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Nitrogen fractions : Status and impact on yield, uptake and availabl[e] nitrogen in long term fertiliser experiment

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Abstract : A study was taken up in the existing Long Term Fertiliser Experiment in Tamil Nadu Agricultural University, Coimbatore, conducted since 1972, to study the status and content of various nitrogen fractions both organic and inorganic and the effect on crop yield, uptake by crops and availability of nitrogen in the soil. Exchangeable NH_4-N and NO_3-N were significantly increased by incremental additions of N. Inclusion of FYM along with inorganic fertilisers, had a positive effect on the buildup of all the organic N fractions. Path analysis revealed that hydrolysable NH_4-N was the principal fraction for yield prediction in case of finger millet, unidentified hydrolysable -N for crop N uptake and nitrate N to predict the available N in the post harvest soil samples after finger millet. (*Key words: Long term fertiliser experiment, Nitrogen, Nitrogen fractions, Yield, Uptake*)

Increased application of chemical fertilisers has been the major input in achieving high production levels under intensive cropping system. The continuous application of these chemical fertilisers may have their effect on soil physical, chemical as well as biological properties. These effects are monitored through long term fertiliser experiments. The long term fertiliser Experiment conducted in Coimbatore, Since 1972 is in a medium black soil (Vertic Ustropept). A cropping system of finger millet-maize-cowpea is being followed and so far 71 crops have been completed.

Inorganic forms of N in soil constitute only less than two per cent of the total N and the rest is organic (Black, 1968). Continuous addition of fertilisers and manures releases various nitrogenous compounds. About 92-96 per cent of the total N in the soil is conserved in organic form and is derived mainly from plant and animal residues. Deepak Kher and Minhas (1991) stated that hydrolysable nitrogen which contributed 75.8 to 82.9 per cent of total N was constituted by 32.7 per cent of amino acid and 30.4 per cent of hydrolysable NH_4 in the long term fertiliser plots of Palampur after 13 years of cropping. The FYM in conjunction with NPK increased the hydrolysable ammonium, amino acid, hexosamine and unidentified N fractions over 100 per cent NPK treatment. The graded levels of NPK increased the contents of hydrolysable ammonium, hexosamine and amino acid-N as compared to control.

Materials and Methods

The present field trial is being conducted at Coimbatore since 1972 under the Long Term Fertiliser Experiment of the ICAR for studying the effects o[f] various fertility treatments on a fixed rotation of finge[r] millet-maize-cowpea. The climate of this area is semi arid tropical with a dry season from January to Ju[ne] followed by wet season upto December. Temperat[ure] varies from 21°C (December-January) to 31°C. T[he] soil of the experimental site is Vertic Ustropept in t[he] family fine montmorillonitic, isohyperthemic. T[he] initial properties of the soil are: Texture - Sandy cl[ay] loam with clay 32 per cent, silt 4.8 per cent, fine sa[nd] 15.1 per cent and coarse and 39.4 per cent, EC 0.. dSm^{-1}, pH 8.2, organic carbon 0.30 per cent, availabl[e] N 80, available P 4.9, available K 362 pp[m] respectively.

The ten treatments with four replications i[n] a randomised block design are as follows:

T_1 : 50% NPK
T_2 : 100% NPK
T_3 : 50% NPK
T_4 : 100% NPK + Hand Weeding
T_5 : 100% NPK+$ZnSO_4$@25 Kg ha^{-1} (for maize alone)
T_6 : 100% NP
T_7 : 100% N
T_8 : 100% NPK+FYM@10 t ha^{-1} (to finger millet alone)
T_9 : 100% NPK (-S)
T_{10} : Control

The 100 per cent NPK dose, based on .... testing of initial soil was 90, 45 and 17.5, 135, 67.5 and 35 and 25, 50, kg ha^{-1} of N, P_2O_5 and K_2O for finger millet, maize and cowpea (fodder) respectively.

The fertilisers used are urea, single super phosphate, diammonium phosphate (T_9 only), muriate of potash and zinc sulphate. The application of FYM was done only once a year at the time of finger millet planting. The varieties of the crops were Co 11 for finger millet, Co 1 for maize and Co 4 for fodder cowpea. The crops were grown by following recommdended package of practices.

