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IMPACT OF CONTINUOUS ORGANIC AND INORGANIC FERTILIZER APPLICATION ON RICE-RICE CROPPING SYSTEM UNDER TAMIRAPARANI RIVER BASIN IN TAMIL NADU, INDIA

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ABSTRACT

The Permanent Manurial Trials were conducted at Rice Research Station, Ambasamudram with the treatments such as T_1- Control, T_2- Organic Manuring (Farm Yard Manure on N equivalent basis + biofertilizers), T_3- Inorganic Fertilization (as per blanket recommendation-120:40:40 Kg NPK/ha), T_4- Integrated Nutrient Management (FYM 12.5 tha^{-1} + NPK+ biofertilizers). The treatment has been modified slightly with STCR-IPNS recommendation and implemented from 2015 onwards. The mean grain yield of ASD16 was ranged from 2676 to 6564 and from 3952 to 7175 kg/ha during pishanam and kar seasons respectively whereas it was ranged from 2728 to 6774 kg/ha and from 2769 to 5599 kg /ha during pishanam and kar respectively under AS10024. Though the grain yield was more during kar season than the pishanam season, the difference in grain yield between kar and pishanam seasons were narrowed down by the application of nutrients based on STCR-IPNS method. Application of nutrients through INM practice (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha + Bio-fertilizer as per CPG) reduced the nitrogen requirement from 14.25 kg/t to 11.75 kg/t of rice grain production. The soil available nitrogen content was depleted under control whereas it built up under INM practice with STCR-IPNS. The mean organic carbon content under control and inorganic source of nutrient application was almost same and increased to 0.65 % by the organic source of nutrient application and to 0.70 % by the INM practice of nutrient application. The soil was compacted under the continuous application of inorganic fertilizer and loosened with more pore space by the application of nutrients through organic alone or in combined with inorganic fertilizer as observed from the reduced bulk density from 1.35 to 1.23 Mg/m^3.

KEYWORDS: Rice, PME, Organic farming, Inorganic farming& STCR-IPNS

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INTRODUCTION

Soil is dynamic living body and contains numerous organisms ranging from the invisible microbes to the more familiar macro-fauna and even larger animals. These organisms play a significant role in soil health and plant growth by virtue of their role in many soil biochemical reactions and soil processes, particularly those play role in the formation of soil structure, carbon and biogeochemical cycling of nutrient elements, decomposition of plant and animal residues and release of nutrients from the inorganic minerals and applied fertilizers (Chandra, 2017). Soil health deterioration due to unbalanced and indiscriminate use of plant nutrients often far below their removal by crops led to continuous mining or nutrients from native soil reserves. As a result, not only the number of deficient nutrients increased but also the extent of nutrient deficiencies in soil becomes larger and larger. The problem is severe in intensively cropped regions (Deivedi, 2017). In this context attempts were made to improve soil nutrient supplying capacity and organic carbon content besides enhancing rice grain yield through individual and combined

application of various sources of nutrients (organic and inorganic) continuously for nearly 1 decade under intensive rice cultivation.

MATERIALS AND METHODS

The Permanent Manurial experiments were conducted in both *kar* and *pishanam* seasons from 2010 - 2018 at Rice Research Station, Ambasamudram to study the individual and combined effect of organic and inorganic source of nutrients on physical chemical and biological properties of the soil and to study the effect of continuous practices of organic and inorganic and INM on growth and yield of rice besides to measure the cumulative effect of fertilization practices on yield sustainability, grain quality of rice and soil microbial population. Initially the experiment was conducted with the treatments such as T_1- Control, T_2- Organic Manuring (Farm Yard Manure on N equivalent basis + biofertilizers), T_3- Inorganic Fertilization (as per blanket recommendation-120:40:40 Kg NPK/ha), T_4- Integrated Nutrient Management (FYM 12.5 tha^{-1} + NPK+ biofertilizers). The test crop of ASD 16 was raised by following SRI method of rice cultivation. The treatment has been slightly modified as by including STCR-IPNS recommendation instead blanket recommendation and implemented from 2015 onwards. The modified treatments were T_1 – Control, T_2 - Organic (FYM on N equivalent basis and bio-fertilizer as per CPG, T_3 - Inorganic (STCR recommendation for 5 t /ha) and T_4 - INM (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha +Biofertilizer as per CPG. The test crop of rice culture AS 10024 was raised by following SRI method of rice cultivation. The size of the plot for each treatment was 240 m^2 (15 x 16 m^2). The grain yield from each plot was recorded as kg $plot^{-1}$ and converted to kg ha^{-1}. The moisture content of the grain was estimated by oven drying at 80^0C and the grain yield was adjusted to 14 percent moisture content. The grain yields for the plants removed for sampling purposes from each plot were computed based on the number of hills and added to the harvested yields of their respective plots. The plant (grain and straw) and post harvest soil samples were processed and analyzed for its nutrient content by following standard methods. The data were interpreted with suitable data analytical tools and presented below.

