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Nitrogen mineralisation of green manure crops during *rabi* – a relative analysis

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ABSTRACT

The relationship between the nitrogen content, biomass produced by the green manure crops (green gram, black gram, horse gram, cowpea, sunhemp, dhaincha and pillipesara) and the soil microbial communities with the nitrogen mineralization of the green manure residues at 20 and 40 days after incorporation (DAI) during rabi was studied at College of Agriculture, Rajendranagar, Hyderabad. The relative analysis indicated that the nitrogen content of the green manure crops had a strong positive relation with both NH_4^+-N (ammonical nitrogen) and NO_3^-N (nitrate nitrogen) mineralization at both the periods of observations (20 and 40 DAI). Similarly, the biomass produced by the green manure crops was found to be more strongly related to both NH_4^+-N and NO_3^--N mineralization. Both the nitrogen fractions (NH_4^+-N and NO_3^--N) released were positively and strongly related to microbial population up to 40 DAI.

***Keywords*:** Biomass, green manures, nitrogen content, nitrogen mineralization, soil microbial communities

Returning the above-ground crop residues to soil has a number of advantages in agroecosystems, including improved soil physical characteristics, greater nutrient availability, and soil organic matter conservation (Chen *et al*., 2014). Green manure residues are rich in nitrogen (N), which can be supplied to the succeeding crops once residues are returned to the soil system. However, the extent of this "nitrogen effect" varies with legume species, agricultural management, and site (Peoples *et al*., 2009).

Understanding the N mineralization patterns of leguminous green manure residues is critical for synchronizing N release from plant residue with subsequent crop uptake. Green manure decomposition and subsequent N release are substantially influenced by residue quality and amount, soil moisture and temperature, and specific soil characteristics such as texture, mineralogy, and acidity, as well as biological activity and the presence of other nutrients (Myers *et al*., 1994). In studies on litter mineralization, the rate of nutrient release has been connected to biochemical characteristics, particularly lignin, polyphenols, and N concentration (Palm and Sanchez, 1991; Palm *et al*., 2001; Wang *et al*., 2004). When the N release pattern from decaying materials and the nutritional needs of the subsequent crop coincides at the same time, soil integrated legume leftovers become valuable to the succeeding crop (Myers *et al*., 1994). In this view, the interaction between the N content of leguminous green manure crops and the biomass produced by them and soil microbial population on the net N mineralized in soil was related to understand the quality, decomposition and nutrient release of green manure crops during *rabi*.

MATERIALS AND METHODS

A field experiment was undertaken at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana located at 17^{0}32' N latitude and 78^{0}40' E longitude with an altitude of 550 m AMSL. The experiment was laid out in a strip plot design with three replications during *rabi*, 2020-21. The vertical strip plot included seven different green manure crops *viz.* green gram, black gram, horse gram, cowpea, sunhemp, dhaincha and pillipesara whereas the horizontal strip included three different decomposition enhancers *viz.* urea + single super phosphate (SSP), urea + SSP + microbial consortia, and urea + SSP + waste decomposer with a control wherein the green manure residues were incorporated without any addition of decomposition enhancer. The microbial consortia used in the experiment, called PUSA compost inoculant, comprised of four hyper-lignocellulolytic fungal cultures *viz. Aspergillus nidulans, Trichoderma viride, Phanerochaete chrysosporium* and *Aspergillus awamori* while the waste decomposer was manufactured by the National Centre for Organic Farming (NCOF). After the harvest of the green manure crops, they were incorporated *in situ* and the decomposition enhancers were applied and observed for 40 days after incorporation.

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Nitrogen mineralization was studied by determining the ammonical N and nitrate N fractions. Inorganic N in the soil was measured by extracting fresh soil samples with 2*M* KCl and determining the inorganic N in the extract by the MgO-Devarda alloy distillation method of Keeney and Nelson (1982). The number of potential lignocellulosic compounds degrading microorganisms was worked out using the enrichment culture technique. For estimation of lignolytic microorganisms, 10^{-3} dilution was used and for the estimation of cellulolytic microorganisms, 10^{-2} dilution was used . Population was expressed as following:

$$\text{No. of microorganisms (CFUg}^{-1}) = \frac{\textit{Number of colonies counted on the plate}}{\textit{Volume of the sample taken} \times \textit{Dilution factor}}$$

ANOVA was done for N mineralized and the population of the soil microbial organisms, following the standard statistical procedures. The linear correlation between N content, biomass produced by the green manure crops, and net N mineralized at each sampling period was determined by the Pearson's correlation coefficient and tested for significance at $\alpha = 0.05$.