Computation of yields

The whole plot or randomly selected area of each treatment was harvested. The grain and straw samples of finger millet and maize were drawn from the lot at time of thrashing and cowpea (fodder) samples were taken at the time of cutting. The samples were oven dried at 70°C for 24 hours and later ground with grinder. The total nitrogen in the plant samples were determined by microkjeldahl method. In the acid digest of plant samples, phosphorus was determined by vanadomolybdate yellow colour method (Jackson, 1973) and potassium using flame photometer.

Inorganic N fractions

The fractions of soil nitrogen was carried out by an adapted version of the procedure given by Cheng and Kurtz (1963) and Keeney and Bremner (1964). The individual fractions were estimated according to the procedure given by Bremner (1965).

Organic N fractions

The soil residue after 2M KC1 extraction was transferred to 500 ml flask. Added two drops of octyl alcohol and 6N HC1. The suspension was digested for 12 h in a water bath at 100°C under reflux. The hydrolysate mixture was filtered through Whatman No.50 filter paper. The residue was washed 3 or 4 times with distilled water to make approximately 60 ml of volume. The pH was adjusted to 6.5±0.1 and volume made upto 100 ml. The soil residue left on the filter paper was preserved for estimation of fixed NH_4-N. This hydrolysate was further used for the estimations of total hydrolysable -N, hydrolysable NH_4-N, hexosamine-N, amino acid-N, unidentified hydrolysable-N, fixed NH_4-N and unidentified non-hydrolysable-N. Simple correlations and multiple regression equations were worked out between N-fractions, yield and nutrient to ascertain the degree of relationship among different variables. Path analysis was carried out as described by Dewey and Lu (1959).

Results and Discussion

Considerable build-up in all the N-fractions, *Viz.* exchangeable NH_4-N, NO_3-N, fixed NH_4-N, hydrolysable NH_4-N, amino acid-N, unidentified hydrolysable-N and unidentified non-hydrolysable-N was observed in NPK+FYM treatment while the least concentrations of these fractions were in the unmanured control. An increase in the rate of applied N was found to be associated with an increase in the build up of total and available N and also the organic matter content of the soil (Minhas and Bora, 1982) and a similar trend was reflected in terms of various N-fractions evaluated.

Inorganic N fractions (Table 3)

Exchangeable NH_4-N

The content of NH_4-N was the highest under NPK+FYM. Mineralisation of FYM releases appreciable amounts of ammoniacal N, (Yadav and Singh, 1991), which could contribute to the exchangeable NH_4-N. Increasing rates of NPK application also had a favourable influence on the exchangeable NH_4-N, build up which is the direct result of higher amounts of applied N(Prasad and Rokima, 1991) and also due to the increase in the organic carbon content of the soil. As the organic carbon content is directly related with CEC, the N released through mineralisation of organic matter and inorganic fertilisers applied could be retained in the exchange sites.

Nitrate-N

Nitrate N usually forms 0.7 to 2.7 per cent of total N. In the present investigation, combined addition of NPK + FYM ensured higher NO_3 - N content of soil as compared to control which could be due to increased microbial activity and resultant enhanced nitrification process with a concomitant reduction in leaching losses (Udayasoorian *et al.* 1989). Increase in the rate of inorganic N added also enhanced the NO_3-N content possibly due to the conversion of applied mineral N via nitrification process (Yadav and Singh, 1991).

Fixed NH_4-N

As is the case of exchangeable NH_4-N and NO_3-N, the integrated use of organics and inorganic recorded higher amount of fixed NH_4-N which was a direct consequence of higher total N in this treatment (Table 1). The content of fixed NH_4-N is related to the kinds and amounts of clay minerals that are present with the highest content being typical of soils rich in micaceous clays (Stevenson, 1982).

Organic Nitrogen Fraction (Table 2)

Various organic N fractions evaluated showed

Table 1. Treatmental effect on organic carbon (%) and total N (ppm) of the post harvest soil-Finger millet

