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Research Paper

Organic farming practices in rainfed lowland rice in hill zone of Karnataka, India

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ABSTRACT

A large-scale field trial was conducted at Agricultural Research Station (Paddy), Sirsi of the University of Agricultural Sciences, Sirsi, Karnataka, India, during 2004–15 on a fixed site, to study the effect of different organic farming practices on productivity of rice (*Oryza sativa* L.) under inorganic and integrated nutrient-management practices. The trial consisted of 5 treatments, viz. T_1, Organic [75% N through organic manures + 100% organic plant protection (PP) measures]; T_2, organic [100% N through organic manure + 100% organic plant protection (PP) measures]; T_3, integrated nutrient management [50% N through organic manures + 50% RDF + integrated PP measures]; T_4, inorganic treatment [recommended dose of fertilizers (RDF) alone + inorganic PP measures]; and T_5, recommended practice (RDF + FYM 10 t/ha + integrated PP measures). The rice variety 'Abilash' was grown during the rainy (*kharif*) season with these treatments. At the end of 12th year, i.e. during 2015, the grain yield recorded in treatment T_2 (6.418 t/ha) was the maximum and was found on a par with T_5 (6.328 t/ha). How-ever, the straw yield was the maximum in T_5 (7.577 t/ha), being at par with T_2 (7.494 t/ha). The net returns realized were significantly highest with treatment T_2 (₹41,045/ha) compared to all the other treatments. The soil organic carbon (0.77%), available major (221.2, 22.0 and 67.0 kg/ha of N, P and K, respectively) and micro-nutrients (515.5, 100.8, 5.6 ppm of calcium, magnesium and zinc, respectively and 7.6 kg/ha of sulphur) were also higher with treatment T_2.

Key words: Eupatorium, Lowland Rice, Organic farming, RDF, Soil fertility

Rice (*Oryza sativa* L.) is the most important food crop, occupying about 43.7 million ha area and contributing about 41.7% of the total foodgrain production in India (MoA&FW, 2020). In hill zone of Karnataka, rice is the major crop grown under rainfed situation. The productivity of rice is lower in the hill zone as compared to the state average. Hence, the conventional rice farming has been oriented towards enhancing rice yield by encouraging inorganic fertilizer and pesticides. Though the dosage of fertilizer had been increased, crop productivity was not in balance with supplying additional fertilizer. Further, the dependence on higher doses of chemical fertilizers and pesticides potentially reduced the soil organic carbon and mineral nutrients (Prakash *et al*., 2008) and resulted in reduced land productivity (Patil, 2008). This emerging scenario necessitates the need of adoption of the practices which maintains soil health, and provides qualitative food for meeting the nutritional requirements. Organic farming is one of the practices to make the production system more sustainable without adverse effects on the natural resources and the environment (Stockdale *et al*., 2001; Debjani Sihi *et al*., 2017). The research on organic farming in rice is directed towards a complete or partial substitution of chemical fertilizers with organic fertilizers to enhance rice yield. But, no one source of nutrient usually suffices to maintain productivity and quality control in organic system. In addition, the inputs to supplement nutrient availability are often not uniform presenting additional challenges in meeting the nutrient requirement of crops in organic farming (Singh *et al*., 2007). Keeping these in view, a large-scale field experiment was conducted to find out a suitable organic farming practice for rainfed lowland rice grown under transplanted situation.

MATERIALS AND METHODS

A large-scale field trial was conducted at Agricultural Research Station (Paddy), Sirsi, of the University of Agricultural Sciences, Dharwad, Karnataka, India, during 2004–15 on a fixed site. The experimental site is situated in the hill zone (Zone - 9) of Karnataka which comes

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under high-rainfall situation. The site is located between 14º 37' 12.06'' N and 74º 50' 60.09'' E. Average annual rainfall of 12 years (2004 to 2015) was 2,142 mm, highest maximum temperature was 35.3ºC during April and minimum temperature 14.0ºC during January. The soil was sandy clay loam.

