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Research Paper

Impact of vermicompost derived from different substrates on soil carbon pools in Rhizosphere of common bean (*Phaseolus vulgaris* L.)

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ABSTRACT

It is a generally accepted fact that addition of organic manures increases the organic carbon content of soils. However, there is a little information available on contribution of organic manure to different pools of organic carbon in soils. In this study, we tried to work out the contribution of vermicompost to different organic carbon pools in a short term experiment on common bean. Vermicompost synthesized from different substrates; apple pomace, saw dust, dal weed and kitchen waste mixed with different proportions of cow dung was applied to pots under controlled condition. It was found that vermicompost derived from different substrates contributed differently to soil carbon pools. Sawdust based composts reported highest contribution to passive carbon pool i:e 1.77 % and 1.82% for 70% saw dust and 100% saw dust respectively. The highest active pool (0.84%) of organic carbon was reported for compost containing 50% of apple pomace and 50% cow dung. There was a significant increase in total carbon pool compared to control experiment implying the importance of short term management practices on soil carbon sequestration.

Key words: Management practices, soil organic carbon, substrate, vermicompost

The massive quantum of carbon is released towards environment through anthropogenic activities. However, all this does not become a part of atmosphere and is stored in soil via carbon sequestration. Soil are the largest sink for global carbon where in organic pools are much higher than inorganic pools (Lal, 2018). Hence, soil acts as a sink and source of atmospheric carbon (Hoffmann *et al*., 2018). Therefore, it becomes important to have comprehensive knowledge about storage of carbon in soils in light of increasing demand of agricultural land and improving soils undergoing degradation. The carbon in soils is stored in different layers and highest is stored in the top soil. Its quantity and quality depends upon composition of species e.g. relative abundance of N-fixing bacteria or a complete change in community structure like a shift from grassland to woodland or forest. Sometimes these changes are also a result of management or natural variations in edaphic conditions on a local scale (Binkley and Menyailo, 2005; Hart *et al*., 2005).The carbon in top soil responds to slightest change in composition due to management practices. Hence, any shift in management practice over a large area can lead to substantial emission of carbon dioxide and cycling in any ecosystem (Hoffmann *et al*., 2018).In order to keep a check on changing health within the soil, it is important to keep a check on changing soil organic carbon stock. However, it is very difficult to detect short term and medium term changes in total SOC due to high background carbon and spatial variability within recalcitrant pool. A bit more sensitive indicators include labile pools like readily oxidizable carbon, microbial biomass carbon, hot water-soluble C (HWC), $KMnO_4$-oxidizable C, organic-C fractions of different oxidizability and Mineralizable C (Ghani *et al.*, 2003; Benbi *et al*., 2015). The water soluble carbon is the main source of energy for microorganisms and is added to soil through organic matter decomposition and litter leaching (Huang and Song, 2010). Microbial biomass carbon is also a source of energy for micro-organisms and comprised of living microbes that help in nutrient conservation (Watts *et al.*, 2005) and readily oxidizable carbon is beneficial in measuring soil carbon due to its ease of measurement (Melero *et al.*, 2009).The labile fraction of soil organic carbon is more sensitive to change in management than total organic matter. There are multiple studies which infer that management practices either cause net build up or net depletion of SOC stock (Kong *et al.*, 2005). Among different cultural practices, applying soil amendments can influence the dynamics of SOM and overall biogeochemical processes, thus can act an important tool for management of poor agricultural soils. Generally long term application of organic amendments give better results in terms of improving SOC stocks as in most cases the impact of management and cultural practices in long term experiments of chemical or organic inputs are taken into consideration. In most of the cases, comparison between chemical and organic inputs has been studied with a very little focus on comparison between different organic amendments. However, very little efforts have been made to study the effect of short term cultural practices on SOC pools. Among short term experiments, the most widely studied is the impact of cultural practices on cereal based cropping systems. There are very few studies to study the impact of management practices SOC in pulse crops.

Pulses are considered as the best replacement of red meat for vegetarians. In addition to their nutritious qualities, legumes provide major benefits to cropping systems and the environment because of their natural ability to perform symbiotic nitrogen fixation (SNF) in their root nodules (Stagari *et al.*, 2017). Additionally legumes and pulses can be effective in restoring soils prone to erosion, or have some kind of physical degradation (Ghosh *et al.*, 2012). In studies from semi-arid regions India, it was observed that inclusion of pulses and organic inputs sequestered more carbon than continuous cereal based cropping system. Keeping in view, the importance of pulses and organic applications on soil organic carbon, we hypothesize that addition of organic amendments can impact the labile pools of organic carbon in soil under short term management practices. Therefore, this study was planned to determine the impact of vermicompost derived from different substrates on changes in different fractions of labile pools of organic carbon in soils growing common beans (*Phaseolus vulgaris* L.).

