



Dynamics of nitrogen fractions in different cropping systems and soil fertility under organic, inorganic and integrated nutrient management practices

Vidyavathi^{1*}, GS Dasog², HB Babalad³, NS Hebsur⁴, GS Yadahalli⁵

¹ Assistant Professor of Soil Science and Agril Chemistry College of Agriculture Vijayapur, UAS Dharwad, Karnataka, India

² Rtd Dean (Agri) and Professor of Soil Science and Agril Chemistry UAS Dharwad, Rtd Dean (Agri), Karnataka, India

³ Librarian and Professor of Agronomy University of Agricultural Sciences Dharwad, Librarian, Karnataka, India

⁴ Professor of Soil Science and Agril Chemistry UAS Dharwad, Karnataka, India

⁵ Senior Scientist and Head, Agronomist UAS Raichur, Karnataka, India

Abstract

The effect of organic, inorganic and integrated nutrient management practices on release pattern of nitrogen fractions under five different cropping systems mainly Soybean-Wheat, Groundnut-Sorghum, Maize-Chickpea, Potato-Chickpea and Chilli+Cotton was studied by conducting field experiment during both *kharif* and *rabi* seasons of 2007-08 at UAS, Dharwad, Karnataka. The study conducted was the fourth year of long term field experiment (LTFE) of Network project on organic farming at Institute of Organic Farming, UAS, Dharwad. At the end of *kharif* and *rabi* season of fourth year 2007-08, the organic and inorganic forms of nitrogen were significantly high under organic nutrient management practices than with inorganic nutrient management practices, however was on par with integrated nutrient management practices. Among the organic N fractions, total hydrolysable N fraction accounted for a major portion of organic N followed by acid insoluble N of soil. Among the cropping systems, legume based cropping system during both *kharif* and *rabi* seasons recorded significantly higher organic and inorganic forms of nitrogen in the soil than non-legume system. At the end of *kharif* and *rabi* season of fourth year (2007-08), application of organic manures resulted in significantly higher organic carbon. Whereas integrated application of manure and fertilizers resulted in significantly higher available N, P₂O₅, K₂O and S than chemical fertilizers alone. Significantly higher uptake of N, P and K by *kharif* and *rabi* crops was recorded in integrated practice compared to inorganic nutrient management practice. The available N, P₂O₅, K₂O and S were significantly higher in legume based cropping systems during both the seasons of the study than non-legume system.

Keywords: cropping systems, nitrogen fractions and nutrient management practices

Introduction

The addition of organic matter in the form of manures greatly influences the transformation and availability of nitrogen (N) and several other essential plant nutrients through its impact on the chemical and microbiological properties of soil. Of these the role of organic manures in supplying plant nutrients, particularly N is most prominent. Crop response to fertilization by N is inextricably linked to its biogeochemical cycling among its numerous biotic and abiotic forms in soil. Since microbes carry out the most significant N cycle processes, they have a major impact on the abundance of all forms of soil N.

Most of the nitrogen in the soil is organically bound and the pool of acid hydrolysable, amino sugars and amino acids seems to be net source of N for plant and micro-organism, however, only small fraction of it remains in available form. Large proportion of organic nitrogenous substances in soil can be considered as potential reserves of nitrogen from plant nutrients point of view. Organic pools of N in soils are affected by cultivation, cropping and long-term fertilizer use. Transformation of N fraction influences N availability in soil which in turn governs the crop growth and development and quality of the produce. The contribution of different N pools to crops may also vary from soil to soil depending on the fertilizer inputs and cropping intensity.

Continuous application of manures and fertilizers are found to influence the various fractions of soil N besides influencing other soil properties. Normally only 35 to 40 per cent of N from organic manure added is available for the use of crop. Rest of it is available to the succeeding crops. Hence, the nutrient management on a cropping system basis is the need of the hour to know the residual effect of organics to the succeeding crops. The beneficial effect of including legumes in the crop rotation is due to improvement of soil health, structure and fertility due to addition of organic manure and nitrogen by the extensive root system of leguminous crops. Therefore, integrated use of fertilizer, organic manure and recyclable crop residue along with residual fertility plays important role in maintaining soil health as well as raising productivity of the system.

