International Journal of Bio-resource and Stress Management 2014, 5(2):213-220
DOI: 10.5958/0976-4038.2014.00558.2

Full Research Article

Studies on N Mineralization from Soils Amended with Green Manures under the Influence of Two Different Moisture Regime

Sujan Biswas[1*], Arunava Ghosh[2], Abhas Kumar Sinha[3] and Prabir Mukhopadhyay[3]

[1]Coochbehar Krishi Vigyan Kendra, [2]Department of Agricultural Statistics,
[3]Department of Soil Science and Agricultural Chemistry, UBKV, Pundibari, CoochBehar, West Bengal (736 165), India

Article History

Manuscript No. AR634
Received in 31st January, 2014
Received in revised form 25th May, 2014
Accepted in final form 6th June, 2014

Correspondence to

*E-mail: biswassujan@rocketmail.com

Keywords

Green manure, moisture, mineralization, nitrogen, potential, rate constant

Abstract

A laboratory experiment was conducted over 12 weeks to study the nitrogen (N) mineralization pattern and kinetics from nine locally available green manure (GM) at submergence and field capacity (FC), when incorporated into typical rice growing teesta alluvial soils of the district Coochbehar located at Terai Agro-climatic region of West Bengal. Rapid mineralization was evidenced by the fact that out of total N mineralized at the end of incubation, 20.43-100.59% and 27.60-76.17% released during 1st week at submergence and FC, respectively. After 12 weeks highest N was mineralized from *C. sophera* (162.57 mg kg^{-1} soil) and *G. sepium* (195.72 mg kg^{-1} soil) amended soil at submerge and FC moisture condition, respectively. At submergence, soils amended with *I. cornea* and *V. ungiculata* and at FC, *G. sepium* and *E. indica* amended soil exhibited most consistent trend of successive increase till the end with a few exception; whereas mean (of moisture regime) cumulative mineralization showed most consistency in case of *V. ungiculata* and *C. sophera*. Mean (of GM) cumulative mineralization was better at submergence over FC moisture regime during early period; whereas reverse was the trend during later period of incubation. Similar was the trend for individual GMs except *C. sophera, G. sepium* and *I. cornea* recording higher value at FC almost all throughout the incubation period. FC moisture regime recorded higher mineralization potential (N_0) and lower rate constant (k) for all GMs; except N_0 value for *P. pinnata*. Considering all these above *C. sophera* and *V. ungiculata* were identified as best GM species across moisture regime as well as at submergence; whereas at FC moisture regime *G. sepium* and *E. indica* were best performing GM species.

1. Introduction

N is the most yield limiting nutrient in all rice-based cropping system (Cassaman et al., 1996) and high grain yield can be obtained only when rice assimilates adequate amount of N during growth period; but because of many opportunity for losses especially in alternating wet-dry cycles of rice system, it is most difficult to manage also. Further, soils of the district CoochBehar are inherently low in N status (Biswas et al., 2008). Moreover, from 90's onwards concerns about sustainable soil productivity, ecological and environmental quality, soil sickness and factor productivity decline in some cropping sequences, especially in rice-wheat cropping have caused renewed interest in carbon (C) renewal in soils and addition of organic manures (OMs) viz. farm yard manure (FYM), compost and green manure (GM) species as sources of plant nutrients have become focused research issues (Singh et al. 1988). Common sources of organic manures such as FYM are limited in supply as well as low and variable in nutrient contents. Moreover, farmers always prefer to apply these common sources of OM in cash crops which fetch much higher return than rice or wheat. Under this perspective, it has become the felt need to identify alternative, locally available potential biological N sources which would have promise to supply N to fulfill at least partial requirement of the crop and thus would enable to minimize the sole reliance on chemical N-fertilizer and promote environment friendly management system.

Decomposition of plant litter is the most important source of nutrients for crops. Many studies in India have highlighted the positive responses of green manuring (Katyal et al., 2001); however, suitability of a plant species as source of N to winter rice when incorporated into soil depends on synchronization of N release pattern from plant species and growth stage wise demand for N by the crop, which cannot be easy to achieve (Pang and Letey, 2000). A clear understanding on the estimates of N mineralization pattern, mineralization potential (N_0), mineralization rate constant (k) and N recovery from plant litter when incorporated into soil is necessary, to identify alternative potential biological N sources for green manuring. Further, mineralization from GM species when incorporated into soil is influenced by soil moisture (Sihag and Singh, 1999). Keeping these facts in mind, the present laboratory incubation experiment was under taken to compare the effect of different GMs on N mineralization kinetics in typical rice growing teesta alluvial soil at two different moisture regime viz. field capacity and submergence.

