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Effect of Organics and Fertilizer on Carbon Dynamics and Crop Yields under Different Rice Planting Methods

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Abstract: *Field experiments were conducted in clay loam soil to study the effect of organics and fertilizer on carbon dynamics and yield under different planting methods in rice –rice-maize sequence for two years. The experiment was conducted in factorial RBD with following treatments Factor A- Planting methods viz., Direct sowing, convential planting and system of rice intensification and Factor B-T_1-Control, T_2- RDF, T_3- RDF + FYM@12.5 t ha^{-1} T_4- RDF + Vermicompost@ 5 t ha^{-1} ,T_5- RDF + green manure@6.25 t ha^{-1} and T_6- RDF + Pressmud @ 10 tha^{-1} . The results revealed addition of RDF alone or in combination with different organics significantly improved grain and straw/ stover yields in rice-rice-maize sequence. The highest grain yield was noticed in T_5-RDF + GM (6432 ,5288kg ha^{-1})and straw yield (7832 ,6339 kg ha^{-1}) in Kharif and Rabi season respectively and addition of pressmud@ 10t ha^{-1} recorded the highest grain (5566 kg ha^{-1}) and stover yield(9327 kg ha^{-1}) of maize in the first year. With respect to planting methods, direct sowing registered the highest grain (5853, 4722 kg ha^{-1}) and straw yields (6972, 5468 kg ha^{-1}) of rice in kharif and rabi seasons respectively. The highest grain yield of maize (5094 kg ha^{-1}) and stover yield (9510 kg ha^{-1}) was noticed under SRI method .Total carbon (13.34, 13.55, and 13.64 g kg^{-1}) and soil organic carbon(7.7, 8.0, 8.3 g kg^{-1}) was maximum in soil which received FYM in kharif, rabi and Navarai seasons respectively. With respect to planting methods, total carbon (13.27, 13.38 and 13.42g $kg-^{1}$) an soil organic carbon (7.7, 7.1, 7.3 g kg^{-1}) was noticed in direct sowing. Soil incorporated with FYM @ 12.5 t ha^{-1} registered the higher carbon stock (14.42, 14.30, 14.24 t ha^{-1}). With regard to planting methods, carbon stock was highest in direct sowing (13.30, 13.11, 12.17 t ha^{-1}). Similar results were observed when the experiment was conducted in the second year. Carbon sequestration rate at the end of two years of rice-rice-maize cropping sequence showed that addition of organics and RDF recorded higher carbon sequestration rate over control at all planting methods. Incorporation of FYM @ 12.5 t ha^{-1} registered the highest carbon sequestration rate (3.04 t ha^{-1}) and was significantly superior to rest of the treatments. Carbon sequestration rate was least in RDF alone (1.06 t ha^{-1}).Among organics, green manure amended soil recorded least carbon sequestration rate (1.66 t ha^{-1}).Carbon sequestration rate was highest in conventional planting (2.12 t ha^{-1}) and was comparable with SRI but superior to direct sowing.*

Key words: *Manures, fertilizers, rice yield, SOC, carbon sequestration*

INTRODUCTION

Dynamics of carbon in terrestrial ecosystem have been at the centre of attention and there is much interest in assessing the potential capacity of highly managed agricultural soil to store surplus atmospheric carbon. Agricultural ecosystem represent an estimated 10% of the earth land surface which include some of the most productive and carbon rich soils (Subhadip *et al.*, 2012). SOC concentration reflects soil and ecosystem processes as well as past management practices for both agricultural and non agricultural soils (Collins *et al.*, 2000). Maintain or increase SOM is critical to achieve optimum soil function and therefore soil fertility and crop productivity. As a component of the terrestrial carbon cycle, soil can be either source or sink of

