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Short Research Article

Influence of Inorganic Fertilizers and Organic Amendments on Plant Nutrients and Soil Enzyme Activities under Incubation

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Abstract

An incubation experiment was carried out in the department of Soil Science and Agricultural Chemistry, ANGRAU, Hyderabad, India during 2013−14 with 12 treatments including control to study the mineralization pattern and timely release of nutrients (N, P, K and soil enzymes) to plant from different sources and periods. Mineralization of nitrogen (NH_4^+-N and NO_3^--N), phosphorus (P_2O_5) potassium (K_2O) and soil enzymes (urease, acid and alkaline phosphatase and dehydrogenase) activities from different treatments were evaluated. During initial period 7 to 21 days after incubation (DAI), the recommended dose of fertilizer (RDF) had maximum release of NH_4^+-N and NO_3^--N and later on decreased in the succeeding days but manures combination treatment has taken lead to release the N from 1 DAI to 70 DAI than control. Similar trends were followed in available P_2O_5 and K_2O. The maximum quantity of urease and DHA were reached 203 to 227 µg NH_4^+-N g^{-1} soil h^{-1} and 10.6 to12.4 µg TPF g^{-1} soil h^{-1} from combination of poultry manure and neem cake at 70 DAI, respectively. Maximum released of acid and alkaline phosphatase were observed in 21 DAI and 35 DAI in RDF respectively. Among the manures treatment, PM+NC had superior in releasing of alkaline phosphatase over other, followed by poultry manure and FYM+PM. Correlation study between nutrients (N, P and K) and enzymes activity showed that a significant ($p<0.05$) positive relationship with each others.

1. Introduction

Fertile and well-managed soils form the basis for efficient crop production. The three most important elements are needed for crop productions are nitrogen (N), phosphorus (P) and potassium (K). Nitrogen (N) is a vitally important plant nutrient and is the most frequently deficient of all nutrients. There is an apprehension that the use of chemical fertilizers over the years might beimpairing the soil fertility. In continuous cropping, use of imbalanced nutrients (N or NP alone) through inorganic fertilizers without organic manure cannot sustain the desired level of crop production (Tiwari et al., 2002).

Soil amendment could play an important role in plant nutrition in the organic agriculture movement as well as under the integrated soil fertility system. Since the sole use of mineral fertilizer has been reported to lack the capacity to sustain productivity under the continuous intensive cropping system found in most commercial farms (Benbi et al., 1998). Long term use of mineral fertilizer without organic amendments has been reported to result in reduction in soil base saturation and increased acidity over (Hills et al., 2000), while the application of organic material has been reported to improve soil physical properties, nutrient supply, crop yield (Yaduvanshi, 2003) and soil microbial activities (Nath and Yadav, 2011).

Agriculture farm based product viz. farm yard manure (FYM), vermicompost, poultry manure and other organic resources play a dominant role in soil fertility management (Palm et al., 2001), available in abundance in India (Ramesh et al., 2005) and estimated to supply about 7.1, 3.0 and 7.6 Mt of N, P and K, respectively (Tiwari, 2002). Manure product had a lower C/N ratio, higher protein: organic C ratio, and higher levels of N, which indicates that the manures were more suitable for soil amendment use (Goyal et al., 1992).

In containerized production systems, manures used as an alternative soil amendment could help reduce several problems associated with the use of conventional synthetic fertilizer such as excessive leaching loss of nutrients and salinity-induced plant stress. In addition manures can improve soil porosity, and thus provide a better root growth medium (Hala et al., 2003).

Soil nutrients and enzyme activities respond much more quickly to the changes in soil management practices as compared to total soil organic matter (Doran et al., 1996). Therefore, measurement of nutrients release provides a sensitive indication of organic matter turnover. This results in consumption of C, N and other nutrient elements by the microbes and their subsequent release for plant use. This depicts the known microbial immobilization and mineralization of nutrients for plant use (Fatunbi and Ncube, 2009). The duration of this phenomenon in a system will either allows or debars the utility of organic materials as source of plant nutrients in the short–run. The duration is known to be affected by the chemical characteristics of the organic materials viz., C:N, Lignin, polyphenols, total N and climatic variables such as moisture, temperature, relative humidity etc., (Bayala et al., 2005). Thus, there is a need to determine the immobilization/ mineralization time lag, when applied organic materials. This will provide information that could be used to synchronize the time of organic materials and fertilizer application with that of plant nutrient need. Therefore, the present work was undertaken to know the application of organic manures and fertilizer on time of nutrients (N, P and K) availability and soil enzymes activity in incubation.

