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# Dynamics of plant residue decomposition and availability of nutrients

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**Abstract**
An experiment in relation to "Dynamics of plant residue decomposition and availability of nutrients" 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 study includes $CO_2$ evolution study as well as availability of nutrients. Different organic residues like cowdung, paddy straw, wheat straw, sugarcane trash, gliricidia loppings, subabul leaves, soybean stalks and green gram stalks were used in the investigation. $CO_2$ evolution was high on the first day and then it attained an approximately steady rate of evolution up to 10$^{th}$ day. Thereafter, it started increasing with a considerable amount and reached the peak on 8$^{th}$ week from where it declined till 120$^{th}$ day. From the cumulative $CO_2$ evolution of different mixtures, it was found that the highest evolution was generated by green gram stalks mixture ($T_9$) and lowest was recorded by control pot ($T_1$). Nutrient availability was also influence significantly due to different organic residues. The subabul leaves mixture was found superior among the others with respect to available nitrogen content (170.49 kg ha$^{-1}$) and highest P content (16.69 kg ha$^{-1}$) was found in Gliricidia lopping mixture. Where as green gram stalks mixture recorded highest potassium i.e., 395.2 kg ha$^{-1}$.

**Keywords:** Organic residue, cow dung, decomposition, carbon di oxide evolution, availability of nutrients

## Introduction
When organic waste, such as food and garden litter, is subjected to biological treatment, the remaining product can be referred to as organic residue. Variety of crop residues, the noneconomic plant parts left in the field after harvest, which include straws, stubble, stover and haulms of different crops and process wastes like groundnut shell, oil cakes, rice husks and cobs of maize and sorghum discarded during crop processing can be used for composting. Indian agriculture produces about 500 Mt of crop residues annually. Out of which 14.38 per cent (0.41 Mt) crop residue is burnt annually which directly contributes to global warming. 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. It also improves the structure, water and air balance as well as microbiological activity of the soil. 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, these crop residues are undertaken as treatments in the present study.

## Materials and Methods
An experiment in relation to "Dynamics of plant residue decomposition and availability of nutrients" 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 study includes $CO_2$ evolution study as well as availability of nutrients. Hence, the experiment was conducted as incubation study and a pot culture experiment in order to investigating $CO_2$ evolution and nutrient availability. Pot culture experiment was conducted in pot house whereas; incubation study was carried out in PG laboratory of the section. The soil for experiment was taken from college farm then used in the pots for experiment.

The soil was medium to deep black (Vertisol) and well drained. In order to study the chemical properties and biological properties of soil; soil was mixed very well and randomly one sample was taken for initial analysis. Soil sample was analysed for various soil properties in order to assess the fertility status of soil in advance. For the present investigation, it was planned to study the decomposition potential of different organic residues like cowdung, paddy straw, wheat straw, sugarcane trash, gliricidia loppings, subabul leaves, soybean stalks and green gram stalks. Cow dung was procured from Animal husbandry and dairy science (AHDS), College of Agriculture, Nagpur. Paddy straw, wheat straw, soybean stalks and green gram stalks were procured from incharge, Extra Assistant Director, College of Agriculture, Nagpur, whereas; Agroforestry research farm, College of Agriculture, Nagpur helped to get gliricidia leaves and subabul loppings. Sugarcane trash was procured from local vendor. The samples were then dried and analysed for nutrient content. The residue was added to 5 kg soil at 10 t $ha^{-1}$ on fresh weight basis. The mixture was mixed thoroughly and was transferred to earthen planters.

For incubation study ($CO_2$ evolution), 100 g mixture was taken from earthen planters and transferred to 1 L conical flasks. $CO_2$ evolution was studied daily for first 10 days and thereafter, at weekly intervals upto 120 days. $CO_2$ evolution was determined by alkali trap method. Flasks were covered tightly by rubber stoppers and were waxed and then they were kept at a safe place, after the specified time period (every day upto 10 days and thereafter at 1 week interval) contents of test tube were transferred to the beakers giving several washings to the test tubes for complete transfer and $CO_2$ evolution was determined by alkali trap method. Available nitrogen in soil was estimated using alkaline permanganate method (Subbiah and Asija, 1956) [18]. Olsen's method using spectrophotometer was adopted for estimating available phosphorus in soil (Olsen's and Sommer, 1982) [13]. Available potassium in soil was extracted by neutral ammonium acetate solution and was determined using flame photometer (Jackson, 1973) [9]. Available sulphur was determined by turbidimetric method mentioned by Chesnin and Yien (1951) [4].