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atmospheric carbon dioxide (Lal, 2007). Soil organic carbon which is very reactive, ubiquitous component in soils, is an important soil quality indicator that influence the productivity and physical well being of soils (Konatsuzuki and Ohta, 2007). Nieder *et al*., (2003) opined that improved SOC density can improve the productivity of agricultural crops. Benbi and Chand (2007) observed that each Mg of SOC in 0-15 cm soil layer increased wheat productivity by 15-33 kg ha^{-1} in semi arid climate. Thus it follows that to enhance the quality of natural resources in turn to have sustainable crop and soil productivity, SOC density have to improved. It is important to have high potential of soil in carbon sequestration because it could contribute to grater agronomic, physiological and recovery efficiency of nitrogen, phosphorus and potassium (Rahman, 2013) Soil organic carbon storage has been widely considered as a measure for carbon sequestration (Huang *et al.,* 2010). The estimated potential of agricultural intensification on SOC sequestration in soils of India range between 12.7 to 16.5 Tg^{-1} per year (Lal, 2003) . There is clear evidence of decline in the soil organic carbon (SOC) in many soils in modern intensive agriculture (Swarup *et al*., 2000. Kong *et al*., 2005). One of the more promising way to reduce the rate of atmospheric carbon dioxide is to encourage management policies that promote carbon sequestration in vegetation and ultimately in soils (Idso an Idso, 2002) The SOC concentration of most soils in India is less than 10g kg^{-1} and generally less than 5gkg^{-1}. In India, the importance of organic matter addition was considered so important that many studies with organic manures were conducted. Long term studies have shown that practice like improved fertilizer management, manures an compost application, residue incorporation enhanced soil carbon build up and storage (Kimble *et al*., 2002). This practice not only promotes sustainable agriculture but also mitigate the impact of climate change through carbon sequestration. The cropping system and management practices that could provide carbon input higher than the above critical level are likely to sustain the SOC level and maintain good soil health in the subtropical region of Indian subcontinent (Mandal *et al*., 2007) Direct seeding of rice is becoming a popular alternative to transplanting system as it reduces labor requirement, cost of cultivation, shortens the duration of crop and provide comparable grain yield with transplanting (Sharma *et al.,* 2005). Only few studies have been conducted on SOM dynamics and yield of crops in relation to different fertilizer and manure management practices (Rudrappa *et al*., 2006) Hence present study was conducted to evaluate the effect of organics and RDF on carbon dynamics and yield in rice-rice-maize cropping sequence.

MATERIALS AND METHOS

Field experiments were conducted in the experimental farm, Faculty of Agriculture; Annamalai University in clay loam soil belonging to (Kondal series- Typic Haplustets) The experimental field is geographically situated 11.10°N and 79.67°E at an altitude of 5.5 m above mean sea level. The experimental soil had pH- 7.13, EC- 0.52 dSm^{-1}, organic carbon- 1.18g kg^{-1}, total carbon- 18.12 g kg^{-1}, $KMnO_4$-N – 98 kg ha^{-1}, Olsen-P- 9.9 kg ha^{-1}, NH_4OAc-K – 238 kg ha^{-1} The treatment consists of Factor A- planting methods viz., direct sowing, conventional planting and system of rice intensification (SRI) and factor B- manorial treatments viz., T_1- Absolute control, T_2- RDF (120: 60 60 N, P_2O_5, K_2O kg ha^{-1}), T_3- RDF + FYM @12.5 t ha^{-1}, T_4- RDF + vermicompost @ 5 t ha^{-1}, T_5- RDF + green manure @ 6.25 t ha^{-1} and T_5 – RDF + press mud @ 10 t ha^{-1}. The treatment was imposed in cropping sequence Rice (kharif)- Rice (Rabi)- Maize (Navarai). In maize crop only recommended dose of fertilizer (N, P_2O_5, K_2O kg ha^{-1}) was applied. The experiment was conducted in FRBD with three replications. The kharif rice was ADT 43, Rabi rice was ADT 36 and maize was Ganga hybrid- The experiment was conducted for two years. At harvest of each crop, grain and straw/ stover yield was recorded. Post harvest soil after each crop was analyzed for total carbon (CHN analyzer) and expressed as g kg^{-1}, soil organic carbon (Walkley and Black, 1934) and expressed as g kg $^{-1}$ After harvest each crop, soil organic carbon stock was worked out with the following formula proposed by (Majumdar *et al*., 2007).

SOC stock = Σ profile volume bulk density x SOC content

From SOC stock, SOC sequestration was calculated separately for each treatment over control on the basis of two years experimentation (Kundu *et a*l., 2007) with following formula

SOC sequestration rate = (Increase in SOC stock due to treatments over control / number of years of experimentation)

RESULTS AND DISCUSSION

Rice Yield

Irrespective of method of planting, addition of chemical fertilizer alone or in combination with different organics significantly improved the grain and straw yield over control (Table 1). The grain yield ranged from 3052 to 6432 kg ha^{-1}(Kharif), 3111 to 7011 kg ha^{-1} (Kharif), 2685 to 5288 kg ha^{-1} (Rabi) and 2858 to 6402 kg ha^{-1}(Rabi) in first and second year respectively. Similarly straw yield ranged from 3685 to 7832 kg ha^{-1}(Kharif), 3833 to 8194 kg ha^{-1} (Kharif), 3331 to 6339 kg ha^{-1} (Rabi) and 3850 to 7182 kg ha^{-1} (Rabi) in first and second year respectively. The grain yield response ranged from 2195 to 3380 kg ha^{-1} (Kharif), 2398 to 3900 kg ha^{-1} (Kharif), 1600 to 2603 kg ha^{-1} (Rabi) and 2285 to 3544 kg ha^{-1} (Rabi) of first and second year respectively. The highest grain yield (6432, 7011 kg ha^{-1}) and (5288, 6402 kg ha^{-1}) and straw yield (7832,8194 kg ha^{-1}) an (6339, 7182 kg ha^{-1}) was noticed in green manure amended soil in kharif an rabi of first and second year respectively. The best treatment caused 110.7, 125.4% (Kharif), 96.9, 124.0% (Rabi) and 22.6 27.3% (Kharif) and 23.4, 24.5% increase in grain and straw yield over control and RDF alone and in first and second year respectively.

