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Nitrogen fractionations in soil under different horticultural land use systems

Purnananda BC, LB Ashok, BC Dhananjaya, Basavalingaia

Department of Soil Science and Agricultural Chemistry, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Abstract
The study was conducted to know the distribution of nitrogen fractions under different horticultural land use systems in Hiriyur Taluk, Chitradurga district during 2015-16. Soils were clay to sandy clay loam in texture in selected land use systems and clay content higher in sub-surface than the surface soils. The bulk density was medium to high and increased with increasing the depth. Soils were slightly alkaline to alkaline in reaction. Electrical conductivity and organic carbon were medium to high. Major portion of study area was low to medium in available nitrogen and low to medium in available phosphorus and potassium. Nitrogen fractions content were directly related with the organic carbon of the soils. Inorganic nitrogen fractions like nitrate and ammonical nitrogen showed decreasing trend with increasing the depth. Organic nitrogen fractions showed the irregular distribution with the depth it may be due to slow mineralization in the sub-surface soils as compared to surface soils. Total hydrolysable nitrogen was dominant fraction and nitrate nitrogen was the least fraction. The dynamics status of nitrogen fractions is related to organic carbon content. So frequent N fertilization with small amount but multiple times so that nitrogen concentration in soil solution may be maintained at a higher and more stable value for sustainable production of horticultural crops.

Keywords: nitrogen fractions, hydrolysable ammonical nitrogen, total hydrolysable nitrogen, amino acid nitrogen, hexosamine nitrogen

Introduction
Nitrogen occupies the unique position among the elements essential for crop growth and plays a fundamental role in various metabolic processes. In plants it is a major component of many important molecules including proteins, nucleic acids, certain hormones and chlorophyll. It was estimated that over 85 per cent of the total N is present in bound form and the major fractions are amino acid-N, hydrolysable and amino sugar-N (Aggarwal *et al.,* 1990) [1]. Only a smaller portion of the total N was in the inorganic forms which constitute exch. NH_4^+-N, NO_3^--N and NO_2^--N (Walia *et al.*, 1998) [17].
Since a major portion of the soil total N is in organic form, the remaining inorganic forms of N present as NH_4^+-N is the precursor for all other remaining inorganic forms of N in both aerobic and anaerobic conditions. These inorganic forms may be lost from the soil through volatilization, leaching, runoff and are unavailable to the plants by fixation and immobilization.
Hence, knowledge of relationship between soil N type, soil conditions and various physical and chemical properties with different N pools, their distribution and availability in soils may prove to be the best approach for obtaining reliable information about the soil N.

Material and Methods
The relative proportion of sand, silt and clay particles present in soil sample was determined by international pipette method using sodium hexa-metaphosphate as a dispersing agent (Piper, 1966) [9]. The bulk density of soil was carried out by laboratory method for disturbed soil as per the procedure described by Piper (1966) [9]. Weighed a large bottle of about 50 ml capacity without a stopper, filled up with soil, flushed up to the brim tapping the bottle about 20 times and weighed. Removed the soil and now filled the bottle with water by means of burette and note down the exact volume of water needed to fill the bottle. The bulk or apparent density was obtained by dividing the weight of the soil and volume of the soil. Soil pH was determined in 1:2.5 soils: water suspension by potentiometric method involving digital systronic pH meter using glass electrode as described by Jackson (1973) [4]. Electrical conductivity (EC) in soil samples was measured in 1:2 soil to water extract using conductivity bridge as outlined by Jackson (1973) [4]. The results were expressed as of dSm^{-1} at 25 ^{0}C. Available nitrogen in the soil (kg ha^{-1}) was determined by alkaline potassium permanganate method as described by Subbaiah and Asija (1956). Available phosphorus was extracted from soil by using Bray's No.1 extractant (0.03 *N* NH_4F + 0.025 *N* HCl) and the concentration of phosphorus in the extract was determined by chlorostannous reduced molybdophosphric acid blue color in HCl system using spectrophotometer (Jackson, 1973) [4]. Available potassium was extracted from the soils using neutral *N* ammonium acetate in 1:5 soils to extract ant ratio and the concentration of potassium present in the extract was determined by flame photometric method (Jackson, 1973) [4]. The fractionation of soil nitrogen was carried out by an adopted version of the procedure given by Page *et al.* (1982) [8].