RESULTS AND DISCUSSIONS

Grain and Straw Yields

The grain yield of rice was influenced by the source of nutrient application during both the seasons under both the varieties. The mean grain yield of ASD16 was ranged from 2676 to 6564 kg/ha and from 3952 to 7175 kg/ha during pishanam and kar seasons respectively whereas it was ranged from 2728 to 6774 kg/ha and from 2769 to 5599 kg /ha during pishanam and kar seasons respectively under AS 10024 (Table 1). In general, the grain yield was more during kar season than the pishanam season. However, the difference in grain yield between kar and pishanam seasons were narrowed down by the application of various sources nutrients based on STCR-IPNS method (Figure 1 and 2). The rice culture AS 10024 gave equal or slightly more grain yield during pishanam season than the kar season. This shows the impact of STCR-IPNS method of nutrient application on grain yield of rice with better uptake of P and K from the soil even under the varied climatic and seasonal conditions. This finding indicated that integrated use of chemical fertilizers with FYM or green manure facilitated to curtail the use of chemical fertilizers upto 50 % besides increasing grain yield of rice (Urkurkar et al. 2010).

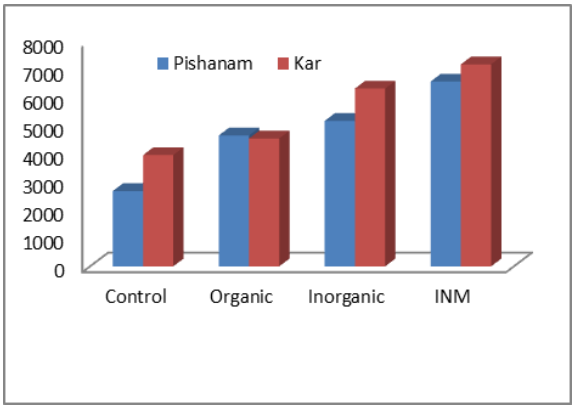


Figure 1: Grain yield of rice (kg ha^{-1}) as influenced by source of nutrient application in ASD 16

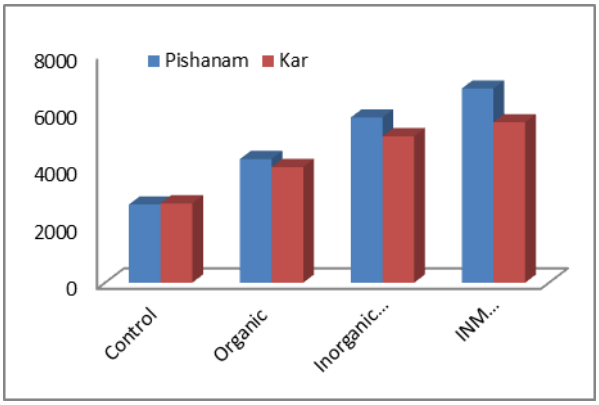


Figure 2: Grain yield of rice (kg ha^{-1}) as influenced by source of nutrient application in AS 10024

The straw yield of rice followed the same trend as that of grain yield in both the variety. The straw yield ranged from 3183 to 7216 kg /ha and from 3016 to 8475 kg/ha during *pishanam* and *kar* seasons respectively under ASD16 where as it was ranged from 1973 to 8239 kg/ha and 2213 to 6442 kg/ha during *pishanam* and *kar* seasons respectively under AS10024 (Table 2).