2. Materials and Methods

A 70 days incubation experiment was conducted during in 2013–14 at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, Hyderabad, India, to know the mineralization pattern of primary plant nutrients and soil enzymes activity from different organic manures and fertilizer treatments. The characteristics of incubation conducted soil presented in Table 1. The soil used for the study was collected at depth (0−15 cm) from a frequently cropped field at the college research farm. The soils of the area were classified as Alfisols. The chemical properties of the soil include; pH 8.1, EC 0.42 dS m^{-1}, Organic C 7.9 mg kg^{-1}, available N 82.9 mg N kg^{-1}, available P 5.6 mg P kg^{-1} and available K 76.1 mg K kg^{-1}, Urease activity131.2 µg of NH_4^+ N released g^{-1} soil h^{-1}, acid and alkaline phosphatase 14.71 and 49.4 µg of p-nitrophenol g^{-1} soil h^{-1} respectively and dehydrogenase (DHA) 4.21 µg of TPF g^{-1} soil d^{-1}. Manures, vermicompost and neem cake were collected from National Institute of Rural Development (NIRD), Rajendranagar, Hyderabad. Poultry manure was collected from AICRP on Poultry Breeding, Sri Venkataswara Veterinary University, while FYM was collected from Dairy Farm, College of Veterinary Science, Rajendranagar, Hyderabad.The characteristics of the organic materials physico-chemical and total nutrients are presented in Table 2.

Table 1: Salient characteristics of soil under incubation study

Soil properties	Values
Bulk density (Mg m^{-3})	1.64
Textural class	Sandy clay loam
Porosity (%)	40.22
Water holding capacity (%)	37.0
Soil reaction (pH)	8.13
Electrical conductivity (EC) [dS m^{-1}]	0.42
Cation exchange capacity (CEC) [cmol (p^+) kg^{-1}]	21.92
Organic carbon (mg kg^{-1})	7.9
Nitrogen (mg N kg^{-1})	82.9
Phosphorus (mg P kg^{-1})	5.6
Potassium (mg K kg^{-1})	76.1
Urease (µg of of NH_4^+-N g^{-1} soil h^{-1})	131.2
Acid phosphatase (µg of p-nitrophenol g^{-1} soil h^{-1})	14.71
Alkaline phosphatase (µg of p-nitrophenol g soil h^{-1})	49.4
Dehydrogenase (DHA) (µg of TPF g^{-1} soil d^{-1})	4.21

1 kg processed soil was filled in suitable plastic containers (capacity 1.5 kg). Prior to filling required quantity of organic manures (FYM, poultry manure, vermicompost and neem cake) and inorganic fertilizers [urea, single super phosphate (SSP) and murate of potash (MOP)] were mixed in soil as per treatment. Low quantity of fertilizers was dissolved in water for a treatment and equal amount of solution was distributed in respective replications to make the replication homogenous. The organic manures were applied based on the N-equivalent basis. The treated soil was brought to about 60% of water holding capacity (WHC) and then incubated at 25±1 °C. These plastic containers were covered with polythene sheet to prevent ammonia volatilization and evaporation losses. Soil samples were collected at 0, 7, 14, 21, 35, 50 and 70 days interval and

Table 2: Nutrient composition of different organic manures

Manures	pH	EC (dS m^{-1})	Total nutrients (g kg^{-1})		
			N	P	K
FYM	7.23	1.12	107	40	78
Poultry manure	6.96	1.62	347	133	112
Vermicompost	7.47	0.35	112	40	73
Neem cake	5.07	1.45	3.43	30	121

analyzed for N, P, K and urease, acid, alkaline phosphate and dehydrogenase activity under different treatments.

The experiment was laid out in a CRD (completely randomized design) with each treatment being replicated thrice. The treatments details are T_1-Control; T_2-RDF (recommended dose of fertilizers) N, P and K (100, 50 and 50 kg ha^{-1}); T_3-100% RDN (recommended dose of nitrogen) through FYM; T_4-100% RDN through vermicompost; T_5-100% RDN through poultry manure; T_6-100% RDN through neem cake; T_7-50% RDN through FYM+50% RDN through vermicompost; T_8-50% RDN through FYM+50% RDN through poultry manure; T_9-50% RDN through FYM+50% RDN through neem cake; T_{10}-50% RDN through vermicompost+50% RDN through poultry manure; T_{11}-50% RDN through vermicompost+50% RDN through neem cake and T_{12}-50% RDN through poultry manure+50% RDN through neem cake.

2.1. *Analysis of organic manures and soil*

The nutrient composition of FYM, neem cake, vermicompost and poultry manure were determined. Total N was determined by Kjedahl method. For other nutrients, manures were subjected to wet digestion using Tri-acid mixture, 9:4:1 ml of HNO_3:H_2SO_4:$HClO_4$ acids. The filtrate was used for nutrients determination. Total P was determined by colorimeter and K by flame photometer.