Material and Methods

A long term studies on the "Impact of organic, integrated and inorganic nutrient management practices and cropping systems on nitrogen fractions in vertisols" was carried out at MARS, Dharwad during 2007-08. The present investigation is the part of the "Network Project on Organic Farming" (NPOF) of the

Institute of Organic Farming, UAS, Dharwad. The studies were initiated during 2004-05 simultaneously at 13 centres across the country under the aegis of ICAR's Project Directorate for Farming Systems Research, Modipuram. The total annual rainfall received during 2007 was 1081.10 mm as against normal rainfall of 761.41 mm for the past 58 years. The mean monthly minimum and maximum temperatures were 18.7 and 30.67°C respectively with 68.58 per cent of mean relative humidity during the period of investigation. The soil of the experimental site is Typic Haplustert with clay texture (clay 50.2 %, silt 30.9 % and sand 18.9 %) having pH of 7.3, EC 0.31 dS/m in the top 15 cm soil. The available N, P₂O₅, K₂O and S were 240, 16, 330 and 12 kg/ha, respectively. The organic carbon concentration of the soil was 0.49 %. The field capacity and bulk density of the surface soil were 30.3 % and 1.2 Mg/m³, respectively. The trial was initiated during 2004-05 as fixed site as long term field experiment (LTFE) at Main Agricultural research Station, Dharwad. The organic, inorganic and integrated strips of 14 m were laid out with the cropping systems as sub plots of 23 m length. The strips were separated by the hedge rows of subabul and maintained by pruning at a height of 1 m. Across the three main strips of organic, inorganic and integrated nutrient management practices, five cropping systems mainly soybean-wheat, groundnut-soybean, maize-chickpea, potato-chickpea and chilli + cotton were laid out. The design followed was strip plot with three main plots and five sub-plots and three replications were made. In organic nutrient management practices -100% RDN given through 1/3rd FYM, 1/3rd VC and 1/3rd GLM, in integrated nutrient management practices -50% RDN given through fertilizers and 50% RDN through 1/3rd FYM, 1/3rd VC and 1/3rd GLM and in inorganic nutrient management practices -100% recommended chemical fertilizers only were added. These manures were applied based on the nitrogen equivalent basis and nutrient requirement of each crop. Phosphorus requirement of the crops were supplemented through rock phosphate in organic nutrient management practices. The nutrient composition of FYM, Vermicompost and green leaf manure were 0.5-0.18 -0.53, 1.2-0.70-0.94 and 0.5-0.35-1.02 % N, P and K, respectively.

The land was ploughed cultivated and harrowed twice to get fine tilth and weeds were removed before sowing of the seeds. The organic manures according to the treatment details were applied two weeks before sowing of crops for both organic and integrated nutrient management plots. Basal application of entire nitrogen, phosphorus and potassium as per recommendations for soybean, groundnut, chickpea *rabi* sorghum and wheat in other crops entire phosphorus and potassium and 50% of nitrogen was applied in the form of urea, SSP and MOP, respectively at the time of sowing. The top dress of 50% nitrogen through urea was given at 30 DAS for potato, chilli, maize and cotton during *kharif* season. Shallow furrows of 15 cm were opened with markers and the seeds of groundnut (30 x 10 cm), soybean (30 x 10 cm) and maize (75 x 20 cm) were dibbled in the furrow by maintaining one seed

per hill and covered with soil as per the spacing recommended for each crop. Whereas, potato tuber were planted in a furrow opened at 60 cm at 10 cm apart. The chilli seedlings were transplanted at a spacing of 60 x 30 cm. Similarly, *rabi* sorghum (30 x 10 cm) and wheat were line sown at 30 cm rows and chickpea was dibbled at a spacing of 30 x 10 cm and cotton was dibbled one hill in between two chilli plants in the row. Gap filling and thinning was taken up within 10 to 15 days after sowing to maintain the required plant population. To control pest and disease no chemical pest and disease management practices in organic nutrient management strip. IPM and IDM in integrated nutrient management strips and chemicals in inorganic nutrient management strips were taken up. The crops were harvested when the crops reached physiological maturity. Chilli fruits and cotton were harvested upto four pickings. Soil samples were collected at the end of third year of LTFE and at the harvest of *kharif* and *rabi* crops of fourth year (2007-08). The collected samples were analysed for different organic and inorganic nitrogen fractions following standard procedures given by Page *et al.* (1982). The data collected from the laboratory analysis were subjected to statistical analysis by adopting Fischer's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P=0.05. Critical differences were calculated wherever 'F' test was significant.