Table 1: Grain yield (kg /ha) of Rice as influenced by Organic and Inorganic source of Nutrients over a period of Time under PME

Variety :ASD 16

Treatment	Pishanam						Kar			
	2010	2011	2012	2013	2014	Mean	2011	2013	2014	Mean
T1 - Control	3542	2000	2929	2335	2573	**2676**	3333	5598	2925	**3952**
T2 - Organic (FYM on N equivalent basisand bio-fertilizer as per CPG	4625	5167	5490	4239	3728	**4650**	4292	5575	3755	**4541**
T3 - Inorganic (120:40:40 kgNPK /ha)	7375	3917	5081	5124	4340	**5167**	5792	8591	4565	**6316**
T4 - INM (FYM 12.5 t/ha + Rec. NPK +Biofertilizer as per CPG	7917	6167	7106	6119	5511	**6564**	6375	9985	5165	**7175**

Variety : AS 10024

Treatment	Pishanam			Kar		
	2015	2017	Mean	2015	2016	Mean
T1 - Control	2415	3041.7	**2728**	3258	2280	**2769**
T2 - Organic (FYM on N equivalent basis and bio-fertilizer as per CPG	3915	4708.3	**4312**	5116	2954	**4035**
T3 - Inorganic (STCR recommendation for 5 t /ha)	5863	5666.7	**5765**	6814	3402	**5108**
T4 - INM (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha +Bio fertilizer as per CPG	6965	6583.3	**6774**	7236	3961	**5599**

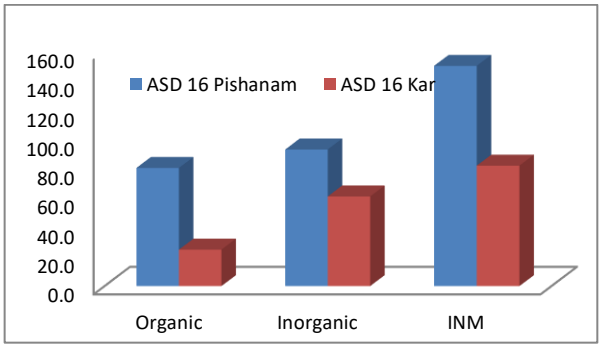
Table 2: Straw Yield (kg /ha) of Rice as influenced by Organic and Inorganic source of Nutrients over a period of time under PME

Variety :ASD 16

Treatment	Pishanam						Kar			
	2010	2011	2012	2013	2014	Mean	2011	2013	2014	Mean
T1 - Control	3792	3417	3426	2131	3147	**3183**	3542	3376	2131	**3016**
T2 - Organic (FYM on N equivalent basisand bio-fertilizer as per CPG	5563	6125	6704	2611	4247	**5050**	5146	7097	2631	**4958**
T3 - Inorganic (120:40:40 kgNPK /ha)	8917	4458	6204	3868	4836	**5657**	6953	6322	3868	**5714**
T4 - INM (FYM 12.5 t/ha + Rec. NPK +Biofertilizer as per CPG	9563	7042	8678	4677	6120	**7216**	7652	13096	4677	**8475**

Variety: AS 10024

Treatment	Pishanam			Kar		
	2015	2017	Mean	2015	2016	Mean
T1 - Control	1822	2123	**1973**	2452	1974	**2213**
T2 - Organic (FYM on N equivalent basis and bio-fertilizer as per CPG	4725	3765	**4245**	5716	2199	**3958**
T3 - Inorganic (STCR recommendation for 5 t /ha)	8462	4509	**6486**	8716	2637	**5677**
T4 - INM (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha +Biofertilizer as per CPG	10892	5585	**8239**	9550	3334	**6442**



