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S Suresh
Department of Soil Science & Agricultural Chemistry Agricultural College & Research Institute, Killikulam, Vallanadu, Tamil Nadu, India

Corresponding Author:
S Suresh
Department of Soil Science & Agricultural Chemistry Agricultural College & Research Institute, Killikulam, Vallanadu, Tamil Nadu, India

Direct and residual effect of organic sources and inorganic fertilizers on rice productivity and soil properties of Vertisol in the High Rainfall Zone

S Suresh

Abstract
Rice is an important cereal food crop for more than half of the world's population. The introduction of high yielding and fertilizer responsive varieties after the Green Revolution witnessed an increase in the use of synthetic fertilizers. Due to the continuous use of chemical fertilizers alone, has caused declining trend in rice productivity in India. Therefore emphasis should be to optimize the use of chemical fertilizers and to improve their use efficiency. Therefore to optimize the use of chemical fertilizers, to improve their use efficiency, the integrated nutrient management with usage of cost-effective organic resources will improve the soil fertility and productivity of rice The reduction in the cattle population and low cost of paddy straw lead to the *insitu* incineration of paddy straw in the fields, which leads to further deterioration of soil health and environment. Therefore to effectively utilize the local organic resources available, to reduce the usage of inorganic fertilizers, to improve the yield and soil fertility status, field experiments were conducted at Agricultural Research Station, Thirupathisaram in a Vertisol of high rainfall zone, Tamil Nadu consecutively for three years. Two organic sources *viz.* rice crop residue (stubble/straw) and green manure (*Sesbania aculeata*) in different combination and along with chemical fertilizers were tested in a randomized block design. The results showed that the application of Rice Crop Residue(6.25t/ha) + Green Leaf Manure (3.13 t/ha) along with recommended NPK and TNAU wetland rice MN mixture@ 25 kg/ha recorded the highest number of productive tillers m^{-2} with the pooled mean value of 329 & 364 for the kharif and rabi seasons respectively. The above treatment also recorded the highest mean grain and straw yields over years during both the seasons (7.15 & 10.0 t/ha; 7.03 & 9.83 t/ha for the kharif & Rabi seasons respectively) which was 29.1 & 24.0% higher than combined application of recommended NPK with $ZnSO_4$. The B:C ratio was 2.29 & 2.46 during the kharif seasons I & II and 2.20, 2.45 & 2.47 during the rabi seasons I,II & III respectively. The residual soil properties were marginally influenced by the treatments tested.

Keywords: Residual effect, productivity, nutrient management, soil properties

Introduction
Rice is the foremost staple food internationally. The introduction of high yielding and fertilizer responsive varieties after the Green Revolution witnessed an increase in the use of synthetic fertilizers. Due to the continuous use of chemical fertilizers alone, has caused declining trend in rice productivity in India. (Uma Shankar Ram *et al*. 2013) [9]. Therefore emphasis should be to optimize the use of chemical fertilizers and to improve their use efficiency. Organic sources constitute an important component of the Integrated Nutrient Management. Addition of nutrients through organic manures and the release of these nutrients from the organics depend on their C/N ratio and lignin content. The profitability of organic sources such as straw and FYM when used as a complementary dose to inorganic NPK was reported by Singh *et al*. (2010). The continuous use of inorganic fertilizers *viz.*, DAP, urea, potash and NPK complex, omitting the organic manures (high cost involved) caused the deterioration of soil fertility status especially, the reduction in the soil organic carbon content from 4.5 to 4.0 g kg^{-1}. Moreover the continuous puddling resulted in the deterioration of soil structure and ultimately leads to the development of fluffy soils. The reduction in the cattle population and low cost of paddy straw lead to the *insitu* incineration of paddy straw in the fields, which leads to further deterioration of soil health and environment. Therefore to optimize the use of chemical fertilizers, to improve their use efficiency, the integrated nutrient management with usage of cost-effective organic resources will improve the soil fertility and productivity of rice cultivated in these soils.

Therefore to effectively utilize the local organic resources available, to reduce the usage of inorganic fertilizers, to improve the yield and soil fertility status, the present study has been contemplated.