With respect to planting methods, in both years and seasons, direct sowing registered the highest grain yield (5853, 6100 kg ha^{-1}) in kharif and (4722, 5620 kg ha^{-1}) in rabi of first and second years respectively an it was significantly superior to SRI and conventional planting. Similarly, the direct sowing registered the highest straw yield (6972, 7379 kg ha^{-1}) in kharif and (5468, 6416 kg ha^{-1}) in rabi of first and second year respectively.

Irrespective of method of planting, addition of chemical fertilizer alone or in combination with different organics significantly improved the grain and stover yield of maize over control (Table 2). Grain yield ranged from 3606 to 5566 kg ha^{-1}. and 3355 to 5787 kg ha^{-1} in first and second year respectively. Similarly, stover yield ranged from 6034 to 9327 kg ha^{-1} and 5603 to 9697 kg ha^{-1} in first and second year respectively. The highest grain yield (5566, 5787 kg ha^{-1}). and stover yield (9327, 9697 kg ha^{-1}) was noticed with pressmud @ 10 t ha^{-1}. The grain yield response ranged from 1255 to 1960 kg ha^{-1} and percent increase in grain yield over control ranged from 34.8 to 54.4. (first year) The grain yield response ranged from 1628 to 2432 kg ha^{-1} and per cent increase of grain yield over control was 48.5 to 72.5. (Second year). With respect to methods of planting, grain yield ranged from 4892 to 5094 kg ha^{-1} and 4872 to 5232 kg ha^{-1} The highest grain yield was noticed with SRI method (5094, 5232 kg ha^{-1}) in first and second year respectively and was significantly superior to other methods Stover yield of maize ranged from 8215 to 8833 kg ha^{-1} and 8392 to 8793 kg ha^{-1} and The highest stover yield was noticed with SRI method (8833, 8793 kg ha^{-1}) in first an second year respectively and significantly superior to direct sowing and conventional planting.

Crop establishment techniques differed significantly in their ability to produce number of productive tillers, total and filled grains per panicle. Significantly more number of productive tiller m^{-2}, total and filled grains panicle^{-1} were observed with direct sowing, which was comparable with SRI but higher than conventional planting.(not reported) resulted in higher yield Further varied levels of absorption of nutrients under different methods of crop establishment has also been reported by Singh *et al.* (2007) and Singh *et al.* (2008); the results of which, duly agree with the findings of the present investigation (data not reported) have contributed higher yield in direct sowing.

Application of NPK either through inorganic fertilizer or in the combination with different organic manures significantly increased the yield over control which clearly indicated the importance of application of adequate quantities of nutrients in recommended dose with or without organic manures for sustaining the productivity of rice-rice-maize system in veeranam ayacut area Enhanced grain and straw yield could be due to supply of nutrients especially macro and micronutrients which induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency, regulation of water to cells, conducive physical environment, facilitating to better aeration, root activity and nutrient absorption leading to higher rice yield (Singh *et al*., 2004). Favorable effect of organics along with inorganic fertilizer has been reported for sustainable rice- wheat productivity (Nayak *et al*., 2012). Kumara *et al*., (2015) reported higher maize yield in rice-maize cropping sequence on addition of RDF + FYM@ 10 t ha^{-1} Sarker *et a*l.,

Table 1
Effect of organics and fertilizer on rice yield

Treatments	*Grain yield (kg/ha)*				*Straw yield (kg/ha)*			
	A I	*A II*	*A III*	*A IV*	*A I*	*A II*	*A III*	*A IV*
T_1- Absolute control	3052	2685	3111	2858	3685	3331	3833	3550
T_2- RDF	5247	4285	5509	5143	6395	5095	6849	6200
T_3 RDF + FYM	5471	4964	6019	5458	6731	5578	7459	6489
T_4 RDF + Vermicompost	6240	5244	6708	6230	7675	5790	8114	6978
T_5 RDF + green manure	6432	5288	7011	6402	7832	6339	8194	7182
T_6 RDF + Pressmud	6152	5085	6583	6153	7557	5702	7858	6848
Planting methods								
Direct sowing	5853	4722	6100	5620	6972	5468	7379	6416
Conventional planting	5361	4486	5546	5150	6335	5165	6713	6008
SRI	5582	4568	5824	5353	6632	5285	7062	6200
CD($p < 0.05$)								
T	220	98.6	333	417	200	41.9	557	464
P	160	69.7	235	295	100	29.7	394	328
T x P	383	170.8	576	722	300	72.6	964	804

