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## Influence of organic residue addition on CO<sub>2</sub> evolution and N mineralization in soil

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**Abstract**

A combination of pot culture experiment and incubation study was conducted at the soil science and agricultural chemistry section, college of agriculture, nagpur to assess the decomposition potential and rate of mineralization of nitrogen of different organic residues. Initially, the rate of CO<sub>2</sub> evolution was near constant during 10 days of incubation peaking on 3<sup>rd</sup> day after incubation. There was a steep increase in CO<sub>2</sub> evolution in all the treatments after 10 days, attaining its peak at 70 days after incubation thereafter it began to decrease in a non-uniform pattern upto 120 days. Cummulatively, maximum CO<sub>2</sub> evolution was recorded in green gram stalks followed by sugarcane trash and lowest was found in control pot. Nitrogen mineralization in pot culture experiment was analysed at 4 monthly intervals viz. 30, 60, 90 and 120 days. There was a sharp increase in the rate of N mineralization at 60 days interval and altogether, there was a decreasing trend of nitrogen mineralization after 60 days of experimentation. The peak amount of mineralization was observed at 90 days in near about all the treatments. Subabul leaves mixture (T<sub>7</sub>) recorded maximum ammoniacal nitrogen (48.98 mg kg<sup>-1</sup>, 52.66 mg kg<sup>-1</sup>, 56.99 mg kg<sup>-1</sup> and 44.99 mg kg<sup>-1</sup>) and nitrate nitrogen (26.25 mg kg<sup>-1</sup>, 38.02 mg kg<sup>-1</sup>, 30.01 mg kg<sup>-1</sup> and 20.83 mg kg<sup>-1</sup>) throughout the experimentation. The results highly indicated that addition of all residues produced a significant increase in soil organic carbon and nitrogen but, leguminous residues showed a higher response.

**Keywords:** Organic residues, CO<sub>2</sub> evolution, nitrogen mineralization, decomposition potential

**Introduction**

Organic residues should be seen not as wastes but as providers of essential environmental services, assuring the perpetuation of productive agro ecosystem. Crop residues represent substantial global stores of fiber, energy, and plant nutrients. The total amount of principal nutrients in crop residues ranges from 40 to 100 kg tons<sup>-1</sup>. Organic residues can be used for improving soil health and productivity and are a major source of lignocellulose entering the soil. Actual rate and degree of decomposition are moderated by the local activity of the decomposer organisms and the environmental conditions, but residue quality is one of the factors most amenable to management in agricultural systems (Giller and Cadisch, 1997) [2]. The decomposition of crop residues is a microbial-mediated progressive breakdown of organic materials with ultimate end products C and nutrients released into the biological circulation in the ecosystem at both a local and a global scale. The use of these organic materials should be increased in agriculture since they can be beneficial for the crops and at the same time, provide an efficient and cost-effective method for its disposal. Organic residues are often applied to agricultural soils at rates necessary to obtain desired levels of available N.

Plants die and decompose through a complex process involving microorganisms such as fungi, bacteria and actinomycetes. In this process many nutrients are released to soil and plants can uptake them for their growth. It is vital to investigate the mineralisation of organic matter and the pattern of release of carbon and nitrogen to the soil. Therefore, this research study was conducted by an incubation study incorporating different organic residues to soil. Nitrogen mineralization-immobilization turnover mainly depends on a variety of factors with the C to N ratio being regarded as the single most predictive measurement of the N mineralization capacity of composts (Sikora and Szmids, 2001) [10]. For beneficial utilization of organic materials added to soils, quantitative information on the decomposition and mineralization rates of various sources of organic C and N is required.

Therefore, the aim of this study was to assess the decomposition potential and rate of mineralization of nitrogen from a range of organic residues that differ in their C to N ratio and C quality.