Results and Discussion

Inorganic nitrogen fractions

NO₃-N and NH₄-N differed significantly with nutrient management practices and cropping systems. At the end of third year of LTFE (Table 1), after harvest of *kharif* (Table 2) and *rabi* (Table 3) crops of fourth year of LTFE organic nutrient management practices recorded significantly higher the NO₃-N content in soil (Fig.1). It was found superior over inorganic nutrient management practices, however was on par with integrated nutrient management practices. With advancement of time it was noticed that there was buildup of NO₃-N and NH₄-N in the soil in all the nutrient management practices. This increasing trend of release of NH₄-N and NO₃-N with time might be due to enhanced mineralization rate of FYM, vermicompost and green leaf manures to release the nitrogen fractions of organic manures. When fully decomposed FYM was added to soil, there is a release of nitrogen upto 110 days due to accelerated decomposition of organic constituent (Toor *et al.*, 2001) [22] which was ascribed to increased microbial activity and resultant enhanced nitrification process with a reduction in leaching loss. The evidence of nitrification and release of nitrogen with addition of FYM was reported by Duhan *et al.* (2005) [4]. Both under integrated and organic nutrient management practices, subabul pruning as green leaf manure was used which accounted for rapid accumulation of mineral N suggesting considerable net mineralization of N. Similar findings were reported by Sridevi *et al.* (2006) [26] and Dinesh and Dubey (1999) [3].

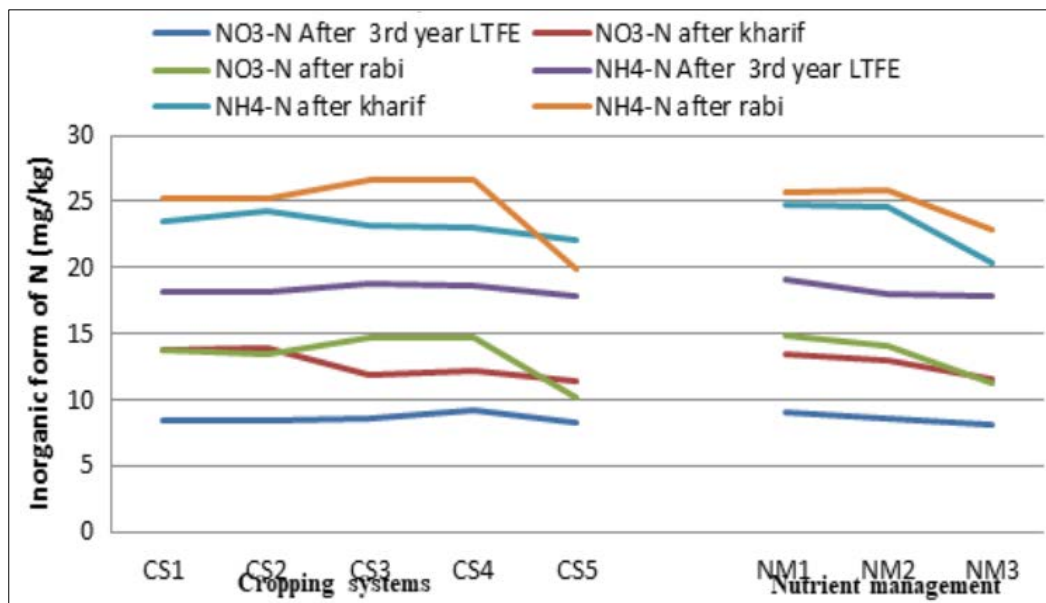


Fig 1: Effect of nutrient management practices and cropping system on inorganic form N (mg/kg) after 3rd year LTFE, after harvest of *kharif* and *rabi* crops

After harvest of both the *kharif* and *rabi* crops, the legumes in cropping systems recorded significantly higher content of soil NH_4-N and NO_3-N than with chilli + cotton system irrespective of nutrient management practices. This can be attributed to atmospheric N_2 fixation by legume crops and replenishment of N into the soil. Olemann *et al.* (2007) [12] observed that presence of legumes correlated positively with soil NO_3-N concentrations because of atmospheric N_2 fixation, whereas in chilli-cotton being an non-legume system and are exhaustive and deep rooted

crops which might have depleted the N in later stages. There is build of NO_3-N and NH_4-N under integrated and organic nutrient management practices irrespective of cropping system when compared to inorganic nutrient management practices. This might be due to continuous addition of organic manures which accounts for higher NO_3-N and NH_4-N release with time (Toor *et al.*, 2001) [22]. Whereas there is no source for buildup and replenishment of N in soil under inorganic nutrient management particularly with chilli+cotton system.