Results
The texture of soils from coconut and areca nut land use system were sandy clay, sandy clay loam, and sandy loam and in pomegranate, banana, onion, chilli land use system texture observed were clay, clay loam, sandy loam and sandy clay loam. Higher bulk density was recorded in all the land use systems. Among them arecanut land use system was recorded

highest bulk density (1.68 Mg m^{-3}) and lowest bulk density under banana land use system (1.30 Mg m^{-3}). Soils of different land use systems were alkaline in reaction, soils under pomegranate land use system recorded lowest mean value of pH (7.92) and soils under coconut land use systems recorded higher mean value of pH (8.38) compared to soils under other land use systems. The salt content present in soils varied from 0.19 to 0.88 dSm^{-1} under different land use system indicating normal to critical in range for growing of different crops. Soils under coconut land use system recorded lowest electrical conductivity (0.19 dSm^{-1}) and highest in areca nut land use system (0.88 dS m^{-1}) compared to soils under other land use systems. The soil organic carbon content was significantly higher under chilli land use system (8.88 g kg^{-1}) and lower under pomegranate land use system (6.15 g kg^{-1}) compared to other land use systems. Higher available nitrogen (365.28 kg ha^{-1}) was observed under coconut land use system and lowest available nitrogen under onion land use system (245.57 kg ha^{-1}) compared to other land use systems. Among the different land use systems, highest available phosphorus (32.66 kg ha^{-1}) was observed under coconut land use system and lowest available phosphorus (24.24 kg ha^{-1}) observed under chilli land use system. Available potassium was highest under coconut land use system (325.20 kg ha^{-1}) and lowest under areca nut land use system (266.82 kg ha^{-1}) among all the land use systems.

Soils under coconut land use system the total nitrogen content in the soils decreased with depth from 407 to 334.52 ppm. Exchangeable ammonical nitrogen and nitrate nitrogen fractions mean values varied from15.56 to 14.33 ppm and 27.63 to 8.19 ppm in surface and sub surface, respectively. Amino acid and hydrolysable ammonical nitrogen content decreased with depth and its mean values varied from136.88 to 108.25 ppm and 113.72 to 101.61 ppm in surface and sub surface, respectively. Hexosamine nitrogen was high in surface 30.29 ppm and slightly decreased to 26.52 ppm in sub surface soil. Unidentified hydrolysable nitrogen contents varied from 75.60 to 83.03 ppm. Soil under arecanut land use system showed that the higher total nitrogen

Table 1: Mean values of Chemical properties of soils under different horticultural land use systems

Land use systems	**pH**	**EC (dSm^{-1})**	**OC (g kg^{-1})**	**Available N (kg ha^{-1})**	**P_2O_5 (kg ha^{-1})**	**K_2O (kg ha^{-1})**
	0-15 cm					
Coconut	8.13	0.19	8.2	365.28	30.59	325.2
Arecanut	8.4	0.45	6.47	320.12	30.13	276.82
Pomegranate	7.92	0.2	8.56	340.52	26.23	308.88
Banana	8.17	0.46	7.69	321.76	27.06	311.64
Onion	8.22	0.46	6.96	275.63	25.27	307.62
Chilli	8.08	0.2	8.88	364.13	24.24	290.9
	pH	EC (dSm^{-1})	OC (g kg^{-1})	Available N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
	15-30 cm					
Coconut	8.38	0.31	6.32	274.58	32.66	322.69
Arecanut	8.37	0.88	4.49	261.5	32.52	266.82
Pomegranate	8.16	0.55	6.15	273.02	28.53	306.96
Banana	8.36	0.6	6.42	282.33	29.71	307.8
Onion	8.33	0.58	6.21	245.57	28.41	303.31
Chilli	8.19	0.32	6.39	286.44	27.6	288.44

