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Effect of Vermicompost and Fertilizer on Microbial Biomass, Carbon Pools and Hydrolyzable Carbohydrate Acid in Pot Culture Rice

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Abstract: Integrated application of organic and inorganic sources elevates the soil physical, chemical and biological properties along with stabilization of soil health deterioration. Pot culture experiment was carried out at RPCAU, Pusa in *kharif,* 2019 with four levels of vermicompost (0 t $ha^{-1,}$ 1.25 t ha^{-1}, 2.5 t ha^{-1} and 3.75 t ha^{-1}) and three levels of fertilizer RDF (0 ,50 and 100 % RDF) on rice for analyzing its effect on soil microbial biomass nitrogen, phosphorus and carbon pool. The microbial biomass carbon, nitrogen, phosphorus and the different carbon pool content elevated from tillering to post harvest stage in soil with response to the higher dose of vermicompost and fertilizer RDF i.e. 3.75 t ha^{-1} vermicompost + 100 % NPK. microbial biomass carbon increased up to116%, 125% over control in tillering and post harvesting stage of crop. microbial biomass nitrogen, prosperous and carbon pool content also showed higher results in both crop growth stages due to the higher amount of organic matter addition elevated the carbon pool content and provided the substrate for microbial biomass component increase in pot culture soil.

Keywords: Pot culture, Carbon pools, Rice, Vermicompost, Enriched, Fertilizer

The population growth is increasing day by day and to satisfy the need the farmers are applying large quantities of inorganic fertilizers leading to the destruction of overall soil health and decline in yield capacity of the soil. Toxicity of nutrients leads to cause imbalance of major nutrients like nitrogen, phosphorus, potassium as well as micro nutrients in soil. Rice is the major crop cultivated in the whole world and in Asia provides livelihood support to 70% of farmers. Balanced use of vermicompost and fertilizer improves the soil physical, chemical, biological, enzymatic properties (Alshehrei and Ameen 2021) as well as elevates the growth and yield of rice crops ensuring sustainability in agriculture. Vermicomposting is the process of conversion of waste materials into finely divided, enriched in nutrients and enzymes containing organic products by the use of earthworms. Prolonged application of vermicompost with fertilizers increases the buildup of carbon and nutrients pool in soil which is critical for soil fertility maintenance and enhancement (Kumar et al 2020). Enriched soil microbial diversity helps in recycling of different nutrients in soil which can be utilized by crop plants in soil which increases the yield of crops and minimizes the pollutions in environment (Prakash 2021).

MATERIAL AND METHODS

A pot culture experiment was conducted with rice crop at RPCAU, Pusa in *kharif,* 2018 with four levels of vermicompost and three levels of fertilizer with twelve treatments replicated thrice using CRD design in two factors with standard ANOVA table and OPSTAT application.

RESULTS AND DISCUSSION

Microbial biomass carbon (µg g^{-1}): The fertilizer application of 50 % and 100 % RDF with higher vermicompost dose were significantly superior over no fertilizer application (Table 2). The increase in the microbial biomass carbon in soil from tillering to post-harvest might be due to availability of more nutrients caused by enhanced rhizospheric effects, secretion of organic acids and root exudates leading to more microbial activities thus more microbial biomass carbon. The increase in the microbial biomass carbon in pot-culture experiment was slightly higher than incubation experiment. The results obtained in the incubation experiment for biomass carbon was in line with the findings of Ramachandran (2013) and Ashraf et al (2021).

Microbial biomass nitrogen (µg g^{-1}): The 50 and 100 % RDF level also gave significantly higher microbial biomass nitrogen over no fertilizer level application (Table 3). The interactions in between vermicompost and fertilizer levels were found significant. The elevated microbial biomass nitrogen was found in the treatment receiving (vermicompost-3.75 t ha^{-1} + 100 % RDF) i.e. 105.69 which was significantly superior over control (49.56 µg g^{-1}). The increase in the microbial biomass nitrogen from tillering to post-harvest could be due to availability of more nutrients caused by enhanced rhizospheric effects, secretion of organic acids and root exudates leading to more microbial activities thus more microbial biomass nitrogen. The increase in the microbial biomass nitrogen in pot-culture experiment was slightly higher than incubation experiment. Katkar et al (2011) in the incubation experiment for biomass nitrogen indicated similar trend.