For a combined glass calomel electrode was used to determine the pH of aqueous suspension (1:2.5 soil:water ratio). Organic C was determined by Walkley and Black (1934), available nitrogen by Subbiah and Asija (1956) methods. Available potassium was extracted with 1M NH_4OAc and then measured by atomic absorption spectrophotometer. Available phosphorus (AP) was extracted by Olsen method (Olsen et al., 1954) and then determined by colorimetric spectrophotometer. Mineralization of nitrogen in exchangeable forms (NH_4 and NO_3-N) was estimated by three steps, first was extraction using 2M KCl solution (Dorich and Nelson, 1983) following by steam distillation method using MgO–Devarda alloy. After removal of NH_4-N form the same sample used to estimate NO_3-N by adding Devarda alloy. P and K were estimated by similar procedure used for analysis of initial soil sample analysis (Jackson, 1973).

Soil enzymes**,** urease activity was assessed as the rate of urea hydrolysis in the soil samples by determining the urea remaining (unhydrolysed) at different days of incubation following the method modified by Tabatabai and Bremner (1972). Phosphomonoesterases (acid and alkaline phosphatases) were analyzed following the method of Tabatabai and Bremner (1969) and Eivazi and Tabatabai (1977). Dehydrogenase was estimated as described by Casida et al. (1964).

2.2. *Statistical analysis*

Measured data was analyzed for analysis of variance (ANOVA) using SAS statistical package (SAS Institute, 1999) to examine the effect different manures and period on mineralization of manures. Statistical significance of each attribute was assessed using Fisher's least significant difference (LSD) at $p<0.05$ level.

3. Results and Discussion

3.1. *Nitrogen mineralization*

Addition of manures and fertilizers increased NH_4^+-N and NO_3^--N content of the soils (Table 3). The release nitrogen was dependent on the manure combinations and duration. Among the treatments, T_2 had maximum release of NH_4^+-N content up to 21 DAI (157 mg kg^{-1}) followed by 35 to 70 DAI (126 to 90.3 mg kg^{-1}), where decreasing order was observed. In the succeeding weeks NH_4^+-N content release was dominant by manures treatments. Among the manures combination, Neem cake with Poultry manures (T_{12}) and FYM (T_9) had superior release of NH_4^+-N content (112.8 and 106.5 mg kg^{-1}) at 70 DAI. Considering NO_3^--N content of the study, since 1 DAI to 50 DAI gradually increasing orders in manures treatments but later on decreased. Among the treatments, T_2 had dominant release of NO_3^--N content in initial stage (70 mg kg^{-1}). Treatments like T_8, T_{10} and T_{12} exhibited superior release of NO_3^--N content over others. The poultry manure combined with FYM and neem cake showed significant higher release of NO_3^--N content than others. A NO_3-N level generally increased with incubation time which was probably due to the transformation of ammonium to nitrate. Addition of manures and fertilizers had great influence on mineralization of nutrients than control for the entire incubation period. Similar kinds of results were also reported by Kar et al. (2007). Other factors as the soil C:N ratio, soil macro fauna, soilmicrobial activities and soil pH has been reported tocontribute to N mineralization when organic materials are added to the soil (Khalil et al., 2005). The higher mineral N from the application of poultry manure, FYM and their separate combination with neem cake, further confirm the time of release the N from organic materials as a more suitable for soil amendment. Moreover, these materials also exhibited a high degree of ammonification concurrently with mineralization; which signified the occurrence of Nimmobilization and rapid remineralization over time (Khalil et al., 2005).

3.2. *Phosphorus mineralization*

Application of manures and fertilizers were improved the plant available P (Table 4). There was a gradual increase in the release of P from incubation with the advancement of time. Among the treatments, T_2 (RDF) had maximum P (90.8 mg kg^{-1}) mineralization at 35 DAI, compare to control (21.2 mg kg^{-1}). Other manures and their combination treatments could not

Table 3: Influence of manures and fertilizer on nitrogen release from incubated soil

Treatments	NH_4^+-N (mg kg^{-1})						NO_3^--N (mg kg^{-1})					
	Days after incubation											
	7	14	21	35	50	70	7	14	21	35	50	70
T_1	42.0	42.3	45.3	39.3	38.0	36.3	34.6	34.0	36.0	36.6	33.0	32.0
T_2	148.6	154.6	157.0	126.0	116.0	90.3	70.0	63.3	64.1	59.0	47.6	41.1
T_3	52.6	61.4	64.6	71.6	78.6	77.0	42.0	49.3	50.8	56.6	53.6	43.7
T_4	46.6	51.0	58.6	66.9	61.0	54.3	44.0	50.0	52.0	52.6	48.6	40.8
T_5	60.6	64.5	68.3	80.1	78.7	81.1	54.6	58.7	59.8	63.0	65.9	49.9
T_6	58.0	57.5	61.5	72.9	77.3	81.6	52.3	57.7	61.0	65.3	63.1	50.8
T_7	50.6	78.8	81.8	83.6	85.2	82.6	48.0	51.4	53.4	56.0	58.1	54.9
T_8	77.3	80.4	86.6	90.6	96.3	97.3	60.0	63.0	68.0	72.0	80.3	57.1
T_9	64.6	65.4	68.1	92.0	101.2	106.5	56.0	59.0	61.8	77.3	77.9	63.2
T_{10}	65.3	69.4	72.0	75.0	82.4	83.0	56.6	62.2	69.0	73.3	59.0	44.2
T_{11}	63.3	64.6	65.6	68.0	68.2	74.6	55.3	58.8	60.8	64.6	57.9	43.8
T_{12}	75.0	78.3	81.8	103.5	104.3	112.8	58.6	61.7	66.5	77.0	80.5	59.2
LSD (p=0.05)	22.8	18.2	13.9	16.5	16.2	9.8	18.0	11.2	10.9	15.0	9.2	10.9

