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Release of Nitrogen, Phosphorus and Potassium from Decomposing *Crotalaria juncea* L. in Relation to Different Climatic Factors

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Abstract

The nutrients bound in the litter especially nitrogen, phosphorus and potassium are released as a result of decomposition of different substrates like green manure. The NPK status of the green manure after incorporation in soil was evaluated from July 2007 to May 2008. From the results, the absolute amount of nitrogen was found to decline continuously starting from maximum of 0.86 g nitrogen during July 2007 to the minimum of 0.177 g nitrogen during May 2008. Same pattern was also observed for the phosphorus and potassium. The maximum phosphorus (0.063 g) and potassium (0.041 g) were found in July, 2007 and minimum phosphorus and potassium were found in May, 2008 i.e. 0.019 g and 0.127 g, respectively. The range of variation in the mineral nutrient content (%) of green manure mixed in soil is from 0.47 to 1.98 for nitrogen 0.028 to 0.039 for phosphorus and 0.47 to 0.61 for potassium.
Key words : Decomposition, Green Manure, Nutrient Release.

The decomposition of organic matter is pivotal to the functioning of an ecosystem. This process involves three major aspects : the microbial system, release of energy and release of nutrients. The last one is important to the stability of the ecosystem as a whole (1). Decomposition is a key process in the control of nutrient cycling and formation of soil organic matter (2). Decomposition of litter is also an integral and significant part of biochemical (i.e. intra system) nutrient cycling and food webs. This refers to both the physical and chemical breakdown of litter and the mineralization of nutrients. Decomposition of plant material is an important component for the maintenance of soil structure because of its critical role in nutrient cycling. The nutrients bound in the litter especially nitrogen, phosphorus and potassium are released as a result of decomposition of these elements for recirculation which provides stability to the ecosystem. The extensive studies have been done on the various aspects of green manure decomposition and mineral release but still there is a lack of comprehensive information on the mineralization of green manure in the field during the decomposition. Therefore this work was undertaken.

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Methods

The green manure crop, sunnhemp (*Crotolaria juncea*) was sown in the last week of May (27 May 2007) in an experimental field in the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. After eight weeks (the second week of July, i.e. July 14 July 2007), it was cut down and buried in the soil and left for decomposition. Sampling program was run from July 2007 to May 2008 at monthly intervals during decomposition of sunnhemp. The decomposing green manure samples were collected from 20 places. All the samples were brought in the laboratory and dried at 80 C for 48 hour and nitrogen, NPK estimation. The decomposition was also studied by nylon net technique. The sunnhemp litter was cut into small pieces (2—3 cm). Fifty of such nylon net bags of 1 mm^2 mesh size were prepared. Fifty gram of air-dried leaf litter was filled in each nylon net bag (30 × 5 cm). A trench with an area of 4m × 4m × 10 cm was made in the field. All the nylon net bags were

Table 1. Meteorological data standard (month wise) of Varanasi during 2006—2008.

Months	Rain-fall (mm)	Temperature (C) Max	Min	Relative humidity (%) Max	Min
Jul 2007	223.4	34.8	24.6	85	60
Aug	093.2	33.4	25.4	88	70
Sep	165.2	33.6	24.8	90	68
Oct	048.6	32.4	22.0	85	45
Nov	Nil	29.8	14.6	80	40
Dec	Nil	24.4	7.8	85	36
Jan 2008	011.8	22.2	8.6	78	42
Feb	016.6	24.4	9.6	75	36
Mar	Nil	34.4	16.2	65	32
Apr	001.8	40.2	21.6	50	15
May	015.6	41.6	24.8	46	16

placed in trench at depth of 10 cm. Sampling program was done at monthly interval.

During the experiment the climate was typically monsoonal characterized by three seasons viz., warm and moist rainy season (July—October), cool and dry winter season (November—February) and dry and hot summer (March—May). The total rainfall for the period July 2007 to May 2008 was 576.20 mm of which > 92% fell in rainy season alone (Table 1). The usual oven-dried method was adopted for moisture content estimation during the decomposition. The pH of the decomposed samples was estimated by Elico-electric pH meter.

Nitrogen content was estimated by micro Kjeldahl method (3) in each month. The material of different months was powdered in a mechanical grinder using fine mesh and the powder (0.10 g) was mixed with a little catalyst mixture (Na_2SO_4, $CuSO_4$ and selenium powder) and H_2SO_4. The mixture was digested in a micro Kjedahl flask. The volume of digest was made to 100 ml ; 10 ml aliquot of the solution was taken and distilled with 40% NaOH in distillation plant and the distillate was collected in a flask containing 10 ml of 2% boric acid with two drops of mixed indicator. This distillate was titrated against N/28 hydrochloric acid to a sharp pink end point. One ml N/28 hydrochloric acid is equal to 0.5 mg of nitrogen, from which nitro-

Table 2. Concentration, standing state and percent of original standing state of nitrogen during decomposition of green manure under experimental conditions. Values given in ± are standard deviation.