A 1- Kharif, AIII-Rabi (first year), AII- Kharif, AIV- Rabi (second year)

Table 2
Effect of organics and fertilizer on maize yield

Treatments	*Grain yield (kg/ha)*		*Stover yield (kg/ha)*	
	First year	*Second year*	*First year*	*Second year*
T_1- Absolute control	3606	3355	6034	5603
T_2- RDF	4861	4983	8418	8408
T_3 RDF + FYM	5481	5688	9223	9550
T_4 RDF + Vermicompost	5331	5553	9043	9340
T_5 RDF + green manure	5007	5200	8639	8838
T_6 RDF + Pressmud	5566	5787	9327	9697
Planting methods				
Direct sowing	4892	4872	8215	8392
Conventional planting	4939	5079	8393	8532
SRI	5094	5232	8833	8793
CD ($p < 0.05$)				
T	5.19	273	3.67	324
P	3.67	193	2.60	229
T x P	8.99	473	6.36	561

(2013), Sahu *et al*., (2013) and Sekhar *et al*., (2014) reported increased yield due to application of manures with chemical fertilizer and it is attributed to increased vegetative growth of plants.

Carbon Dynamics

Addition of organics along with recommended dose of fertilizer registered significantly higher total carbon over control at all methods of planting (Fig. 1a) in both years at all seasons. Addition of different organics significantly improved total organic carbon content over RDF and absolute control. The total carbon content ranged from 12.30 to 14.03 g kg^{-1}. (Kharif), 11.58 to 13.85 g kg^{-1} (Rabi) and 11.54 to 14.35 g kg^{-1} (maize) in first year . Similarly in second year, total carbon ranged from 11.32 to 14.54 g kg^{-1}(kharif), 11.16 to 14.70 g kg^{-1} (rabi) and 11.10 to 14.79 g kg^{-1} (maize). The highest total carbon content was noticed with FYM @ 12.5 t ha^{-1} (13.34, 13.55, 13.64 g kg^{-1}(first year), 13.83, 13.99,14.08 g kg^{-1} (second year) in kharif, rabi season an maize respectively and was comparable with pressmud but significantly superior to vermicompost are green manure. With respect to planting methods, direct sowing registered the highest total carbon (13.27, 13.38, 13.42 g kg^{-1} in first year) and (13.48, 13.5513.57 g kg^{-1} in second year) in kharif, rabi and maize respectively was significantly superior to SRI and conventional planting. (Fig 1b). Addition of organics along with recommended dose of fertilizer registered significantly higher soil organic carbon over control at all methods of planting (Fig 2a) in both years at all seasons. The addition of different organics significantly improved organic carbon over RDF alone and control. The soil organic carbon among treatments ranged from 5.9 to 7.7, 4.8 to 8.4, 4.9 to 8.6 g kg^{-1}. (first year) and 5.0 to 8.9, 5.4 to 8.7 , 5.3 to 9.2 g kg^{-1}. (second year) in kharif, rabi and maize, respectively. The highest soil organic carbon (7.7,8.0, 8.3 g kg^{-1} first year) and (8.6,8.7,8.9 g kg^{-1}- second year) in kharif, rabi and maize , respectively was noticed on addition of FYM @ 12.5 t ha^{-1} along with RDF was comparable with pressmud but superior to rest of the treatments. With respect to planting methods, direct sowing caused the highest soil organic carbon (7.2, 7.1, 7.3 g kg^{-1} first year) and (8.6,8.7, 7.9 g kg^{-1} in second year) in kharif, rabi and maize , respectively was comparable with SRI and superior to conventional method (Fig 2b).