The experiment was laid out in randomized complete-block design (RCBD) with 5 treatments, viz. T_1, organic [75% recommended dose of nitrogen (RDN) through organic manures + 100% organic plant protection (PP) measures]; T_2, organic (100% RDN through organic manure + 100% organic PP measures); T_3, integrated nutrient management [50% RDN through organic manures + 50% recommended dose of fertilizer (RDF) + integrated PP measures); T_4, inorganic treatment (RDF alone + inorganic PP measures); and T_5, recommended package of practice (RDF + FYM 10 t/ha + integrated PP measures) and replicated 4 times. Each treatment was imposed in 500 m^2 area. To make observations on crop yield, plot size of 5 m × 5 m was marked in each treatment at 5 different spots randomly. The details of practices followed in different treatments including plant-protection measures are given in Table 1. Eupatorium (*Chromolaena odorata*), an obnoxious weed found in abundance in the region whose nitrogen is quite comparable to other conventional green/green-leaf manures (Manjappa, 1999) was used as green-leaf manure to supply required recommended dose of nitrogen in different treatments. The quantity of eupatorium was derived based on its nitrogen and moisture content in each year. The quantity of organic manures used and their nutrient content are given in Table 2. The organic manures were incorporated every year into the soil 2 weeks before planting as per the treatments.

A long-duration (155 days) rice variety 'Abilash' was used. For planting, 30-day-aged seedlings were used, and 2–3 seedlings were planted at each hill. The fertilizers were applied in accordance with the treatments. Recommended dose of fertilizer used was 75 kg N, 75 kg P_2O_5 and 87.5 kg K_2O/ha (UAS, 2004). At the time of planting, 50% each of N and K_2O and entire dose of P_2O_5 were applied. Remaining 50% of N and K_2O were given in 2 equal split doses as top-dressing at 25 and 50 days after planting (DAP).

Observations on grain and straw yield were made at harvesting of crop each year and economics was worked out based on the prevailed market prices of both input and output during each year of experimentation. Before the start of the experiment, initial composite soil sample was collected, processed, and analysed for organic carbon and available major (N, P and K) and micro (Zn, Cu, Mn and Fe) nutrients. At the end of 12th year, the soil samples were collected from individual treatments after the harvesting of rice crop and were analysed for organic carbon and available major nutrients. The data were analysed statistically as per the RCBD design under M-STAT-C programme.

RESULTS AND DISCUSSION

Grain and straw yield

During the first year of experimentation, the highest grain yield was recorded with recommended package of practice (RPP) treatment (5.353 t/ha) followed by integrated practices (5.126 t/ha) and 100% organic practice (4.835 t/ha) and both were found at par (Table 3). Our results confirm the findings of Singh and Dhar Dolly (2011). The lowest grain yield was recorded with 75% organic treatment (4.110 t/ha). During 2015 (12th year), the maximum grain yield was observed in 100% organic treatment (6.418 t/ha), being at par with RPP treatment (6.328 t/ha). The grain yield obtained with INM (50% organic + 50% inorganic) treatment (5.433 t/ha) was at par with that of inorganic treatment (5.434 t/ha). The significantly lower yield was recorded with 75% organic treatment. The same trend was also noticed in pooled data. In general, the grain yield was the maximum with RPP treatment compared to 100% organic treatment during initial 6 years only (2004 to 2009). Thereafter, the grain yield was found maximum with 100% organic treatment where eupatorium green-leaf manure was used to supplement 100% RDN as compared to RPP treatment in all the years except during 2006 and 2007. The beneficial effect of green-leaf manure may be because of its capacity to supply nitrogen in addition to their solubilizing effect on native soil nutrients owing to the action of organic acids produced during decomposition (Pandey *et al.,* 2007; Tripathi *et al*., 2009). This is evident from the data on N, P and K content of eupatorium in different years of experimentation which was higher in eupatorium compared to FYM (Table 2). The superiority of green-manure to FYM in increasing the productivity of rice was also reported by Moola Ram *et al*. (2011) and Tao Li *et al*. (2019). Further, the study clearly indicates that it took nearly 6 years (except second year) to stabilize the rice yield in 100% organic treatment.

The straw yield recorded with RPP treatment was signicantly higher than all the other treatments during first 4 years (2004 to 2007) of experimentation. From 2012 (9th year) onwards, 100% organic treatment resulted in the maximum straw yield compared to RPP treatment (Table 4). However, the differences were non-significant, indicating improvement in grain yield in 100% organic treatment only after 4 years of continuous application of green-leaf manure. At 12th year of experimentation (2015), 100% organic treatment recorded the maximum straw yield (7.694 t/ha) which was on par with RPP treatment (7.577 t/ha). The straw yield obtained with INM (50% organic + 50% inorganic) treatment (6.042 t/ha) and inorganic treat-