Microbial biomass phosphorus (µg g^{-1}): The integrated application of vermicompost (3.75 t ha^{-1}) + 100 % NPK showed higher amount of microbial biomass phosphorus content i.e. 4.95 µg g^{-1} and 5.29 µg g^{-1} in soil at tillering and post-harvest, respectively over the control (Table 4). The

Table 1. Standard analysis procedure

Parameters	Method	References
Microbial biomass carbon	Fumigation-extraction	Vance et al (1987)
Microbial biomass nitrogen	Fumigation-extraction, KCl extraction	Brookeset al (1985)
Microbial biomass phosphorus	Fumigation-extraction, 660nm, 0.5 M $NaHCO_3$	Brookes et al (1982)
Water soluble carbon		Ghani et al (2003)
Acid hydrolyzable carbohydrate	Standard anthrone process	Chesire and Mundie (1966)
$KMnO_4$ carbon	Permanganate extraction method	Blair et al (1995)
Organic carbon	Wet digestion technique	Walkley and Black (1934)

Table 2. Effect of vermicompost and fertilizer on microbial biomass carbon in soil of rice crop during growth period (µg g^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	85.62	114.66	100.79	100.36	107.80	164.74	121.72	131.42
$V_{1.25}$	92.40	164.64	137.23	131.43	135.13	193.04	201.07	176.41
$V_{2.5}$	128.38	178.05	143.84	150.09	178.17	220.47	215.08	204.57
$V_{3.75}$	136.59	185.67	172.57	164.94	200.62	243.29	222.69	222.20
Mean	110.75	160.76	138.61		155.43	205.38	190.14	
Factors	CD (5%)							
Vermicompost (V)	0.50				0.55			
Fertilizers (F)	0.43				0.48			
V X F	0.86				0.96			

V_o= Vermicompost (no manure), $V_{1.25}$= Vermicompost (1.25 t ha^{-1}), V2.5= Vermicompost (2.5 t ha^{-1}), $V_{3.75}$= Vermicompost (3.75 t ha^{-1}), F_0= Fertilizer (no fertilizer) , F_{100}= Fertilizer (100% RDF), F_{50}= Fertilizer (50 % RDF) and V_0F_0 = control (no vermicompost + no fertilizer)

Table 3. Effect of vermicompost and fertilizer on microbial biomass nitrogen in soil of rice crop during growth period (µg g^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	49.56	90.73	85.22	75.17	65.40	118.52	88.65	90.85
$V_{1.25}$	87.81	94.53	93.00	91.78	90.75	157.41	122.52	123.56
$V_{2.5}$	91.07	99.33	94.57	94.99	92.89	163.12	125.65	127.22
$V_{3.75}$	92.64	105.69	95.34	97.89	94.04	159.83	158.79	137.56
Mean	80.27	97.57	92.03		85.77	149.72	123.90	
Factors	CD (5%)							
Vermicompost (V)	0.44				0.46			
Fertilizers (F)	0.38				0.40			
V X F	0.77				0.80			

increase in the microbial biomass phosphorus from tillering to post-harvest might be due to availability of more nutrients caused by enhanced rhizospheric effects, secretion of organic acids and root exudates leading to more microbial activities thus more microbial biomass phosphorus. The increase in the microbial biomass phosphorus in pot-culture experiment was slightly higher than incubation experiment. Similar results were obtained in the incubation experiment for biomass phosphorus by Babu et al (2017) and Ashraf et al (2021).