Materials and Methods

Field experiments were conducted consecutively for three years in a clay soil of high rainfall zone during both kharif and rabi seasons at Agricultural Research Station, Thirupathisaram, Tamil Nadu Agricultural University. The soil was clay in texture, having bulk density 1.18 Mg m^{-3}, normal in pH (7.4) with low in organic C (4.7 g kg^{-1}), available N (199 kg ha^{-1}), available P (10.0 kg ha^{-1}), DTPA-Zn (0.85 mg kg^{-1}) and medium in available K (170 kg ha^{-1}). The experiment was conducted with 16 treatments in a randomized block design with three replications. The treatments include absolute control (T_1), recommended N, P & K through fertilizers (RDF) + $ZnSO_4$ @ 25 kg ha^{-1} (T_2), RDF + TNAU wetland rice MN mixture @ 25 kg ha^{-1} (T_3), RDF + Bio-mineralizer @ 2 kg ton^{-1} of rice crop residue (T_4), rice crop residue (RCR) @ 12.5 t ha^{-1} (T_5), RCR+RDF + $ZnSO_4$ @ 25 kg ha^{-1} (T_6), RCR+RDF + TNAU wetland rice MN mixture @ 25 kg ha^{-1} (T_7), RCR+RDF + Bio-mineralizer @ 2 kg ton^{-1} of rice crop residue (T_8), Green manure (GM) @ 6.25 t ha^{-1} (T_9), GM+RDF + $ZnSO_4$ @ 25 kg ha^{-1} (T_{10}), GM+RDF + TNAU wetland rice MN mixture @ 25 kg ha^{-1} (T_{11}), GM+RDF + Bio-mineralizer @ 2 kg ton^{-1} of rice crop residue(T_{12}), rice crop residue @ 6.25 t ha^{-1} + Green manure @ 3.13 t ha^{-1} (50% RCR + 50% GM) (T_{13}), 50% RCR + 50% GM +RDF + $ZnSO_4$ @ 25 kg ha^{-1} (T_{14}), 50% RCR + 50% GM +RDF + TNAU wetland rice MN mixture @ 25 kg ha^{-1} (T_{15}) and 50% RCR + 50% GM +RDF + Bio-mineralizer @ 2 kg ton^{-1} of rice crop residue (T_{16}), The rice crop residue (stubble/straw: N - 0.40%, P – 0.18%, & K – 0.51%) was quantified and incorporated into the soil after the harvest of the rice crop. The green manure (*Sesbania aculeate*: N – 2.1%, P – 0.40% & K – 1.7%) was incorporated in to the soil as per the specified quantity in the treatment schedule. The bio-mineralizer @ 2 kg ton^{-1} of crop residue was applied during the incorporation into the soil.

The recommended N, P and K fertilizers were 125:40:40 and 150:50:50 kg ha^{-1} respectively for kharif and rabi seasons. After accounting for added N through organics, the remaining N dose from the recommended was added through urea in four equal splits (at basal, tillering, panicle initiation and heading stages) to the respective treatments involving integrated nutrient management and inorganic fertilizers only. Phosphorus was applied basally as single super phosphate on equal nutrient basis as that of N. The potassium was applied on equal nutrient basis as muriate of potash in four equal split doses as that of N. The zinc sulphate @ 25 kg ha^{-1} was applied during every season. Irrigation and plant protection measure was taken as per the recommended schedule of practices. The rice variety ASD 16 (kharif) and TPS 5 (Rabi) was taken as test crop.

The yield attribute *viz*., no. of productive tillers m^{-2} was recorded. The yield of grain and straw were recorded at harvest. The uptake of nutrients *viz*. N,P,K and Zn were quantified at harvest. The soil samples were analysed for organic C, available N,P, K and DTPA-Zn by adopting standard methods. The data obtained were statistically scrutinized following standard procedure. The cost of cultivation was worked out for each treatment (Price of rice grain - Rs. 15 kg^{-1}) and based on the economics, the best treatment was identified.