2. Materials and Methods

The incubation study was conducted during the year 2009-10 at the laboratory, Regional Research Station, UBKV, Pundibari, Coochbehar, West Bengal (WB), India. Soils collected from top (0-20 cm) layer of 20 cultivated fields under typical rice-wheat cropping system 10 days before harvesting of rice was used for the experiment. Sampling fields were located at the village Bararangras ($26^0$19' N, $89^0$23' E; 43 m above mean sea level) of Coochbehar district of Terai Agro-climatic Zone, West Bengal under humid subtropical India. Soils of the collected area belong to taxonomic class Aquic Ustifluvents. A composite sample was prepared from collected samples for use in laboratory incubation experiment. Physico-chemical properties of the soil were as follows : Texture-sandy loam (sand-62%, silt-21% and clay-17%), pH-5.48, Electrical conductivity-0.20 dsm^{-1}, Organic C-11.40 mg kg^{-1}, total N-912 mg kg^{-1}, available N-79.46 mg kg^{-1}, inorganic N-18.06 mg kg^{-1}, available P-16.52 mg kg^{-1}, available K-45.54 mg kg^{-1}), maximum moisture holding capacity-38.72% (w/w) and field capacity-22.48% (w/w).

Above ground portions of *V. ungiculata* and *A. hypogea* without reproductive parts, 32 days old plants of *S. rostrata*, tender shoot and leaves of *C. cajan*, *C. sophera, G. sepium, E. indica, P. pinnata* and *I. cornea* were collected. The samples were washed and then air dried first followed by sun drying and ground to pass through 0.5 mm sieve for use in laboratory experiment. Moisture content in the sun dried samples ranged from 9.1-10.2%. For chemical analysis a portion of washed and air dried samples were oven dried at 60^0 C until constant weight is obtained and ground to pass through 0.5 mm sieve. Ground plant materials were analyzed for total C by combustion method Guar et al. (1973) and total N by semi-micro Kjeldahl method of Bremner and Mulvaney (1982). Total C and N content of plant materials used in the experiment were as follows: *V. ungiculata*-45.70 & 2.55% , *A. hypogea*-47.10 & 2.42%, *S. rostrata*-45.10 & 2.98%; *C. cajan*-44.30 & 3.57%, *C. sophera*-42.60 & 3.18%, *G. sepium*-45.10 & 3.04%, *E. indica*-45.90 & 3.67%, *P. pinnata*-48.80 & 2.55% and *I. cornea*-49.70 & 2.31%. 1.21 kg of field moist soil (equivalent to 1 kg of oven dry soil) was placed in each plastic pot and ground plant materials were mixed with soil @ 400 mg N kg^{-1} soil and incubated at room temperature for twelve weeks at two moisture regimes *i.e.* submergence (1 cm depth of water at surface of the soil) and FC (22.48% moisture w/w) during the period from 1st December, 2009 to 22nd February, 2010. A control soil without addition of GM was also included. Each treated was replicated thrice. Moisture loss was replenished by adding required amount of distilled water every alternate day. Soil sub-samples were taken after 1st, 2nd, 3rd, 4th, 6th, 8th and 12th week for determination of mineral N (NH_4^+-N and NO_3^- -N) content following method of Keeney and Nelson (1982). Significance of moisture level and GM on cumulative mineralization was analyzed by applying standard method known as 'Analysis of variance' as applicable in factorial CRD using MSTATC statistical package (MSTATC, East Lansing, Mich.). The significance of treatments was tested using least significant difference (LSD) value at p=0.05, worked out for comparison between moisture levels, GMs and their interactions over the entire period of incubation. Best fit models for describing the cumulative N mineralization pattern and thereby to calculate the kinetic parameters of N mineralization in soils were chosen by using linear method and Levenberg-Marquardt method of parameter estimation for nonlinear models considering lower MSE and higher R^2 as the basis for choosing the best fit model. Linear model was not found to be suitable for describing the mineralization pattern as the values of MSE and R^2 were insignificant. Among the nonlinear models, cumulative N mineralization pattern over 12 weeks of incubation at both moisture regimes was best described using either logistic model : $N_t=N_0 / [1+(N_0/N_i-1)^* e^{-kt}]$ or exponential model : $N_t=N_0 (1- e^{-kt})+N_i$ (Yonebayashi and Hattori, 1986), where N_t=total inorganic N content in soil at time t (mg kg^{-1} soil), N_0=N mineralization potential (mg kg^{-1} soil), N_i=initial inorganic N content of soil (mg kg^{-1} soil), k=mineralization rate constant ($week^{-1}$) and e=base for natural logarithm. Mineralization kinetic parameters (N_0 & k) were calculated by iteration process using Levenberg-Marquardt method of parameter estimation for nonlinear models. Predicted value of total mineral N at each sampling time was calculated by putting the value of N_0, k and t in the best fit model equation.