MATERIALS AND METHODS

The vermicompost used in this experiment was synthesized at FoAWadura during the year 2021 and 2022 using saw dust, apple pomace, kitchen waste and dal weed as a raw material mixed with cow dung in different proportions. Apple pomace was procured from JKHPMC juice plant Sopore, Kashmir. Saw dust was obtained from a local market. Kitchen waste was collected and segregated from hostels located within campus and dal weed was collected from Dal lake located in Srinagar city. All raw material without and with different proportions of cow dung were treated with earthworm *Esenia fetida* for conversion to vermicompost. Excess moisture from wastes like apple pomace and Dal weed was dried before subjecting to composting process. Kitchen wastes were chopped and wastes like onion peels, garlic peels and egg shells were separated. Cow dung was procured from Dairy farm Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India and pre composted to destroy pathogens and release harmful gases. The moisture and pH of vermicompost was constantly monitored and maintained to avoid worm death. The compost was turned every 15 days to allow proper aeration. After the process was over, vermicompost was harvested and stored for use.

Experiment details: The experiment was conducted in controlled conditions at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, FoA, Wadura campus during kharif season 2021 and 2022. Soil was collected from an isolated plot of the University campus and filled in 5 kg pots. The seeds of common bean (*cv*. Shalimar French Bean 1) were sown in sterilized pots and as per standard agronomic practices. Recommended dose of fertilizers along with treatments was applied to all experimental plots as a basal dose. Soil samples were collected before sowing (PS) and at the end of growing season for determination of different fractions of oxidizable organic carbon.

The concentration of oxidizable organic carbon was determined by method laid down by Walkley and Black (1934). One-half gram of <0.05mm soil was treated with 10ml of 0.167M $K_2Cr_2O_7$ and 20ml of H_2SO_4. The un-oxidized $K_2Cr_2O_7$ was determined by titrating against $FeSO_4$. Same procedure was repeated acid: aqueous solutions of 0.5:1, 1:1 and 2:1 corresponding 12N, 18N and 24N of H_2SO_4 (Walkley, 1947). The organic carbon was separated into following pools:

Pool I: Organic carbon oxidizable under 12 N H_2SO_4.
Pool II: the difference in oxidizable organic carbon extracted between 18 N and 12 N H_2SO_4.
Pool III: The difference in oxidizable organic carbon extracted between 24 N and 18 N H_2SO_4:

The 24 N H_2SO_4 is equivalent to the standard Walkley-Black method. Pool IV (TOC-24 N H_2SO_4)-residual organic carbon after reaction with 24 *N* H_2SO_4 when compared with the total carbon determined by the combustion method. Pool I + Pool II together constituted active carbon pool and Pool III and Pool IV together constituted passive organic carbon pool.

Table 1: Combination of different substrates for synthesis of vermicompost

Substrate combination	Treatment	Average Nutrient content			
		C%	N%	P%	K%
Control	C	-	-	-	-
100 % Saw dust + 0 % Cow dung	1 S	18	0.26	0.12	0.77
75% Saw dust + 25% Cow dung	7 S	17.79	0.31	0.18	1.02
50 % Saw dust + 50 % Cow dung	5 S	17.23	0.32	0.21	1.21
100 % Apple pomace + 0 % cow dung	1 A	16.05	1.62	0.83	1.3
75% Apple pomace + 25 % cow dung	7 A	14.69	1.63	0.85	1.32
50 % Apple pomace + 50 % cow dung	5 A	19.18	2.17	1.05	1.44
100 % Kitchen waste + 0 % cow dung	1 K	18.76	1.65	0.22	0.83
75 % Kitchen waste + 25 % cow dung	7 K	17.53	1.83	0.41	0.87
50% Kitchen waste + 50 % cow dung	5 K	17.36	1.91	1.09	1.05
100 % Dal weed + 0 % cow dung	1D	18.54	1.58	0.94	1.21
75 % Dal weed + 25 % cow dung	7 D	18.01	1.89	1.10	1.23
50% Dal weed + 50 % cow dung	5 D	16.86	2.57	1.52	1.45

Statistical analysis: The statistical analysis of variance (ANOVA) was conducted based on completely randomized design. Least significant difference was calculated a $P<0.05$ to determine difference among treatments in R software. Also per cent contribution of different organic pools in soils receiving different treatment was calculated and represented graphically using Origin pro.