The relationship between dry matter production of green manure crops, their N content, soil microbial population with N mineralization of green manures at 20 and 40 days after incorporation (DAI) was established by a linear quadratic function,

$$y = a+bx$$

where,

y = dependent variable

a = intercept

b = regression coefficient indicating the magnitude of variation per unit increase independent variable, and

x = independent variable

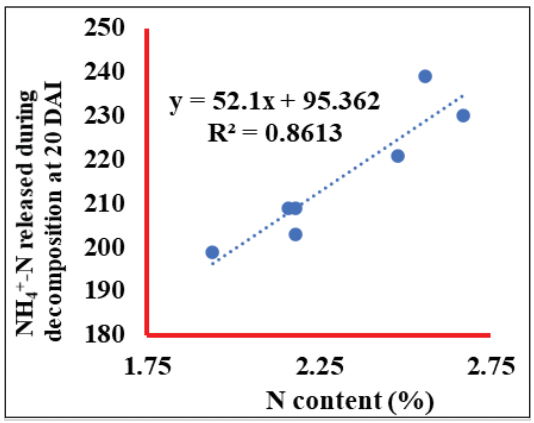
RESULTS AND DISCUSSION

The nitrogen content of the green manure crops showed a positive and strong relation with NH_4^+-N and NO_3^--N mineralisation at both the periods of observations (20 and 40 DAI) (Fig. 1a and 2a). The relation as established between N content of the green manure crops and its mineralisation in terms of NH_4^+-N and NO_3^--N suggested that the first-degree polynomial *i.e.* the linear function represented the data >80% at 20 DAI and >70% at 40 DAI. Both the linear (b) term and determination coefficient (R^2) indicated high predictive efficiency of the functions. The total explained variation in the prediction of N mineralisation through N content in green manure crops was 0.86 and 0.77 for NH_4^+-N and 0.83 and 0.75 for NO_3^--N mineralisation at 20 and 40 DAI, respectively.

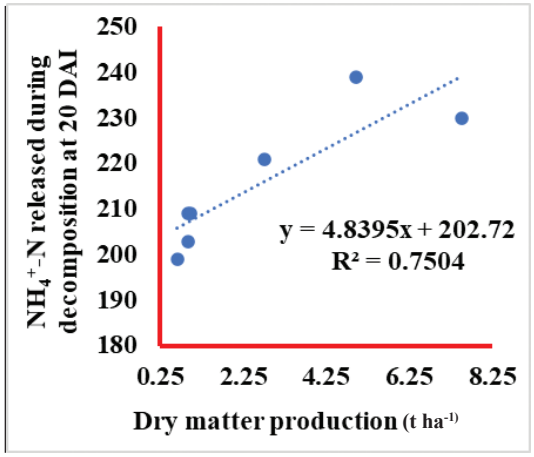
The relationship established between dry matter production of green manure crops and N mineralisation upon their incorporation indicated that the linear function represented the data > 70% at both the dates of sampling (20 and 40 DAI). The predictive efficiency of the linear term (b) and the determination coefficient (R^2) was high (Fig. 1b and 2b). The total explained variation in N mineralisation measured in terms of NH_4^+-N and NO_3^--N in relation to dry matter production of green manure crops was 0.75 and 0.79 for NH_4^+-N and 0.75 and 0.78 for NO_3^--N mineralisation at 20 and 40 DAI, respectively.

The lignocellulolytic microorganisms represented as microbial population had a strong relation with N mineralisation during initial days (20 DAI) of decomposition (Fig. 1c and 2c). With the progress of decomposition, the N mineralisation in relation to microbial population was moderate at 40 DAI. The linear function drawn between the microbial population and N mineralisation represented the data > 90% at 20 DAI and 64-66% at 40 DAI. The total explained variation in N mineralisation measured in terms of NH_4^+-N and NO_3^-N in relation to microbial population during the decomposition of green manure crops was 0.90 and 0.64 for NH_4^+-N and 0.91 and 0.66 for NO_3^--N mineralisation at 20 and 40 DAI, respectively.