3. Results and Discussion

3.1. Mean effect of GM species on N mineralization in soils

Mean cumulative N mineralization (Table 1) after 12 weeks of incubation ranged from 99.60 mg kg^{-1} soil in case of *A. hypogea* to 171.74 mg kg^{-1} soil in case of *C. sophera* amended soil with 91.24% and 229.76% increase over control (52.08 mg kg^{-1} soil); which was followed by *E. indica* (157.97 mg kg^{-1} soil), *G. sepium* (156.47 mg kg^{-1} soil) and *V. ungiculata* (155.69 mg kg^{-1} soil) amended soil with 203.32, 200.44 and 198.94% increase over control, respectively. At the mid stage *i.e.* after 6 weeks of incubation cumulatively mineralized N content was highest in *S. rostrata* (180.22 mg kg^{-1} soil) followed by *C. sophera* (169.54 mg kg^{-1} soil) and *C. cajan* (165.41 mg kg^{-1} soil) amended soil as against the lowest amount in case of *A. hypogea* (105.05 mg kg^{-1} soil) amended soil. Rapid mineralization at initial period was evidenced by the fact that out of cumulative N mineralized after 12 weeks of incubation, 35.23 to 81.18% released during 1st week, being highest and lowest in case of *S. rostrata* and *A. hypogea* amended soil, respectively. Such rapid mineralization during initial period can be explained by higher active microbial biomass during initial stages (Franzluebbers et al., 1994).

Pattern of mean cumulative N mineralization (of moisture regimes) followed complex differential trends according to GM species (Table 1). Nearly similar was the observation of Oglesby and Fownes (1992). Among all the GM species, *V. ungiculata* amended soil showed most consistent trend of successive increase with advancement of time period up to the end of the incubation (155.69 mg kg^{-1} soil). Soil amended with *A. hypogea* and *C. sophera* followed identical mineralization pattern of continuous increase, reaching peak value after 8 week of incubation (109.92 & 184.96 mg kg^{-1} soil, respectively) and a decline thereafter; but magnitude of cumulative mineralization was significantly higher from soil treated with *C. sophera*. Identical pattern of continuous increase up to 6th week (165.41 mg kg^{-1} soil) followed by differential trend of gradual decline was observed in case of *C. cajan* which corroborate findings of Fox et al. (1990) and Singh and Kumar (1996). Soils amended with *G. sepium, E. indica* and *I. cornea* showed similar pattern of cumulative mineralization up to 8th week-a sharp increase during first 3 week followed by a break at 4th week and again continuous increase up to 8th week but thereafter the increasing trend continued for *I. cornea* amended soil where as *G. sepium* and *E. indica* treated soil maintained almost a plateau with slight inclination towards decrease. Tian et al., (1992) also reported almost similar trend in case of *G. sepium* amended soil. Magnitude of mineralization was significantly higher in case of *G. sepium* and *E. indica* over *I. cornea* treated soil all throughout the incubation period. Among the GM species, *S. rostrata* amended soil recorded steep rise up to 4th week (189.21 mg kg^{-1} soil) followed by a sharp decline up to the end which was at par with findings of Pathak and Sarkar (1994). On the other hand *P. pinnata* amended soil showed a continuous increase up to 3rd week followed by alternative decline and increase reaching peak at 6th week. It was also noted from the Table 1 that in case of *C. cajan*, *S. rostrata*, *C. sophera*, *G. sepium* and *E. indica* amended soil comparatively sharper rise was observed up to 3rd week. This might be due to narrower C:N ratio (12.53 to 15.14) compared to other species (18 to 21.58) used in the experiment.