(316.74 ppm) was recorded in surface lower (270.85 ppm) was in sub surface soils. Exchangeable ammonical nitrogen was appreciable and recorded 11.82 to 11.87 ppm in surface and sub surface, respectively. Nitrate nitrogen was in the range of 21.00 to 6.78 ppm in surface and subsurface, respectively. Amino acid nitrogen and total hydrolysable nitrogen decreased with the soil depth and its values ranged between 104.07 ppm to 89.65 ppm and 283.90 to 252.20 ppm in surface and sub surface, respectively. Hexosamine nitrogen was 22.93 ppm in surface and 21.96 ppm in sub surface soils. Hydrolysable ammonical nitrogen also followed the same trend as Hexosamine nitrogen to some extent and its values ranged from 86.46 to 84.15 ppm. Unidentified hydrolysable nitrogen varied from 70.34 to 56.43 ppm in surface and sub surface soils, respectively. Soils under pomegranate land use system total nitrogen content in soils decreased with depth with lowest and highest value being 230.74 ppm and 515.94 ppm respectively. Exchangeable ammonical nitrogen and nitrate nitrogen with nitrite nitrogen fractions varied from 14.90 to 14.46 ppm and 26.47 to 8.26 ppm in surface and sub surface soils, respectively. Amino acid and total hydrolysable nitrogen values decreased from 131.18 to 109.21 ppm and 354.90 to 309.61 ppm in surface and sub surface, respectively. Hydrolysable ammoniocal nitrogen ranged from 108.99 to 102.50 ppm in surface and sub surface soils, respectively. Hexosamine nitrogen ranged between 29.03 to 26.75 ppm.

The mean value of total nitrogen content in the soils of banana land use system decrease from 384.41 to 332.63 ppm. Ammonical nitrogen decreased from 12.44 to 11.75 ppm with the increase in depth. Nitrate and nitrite nitrogen followed almost the same pattern of distribution. Their values ranged from 23.28 to 6.30 ppm. Amino acid nitrogen and total hydrolysable nitrogen decreased with the increase in soil depth and their mean values ranged between 127.63 to 106.36 ppm and 343.17 to 310.10 ppm in surface and sub surface, respectively. Hexosamine nitrogen and hydrolysable ammonical nitrogen showed an irregular distribution pattern in the soils and the mean values ranged from 25.82 to 24.63 ppm and 105.51 to 99.72 ppm in surface and sub surface respectively. Unidentified hydrolysable nitrogen varied from

84.19 to 79.39 ppm in surface and sub surface, respectively. Soils under onion land use system the mean values of total nitrogen was relatively higher at the surface soils (313.76 ppm) and latter its contents declined (268.96 ppm) in the sub surface soils. Exchangeable ammonical and nitrate nitrogen fraction together form the inorganic soil nitrogen. All these fractions decreased with the increase in soil depth and their mean values ranged from 8.84 to 9.98 ppm, and 18.02 to 4.89 in surface

Table 2: Mean values of nitrogen fractions of soils under different horticultural land use systems

Land use systems	NO_3^--N	NH_4^+-N	HA-N	HS-N	AA-N	UH-N	TH-N	Total-N
	0-15 cm							
Coconut	27.63	15.56	113.72	30.29	136.88	83.03	363.97	407.12
Arecanut	21	11.82	86.46	22.93	104.07	70.34	283.9	316.74
Pomegranate	26.47	14.9	108.99	29.03	131.18	85.68	354.9	396.3
Banana	23.28	11.75	105.51	25.82	127.63	84.19	343.17	384.41
Onion	18.02	8.84	83.48	19.95	101.09	76.4	280.92	313.76
Chilli	26.76	15.07	110.17	29.26	132.61	89.89	362.02	403.86
	NO_3^--N	NH_4^+-N	HA-N	HS-N	AA-N	UH-N	TH-N	Total-N
	15-30 cm							
Coconut	8.19	14.33	101.61	26.52	108.25	75.6	311.99	334.52
Arecanut	6.78	11.87	84.15	21.96	89.65	56.43	252.2	270.85
Pomegranate	8.26	14.46	102.5	26.75	109.21	71.14	309.61	332.34
Banana	6.3	12.44	99.72	24.63	106.36	79.39	310.1	332.63
Onion	4.89	9.98	82.26	20.07	87.76	60.22	250.31	268.96
Chilli	8.67	15.17	107.54	28.06	114.57	71.91	322.09	345.94

