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Dynamics of Organic Residue Decomposition and Mineralization of Nutrients in Soil

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Abstract

The present study was undertaken to investigate "Dynamics of Organic Residue Decomposition and Mineralization of Nutrients in Soil" during the year 2018-19 at Soil Science and Agricultural Chemistry Section, College of Agriculture, Nagpur. The experiment was laid out in completely randomized design (CRD) with nine treatments replicated thrice. The treatments were absolute control in T_1, cowdung mixture in T_2, paddy straw in T_3, wheat straw in T_4, sugarcane trash in T_5, gliricidia lopping in T_6, subabul leaves in T_7, soybean stalks in T_8, greengram stalks in T_9. Subabul leaves mixture (T_7) recorded maximum ammoniacal nitrogen and nitrate nitrogen throughout experimentation. Gliricidia lopping mixture ranked 1st by recording maximum P mineralization for 30, 60 (7.33 mg kg^{-1}), 90 (7.55 mg kg^{-1}) and 120 (7.45 mg kg^{-1}) days of experimentation. Sulphur mineralization was also found highest in T_6 by application of gliricidia lopping mixture during experimentation. Hence, for fast decomposition and nutrient mineralization legume residue is more efficient than cereal or other organic residue.

1. Introduction

The addition of organic wastes to soils is a current environmental and agricultural practice for maintaining soil quality. It has a great effect on organic matter and nutrient contents. Organic waster when added to soil not only improves the structure, water and air balance but also microbiological activity of the soil. Organic waste treated soils were reported to have significant effects on the soil organic matter content, pH and salinity. The organic residues should no longer be considered as a waste product, but rather a resource that should be manufactured and utilized in the best possible way. Organic residue added to the soil undergoes decomposition by the microbial biomass present in the soil and/or residues. Part of the carbon in the decomposing residues is evolved as CO_2 and part is assimilated by the microbial biomass involved in the decomposition process (Alexander, 1977; Gilmour *et al.*, 2003). Crop residues like paddy straw, wheat straw, sugarcane trash, soybean and green gram stalk are a potential source of nutrients in field. They can improve soil structure, increase organic matter content in the soil and help fix nutrients and CO_2 in the soil. Hence, some crop residues are taken as treatments in the present study to evaluate decomposition of different organic residues and mineralization of nutrients in a pot culture experiment.

2. Material and Methods

An experiment in relation to "dynamics of organic residue decomposition and mineralization of nutrients in soil" was conducted during the months of August to December of the year 2018 in Soil Science and Agricultural Chemistry Section, College of Agriculture, Nagpur. The experiment was laid out in completely randomized design (CRD) with nine treatments replicated thrice (Table 1).

Table 1: Details of treatments used in study

T_1	Absolute control
T_2	Cowdung mixture
T_3	Paddy straw mixture
T_4	Wheat straw mixture
T_5	Sugarcane trash mixture
T_6	Gliricidia lopping mixture
T_7	Subabul leaves mixture
T_8	Soybean stalks mixture
T_9	Green gram stalks mixture

The soil required for the present study was procured from Agronomy Farm, College of Agriculture, Nagpur. The soil was mixed well and was made free from stones, gravels and other organic matter. Before addition of residues, one composite sample was drawn and was analysed for soil chemical properties. The results presented in Table 2 revealed that, the soil was neutral in reaction and low in salt content. The OC

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in the soil was recorded as 4.9 g kg^{-1} which is low. Regarding availability of nutrients, soil was found low in available N and P and was high in available K. Sulphur content of soil was found to be 12.80 kg ha^{-1}.

Table 2: Chemical properties of initial soil sample

Sl. No.	Chemical soil properties	Result
1	pH	7.53
2	Electrical conductivity	0.491 dS m^{-1}
3	Organic carbon	4.9 g kg^{-1}
4	Available Nitrogen	137.98 kg ha^{-1}
5	Phosphorus	13.56 kg ha^{-1}
6	Potassium	270.65 kg ha^{-1}
7	Sulphur	12.80 kg ha^{-1}

The dried residue was added to 5 kg soil at 10 t ha^{-1}. The mixture was mixed thoroughly and was transferred to earthen planters. For N, P and S mineralization, soil samples were taken from these earthen planters at 30, 60, 90, 120 days. All standard scientific procedures were adopted for nutrient analysis. Organic carbon was determined by the method of dry combustion method given by Nelson and Sommers (1996). Nitrogen mineralization was determined by double distillation method given by Keeney (1982) and available nitrogen was estimated using alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus was determined by Olsen's method using spectrophotometer (Olsen's and Sommer, 1982), whereas; available potassium in soil was extracted by neutral ammonium acetate solution and determined using flame photometer (Jackson, 1973). It was determined by turbidimetric method given by Chesnin and Yien (1951).

3. Results and Discussion

The present study includes influence of organic residue addition on mineralization of nutrients. Mineralization is conversion of organic and insoluble form of nutrients into inorganic and available form. Due to addition of organic residue to soil there were variable changes in nutrient mineralization.

