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Effect of Green Manuring Crops on Carbon Mineralization, Dehydrogenase and β-Glucosidase Activities in Inceptisols

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Abstract: Pot culture and incubation studies were conducted to assess the carbon mineralization and soil enzyme activities with green manure crop residue in Inceptisols. The studies were undertaken with six green manure crop residues *viz.*, sunhemp (*Crotolaria juncea*), cluster bean (*Cymopsis tetragonaloba*), cow pea (*Vigna unguiculata*), mutant dhaincha (*Sesbania rostrata)*, green gram *(Vigna mungo*) and soybean (*Glycine max L. Merrill*) which were grown up to 50 per cent flowering in the pot along with control at Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune during 2020-21 in completely randomized design with three replications. Carbon mineralization and soil enzyme activities *i.e.* dehydrogenase and β- glucosidase were studied by incorporating green manure crop residues in soil. In the incubation study, the mutant dhaincha recorded significantly higher release of CO_2-C throughout the incubation period than other treatments. The rate of release of CO_2-C was slow at 0 and 15 days after incubation but increased at 45 days after incubation and thereafter, gradual decline in all green manures incorporated treatments was observed. Higher dehydrogenase and β- glucosidase activity were recorded in sun hemp treated pots.

Key words: *Carbon mineralization, dehydrogenase, β-Glucosidase, green manure crops*

Introduction

Now a days, chemical fertilizers are becoming costlier and their indiscriminate use is increasing the cost of cultivation and create environmental pollution. Use of green manure reduces our dependence on inorganic fertilizers because they are vital sources for maintaining the nutrient and organic carbon status of soil. Leguminous green manure crops are an important component of sustainable cropping systems. Leguminous green manure crops like Sunhemp (*Crotolaria juncea*), Cluster bean (*Cymopsis tetragonaloba*), Cow pea (*Vigna unguiculata*), Mutant Dhaincha (*Sesbania rostrata)*, Green gram *(Vigna mungo*), Soybean (*Glycine max L. Merrill*) *etc*. provide organic matter as well as nutrients, notably carbon and nitrogen (Qiu *et al.* 2018).

Carbon mineralization assists in anticipating CO_2 emissions in the environment, increase nutrient availability to plants and prevents carbon from escaping into the atmosphere. When organic matter is introduced to a soil, it begins to degrade, resulting in the emission of several gases, most notably CO_2, which depends on microbial activity and soil moisture and temperature (Rahman 2013). A net reduction in CO_2 emissions leads to increased soil carbon storage, often known as C sequestration. C sequestration is required to improve soil quality, increase agronomic productivity and maximise the effectiveness of inputs as fertilizers and water.

Green manuring is beneficial for increasing not

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only for the production but also for enhancing soil quality. Therefore, recycling of crop residues is suggested as a potential means of sustaining soil fertility and productivity over the long term (Singh and Rangel 2007). To optimize the use of legume residues, especially green manure crops, there is a need to estimate their mineralization rate, microbial and enzyme activity after being incorporated in the soil. As carbon produces approximately 40 per cent of the total dry plant biomass, carbon mineralization is often used as a general indicator of the persistence or decomposability of organic materials (Janzen and Kucey 1988).

It is obvious that green-manuring crops can be used to build cost-effective and efficient soil organic management techniques. In this context, present study was undertaken to study carbon mineralization and green manuring crops in Inceptisols on soil enzymes b-glucosidase activities.

Materials and Methods

The pot culture experiment was conducted to study the influence of green manure crops in C mineralization and enzyme activity during *rabi* 2020-21 at the Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Maharashtra. There were seven treatments including one control and six green-manuring crops namely sun hemp, cluster bean, cowpea, mutant dhaincha, green gram and soybean with three replications in a completely randomized design.

Inceptisols soil required for the experiment was obtained from a research farm, College of Agriculture, Pune was pass through a 2.0 mm sieve. The initial and during incubation period, chemical and biological soil properties were analyzed at a pre-determined time interval. The initial soil physical and chemical properties are given in table 1.