Results and Discussion

Yield attribute

The number of productive tiller m^{-2} varied significantly for the different combinations over years and seasons (Table 2.). The performance of rice crop with integrated application of rice crop residue, green manure along with the inorganic fertilizers was found better than the application of organic manures alone. This trend was observed during all the seasons and different years of study. The number of productive tiller m^{-2} ranged from 180 to 354 during kharif season and from 250 to 370 during rabi seasons respectively with the pooled mean value of 329 and 364 respectively during kharif and rabi season. Among the treatments Rice Crop Residue(6.25t/ha) + Green Leaf Manure (3.13 t/ha) along with recommended NPK and TNAU wetland rice MN mixture@ 25 kg/ha (T_{15}), recorded the highest number of productive tiller m^{-2} during both the seasons and years (pooled mean of 329 and 364 respectively during kharif and rabi season). This was followed by the combined application of recommended NPK with rice crop residue @ 6.25 t ha^{-1}, Green manure @ 3.13 t/ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1} during both the seasons and all the years with the pooled mean value of 323 and 349 respectively. The variation observed in the number of productive tillers m^{-2} was due to variation in the availability of nutrients. The chemicals fertilizers promotes readily availability in soil, but the organic manures release nutrient slow and steadily. The integrated application promoted the balanced plant nutrition and supplied the required nutrients during crop demand. This favored higher number of productive tillers m^{-2} (Rakshit *et al.*, 2008) [6].

The application of micronutrient especially zinc showed favourable influence due to the electrochemical and bio chemical reactions upon submergence that favoured beneficial effect on the production of productive tillers (Impa *et al.*, 2013) [3]. The superiority over the other treatments might be due to the increasing uptake of nutrients and translocations due to extraneous application (Vandna and Rajesh, 2018).

Yield of grain and straw

The highest grain yield of rice (6.90 and 7.40 t ha^{-1} respectively) was recorded by the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} along with Green manure @ 3.13 t/ha^{-1} and TNAU wetland MN mixture @ 25 kg ha^{-1}in the kharif season I and II (Table 2). During rabi seasons (I, II & III) the same treatment recorded the highest grain yield of 6.60, 7.00 & 7.50 t ha^{-1} respectively. The pooled mean grain yield for the same treatment was 7.15 and 7.03 t ha^{-1} respectively for kharif and rabi seasons. The mean increase in grain yield was 29.1 percent during kharif and 24.2 percent during rabi season over the recommended NPK with $ZnSO_4$ @ 25kg ha^{-1} alone application. This might be due to the efficient utilization of all the applied nutrients including micronutrient. This was in agreement with Sandrakirana, R and Arifin, Z. (2021) [7]. This was on par with the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1}. The highest B:C ratio of 2.29 and 2.46 during kharif I & II and 2.20, 2.25 & 2.47 during rabi seasons I, II & III respectively was recorded with the above treatment (Table. 4). The correlation study showed significant positive influence for the nutrients uptake and grain yield.

The highest straw yield varied from 9.70 and 10.3 t ha $^{-1}$ respectively in the kharif season I & II with mean yield of 10.0 t ha $^{-1}$ was recorded with the application of recommended NPK with rice crop residue @ 6.25 t ha $^{-1}$ and Green manure @ 3.13 t/ha $^{-1}$ and TNAU wet land MN mixture @ 25 kg ha $^{-1}$. In the rabi season I, II & III the same treatment recorded the highest straw yield respectively of 9.40, 9.65 & 10.5 t ha $^{-1}$ with the mean yield of 9.83 t ha $^{-1}$ (Table. 3). This was followed by the application of recommended NPK with rice crop residue @ 6.25 t ha $^{-1}$ + Green manure @ 3.13 t/ha $^{-1}$ and $ZnSO_4$ @ 25 kg ha $^{-1}$. This might to due to the reason that the soil is deficient in Zn status and the application of micronutrient favoured the release and effective utilization. The similar finding was also reported by Das *et al.* (2013) [1].

Table 1: Effect of treatments on number of productive tillers m $^{-2}$ of rice during different seasons and years

Tr. No.	Treatments	*Kharif*		Rabi			*Kharif*	Rabi
		I Year	II Year	I Year	II Year	III Year	Pooled	mean
T_1	Absolute Control	180	183	258	250	252	182	253
T_2	RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	250	260	316	314	284	255	305
T_3	RDF + TNAU wetland MN mixture @ 25 kg ha $^{-1}$	264	274	318	328	298	269	315
T_4	RDF + Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	240	250	286	302	272	245	287
T_5	RCR @ 12.5 t ha $^{-1}$	180	184	264	260	264	182	263
T_6	RCR + RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	282	312	320	344	334	297	333
T_7	RCR + RDF + TNAU wetland MN mixture @ 25 kg ha $^{-1}$	286	316	340	354	344	301	346
T_8	RCR + RDF + Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	270	290	294	336	316	280	315
T_9	GM @ 6.25 t ha $^{-1}$	186	190	270	268	272	188	270
T_{10}	GM + RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	288	328	326	356	352	308	345
T_{11}	GM + RDF+ TNAU wetland MN mixture @ 25 kg ha $^{-1}$	292	332	344	358	354	312	352
T_{12}	GM + RDF+ Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	280	300	304	344	324	290	324
T_{13}	50% RCR (6.25 t ha $^{-1}$) + 50% GM (3.13 t ha $^{-1}$)	184	188	272	274	278	186	275
T_{14}	50% RCR + 50% GM + RDF+ $ZnSO_4$ @ 25 kg ha $^{-1}$	298	348	330	362	356	323	349
T_{15}	50% RCR + 50% GM + RDF+ TNAU wetland MN mixture @ 25 kg / ha	304	354	362	370	360	329	364
T_{16}	50% RCR + 50% GM + RDF+ Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	276	296	310	340	320	286	323
	SED	10.4	14.3	9.28	11	10.5	12.4	10.3
	CD (5%)	21	29	19	22	21	25	21