### Materials and Methods

The organic residues used in the study are absolute control (T<sub>1</sub>), cowdung mixture (T<sub>2</sub>), paddy straw mixture (T<sub>3</sub>), wheat straw mixture (T<sub>4</sub>), sugarcane trash mixture (T<sub>5</sub>), gliricidia lopping mixture (T<sub>6</sub>), subabul leaves mixture (T<sub>7</sub>), soybean stalks mixture (T<sub>8</sub>) and green gram stalks mixture (T<sub>9</sub>). The nine treatments were replicated thrice under completely randomized block design (CRD). The residue samples were analysed chemically and are depicted in table 1. Total nitrogen content of the residue was determined by Kjeldahl's method given by Piper (1966) [9] and organic carbon was determined by the method of dry combustion method given by Nelson and Sommers (1996) [7]. All the residues were crushed and then mixed into the soil. A rate of residue equivalent to 10 t ha<sup>-1</sup> dry weight was incubated with 5 kg soil for 120 days for pot culture experiment for N mineralization and 100 g of soil mixture was taken for incubation study.

The soil was collected from Agronomy farm, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). CO<sub>2</sub> evolution was studied by incubating soil samples for 120 days. The organic residues were added at the rate of 10 t ha<sup>-1</sup>. One hundred gram sieved (< 2 mm) air-dried soil was taken in a 500 ml conical flask and the above treatments were imposed. CO<sub>2</sub> evolution was studied using the alkali trap method daily for first 10 days and

thereafter, at weekly intervals upto 120 days.

The N mineralization was studied at 4 monthly intervals at 30, 60, 90 and 120 days after incubation. For mineral N extraction, 25 ml of 2 M KCl was added to the soil samples, followed by shaking for 30 minutes. The next step carried out was filtering the solution through Whatman No. 42 filter paper and mineral N was determined in the extract by double distillation method (Keeney, 1982) [5].

### Results and Discussion

#### Soil Analysis

The soil used in the experiment was deep black in colour, neutral in reaction and low in salt content. The organic carbon in the soil was recorded as 4.90 g kg<sup>-1</sup> which comes under low category. The soil was also found low in available N and P i.e., 137.98 kg ha<sup>-1</sup> and 13.56 kg ha<sup>-1</sup> respectively and was found high in available K content (270.65 kg ha<sup>-1</sup>). Sulphur content in soil was determined as 12.80 kg ha<sup>-1</sup>.

#### Organic residue analysis

The results indicated that, among the different organic residues, the organic carbon content was found highest in soybean stalks i.e., 51.1 per cent, whereas; gliricidia lopping (31.5%) recorded least organic carbon content (Table 1). Subabul leaves recorded highest nitrogen content which was 3.2 per cent and the least was found in sugarcane trash with 0.4 per cent. The lowest C:N ratio was recorded by gliricidia lopping (12.60) followed by subabul leaves (15.06) whereas, highest was recorded by sugarcane trash (88.75).

**Table 1:** Nutrient composition (%) of different organic residues.

Treatment	O.C.	N	C:N
T <sub>2</sub> - Cow dung mixture	38.2	1.61	23.73
T <sub>3</sub> - Paddy straw	42.5	0.61	69.67
T <sub>4</sub> - Wheat straw	31.8	0.67	47.46
T <sub>5</sub> - Sugarcane trash	35.5	0.4	88.75
T <sub>6</sub> - Gliricidia lopping	31.5	2.5	12.60
T <sub>7</sub> - Subabul leaves	48.2	3.2	15.06
T <sub>8</sub> - Soybean stalks	51.1	1.05	48.67
T <sub>9</sub> - Green gram stalks	44.8	1.1	40.73

#### CO<sub>2</sub> evolution

CO<sub>2</sub> evolution of different soil and residue mixtures were studied by incubating samples for 120 days under laboratory conditions. The study revealed that CO<sub>2</sub> evolution from different soil mixtures increased significantly throughout the period of incubation. On day 1 of incubation, the range of CO<sub>2</sub> evolution varied from 37.7 mg 100 g<sup>-1</sup> to 60.87 mg 100 g<sup>-1</sup>, highest being discovered in green gram stalks mixture (T<sub>9</sub>) and the lowest in the control pot (Table 2). The evolution caught its peak on the third day, where it was found highest again in green gram stalks mixture (T<sub>9</sub>) and lowest was recorded in control only. After 10 days of incubation, there was again steep increase in CO<sub>2</sub> evolution in all the treatments.