Addition of organics along with RDF or RDF alone at all planting methods caused significant improvement in carbon stock an carbon sequestration rate over control (Table 3). In the soil, carbon stock ranged from 10.0 to 15.19 8.50 to 15.12,

Table 3
Effect of organics and fertilizer on carbon stock (t ha^{-1})

Treatments	*First year*			*Second year*		
	Kharif	*Rabi*	*Maize*	*Kharif*	*Rabi*	*Maize*
T_1- Absolute control	10.77	9.17	8.54	9.30	9.39	9.43
T_2- RDF	11.80	11.38	10.55	11.16	11.17	11.53
T_3 RDF + FYM	14.42	14.30	14.29	14.57	15.78	15.51
T_4 RDF + Vermicompost	12.56	13.22	12.34	13.72	13.85	13.68
T_5 RDF + green manure	12.47	11.66	11.49	12.52	12.69	12.76
T_6 RDF + Pressmud	13.35	13.82	12.82	14.35	14.56	14.43
Planting methods						
Direct sowing	13.30	13.11	12.17	13.12	13.48	13.37
Conventional planting	12.53	12.06	11.60	12.66	12.92	12.82
SRI	11.85	11.60	11.25	12.03	12.32	12.48
CD($p < 0.05$)						
T	0.43	0.22	0.18	0.32	0.24	0.25
P	0.30	0.16	0.13	0.22	0.17	0.17
T x P	0.75	0.39	0.31	0.55	0.41	0.43