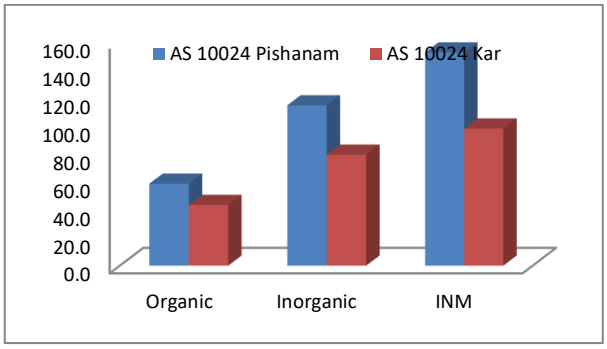


Figure 3: Percentage increase of Grain Yield over control as influenced by Nutrient Sources

Nutrient uptake and its Requirement

In general, the mean nutrient uptake of N and P was more during *kar* season (113.6 and 19.23 kg/ha) than *pishanam* season (88.92 and 17.05 kg /ha) whereas the K uptake was more during pishanam season (101.23 kg/ha) than kar season (93.50 kg/ha). The higher NPK uptake of 113.6, 19.23 and 101.23 kg/ha was observed under the rice variety ASD 16 under INM (FYM 12.5 t/ha + Recommended NPK +Bio fertilizer as per CPG) whereas the rice culture AS 10024 also showed the same trend as that of ASD 16 and the higher NPK uptake of 77.59, 22.66 and 121.26 kg/ha respectively was recorded by the INM (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha +Bio-fertilizer as per CPG) practices of nutrient application (Table 3). This was followed by the inorganic source of nutrient application and organic source of nutrient application in both the variety during all the seasons of rice cultivation.

The nitrogen requirement varied from **12.5 to 13.55** and **13.83 to 15.8** kg / t of rice grain during *pishanam* and *kar* seasons respectively under ASD 16 whereas it was from **11.75 to 14.25** and **14.05 to 15.85** kg/t of rice grain respectively under AS 10025 (Table 4). Application of nutrients through INM practice (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha + Bio-fertilizer as per CPG) reduces the nitrogen requirement from 14.25 kg/t under inorganic source of N application to 11.75 kg/t of rice grain production and from 15.85 to 14.05 kg/ t during pishanam and kar seasons respectively which indicated the better N uptake and utilization by the rice under the INM practice of nutrient application. Application of N through organic sources also reduced the nitrogen requirement from 14.25 to 13.30 and 15.85 to 14.80 kg/t during *kar* and *pishanam* seasons respectively than inorganic source of nutrient application. The more nutrients requirement was observed to produce grain under the practice of integrated use of manures and fertilizers than the individual entities (Salunkhe et al., 2018).

Table 3: Nitrogen uptake (kg/ha) of Rice Grain as influenced by Organic and Inorganic Source of Nutrients over a period of time under PME

Variety: ASD 16

Treatment	Pishanam						Kar			
	2010	2011	2012	2013	2014	Mean	2011	2013	2014	Mean
T1 - Control	41.30	27.30	34.20	24.52	29.85	**31.62**	37.33	53.18	33.64	**42.42**
T2 - Organic (FYM on N equivalent basisand bio-fertilizer as per CPG	58.30	63.70	69.60	51.29	48.46	**58.32**	57.94	96.00	50.32	**62.82**
T3 - Inorganic (120:40:40 kgNPK /ha)	93.50	46.60	62.00	64.05	59.02	**64.98**	84.56	128.87	68.02	**93.69**
T4 - INM (FYM 12.5 t/ha + Rec. NPK +Biofertilizer as per CPG	103.40	77.70	92.90	88.73	79.91	**88.92**	98.81	161.76	81.61	**113.60**

Variety: AS 10024

Treatment	Pishanam			Kar		
	2015	2017	Mean	2015	2016	Mean
T1 - Control	30.63	29.85	**30.24**	53.76	39.22	**46.49**
T2 - Organic (FYM on N equivalent basisand bio-fertilizer as per CPG	32.36	40.15	**36.26**	73.16	45.20	**59.18**
T3 - Inorganic (STCR recommendation for 5 t /ha)	56.77	65.92	**61.34**	103.57	56.13	**79.85**
T4 - INM (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha +Biofertilizer as per CPG	70.94	64.60	**67.77**	96.96	58.23	**77.59**