During the daily examination of first 10 days of incubation, maximum CO<sub>2</sub> evolution was observed on the first day and afterwards, it showed an irregular pattern. Among all the treatments, green gram- T<sub>9</sub> (455.33 mg 100 g<sup>-1</sup>) showed highest CO<sub>2</sub> evolution followed by subabul leaves mixture – T<sub>7</sub> (438.97 mg 100 g<sup>-1</sup>). Control pot (T<sub>1</sub>) recorded the lowest evolution during the whole experiment. The CO<sub>2</sub> evolution in almost all the treatment mixtures showed a non-uniform increase during the next 60 days i.e., upto 70 days after

incubation. The green gram stalk mixture (T<sub>9</sub>) maintained its highest position (160.40 mg 100 g<sup>-1</sup>) in CO<sub>2</sub> evolution upto 30 days after incubation followed by soybean stalk mixture (T<sub>8</sub>) (155.70 mg 100 g<sup>-1</sup>). After 50 days of incubation, the sugarcane trash (T<sub>5</sub>) has become highest in releasing CO<sub>2</sub> followed by green gram stalks mixture (T<sub>9</sub>). The control pot showed the least evolution throughout the period. During the whole incubation study of 120 days, the evolution increased upto 70 days of incubation where it was observed that the highest evolution was recorded by green gram stalks mixture (T<sub>9</sub>) (354.20 mg 100 g<sup>-1</sup>) and lowest was in control pot (T<sub>9</sub>) (190.37 mg 100 g<sup>-1</sup>). Paddy straw mixture and sugarcane trash were found at par with green gram stalks. The pattern of CO<sub>2</sub> evolution showed that it increased to the peak and then started to decrease afterwards during the 90 days of incubation. The highest evolution was recorded in treatment T<sub>9</sub> (215.57 mg 100 g<sup>-1</sup>) which is green gram stalks mixture followed by T<sub>5</sub> i.e., sugarcane trash mixture (211.57 mg 100 g<sup>-1</sup>). Towards the end of incubation, the CO<sub>2</sub> evolution decreased and reached to the minimum, till 120 days. Control pot (T<sub>1</sub>) showed the least evolution of CO<sub>2</sub> while the highest was recorded in T<sub>8</sub> (soybean stalks mixture) (139.34 mg 100 g<sup>-1</sup>) which was followed by T<sub>4</sub> i.e., wheat straw mixture (116.86 mg 100 g<sup>-1</sup>)

The highest evolution by T<sub>9</sub> pot is attributed to the presence of one of the highest initial carbon content in green gram stalks. The result of the present experiment is in accordance with the experiment conducted by Hossain *et al.* (2017) [4] in which the CO<sub>2</sub> evolution from organic residues reached peak at 5<sup>th</sup> week of incubation and then decreased with irregular fashion until 21<sup>st</sup> week.

### Cumulative CO<sub>2</sub> evolution

The study on cumulative CO<sub>2</sub> evolution of different mixtures indicated that, the highest evolution was generated by green gram stalks mixture (T<sub>9</sub>) and lowest was recorded by control pot (T<sub>1</sub>) (Table 2). The pattern of CO<sub>2</sub> released from different mixtures was in order of green gram stalks (T<sub>9</sub>) > sugarcane trash (T<sub>5</sub>) > soybean stalks (T<sub>8</sub>) > subabul leaves (T<sub>7</sub>) > paddy straw (T<sub>3</sub>) > wheat straw (T<sub>4</sub>) > gliricidia lopping (T<sub>6</sub>) > cow dung (T<sub>2</sub>) > control (T<sub>1</sub>). Amid the results, it is obvious that all the residue mixtures showed significant amount of CO<sub>2</sub> evolution against the control pot. This result may be due to the microbial degradation of newly added organic residues in soil which evolved more CO<sub>2</sub> upon oxidation. Therefore, more carbon was mineralized in the form of its evolution. Dutta *et al.*, 2001 [1] and Paul and Solaiman, 2002 [8] also reported more CO<sub>2</sub> evolution from organic residue incubated by organic materials than control pot. There was a positive relationship between incubation period and cumulative CO<sub>2</sub> evolution. The most probable reason may be because in the beginning of decomposition, the residue is much complex in nature and also there is comparatively less number of microorganisms present for decomposition in soil, which goes on increasing upon organic residue addition. Hence, the evolution was going on gradually in the beginning and then, it took a jump after 30 days of incubation. Similar analytical results were reported by Ghimire *et al.*, (2017) [3] which also showed an increase in CO<sub>2</sub> evolution by addition of organic residues in soil.