3.1 Nitrogen Mineralization

Nitrogen mineralization in the form of NH_4-N and NO_3-N was studied at 30, 60, 90 and 120 days and the data regarding same is presented in Table 3. From the results of nitrogen mineralization, it was revealed that, nitrogen mineralization in the soil differs significantly due to addition of different organic residues. At all the monthly intervals, it was observed that highest N mineralization was recorded by subabul lopping mixture (T_7). Overall, gliricidia lopping mixture (T_6) was found at par with subabul lopping mixture at every interval. It is observed that, there is slight variation in NH_4-N and NO_3-N content from 60 days onwards. Though, the trend of mineralization was irregular but it can be observed that at 60 days, it increased and thereafter, it again decreased. During initial period, microorganisms utilise available carbon source and native nitrogen hence, the rate of mineralization found increasing during first few days thereafter microorganisms get lesser carbon and nutrients. This might be the reason behind slow rate of N mineralization in later stages of incubation.

Table 3: Effect of different organic residues on N mineralization (mg kg^{-1})

Treatments	30 days		60 days		90 days		120 days	
	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
T_1	27.54	16.27	34.15	15.12	26.11	16.60	20.61	11.94
T_2	44.24	22.18	50.3	35.49	54.00	28.02	42.63	19.57
T_3	32.15	20.79	48.41	32.94	47.29	26.00	37.33	17.50
T_4	31.01	20.46	47.25	32.13	46.33	25.37	36.57	16.89
T_5	28.18	19.88	44.94	31.73	46.95	25.05	37.06	16.35
T_6	44.70	24.79	51.61	36.60	54.63	28.90	43.13	20.07
T_7	48.98	26.25	52.66	38.02	56.99	30.01	44.99	20.83
T_8	40.32	21.32	49.93	33.53	49.17	26.47	38.28	18.21
T_9	39.57	23.59	50.55	34.67	50.03	27.37	40.05	18.51
S. E. ±	1.47	0.56	0.54	0.98	0.91	0.45	0.71	0.28
C.D. @ 5%	4.41	1.68	1.63	2.94	2.73	1.34	2.12	0.83

Adediran *et al.* (2003) also revealed that, cumulative N mineralization increased with increase in incubation period upto certain stage and then decreased. Mishra *et al.* (2016) also stated that maximum N mineralization was recorded at 45th day of incubation and thereafter, it started decreasing.

3.2 Phosphorus Mineralization

P mineralization was also studied at monthly intervals until 120 days and the data pertaining to the same is presented in Table 4. The results revealed that, P mineralization in the soil differs significantly due to the addition of different organic residues. Gliricidia lopping mixture in T_6 recorded highest P at all the monthly intervals and every time green gram stalks mixtures in T_9 ranked second in recording P mineralization. It was observed that, at 30 days and 120 days interval green gram stalks mixture (T_9) was found at par with gliricidia lopping mixture (T_6). Behaviour of P in soil is little strange and many factors affect its mineralization and hence, availability. The organic acids liberated during decomposition of native as well as insoluble P results in increased P mineralization. P mineralization is basically a function controlled by C:P ratio of organic residues. Though the P content of green gram stalks mixture was highest its C:P ratio was higher than that of gliricidia lopping mixture. This might be a reason behind fast and steady mineralization of P in gliricidia lopping mixture.

Table 4: Effect of different organic residues on P mineralization (mg kg^{-1})

Treatments	30 days	60 days	90 days	120 days
T_1	6.06	6.21	6.30	6.27
T_2	6.67	6.99	7.22	7.15
T_3	6.65	7.03	7.25	7.15
T_4	6.29	6.53	6.75	6.65
T_5	6.42	6.62	6.84	6.77
T_6	6.99	7.33	7.55	7.45
T_7	6.56	6.78	7.01	6.93
T_8	6.22	6.39	6.62	6.56
T_9	6.97	7.13	7.35	7.28
S. E. ±	0.08	0.06	0.06	0.06
C.D. @ 5%	0.23	0.17	0.17	0.17

The results are in agreement with Brown and Dickey (1970) who, observed that, burried organic residues showed maximum P mobilisation after 3 months. Also Chrispin (2009) observed that, the mineralization levels in P increases after the application of organic inputs.

3.3 Sulphur Mineralization

S mineralization study was also performed at four monthly intervals at 30, 60, 90 and 120 days. The data regarding S mineralization is presented in Table 5. From the results of sulphur mineralization from 30 to 120 days of experimentation it was revealed that, sulphur mineralization in the soil differs significantly due to addition of different organic residues.

Among all organic residues, sulphur content was found highest in gliricidia lopping mixture whereas subabul leaves mixture ranked second. The lowest S content was recorded highest in sugarcane trash mixture (T_5) after control. The lowest C:S ratio was observed in gliricidia lopping whereas highest ratio was recorded in soybean stalks.