Table 4: Nitrogen requirement (kg/t) of Rice Grain as influenced by Organic and Inorganic Source of nutrients over a period of time under PME

Variety :ASD 16

Treatment	Pishanam						Kar			
	2010	2011	2012	2013	2014	Mean	2011	2013	2014	Mean
T1 - Control	-	-	-	-	-	-	-	-	-	-
T2 - Organic (FYM on N equivalent basis and bio-fertilizer as per CPG	12.61	12.33	12.68	12.1	13	**12.54**	13.5	14.6	13.4	**13.83**
T3 - Inorganic (120:40:40 kgNPK /ha)	12.68	11.90	12.20	12.5	13.6	**12.58**	14.6	15	14.9	**14.83**
T4 - INM (FYM 12.5 t/ha + Rec. NPK +Biofertilizer as per CPG	13.06	12.60	13.07	14.5	14.5	**13.55**	15.5	16.2	15.8	**15.83**

Variety: AS 10024

Treatment	Pishanam			Kar		
	2015	2017	Mean	2015	2016	Mean
T1 - Control	-	-	-	-	-	-
T2 - Organic (FYM on N equivalent basis and bio-fertilizer as per CPG	13.4	13.2	**13.30**	14.3	15.3	**14.80**
T3 - Inorganic (STCR recommendation for 5 t /ha)	14.5	14	**14.25**	15.2	16.5	**15.85**
T4 - INM (FYM 12.5 t/ha + STCR-IPNS based recommendation for 5 t/ha +Biofertilizer as per CPG	12.1	11.4	**11.75**	13.4	14.7	**14.05**

Soil Fertility Level

The mean soil available N content vary from 206.2 to 270.4 and 203.3 to 270 kg/ha under ASD 16 during *pishanam* and *kar* seasons respectively whereas it varied from 200 to 294.5 and 214 to 311 kg/ha under AS 10024 during *pishanam* and *kar* seasons respectively. It was clear that the available nitrogen content was depleted under control where no nutrients were added. However, the build up of available nitrogen content in soil was noticed over the years and specifically when the INM practice of applying STCR-IPNS based nutrients under AS 10024 than INM with recommended inorganic fertilizer application. This is in line with the reported work of Jothimani (2013).

In general, the mean soil available P content varied from 41.9 to 62.66 and 41.7 to 63.0 kg/ha under ASD 16 during *pishanam* and *kar* seasons respectively whereas it varied from 41.7 to 68.93 and 42.05 to 74.55 kg/ha under AS 10024 during *pishanam* and *kar* seasons respectively (Jothimani and Thiyagarajan, 2005). However, the available phosphorus content in soil was improved over the years. The improvement was spectacular when the nutrients were applied based on STCR-IPNS technique under AS 10024.

Though the available potassium content in soil was depleted under control, the improvement of available potassium status was observed when the source of nutrients added under INM. However, the effect was more pronounced when the nutrients were added based on STCR-IPNS both during *kar* and *pishanam* seasons.

Jadhao et al. (2019) observed substantial improvement on available plant nutrients under the conjoint use of chemical fertilizer along with FYM which created favourable soil conditions and helped to mineralize the additional nutrients and build-up higher soil available nutrients.

The organic carbon content was ranged from 0.54 to 0.83 per cent. However, the mean organic carbon content under control and inorganic source of nutrient application was almost same and maintained 0.57 to 0.58% respectively and it was increased to 0.65 % by the organic source of nutrient application. The highest organic carbon content of 0.70 % was registered by the INM where both organic and inorganic source of nutrients were applied. Consequently, the microbial biomass carbon in soil was also varied from 0.73 % during initiation of experiment to 1.93 % under organic source of nutrient application and further enhanced to 2.85 % by the combined application of both organic and inorganic sources of nutrients through INM practice.