**Table 2:** Effect of different organic residues on cumulative CO<sub>2</sub> evolution (mg 100 g<sup>-1</sup> soil).

Treatments	10 days	30 days	50 days	70 days	90 days	120 days	Cumulative
T <sub>1</sub>	326.90	113.70	147.03	190.37	136.37	69.35	984.82
T <sub>2</sub>	395.63	146.47	196.60	278.07	163.90	93.10	1272.67
T <sub>3</sub>	399.70	146.80	179.97	343.57	185.53	87.09	1342.66
T <sub>4</sub>	398.00	145.70	198.80	294.70	181.77	116.86	1335.83
T <sub>5</sub>	412.70	153.17	214.57	337.33	211.57	99.93	1429.27
T <sub>6</sub>	429.27	137.73	176.90	264.90	142.80	93.13	1244.72
T <sub>7</sub>	438.97	147.40	208.53	316.43	159.67	88.73	1359.73
T <sub>8</sub>	425.47	155.70	202.50	305.60	195.77	139.34	1424.37
T <sub>9</sub>	455.33	160.40	210.20	354.20	215.57	82.55	1478.25
S. E. ±	7.35	6.60	5.82	21.93	16.60	4.59	24.22
C. D. @ 5%	22.03	19.78	17.45	65.75	49.74	13.77	72.60

### Nitrogen mineralization

Nitrogen mineralization was studied in the form of NH<sub>4</sub>-N and NO<sub>3</sub>-N at different intervals. The data on nitrogen mineralization from 30 to 120 days of experimentation revealed that, nitrogen mineralization in the soil differs significantly due to addition of different organic residues. The NH<sub>4</sub>-N content of mixtures ranged between 27.54 mg kg<sup>-1</sup> to 48.98 mg kg<sup>-1</sup> at 30 days. The lowest N mineralization was recorded in control pot (27.54 and 16.27 mg kg<sup>-1</sup>) whereas, subabul leaves mixture in T<sub>7</sub> pot recorded the highest NH<sub>4</sub>-N (48.98 mg kg<sup>-1</sup>), NO<sub>3</sub>-N content (26.25 mg kg<sup>-1</sup>) was also recorded highest in subabul leaves mixture. Amidst all the organic residue mixtures, subabul leaves contained 3.2 per

cent of total nitrogen which might have decomposed faster owing to narrow C:N ratio. This might be the possible reason behind highest mineralization during the first stage. There was a sharp increase in N mineralization at 60 days interval. The treatments recorded a high nitrogen mineralization (NH<sub>4</sub>-N and NO<sub>3</sub>-N content) than at 30 days. At 60 days also, the great amount of NH<sub>4</sub>-N content (52.66 mg kg<sup>-1</sup>) was recorded in subabul leaves mixture in T<sub>7</sub> and gliricidia lopping mixture in T<sub>6</sub> (51.61 mg kg<sup>-1</sup>) was found at par with subabul lopping mixture (T<sub>7</sub>). The same trend was observed in case of NO<sub>3</sub>-N content. After 90 days, we noticed a slender decrease in NH<sub>4</sub>-N and NO<sub>3</sub>-N content compared to 30 and 60 days. Subabul leaves mixture in T<sub>7</sub> recorded 56.99 mg kg<sup>-1</sup> and 20.83 mg kg<sup>-1</sup> NH<sub>4</sub>-N and NO<sub>3</sub>-N respectively, which were higher than all the other treatments. The NH<sub>4</sub>-N content was found lowest in control treatment (T<sub>1</sub>) while sugarcane trash mixture recorded the lowest NO<sub>3</sub>-N which was 16.35 mg kg<sup>-1</sup>. During the last interval, there was again little decrease in NH<sub>4</sub>-N and NO<sub>3</sub>-N content. Subabul leaves mixture recorded highest NH<sub>4</sub>-N and NO<sub>3</sub>-N content (44.99 mg kg<sup>-1</sup> and 30.01 mg kg<sup>-1</sup> respectively). Finally, after the last interval, the N content in the form of both NH<sub>4</sub>-N and NO<sub>3</sub>-N reached the least value.