And sub surface soils, respectively. amino acid nitrogen and total hydrolysable nitrogen followed the trend of total nitrogen, higher values were recorded in the surface soils and contents decreased with depth from 101.09 to 87.76 ppm and 280.92 to 250.31 ppm in surface and sub surface, respectively. The mean values of hydrolysable ammoncial nitrogen was lower in the sub surface (82.26 ppm) compared to surface soils (83.48 ppm). Amino sugar nitrogen mean values in sub surface soils (20.07 ppm) higher than the surface (19.95 ppm) Unidentified hydrolysable nitrogen decreased down the depths from 76.40 to 60.22 ppm. In the chilli land use system the mean values of total nitrogen in the soils varied from 403.86 to 345.94 ppm. Exchangeable nitrogen showed irregular trend with depth. Nitrate nitrogen was maximum (26.76 ppm) in surface soils and decreased to in sub surface soils (8.67 ppm). The mean values of amino acid nitrogen and total hydrolysable nitrogen fraction ranged between 132.61 to 114.57 ppm and 362.02 to 322.09 ppm in surface and sub surface, respectively. The mean values of hydrolysable ammonical nitrogen and hexosamine nitrogen fractions were 110.17 to 107.54 ppm and 29.26 to 28.06 ppm in surface and sub surface soils, respectively. The mean values of unidentified hydrolysable nitrogen decreased from 89.89 to 71.91 ppm in surface and sub surface, respectively.

Discussion

Soil texture varied from sandy clay loam, sandy clay and sandy loam with sand as the dominant mineral fraction. This may attribute to their parent materials (granite) which were in conformity with the findings of (Basavaraju *et al*., 2005) [2]. Clay was the dominant fraction it might be because of basalt parent material and showed the marked tendency to become heavier with the depth, the similar findings with the Sing *et al*. (1998) [13, 14]. The soil was alkaline in reaction, which showed increasing trend with increase in depth. It is confirmation with the observations made by Mruthunjaya and Kenchanagouda (1993) [7]. The organic carbon content decreased with depth similar findings are made by Sarkar *et al.* (2002) [10]. The electrical conductivity was higher in sub surface layer than in surface layer (Fig. 2). This is the conformity with the observation made by Shivaprasad *et al.* (1998) [12]. It might be due to leaching of salts from the soil surface to lower depths due to irrigation and their accumulation in lower depths (Dasog and Hadimani, 1980) [3]. Available nitrogen follow similar trend as that of organic carbon. A relatively higher content of nitrate nitrogen in surface soils is due to high nitrification. Surface soils recorded slightly