RDF-Recommended Dose of Fertilizer; RCR-Rice Crop Residue;

Table 2: Effect of treatments on the grain yield (t/ha) of rice during different seasons and years

Tr. No.	Treatments	*Kharif*		Rabi			*Kharif*	Rabi
		I year	II year	I year	II year	III year	Pooled	mean
T_1	Absolute Control	4.70	4.72	3.67	3.60	3.62	4.71	3.63
T_2	RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	5.50	5.57	5.67	5.60	5.70	5.54	5.66
T_3	RDF + TNAU wetland MN mixture @ 25 kg ha $^{-1}$	5.60	5.67	5.73	5.75	5.85	5.64	5.78
T_4	RDF + Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	5.30	5.40	5.13	5.50	5.60	5.35	5.41
T_5	RCR @ 12.5 t ha $^{-1}$	4.90	4.95	4.80	5.00	5.05	4.93	4.98
T_6	RCR + RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	6.30	6.50	5.80	6.45	6.75	6.40	6.33
T_7	RCR + RDF + TNAU wetland MN mixture @ 25 kg ha $^{-1}$	6.40	6.70	6.17	6.55	6.85	6.55	6.52
T_8	RCR + RDF + Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	5.70	5.90	5.33	5.90	5.45	5.80	5.56
T_9	GM @ 6.25 t ha $^{-1}$	5.10	5.15	4.87	5.25	5.27	5.18	5.13
T_{10}	GM + RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	6.60	7.00	5.90	6.75	7.13	6.80	6.59
T_{11}	GM + RDF+ TNAU wetland MN mixture @ 25 kg ha $^{-1}$	6.70	7.10	6.00	6.90	7.30	6.90	6.80
T_{12}	GM + RDF+ Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	5.90	6.10	5.53	6.00	6.40	6.00	5.98
T_{13}	50% RCR (6.25 t ha $^{-1}$) + 50% GM (3.13 t ha $^{-1}$)	5.00	5.08	4.90	5.25	5.30	5.04	5.15
T_{14}	50% RCR + 50% GM + RDF+ $ZnSO_4$ @ 25 kg ha $^{-1}$	6.80	7.30	6.20	6.95	7.43	7.05	6.79
T_{15}	50% RCR + 50% GM + RDF+ TNAU wetland MN mixture @ 25 kg / ha	6.90	7.40	6.60	7.00	7.50	7.15	7.03
T_{16}	50% RCR + 50% GM + RDF+ Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	5.80	6.00	5.63	5.90	6.10	5.90	5.88
	SED	0.196	0.258	0.157	0.307	0.290	0.227	0.251
	CD (5%)	0.40	0.53	0.33	0.64	0.60	0.47	0.50

Table 3: Effect of treatments on the straw yield (t/ha) of rice during different seasons and years

Tr. No.	Treatments	*Kharif*		Rabi			*Kharif*	Rabi
		I year	II year	I year	II year	III year	Pooled	mean
T_1	Absolute Control	5.70	5.73	5.67	5.25	5.30	5.72	5.41
T_2	RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	7.20	7.37	7.53	7.45	7.60	7.29	7.53
T_3	RDF + TNAU wetland MN mixture @ 25 kg ha $^{-1}$	7.40	7.57	7.73	7.60	7.75	7.49	7.69
T_4	RDF + Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	6.80	6.97	6.63	7.15	7.30	6.89	7.03
T_5	RCR @ 12.5 t ha $^{-1}$	6.00	6.07	6.17	6.35	6.42	6.04	6.31
T_6	RCR + RDF + $ZnSO_4$ @ 25 kg ha $^{-1}$	8.50	8.83	8.00	8.75	9.08	8.67	8.61
T_7	RCR + RDF + TNAU wetland MN mixture @ 25 kg ha $^{-1}$	8.70	9.03	8.17	9.10	9.43	8.87	8.90
T_8	RCR + RDF + Bio mineralizer @ 2 kg ton $^{-1}$ of rice crop residue	7.60	7.87	7.03	7.95	8.20	7.74	7.73