T_1-Control; T_2-RDF (recommended dose of fertilizers) N, P and K (100, 50 and 50 kg ha^{-1}); T_3-100% RDN (recommended dose of nitrogen) through FYM; T_4-100% RDN through vermicompost; T_5-100% RDN through poultry manure; T_6-100% RDN through neem cake; T_7-50% RDN through FYM+50% RDN through vermicompost; T_8-50% RDN through FYM+50% RDN through poultry manure; T_9-50% RDN through FYM+50% RDN through neem cake; T_{10}-50% RDN through vermicompost+50% RDN through poultry manure; T_{11}-50% RDN through vermicompost+50% RDN through neem cake and T_{12}-50% RDN through poultry manure+50% RDN through neem cake

comparable with fertilizer treatment. Manures combinations like T_5, T_8 and T_{12} have more efficient than individual application. The P mineralization under fertilizer treatment was increasing up to 35 DAI, later on decreasing order was observed but manures are keeping increasing order 1 DAI to 70 DAI. The manures combinations, T_8 and T_{12} have shown maximum amount of mineralized P (60.3 and 61.2 mg kg^{-1}, respectively) at 70 DAI. The increase in available P might be due to the organic acids, which were released during microbial decomposition of OM and helped in the solubilization of native phosphates; as a result, the available-P content increased. Applied OM may lead to the formation of a protective coating on the sesquioxides and may cause a reduction in the phosphate-fixing capacity of soil in manure-treated. A similar result was reported by Ayeni (2011). However, the combined use of poultry manure with FYM and Neem cake were found to be more beneficial than sole use of either of them in terms of nutrient supply and balanced nutrition since poultry manure mainly supplied P (Ano and Agwu, 2006). The slower release of nutrients especially P from organic manures compared with fertilizer due to the low C/N ratio might have enhanced faster decomposition of poultry manure and thereby enhanced more and quick release of P by Ayeni (2011).

3.3. Potassium mineralization

Influence of manures and fertilizer on mineralize K was present in Table 4. Amount of mineralization of K was increased all the treatments compare to control. Among the treatments, T_2 (RDF) had the highest rate of K release at 14 (428 mg kg^{-1}) and 21 DAI (431 mg kg^{-1}) and subsequent weeks are gradually decreased. Manures treatments are significant amount enhanced K than control (182 to 167 mg kg^{-1}) but not pair with fertilizer. Among them, T_{12} (239 mg kg^{-1}) and T_8 (241 mg kg^{-1}) reached maximum at 50 and 70 DAI. The maximum release of nutrients from manures was observed in later period of incubation. The release of K was greater with the K fertilizers than with manure, but with the increase in time of incubation there was a greater decrease in K from fertilizer treatments, mainly due to the fixation of inorganic K, than from manure treatments. This indicates that manures combination may maintain a higher level of K in soil solution for a longer period than the fertilizer alone. The higher availability of K may be due to beneficial effect of organic manures on the reduction of K fixation; a direct effect of addition of K through mineralization from the manures, higher CEC, and holding higher amount of exchangeable K on the exchange complex. Bulluck et al. (2002) also reported that K concentration in soil amended with organic wastes

Table 4: Influence of manures and fertilizer on phosphorus and potassium release from incubated soil

Treatments	P_2O_5 (mg kg^{-1})						K_2O (mg kg^{-1})					
	Days after incubation											
	7	14	21	35	50	70	7	14	21	35	50	70
T_1	20.0	21.0	19.1	21.2	19.1	18.7	182	184	182	179	168	167
T_2	74.7	81.0	84.6	90.8	80.9	72.2	396	428	431	395	365	344
T_3	31.7	32.1	34.4	36.4	39.8	41.2	205	215	218	222	220	226
T_4	31.3	30.2	33.1	32.9	33.3	34.4	202	211	216	225	218	221
T_5	32.2	35.9	38.0	40.6	46.6	53.6	209	219	222	230	231	237
T_6	22.2	27.1	31.5	33.2	38.9	42.3	211	215	216	223	228	234
T_7	32.4	36.5	36.5	44.1	45.3	45.4	207	220	224	229	230	231
T_8	35.8	36.5	40.0	42.0	51.1	60.3	217	223	227	236	241	231
T_9	26.1	29.5	31.0	33.4	40.4	45.9	211	221	223	225	231	230
T_{10}	35.2	37.6	41.1	40.7	43.5	52.9	211	213	216	218	220	215
T_{11}	18.4	30.7	30.2	35.8	36.3	38.0	208	217	221	225	217	221
T_{12}	30.2	33.4	38.5	43.7	46.2	61.2	220	225	231	236	239	239
LSD (p=0.05)	8.3	7.7	9.9	13.8	11.5	8.1	20.5	18.4	12.2	18.1	11.0	16.5

increased compared to soils fertilized with mineral fertilizers. Organic manures are slowly available over a period of time compared to mineral fertilizers. This often limits plant growth due to mismatch between crop nutrient demand and nutrient supply from organic sources, especially during initial phase of conversion from conventional to organic management systems (Ramesh et al., 2009).