At all the monthly intervals, it was observed that highest N mineralization was recorded by subabul lopping mixture (T<sub>7</sub>) and gliricidia lopping mixture (T<sub>6</sub>) was found at par with subabul lopping mixture at every interval. It is observed that, there is slight difference in NH<sub>4</sub>-N and NO<sub>3</sub>-N content from 60 days onwards. Although, the trend of mineralization was not uniform but it can be observed that at 60 days, it increased and thereafter, it again decreased (i.e., immobilized). In other words, there was decreased trend of nitrogen mineralization after 60 days of experimentation. 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. Mishra *et al.*, (2016) [6] also stated that maximum N mineralization was attained at 45<sup>th</sup> day of incubation and thereafter, it started decreasing.

**Table 3:** Effect of different organic residues on N mineralization (mg kg<sup>-1</sup>).

Treatments	30 days		60 days		90 days		120 days	
	NH <sub>4</sub> -N	NO <sub>3</sub> -N	NH <sub>4</sub> -N	NO <sub>3</sub> -N	NH <sub>4</sub> -N	NO <sub>3</sub> -N	NH <sub>4</sub> -N	NO <sub>3</sub> -N
T <sub>1</sub>	27.54	16.27	34.15	15.12	26.11	16.60	20.61	11.94
T <sub>2</sub>	44.24	22.18	50.3	35.49	54.00	28.02	42.63	19.57
T <sub>3</sub>	32.15	20.79	48.41	32.94	47.29	26.00	37.33	17.50
T <sub>4</sub>	31.01	20.46	47.25	32.13	46.33	25.37	36.57	16.89
T <sub>5</sub>	28.18	19.88	44.94	31.73	46.95	25.05	37.06	16.35
T <sub>6</sub>	44.70	24.79	51.61	36.60	54.63	28.90	43.13	20.07
T <sub>7</sub>	48.98	26.25	52.66	38.02	56.99	30.01	44.99	20.83
T <sub>8</sub>	40.32	21.32	49.93	33.53	49.17	26.47	38.28	18.21
T <sub>9</sub>	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

### Conclusions

The results of soil and residue analysis were interpreted using the literature and the results of this study highlighted that CO<sub>2</sub> evolution occurs rapidly till 70<sup>th</sup> day of decomposition and after that, it decreases. The CO<sub>2</sub> evolution was found more in legume residues and more specifically in green gram stalks mixture. The N mineralization was at the peak after 60 days. Subabul leaves mixture was found superior over the other

organic residues in mineralization of N. Also, nitrogen was highly available after 30 days (i.e., 1 month) of residue application after this period it started to get immobilized. Therefore, to increase the availability of nutrients for crop use, organic residues should be applied approximately one month prior to sowing to ensure a greater availability of nutrients from the organic residues. The final conclusion states that for fast decomposition and nitrogen mineralization leguminous residue is more efficient than cereal or other organic residue. These analyses may help farmers to decisively use the residues of previous season in their field and ensure higher resource use, reduce the cost and harmfulness of chemical fertilizers. Still detailed study and improvement is needed in this area to improve the efficiency of organic residues.

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