## Results and Discussion

The data pertaining to nutrient content of organic residues is presented in table 1. From the data, it is revealed that, the organic carbon content was highest in soybean stalks (51.1%), whereas; gliricidia lopping (31.5%) recorded lowest OC content. Regarding nitrogen, it was observed that, highest nitrogen content was found in subabul leaves (3.2%) and lowest was recorded in sugarcane trash (0.4%). Wheat straw recorded lowest phosphorus content while, soybean stalks was lowest in sulphur content (0.05%). Mishra *et al.*, (2016) [11] studied nutrient content of different organic wastes and found that, sugarcane trash contains about 0.44 per cent total nitrogen and 45.24 per cent organic carbon. Manivasagaperumal *et al.,* (2011) found that, nitrogen, phosphorus and potassium content in the green gram as 54.4 mg $g^{-1}$, 5.4 mg $g^{-1}$ and 32.9 mg $g^{-1}$ respectively.

## Influence of organic residue addition on $CO_2$ evolution

Carbon dioxide is one of the principle metabolic products of heterotrophic microorganisms and $CO_2$ evolution from soil has frequently been used as a measure of microbial activity and rate of decomposition of added residues (organics). The data pertaining to cumulative $CO_2$ evolution is presented in table 2, whereas weekly $CO_2$ is depicted in figure 1. It was revealed that, $CO_2$ evolution from different soil mixtures increases significantly throughout the period of incubation. Initially the $CO_2$ evolution was studied on daily basis where it was found that the\$CO_2$ evolution ranged from 37.7 mg 100 $g^{-1}$ to 60.87 mg 100 $g^{-1}$. The evolution catches its peak on third day where it was found highest again in green gram stalks mixture ($T_9$) and lowest was recorded in control only. After 10 days of incubation, there was again steep increase in $CO_2$ evolution in all the treatments. During the first 10 days of incubation, maximum cumulative evolution was observed on the first day and onwards it showed an irregular pattern. The highest evolution was found in green gram stalks mixture ($T_9$) while the lowest was recorded in control pot ($T_1$). Treatments cow dung mixture ($T_2$), paddy straw mixture ($T_3$), wheat straw mixture (T4) and subabul leaves ($T_7$) mixture were found at par with green gram stalks mixture ($T_9$). The $CO_2$ evolution continued to increase in every pot upto 50 days of soil incubation. The lowest $CO_2$ evolution was recorded in control pot whereas highest evolution was recorded in $T_5$ with application of sugarcane trash followed by $T_9$ containing green gram stalks mixture. The treatments which were found at par with $T_5$ were wheat straw mixture ($T_4$), subabul leaves mixture ($T_7$), soybean stalks mixture ($T_8$) and green gram stalks mixture ($T_9$). Towards the end of incubation, the $CO_2$ evolution decreased and reached to minimum, till 120 days. Control pot ($T_1$) showed the least evolution of $CO_2$ while the highest was recorded in $T_8$ (soybean stalks mixture) which was followed by $T_4$ (wheat straw mixture). Ghimire *et al.*, (2017) [7] also reported that addition of organic residues increases the $CO_2$ evolution in soil.

From the cumulative $CO_2$ evolution of different mixtures, it was found that the highest evolution was generated by green gram stalks mixture ($T_9$) and lowest was recorded by control pot ($T_1$). The pattern of $CO_2$ released from different mixtures was in order of green gram stalks ($T_9$) > sugarcane trash ($T_{5)}$ > soybean stalks ($T_8$) > subabul leaves ($T_7$) > paddy straw ($T_3$) > wheat straw ($T_4$) > gliricidia lopping ($T_6$) > cow dung ($T_2$) > control ($T_1$). From the results, it is evident that all the residue mixtures showed significant $CO_2$ evolution against control pot. This may be due to microbial degradation of newly added organic amendments in soil which evolved more $CO_2$ upon oxidation. Therefore, more carbon was mineralized. Dutta *et al.*, 2001 [6] and Paul and Solaiappan, 2002 [17] also reported more CO2 evolution from organic residue incubated than control pot.