T_9	GM @ 6.25 t ha^{-1}	6.50	6.57	6.17	7.40	7.47	6.54	7.01
T_{10}	GM + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	9.10	9.57	8.67	9.10	9.53	9.34	9.10
T_{11}	GM + RDF+ TNAU wetland MN mixture @ 25 kg ha^{-1}	9.30	9.73	8.83	9.40	9.87	9.52	9.37
T_{12}	GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	8.00	8.27	7.27	8.30	8.55	8.14	8.04
T_{13}	50% RCR (6.25 t ha-1) + 50% GM (3.13 t ha-1)	6.20	6.27	6.20	6.55	6.62	6.24	.6.46
T_{14}	50% RCR + 50% GM + RDF+ $ZnSO_4$ @ 25 kg ha^{-1}	9.40	10.0	9.33	9.60	10.2	9.70	9.71
T_{15}	50% RCR + 50% GM + RDF+ TNAU wetland MN mixture @ 25 kg / ha	9.70	10.3	9.40	9.65	10.5	10.0	9.83
T_{16}	50% RCR + 50% GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	7.70	7.97	7.43	7.95	8.20	7.84	7.86
	SED	0.302	0.388	0.202	0.390	0.230	0.345	0.274
	CD (5%)	0.83	0.79	0.42	0.82	0.47	0.72	0.58

Table 4: Effect of treatments on the B-C ratio of rice during different seasons and years

Tr. No.	Treatments	Kharif		Rabi		
		I year	II year	I year	II year	III year
T_1	Absolute Control	1.88	1.85	1.76	1.78	1.74
T_2	RDF + $ZnSO_4$ @ 25 kg ha^{-1}	1.95	1.96	2.01	1.94	1.96
T_3	RDF + TNAU wetland MN mixture @ 25 kg ha^{-1}	1.99	1.98	2.04	1.99	2.02
T_4	RDF + Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	1.88	1.90	1.81	1.90	1.93
T_5	RCR @ 12.5 t ha^{-1}	1.85	1.84	1.80	1.71	1.81
T_6	RCR + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	2.12	2.18	1.90	2.14	2.24
T_7	RCR + RDF + TNAU wetland MN mixture @ 25 kg ha^{-1}	2.15	2.25	2.09	2.17	2.28
T_8	RCR + RDF + Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	1.91	1.98	1.84	1.90	1.82
T_9	GM @ 6.25 t ha^{-1}	1.87	1.87	1.77	1.87	1.87
T_{10}	GM + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	2.16	2.30	1.94	2.18	2.32
T_{11}	GM + RDF+ TNAU wetland MN mixture @ 25 kg ha^{-1}	2.19	2.33	2.05	2.23	2.37
T_{12}	GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	1.93	2.00	1.80	1.94	1.97
T_{13}	50% RCR (6.25 t ha-1) + 50% GM (3.13 t ha-1)	1.86	1.86	1.82	1.88	1.88
T_{14}	50% RCR + 50% GM + RDF+ $ZnSO_4$ @ 25 kg ha^{-1}	2.26	2.43	2.10	2.28	2.44
T_{15}	50% RCR + 50% GM + RDF+ TNAU wetland MN mixture @ 25 kg / ha	2.29	2.46	2.20	2.45	2.47
T_{16}	50% RCR + 50% GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	1.92	1.99	1.86	1.93	2.00

Table 5: Effect of treatments on total uptake of nutrient by rice crop (pooled mean)