3.4. Ureases activity

Addition of nutrients through manures and fertilizers showed significant increase in urease activities (Table 5). In fertilizer treatment, there was a sharp increased in ureases activity (200 µg NH_4^+-N g^{-1} soil h^{-1}) only up to 21 DAI. After that the enzyme activities exhibited a rapid decline. On the other hand application of organic manures gradually increased up to 70 DAI (227 µg NH_4^+-N g^{-1} soil h^{-1} in T_{12}) except T_{10} and T_{11}. Among the treatments, T_{12} showed higher urease activity followed by T_8 and T_2 up to 21 DAI. During the later period, T_9 (216 µg NH_4^+-N g^{-1} soil h^{-1} at 70 DAI) was dominated. In general, neem cake, poultry manure and FYM combination

Table 5: Influence of manures and fertilizer on urease and dehydrogenase activity from incubated soil

Treatments	Urease activity (µg NH_4^+-N g^{-1} soil h^{-1})						Dehydrogenase (µg TPF g^{-1} soil 24 h^{-1})					
	Days after incubation											
	7	14	21	35	50	70	7	14	21	35	50	70
T_1	152	156	158	149	149	145	4.8	5.0	5.1	5.1	4.9	4.6
T_2	188	196	200	183	160	156	6.1	6.6	6.1	5.9	5.5	5.5
T_3	184	185	186	192	191	197	8.4	8.7	8.9	9.3	9.4	9.6
T_4	176	179	193	181	186	189	7.2	7.3	7.8	7.9	7.5	7.5
T_5	191	194	195	198	201	207	10.7	11.1	11.2	11.2	10.3	10.1
T_6	189	193	195	198	201	210	10.6	11.0	10.8	11.3	11.7	12.1
T_7	185	186	190	193	193	201	7.7	8.5	8.8	9.1	9.3	9.5
T_8	193	199	204	205	207	209	10.1	11.5	11.8	11.8	11.9	12.1
T_9	190	193	196	208	214	216	11.1	11.4	11.2	12.0	12.2	12.4
T_{10}	193	195	199	201	203	204	8.7	10.4	10.6	10.7	9.1	9.4
T_{11}	184	184	198	201	181	199	7.6	8.9	8.8	8.9	8.3	9.2
T_{12}	203	205	209	213	217	227	10.6	10.6	10.7	11.5	11.9	12.4
LSD (p=0.05)	17.7	12.5	16.2	20.8	21.5	25.0	1.0	1.8	1.0	1.9	1.3	1.5

treatments released high urease enzyme during incubation. This may be due to the organic matter being more readily available to microorganisms in manures than in the fertilizer, since organic matter in manures is thought to be stabilized by the formation of a clay complex (Chan and Heenan, 1995). Addition of organic sources acts as good source of carbon and energy to heterotrophs by which their population increased with an increase in enzymic activities. Similar relationships between organic carbon and enzymic activities were reported by Bohme and Bohme (2006).

3.5. *Acid and alkaline phosphatase activities*

Acid and alkaline phosphatase enzyme activities increased with addition of fertilizer and manures than control (Table 6). Maximum release of acid and alkaline phosphatase were 21 DAI (30) and 35 DAI (85.8 µg of pNP g^{-1} soil h^{-1}), respectively, in T_2 (RDF). Manures and their combination treatments are influence much more release phosphatase than fertilizer and control. Among the manures, significant level of acid phosphotase activity was observed from T_8 (42.8), T10 (39.6) and T_5 (36.6 µg of pNP g^{-1} soil h^{-1}) at 70 DAI. Rest of the manures treatments also doesn't have much difference on release of phosphatase. Among the manures treatment, T_{12} (73.9 to 101.1 µg of pNP g^{-1} soil h^{-1}) had superior in releasing of alkaline phosphatase over a time, followed by T_5 and T_8 also on pair with each others. As organic P forms must be mineralized via phosphatases into inorganic P prior to plant uptake, soil biological activity and enzyme production related to organic P hydrolysis will affect P cycling (Magid et al., 1996). Acid phosphatase activity was lesser than alkaline phosphatase for the total incubation period. It may depend on soil properties. Soil phosphatase activity was strongly inhibited by inorganic phosphate. Manure can stimulate phosphatase activity by providing soil microorganisms with sources of C, N, and P (Heidi et al., 2011). Phosphatases can also affect environmental quality following mismanagement of manure, as P in surface runoff is related to organic P content and phosphatase activity (Yu et al., 2006).