S.No.	Treatments	Organic Carbon		Total N	
		D1	D2	D1	D2
1.	50% NPK	0.46	0.38	436	388
2.	100% NPK	0.52	0.39	510	418
3.	150% NPK	0.54	0.39	549	445
4.	100% NPK + HW	0.51	0.39	487	400
5.	100% NPK + $ZnSo_4$	0.52	0.39	513	420
6.	100% NP	0.51	0.39	518	423
7.	100% N	0.42	031	523	428
8.	100% NPK + FYM	0.59	0.45	626	484
9.	100% NPK (-S)	0.50	0.39	496	408
10.	Control	0.32	0.24	300	248
	CD (P=0.05) D	0.011		21.5	
	T	0.017		34.0	

an appreciable build-up under NPK + FYM and 150 per cent NPK treatments while control had the least. Graded levels of NPK added had a positive influence on various organic N fractions. Among the organic N fractions determined, amino acid-N and hydrolysable NH_4-N formed the dominant fractions constituting nearly 29.0 and 23.4 per cent of the total N. Hydrolysable N constituted 82 per cent of total N confirming the general trend that major portion of the soil N is in the organic from (Tisdale *et al.* 1985)

Organics by virtue of their inherant capability help in augmenting the rate of added fertiliser N addition to complexing/chelating processes that could account for higher organic N (Prasad and Rokima, 1991). Addition of N along with FYM could lower the C:N ratio and create a conducive medium for better microbial decomposition of organic residues and addition of large amount of microbial protein to the soil (Kamat *et al.* 1982) Increased amounts of organic N fractions under NPK + FYM could be due to the series of transformation processes undergone by the added N contributing to increased levels of amino acid-N which ultimately contributes to the pool of organic N (Duraisamy, 1992). The organic N subsequently undergoes mineralisation with time to meet crop requirement. There could also be mineralisation of the applied fertiliser N in the form of amino acid-N or greater synthesis and transformation of complex N compounds in the presence of available N. Apart from this, legumes are reported to immobilise applied N in the form of amino acid-N. (Subba Rao and Ghosh, 1981), which is possible in this investigation where cowpea is one of the crop component.

Levels of N applied played a significant role in increasing the content of organic N, probably due to increase in the organic C content which could have immobilised the applied N in different hydrolysable fractions and improved the level of organic N.

Since the addition of fertilisers and manure is confined to the surface layer and crops grown were also shallow rooted, the organic C content was the highest at 0-15 cm layer (Table 1). This in turn resulted in a higher concentration of organic N fractions in the surface layer owing to the enhanced biological activity and transformation processes. The control treatment registered the lowest concentration in organic N consequent to lower organic C and N contents.

Nitrogen fractions in relation to yield, N uptake and available N (Table 4)

Correlation studies revealed a positive relationship between various N fractions and yield, N uptake and N availability in all the three crops. Among the fractions, the non-hydrolysable-N and NO_3-N had better correlation with these parameters in all the three crops. This suggests that crop requirement for N is also met from the organic pool as NO_3-N content of soil at the initial stages was insufficient to meet the crop requirement.

Table 2. Effect of treatments on organic N fractions

S.No.	Treatment	Organic N fractions (ppm) Hydrolysable NH_4-N		Hexosamine-N		Amino acid-N		Total Hydrolysable N		Unidentified Hydrolysable N		Unidentified Hydrolysable N	
		D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
1.	50% NPK	103.8	79.5	16.6	13.0	120.2	98.3	358	301	117.4	110.2	54.3	51.5
2.	100% NPK	118.2	81.3	20.9	14.0	147.9	104.3	419	323	132.0	123.4	59.7	55.2
3.	150% NPK	127.3	86.0	22.8	18.0	161.4	113.5	450	344	138.5	126.5	63.3	57.5
4.	100% NPK + HW	115.5	80.0	19.6	14.0	137.2	101.1	405	311	132.7	115.9	52.6	57.5
5.	100% NPK + $ZnSO_4$	119.4	82.0	21.0	15.0	147.7	104.0	422	325	133.9	124.0	59.1	55.2
6.	100% NP	121.0	83.0	23.0	16.0	151.1	106.6	426	328	130.9	122.4	59.9	55.1
7.	100% N	122.5	84.0	23.0	16.0	159.0	110.6	431	334	126.5	123.4	58.9	56.1
8.	100% NPK + FYM	145.8	95.0	36.0	24.1	188.7	125.8	510	370	139.5	125.1	71.3	61.8
9.	100% NPK +FYM	145.8	95.0	36.0	24.1	188.7	125.8	510	370	139.5	125.1	71.3	61.8
10.	100% NPK (-S)	118.0	82.0	22.3	16.0	142.5	101.8	412	316	129.2	116.2	55.4	53.0
10.	Control	72.0	52.1	9.6	7.7	81.7	66.0	241	193	77.4	67.2	45.0	33.4
	CD (P=0.05) D	5.85		2.22		7.76		173		11.08		6.43	
	T	9.25		3.52		12.27		27.4		17.52		10.17	

