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EFFECT OF ORGANIC NUTRIENT AND PROTECTION SOURCES ON YIELD ATTRIBUTES AND NUTRIENT UPTAKE IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

A field experiment was conducted in model organic farm at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India, during the *Kharif* season 2013 and 2014 to evaluate the effect of organic nutrients and plant protection management practices on yield attributes, yield and nutrient uptake of rice. Results showed that the treatment combination of *Sesbania* green manure, vermicompost and mustard cake each @ 20 kg N equivalent ha^{-1} coupled with seed treatment with brahmastra + foliar spray with brahmastra @ 2ml lit^{-1} (at 15, 30, 45, 60, 75 DAT) + *Trichoderma harzianum* soil application @ 130 kg ha^{-1} recorded the highest number of effective tillers m^{-2} (327.4) by producing grain yield of 3.82 t ha^{-1} with highest nutrient uptake N (98.67 kg ha^{-1}), uptake P (349 kg ha^{-1}) and uptake K (97.3 kg ha^{-1}) and it was closely followed by the treatment *Sesbania* green manure @ 20 kg N equivalent ha^{-1} + vermicompost @ 20 kg N equivalent ha^{-1} + mustard cake @ 20 kg N equivalent ha^{-1} coupled with seed treatment with brahmastra + foliar spray with brahmastra @ 2 ml lit^{-1} (at 15, 30, 45, 60, 75 DAT).

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple foods for the people of southeast Asia including India. In the Global context, India stands first in area with 43.42 million hectares and second in production next to the China with 106.54 million tonnes. In India West Bengal is the leading state in rice production with 15.31 million tonnes during 2013-14 (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. Decline in crop yields due to continuous and indiscriminate use of high analysis chemical fertilizers has been observed throughout the world. 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, the decline in organic C content of the soil could be arrested and the gap between potential and actual yield could be bridged to a large extent, if chemical fertilizers are applied in conjunction with organic manures. The concept of organic farming has been gaining momentum with the use of different manures and crop residues in order to increase the productivity of crop as well as the soil fertility status (Arun Kumar *et al*., 2014). Organic farming is a new agricultural production system involves locally and naturally available organic materials or agro inputs to meet the production system without endangering our precious natural resources. The integrated use of organic manures with liquid organic manures can help to maintain optimum crop yield by maintaining the fertility status of the soil (Divya Sahare, 2015). Organic manure works as inducer in nature and generally determined in terms of physical, chemical and biological properties of soil and crop growth. In organic farming, the nutritional demands of crop are met mainly through on farm organic wastes, bio-fertilizer, green manure crop and vermicompost. Keeping above factors in view the present investigation has been carried out with the objective to study the effect of different organic package of practices on growth, yield and yield components of rice crop.

MATERIALS AND METHODS

The field experiment was conducted in 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°C to 38.04°C. The present experiment was carried out with the broader

objective of assessing the effect of organic nutrients and plant protection management practices on yield attributes and nutrient uptake of rice. The treatments includes N_1: Vermi compost @ 60 kg N equivalent ha^{-1} (Basal and Top dressing), N_2: Mustard cake @ 60 kg N equivalent ha^{-1} (Basal and 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 3rd 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 plots at the time of puddling. 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 different 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. In each plot, half of the area was marked for recording biometrical observations including destructive samplings while the other half was kept undisturbed for recording yield attributes and yield. After the harvesting of crop, nutrient uptake by plant was analyzed in laboratory.

RESULTS AND DISCUSSION

In both the years of study, the panicle length and the test (1000 grain) weight of rice was not influenced significantly with the organic nutrient management treatments (Table 1), by the pooled data the panicle length range varies from 23.83 cm under the treatment N_1 to 24.29 cm was achieved under the treatment N_6 whereas, test weight varies from 18.08 g under the treatment N_5 to 18.29 g under the treatment N_4. Both panicle length and test weight of rice were influenced significantly by the plant protection treatments during both the years of experimentation. The highest panicle length (24.65 cm) was achieved with the treatment P_3 followed by P_1 (24.42 cm) without any significant difference among them and the lowest panicle length was obtained in the treatment P_4 (23.29 cm) during the 1st year of experimentation. The same trend was observed in 2nd year and pooled data also by recording the values of 24.53 cm and 24.59 cm under the treatment P_3, 24.32 cm and 24.37 cm under the treatment $P_1$and 23.18 cm and 23.23 cm under the treatment P_4 in 2nd year and in pooled data respectively. Whereas in case combination of both organic nutrient and protection management treatments the panicle length and test weight were not influenced significantly