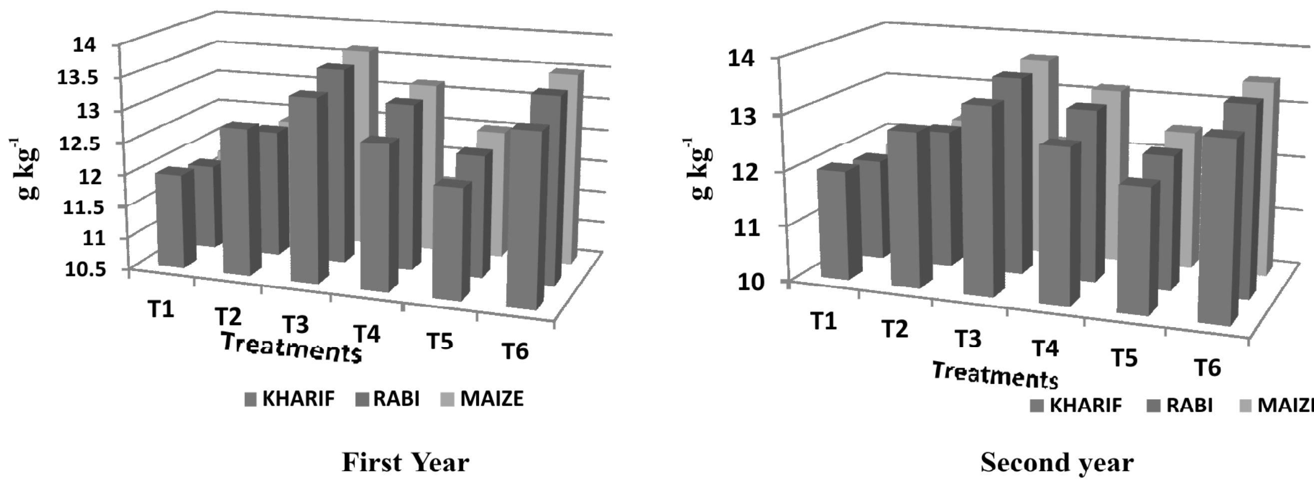


Figure 1a: Effect of organics and fertilizer on total carbon content in soil

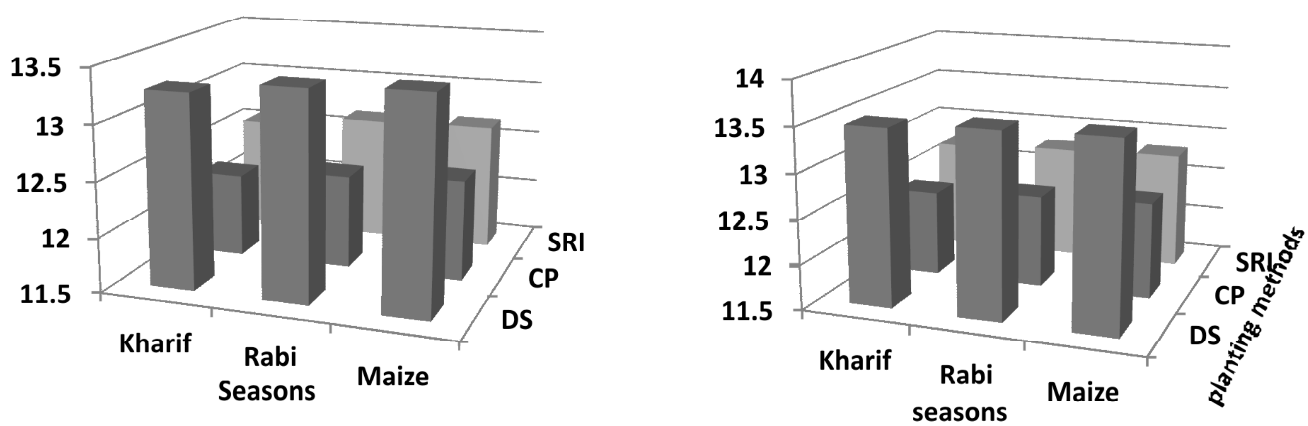


Figure 1b: Effect of planting methods on total carbon in soil

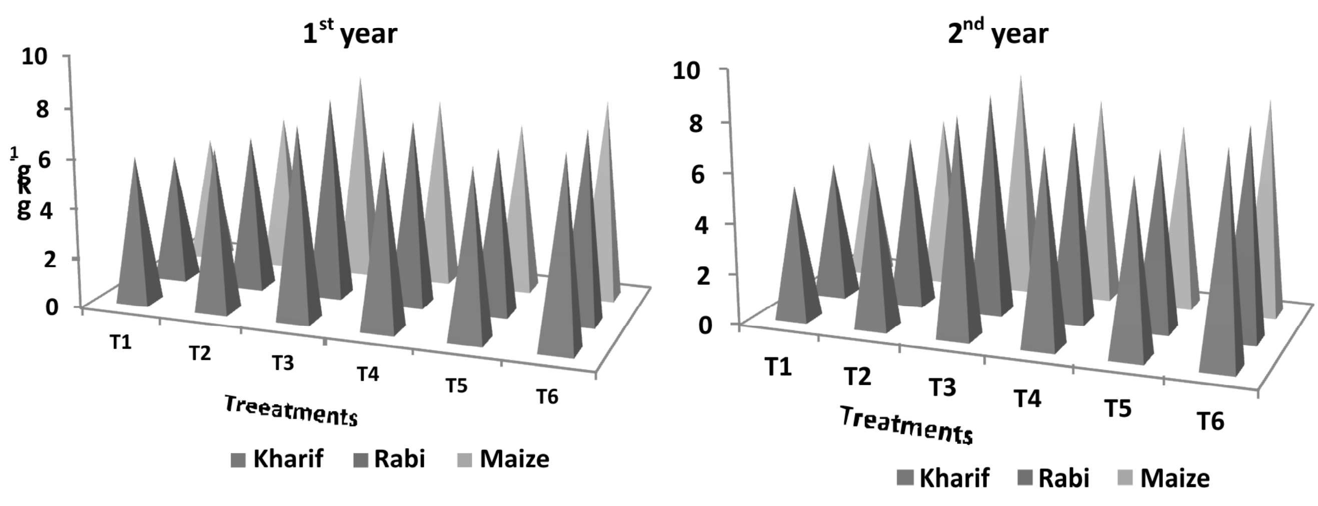


Figure 2a: Effect of organics and fertilizer on soil organic carbon content in soil