Hence, S mineralization was recorded highest in all the intervals except at 120 days where it was found highest in sugarcane trash. S mineralization is attributed to biological process just as in case of N and P mineralization. And the process is strictly governed by microorganisms. Owing to narrowest C:S ratio in gliricidia lopping, there might be highest mineralization throughout the period. Gharmakher *et al.* (2012) also reported that, addition of organic residues have modified the rate of decomposition and the gross and net S mineralization.

Table 5: Effect of different organic residues on S mineralization (mg kg^{-1})

Treatments	30 days	60 days	90 days	120 days
T_1	5.71	5.72	5.74	5.73
T_2	6.16	6.24	6.32	6.27
T_3	6.08	6.07	6.13	6.09
T_4	6.14	6.14	6.22	6.19
T_5	5.85	5.99	5.99	5.97
T_6	6.34	6.38	6.40	6.37
T_7	6.24	6.27	6.37	6.32
T_8	5.90	5.94	5.99	5.96
T_9	5.98	6.03	6.07	6.05
S. E. ±	0.03	0.02	0.03	0.03
C.D. @ 5%	0.08	0.07	0.09	0.09

During initial period, microorganisms utilise available carbon source and native nutrient hence, the rate of mineralization found increasing during first few days thereafter microorganisms get lesser carbon and nutrients. This might be the reason behind slow rate of S mineralization at later stages. Mishra *et al.* (2016) showed that sugarcane trash was second highest in the mineralization of sulphur after press mud.

3.4 Organic Carbon

Different treatment combinations significantly improved the OC content of soil (Figure 1). The value of soil OC ranged from 4.88 to 5.92 g kg^{-1} after application of different organic residues. The initial OC of soil was 4.9 g kg^{-1} and after experimentation it fell down to 4.88 g kg^{-1} in control pot. There is 2 percent decrease in OC content of control pot over initial. The highest OC content was found in soybean stalks mixture (T_8) which was 5.92 g kg^{-1} while, the lowest was recorded under treatment T_1 which was absolute control. Treatment T_8 *i.e.,* soybean stalk mixture was found at par with subabul leaves mixture (T_7). There is about 17.56 percent increment in OC over control treatment. Subabul leaves mixture (T_7) showed second highest OC content among all the treatments. The general trend of OC of all the treatments was observed as $T_8>T_7>T_3>T_9>T_2>T_6>T_5>T_8>T_1$. The increase in soil organic carbon content with organic source application might be due to additional supply of organic matter. The highest OC content was recorded in soybean stalks mixture (T_8) which might be due to high OC content in soybean stalks mixture which contributed to increase in OC content of soil. Rasal *et al.* (1989) reported that incorporation of sugarcane trash increased soil organic carbon.

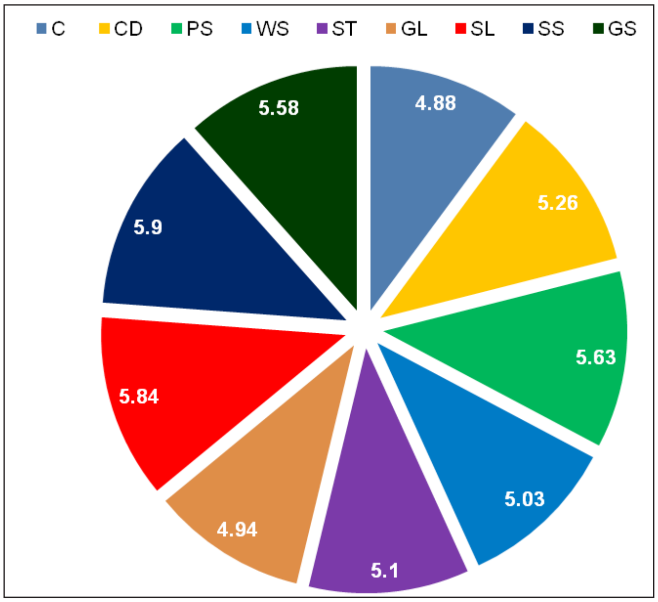

Figure 1: Effect of different organic residues on organic carbon content of soil in (g kg^{-1})

From above results it can be concluded that, mineralization was at the peak at 60 days. Subabul leaves mixture was found superior over the other organic residues in mineralization of N whereas, gliricidia lopping mixture was found superior in mineralization of P and S. Also, the nutrients N, P and S are highly available after 30 days (*i.e.,* 1 month) of residue application. Therefore, to increase the availability of nutrients for crop use, organic residues should be applied approximately 1 month prior to sowing. It was that, for fast decomposition and nutrient mineralization legume residue is more efficient than cereal or other organic residue.

4. Conclusion

From the present findings, it can be concluded that, N, P and S mineralization was at the peak at 60 days. Subabul leaves mixture was found superior over the other organic residues in mineralization of N whereas, gliricidia lopping mixture was found superior in mineralization of P and S. Organic carbon content was also found increased over initial due to addition of organic residues.

Finally, it can be concluded that, for fast decomposition and nutrient mineralization legume residue is more efficient than cereal or other organic residue.

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