Table 1: Effect of nutrient management practices and cropping systems on nitrogen fraction in soil after third year of LTFE

Treatments	NO_3-N	NH_4-N	Total Hydrolysable-N	Hydrolysable NH_4-N	Amino acid-N	Amonio sugar-N	Unident -ified-N	Acid insoluble-N	Total-N
Nutrient management practices									
1. organic	9.1	19.1	336.7	81.2	151.4	57.1	47.1	140.5	477.2
2. integrated	8.5	18.0	311.5	76.5	139.8	52.1	43.1	132.1	443.6
3. inorganic	8.1	17.9	304.8	75.3	136.8	51.1	41.5	129.8	434.6
SEm+	0.13	0.25	6.29	0.93	2.43	1.19	0.72	1.33	7.30
CD at 5%	0.51	0.96	24.71	3.65	9.55	4.67	2.83	5.24	28.68
Cropping systems									
Soybean-Wheat	8.4	18.1	313.1	76.6	140.7	52.7	43.1	132.6	445.7
Groundnut-Sorghum	8.4	18.1	312.7	76.6	140.0	52.7	43.3	132.7	445.3
Maize-Chickpea	8.6	18.8	323.2	78.9	145.3	54.2	44.8	136.1	459.3
Potato-Chickpea	9.2	18.7	331.0	80.3	148.7	55.2	46.9	138.3	469.3
Chilli+Cotton	8.3	17.8	308.3	76.0	138.7	52.4	41.2	131.0	439.3
SEm+	0.20	0.43	5.78	2.09	3.43	1.71	0.93	3.55	6.21
CD at 5%	0.57	NS	NS	NS	NS	NS	2.72	NS	18.11

Table 2: Effect of nutrient management practices and cropping systems on nitrogen fraction in soil after harvest of *kharif* crops of fourth year of LTFE

Treatments	NO_3-N	NH_4-N	Total Hydrolysable-N	Hydrolysable NH_4-N	Amino acid-N	Amonio sugar-N	Unident -ified-N	Acid insoluble-N	Total-N
Nutrient management practices									
1. organic	13.4	24.7	377.0	110.7	169.2	74.0	23.0	153.6	530.6
2. integrated	12.9	24.6	375.2	109.6	168.4	72.3	24.9	153.4	528.6
3. inorganic	11.5	20.4	334.4	91.9	150.1	61.5	30.9	140	474.4
SEm+	0.19	0.27	3.62	1.36	2.82	1.04	0.64	1.02	8.51
CD at 5%	0.75	1.04	14.22	5.36	11.07	4.09	2.52	3.99	33.42

Cropping systems									
Soybean-Wheat	13.8	23.5	371.3	103.1	167.1	73.0	27.1	150.3	523.3
Groundnut-Sorghum	13.9	24.3	373.0	104.6	167.0	73.7	23.8	154.7	526.0
Maize-Chickpea	11.8	23.2	362.0	100.5	162.5	68.3	27.7	148.7	510.7
Potato-Chickpea	12.2	23.0	361.7	102.4	162.3	66.9	26.6	148.7	510.7
Chilli+Cotton	11.4	22.1	343.0	98.5	154.0	64.6	26.0	142.7	485.7
SEm+	0.19	0.38	6.71	3.80	2.99	1.06	0.71	2.69	7.99
CD at 5%	0.55	1.10	19.58	NS	8.72	3.11	2.08	NS	23.33

Table 3: Effect of nutrient management practices and cropping systems on nitrogen fraction in soil after harvest of *rabi* crops of fourth year of LTFE