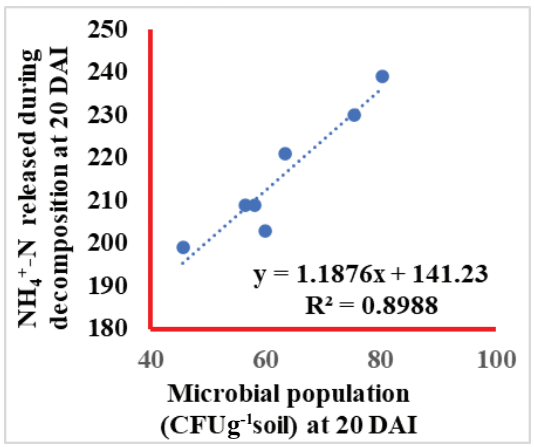
The mineralization of both micro-organisms and plant extractable forms (NH_4^+-N and NO_3^--N) of N of the incorporated green manure residues was more related to their N content. N mineralisation increased with the increase in the N content of the green manure crops. Similarly, biomass production was found to be more strongly related to both NH_4^+-N (R^2 values at 20 DAI – 0.75 and 40 DAI – 0.79) and NO_3^--N mineralisation (R^2 values at 20 DAI – 0.75 and 40 DAI – 0.78). Higher biomass production aided the release of more NH_4^+ and NO_3^- fractions by the decomposing green manure crops. But decreasing variation as the decomposition progressed indicated immobilisation of the N fractions. This could be validated by the relation of microbial population with the N mineralization. Both the N fractions (NH_4^+-N and NO_3^--N) released were positively and strongly related to microbial population up to 40 DAI (R^2 values of 0.90 (20 DAI) and 0.64 (40 DAI) for NH_4^+-N-Microbial population and R^2 values of 0.91 (20 DAI) and 0.66 (40 DAI) for NO_3^--N-Microbial population). Higher release of N fractions due to lesser microbial population initially at 20 DAI caused a greater variation due to variable amounts of dry matter added to the soil. However, the differences were lessened as the decomposition progressed due to immobilisation caused by increased microbial community.



(a) Correlation of N content (%) of the green manure crops with the NH_4^+-N released during decomposition at 20 and 40 DAI



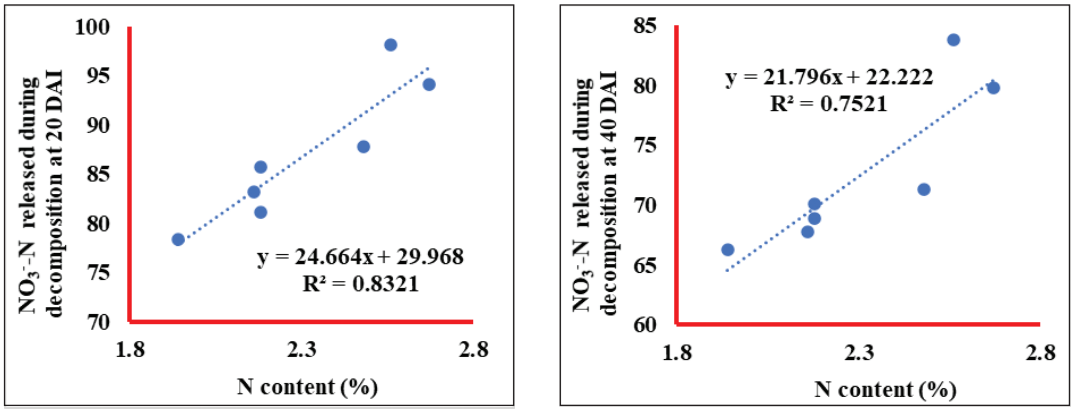
(b) Correlation of dry matter content (t ha^{-1}) of the green manure crops with the NH_4^+-N released during decomposition at 20 and 40 DAI