Table 1. Details of practices followed in different treatments of the experiment

Treatment	Practices followed			
	Fertilizer	Organic / green-leaf manure	Biofertilizers	Plant protection (PP) measures
T_1, Organic [75% N through organic manures + 100% organic plant protection (PP) measures]	–	Eupatorium to supplement 75% RDN	*Azospirullum* + PSB seedling dip	1 spray of *Pseudomonos fluroscence* (10 ml/litre) 1 spray of *mukkadaka** extract for leaf folder
T_2, Organic (100% N through organic manure + 100% organic PP measures)	–	Eupatorium to supplement 100% RDN	*Azospirullum* + PSB seedling dip	1 spray of *Pseudomonos fluroscence* (10 ml/litre) 1 spray of *mukkadaka* extract for leaf folder
T_3, Integrated nutrient management (50% N through organic manures + 50% RDF + integrated PP measures)	50% RDF	Eupatorium to supplement 50% RDN	*Azospirullum* + PSB seedling dip	1 spray of *Pseudomonos fluroscence* (10 ml/litre), 1 spray of tricyclozole @ 0.6 g/litre, 1 spray of *mukkadaka* extract for leaf folder 1 spray of chloropyriphos (2 ml/litre)
T_4, Inorganic treatment (RDF alone + Inorganic PP measures)	100% RDF	–	–	Seed treatment with bavistin (2 g/kg) 1 spray of tricyclozole @ 0.6 g/litre 1 spray of *mukkadaka* extract for leaf folder 1 spray of chloropyriphos (2 ml/litre)
T_5, Recommended practice (RDF + FYM 10 t/ha + integrated PP measures)	100% RDF	FYM (10 t/ha)	*Azospirullum* + PSB seedling dip	Seed treatment with bavistin (2 g/kg) 1 spray of tricyclozole @ 0.6 g/litre 1 spray of chloropyriphos (2 ml/litre)

RDN, Recommended dose of nitrogen; PSB, phosphate-solubilizing bacteria; RDF, recommended dose of fertilizer; **Pterospermum acerifolium* (L.) Willd.

Table 2. The quantity of eupatorium used, and its nitrogen and moisture content and nitrogen added by farmyard manure applied in different years of experimentation

Particulars	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nitrogen content (%) of eupatorium on dry weight basis	1.82	2.55	1.77	1.52	2.22	1.95	1.87	2.02	1.86	1.87	1.92	1.95
Phosphorus content (%) of eupatorium on dry weight basis	0.19	0.23	0.19	0.17	0.22	0.20	0.18	0.21	0.20	0.21	0.22	0.19
Potassium content (%) of eupatorium on dry weight basis	2.18	2.34	1.98	1.77	2.32	1.96	1.92	2.01	2.04	1.99	2.01	2.00
Moisture content (%)	74.2	78.1	75.4	73.2	75.4	74.1	75	73.3	75.1	74.1	74.7	75.6
Quantity of fresh eupatorium used (kg/ha) in T_1 (75% RDN)	11,979	10073	12,919	13808	10300	11138	12032	10429	12145	11614	11580	11822
Quantity of fresh eupatorium used (kg/ha) in T_2 (100% RDN)	15,972	13430	17,225	18411	13733	14850	16043	13906	16194	15485	15440	15763
Quantity of fresh eupatorium used (kg/ha) . in T_3 (50% RDN)	7,986	6715	8612	9206	6867	7425	8021	6953	8097	7743	7720	7881
Nitrogen content of FYM (%)	0.97	0.95	0.95	0.98	0.85	0.92	0.88	0.95	0.89	0.85	0.86	0.87
Phosphorus content of FYM (%)	0.43	0.39	0.41	0.40	0.39	0.41	0.38	0.42	0.39	0.38	0.39	0.40
Potassium content of FYM (%)	0.21	0.22	0.19	0.20	0.18	0.20	0.17	0.21	0.19	0.17	0.17	0.19
Moisture content (%)	46.2	45.8	46.0	47.1	42.0	45.6	45.8	43.4	43.2	45.2	46.1	42.0
Amount of N added (kg) by FYM (10 t/ha)	52.2	51.5	51.3	51.8	49.3	50.0	47.7	53.8	50.6	46.6	46.4	50.5

RDN, recommended dose of nitrogen

Table 3. Effect of organic farming treatments on grain yield of rainfed transplanted rice