Treatments	NO ₃ -N	NH ₄ -N	Total Hydrolysable-N	Hydrolysable NH ₄ -N	Amino acid-N	Aminosugar-N	Unident -ified-N	Acid insoluble-N	Total-N
Nutrient management practices									
1. organic	14.8	25.7	403.4	117.2	181.1	77.1	28.0	162.2	565.6
2. integrated	14.0	25.8	403.2	119.0	180.9	78.9	24.4	162.2	565.4
3. inorganic	11.3	22.8	373.6	102.3	167.7	66.7	36.9	152.6	526.2
SEm+	0.21	0.29	5.33	2.45	2.85	1.47	0.64	1.22	6.32
CD at 5%	0.84	1.15	20.94	9.64	11.20	5.76	2.50	4.77	24.83
Cropping systems									
Soybean-Wheat	13.8	25.3	402.0	115.7	180.4	77.1	28.8	161.7	563.7
Groundnut-Sorghum	13.4	25.2	400.3	115.0	179.5	76.7	29.2	161.3	561.7
Maize-Chickpea	14.7	26.7	416.0	120.3	186.8	80.6	28.3	166.3	582.3
Potato-Chickpea	14.7	26.7	416.7	121.0	186.6	79.9	28.1	166.3	582.0
Chilli+Cotton	10.1	19.9	333.0	92.1	149.5	56.8	36.2	139.3	472.3
SEm+	0.33	0.57	6.78	3.36	3.76	1.71	0.68	3.10	7.85
CD at 5%	0.97	1.67	19.78	9.79	10.97	5.00	1.99	9.05	22.92

Organic Nitrogen Fractions

The organic nitrogen fractions differed significantly with nutrient management practices. Among the organic N fractions, total hydrolysable N fraction accounted for a major portion of organic N followed by acid insoluble N of soil. Of this, aminoacid N and hydrolysable NH₄⁺-N were the major fractions followed by aminosugar N (Mohapatra and Khan., 1987 and Sridevi *et al.*, 1998) [10, 16].

At the end of third year of LTFE, after harvest of *kharif* and *rabi* crops of fourth year of LTFE, the total hydrolysable N was significantly high under organic nutrient management practices than with inorganic nutrient management practices but was on par with integrated nutrient management practices (Fig.2). Similarly organic nutrient management practices recorded significantly higher hydrolysable NH₄⁺-N, aminoacid N and aminosugar N at the end of third year of LTFE, after harvest of *kharif* and *rabi*

crops of fourth year of LTFE. It was superior over inorganic nutrient management practices and on par with integrated nutrient management practices. Subba Rao and Ghosh (1981) [20] observed an increase in the level of hydrolysable N due to the addition of organic manures and also reported the existence of a metastable equilibrium between immobilization and mineralization processes going on in individual fraction with a clear perceptible shift towards greater immobilization and consequent accumulation of N in same forms. Similarly, Kamat *et al.* (1982) [8] reported that use of 100 per cent N along with FYM increased the aminoacid N, hydrolysable NH₄⁺-N, hexosamine N and total hydrolysable N, while use of only inorganic fertilizer did not show any improvement in the amounts of the N fraction. Higher organic N status of soil due to addition of green manures and FYM was recorded by Srivastava (1988) [19] and Udayasoorian *et al.* (1989) [23].

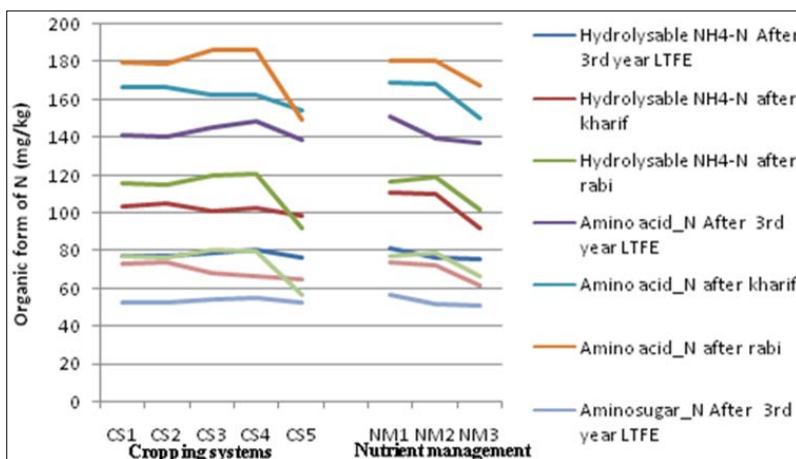


Fig 2: Effect of nutrient management practices and cropping system on organic form N (mg/kg) after 3rd year LTFE, after harvest of *kharif* and *rabi* crops

The total N and acid insoluble N were also significantly high under organic nutrient management practices at the end of third year, after harvest of *kharif* and *rabi* crops of fourth year of LTFE when compared to inorganic nutrient management practices and was on par with integrated nutrient management practices. This is because of high organic matter content which directly accounts for total N. Higher the organic carbon or matter higher will be the total N (Verma *et al.*, 1980) [25]. Kale *et al.* (1992) [7] highlighted the use of vermicompost as source of organic manure. By use of vermicompost, the total N will increase as it contains higher N per cent.