3.2. *Mean effect of moisture regime on N mineralization in soils*

Soil moisture levels at which incubation studies were carried out found to exert a profound influence on mean (of GM residues) cumulative N mineralization in soil (Table 2). Pattern of mean cumulative mineralization at both submergence and FC moisture level was identical during early stages of incubation. Mean cumulative N mineralized at submerge moisture regime progressively increased with time period reaching peak at 4th week (127.58 mg kg^{-1} soil) followed by

Table 1: Mean cumulative N mineralization in soils (mg kg^{-1}) over the period of incubation as influenced by GM residues

GM residues	Period of incubation (week)						
	1st	2nd	3rd	4th	6th	8th	12th
V. ungiculata	57.36	74.64	102.08	106.00	147.23	151.75	155.69
A. hypogea	35.09	60.86	82.15	95.44	105.05	109.92	99.60
S. rostrata	119.26	153.97	174.12	189.21	180.22	155.47	146.91
C. cajan	83.59	117.60	148.45	153.92	165.41	164.89	147.53
C. sophera	101.01	148.03	168.54	169.17	169.54	184.96	171.74
G. sepium	75.84	102.95	149.90	127.67	143.06	158.00	156.47
E. indica	91.41	116.27	149.28	141.71	146.48	158.94	157.97
P. pinnata	59.66	84.60	100.47	94.49	113.80	104.94	112.30
I. cornea	50.95	58.67	103.92	99.06	119.90	132.10	137.14
Control	38.77	45.49	54.49	55.00	56.51	44.77	52.08
SEd	3.81	5.16	4.98	4.81	4.76	4.92	5.30
LSD (p=0.05)	7.70	10.43	10.07	9.74	9.63	9.94	10.71

alternative decrease and increase in successive time periods; which was nearly similar with observation of Singh et al., (1991). On the other hand at FC moisture level a gradual increase in cumulative mineral N up to 3rd week followed by a decline at 4th week, reaching peak at 6th week (150.79 mg kg^{-1} soil) and thereafter a plateau was observed. Nearly similar was the observation of Pathak and Sarkar (1995). Magnitude of cumulative mineralization was higher at submergence during early periods; whereas at later periods significantly higher value was recorded under FC. Singh et al., (1988) and Dey and Jain (1996), also recorded higher N mineralization at FC than under waterlogged condition. Sihag and Singh (1999) also observed higher N mineralization at 50% and 75% water holding capacity (WHC) than that recorded at 100% WHC. Superiority of submergence over FC moisture condition at early periods of incubation was probably due to increased activity of anaerobic microbial organisms whereas the reverse trend at later periods of incubation was presumably because of greater nitrogen losses by de-nitrification or lower microbial activity due to lack of oxygen at submergence. The trend of mineralization indicates that continuous submergence at early periods followed by drying may favour better mineralization. Saha et al. (2013) maintenance of a drying phase in a submerged soil at pre-tillering or pre-flowering stage favours consumption of higher amount of N from the soil system.

3.3. Interaction effect of GM species and moisture regime on N mineralization

A perusal of data presented in Table 3 showed that cumulative N mineralized over entire period of incubation was significantly influenced by GM sources at both submerge and FC moisture levels. Cumulative N mineralization from soils amended with GMs accorded significantly higher value over control soil throughout the incubation period both at submerge and FC moisture regimes with exception in case of *A. hypogea* (39.67 mg kg^{-1} soil) and *I. cornea* amended soil (24.98 mg kg^{-1} soil) at 1st week under submergence. After 1st week of incubation highest and lowest value of mineralized N was accrued with *S. rostrata* (125.43 mg kg^{-1} soil) and *I. cornea* amended soil which was significantly lower than that in the control (43.57 mg kg^{-1} soil). On the other hand at FC after completion of 1st week of incubation *C. sophera* (137.80 mg kg^{-1} soil) amended soil resulted to release highest cumulative N followed by *S. rostrata* (113.08 mg kg^{-1} soil) and *E. indica* amended soil (85.96 mg kg^{-1} soil) and lowest amount in soil treated with *A. hypogea* (30.52 mg kg^{-1} soil), which was lower than the control (33.97 mg kg^{-1} soil). Magnitude of cumulative mineralization under submergence at the end of incubation ranged from 88.62 mg kg^{-1} soil in case of *A. hypogea* to 162.57 mg kg^{-1} soil in case of *C. sophera* amended soil with respective increase of 195.76 and 359.11% over control (45.27 mg kg^{-1} soil); whereas at field capacity highest and lowest magnitude was recorded in soil treated with *G. sepium* (195.72 mg kg^{-1} soil) and *A. hypogea* (110.57 mg kg^{-1} soil) with respective increase in the tune of 332.29 and 187.73% over control ((58.90 mg kg^{-1} soil).