Table 1: Effect of organic nutrient and plant protection management treatments on panicle length and yield attributing parameters of rice

Treatments	Panicle length (cm)			Effective tillers m^{-2}			Filled grains $panicle^{-1}$			Test weight (g)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Nutrient Management Treatments												
N_1	23.89	23.77	23.83	266.32	285.00	275.66	122.18	124.02	123.40	18.04	18.13	18.09
N_2	24.24	24.15	24.19	276.65	297.92	287.28	124.07	126.55	125.31	18.07	18.32	18.19
N_3	23.91	23.79	23.85	268.75	286.84	277.79	122.57	125.02	123.79	18.02	18.24	18.13
N_4	24.01	23.89	23.95	270.60	288.71	279.65	121.53	123.96	122.15	18.23	18.35	18.29
N_5	24.02	23.90	23.96	271.02	290.76	280.89	120.20	122.60	121.40	18.21	17.95	18.08
N_6	24.35	24.23	24.29	284.63	306.50	295.57	122.28	124.72	123.50	18.28	17.91	18.09
SEm (±)	0.18	0.18	0.31	2.19	2.20	3.71	0.25	0.32	0.41	0.14	0.14	0.24
CD at 5%	NS	NS	NS	6.90	6.93	11.69	0.78	0.89	1.18	NS	NS	NS
Plant Protection Management Treatments												
P_1	24.42	24.32	24.37	288.36	307.46	297.91	122.18	124.62	123.40	18.45	18.28	18.37
P_2	23.92	23.80	23.86	263.33	284.68	274.01	122.38	124.83	123.61	18.16	18.06	18.11
P_3	24.65	24.53	24.59	297.15	316.33	306.74	123.18	125.64	124.41	18.29	18.46	18.38
P_4	23.29	23.18	23.23	243.12	262.02	252.57	120.81	123.23	122.02	17.66	17.80	17.73
SEm (±)	0.11	0.12	0.20	1.34	1.42	2.44	0.22	0.24	0.31	0.09	0.09	0.15
CD at 5%	0.40	0.40	0.70	4.84	4.92	8.45	0.59	0.68	0.78	0.31	0.31	0.53

Treatment details: N_1: Vermi compost @ 60 kg N equivalent ha^{-1},$^1N_2$: 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},^{1}&P_3: P_1 + P_2 &P_4: Control

Table 2: Effect of organic nutrient and plant protection management treatments on N, P & K uptake by riceplant and grain yield

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			Grain yield (t ha^{-1})		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Nutrient Management Treatments												
N_1	82.13	85.54	83.84	29.45	30.61	30.03	78.951	82.03	80.49	3.08	3.34	3.21
N_2	86.32	90.01	88.16	30.84	32.19	31.52	83.79	87.08	85.44	3.27	3.56	3.41
N_3	82.16	85.64	83.90	29.47	30.68	30.07	80.29	83.50	81.86	3.14	3.38	3.26
N_4	83.01	86.73	84.87	29.63	30.93	30.28	80.24	83.72	81.97	3.12	3.38	3.25
N_5	83.16	86.78	84.97	29.81	31.14	30.47	79.78	82.98	81.38	3.11	3.43	3.27
N_6	88.44	91.48	89.96	31.43	32.54	31.98	85.78	88.98	87.38	3.30	3.65	3.48
SEm (±)	0.657	0.683	1.133	0.235	0.245	0.406	0.631	0.656	1.088	0.02	0.02	0.04
CD at 5%	2.069	2.153	3.569	0.742	0.772	1.280	1.989	2.067	3.429	0.07	0.08	0.13
Plant Protection Management Treatments												
P_1	89.23	92.81	91.02	31.27	32.50	31.89	84.86	88.32	86.59	3.27	3.64	3.46
P_2	81.90	84.87	83.38	29.41	30.50	29.95	77.49	80.38	78.94	3.02	3.31	3.16
P_3	91.62	95.22	93.42	31.96	33.21	32.58	90.27	93.68	91.98	3.47	3.79	3.63
P_4	74.07	77.89	75.98	27.78	29.18	28.48	73.22	76.48	74.85	2.92	3.09	3.01
SEm (±)	0.425	0.440	0.749	0.150	0.155	0.264	0.405	0.418	0.713	0.02	0.02	0.02
CD at 5%	1.470	1.523	2.593	0.519	0.537	0.915	1.400	1.448	2.467	0.05	0.06	0.09