Tr. No.	Treatments	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		Zn uptake (g ha^{-1})	
		Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
T_1	Absolute Control	96.1	86.7	12.3	11.1	72.7	67.0	108	98.8
T_2	RDF + $ZnSO_4$ @ 25 kg ha^{-1}	147	137	19.2	17.5	115	107	158	146
T_3	RDF + TNAU wetland MN mixture @ 25 kg ha^{-1}	153	143	20.8	19.2	128	119	175	162
T_4	RDF + Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	138	126	17.1	15.4	107	97.8	133	121
T_5	RCR @ 12.5 t ha^{-1}	106	95.8	15.3	13.7	85	77.3	118	108
T_6	RCR + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	179	163	22.4	19.7	142	128	194	175
T_7	RCR + RDF + TNAU wetland MN mixture @ 25 kg ha^{-1}	187	173	24.2	22.4	151	142	213	197
T_8	RCR + RDF + Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	153	136	20.3	17.7	121	109	154	136
T_9	GM @ 6.25 t ha^{-1}	115	108	16.2	14.9	93.6	88.8	133	122
T_{10}	GM + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	183	161	24.0	21.0	156	136	216	189
T_{11}	GM + RDF+ TNAU wetland MN mixture @ 25 kg ha^{-1}	195	170	25.9	23.5	165	148	244	220
T_{12}	GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	157	142	19.6	17.6	127	114	167	150
T_{13}	50% RCR (6.25 t ha-1) + 50% GM (3.13 t ha-1)	113	103	16.5	14.2	93.1	86.4	128	116
T_{14}	50% RCR + 50% GM + RDF+ $ZnSO_4$ @ 25 kg ha^{-1}	196	172	26.9.	23.8	168	149	246	227
T_{15}	50% RCR + 50% GM + RDF+ TNAU wetland MN mixture @ 25 kg / ha	204	187	27.3	24.8	174	161	253	231
T_{16}	50% RCR + 50% GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	154	141	20.5	18.8	127	115	163	152
	SED	8.10	6.76	1.097	0.961	6.175	4.226	8.97	7.289
	CD (5%)	17.0	14.2	2.3	2.0	13	8.9	19.0	15

Table 5: Simple correlation matrix showing the relationship of No. of productive tillers m^{-2}, nutrient uptake and grain yield of rice.

No. of productive tillers m^{-2}	No. of productive tillers m^{-2}	N Uptake	P uptake	K uptake	Zn uptake	Grain yield
	1					
N uptake	0.80**	1				
P uptake	0.74**	0.76 **	1			
K uptake	0.84**	0.78**	0.77**	1		
Zn uptake	0.87**	0.83**	0.75*	0.79**	1	
Grain yield	0.89**	0.88**	0.82**	0.86**	0.76**	1

* Significant at 0.05 probability and ** significant at 0.01 probability level

Nutrient uptake: The results indicated that the highest mean uptake of N (204 & 187 kg ha^{-1} respectively), P (27.3 & 24.8), K (174 & 161 kg ha^{-1} respectively) & Zn (253 & 231 g ha^{-1} respectively) during *kharif* and *rabi* seasons was recorded by the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} + Green manure @ 3.13 t/ha^{-1} along with TNAU wet land MN mixture @ 25 kg ha^{-1}. The trend was similar for the different seasons and during the different years. This was followed by the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1} (Table 5). The application of balanced nutrition (N, P, K, Zn and micronutrient) promoted their increased soil availability, content in plant and dry matter production. The similar finding was also reported by Ghosh *et al.* (2014) [2].

Soil available nutrient: The application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and TNAU wet land MN mixture @ 25 kg ha^{-1} marginal increased the residue soil organic carbon (0.54%), available N (227 kg ha^{-1}), available P (12.7 kg ha^{-1}) and available K (199 kg ha^{-1}). The marginal increase in DTPA – Zn (0.99 mg kg^{-1}) was recorded with the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1} (Table 6). The integrated application of inorganic fertilizers and organic manure increased the availability and uptake all the nutrients was reported by Panta and Parajulee (2021) [5].