Table 1. Initial physico-chemical characters of the soil

Soil properties	Value
Sand (%)	33.00
Silt (%)	38.50
Clay (%)	28.50
Bulk density (mg m^{-3})	1.34
Moisture content 33kPa	37.40
pH (1:2.5)	7.73
EC (dS m^{-1})	0.21
Organic carbon (%)	0.30
$CaCO_3$ (%)	6.93
Available nitrogen (kg ha^{-1})	112.90
Available phosphorus (kg ha^{-1})	20.13
Available potassium (kg ha^{-1})	353.60
DTPA extractable Fe (mg kg^{-1})	12.86
DTPA extractable Mn (mg kg^{-1})	14.21
DTPA extractable Cu (mg kg^{-1})	3.17
DTPA extractable Zn (mg kg^{-1})	4.02

The seed of *Sesbania rostrata i.e.,* mutant dhaincha (TSR-l) was procured from Bhabha Atomic Research Centre, (BARC) Mumbai and other crop seeds were collected from a local market. All the green manuring crops were sown in 21 plastic pots (41 cm diameter and 38 cm height) (7 treatments x 3 replications) containing 20 kg sieved soil. Green manuring crops were grown up to 50% flowering and incorporated into the same pot for the incubation study up to 75 days.

Table 2. Nutrient composition of green manuring crops

Treatments	Major nutrients			Total C	C:N ratio	Micronutrients			
	N	P	K			Fe	Mn	Cu	Zn
	(%)					(mg kg^{-1})			
T_1: Sunhemp	2.98	0.44	1.84	51.35	17.23	173	26.86	32.33	31.12
T_2: Cluster bean	2.60	0.25	1.91	50.70	20.27	236	22.73	20.67	30.87
T_3: Cow pea	2.05	0.40	1.94	46.21	22.54	240	23.40	18.00	20.10
T_4: Mutant Dhaincha	3.94	0.44	2.11	58.68	14.90	180	38.12	33.33	32.82
T_5: Green gram	2.90	0.35	1.36	55.59	19.16	149	28.57	18.67	26.98
T_6: Soybean	2.85	0.39	1.74	53.54	18.78	199	19.40	19.33	29.07
S.E. (m) ±	0.18	0.03	0.20	0.49	1.22	4.94	2.13	2.59	1.82
CD at 5%	0.55	0.09	0.44	1.55	3.61	15.78	4.80	5.86	5.66

In the laboratory, an incubation experiment was conducted to study the carbon mineralization and soil enzyme activities amended with green manure crop residues. The soil samples from each treatment and replication were drawn at 0, 15, 30, 45, 60, and 75 days (15-20 cm depth) after incubation and analysed immediately for carbon mineralization (CO_2 evolution). The enzymes (dehydrogenase and β-Glucosidase) activities in the soil at 0, 30, and 60 days were recorded. The carbon mineralization was estimated by the alkali trap method as outlined by Pramer and Schimidt (1964), whereas the dehydrogenase and β-Glucosidase enzyme activities was assayed by method outlined by Casida *et. al.* (1964) and Koichi (1973). The experimental data were statistically analysed as per the methods described by Panse and Sukhatme (1985).

Results and Discussion

Periodical and cumulative carbon mineralization

A variation in carbon mineralization was noticed among the different treatments of green manuring crops (Table 3). The green manure crop residues incorporated soil significantly higher amounts of CO_2-C over the control treatment. The results indicated that mutant dhaincha had higher C mineralization (at 0 days and 75 days) compared to the rest of treatments. At 45 days of incubation, mutant dhaincha recorded higher C mineralization (20.60 mg CO_2-C 100 g^{-1}), which was at par with sun hemp, green gram, cluster bean, soybean and cowpea (19.07, 18.03, 17.90, 17.90, and 17.83 mg CO_2-C 100 g^{-1}, respectively). The periodical CO_2-C release by different treatments showed a slower rate at the initial stage and attained a peak at 45 days of incubation followed by a gradual decline. Higher cumulative CO_2-C was observed in mutant dhaincha (216.28 mg CO_2-C 100 g^{-1}), sunhemp (189.90 mg CO_2-C 100 g^{-1}), cowpea (179.02 mg CO_2-C 100 g^{-1}) and soybean (167.15 mg CO_2-C 100 g^{-1}) than other treatments. Among the treatments, green gram possessed lowest release of CO_2-C (162.13 mg CO_2-C 100 g^{-1}) during the incubation period, but it was higher than the control (97.40 mg CO_2-C 100 g^{-1}). Among the crop residues, the cumulative carbon mineralization-release pattern in different treatments followed a decreasing trend in following order mutant dhaincha> sunhemp> cowpea > soybean >cluster bean> green gram > control.