The pattern of mineralization at submergence from *A. hypogea, C. sophera* and *S. rostrata* amended soil were identical throughout the incubation period following gradually increasing trend up to 4th week followed by alternative decline and rise at 6th, 8th and 12th week attaining highest value at 8th week in case of *A. hypogea* & *C. sophera* (104.89 & 173.87 mg kg^{-1} soil, respectively) and at 4th week in case of *S. rostrata* amended soil (191.28 mg kg^{-1} soil). Mineralization values further indicated that up to 4th week mineralization was significantly higher with *S. rostrata* than soils treated with rest two species; whereas 4th week onwards the values were significantly higher in soils amended with *C. sophera.* On the other hand *C. cajan* and *G. sepium* treated soil maintained a close parity with each other with successive increase up to 3rd week, wherein they reaches peak value (149.79 & 132.34 mg kg^{-1} soil, respectively) followed by gradual decline at 4th and 6th weeks and then alternative increase and decrease. Here also magnitudes of mineralization significantly varied between *C. cajan* and *G. sepium* amended soils except at 2nd, 6th and 12th week. Further, soils treated with *I. cornea* and *V. ungiculata* exhibited nearly similar pattern of mineral N release showing consistent continuous increase with advancement of time period till the end with only exception in case of *V. ungiculata* amended soil in between 3rd-4th week. Rest two GM species - *P. pinnata* and *E. indica* when mixed with soils and incubated, nearly identical trend of cumulative N release-an increase in value up to 3rd and 2nd week, respectively, followed by alternative decrease and increase attaining highest value at 3rd (115.72 mg kg^{-1} soil) and 4th (158.21 mg kg^{-1} soil) week, respectively was observed. On the other hand at field capacity

Table 2. Cumulative N mineralization in soil (mg kg^{-1}) over the period of incubation as influenced by moisture condition

Moisture conditions	Period of incubation (week)						
	1st	2nd	3rd	4th	6th	8th	12th
Submerge	69.99	103.85	125.52	127.58	118.65	122.95	117.12
Field capacity	72.92	88.76	121.16	118.75	150.79	150.20	150.36
SEd	1.70	2.31	2.23	2.15	2.13	2.20	2.37
LSD (p=0.05)	3.44	4.67	4.51	4.35	4.31	4.45	4.79

moisture level pattern of cumulative N mineralization from soil amended with *V. ungiculata* was nearly identical to that under submergence following a gradual and consistent increase up to the end of the incubation excepting only one break at 8th week. Further, pattern of cumulative mineralization from *G. sepium* and *E. indica* amended soils were identical throughout the incubation period; consistently increased up to the end of incubation where they reached peak values (195.72 & 181.94 mg kg^{-1} soil) with a break at 4th week. The pattern was quite similar to that observed by Mohanty et al. (2010) in case of *G. sepium*. Cumulative N mineralization pattern from *I. cornea* amended soils followed alternative rise and decline during initial stages of incubation but 4th week onward there was consistent increase up to the end of incubation and the trend was identical to that of *G. sepium* and *E. indica* amended soils. Although the differences in magnitude of cumulatively mineralized N between soils amended with *G. sepium* and *E. indica* were not significant except at 6th and 8th week; but both the GM species recorded significantly higher values over *I. cornea* throughout the incubation period. Soils when treated with *A. hypogea*, *S. rostrata* and *C. cajan* and incubated at field capacity moisture level followed gradual increase in cumulatively mineralized N with highest values at 6th week (121.41, 215.74 & 202.51 mg kg^{-1} soil, respectively) and gradual decline thereafter. It was further noticed that differences in magnitudes of cumulatively mineralized N from soils amended with *S. rostrata* and *C. cajan* were significant only during early period i.e. up to 4th week. Further, soils amended with *C. sophera* released mineral N in similar pattern like that of soils amended with *G. sepium* and *E. indica* up to 8th week. Similarly, trend of mineralization from *P. pinnata* amended soil was identical to *G. sepium* and *E. indica* amended soils except another decline at 8th week.