Treatment details: N_1: Vermi compost @ 60 kg N equivalent ha^{-1},$^1N_2$: 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},$^1N_5$: 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},^{1}&P_3: P_1 + P_2 &P_4: Control

during both the years of experimentation. The highest 1000 grain weight (18.45 g) was achieved with the treatment P_1 and it was statistically similar with P_3 (18.29 g) during the 1st year of experimentation. While in the 2nd year, the 1000 grain weight was maximum (18.46 g) under the treatment P_3 and it was statistically similar with P_1 (18.28 g). In both the years of investigation, the least 1000 grain weight was obtained in the treatment P_4 (17.66 g and 17.80 g during 1st and 2nd years respectively). By the pooled data of both the years the highest 1000 grain weight (18.38 g) was achieved with the treatment P_3 and it was closely followed by P_1 (18.37 g)and P_2 (18.11 g) without any significant difference and the least 1000 grain weight was obtained in the treatment P_4 (17.33 g).

The number of effective tillers m^{-2},grain yield (t ha^{-1}) and N, P, K uptake by rice plant were changed significantly with organic nutrient and plant protection management treatments in both the years of study (Table 1 & 2). Significantly the highest number of effective tillers (284.63m^{-2}) was achieved with the treatment N_6 followed by N_2 (276.65 m^{-2}) and N_5 (271.02 m^{-2}) during the 1st year of experimentation. Similarly in 2nd year also the highest number of effective tillers (306.50 m^{-2}) was noticed under the treatment N_6 followed by N_2 (297.92m^{-2}) and N_5 (290.76m^{-2}). In both the years of investigation, the least effective tillers were obtained in the treatment N_1 (266.32 m^{-2} and 285 m^{-2} during 1st and 2nd year respectively). In the pooled data of both the years also the highest number of effective tillers (295.57 m^{-2}) was observed with the treatment N_6 and it was statistically at par with N_2 (287.28 m^{-2}) and the least number of effective tillers was obtained in the treatment N_1 (275.66 m^{-2}). Among organic plant protection management treatments the highest number of effective tillers (297.15 m^{-2}) was achieved with the treatment P_3 followed by P_1 (288.36 m^{-2}) and the lowest number of effective tillers were obtained in the treatment P_4 (243.12 m^{-2}) during the 1st year of experimentation. The same trend was observed during 2nd year and in pooled data by following the values of 316.33 m^{-2} and 306.74 m^{-2} with the treatment P_3, 307.46 m^{-2} and 297.91 m^{-2} under the treatment P_1 and 262.02 m^{-2} and 252.57 m^{-2} under the treatment P_4 in 2nd year and in pooled data respectively. Whereas, the combination of both organic nutrient and protection management treatments (Table 3), significantly the highest number of effective tillers (314.91 m^{-2}) was noted with the treatment N_6P_3 followed by N_6P_1 (303.10 m^{-2}) and N_2P_3 (297.51 m^{-2}) N_2P_1 (295.91 m^{-2}) during the 1st year of experimentation. Same trend was observed during 2nd year and in the pooled data also by recording the values of 340.04 m^{-2}, 327.48 m^{-2} under the treatment N_6P_3, 321.23 m^{-2} and 312.17 m^{-2} under the treatment N_6P_1, 316.80 m^{-2} and 312.71 m^{-2} under the treatment N_2P_3 and 307.16 m^{-2} and 304.31 m^{-2} under the treatment N_2P_1. Whereas the least number of effective tillers were obtained in the treatment N_3P_4 (237.09 m^{-2}, 252.78 m^{-2} and 244.94 m^{-2} during 1st, 2nd and pooled data respectively) throughout the experiment. The number filled grains panicle^{-1} of rice was influenced significantly with organic nutrient and plant protection management treatments in both the years of study (Table 1).Among the organic nutrient management treatments, significantly the highest number of filled grains panicle^{-1} (124.07) was achieved under the treatment N_2 and which was followed by N_3 (122.57)and N_6 (122.28) without any significant difference between N_3 and N_6. The same trend was observed during 2nd year also by recorded the values of 126.55, 125.02 and 124.72 under the treatment N_2, N_3 and N_6 respectively. By the pooled data the trend was observed as $N_2 > N_3 \geq N_6 \geq N_1 > N_4 > N_5$.Whereas, with organic plant protection management treatments (Table 1), the highest filled grains panicle^{-1} was achieved with the treatment P_3 and the least values were observed in the treatment P_4 during both the years of study. By the pooled data of both the years, the trend was followed as P_3 (124.41) > P_2 (123.61) ≥ P_1 (123.40) > P_4 (122.02). However, the filled grains panicle^{-1} was not influenced significantly by combined application of both organic nutrient and protection management treatments. The