The results indicated positive relationship between incubation period and cumulative $CO_2$ evolution. It was most probably because in the beginning of decomposition, the residue is much complex in nature and also there is very less number of microorganisms present for decomposition. Hence, the evolution was going on steadily for first few days and then, it took a leap after 30 days of incubation period.

## Influence of organic residue addition on soil properties after incubation period

The modern agriculture needs to concentrate on use of nutrients through varying sources. The chemical fertilizer which are one of the major nutrient sources and are efficient and effective but at the same time are expensive and sometimes harmful. Therefore, the current trend is to explore the possibility of supplementing soil with organic ones particularly recycling them into usable nutrients. In the present heading, influence of organic residue is studied and presented in tabulated as well as diagrammatic forms.

**pH**

The data regarding changes in soil reaction and electrical conductivity due to addition of different organic residues is presented in table 3. Different organic residues added to soil non significantly altered the soil pH and electrical conductivity.

The initial soil pH was 7.53. After application of treatment, the highest soil pH value (7.53) was recorded in treatment absolute control i.e., $T_1$. The lowest pH reported was 7.21 in paddy straw ($T_3$). Ghuman *et al.* (1997) [8] found decrease in soil pH with green manuring of sunhemp while Shirale (2004) [16] reported non significant influence on addition of organic sources on soil pH and found lowest soil pH with application of gliricida.

**Soil Electrical Conductivity**

The values of electrical conductivity of soil ranged between 0.455 – 0.588 dS $m^{-1}$ with the application of different organic residues. The lowest EC was recorded in $T_1$ – control treatment. Mponya *et al.*, (2014) [12] informed that, the EC of soil recorded 0.89 dS $m^{-1}$ under RDF whereas, 0.76 dS $m^{-1}$ with application of organic material.

**Organic Carbon**

The soil organic carbon is one of the crucial parameter in substantial agricultural production and soil health and improves under integrated nutrient management and balanced amount of organic inputs. The result of organic carbon is shown in table 3. Different treatment combinations significantly improved the OC content of soil. 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 per cent 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 T8 i.e., soybean stalk mixture was found at par with subabul leaves mixture ($T_7$). There is about 17.56 per cent increment in OC over control treatment. Subabul leaves mixture ($T_7$) showed second highest OC content among all the treatments.

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 (T8) 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) [15] reported that incorporation of sugarcane trash increased soil organic carbon.

**Available nutrients**

India has a vast resource of organic waste with nutrient potential of about 6 Mt of nitrogen, phosphorus and potassium (Mishra *et al.*, 2016) [11]. The use of organic wastes is not only beneficial for crop yield but also increases store house of soil. The different organic residue mixture significantly altered availability of nutrients in soil. The data regarding availability of nutrients is presented in table 4 and illustrated in figure 1 and 2.

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

| Treatment | O.C. | N | P | K | S |
|---|---|---|---|---|---|
| $T_2$ -Cow dung mixture | 38.2 | 1.61 | 0.25 | 1.2 | 0.12 |
| $T_3$ - Paddy straw | 42.5 | 0.61 | 0.21 | 1.6 | 0.09 |
| $T_4$ - Wheat straw | 31.8 | 0.67 | 0.11 | 1.42 | 0.11 |
| $T_5$ - Sugarcane trash | 35.5 | 0.4 | 0.13 | 0.65 | 0.06 |
| $T_6$ - Gliricidia lopping | 31.5 | 2.5 | 0.52 | 1.48 | 0.15 |
| $T_7$ - Subabul leaves | 48.2 | 3.2 | 0.22 | 1.8 | 0.18 |
| $T_8$ - Soybean stalks | 51.1 | 1.05 | 0.2 | 2.2 | 0.05 |
| $T_9$ - Green gram stalks | 44.8 | 1.1 | 0.53 | 3.2 | 0.08 |