Baggs *et al*. (2000) and Liu *et al*. (2014) stated that CO_2 emissions are increased when agricultural crop residues are added to the soil. The results indicated that CO_2-C release pattern of different green manure crops are considerably different, which might be due to differences in the chemical composition of green manure crops and its C mineralization rate in soil (Millar and Baggs 2004). Jiménez *et al*. (2012) stated that the CO_2-C production depends on the nature and amount of green manure crop residues applied as well as soil and climatic conditions. The results are also consistent with the findings reported by Srinivasan *et al.* (2017) and Wu *et al*. (2015).

Table 3. Effect of green manuring crop residues on periodical CO_2-C evolution

Treatments	Periodical CO_2 evolution (mg CO_2-C 100 g^{-1})						Cumulative total
	0 days	15 days	30 days	45 days	60 days	75 days	
T_1: Sunhemp	19.07	24.80	33.63	48.68	36.97	26.77	**189.90**
T_2: Cluster bean	17.90	25.43	29.17	40.37	30.13	22.70	**165.70**
T_3: Cow pea	17.83	24.80	32.30	46.85	33.40	23.83	**179.02**
T_4: Mutant Dhaincha	20.60	33.13	40.37	53.12	39.00	30.07	**216.28**
T_5: Green gram	18.03	24.07	31.03	38.80	28.47	21.73	**162.13**
T_6: Soybean	17.90	25.47	30.01	41.27	30.20	22.30	**167.15**
T_7: Control	14.90	15.27	19.30	17.73	16.87	13.33	**97.40**
S.E.(m) ±	1.38	2.28	2.53	3.41	2.20	1.99	--
CD at 5%	4.2	7.0	7.7	10.4	6.7	6.1	--

Dehydrogenase activity

The treatments having green manure crops showed higher dehydrogenase activity than control (Table 4). The incorporation of sun hemp at 0, 30, and 60 days of incubation recorded higher dehydrogenase activity (41.2, 43.5 and 48.7 µg TPF g^{-1} soil 24 hr^{-1}, respectively) over other green manure crops. This was at par with incorporation of mutant dhaincha (39.8, 40.7 and 45.7 µg TPF g^{-1} soil 24 hr^{-1}, respectively). The control treatment showed lower dehydrogenase activity (21.0, 21.7 and 22.7µg TPF g^{-1} soil 24 hr^{-1}, respectively) throughout the incubation period. Melero *et al*. (2006) observed that the decomposition of crop biomass leads to the production of decaying organic matter due to increase in microbial activity that releases nutrients in soil and this process is catalyze by dehydrogenase enzyme which ultimately leads to increasing dehydrogenase enzymatic activity.

Table 4. Effect of green manuring crop residues on periodical dehydrogenase activity

Treatments	Dehydrogenase Activity (µg TPF g^{-1} soil 24 hr^{-1})		
	0 days	30 days	60 days
T_1: Sunhemp (*Crotolaria juncea*)	41.23	43.51	48.77
T_2: Cluster bean (*Cymopsis tetragonaloba*)	35.77	36.93	42.09
T_3: Cow pea (*Vigna unguiculata*)	33.50	36.17	39.30
T_4: Mutant Dhaincha (*Sesbania rostrata*)	39.80	40.73	45.73
T_5: Green gram (*Vigna mungo*)	33.70	36.07	37.97
T_6: Soybean (*Glycine max L. Merrill*)	30.93	32.80	35.13
T_7: Control	21.02	21.77	22.77
S.E.(m) ±	1.56	1.60	1.79
CD at 5%	4.77	4.89	5.48

β-glucosidase activity

The data (Table 5) on β-glucosidase activity indicated that there was a significant effect of the incorporation of green manure crop residues. During 0 days of incubation, significantly higher β-glucosidase activity was recorded by the incubation of soybean as a green manuring crop (138.17 µg PNP g^{-1} soil hr^{-1}) over control (123.93 µg PNP g^{-1} soil hr^{-1}). This was at par with sunhemp, mutant dhaincha, cowpea and green gram (137.23, 136.57, 133.13, and 129.37 µg PNP g^{-1} soil hr^{-1}, respectively). At 30 and 60 days of incubation, significantly higher activity was observed in the sunhemp (147.10 and 151.43 µg PNP g^{-1} soil hr^{-1}) compared with control (126.87and 123.87 µg PNP g^{-1} soil hr^{-1}).