Table 3: Interaction effect of organic nutrient and plant protection management treatments on nutrient uptake by riceplant and effective tillers and grain yield

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			Effective tillers m^{-2}			Grain yield (t ha^{-1})		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
N_1P_1	86.47	90.08	88.27	30.49	31.61	31.05	79.84	82.74	81.29	276.18	299.50	287.84	3.08	3.48	3.28
N_1P_2	79.91	82.81	81.36	28.86	29.91	29.38	76.03	78.79	77.41	259.89	275.64	267.77	2.98	3.15	3.07
N_1P_3	88.60	92.30	90.45	30.92	32.32	31.62	86.91	90.53	88.72	290.40	307.48	298.94	3.36	3.67	3.51
N_1P_4	73.56	76.98	75.27	27.55	28.60	28.07	73.01	76.05	74.53	238.79	257.39	248.09	2.89	3.07	2.98
N_2P_1	89.84	93.77	91.80	32.29	33.63	32.96	89.93	93.68	91.80	295.91	312.71	304.31	3.51	3.77	3.64
N_2P_2	85.79	88.91	87.35	30.34	31.61	30.97	79.43	82.74	81.08	271.45	298.82	285.14	3.06	3.45	3.26
N_2P_3	95.35	99.33	97.34	32.79	34.05	33.42	92.57	95.44	94.01	297.51	316.80	307.16	3.57	3.89	3.73
N_2P_4	74.30	78.03	76.16	27.96	29.49	28.72	73.24	76.48	74.86	241.71	263.35	252.53	2.93	3.11	3.02
N_3P_1	88.33	92.02	90.18	30.70	31.98	31.34	82.83	86.28	84.55	289.21	306.47	297.84	3.25	3.62	3.44
N_3P_2	77.33	80.14	78.73	28.73	29.77	29.25	75.34	78.08	76.71	255.17	275.57	265.37	2.98	3.15	3.07
N_3P_3	89.84	93.59	91.71	31.24	32.54	31.89	89.88	93.63	91.75	293.51	312.52	303.02	3.45	3.73	3.59
N_3P_4	73.14	76.84	74.99	27.21	28.42	27.81	72.85	76.02	74.43	237.09	252.78	244.94	2.87	3.02	2.95
N_4P_1	87.88	91.55	89.71	30.61	31.89	31.25	82.25	85.68	83.96	288.23	305.00	296.62	3.11	3.51	3.31
N_4P_2	81.05	83.99	82.52	28.88	29.93	29.40	76.68	79.46	78.07	260.38	278.33	269.36	3.03	3.21	3.12
N_4P_3	89.16	93.59	91.37	31.18	32.54	31.86	88.94	93.63	91.28	293.51	312.52	303.02	3.44	3.73	3.58
N_4P_4	73.94	77.81	75.87	27.83	29.36	28.60	73.05	76.11	74.58	240.26	258.99	249.63	2.91	3.09	3.00
N_5P_1	86.50	90.11	88.30	30.50	31.76	31.13	80.39	83.74	82.06	277.55	299.82	288.69	3.09	3.49	3.29
N_5P_2	82.73	85.74	84.24	29.66	30.73	30.20	78.25	81.09	79.67	266.07	285.90	275.99	3.03	3.42	3.22
N_5P_3	89.08	92.88	90.98	31.03	32.48	31.75	86.95	90.57	88.76	293.04	308.63	300.84	3.38	3.68	3.53
N_5P_4	74.33	78.41	76.37	28.04	29.58	28.81	73.54	76.55	75.04	247.41	268.70	258.06	2.94	3.13	3.03
N_6P_1	96.35	99.33	97.84	33.03	34.16	33.59	93.91	97.82	95.87	303.10	321.23	312.17	3.58	3.99	3.78
N_6P_2	84.57	87.64	86.10	29.97	31.06	30.52	79.24	82.11	80.68	267.03	293.83	280.43	3.05	3.44	3.25
N_6P_3	97.67	99.67	98.67	34.61	35.31	34.96	96.34	98.31	97.33	314.91	340.04	327.48	3.62	4.02	3.82
N_6P_4	75.17	79.30	77.23	28.10	29.64	28.87	73.63	77.67	75.65	253.48	270.9	262.19	2.97	3.14	3.06
SEm (±) NXP	1.092	1.137	1.652	0.394	0.410	0.595	1.052	1.093	1.589	3.66	3.65	5.41	0.04	0.04	0.06
SEm (±) PXN	1.014	1.055	1.473	0.365	0.380	0.529	0.975	1.013	1.413	3.39	3.39	4.82	0.03	0.04	0.05
CD at 5% (NXP)	3.260	3.395	4.976	1.175	1.223	1.792	3.138	3.262	4.785	10.91	10.91	16.31	0.12	0.13	0.19
CD at 5% (PXN)	3.030	3.153	4.421	1.090	1.134	1.587	2.912	3.024	4.241	10.13	10.14	14.48	0.11	0.12	0.17