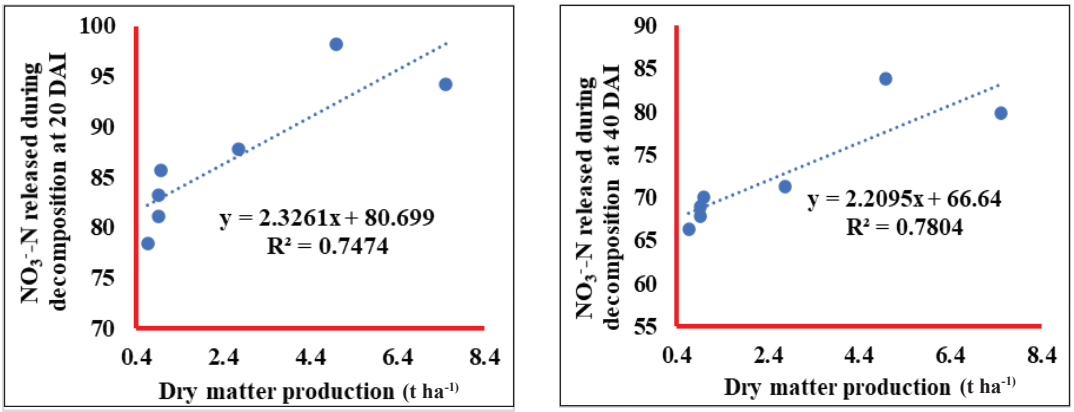
****R^2 values were significant at P=0.05**

(c) Correlation of microbial population (CFU g^{-1} of soil) of the soil with the NH_4^+-N released during decomposition at 20 and 40 DAI

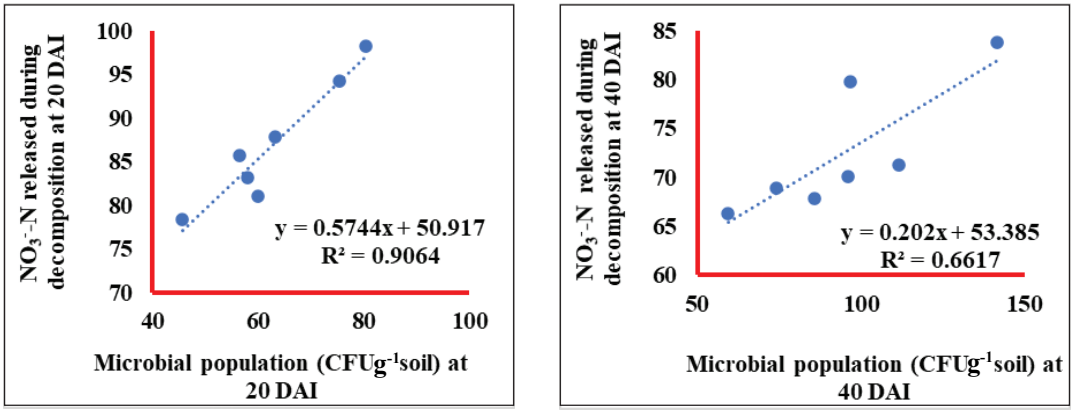
Fig. 1: (a), (b) & (c). Correlation of nitrogen content, dry matter of the green manure crops and microbial population of the soil with the NH_4^+-N released during decomposition



(a) Correlation of N content (%) of the green manure crops with the NO_3^-–N released during decomposition at 20 and 40 DAI



(b) Correlation of dry matter content (t ha^{-1}) of the green manure crops with the NO_3^--N released during decomposition at 20 and 40 DAI



(c) Correlation of microbial population (CFU g^{-1} of soil) of the soil with the NO_3^--N released during decomposition at 20 and 40 DAI

****R^2 values were significant at *P=0.05***

Fig. 2: (a), (b) & (c). Correlation of the nitrogen content, dry matter content of the green manure residues and microbial population of the soil with the NO_3^--N content during decomposition.

It could be understood from the linear function drawn between the N mineralization and the dry matter production of the green manure crops, their N contents and soil microbial communities that a strong positive correlation did exist between them with R^2 values ranging from 0.75 to 0.91 at 20 DAI and 0.64 to 0.79 at 40 DAI, indicating that these parameters are dependable to estimate the amount of N mineralized as a result of the decomposition of green manure crops at 20 and 40 DAI.

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