Table 5. Effect of green manuring crop residues on periodical β glucosidase activity

Treatments	**β -glucosidase activity (µg PNP g^{-1} soil hr^{-1})**		
	0 days	**30 days**	**60 days**
T_1: Sunhemp (*Crotolaria juncea*)	137.23	147.10	151.43
T_2: Cluster bean (*Cymopsis tetragonaloba*)	124.63	135.80	139.40
T_3: Cow pea (*Vigna unguiculata*)	133.13	140.83	143.43
T_4: Mutant Dhaincha (*Sesbania rostrata*)	136.57	146.07	147.43
T_5: Green gram (*Vigna mungo*)	129.37	139.43	143.53
T_6: Soybean (*Glycine max L. Merrill*)	138.17	146.40	148.17
T_7: Control	123.93	126.87	123.87
S.E.(m) ±	3.26	2.73	2.86
CD at 5%	10.00	8.37	8.74

Conclusion

Organic C mineralization as measured by CO_2 evolution is used as an indicator of the persistence or decomposability of organic materials applied to soil. The soil incorporated with green manure crop residues showed a higher amount of C mineralization throughout the incubation period than the control. The release rate of CO_2-C was slower at the initial stage of incubation and increased to a peak at 45 days, followed by a gradual decline. The C-release patterns from different green manure residues incorporation into soil showed a trend as: mutant dhaincha> sunhemp> cowpea > soybean > cluster bean > green gram > control. The green manuring crop residues incorporated soil had higher enzyme activity than untreated soil. Among all green manure crops, sun hemp-incubated soil recorded significantly higher dehydrogenase and β-glucosidase activity. Soil enzyme activities recorded slower rate at beginning and thereafter increased up to 60 days of incubation in all the soil incorporated with green manuring residue.

References

Baggs, E., Rees, R., Smith, K. and Vinten, A. (2000). Nitrous oxide emission from soils after incorporating crop residues. *Soil Use Manage* **16,** 82–87.

Casida, L.E., Jr. Klein, D. and Santora, R. (1964). Soil dehydrogenase activity. *Soil Science* **98**, 371-378.

Janzen, H.H. and Kucey, R.M. (1988). Carbon and Nitrogen mineralization of crop residues as influenced by crop species and nutrient regime. *Plant and Soil* **106**, 35-41.

Jiménez, A., Reyes, J. and Silveira, M. (2012). Secuestroy distribucion de carbon organico del sue loba jo different essistem asd em ane jode pasturas. Series de Publicacion (SL363). Universidad de Florida.

Koichi, H. (1973). A method for the determination of β-glucosidase activity in soil. *Soil Science and Plant Nutrition* **19,** 103-108.

Liu, S., Hu, R., Zhao, J., Bru¨ggemann, N., Bol, R., Cai, G., Lin, S. and Shaaban, M. (2014). Flooding effects on soil phenol oxidase activity and phenol release during rice straw decomposition. *Journal of Soil Science and Plant Nutrition* **177**, 541–547.

Melero, S., Ruiz Porras, J.C., Herencia, J.F. and Madejón, E. (2006). Chemical and biochemical properties in a silty loam soil under conventional and organic management. *Soil and Tillage Research* **90**, 162–170.

Millar. N. and Baggs, E. (2004). Chemical composition, or quality, of agroforestry residues influences N_2O emissions after their addition to soil. *Soil Biology and Biochemistry* **36**, 935–943.

Panse, V.G. and Sukhatme, P.V. (1985). Statistical methods for agricultural workers. IV Ed. Indian Council of Agricultural Research, New Delhi, 157- 165.

Pramer, D. and Schmidt, E.L. (1964). Experimental Soil Microbiology. Burgess Publishing Co., Minneapolis, Minnesota, USA. Sons Ltd. Beecles and London. p. 6-13.

Rahman, M.H., Islam, M.R., Jahiruddin, M., Rafii, M.Y., Hanafi, M.M. and Malek, M.A. (2013). Integrated nutrient management in maize-legume-rice cropping pattern and its impact on soil fertility. *Journal of Food Agriculture and Environment* **11**, 648-652.

Singh, B. and Rengel, Z. (2007). The Role of Crop Residues in Improving Soil Fertility. In P. Marschner, and Z. Rengel (Eds.), *Nutrient Cycling in Terrestrial Ecosystems.* 183-214.

Srinivasan, V., Maheswarappa, H.P. and Lal, R. (2017). Long term effects of topsoil depth and amendments on particulate and non-particulate carbon fractions in a miamian soil of central ohio. *Soil and Tillage Research* **121**, 10–17.

Wu, Y., Liu, T., Peng, Q., Shaaban, M. and Hu, R. (2015). Effect of straw returning in winter fallow in Chinese rice yields on greenhouse gas emissions: evidences from an incubation study. *Soil Research* **53**, 298–305.

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