Months	Concen-tration (%)	Standing state (g)	Percent standing state
Jul 2007	1.95±0.050	0.860±0.000	100.00
Aug	2.08±0.057	0.750±0.007	87.21
Sep	2.09±0.028	0.630±0.029	73.25
Oct	2.10±0.025	0.443±0.024	51.51
Nov	2.12±0.050	0.416±0.014	48.37
Dec	2.14±0.040	0.389±0.020	45.23
Jan 2008	2.15±0.028	0.325±0.026	37.79
Feb	2.20±0.050	0.298±0.015	34.65
Mar	2.21±0.058	0.260±0.007	30.23
Apr	2.34±0.050	0.213±0.008	24.77
May	2.54±0.025	0.177±0.029	20.58

Table 3. Concentration, standing state and percent of original standing state of phosphorus during decomposition of green manure under experimental conditions. Values given in ± are standard deviation.

Months	Concen-tration (%)	Standing state (g)	Percent standing state
Jul 2007	0.0488±0.066	0.0630±0.0003	100.00
Aug	0.0489±0.005	0.0625±0.0002	99.21
Sep	0.0493±0.006	0.0582±0.0003	92.38
Oct	0.0494±0.008	0.0483±0.0004	76.67
Nov	0.0494±0.007	0.0325±0.0004	51.59
Dec	0.0494±0.008	0.0310±0.0005	49.21
Jan 2008	0.0495±0.006	0.0298±0.0006	47.31
Feb	0.0495±0.007	0.0256±0.0003	40.63
Mar	0.0495±0.003	0.0210±0.0004	33.33
Apr	0.0496±0.002	0.0200±0.0007	31.75
May	0.0496±0.005	0.0190±0.0005	30.16

Table 4. Concentration, standing state and percent of original standing state of Potassium during decomposition of green manure under experimental conditions. Values given in ± are standard deviation.

Months	Concen-tration (%)	Standing state (g)	Percent standing state
Jul 2007	0.770±0.006	0.410±0.000	100.00
Aug	0.790±0.008	0.400±0.002	97.57
Sep	0.820±0.007	0.250±0.003	60.98
Oct	0.840±0.004	0.240±0.004	58.54
Nov	0.860±0.005	0.210±0.003	51.22
Dec	0.860±0.006	0.190±0.004	46.35
Jan	0.870±0.007	0.140±0.003	34.15
Feb	0.875±0.005	0.138±0.002	33.66
Mar	0.880±0.004	0.129±0.003	31.47
Apr	0.885±0.005	0.128±0.003	31.22
May	0.886±0.004	0.127±0.003	30.34

Table 5. Mineral content of the decomposing green manure mixed with soil. Values given in ± are standard deviation.

Months	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Jul 2007	1.98±0.045	0.039±0.004	0.60±0.001
Aug	1.84±0.040	0.038±0.005	0.61±0.006
Sep	1.19±0.045	0.037±0.006	0.56±0.005
Oct	1.15±0.048	0.037±0.007	0.53±0.004
Nov	0.47±0.050	0.035±0.006	0.49±0.005
Dec	0.98±0.040	0.034±0.005	0.48±0.006
Jan 2008	0.85±0.042	0.033±0.006	0.47±0.005
Feb	0.78±0.047	0.033±0.007	0.48±0.004
Mar	0.48±0.035	0.030±0.006	0.48±0.005
Apr	0.72±0.030	0.028±0.005	0.47±0.004
May	0.98±0.035	0.029±0.006	0.48±0.005

Table 6. The pH and moisture content of decomposing litter under experimental conditions. Values given after (±) are standard deviation.

Months	pH	Moisture content (%)
Jul 2007	6.9	20.86±0.69
Aug	7.1	33.26±0.64
Sep	7.0	36.14±0.23
Oct	7.1	13.82±0.51
Nov	7.2	6.92 ±0.86
Dec	7.4	8.01 ±0.61
Jan 2008	7.3	6.11 ±0.47
Feb	7.0	3.62 ±0.63
Mar	7.1	8.69 ±0.52
Apr	7.2	2.02 ±0.42
May	7.1	2.63 ±0.22

gen (%) and total nitrogen was calculated.

Wet ashing technique (3) was used for estimation of phosphorus. The plant material (0.5 g) was taken in a 500 ml Kjeldahl flask and was digested with ternary acid (HNO_3+H_2SO_4+$HClO_4$ in proportion of 10 : 1 : 4). The digestion was continued until the major portion of the acid mixture got volatized and become colorless. After cooling it was diluted with distilled water and filtered in a 100 ml volumetric flask and the volume was maintained.