Water soluble carbon (mg kg^{-1}): The water soluble carbon in soil as influenced by vermicompost and fertilizer levels was statistically significant (Table 5). The integrated application of vermicompost (3.75 t ha^{-1}) + 100 % NPK showed significant higher amount of water soluble carbon content i.e. 0.099 and 0.106 mg kg^{-1}in soil at tillering and post-harvest, respectively over the control.

Hot-water soluble carbon (mg kg^{-1}): The elevated hot-water soluble carbon was found in the treatment receiving (vermicompost-3.75 t ha^{-1} + 100 % RDF) i.e. 0.138 mg kg^{-1}which was higher over control (0.100 mg kg^{-1}) (Table 6). The higher level of vermicompost (3.75 t ha^{-1}) + 100 % RDF recorded higher hot-water soluble carbon i.e. 0.137 mg kg^{-1} over control (0.103 mg kg^{-1}) and might be due to solubilization an accumulation of carbon over a longer period of time and close to similar findings were given by Ashraf et al (2021).

Acid hydrolyzable carbohydrate (mg kg^{-1}): The effect of different levels of vermicompost and fertilizer on acid hydrolyzable carbohydrate in soil is was statistically significant (Table 7). The interactions regarding vermicompost and fertilizer levels were non-significant. However the vermicompost of 3.75 t ha^{-1} + 100 %6) RDF recorded higher acid hydrolyzable carbohydrate i.e. 133.80 mg kg^{-1}over control (94.13 mg kg^{-1}).The integrated application of vermicompost (3.75 t ha^{-1}) + 100 % NPK showed higher amount of acid hydrolyzable carbohydrate content i.e. 94.60 mg kg^{-1}in soil at post-harvest over the control (48.59 mg kg^{-1}).

$KMnO_4$-carbon (g kg^{-1}): The $KMnO_4$-carbonin soil was statistically significant as influenced by vermicompost and

Table 4. Effect of vermicompost and fertilizer on microbial biomass phosphorus in soil of rice crop during growth period (µg g^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	3.75	4.29	3.91	3.98	4.28	4.57	4.47	4.44
$V_{1.25}$	4.09	4.6	4.54	4.43	4.52	4.78	4.67	4.66
$V_{2.5}$	4.39	4.83	4.65	4.63	4.56	4.91	4.73	4.73
$V_{3.75}$	4.60	4.95	4.73	4.76	4.69	5.29	4.89	4.96
Mean	4.21	4.69	4.46		4.51	4.89	4.69	
Factors	CD (5%)							
Vermicompost (V)	0.11				0.10			
Fertilizers (F)	0.09				0.09			
V X F	NS				NS			

Table 5. Effect of vermicompost and fertilizer on water soluble carbon in soil of rice crop during growth period (mg kg^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	0.060	0.071	0.065	0.065	0.062	0.081	0.066	0.069
$V_{1.25}$	0.068	0.083	0.075	0.075	0.055	0.093	0.086	0.078
$V_{2.5}$	0.067	0.090	0.078	0.078	0.076	0.099	0.089	0.088
$V_{3.75}$	0.075	0.099	0.089	0.088	0.081	0.106	0.096	0.094
Mean	0.068	0.086	0.077		0.069	0.095	0.084	
Factors	CD (5%)							
Vermicompost (V)	0.005				0.12			
Fertilizers (F)	0.004				0.10			
V X F	NS				NS			

fertilizer levels (Table 8). The fertilizer levels of 50 % and 100 % RDF were significantly superior over no fertilizer level application. The interactions among the different levels of vermicompost and fertilizer were significant. The integrated application of vermicompost (3.75 t ha^{-1}) + 100 % NPK showed significant higher amount of $KMnO_4$-carboncontent i.e. 0.80 and 1.51 g kg^{-1}in soil at tillering and post-harvest, respectively over the control, Kumar et al (2020).also observed the same trend.