Soil Physical Properties

The soil physical properties such as bulk density, particle density and pore space were improved by the addition of organic source of nutrient application both as individually and combination with inorganic source of nutrients. The soil was compacted under the continuous application of inorganic fertilizer alone and maintained higher bulk density of 1.35 Mg/m^3

Table 5: Soil Physical properties as influenced by organic and Inorganic source of Nutrients over a period of time under PME

Treatment	Bulk Density			Particle Density			Pore-space		
	2010	2014	2017	2010	2014	2017	2010	2014	2017
T1 - Control	1.50	1.42	1.40	2.20	2.20	2.20	31.82	35.45	36.36
T2 - Organic (FYM on N equivalent basis and bio-fertilizer as per CPG	1.50	1.29	1.24	2.20	2.22	2.25	31.82	41.90	44.88
T3 - Inorganic (Blanket recommendation)	1.50	1.33	1.35	2.20	2.22	2.26	31.82	40.10	40.26
T4 - INM (FYM 12.5 t/ha + Rec. NPK + Biofertilizer as per CPG	1.50	1.29	1.23	2.20	2.22	2.25	31.82	41.90	45.33

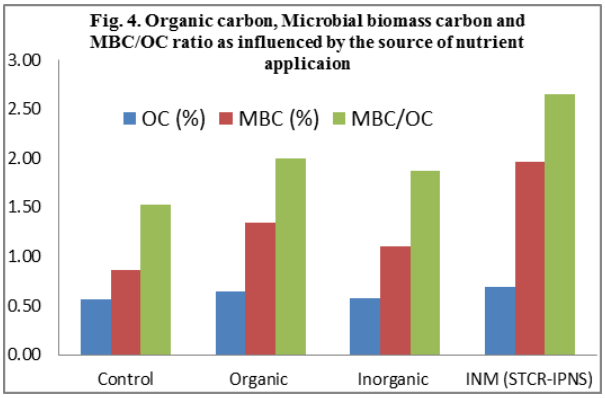
Than the application of nutrients through organic alone or in combination with inorganic sources which maintained the less bulk density of 1.24 and 1.23Mg/m^3 than the control (Table 5). This may be due to the higher pore space of the soil as observed under the application of organic source of nutrient application either alone (44.88 %) or in combination with inorganic source of nutrients (45.33 %). The decrease in bulk density and increase in water holding capacity in FYM application is in conformity with the findings of Pal et al., (2006). Rajkannan et al (2001) stated that addition of organic manures improved soil physical properties and thereby would have provided a conducive environment for better movement of water, nutrients, better foraging of roots to deeper layers facilitating effective mining of nutrients from deeper layers culminating in higher N uptake and grain yield of crops grown.

Soil Biological Parameters

About 20 and 25 % of organic carbon was derived from the microbial biomass produced by the application of organic and INM practice of nutrient application respectively (Figure 4). The combined application of organic and inorganic source of nutrient contributed 8 % more organic carbon content in soil than the inorganic source of nutrient application. Further, the organic matter produced either by the application of organic alone or in combination with inorganic may mineralize quickly and releases nutrients for plant uptake. This is in line with the reported work of Chandra (2017). According to the study of Subhash Chand et al. (2010), balanced use of nutrient sources and bio-inoculants played a vital role in enhancing the microbial population of the soil besides providing plant nutrients to the crop, mobilizing native nutrients, favourable C/N ratio for higher microbial activity which leads to higher microbial biomass C accumulation in soil.

Table 6: Soil Microbial Population as influenced by Organic and Inorganic source of Nutrients over a period of time under PME

	Bacteria (x 10^4)			**Fungi** (x 10^3)			**Actinomycetes** (x 10^5)		
	2010	2014	2017	2010	2014	2017	2010	2014	2017
T1 -Control	3.7	3.8	3.9	4.0	4.5	4.8	2.0	2.1	2.3
T2 -Organic (FYM on N equivalent basis and bio-fertilizer as per CPG	3.7	8.5	11.2	4.0	10.3	18.4	2.0	5.6	8.9
T3 -Inorganic (Blanket recommendation)	3.7	5.4	8.6	4.0	7.5	11.2	2.0	3.8	5.3
T4 - INM (FYM 12.5 t/ha + Rec. NPK + Biofertilizer as per CPG	3.7	10.8	14.9	4.0	15.6	22.4	2.0	7.6	9.5



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