Treatment details: N_1: Vermi compost @ 60 kg N equivalent ha^{-1},$^1N_2$: 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},$^1N_5$: 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},^{1}&P_3: P_1 + P_2 &P_4: Control

highest grain yield (3.31 t ha^{-1}) was achieved with the treatment N_6 and it was statistically at par with N_2 (3.27 t ha^{-1}) and it was followed by N_3 (3.14 t ha^{-1}) during the 1st year of experimentation. Similarly in 2nd year, the grain yield was maximum (3.65 t ha^{-1}) under the treatment N_6 and it was followed by N_2 (3.56 t ha^{-1}) and N_5 (3.43 t ha^{-1}). In both the years of investigation, the least grain yield was obtained in the treatment N_1 (3.08 t ha^{-1} and 3.34 t ha^{-1} during 1st and 2nd years respectively). By the pooled data of both the years, the highest grain yield (3.48 t ha^{-1}) was observed with the treatment N_6 and it was statistically similar with N_2 (3.42 t ha^{-1})and it was followed by N_5 (3.27 t ha^{-1}) and the least grain yield was obtained in the treatment N_1 (3.21 t ha^{-1}). Among the organic plant protection management treatments the highest grain yield (3.47 t ha^{-1}) was achieved with the treatment P_3 and it was followed by P_1 (3.27 t ha^{-1}) during the 1st year of experimentation. Similar trend was noticed during 2nd year and in pooled data also by obtaining the values of 3.79 and 3.63 under the treatment P_3 and 3.64 and 3.46 under the treatment P_1 during 2nd year and in pooled data respectively. In both the years of investigation, the least grain yield was obtained in the treatment P_4 (2.92 t ha^{-1}, 3.09 t ha^{-1} and 3.01 t ha^{-1} during 1st, 2nd years and in pooled data respectively). Whereas, the combination of both organic nutrient and protection management treatments (Table 3), significantly the highest grain yield (3.62 t ha^{-1}) was achieved with the treatment N_6P_3 and it had statistically no comparable difference with N_6P_1 (3.58 t ha^{-1}), N_2P_3 (3.57 t ha^{-1}) and N_2P_1 (3.51 t ha^{-1}) during the 1st year of experimentation. Similarly in 2nd year also the grain yield was maximum (4.02 t ha^{-1}) under the treatment N_6P_3 and it was statistically at par with N_6P_1 (3.99 t ha^{-1}) and N_2P_3 (3.89 t ha^{-1}) and it was followed by N_2P_1 (3.77 t ha^{-1}). In both the years of investigation, the least grain yield was obtained in the treatment N_3P_4 (2.87 t ha^{-1} and 3.02 t ha^{-1} during 1st and 2nd years respectively). By the pooled data of both the years the highest grain yield (3.82 t ha^{-1}) was achieved with the treatment N_6P_3 and it was statistically at par with N_6P_1 (3.78 t ha^{-1})and N_2P_3 (3.73 t ha^{-1}) and N_2P_1 (3.64 t ha^{-1}) and the least grain yield was obtained in the treatment N_3P_4 (2.95 t ha^{-1}). The variation in yield attributes and increased yield may be due to the fact that combined application of green manures, oilcakes, vermicompost, might have helped in slow and steady release of nutrients in addition to supply of important macro and micro- nutrients besides efficient uptake of respective nutrients by rice plant. These findings also supported by Shashidhar *et al*. (2009). The high yield of rice variety with mustard cake treatment also reported by Sultana *et al*. (2008). Whereas, the organic plant protection treatments brahmastra spraying and *Trichoderma harzianum* soil application reduces the attack of leaf folder insect and also less brown spot disease severity observed in the respective treatments that ultimately increased the rice yields. Similar results also observed by Raikar *et al*., 2009. The presence of different types of bio pesticidal properties in leaf extracts also reported by Anandprakash *et al*. (2008).