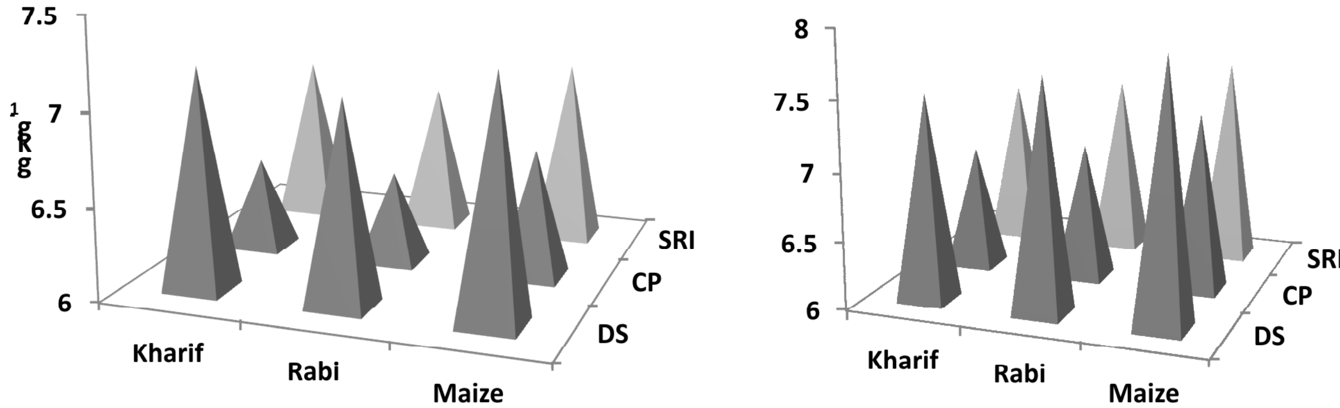


Figure 2b: Effect of planting methods on soil organic carbon in soil

8.03 to 14.58 t ha^{-1} (first year) and 9.20 to 15.09, 8.99 to 16.11, 8.99 to 15.87 t ha^{-1}(second year) in kharif, Rabi and maize respectively. Carbon stock was higher in organically amended soil compared to RDF. The highest carbon stock was noticed in soil which received FYM @ 12.5 t ha^{-1} (14.42, 14.30, 14.29 t ha^{-1}– first year) and (14.57, 15.78, 15.51 t ha^{-1} - second year) in kharif, rabi and maize, respectively and was significantly superior to rest of the treatments. It was followed by pressmud. Carbon stock was comparable between vermicompost and green manure. With regard to planting methods, carbon stock (13.30, 13.1112.17t ha^{-1}-first year) and (13.12, 13.48, 13.37 t ha^{-1}- second year) in kharif, rabi and maize, respectively was highest in direct sowing and was significantly superior to other two methods.

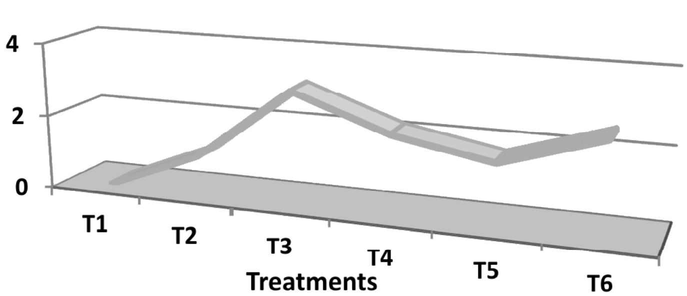
Carbon sequestration rate at the end of two years of rice-rice-maize cropping sequence showed that addition of organics and RDF recorded higher carbon sequestration rate over control at all planting methods (Fig 3.).Carbon sequestration rate ranged from 0.95 to 3.10 t ha^{-1}. Carbon sequestration rate was higher in organics compared to RDF. Carbon sequestration rate ranged from 1.06 to 3.04 t ha^{-1}. Incorporation of FYM @ 12.5 t ha^{-1} registered the highest carbon sequestration rate (3.04 t ha^{-1}) and was significantly superior to rest of the treatments. Carbon sequestration rate was least in RDF alone (1.06 t ha^{-1}). Among organics, green manure amended soil recorded least carbon sequestration rate (1.66 t ha^{-1}). With respect to planting methods, carbon sequestration rate was highest in conventional planting (2.12 t ha^{-1}) and was comparable with SRI but superior to direct sowing.

Soil organic matter is known as revolving nutrient fund that supplies mainly carbon, nitrogen, phosphorus an sulfur. Therefore decline in soil carbon generally decreases crop productivity. Quantity and quality of carbon inputs, cropping intensity soil and crop management practices affect carbon and nitrogen dynamics and carbon sequestration in different soil depths (Marland *et al.,* 2004, Rahman, 2013). Intensive rice-rice-maize cropping sequence without application of fertilizer and organics has resulted in reduction of SOC over initial value. The application of recommended dose of NPK resulted in increase in SOC and total carbon in surface soil over initial value. The higher stubble and root biomass retention commensurate with higher yield in the NPK fertilized plot might have improved SOC and total carbon in soil. Long term experiment has shown that the optimum application of inorganic fertilizer, the SOC content has been increased (Purkayastha *et al.,* 2008, Zhang *et al.,* 2009) or maintained/ slightly increased (Biswas and Benbi, 1997). Addition of organic manures along with NPK increased SOC over NPK alone which is due to additional effect of NPK and organics and interaction between them. A similar build up of SOC due to cropping with application of NPK + organic manures (Ruddrappa *et al.,* 2006, Yadav *et al.,* 2000, Nayak *et al.,* 2012). Among organic manures, incorporation of FYM @ 12.5 t ha^{-1} recorded the highest total carbon and SOC. possibly due to the presence of more humified and recalcitrant C forms.

Application of animal manures results in substantial increase in soil organic carbon content was reported by Izaurralde *et al.,* (1997). Tiwari *et al.,* (2002) reported an increase in organic carbon content of soil due to application of nitrogen through integrated sources under soybean- wheat cropping system on a vertisol. Verma *et al.,* (2014) reported high recovery of soil organic carbon and total carbon under INM practice in maize-groundnut sequence in acid soil of Meghalaya. Brar *et al.,(* 2015) reported 100 % NPK + FYM had 69% significantly higher SOC compared to non treated control in maize- wheat rotation.