An aliquot of the extract solution was taken in 50 ml volumetric flask and pH was adjusted to with the help of Na_2CO_3 and H_2SO_4 using dinitrophenol as indicator. Added sulphomolybdic acid solution to the solution and blue color developed after adding a few drops of chlorostannous acid in the test solution and within the specified time, Transmission was read photometrically at 660 nm wave length. The concentration of test solution was determined by the referring the percentage transmission to the calibration curve prepared for standard solution of KH_2PO_4 at different concentration (4).

For the estimation of potassium, aliquots of the same solution prepared for phosphorus, were taken in a test tube and the base concentration read by systronics flame photometer type 121 (3).

Soil Analysis. The soil analysis was done to observe the changes in the nutrient status by the decomposition of green manure. Soil samples were collect from the experimental trench in which the green manure was sown for NPK estimation.

Nitrogen content by Kjeldahl dilution method, available phosphorus and exchangeable potassium were estimated during experimental period i.e. July 2007 to May 2008 (3).

Results and Discussion

Mineral Nutrient Content of Decomposing Green Manure

Nitrogen. The concentration of nitrogen increased from minimum of 1.95% (July 2007) to maximum of 2.54% (May 2008) despite an increase in the concentration of element. However, its absolute amount of nitrogen was found to decline continuously starting from maximum of 0.86 g nitrogen during July 2007 to the minimum of 0.177 g nitrogen during May 2008 (Table 2). Thus, it is obvious that during the period of study, the amount of nitrogen released (by weight) during the process of decomposition was 79.42%. Out of this, 48.49% was released during first three months from July to September in rainy season and the remainder during winter and summer season.

Further, concentration of nitrogen showed gradual increase, which may be attributed to the release of carbon during decomposition and retention of the element in the microbial tissue. Decomposers immobilize nutrient because initial concentration in litter are below the requirement of decomposers. In addition, fungal activity may contribute to an increase in litter nitrogen, because fungal mycelia permeating litter have higher concentration (generally 3—5%) than the leaf litter tissues. This process results in

transfer of nitrogen from organic matter to the soil during decomposition (5).

Phosphorus. Similarly the concentration of phosphorus in decomposing green manure also increased continuously from the minimum of 0.0488% (July 2007) to maximum of 0.0496% (May 2008). The absolute amount of phosphorus declined continuously (Table 3) along with the loss of dry weight of decomposing litter. It is observed that the absolute amount of phosphorus in green manure 0.0630 g in beginning decreased to 0.019 g. Thus, during the period of study, the amount of nitrogen released (by weight) during the process of decomposition was 69.84% reflecting the disappearance of 48.41% phosphorus during the first four months. A major portion of the disappearance is observed in rainy season.

The decrease in the concentration of phosphorus in the decomposing green manure is due to the microbial population infesting the litter that immobilized this element into the soil (6). Characteristics of the microbial community have some relationship with sediment phosphorus release rates and uptake of phosphorus in cultivated soils (7).

Potassium. The absolute amount of potassium decreased substantially with heavy rainfall in the rainy season (Table 4). The amount of potassium keeps on fluctuating till the summer season within the range of 0.770 to 0.886%. The decreasing concentration of potassium in decomposing litter may be ascribed to the susceptibility of the element to the process of leaching. The sharp decreases in absolute amount of potassium in the decomposing litter happened to be accompanied with decreasing concentration and increasing weight loss. The annual release of potassium was 69.66% out of which 41.46% release during rainy season.

The present findings are in accordance with the result of Bhardwaj and Datt (8) and Sinha (9). The soil water affects the pattern of mineral release during decomposition and added green manure (10). Microbial biomass also affects the mineralization of green manure (4). Soil quality affects the release of potassium as reported earlier (11—13).

Mineral Nutrient Content of Soil Mixed with Green Manure

The range of variation in the mineral nutrient content of green manure mixed in soil is from 0.47 to 1.98 for nitrogen, 0.028 to 0.039 for phosphorus and 0.47 to 0.61 for potassium (Table 5).

The rate at which the nutrients are released from litter is generally governed by the rate of decomposition, various nutrients may be released at different rates and may exhibit different release pattern. The action of soil fauna and microorganisms during the litter decomposition increase the rate of nutrient cycling and consequently increase soil ability to support plant growth. The results indicated higher rate of P, K and N release during the period of decomposition. Similar trend has been observed in the decomposition and mineralization of sunnhemp (14—16).

Conclusion

The study shows that during the decomposition of sunnhemp green manure the monthly loss of mineral and chemical constituents of the green manure suggest the incorporation of these minerals into the soil. The green manuring enhanced the nitrogen, phosphorus and potassium content in the soil. Thus the finding suggests the improvement of the nutritional status of the soil by green manuring.

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