Treatment	Grain yield (t/ha)												
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Pooled
T_1, 75% organic	$4.110^{c\#}$	4.746^{c}	3.801^{c}	4.514^{c}	4.536^{b}	2.572^{c}	4.387^{b}	3.978^{c}	4.439^{c}	4.420^{c}	4.673^{c}	4.095^{c}	4.189^{c}
T_2, 100% organic	4.835^{ab}	6.157^{a}	5.240^{b}	5.415^{b}	5.088^{ab}	3.553^{a}	6.138^{a}	5.631^{a}	6.238^{a}	6.451^{a}	6.304^{a}	6.418^{a}	5.622^{a}
T_3, INM (50 + 50%)	5.126^{a}	5.394^{b}	4.627^{b}	4.747^{c}	4.788^{ab}	3.737^{bc}	5.517^{a}	5.359^{ab}	4.571^{c}	4.876^{b}	5.040^{b}	5.433^{b}	4.935^{b}
T_4, Inorganic	4.552^{b}	5.893^{b}	5.152^{b}	5.488^{ab}	4.321^{c}	2.695^{bc}	5.733^{a}	4.547^{b}	4.855^{b}	5.582^{b}	5.483^{b}	5.434^{b}	4.978^{b}
T_5, RPP	5.353^{a}	6.112^{a}	5.996^{a}	5.941^{a}	5.394^{a}	2.454^{b}	6.047^{a}	5.575^{a}	5.134^{b}	6.123^{a}	5.784^{a}	6.328^{a}	5.465^{a}
SEm±	0.146	0.149	0.205	0.158	0.244	0.129	0.289	0.188	0.175	0.267	0.271	0.280	0.660
CD (P=0.05)	0.438	0.447	0.615	0.474	0.732	0.387	0.866	0.563	0.526	0.799	0.811	0.838	0.183

Details of treatments are given in Table 1, #, means followed by same letters in a column are not differing significantly

Table 4. Straw yield of rainfed transplanted rice as influenced by organic farming treatment

Treatments	Straw yield (t/ha)												
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Pooled
T_1, 75% organic	$4.700^{c\#}$	4.480^{d}	4.494^{d}	5.106^{c}	5.701^{b}	5.613^{c}	7.086^{c}	4.510^{b}	5.280^{c}	4.508^{c}	5.836^{b}	4.512^{c}	5.152^{c}
T_2, 100% organic	5.625^{b}	6.277^{bc}	6.007^{b}	5.783^{b}	6.910^{a}	7.061^{a}	7.796^{b}	6.096^{a}	8.361^{a}	6.990^{a}	7.357^{a}	7.694^{a}	6.830^{a}
T_3, INM (50 + 50%)	5.543^{b}	5.871^{c}	5.139^{cd}	5.348^{b}	5.599^{b}	6.003^{bc}	8.789^{a}	5.614^{ab}	5.726^{bc}	5.806^{b}	5.950^{b}	6.042^{b}	5.953^{b}
T_4, Inorganic	5.909^{b}	6.679^{b}	5.701^{bc}	5.783^{b}	5.690^{b}	5.966^{bc}	9.370^{ab}	5.210^{b}	5.737^{bc}	6.606^{a}	7.228^{a}	6.443^{b}	6.360^{b}
T_5, RPP	7.765^{a}	7.787^{a}	7.097^{a}	7.209^{a}	7.328^{a}	6.376^{b}	9.477^{a}	6.131^{a}	6.100^{b}	6.512^{ab}	7.425^{a}	7.577^{a}	7.232^{a}
SEm±	0.130	0.213	0.266	0.197	0.305	0.167	0.535	0.236	0.1,97	0.257	0.266	0.189	0.163
CD (P=0.05)	0.390	0.639	0.798	0.594	0.914	0.501	0.160	0.709	0.589	0.771	0.798	0.568	0.451

Details of treatments are given in Table 1, #, means followed by same letters in a column are not differing significantly ment (6.443 t/ha) were at par. The 75% organic treatment resulted in significantly lower yield. Similar trend in straw yield was noticed in the pooled data of 12 years also.

These results clearly indicate that, it was possible to get rice yield equivalent to RPP by practicing organic farming where the 100% of RDN was substituted by green-leaf manure, viz. eupatorium. Further, results indicated that the transition period in this organic practice was from 6th year under assured rainfall situation of hill zone of Karnataka. Instances of getting higher and sustainable yield of rice by farmers who adopted organic farming as compared to conventional farming were reported by Sihi Oebjani *et al*. (2012) and Eyhorn *et al*. (2018).