3.6. *Dehydrogenase activity*

The dehydrogenase enzyme activity was increased with addition of organic manures (Table 5). During the initial period (up to 21 DAI), actively release of enzymes from T_9 followed by T_5 and T_8. Trend of dehydrogenase activity is not consistent in entire incubation period. Fertilizer treatment (T_2) is not much impact on dehydrogenase activity but slight on initial period (up to 21 DAI) later on pair with control. Manures combination, T_{12} (12.42) and T_9 (12.4 µg of TPF g^{-1} soil d^{-1}) had maximum release of dehydrogenase at 70 DAI, followed by T_8 and T_6 than others. The result shown that the neem cake based treatments had significant effect on release of dehydrogenase activity than others. Manures treatments are shown good result on dehydrogenase activity than fertilizer and control. So, the application of organic manures influenced dehydrogenase activity. In the entire incubation period, dehydrogenase activity did not show any constant trend. This is due to the fact that other soil properties have a role in releasing dehydrogenase activity. Result was confirmation with Rai and Yadav (2011).

Table 6: Influence of manures and fertilizer on acid and alkaline phosphatase activity from incubated soil

Treatments	Acid phosphatase activity (µg p nitrophenol g^{-1} soil h^{-1})						Alkaline phosphatase activity (µg p nitrophenol g^{-1} soil h^{-1})					
	Days after incubation											
	7	14	21	35	50	70	7	14	21	35	50	70
T_1	18.0	18.0	18.6	19.2	19.1	18.1	43.1	45.0	45.0	44.6	43.5	40.7
T_2	26.0	28.1	30.0	26.4	19.3	19.0	74.4	75.9	81.8	85.8	62.7	51.7
T_3	24.6	24.6	25.9	26.4	29.6	32.8	65.5	69.9	74.8	80.0	88.0	88.2
T_4	24.0	23.0	25.7	28.7	32.3	31.4	66.9	66.5	67.7	70.3	67.8	84.2
T_5	26.3	27.0	30.0	34.4	35.4	36.6	80.2	87.9	88.2	89.2	92.1	99.1
T_6	20.5	23.6	22.1	31.9	32.6	33.7	69.2	73.7	75.2	81.5	79.5	97.1
T_7	25.5	26.3	27.9	28.4	28.4	31.1	67.0	72.9	73.9	75.0	82.8	88.6
T_8	30.5	32.2	33.8	37.4	38.5	42.8	82.3	84.8	88.7	90.2	93.7	96.0
T_9	22.0	22.8	24.5	27.1	33.5	34.2	70.8	76.7	82.8	84.7	86.4	94.0
T_{10}	27.7	28.7	32.8	33.1	36.3	39.6	74.8	78.4	84.4	85.4	94.9	95.4
T_{11}	21.6	24.0	24.4	25.5	27.8	30.3	69.8	70.3	75.5	75.0	76.4	89.3
T_{12}	24.3	27.4	29.6	30.0	35.0	35.8	73.9	80.7	83.3	87.8	100.3	101.1
LSD (p=0.05)	4.9	4.4	6.9	5.7	5.5	6.4	14.3	8.8	16.7	11.5	19.8	20.8

Similarly Trevors (1984) reported positive correlation between dehydrogenase activity and substrate concentration, incubation temperature and soil pH.

It is well known that soil enzymes play a key role in the transformation, recycling, and availability of plant nutrients in soil and they are likely to be influenced by fertilizers and manures (Srivastava and Lal, 1994). Variation in dehydrogenase activity with different treatments could be related to SOC content. Greater dehydrogenase activity was recorded in treatments that promoted higher SOC. Increased nutrient availability in organic-manure treatment could also be due to increased dehydrogenase and phosphatase activity (Gunapala et al., 1998). Ramesh et al. (2006) also reported that the enhanced level of soil enzyme activity due to addition of organic manures promotes the recycling of nutrients in the soil ecosystem stimulates DHA activity because the added material on decomposition may provide intra and extracellular enzymes and may also stimulate microbial activity in the soil (Bhattacharyya et al., 2005). The results indicate that soil organic matter level and soil microbial activities, vital for the nutrient turnover and long-term productivity of the soil, are enhanced by use of organic amendments better crop production.