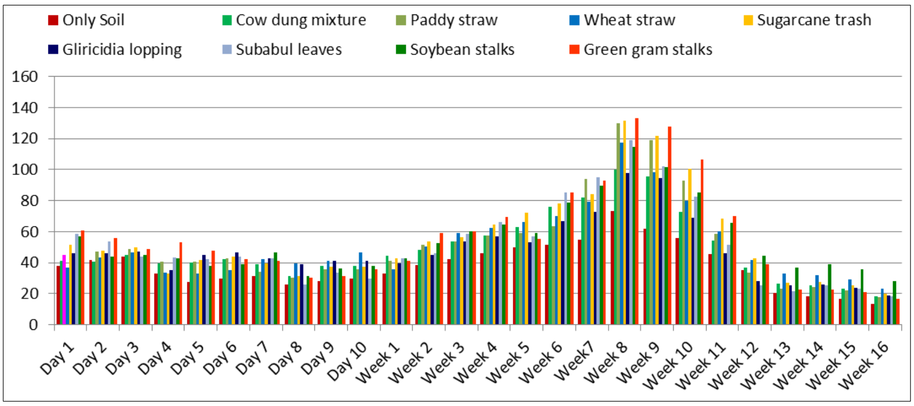


**Fig 1:** $CO_2$ evolution from different treatments on weeky basis

**Table 2:** Effect of different organic residues on cumulative $CO_2$ evolution (mg 100 $g^{-1}$ soil)

| Treatments | 10 days | 30 days | 50 days | 70 days | 90 days | 120 days | Cumulative |
|---|---|---|---|---|---|---|---|
| $T_1$ | 326.90 | 113.70 | 147.03 | 190.37 | 136.37 | 69.35 | 984.82 |
| $T_2$ | 395.63 | 146.47 | 196.60 | 278.07 | 163.90 | 93.10 | 1272.67 |
| $T_3$ | 399.70 | 146.80 | 179.97 | 343.57 | 185.53 | 87.09 | 1342.66 |
| $T_4$ | 398.00 | 145.70 | 198.80 | 294.70 | 181.77 | 116.86 | 1335.83 |
| $T_5$ | 412.70 | 153.17 | 214.57 | 337.33 | 211.57 | 99.93 | 1429.27 |
| $T_6$ | 429.27 | 137.73 | 176.90 | 264.90 | 142.80 | 93.13 | 1244.72 |
| $T_7$ | 438.97 | 147.40 | 208.53 | 316.43 | 159.67 | 88.73 | 1359.73 |
| $T_8$ | 425.47 | 155.70 | 202.50 | 305.60 | 195.77 | 139.34 | 1424.37 |
| $T_9$ | 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 |

**Table 3:** Effect of different organic residues on pH, EC and OC

| Treatments | pH (1:2.5) | EC (dS m-1) | OC (g kg-1) |
|---|---|---|---|
| $T_1$ - Absolute control | 7.53 | 0.43 | 4.88 |
| $T_2$ - Cow dung mixture | 7.49 | 0.573 | 5.26 |
| $T_3$ - Paddy straw mixture | 7.21 | 0.588 | 5.63 |
| $T_4$ - Wheat straw mixture | 7.31 | 0.581 | 5.03 |
| $T_5$ - Sugarcane trash mixture | 7.44 | 0.551 | 5.10 |
| $T_6$ - Gliricidia lopping mixture | 7.50 | 0.557 | 4.94 |
| $T_7$ - Subabul leaves mixture | 7.22 | 0.463 | 5.84 |
| $T_8$ - Soybean stalks mixture | 7.37 | 0.489 | 5.92 |
| $T_9$ - Green gram stalks mixture | 7.30 | 0.455 | 5.58 |
| Initial | 7.53 | 0.491 | 4.90 |
| S. E. ± | 0.12 | 0.075 | 0.07 |
| C. D. @ 5 % | - | - | 0.22 |

**Table 4:** Effect of different organic residues on available nutrients of soil (kg ha-1)

| Treatments | N | P | K | S |
|---|---|---|---|---|
| $T_1$ - Absolute control | 138.74 | 14.04 | 283.20 | 12.84 |
| $T_2$ - Cow dung mixture | 154.36 | 16.03 | 324.27 | 14.04 |
| $T_3$ - Paddy straw mixture | 142.17 | 16.02 | 342.93 | 13.65 |
| $T_4$ - Wheat straw mixture | 141.81 | 14.9 | 320.13 | 13.86 |
| $T_5$ - Sugarcane trash mixture | 140.62 | 15.16 | 285.17 | 13.37 |
| $T_6$ - Gliricidia lopping mixture | 165.94 | 16.69 | 339.20 | 14.27 |
| $T_7$ - Subabul leaves mixture | 170.49 | 15.52 | 365.33 | 14.17 |
| $T_8$ - Soybean stalks mixture | 146.35 | 14.69 | 376.53 | 13.36 |
| $T_9$ - Green gram stalks mixture | 153.31 | 16.30 | 395.27 | 13.54 |
| Initial | 137.98 | 13.56 | 280.65 | 12.80 |
| S. E. ± | 1.66 | 0.46 | 6.20 | 0.21 |
| C. D. @ 5 % | 4.97 | 1.38 | 18.60 | 0.63 |