N, P and K uptake by rice plant changed significantly with diversified organic nutrient and plant protection management

treatments in both the years of study and observed the similar trend among them (Table 2). The highest plant N uptake (88.44 kg ha^{-1}) was recording with the treatment N_6 which was statistically at par with the treatment N_2 (86.32 kg ha^{-1}) and it was followed by N_5 (83.16 kg ha^{-1}) during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 91.48 and 89.96 under the treatment N_6 and 90.01 and 88.16 under the treatment N_2 during 2nd year and polled data respectively. During both the years' experimentation, the least plant N uptake was obtained in the treatment N_1 by recording the values of 82.13, 85.54 and 83.84 during 1st, 2nd year and pooled data respectively. Among the plant protection management treatments, significantly highest plant N uptake (91.62 kg ha^{-1}) was achieved with the treatment P_3 which was closely followed by P_1 (89.23 kg ha^{-1}) during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 95.22 and 93.42 under the treatment P_3 and 92.81 and 91.02 under the treatment P_1 during 2nd year and polled data respectively. During both the years, the least plant N uptake was obtained in the treatment P_4 by recording the values of 74.07, 77.89 and 75.98 during 1st, 2nd year and pooled data respectively. Whereas, the combination of both organic nutrient and protection management treatments (Table 3), significantly highest N uptake (97.67 kg ha^{-1}) by plant was achieved with the treatment N_6P_3 which was closely followed by N_6P_1 (96.35 kg ha^{-1}) and N_2P_3 (83.16 kg ha^{-1}) without any significance among them during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 99.67 and 98.67 under the treatment N_6P_3 and 99.33 and 97.84 under the treatment N_6P_1 during 2nd year and polled data respectively. During both the years, the least plant N uptake was obtained in the treatment N_3P_4 by recording the values of 73.14, 76.84 and 74.99 during 1st, 2nd year and pooled data respectively. The highest plant uptake of P (31.43 kg ha^{-1}) was recorded with the treatment N_6 which was statistically at par with the treatment N_2 (30.84 kg ha^{-1}) during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 32.54 kg ha^{-1} and 31.98 kg ha^{-1} under the treatment N_6 and 32.19 kg ha^{-1} and 31.52 kg ha^{-1} under the treatment N_2 during 2nd year and pooled data respectively. During both the years, the least plant uptake of P was obtained in the treatment N_1 by recording the values of 29.45 kg ha^{-1}, 30.61 kg ha^{-1} and 30.03 kg ha^{-1} during 1st, 2nd year and pooled data respectively. Among the plant protection management treatments the highest plant uptake of P (31.96 kg ha^{-1}) was recorded with the treatment P_3 which was closely followed by P_1 (31.27 kg ha^{-1}) during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 33.21 kg ha^{-1} and 32.58 kg ha^{-1} under the treatment P_3 and 32.50 kg ha^{-1} and 31.89 kg ha^{-1} under the treatment P_1 during 2nd year and pooled data respectively. During both the years, the least plant uptake of P was obtained in the treatment P_4 by recording the values of 27.78 kg ha^{-1}, 29.18 kg ha^{-1} and 28.48 kg ha^{-1} during 1st, 2nd year and pooled data respectively. Whereas, the combination of both organic nutrient and protection management treatments (Table 3), significantly the highest plant uptake of P (34.61 kg ha^{-1}) was achieved with the treatment N_6P_3 which was closely followed by N_6P_1 (33.03 kg ha^{-1}), without any significance among them during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 35.31 kg ha^{-1} and 34.96 kg ha^{-1} under the treatment N_6P_3 and 34.16 kg ha^{-1} and 33.59 kg ha^{-1} under the treatment N_6P_1 during 2nd year and polled data respectively. During both the years, the least plant uptake of P was obtained in the treatment N_3P_4 by recording the values of 27.21 kg ha^{-1}, 28.42 kg ha^{-1} and 27.81 kg ha^{-1} during 1st, 2nd year and pooled data respectively. The highest plant uptake of K (85.78 kg ha^{-1}) was achieved with the treatment N_6 which was statistically at par with the treatment N_2 (83.79 kg ha^{-1}) during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 88.98 kg ha^{-1} and 87.38 kg ha^{-1} under the treatment N_6 and 87.08 kg ha^{-1} and 85.44 kg ha^{-1} under the treatment N_2 during 2nd year and polled data respectively. During both the years, the least plant uptake of K was obtained in the treatment N_1 by recording the values of 78.95 kg ha^{-1}, 82.03 kg ha^{-1} and 80.49 kg ha^{-1} during 1st, 2nd year and pooled data respectively. Among the plant protection management treatments the highest plant uptake of K (90.27 kg ha^{-1}) was achieved with the treatment P_3 which was closely followed by P_1 (84.86 kg ha^{-1}) during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 93.68 and 91.98 under the treatment P_3 and 88.32 kg ha^{-1} and 86.59 kg ha^{-1} under the treatment P_1 during 2nd year and polled data respectively. During both the years, the least plant uptake of K was obtained in the treatment P_4 by recording the values of 73.22 kg ha^{-1}, 76.48 kg ha^{-1} and 74.85 kg ha^{-1} during 1st, 2nd year and pooled data respectively. Whereas, the combination of both organic nutrient and protection management treatments (Table 3), significantly the highest plant uptake of K (96.34 kg ha^{-1}) was achieved with the treatment N_6P_3 which was closely followed by N_6P_1 (93.9 kg ha^{-1}), without any significance among them during the 1st year of experimentation. Similar trend was observed during second year as well as in pooled data by recording values of 98.31 kg ha^{-1} and 97.33 kg ha^{-1} under the treatment N_6P_3 and 97.82 kg ha^{-1} and 95.87 kg ha^{-1} under the treatment N_6P_1 during 2nd year and pooled data respectively. During both the years of experimentation, the least plant uptake of K was obtained in the treatment N_3P_4 by recording the values of 72.85 kg ha^{-1}, 76.02 kg ha^{-1} and 74.43 kg ha^{-1} during 1st, 2nd year and pooled data respectively.

