85	29811.25	55252.09	25440.84	1.85
N_5	32511.25	52409.33	19898.08	1.61	35111.25	58417.13	23305.88	1.66	33811.25	55413.23	21601.98	1.64
N_6	30511.25	55821.69	25310.44	1.83	33111.25	62110.58	28999.33	1.87	31811.25	58966.13	27154.88	1.85
P_1	32985.00	55426.89	22441.89	1.69	35585.00	62119.78	26534.78	1.76	34285.00	58773.33	24488.33	1.73
P_2	32637.50	50919.31	18281.81	1.57	35237.50	56529.84	21292.34	1.62	33937.50	53724.58	19787.08	1.59
P_3	33472.50	58577.58	25105.08	1.76	36072.50	64452.89	28380.39	1.80	34772.50	61515.23	26742.73	1.78
P_4	32150.00	49059.21	16909.21	1.54	34750.00	52590.13	17840.13	1.53	33450.00	50824.67	17374.67	1.53

Treatment details: N_1: Vermi compost @ 60 kg N equivalent ha^{-1}, N_2: Mustard cake @ 60 kg N equivalent ha^{-1}, N_3: Vermi compost @ 30 kg N equivalent ha^{-1} + Mustard cake @ 30 kg N equivalent ha^{-1}, N4: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 40 kg N equivalent ha^{-1}, N_5: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Mustard cake @ 40 kg equivalent N ha^{-1}, N_6: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 20 kg N equivalent ha^{-1}+ Mustard cake @ 20 kg N equivalent ha^{-1}; P_1: Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75DAT), P_2: Seed treatment with Brahmastra + Trichoderma harzianum soil application @ 130 kg ha^{-1} & P_3: P_1 + P_2 & P_4: Control

Table.4 Combined effect of organic nutrient and plant protection management treatments on economics of rice

Treatments	2013				2014				Average			
	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
N_1P_1	32285.00	52204.26	19919.25	1.62	34885.00	59441.31	24556.31	1.70	33585.00	55822.78	22237.78	1.66
N_1P_2	31937.50	50141.70	18204.20	1.57	34537.50	54214.37	19676.87	1.57	33237.50	52178.04	18940.54	1.57
N_1P_3	32772.50	56432.25	23659.75	1.72	35372.50	62301.20	26928.70	1.76	34072.50	59366.72	25294.22	1.74
N_1P_4	31450.00	48700.05	17250.05	1.55	34050.00	52148.02	18098.02	1.53	32750.00	50424.04	17674.04	1.54
N_2P_1	38285.00	59230.50	20945.50	1.55	40885.00	64024.13	23139.13	1.57	39585.00	61627.31	22042.31	1.56
N_2P_2	37937.50	51726.36	13788.86	1.36	40537.50	59121.49	18583.99	1.46	39237.50	55423.93	16186.43	1.41
N_2P_3	38772.50	60522.00	21749.50	1.56	41372.50	66416.07	25043.57	1.61	40072.50	63469.03	23396.53	1.58
N_2P_4	37450.00	49176.45	11726.45	1.31	40050.00	52848.72	12798.72	1.32	38750.00	51012.59	12262.59	1.32
N_3P_1	35285.00	54951.75	19666.75	1.56	37885.00	61644.50	23759.50	1.63	36585.00	58298.12	21713.12	1.59
N_3P_2	34937.50	50082.74	15145.24	1.43	37537.50	54204.25	16666.75	1.44	36237.50	52143.50	15906.00	1.44
N_3P_3	35772.50	58326.45	22553.95	1.63	38372.50	63384.50	25012.00	1.65	37072.50	60855.47	23782.97	1.64
N_3P_4	34450.00	48286.69	13836.68	1.40	37050.00	51472.33	14422.33	1.39	35750.00	49879.51	14129.51	1.40
N_4P_1	28685.00	53111.10	24426.10	1.85	31285.00	60053.86	28768.86	1.92	29985.00	56582.48	26597.48	1.89
N_4P_2	28337.50	50903.74	22566.23	1.80	30937.50	55006.61	24069.11	1.78	29637.50	52955.17	23317.67	1.79
N_4P_3	29172.50	58188.90	29016.40	1.99	31772.50	63290.20	31517.70	1.99	30472.50	60739.55	30267.05	1.99
N_4P_4	27850.00	48988.90	21138.90	1.76	30450.00	52473.37	22023.37	1.72	29150.00	50731.14	21581.14	1.74
N_5P_1	32685.00	52351.68	19666.67	1.60	35285.00	59700.54	24415.54	1.69	33985.00	56026.11	22041.11	1.65
N_5P_2	32337.50	51189.29	18851.78	1.58	34937.50	58102.74	23165.24	1.66	33637.50	54646.01	21008.51	1.62
N_5P_3	33172.50	56707.35	23534.85	1.71	35772.50	62666.18	26893.68	1.75	34472.50	59686.76	25214.26	1.73
N_5P_4	31850.00	49389.00	17539.00	1.55	34450.00	53199.07	18749.07	1.54	33150.00	51294.03	18144.03	1.55
N_6P_1	30685.00	60712.05	30027.05	1.98	33285.00	67854.33	34569.33	2.04	31985.00	64283.19	32298.19	2.01
N_6P_2	30337.50	51472.05	21134.55	1.70	32937.50	58529.57	25592.07	1.78	31637.50	55000.81	23363.31	1.74
N_6P_3	31172.50	61288.50	30116.00	1.97	33772.50	68659.19	34886.69	2.03	32472.50	64973.85	32501.35	2.00
N_6P_4	29850.00	49814.15	19964.15	1.67	32450.00	53399.24	20949.24	1.65	31150.00	51606.70	20456.70	1.66