## Nitrogen

Significantly, highest available nitrogen was recorded in subabul leaves mixture ($T_7$) which was recorded as 170.5 kg ha$^{-1}$. It was found that, treatment $T_7$ with application of subabul leaves mixture recorded 18.65 per cent more availability of nitrogen than control. From the results, it is evident that subabul lopping mixture is at par with gliricidia lopping mixture ($T_6$) which recorded 165.9 kg ha$^{-1}$ nitrogen. There is only 2 per cent increment in availability of nitrogen which shows application of glyricida lopping mixture ($T_6$) is as good as subabul leaves mixture ($T_7$). The lowest available nitrogen was recorded in control pot ($T_1$) which was only soil. The highest availability of nitrogen in subabul leaves ($T_7$) might be due to high content of nitrogen (3.2%) in subabul leaves. Also, The narrow C:N ratio of subabul leaves might be responsible for fast decomposition and easy release of nutrients. Ragheb *et al.*, (2017) [14] had reported significant increase in N, P and K content in soil after the application of organic wastes. Bhat *et al.*, (1991) [3] had also reported an increase in total and available N after application of crop residues.

## Phosphorus

The availability of phosphorus ranged from 14.04 to 16.69 kg ha$^{-1}$. Gliricidia loppings ($T_6$) showed maximum available phosphorus at the end of the study (16.69 kg ha$^{-1}$) followed by $T_9$ with the application of green gram stalks (16.3 kg ha$^{-1}$) and cow dung mixture ($T_2$) (16.03 kg ha$^{-1}$). The higher availability of phosphorus in organic residue treatments might be due to increased activity of microorganisms in the rhizosphere and their effect on solubilizing and mineralizing phosphorus compounds. Treatment $T_6$ was found at par with $T_9$, $T_2$, $T_3$ and $T_7$. It recorded 18.75 per cent and 15.88 per cent more available phosphorous than found in initial soil and control pot respectively. In the present study, the order of increment of available P observed is as gliricidia lopping > green gram stalks > cow dung > paddy straw > subabul leaves > sugarcane trash > wheat straw > soybean stalks > control. Bairathi *et al.*, (1974) [2] observed that different legume residue results into increased available P content of soil over control. Lanjewar *et al.*, (1992) [10] observed that, incorporation of rice straw in soil increases available P upto 20 per cent. Desai *et al.*, (2009) [5] reported that application of crop residues and FYM improved available P and K in soil.

## Potassium

Results revealed that, different organic residue application potassium availability increased significantly over control treatment. The availability of potassium among all the treatments ranged from 283.20 kg ha$^{-1}$ to 395.20 kg ha$^{-1}$. The highest potassium content was observed in green gram stalks in T9 (395.20 kg ha$^{-1}$). While, the lowest available potassium was recorded in treatment $T_1$ without any external input (283.20 kg ha$^{-1}$). The treatment $T_8$ with the application of soybean stalks mixture (376.53 kg ha$^{-1}$) stands second while; subabul lopping mixture ($T_7$) ranked third by recording 365.33 kg ha$^{-1}$ available potassium. Application of green gram stalks mixture in treatment $T_9$ recorded 28.99 and 28.34 per cent increment in available potassium over initial and control values respectively. K content of green gram stalks mixture ($T_9$) was highest among all organic residue which might be mineralized steadily. Hence, the highest available potassium was recorded in $T_9$ with application of green gram stalks. Bahadur *et al.*, (2014) [1] reported that, the organic and inorganic acids convert insoluble K (mica, muscovite, biotite feldspar) to the soluble form of K (soil solution form) with the net result increasing the availability of nutrients to plant. The increasing available K in soil due to addition of organic sources may be described to the reduction in K fixation and release of K due to interaction of organic material with clays besides the direct K addition in the soil (Subehia and Swapna, 2012) [19].

From above results it can be observed that, $CO_2$ evolution was evedent more generally in legume residues and specifically in green gram stalks mixture. It was also found that, the availability of nutrients was increased significantly with legume residues.

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

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