Whereas unidentified N did not follow any trend. The organic forms of N, particularly hydrolysable form is slowly mineralized and is transformed to mineral N through ammonization, ammonification and nitrification process in contrast the non-hydrolysable N is resistant to mineralization. The stability of the organic N is due to the complex organic molecules which resist mineralization. Toor *et al.* (2001) [22] reported that FYM releases N from its organic fractions till 110 to 120 days because of its slow decomposition. Due to increasing trend of total N and organic C buildup with time under organic and integrated nutrient management practices increases the organic N fractions.

It was also noticed that there was buildup of organic N fractions in soil which is ascribed to continuous addition of organic manures since 2003, which might have created favourable environment for the growth and development of heterotrophic microbial activity in the soils. Integrated and organic nutrient management showed a significant increase in organic N fractions over inorganic nutrient management. This might be due to carry-over effect of continuous use of organic sources and accumulation of organic residues, which in turn contributed higher buildup in soil and thus recorded an increase values over initial.

The cropping systems also had influence on all the organic forms of nitrogen after harvest of both *kharif* and *rabi* crops. Again

inclusion of legume in the cropping system had beneficial effects on increasing the soil organic forms of nitrogen. Thakur and Sharma (1990) reported that continuous cropping of cereals resulted in lower residual nitrogen in soil, whereas inclusion of legumes in the crops sequence helped in buildup of soil nitrogen. The superiority in the buildup of soil available N was in the order of cropping patterns having all legumes > legumes > cereals > all cereals. With respect to unidentified N, it did not follow any trend as it is a calculated value of total hydrolysable N and other hydrolysable form of N.

Soil fertility

Under organic and integrated nutrient management practices, there was significant buildup of organic carbon at the end of fourth year (Table 4) as compared to initial values of LTFE. This is due to continuous use of organic manures. Organic carbon contents of soil changes rapidly with addition of organic manures. Bellakki and Badanur (1994) [1] also observed the increase of organic carbon with addition of subabual and sorghum stubbles, whereas organic carbon build up over the years due to application of FYM in medium black soil was reported by Nambiar and Ghosh (1984) [11]. On the other hand, under inorganic nutrient management practices, there was decline in organic carbon content from 0.49 % (initial value of LTFE) to 0.44 % (end of fourth year). This might be due to use of fertilizers alone for a long period, which depletes the organic matter.

The available N, P₂O₅, K₂O and S showed build up in soil over the years under both organic and integrated nutrient management practices (Table 4). The available nutrients were significantly high under integrated nutrient management practices compared to inorganic nutrient management practices, however was on par with organic nutrient management practices both at harvest of *kharif* and *rabi* crops. Whereas, under inorganic nutrient management practices there is declining trend of available nutrient at the end of fourth year.

Table 4: Effect of nutrient management practices on soil fertility status in different cropping systems

Treatments	After 3 rd of LTFE (2006-07)					After harvest of <i>kharif</i> crops (2007-08)					After harvest of <i>rabi</i> crops (2007-08)				
	OC	N	P ₂ O ₅	K ₂ O	S	OC	N	P ₂ O ₅	K ₂ O	S	OC	N	P ₂ O ₅	K ₂ O	S
Organic	0.62	257.2	20.3	322.2	18.0	0.63	268.4	21.5	338.2	16.9	0.65	278.2	21.8	355.1	17.2
Integrated	0.56	258.8	22.7	335.8	15.6	0.56	278.4	23.4	355.0	18.7	0.57	285.8	23.4	361.6	18.5
Inorganic	0.48	247.0	16.6	310.8	13.9	0.44	248.0	17.6	321.8	14.3	0.44	242.9	18.7	320.3	13.7
SEm+	0.02	1.92	0.41	2.58	0.19	0.01	3.38	0.23	5.51	0.29	0.01	3.84	0.65	6.13	0.54
CD at 5%	0.06	7.55	1.62	10.14	0.75	0.03	13.27	0.91	21.64	1.15	0.03	15.06	2.55	24.08	2.11
Cropping systems															
Soybean-Wheat	0.55	254.7	20.0	323.7	15.9	0.56	272.7	22.1	348.3	17.5	0.56	268.9	21.3	345.3	16.7
Groundnut-Sorghum	0.54	251.7	18.9	320.4	15.7	0.55	270.3	21.4	343.7	17.1	0.56	268.3	21.3	342.8	16.8
Maize-Chickpea	0.55	259.3	21.7	331.0	16.5	0.54	265.0	20.7	338.7	16.7	0.55	276.0	22.5	357.3	17.1
Potato-Chickpea	0.56	258.0	20.5	327.0	16.2	0.54	262.7	20.4	332.7	16.6	0.55	275.7	21.8	356.7	17.0
Chilli+Cotton	0.56	248.0	18.0	312.6	14.9	0.54	254.0	19.6	328.3	15.7	0.54	256.0	19.6	326.1	14.7
SEm+	0.02	2.74	0.82	3.93	0.35	0.01	3.63	0.52	4.61	0.37	0.01	4.55	0.64	7.37	0.58
CD at 5%	NS	8.00	2.39	11.47	1.03	NS	10.59	1.53	13.45	1.07	NS	13.27	1.86	21.51	1.71