Organic carbon (g kg^{-1}):. The elevated organic carbon was

Table 6. Effect of vermicompost and fertilizer on hot-water soluble carbon in soil of rice crop during growth period (mg kg^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	0.100	0.115	0.107	0.107	0.103	0.118	0.109	0.110
$V_{1.25}$	0.112	0.124	0.121	0.119	0.115	0.126	0.120	0.120
$V_{2.5}$	0.115	0.128	0.120	0.121	0.115	0.131	0.120	0.122
$V_{3.75}$	0.118	0.138	0.126	0.127	0.117	0.137	0.128	0.127
Mean	0.111	0.127	0.118		0.112	0.128	0.119	
Factors	CD (5%)							
Vermicompost (V)	0.010				0.003			
Fertilizers (F)	0.009				0.003			
V X F	NS				NS			

Table 7. Effect of vermicompost and fertilizer on acid hydrolysable carbohydrate in soil of rice crop during growth period (mg kg^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	94.13	110.33	100.94	101.80	48.59	60.800	52.11	53.84
$V_{1.25}$	106.81	122.54	112.68	114.01	58.22	77.93	65.96	67.37
$V_{2.5}$	110.33	127.93	119.48	119.25	63.85	87.09	70.19	73.71
$V_{3.75}$	116.20	133.80	127.70	125.90	66.90	94.60	85.45	82.32
Mean	106.87	123.65	115.20		59.39	80.11	68.43	
Factors	CD (5%)							
Vermicompost (V)	1.65				2.45			
Fertilizers (F)	1.43				2.13			
V X F	NS				4.25			

Table 8. Effect of vermicompost and fertilizer on $KMnO_4$-carbon in soil of rice crop during growth period (carbon g kg^{-1})

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	0.53	0.55	0.54	0.54	1.30	1.35	1.33	1.33
$V_{1.25}$	0.58	0.62	0.60	0.60	1.37	1.45	1.42	1.41
$V_{2.5}$	0.58	0.73	0.65	0.66	1.39	1.47	1.41	1.42
$V_{3.75}$	0.60	0.80	0.75	0.72	1.39	1.51	1.48	1.46
Mean	0.57	0.68	0.64		1.36	1.44	1.41	
Factors	CD (5%)							
Vermicompost (V)	0.02				0.01			
Fertilizers (F)	0.02				0.01			
V X F	0.03				0.02			

Table 9. Effect of vermicompost and fertilizer on organic carbon in soil of rice crop during growth period

Treatments	Tillering stage				Post-harvest stage			
	F_0	F_{100}	F_{50}	Mean	F_0	F_{100}	F_{50}	Mean
V_0	7.82	8.20	8.17	8.07	6.05	6.22	6.03	6.10
$V_{1.25}$	7.82	8.81	8.12	8.25	6.36	6.55	6.13	6.35
$V_{2.5}$	7.88	8.66	8.33	8.29	5.59	7.50	5.68	6.26
$V_{3.75}$	7.63	9.26	8.57	8.49	5.90	7.21	5.93	6.35
Mean	7.79	8.73	8.30		5.98	6.87	5.94	
Factors	CD (5%)							
Vermicompost (V)	0.19				0.14			
Fertilizers (F)	0.16				0.12			
V X F	0.32				0.24			

in the treatment receiving (vermicompost-3.75 t ha^{-1} + 100 % RDF) i.e. 9.26 g kg^{-1}which was higher over control (7.82 g kg^{-1}). The interactions among vermicompost and fertilizer levels were found significant (Table 9). Similar findings were observed by Ralebhat et at (2021). The higher level of vermicompost (2.5 t ha^{-1}) + 100 % RDF recorded higher organic carbon i.e. 7.50 g kg^{-1}over control (6.05 g kg^{-1}).

CONCLUSION

Application of higher dose of vermicompost (3.75 t ha^{-1}) and fertilizer (100%) in combined manner in soil elevated the carbon content and carbon pool with carbohydrate content, thus enhancing the soil fertility status and soil health with increasing microbial population and thus contributing higher microbial biomass carbon, nitrogen and phosphorus content during crop growth stages in pot culture rice crop.