RESULTS AND DISCUSSION

The total organic carbon (TOC) of soil at the end of sowing period reported a significant increase over soil before sowing (Table 2). The highest TOC at the end of experiment was reported in soils treated with treatment 7A (Fig 1). The TOC of soils increased both over control and pre-sowing. Comparing the means, it could be inferred that some treatments had no significant difference with each other (Table 3), however generally, the use of vermicompost increases the total organic carbon in soils. The findings have been earlier supported by many long term experiments where optimum application of organic fertilizers increased soil organic carbon stock over the years (Wang *et al.*, 2015; Yang *et al.*, 2012). Similar findings

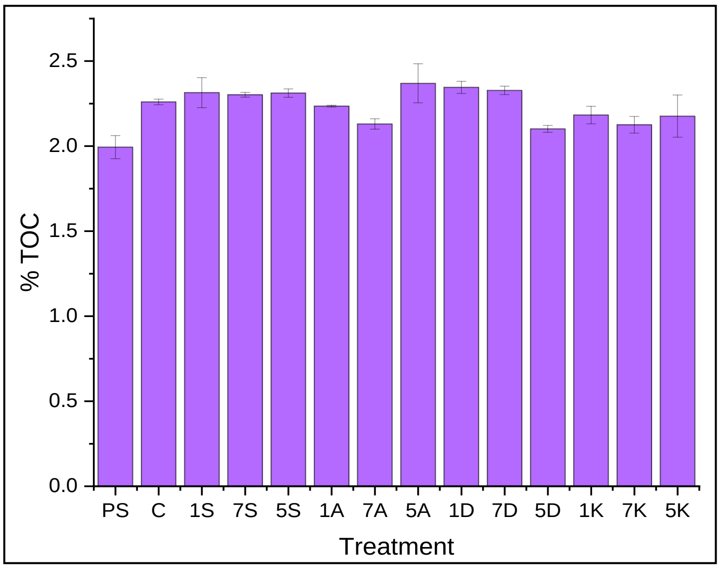

Fig 1: Effect of different treatments on total Organic carbon pool in bean rhizosphere soil

were reported by Nayak *et al.*, (2012) who observed increment in SOC in surface soils by retaining stubbles and root biomass. Moreover, there was a significant difference between carbon content of soils treated with different substrates. This is because the chemical composition of organic matter significantly affects the final composition of compost as already reported by Aslam *et al.* (2019). Higher SOC concentrations in plots fertilized with organic in comparison to untreated plots was also reported by Li *et al.* (2018). Considerable variation was also reported in different pools of organic carbon among different treatments (Fig 2). The highest active pool of organic carbon was reported in treatment containing 50% cow dung and

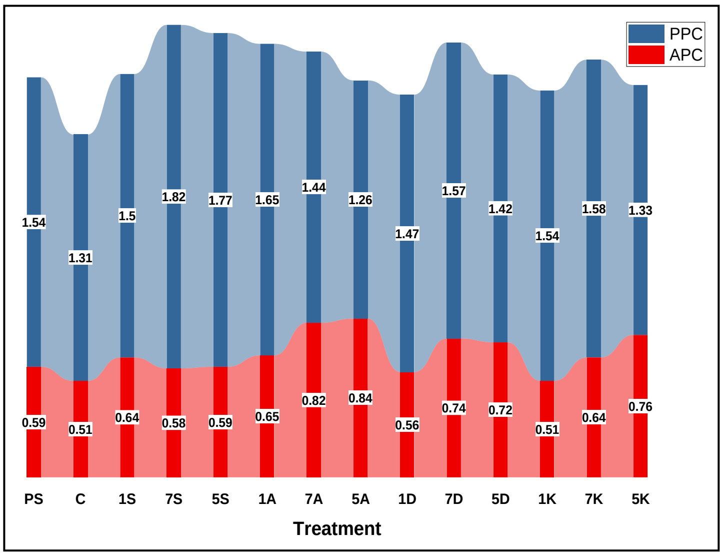

Fig 1: Effect of different treatments on total Organic carbon pool in bean rhizosphere soil