Results presented in Table 3 further showed that after 1 week the magnitude of mineralization was significantly higher at submergence over field capacity from *S. rostrata, C. cajan, E. indica* and *P. pinnata* amended soil but reverse was the result when *C. sophera* and *I. cornea* were mixed with soil; whereas for rest three GM species differences between two moisture regimes were non-significant. Whereas, after 12 weeks of incubation higher cumulative mineralization was recorded at FC than that under submerge moisture level for all GM species used in the experiment and variations were significant

Table 3: Cumulative N mineralization in soil (mg kg^{-1}) over the period of incubation as influenced by GM residues and moisture condition

GM residues	Submergence (period of incubation in week)						
	1st	2nd	3rd	4th	6th	8th	12th
V. ungiculata	61.78	90.45	134.97	119.98	133.17	144.72	146.85
A. hypogea	39.67	70.20	93.89	101.59	88.68	104.19	88.62
S. rostrata	125.43	169.35	181.69	191.28	144.70	132.69	124.70
C. cajan	99.85	120.20	149.79	142.14	128.32	144.30	124.30
C. sophera	64.22	134.75	159.70	173.58	165.62	173.87	162.57
G. sepium	74.65	113.20	132.34	126.98	116.43	127.70	117.22
E. indica	96.87	134.48	129.79	158.21	138.97	144.24	134.00
P. pinnata	65.62	103.20	115.72	106.84	113.05	98.22	105.43
I. cornea	24.98	50.75	97.35	104.96	106.72	118.19	122.28
Control	43.57	51.95	60.00	50.28	50.82	41.39	45.27
GM residues	Field capacity						
V. ungiculata	52.93	58.82	69.19	92.03	161.30	158.78	164.53
A. hypogea	30.52	51.52	70.42	89.29	121.41	115.65	110.57
S. rostrata	113.08	138.59	166.55	187.15	215.74	178.25	169.12
C. cajan	67.33	115.01	147.12	165.70	202.51	185.48	170.76
C. sophera	137.80	161.31	177.38	164.77	173.47	196.05	180.90
G. sepium	77.04	92.71	167.45	128.36	169.68	188.30	195.72
E. indica	85.96	98.06	168.78	125.20	153.99	173.64	181.94
P. pinnata	53.70	66.00	85.22	82.14	114.55	111.65	119.16
I. cornea	76.91	66.60	110.49	93.16	133.07	146.01	152.00
Control	33.97	39.03	48.98	59.72	62.20	48.15	58.90
SEd	5.39	7.30	7.05	6.81	6.74	6.96	7.49
LSD (p=0.05)	10.89	14.76	14.25	13.77	13.62	14.06	15.15

excepting *P. pinnata* treated soil and control one. Bhardwaj and Datt (1995) also reported higher mineralization at field capacity moist soil than water saturated soil when amended with *S. cannabina, C. juncea* and *V. ungiculata*.

Comparisons of trend in cumulative N mineralization between submerge and FC moisture regime from GM species as pointed out that there was general tendency of better mineralization at submergence over field capacity up to 3rd or 4th week and 4th week onward the trend was reverse for most of the GM species. *C. sophera, G. Sepium* and *I. cornea* amended soils recorded higher value at FC over submergence almost all throughout the incubation period except at 4th week for *C. sophera, I. cornea* and at 2nd week in case of *G. Sepium* amended soil. A close agreement between measured and predicted values of cumulative mineralization was observed for all the GM species at both moisture regimes (Figure 1).

3.4. Effect of GM species and moisture regime on N mineralization kinetics

Linear model was found not to be suitable for describing the mineralization pattern in soils amended with GMs at both the moisture regime as the values of MSE and R^2 were insignificant. Among the nonlinear models, exponential and logistic models were found to be fitting best. At submerge moisture regime N mineralization pattern from soils amended with *V. ungiculata, S. rostrata, C. cajan, E. indica* could be best described by exponential equation and logistic equation was found to be best for describing N mineralization pattern from soils treated with *A. hypogea, C. sophera, G. sepium, P. pinnata* and *I. cornea*. Manguiat et al. (1994) also found that N mineralization patterns of flooded soils in the laboratory followed a logistic function. On the other hand at field capacity moisture regime exponential model was identified as the best model for explaining the N mineralization pattern from soils amended with GM species used in the study except *A. hypogea* for which logistic equation was the best one (Table 4). Earlier reports also confirmed that mineralization from cowpea (Franzluebbers et al., 1994) and other legumes (Palm and Sanchez, 1991) could be best described by single exponential model.