The quality and quantity of organics amended contribute to the variation of SOC dynamics after the application of organic amendment Organic amendment high in lignin and cellulose content which is difficult to decomposition by soil microbes as bound to be stabilized in soil (Li *et al.,* 2010) In the present study, there was significant difference in carbon stock among organic manures. The initial carbon concentration in soils under FYM treatment was higher compared to other organic manures treated soil. Therefore, the initial stock was higher in FYM treatment which is also attributed to final carbon stock (Table 3.) It was reported that manure is more resistant to microbial decomposition than plant residues. Consequently, for the same carbon input, carbon storage is higher with manure application than with plant residues (Rahman, 2014) Kundu *et al*., (2007) reported that higher carbon stock in those treatments can be attribute to grater carbon input through organic manures and enhanced crop productivity In the present study, a significant positive linear relationship (R^2= 0.513) between carbon stock and system yield (Fig. 4). Increase in SOC enhanced microbial activities which in turn helped in large turnover of mineral nutrients in available form to plants. Hence linear relationship between SOC stocks with yield was observed.

Carbon sequestration in rice-rice-maize cropping sequence at the end of two years showed significant influence of organics over control. . The amount of C sequestered at a site reflects the long term balance between carbon input and release mechanisms.. Continuous cultivation affects the distribution and stability of soil aggregate and reduces organic C stock in soils (Six *et al.,* 2002). The relationship between soil carbon sequestered and carbon input is regulated by climate, soil properties and management practices (cropping, fertilization) and also organic amendment properties (Stewart *et al.,* 2009). In general paddy soil have higher SOC level relative to upland soil in the same climate zone (Xie *et al.,* 2007). Among the organics, FYM incorporated soil recorded highest crop sequestration and least in green manure amended soil. Many studies have shown that materials with higher lignin content such as FYM results in more carbon sequestration compared to materials with low lignin content (Brar *et al.,* 2015.). Organic manures contains more of carbon in recalcitrant form resulting in more carbon sequestration as it had already gone under some decomposition before application in agricultural fields (Benbi and Senapati, 2009). Kukal *et al*., (2009) observed a higher C sequestration in a 33 year old rice- wheat system due to application of FYM and the cropping system has greater capacity to sequester C because of high C input through enhanced productivity.



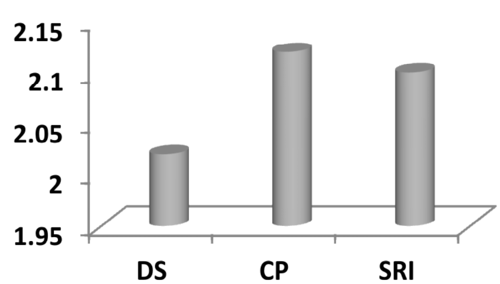


Figure 3: Effect of organics and planting methods on carbon sequestration rate

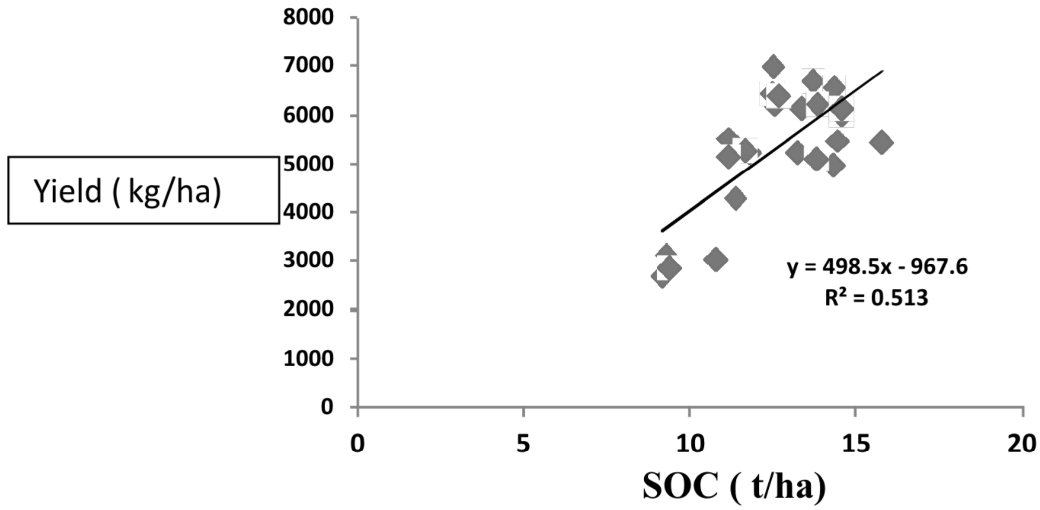


Figure 4: Relationship between SOC stock with system yield

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