Table 3. Content of Inorganic N fractions at different depths

S. No.	Treatments	Inorganic N fractions (ppm)									
		NO_3-N Content					NH_4-N Content				
		D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
1.	50% NPK	4.7	4.2	3.4	2.6	3.7	5.9	5.3	4.2	3.1	4.6
2.	100% NPK	5.7	4.6	3.6	3.0	4.2	7.0	5.9	4.8	3.5	5.3
3.	150% NPK	6.6	4.8	3.8	3.2	4.6	7.8	6.4	5.5	3.8	5.9
4.	100% NPK + HW	5.6	4.5	3.5	3.0	4.2	6.8	5.7	4.8	3.5	5.2
5.	100% NP	5.7	4.8	3.6	2.9	4.3	7.0	6.0	4.9	3.5	5.4
6.	100% NP	5.7	4.6	3.6	3.1	4.3	7.2	5.8	5.0	3.6	5.4
7.	100% N	6.0	4.8	3.6	2.9	4.3	7.2	6.0	5.2	3.8	5.6
8.	100% NPK + FYM	7.4	4.9	3.9	3.2	4.9	8.3	6.3	5.3	3.8	5.9
9.	100% NPK (-S)	5.7	4.5	3.6	2.8	4.2	6.9	5.7	4.8	3.5	5.2
10.	Control	3.5	2.7	2.0	1.9	2.5	3.7	2.9	2.4	2.1	2.8
CD (P=0.05)	D			0.27					0.26		
	T			0.43					0.41		

Table 4. Correlation between N-fractions yield and other parameters

Parameters	Exch.NH_4-N	NO_3-N	Fixed NH_4-N	Hydroly sable NH_4-N	Hexo samine-N	Amino acid-N	Un indentified hydroly sable-N	Un indentifie hydroly sable-N
Grain yield	0.589**	0.640**	0.669**	0.667**	0.628**	0.621**	0.624**	0.628**
Straw yield	0.599**	0.633**	0.666**	0.665**	0.636**	0.630**	0.619**	0.600**
N uptake	0.604**	0.646**	0.692**	0.681**	0.669**	0.654**	0.631**	0.631**
Total N	0.902**	0.933**	0.986**	0.989**	0.893**	0.988**	0.951**	0.938**
Available N	0.861**	0.893**	0.964**	0.968**	0.902**	0.966**	0.898**	0.903**
Organic C	0.727**	0.735**	0.786**	0.805**	0.708**	0.755**	0.736**	0.689**

Multiple regression analysis (Table 5) also revealed that these N fractions could jointly explain, to a tune of 85 per cent variability in the case of yield and N uptake and 99 per cent in the case of available N. In order to quantify the extent and direction of contribution of N fractions to the parameters studied or rather to aportion their total effect into direct and indirect effects, path analysis was carried out.The magnitude and direction of coefficient suggested that hexosamine-N, hydrolysable NH_4-N and unidentified hydrolysable-N in the case of cowpea, finger mille and maize respectively were important in predictin the grain yield.

Continuous addition of optimum levels of NPI in combination with FYM and also higher rates o NPK enhanced the organic carbon content of soi which implies that a considerable quantity of applie N is immobilised in different hydrolysable-N fraction thereby improving the level of organic carbon. Thes

Table 5. Multiple Regression analysis between yied, N uptake, Available N with N fractions

Parameters	Finger Miller	R2 values (%) Maize	Cowpea
Grain yield	85**	77**	—
Straw yield	79**	52**	78**
N uptake	86**	71**	79**
Available N	99**	99**	99**

organic N fractions could subsequently undergo mineralisation favouring crop yields (Sumam, 1988). The NO_3-N, non-hydrolysable N and unidentified hydrolysable-N fractions contributed more towards N uptake by the crops. The available N pool of the soil was significantly influenced by NO_3-N and unidentified hydrolysable-N. The NO_3-N is easily mineralisable and hence their contribution to available pool is natural. Effectiveness of unidentified hydrolysable-N and NO_3-N in contributing to the N pool of soil derives ample support from the finding of Duraisamy, 1992.

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