A perusal of the data presented in Table 5 showed that N_0 which is an estimate of total quantity of soil organic N that is susceptible to mineralization in infinite time was found to be affected by sources of N as well as soil moisture regime. N_0 values were noted to be ranged from 114.13 mg kg^{-1} soil for *A. hypogea* to 186.13 mg kg^{-1} soil for *C. sophera* amended soil at submergence and from 116.84 mg kg^{-1} soil for *P. pinnata* to 191.43 mg kg^{-1} soil for *G. sepium* treated soil at FC. A comparison of N_0 values of soils amended with GM species at submerge condition revealed that GM species used in the experiment followed the descending order- *C. sophera>S. rostrata>V. ungiculata>E. indica>G. sepium>C. cajan>I. cornea>P. pinnata>A. hypogea*; however, at field capacity moisture level the series was quite different and followed the descending order- *G. sepium>V. ungiculata>C. cajan>S. rostrata>C. sophera>E. indica>I. cornea>A. hypogeal>P. pinnata*. Results further indicated that higher values of N_0 were recorded at field capacity for all the GMs except *C. sophera* & *P. pinnata* amended soils. Nearly similar were the observation of Sihag and Singh (1999) who recorded higher N_0 values of *S. aculeata* amended soil at 50% water holding capacity (WHC) than at 75% WHC. On the other hand k, which can determine rate of decomposition, also varied according to the GM species and soil moisture levels. K values at submerge moisture condition varied from 0.563 week^{-1} for *V. ungiculata* to 2.529 week^{-1} for *G. sepium* amended soil and from 0.202 week^{-1} for *V. ungiculata* to 1.391 week^{-1} for *C. sophera* amended soil at field capacity. The k value of 0.0494 day^{-1} in *V. ungiculata* amended moist soil was also reported by Franzluebbers et al. (1994). Further that comparison of k values between two moisture regimes for respective GM source revealed that it was always higher at submergence than at field capacity which is supported by findings of Sihag and Singh (1999), who also noted higher k values with increasing soil moisture content.

Table 4: MSE and R^2 value of best fit models for GM species at different moisture regimes

GM residues	Submergence			Field capacity		
	MSE	R^2	Best fit model	MSE	R^2	Best fit model
V. ungiculata	96.69	0.92	Exponential	341.50	0.89	Exponential
A. hypogea	121.94	0.91	Logistic	183.15	0.96	Logistic
S. rostrata	52.32	0.69	Exponential	55.14	0.76	Exponential
C. cajan	27.37	0.66	Exponential	112.60	0.93	Exponential
C. sophera	45.43	0.99	Logistic	427.68	0.72	Exponential
G. sepium	749.36	0.90	Logistic	317.50	0.84	Exponential
E. indica	96.19	0.77	Exponential	472.27	0.73	Exponential
P. pinnata	39.15	0.88	Logistic	79.32	0.90	Exponential
I. cornea	48.25	0.97	Logistic	342.43	0.75	Exponential

Table 5. Mineralization potential (mg kg^{-1}) and rate constant (week^{-1}) of GM residues at submergence and field capacity

GM residues	Submergence		Field capacity	
	Mineralization potential (N_0)	Mineralization rate constant (k)	Mineralization potential (N_0)	Mineralization rate constant (k)
V. ungiculata	144.24	0.563	191.26	0.202
A. hypogea	114.13	1.578	133.65	0.894
S. rostrata	175.49	1.704	187.28	0.819
C. cajan	137.13	1.304	189.17	0.500
C. sophera	186.13	1.923	178.60	1.391
G. sepium	141.57	2.529	191.43	0.415
E. indica	142.71	1.189	170.84	0.557
P. pinnata	126.00	2.486	116.84	0.431
I. cornea	135.20	1.065	148.84	0.378