50% apple pomace i:e 0.84 per cent followed by treatment containing 75% apple pomace and 25% cow dung. The highest passive carbon pool was reported in treatments containing saw dust viz:- 1.82 per cent and 1.77 per cent. The higher percentage of passive pool in sawdust based compost might be due to high C: N ratio of sawdust compost making their decomposition difficult. This results in slow conversion between different pools. The mean values of Pool I varied significantly from each other with highest values reported for treatments containing 50 % cow dung. Pool II reported maximum value in treatments containing 25% cow dung i:e 0.34, 0.33 and 0.27 per cent for 7K, 7S and 7D respectively. This implies that with decrease in proportion of cow dung, there is a decrease in quantity of labile pool in soil. One of the reasons for increased labile carbon in cow dung may be the presence of aliphatics, carboxylic acids, carboxylates and polysaccharides which positively correlate with Mineralizable fractions of carbon as reported by Bekiaris *et al.,* (2015). Conversely it implies that Pool I and Pool II are the most sensitive indicators of management practices and undergo changes in short period of time. Similar results were reported by Ghosh *et al.,* (2021) while studying the impact of integrated nutrient management practices on paddy. Hence, the application of inorganic fertilizers in combination with radially decomposable organic manures results in more labile carbon, which can act as a source of energy and nutrients.

Table 3: Effect of different treatments on labile and non- labile carbon pools in rhizosphere soils of common bean (*Phaseolus vulgaris* L). Different superscript alphabets show significant difference among the treatments

Pool I		Pool II		Pool III		Pool IV		TOC	
5A	0.6850^{a}	7K	0.3447^{a}	1D	0.4843^{a}	5S	1.6060^{a}	1D	2.3690^{a}
7A	0.6433^{ab}	7S	0.3300^{a}	5D	0.3912^{ab}	1A	1.5580^{ab}	7D	2.3456^{ab}
5K	0.6373^{ab}	7D	0.2700^{ab}	1S	0.3688^{ab}	7S	1.4843^{abc}	5D	2.327^{ab}
1A	0.5500^{bc}	1S	0.2497^{abc}	C	0.3378^{bc}	1K	1.383^{bcd}	7S	2.314^{ab}
5D	0.5150^{cd}	5D	0.2017^{bcd}	PS	0.3094^{bcd}	PS	1.354^{bcde}	1A	2.311^{ab}
7D	0.4672^{cde}	PS	0.1828^{bcd}	7D	0.3072^{bcd}	1D	1.326^{cde}	5S	2.3021^{abc}
5S	0.4218^{def}	7A	0.1775^{bcd}	7K	0.2400^{cde}	7D	1.302^{cdef}	1S	2.2598^{abcd}
7S	0.4167^{def}	5S	0.1652^{bcd}	5A	0.1993^{def}	7A	1.262^{def}	7A	2.235^{abcd}
1D	0.4118^{ef}	C	0.1637^{bcd}	1K	0.1770^{efg}	1S	1.255^{def}	7K	2.183^{bcd}
1S	0.3867^{ef}	1K	0.1577^{cd}	5K	0.1603^{efg}	7K	1.236^{def}	PS	2.176^{bcd}
1K	0.3833^{ef}	5A	0.1577^{cd}	7A	0.1525^{efg}	5D	1.219^{def}	5A	2.130^{cde}
7K	0.3617^{f}	1D	0.1472^{cd}	5S	0.1090^{fg}	5K	1.183^{def}	5K	2.1253^{de}
C	0.3483^{f}	5K	0.1447^{cd}	1A	0.1070^{fg}	C	1.1442^{ef}	1K	2.101^{de}
PS	0.3302^{f}	1A	0.0970^{d}	7S	0.0743^{g}	5A	1.088^{f}	C	1.994^{e}

Least Significant Difference: Pool I 0.1027623; Pool II 0.1075298; Pool III 0.1179478; Pool IV 0.22114

CONCLUSION

It can be concluded from above study that organic amendments can help in carbon sequestration of soils even in short term management practices. Moreover, there is a difference in contribution of organic amendments derived from varied sources to different organic carbon pools. Further, organic amendment synthesized using cow dung as a substrate are beneficial for areas where soils are completely deprived of organic matter and need immediate restoration of organic matter for cultivation. Overall results of the study suggest that application of organic inputs in addition to inorganic inputs increases the overall carbon content in soil which can prove beneficial for improving soil quality over longer period of time.

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