REFERENCES

Alshehrei F and Ameen F 2021. Vermicomposting: A management tool to mitigate solid waste. *Saudi Journal of Biological Sciences* **28**: 3284-3293.

Ashraf MN, Jusheng G, Lei W et al. 2021. Soil microbial biomass and extracellular enzyme–mediated mineralization potentials of carbon and nitrogen under long-term fertilization (> 30 years) in a rice–rice cropping system. *Journal of Soils and Sediments* **21**: 3789-3800.

BabuA, Jatav HS, Verma M and Seema 2017. Effect of FYM and inorganic fertilizer on soil microbial biomass and enzyme activities of Indo Gangetic Plains, Varanasi, India. *International Journal of Current Microbiology and Applied Sciences* **6**: 559-565.

Blair GJ, Lefroy RDB and Lise L 1995. Soil carbon fractions based on their degree of oxidation and the development of a carbon management index for agricultural systems. *Australian Journal Agricultural Resources* **46**: 1459-1466.

Brookes PC, Kragt JF, Powlson DS and Jenkinson DS 1985. Chloroform fumigation and release of soil N: A rapid direct extraction method to measure biomass N in soil. *Soil Biochemistry* **17**: 837-842.

Brookes PC, Powlson DS and Jenkinson DS 1982. Measurement of microbial biomass phosphorous in soils. *Soil Biology and Biochemistry* **14**: 319-321.

Cheshire MVand Mundie CM.1966.The hydrolytic extraction of carbohydrates from soil by sulphuric acid. *Journal of Soil Science* **17**: 372-381.

Chiranjeeb K, Prasad SS, Singh SP, Bharati V and Jha S2020. Effect of household vermicompost and fertilizer on soil microbial biomass carbon, biomass phosphorus and biomass nitrogen in incubation experiment. *International Journal of Current Microbiology and Applied Sciences* **9**: 1508-1516.

Ghani A, Dexter M and Perrott KW 2003. Hot-water extractable carbon in soils: sensitive measurement for determining impacts of fertilisation, grazing and cultivation. *Soil Biology and Biochemistry* **35**: 1231-1243.

Katkar RN, Sonune BA and Kadu PR 2011. Long-term effect of fertilization on soil chemical and biological characteristics and productivity under sorghum-wheat system in vertisol. *Indian journal of Agriculture Science* **81**: 734-739.

McGillWB, Cannon KR, Robertson JA and Cook FD 1986. Dynamics of soil microbial biomass and water-soluble organic C in Breton L after 50 years of cropping to two rotations. *Canadian Journal of Soil Science* **66**: 1-19.

Prakash S 2021. Effect of Vermicompost on water quality and growth of indigenous carps: A case study. *International Journal of Multidisciplinary Research and Growth Evaluation* **2:** 148-150.

Ralebhat BN, Patil RA, Ghangale TS, Kharade MR and Navsupe SD 2021. Effect of different sources of organic fertilizers on nutrient status of soil and incidence of diseases and pests of sweet pepper (*Capsicum annum L.)* under protected condition. *The Pharma Innovation Journal* **10**: 975-978.

Ramachnadran S 2013. *Influence of organic and mineral fertilization on organic carbon fractions, microbial properties and productivity of maize-wheat cropping system on a typichaplustept*. M.Sc. (Agri.) Thesis, Indian agricultural research institute, New Delhi.

Vance ED, Brookes PC and Jenkinson DS 1987. An extraction method for measuring soil biomass carbon C. *Soil Biology and Biochemistry* **19**: 703-707.

Walkly A and Black IA 1934. An examination of the Degtjareff method for determining organic carbon in soil: Effect of variations in digestion conditions and of inorganic soil constituents. *Soil Science* **63**: 251-263.

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