Treatment details: N_1: Vermi compost @ 60 kg N equivalent ha^{-1}, N_2: Mustard cake @ 60 kg N equivalent ha^{-1}, N_3: Vermi compost @ 30 kg N equivalent ha^{-1} + Mustard cake @ 30 kg N equivalent ha^{-1}, N4: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 40 kg N equivalent ha^{-1}, N_5: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Mustard cake @ 40 kg equivalent N ha^{-1}, N_6: Sesbania green manure @ 20 kg N equivalent ha^{-1} + Vermicompost @ 20 kg N equivalent ha^{-1}+ Mustard cake @ 20 kg N equivalent ha^{-1}; P_1: Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75DAT), P_2: Seed treatment with Brahmastra + Trichoderma harzianum soil application @ 130 kg ha^{-1}, & P_3: P_1 + P_2 & P_4: Control

Table.5 Effect of organic nutrient and plant protection management treatments on energy budget of rice

Treatments	Average					
	Total input energy (MJ ha^{-1})	Total output energy (MJ ha^{-1})	Net energy gain (MJ ha^{-1})	Energy Ratio	Specific energy (MJ kg^{-1})	Energy productivity (kg MJ^{-1})
N_1P_1	6223.64	108767.95	102544.31	17.48	0.77	1.31
N_1P_2	6213.62	101744.08	95530.47	16.37	0.82	1.22
N_1P_3	6226.58	114550.13	108323.56	18.40	0.73	1.37
N_1P_4	6212.64	97457.07	91244.43	15.69	0.85	1.17
N_2P_1	5383.64	119038.22	113654.58	22.11	0.61	1.65
N_2P_2	5373.62	107932.49	102558.87	20.09	0.67	1.50
N_2P_3	5386.58	123786.24	118399.66	22.98	0.58	1.72
N_2P_4	5372.64	98425.02	93052.38	18.32	0.73	1.37
N_3P_1	5803.64	113124.97	107321.33	19.49	0.69	1.46
N_3P_2	5793.62	101571.38	95777.77	17.53	0.76	1.31
N_3P_3	5806.58	118030.05	112223.48	20.33	0.66	1.52
N_3P_4	5792.64	96442.52	90649.88	16.65	0.81	1.24
N_4P_1	5883.44	110828.21	104944.77	18.84	0.71	1.41
N_4P_2	5873.42	102827.90	96954.49	17.51	0.77	1.31
N_4P_3	5886.38	117717.14	111830.77	20.00	0.67	1.49
N_4P_4	5872.44	97871.82	91999.38	16.67	0.80	1.24
N_5P_1	5269.64	109205.19	103935.55	20.72	0.65	1.55
N_5P_2	5259.62	105781.16	100521.55	20.11	0.67	1.50
N_5P_3	5272.58	115195.46	109922.88	21.85	0.61	1.63
N_5P_4	5258.64	98978.21	93719.57	18.82	0.71	1.40
N_6P_1	5539.64	125088.65	119549.01	22.58	0.59	1.69
N_6P_2	5529.62	106396.31	100866.69	19.24	0.70	1.44
N_6P_3	5542.58	126537.01	120994.43	22.83	0.59	1.70
N_6P_4	5528.64	99447.75	93919.11	17.99	0.75	1.34