Soil organic matter affects soil fertility and the C and N mineralization capacities of the soil, which determines the availability of plant nutrients. Thus, soil productivity decreases as soil organic matter content decreases. Continuous application of manures increases the level of N, P, K, S, Ca and Mg in the

soil over the years. Thus creating a reservoir of soil nutrients for several years after application, use of FYM, vermicompost and GLM attribute to the mineralization of N in soil and due to high enzyme activities in the soil amended with organic manures will increase the transformation of nutrients to available form. Role of

FYM, vermicompost and green leaf manures in releasing N and improving N availability in soil was reported by Govindan and Thirumurugan (2002)^[5] and Singh *et al.* (2008)^[14]. Similarly, the P availability in soil increased due to use of organics. During decomposition of organic manure, various organic acids will be produced which solubilize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability. Manna *et al.* (2006)^[9] reported that available phosphorus content increased due to addition of FYM over initial and control. The buildup of soil available K due to green manuring or FYM application is due to addition of K applied throughout the solubilizing action of certain organic acids produced during FYM decomposition and its greater capacity to hold K in the available form. Srinivas Rao *et al.* (1997)^[18] recorded higher potassium release in earthworm casts. The buildup of sulphate S content in soil due to use of FYM either alone or in combination with NPK was reported by Singh *et al.* (1999)^[15]. This improvement in soil fertility was attributed to addition of FYM and other organics which stimulated the growth and activity of microorganisms. They participate in the biological cycling of elements and transformation of the mineral compounds and thus increases the availability of nutrients in soil.

The available nutrients in soil had significant effect of cropping systems. At the end of third year and during fourth year (after harvest of *kharif* and *rabi* crops), these available nutrients differed significantly with cropping systems. Wherever the legume crop was grown both in *kharif* and *rabi* seasons recorded significantly higher available nutrient in soil than with non-legume crops. This is due to nodulation of legume crops which fixes atmospheric N and N content in soil increases. As there is synergistic relation of N with P, K and S, this helps in increasing the nutrient content in soil irrespective of nutrient management practices. Kadam *et al.* (2010)^[6] reported that at harvest of soybean, the soil nutrient status was influenced by the nodulation of soybean crop and by the application of organic nitrogen sources.

Inclusion of pulses in intensive agriculture is beneficial, as these improve the soil fertility and crop productivity. Inclusion of *kharif* legumes in cropping cycle has more advantage (Jawale *et al.*, 1998). The benefit of including legumes in cropping cycle which improves soil fertility status was reported by Das *et al.* (2010)^[2]. Similarly, Varalakshmi *et al.* (2005)^[24] reported that the legume cropping helped to increase the available N, P₂O₅ and K₂O content of the soil. On the other hand, chilli+cotton system showed slight buildup of nutrients only under integrated and organic nutrient management practices. This ascribed to addition of organic and slow release of nutrients from the organics. Whereas, under inorganic nutrient management practices, nutrient status after fourth year of LTFE was drastically reduced as compared to the nutrient status at the end of third year of LTFE and at initial LTFE. This is ascribed to exhausting nature of the crop and lack of nutrient source for their replenishment in the soil. Chilli+cotton being a long duration crops, cotton having deep roots and moreover grown as intercrop, there might have be competition for the nutrients which lead to more uptake of release nutrients and their less content in soil.

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