Table 6: Effect of treatments on the residual soil fertility status

Tr. No.	Treatments	Organic C (g kg^{-1})	Available (kg ha^{-1})	Available P (kg ha^{-1})	Available (kg ha^{-1})	DTPA - Zn (mg/kg)
T_1	Absolute Control	4.8	190	9.00	170	0.79
T_2	RDF + $ZnSO_4$ @ 25 kg ha^{-1}	4.9	208	11.3	192	0.93
T_3	RDF + TNAU wetland MN mixture @ 25 kg ha^{-1}	5.0	214	11.7	196	0.90
T_4	RDF + Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	4.8	211	11.0	191	0.83
T_5	RCR @ 12.5 t ha^{-1}	5.2	218	10.7	186	0.84
T_6	RCR + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	5.2	218	11.3	196	0.96
T_7	RCR + RDF + TNAU wetland MN mixture @ 25 kg ha^{-1}	5.2	214	11.7	197	0.92
T_8	RCR + RDF + Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	5.2	220	11.0	192	0.86
T_9	GM @ 6.25 t ha^{-1}	5.2	218	11.7	185	0.84
T_{10}	GM + RDF + $ZnSO_4$ @ 25 kg ha^{-1}	5.2	217	12.0	194	0.98
T_{11}	GM + RDF+ TNAU wetland MN mixture @ 25 kg ha^{-1}	5.3	221	10.7	196	0.90
T_{12}	GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	5.3	218	11.7	190	0.88
T_{13}	50% RCR (6.25 t ha-1) +50% GM (3.13 t ha-1)	5.3	216	12.2	188	0.86
T_{14}	50% RCR + 50% GM + RDF+ $ZnSO_4$ @ 25 kg ha^{-1}	5.3	225	12.3	198	0.99
T_{15}	50% RCR + 50% GM + RDF+ TNAU wetland MN mixture @ 25 kg / ha	5.4	227	12.7	199	0.92
T_{16}	50% RCR + 50% GM + RDF+ Bio mineralizer @ 2 kg ton^{-1} of rice crop residue	5.3	215	12.2	192	0.88
	SED	0.08	6.70	0.306	4.50	0.02
	CD (5%)	0.2	14.0	0.6	9	0.04

Conclusion

The number of productive tillers per m^{-2}, grain and straw yield of rice cultivated in clay soil of high rainfall zone was increased by the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and TNAU wet land MN mixture @ 25 kg ha^{-1}. The application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1} was found to be the next best. In case of uptake the same trend was observed. From the above experiments the application of recommended NPK with rice crop residue @ 6.25 t ha^{-1} and Green manure @ 3.13 t/ha^{-1} and TNAU wet land MN mixture @ 25 kg ha^{-1} was found to be the superior treatment in improving the yield and yield attributes of rice. It is the best alternative and economical treatment for getting higher yield in the clay soil of high rainfall zone.

References

1. Das TK, Bhattacharyya R, Sharma AR, Das S, Saad AA, Pathak H. Impact of conservation agriculture on total soil organic carbon retention potential under an irrigated agro-ecosystem of the western Indo-Gangetic Plains. European J Agron. 2013;51:34-42.
2. Ghosh K, Chowdhury MAH, Rahman MH, Bhattacherjee S. Effect of integrated nutrient management on nutrient uptake and economics of fertilizers use in rice cv. NERICA 10 J Bangladesh Agril. Unv. 2014;12(2):273-277.
3. Impa MS, Mark JRM, Abdelbagi I, Rainer S. Zinc uptake, translocation and grain zinc loading in rice genotypes selected for zinc deficiency tolerance and high grain Zinc. J Expt. Bot. 2013;64(10):2740-2751.
4. Mondal SS, Kundu l, Brahmachari KE, Berg PS, Acharya D. Effect of integrated nutrient management on the productivity, quality improvement and soil fertility in rice onion cowpea sequence. Oryza. 2014;51(3):208-212.
5. Panta S, Parajulee D. Integrated Nutrient Management (INM) in Soil and Sustainable Agriculture int. J Appl. Sci. Biotechnol. 2021;9(3):160-165.
6. Rakshit A, Sankar NC, Sen D. Influence of organic manures and productivity of the two varieties of rice. J Central European Agriculture. 2008;9(4):629-634
7. Sandrakirana R, Arifin Z. Effect of organic and chemical fertilizers on the growth and productionof soybean in dryland. Revista Facultad Nacional de Agronomia Medellin. 2021;74(3):9643-9653.
8. Singh A, Agarwal M, Marshall FM. The role of organic vs. inorganic fertilizers in reducing phytoavailability of heavy metals in a waste water – irrigated area. Ecological Engineering. 2010;36:1733-1740.
9. Uma Shanker Ram, Srivastava VK, Hemantaranjan A, Sen A, Singh RK, Bohra JS. Effect of Zn, Fe and FYM application on growth, yield and nutrient content of rice. Oryza. 2013;50(4):351-357.
10. Vandna C, Rajesh K. Role of zinc application on rice growth and yield. Plant Archives. 2018;18(2):1382-1384.