From the pooled data of both the years, the variations in N supply to plants by the application of different forms of organic manures resulted in differences in growth and nutrient uptake. Among the organic nutrient treatments the treatment N_6 (Sesbania green manure + Vermicompost + Mustard cake each @ 20 kg N equivalent ha^{-1}) recorded maximum nutrient uptake values for nutrients and it was statistically at par with N_2 (Mustard cake @ 60 kg N equivalent ha^{-1}). The lower value of uptake nutrients was found in the treatment N_1 (vermicompost @ 60 kg N equivalent ha^{-1}). Among the organic plant protection treatments in majority of cases the treatment P_3 (Seed treatment with Brahmastra + Foliar spray with Brahmastra + *Trichoderma harzianum* soil application @ 130

kg ha^{-1}) recorded significantly higher values and it was closely followed the treatment P_1 (Seed treatment with Brahmastra + Foliar spray with Brahmastra). And the least nutrient uptake was observed in control plot (P_4). Organic manures when applied in sufficient quantity supplied all the essential nutrients in adequate amount for plant growth and development and ultimately resulted in yield. These findings were in conformity with Shekara *et al*. (2010), they studied that increase in the growth, yield attributes and yield of rice due to addition of various organic manures could be attributed to adequate supply of nutrients, higher uptake and recovery of applied nutrients, which in turn, must have improved synthesis and translocation of metabolites to various reproductive structures of the plant (Upadhyaya *et al*., 2000; Kumari *et al*., 2010). The vermicompost carrier based bio inoculants have also increased the growth, yield and quality of rice was reported by Gandhi and Sivakumar, (2010). The combined use of diversified organic manures improves the physical condition of soil better besides providing nutrients to the plant bit by bit but in a steady manner along with the added advantage of rapid, bounty and easy nutrient supplying to the crops. And, thus, ultimately the maximum uptake by rice plant occurs.

Based on the experimental findings it can be concluded that the treatment combination green manure, vermicompost and mustard cake each @20 kg N equivalent ha^{-1} coupled with seed treatment with brahmastra + foliar spray with brahmastra + *Trichoderma harzianum* soil application @ 130 kg ha^{-1} showed the best results interms of nutrient uptake and grain yield of rice crop.

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