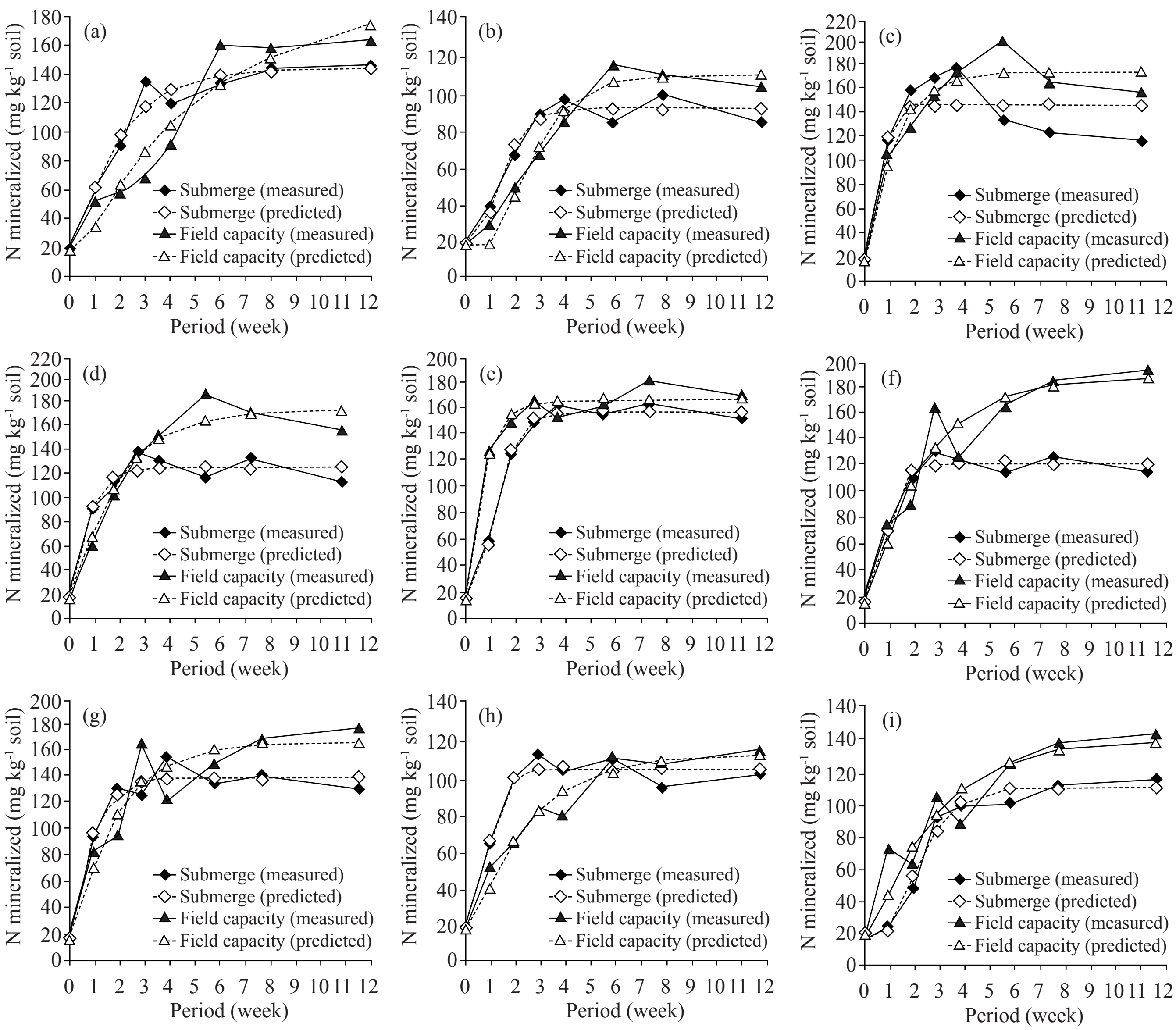

Figure 1: Measured and predicted values of cumulative N mineralization over twelve week period at two moisture regimes in soil amended with (a) *V. ungiculata* (b) *A. hypogea* (c) *S. rostrata* (d) *C. cajan* (e) *C. sophera* (f) *G. sepium* (g) *E. indica* (h) *P. pinnata* & (I) *I. Cornea*

4. Conclusion

From the study it can be concluded that on the basis of magnitude and trends of cumulative mineralization over the incubation period as well as N_0 and k values FC could be considered as the better moisture regime over submergence. *C. sophera* and *V. ungiculata* were identified as best GM species at submergence; whereas at FC moisture regime *G. sepium* and *E. indica* were best performing GM species. *C. sophera* and *V. ungiculata* were found to be best performing GM species when magnitude and pattern of mineralization were considered irrespective of moisture regime.

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