Whereas, the combination of both organic nutrient and protection management treatments (Table 4) in the average of both the years the lowest cost of cultivation was observed with treatment N_4P_4 and it was followed by N_4P_2. Whereas, the highest gross returns and net returns were observed under N_6P_3 followed by N_6P_1 with recording almost similar B:C ratio values.

This is due to less cost of cultivation and higher grain yields in the respective treatments. Though the treatment N_2P_3 recorded comparable values of gross returns, due to high cost of cultivation it recorded least net returns and B: C ratio values. These results were supported by findings of Kumari *et al.*, (2010) and Barik *et al.*, (2011).

Energy budgeting

The energy budgeting of two years crop as reflected in depicts that the variation in energy balance was observed due to the diversification in organic nutritional and plant protection management treatments (Table 5). By the average both the years of the experimental study, the maximum total input energy (6226.58 MJ ha^{-1}) was observed with the treatment N_1P_3 followed by N_1P_1 (6223.64 MJ ha^{-1}). The average highest total output energy (126537.75 MJ ha^{-1}) was recorded with the treatment N_6P_3 followed by N_6P_1 (125088.65 MJ ha^{-1}). The highest net energy gain (120994.43 MJ ha^{-1}) also achieved with the treatment N_6P_3 followed by N_6P_1 (119549.01 MJ ha^{-1}). This is due to the maximum yield achieved under it, so, ultimately the highest net energy was gained with this treatment. However, the treatment N_5P_4 recorded appreciably least total energy input values but due to the poorest yield registered the lowest values of energy output and net energy gain. Depending on the energy input and output values, the highest energy ratio (22.98) was achieved with the treatment N_2P_3 followed by N_6P_3 (22.83). The lowest specific energy (0.59 MJ kg^{-1}) was achieved with the treatment N_1P_4 followed by N_1P_2 (0.82 MJ kg^{-1}). And, the highest energy productivity (1.72 kg MJ $^{-1}$) was achieved with the treatment N_2P_3 followed by N_6P_3 (1.70 kg MJ $^{-1}$). Due to the poorest yield and relatively higher energy input the treatment N_1P_4 was found to be inferior. Regensen and Dalgaard (2004), Sharma *et al.*, (2010) also emphasized on energy budget in organic farming practices.

Based on the economics, energy productivity and soil physical properties it has been concluded that organic package @ 60 kg N equivalent containing *Sesbania* green manuring + vermicompost + mustard cake each @ 20 kg N equivalent along with combination of seed treatment with brahmastra followed by foliar spray of brahmastra (at 15, 30, 45, 60, 75 DAT) and *Trichoderma harzianum* soil mixture (1:40) application@ 130 kg ha^{-1} was found highly profitable by gaining the highest gross returns (Rs. 64973.85), net returns (Rs. 32501.35), B:C ratio (2.00), highest total output energy (126537.75 MJ ha^{-1}) and net energy gain (120994.43 MJ ha^{-1}).

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