Economics

Net returns realized in different organic farming treatments was showed almost similar to that of straw yield. The net returns were the maximum with RPP treatment up to 2010 (first 7 years of study). However, it was on par with 100% organic treatment in all these years except during 2009. From 8th year (2011) onwards, the net returns realized with 100% organic treatment were significantly higher than all the other treatments (Table 5). This might be owing to the influence of continuous addition of green-leaf manure in this treatment. Moola Ram *et al*. (2011) also reported superiority of green-manure to FYM in increasing net income of rice. During the last 5 years (2012 to 2015), the treatments, viz. INM, inorganic treatment and RPP treatment, were found at par with respect to net returns. Benefit: cost (B : C) ratio (Table 6) was also significantly higher in 100% organic treatment (3.31) compared to all other treatments during 2015 as well as in pooled data (2.56). The lower net returns and B : C ratio with RPP treatment than 100% organic treatment was mainly due to increased cost of inorganic plant-protection measures. Teodoro Mendoza (2004) also reported increased cost of cultivation in conventional farming due to increased cost of agro-chemical inputs as compared to organic farming.

Soil-nutrient content

In general, there was an improvement in soil-nutrient content in treatments where green-leaf manure or FYM was used as compared to their respective initial values (Table 7). The initial organic carbon content was 0.30–0.34% in different treatments. At the end of the study (2015), the organic carbon content of rice soil was the maximum in 100% organic treatment (0.77%) followed by 75% organic treatment (0.70) and RPP treatment (0.69%). Yadav *et al.* (2009); Singh and Dhar Dolly (2011) and Rao *et al*. (2014) also reported improvement in soil organic carbon content due to organic farming over control as well as chemical fertilizer application. The lower organic carbon

Table 5. Organic farming treatments on economics (Net returns) of rainfed transplanted rice

Treatment	Net Returns (₹/ha)												
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Pooled
T_1, 75% organic	14,083$^{c\#}$	17,293c	11,827^{d}	19,858^{b}	33,228^{b}	10,118^{b}	30,481^{b}	15,165^{d}	37,752^{b}	35,646^{c}	43,851^{b}	31,099^{c}	25,033^{d}
T_2, 100% organic	18,746^{ab}	27,199a	21,490^{ab}	26,025^{a}	38,485^{a}	21,159^{a}	35,101^{ab}	33,114^{a}	67,845^{a}	68,081^{a}	66,671^{a}	68,625^{a}	41,045^{a}
T_3, INM (50 + 50%)	19,752^{a}	21,406b	16,079^{c}	20,353^{b}	34,989^{b}	18,363^{a}	40,343^{ab}	26,641^{ab}	34,954^{b}	40,255^{b}	41,961^{b}	47,651^{b}	30,396^{c}
T_4, Inorganic	16,168^{bc}	24,961a	19,493^{bc}	25,378^{a}	34,875^{b}	10,184^{b}	45,677^{a}	18,464^{cd}	38,844^{b}	53,563^{b}	53,412^{b}	48,362^{b}	32,448^{bc}
T_5, RPP	22,221^{a}	25,562a	24,062^{a}	28,033^{a}	35,762^{ab}	24,640^{c}	43,053^{a}	24,411^{bc}	37,769^{b}	52,423^{b}	49,512^{b}	57,431^{b}	33,559^{b}
SEm±	1,163	1,047	1,401	1,172	1,055	1,312	3,411	2,131	2,674	4,067	3,859	3,628	774
CD (P=0.05)	3,489	3,141	4,203	3,465	3,165	3,933	102,25	6,390	8,016	12,193	11,570	10,877	2,145

Details of treatments are given in Table 1; #, means followed by same letters in a column are not differing significantly

Table 6. Benefit: cost ratio of rainfed transplanted rice as influenced by organic farming treatments