3.7. *Relationship between variables*

The relationship between primary nutrients (N, P and K) and soil enzymes activity from the added organic materials and fertilizer were showed in Table 7. The NH_4^+-N highly significant and positively correlated with NO_3^--N (r=0.566), P_2O_5 (r=0.886), K_2O (r=0.858), urease activity (r=0.491), acid Phosphatase (r=0.441) and *alkaline Phosphatase* (r=0.517). Both form of nitrogen (NH_4^+-N and NO_3^--N) N are highly significant and positively correlated with P_2O_5, K_2O and soil enzymes, whereas DHA is significant and positively correlated with only NO_3^--N. Results showed that plant primary nutrients and major soil enzymes are positively correlated with each other except K_2O with all enzymes and DHA with P_2O_5. The application of organic materials and fertilizer had significant relationship with the chemical properties of the soil. Similar relationship was also reported by many authors (Valarini et al., 2004; Khalil et al., 2005).

Table 7: Correlation matrix between the different soil properties

Parameters	NH_4^+	NO_3^-	P_2O_5	K_2O	Urease	Acid phophatase	Alkaline phosphatase	DHA
NH_4^+	1							
NO_3^-	0.566**	1						
P_2O_5	0.886**	0.304**	1					
K_2O	0.858**	0.272**	0.902**	1				
Urease	0.491**	0.757**	0.271*	0.109	1			
Acid phosphatase	0.441**	0.530**	0.371**	0.080	0.779**	1		
Alkaline phosphatase	0.517**	0.664**	0.402**	0.174	0.913**	0.864**		
DHA	0.172	0.692**	-0.044	-0.208	0.848**	0.637**	0.779**	1

4. Conclusion

Decomposition and mineralization of the added organic materials and fertilizer to soil, was positively correlated with plant available nutrients (N, P and K) and soil enzymes. Among the treatments, poultry manures combination with neem cake and FYM had better result of the overall experiment. Major finding of the experiment is time of nutrients release and quantity from different treatments; it will avoid the mismatch between crop nutrient demand and nutrient supply from organic sources.

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6. References

Ano, A.O., Agwu, J.A., 2005. Effect of animal manure on selected soil chemical properties. Nigerian Journal of Soil Sciences 14, 14–19.

Ayeni, L.S., 2011. Effect of sole and combined cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer on soil organic carbon, available P and forms of nitrogen on Alfisols in southwestern Nigeria. International Research Journal of Agricultural Science and Soil Science 1, 77–82.

Bayala, J., Mandob, A., Teklehaimanotc, Z., Ouedraogoa, S.J., 2005. Nutrient release from decomposing leaf mulches of karate (*Vitellaria paradoxa*) and nere (*Parkia biglobosa*) under semiarid conditions in Burkina Faso, West Africa. Soil Biology and Biochemistry 37, 533–539.

Benbi, D.K., Biswas, C.R., Bawa, S.S., Kumar, K., 1998. Influence of farmyard manure, inorganic fertilizers and weed control practices on some soil physical properties in a long-term experiment. Soil Use and Management 14, 52–54.

Bhattacharyya, K., Chakrabarti, P., Chakraborty, A., 2005. Microbial biomass and enzyme activities in submerged rice soil amended with municipal solid waste compost and decomposed cow manure. Chemosphere 60, 310–318.

Bohme, L., Bohme, F., 2006. Soil microbiological and biochemical properties affected by plant growth and different long-term fertilization. European Journal of Soil Biology 42, 1–12.

Bulluck, L.R., Brosius, M., Evanylo, G.K., Ristaino, J.B., 2002. Organic and synthetic fertility amendment influence soil microbial physical and chemical properties on organic and conventional farms. Applied Soil Ecology 19, 147–160.

Casida, L.E., Klein, D.A., Santro, J., 1964. Soil dehydrogenase activity. Soil Science 98, 371–376.

Chan, K.Y., Heenan, D.P., 1995. Occurrence of enchytraeid worms and some properties of their casts in an Australian soil under cropping. Australian Journal of Soil Research 33, 651–657.

Doran, J.W., Sarrantonio, M., Liebig, M.A., 1996. Soil health and sustainability. Advances in Agronomy 56, 1–54.

Dorich, R.A., Nelson, D.W.,1983. Direct colorimetric measurement of ammonium in potassium chloride extracts of soils. Soil Science Society of America Journal 47(4), 833–836.

Eivazi, F., Tabatabai, T.C., 1977. Phosphatases in soils. Soil Biology and Biochemistry 9, 167–192.

Fatunbi, A.O., Ncube, L., 2009. Activities of Effective Microorganism (EM) on the Nutrient Dynamics of Different Organic Materials Applied to Soil. American-Eurasian Journal of Agronomy 2(1), 26–35.

Goyal, S., Mishra, M.M., Hooda, I.S., Singh, R.,1992. Organic matter microbial biomass relationships in field experiments under tropical conditions: effects of inorganic fertilization and organic amendments. Soil Biology and Biochemistry 24, 1081–1084.

Gunapala, N., Venette, R.C., Ferris, H., Scow, K.M., 1998. Effects of soil management history on the rate of organic matter decomposition. Soil Biology and Biochemistry 30, 1917–1927.

Hala, I., Chaoui, L.M., Zibilske., Tsutomu, O., 2003. Effects of earthworm casts and compost on soil microbial activity and plant nutrient availability. Soil Biology and Biochemistry 35, 295–302.