Treatment	Benefit: cost ratio												
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Pooled
T_1, 75% organic	$1.90^{d\#}$	2.16^{d}	1.76^{c}	2.27^{b}	2.61^{b}	1.42^{b}	2.27^{b}	1.48^{c}	2.07^{b}	$2.01b^{c}$	2.24^{b}	2.14^{c}	2.03^{c}
T_2, 100% organic	2.20^{bc}	2.66^{a}	2.33^{a}	2.62^{a}	2.69^{b}	1.85^{a}	2.41^{ab}	2.02^{a}	2.87^{a}	2.88^{a}	2.85^{a}	3.31^{a}	2.56^{a}
T_3, INM (50 + 50%)	2.27^{b}	2.26^{c}	1.95^{bc}	2.20^{c}	2.64^{b}	1.62^{ab}	2.44^{ab}	1.75^{b}	1.86^{c}	1.97^{c}	2.04^{b}	2.48^{b}	2.12^{bc}
T_4, Inorganic	2.04^{cd}	2.45^{b}	2.13^{ab}	2.47^{ab}	3.07^{a}	1.40^{bc}	2.78^{a}	1.53^{c}	1.96^{bc}	2.32^{b}	2.32^{b}	2.51^{b}	2.25^{b}
T_5, RPP	2.42^{a}	2.33^{bc}	2.25^{a}	2.45^{ab}	2.23^{c}	1.11^{c}	2.36^{b}	1.60^{bc}	1.81^{c}	2.13^{bc}	2.07^{b}	2.57^{b}	2.11^{bc}
SEm±	0.0584	0.0565	0.0838	0.0686	0.1082	0.0991	0.1248	0.0574	0.0674	0.1095	0.098	0.1072	0.0520
CD (P=0.05)	0.1752	0.1690	0.2510	0.206	0.324	0.297	0.374	0.1720	0.202	0.328	0.293	0.321	0.1441

Details of treatments are given in Table 1; #, means followed by same letters in a column are not differing significantly

Table 7. Organic carbon and major nutrients of soil as influenced by different organic farming treatments

Treatment	Organic carbon (%)		Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	Initial (May 2004)	After harvesting of rice (December 2015)	Initial (May, 2004)	After harvesting of rice (December 2015)	Initial (May 2004)	After harvesting of rice (December 2015)	Initial (May 2004)	After harvesting of rice (December 2015)
T_1, 75% organic	0.31	0.69	184.8	207.2	12.9	20.0	35.4	60.0
T_2, 100% organic	0.34	0.77	165.2	221.2	11.6	22.0	33.0	67.0
T_3, INM (50 + 50%)	0.31	0.60	182.0	212.8	12.1	16.5	37.2	59.0
T_4, Inorganic	0.30	0.57	170.8	204.4	12.5	20.5	37.2	62.0
T_5, RPP	0.32	0.69	179.4	212.8	13.1	21.5	38.5	62.0

Details of treatments are given in Table 1

Table 8. Secondary nutrients of soil as influenced by different organic farming treatments

Treatment	Calcium (ppm)		Magnesium (ppm)		Sulphur (kg/ha)		Zinc (ppm)	
	Initial (May, 2004)	After Harvesting of rice (December 2015)	Initial (May, 2004)	After Harvesting of rice (December 2015)	Initial (May, 2004)	After Harvesting of rice (December 2015)	Initial (May, 2004)	After Harvesting of rice (December 2015)
T_1, 75% Organic	320.2	445.2	60.5	96.2	21.9	16.7	1.8	4.3
T_2, 100% Organic	330.3	515.5	59.2	100.8	22.2	17.6	1.7	5.6
T_3, INM (50 + 50%)	329.5	584.6	57.8	93.7	19.9	14.1	1.8	3.6
T_4, Inorganic	325.5	539.1	58.9	96.3	22.1	23.2	1.7	4.1
T_5, RPP	327.2	595.4	58.1	90.4	21.7	28.0	1.8	4.8

Details of treatments are given in Table 1

content was recorded in inorganic treatment (0.57). The improvement in organic carbon content in these treatments was mainly attributed to continuous use of eupatorium or FYM. The status of available nitrogen, phosphorus and potassium content of soil also indicated improvement in treatments where greenleaf manure or FYM was used as compared to inorganic treatment. The available nitrogen (221.2 kg/ha), phosphorus (22.0 kg/ha) and potassium (67.0 kg/ha) contents were maximum with 100% organic treatment. Debjani Sihi *et al*. (2017) reported similar results, indicating improvement in soil organic carbon and nutrient content owing to long-term application of organic manures in certified organic farms as compared to conventional farms.

It can be concluded that, continuous application of eupatorium green-leaf manure to supply recommended dose of nitrogen and practicing all plant-protection measures organically found to give equivalent rice yield and net returns as that of recommended package of practices from 6th year onwards.

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