Heidi, M., He, W.Z., Erich, M.S., 2011. Effects of poultry manure amendment on phosphorus uptake by ryegrass, soil phosphorus fractions and phosphatase activity. Biology and Fertility of Soils 47(4), 407–418.

Hills, A., Miller, E., Miller, A., 2000. Management of soil acidity in agricultural land [Western Australia]: Farm note 80/2000, Agriculture Western Australia, Lake Grace.

Jackson, M.L., 1973. Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi.

Kar, S., Majumder, R., Chatterjee, P., Gupta, S.K., 2007. Nitrogen mineralization of some added organic manures in soils. Indian Agriculturist 51(3/4), 165–172.

Khalil, M.I., Hossain, M.B., Schmidhalter, U., 2005. Carbon and nitrogen mineralization in different upland soils of the subtropics treated with organic materials. Communications in Soil Science and Plant Analysis 32, 2893–2907.

Magid, J., Tiessen, H., Condron, L.M., 1996. Dynamics of organic phosphorus in soil natural and agricultural ecosystems. In: Piccolo A (eds.) Humic substances in terrestrial ecosystems. Elsevier, Amsterdam, 429–466.

Olsen, S.R., Cole, C.V., Wetanabe, F., Bean, L.A., 1954. Estimation of available phosphorus by extraction with sodium bicarbonate. USDA, Washington, D C, 939.

Palm, C.A., Gachengo, C.N., Delve, R.J., Cadisch, G., Giller, K.E., 2001. Organic inputs for soil fertility management in tropical agro ecosystems: application of an organic resource database. Agriculture Ecosystems Environment 83, 27–42.

Nath, R.T., Yadav, J.A., 2011. Influence of inorganic and organic nutrient sources on soil enzyme activities. Journal of the Indian Society of Soil Science 59(1), 54–59.

Ramesh, P., Panwar, N.R., Singh, A.B., Sivakoti, R., Subba Rao, A., 2009. Impact of organic-manure combinations on the productivity and soil quality in different cropping systems in central India. Journal of Plant Nutrition and Soil Sciences 172, 577–585.

Ramesh, P., Singh, M., Subba Rao, A., 2005. Organic farming: Its relevance to the Indian context. Current Science 88, 561–568.

Ramesh, P., Singh, M., Panwar, N.R., Singh, A.B., Ramana, S., 2006. Response of pigeonpea varieties to organic manures andtheir influence on fertility and enzyme activity of soil. Indian Journal of Agricultural Sciences 76, 252–254.

SAS Institute., 1999. Statistical Analysis System Inc. SAS users guide, Statistical Analysis Institute. Carry NC, 112.

Srivastava, S.C., Lal, J.P., 1994. Effects of crop growth and soil treatment on microbial C, N and P in dry tropical arable land. Biology and Fertility of Soils 17, 108–114.

Subbaiah, B.V., Asija, G.L., 1956. Arap procedure for determation of available nitrogen in soils. Current Science 25, 259–260.

Tabatabai, M.A., Bremner, J.M., 1969. Use of P nitro phynel phosphate for assay of soil phosphatase activity. Soil biology and Biochemistry 1, 301–307.

Tabatabai, M.A., Bremner, J.M., 1972. Assay of urease activity in soils. Soil Biology and Biochemistry 4, 479–487.

Tiwari, A., Dwivedi, A.K., Dikshit, P.R., 2002. Long-term influence of organic and inorganic fertilizers on soil fertility and productivity of soybean-wheat system in a Vertisol. Journal of the Indian Society of Soil Science 50, 472–475.

Tiwari, R.C., 2002. Recycling of industrial organic wastes and urban digested sludge through integrated plant nutrient supply system. Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University,Varanasi, Unpublished data of Research Project Report.

Trevors, J.T., 1984. Effect of substrate concentration temperature and pH on dehydrogenase activity of soil. Plant and soil 77, 285–293.

Valarini, P.J., Baldock, J.A., Dalal, R.C., Moody, P.M., 2004. Decomposition dynamics of plant materials in relation to nitrogen availability and biochemistry determined by NMR and wet-chemical analysis. Soil Biology and Biochemistry 36, 2045–2058.

Walkley, A.J., Black, I.A., 1934. An examination of soil organic matter and proposed modification of the organic acid titration method. Soil Science 37, 28–29.

Yaduvanshi, N.P.S., 2003. Substitution of inorganic fertilizers by organic manures and the effect on soil fertility in rice–wheat rotation on reclaimed sodic soil in India. Indian Journal of Agricultural Sciences 140, 161–168.

Yu, S., He, Z.L., Stoffella, P.J., Calvert, D.V., Yang, X.E., Banks, D.J., Baligar, V.C., 2006. Surface runoff phosphorus (P) loss in relation to phosphatase activity and soil P fractions in Florida sandy soils under citrus production. Soil Biology and Biochemistry 38, 619–628.