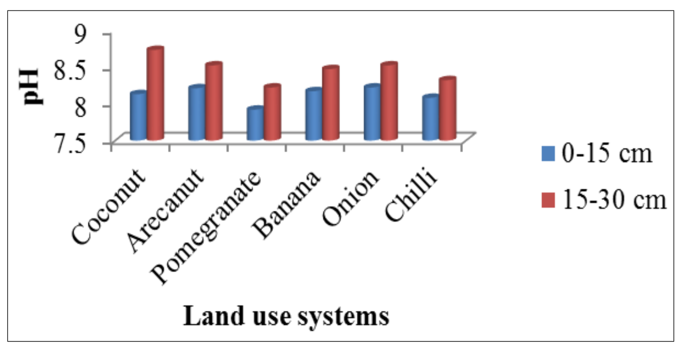

Fig 1: Status of pH

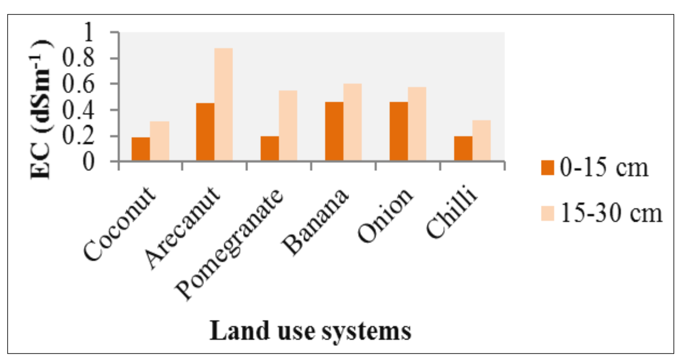

Fig 2: Electrical conductivity

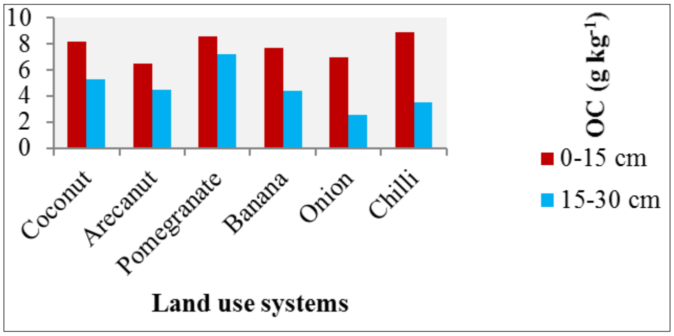

Fig 3: Organic carbon

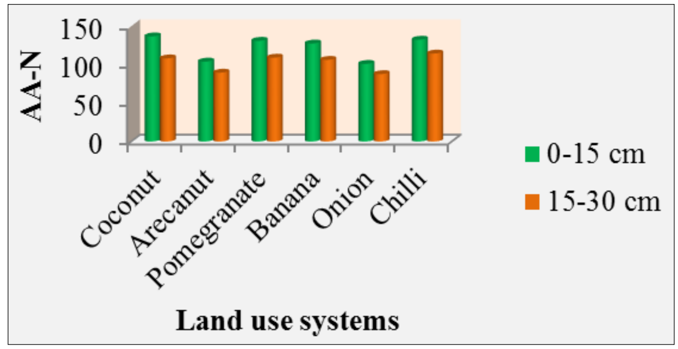

Fig 5: Amino acid nitrogen

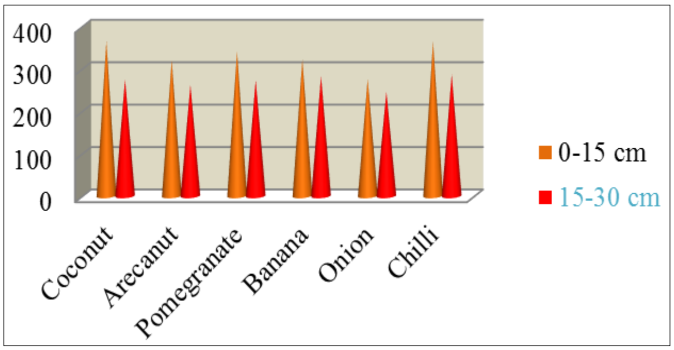

Fig 4: Available N (kg ha^{-1})

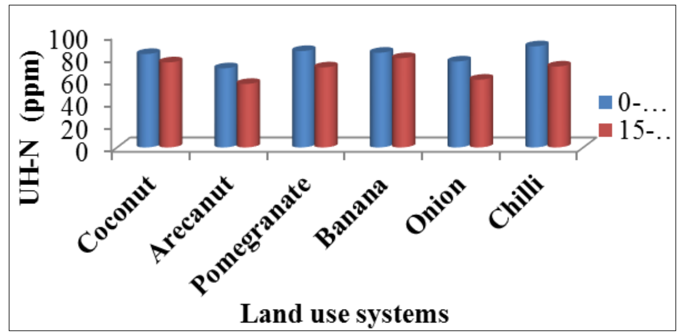

Fig 6: Unidentified hydrolysable nitrogen

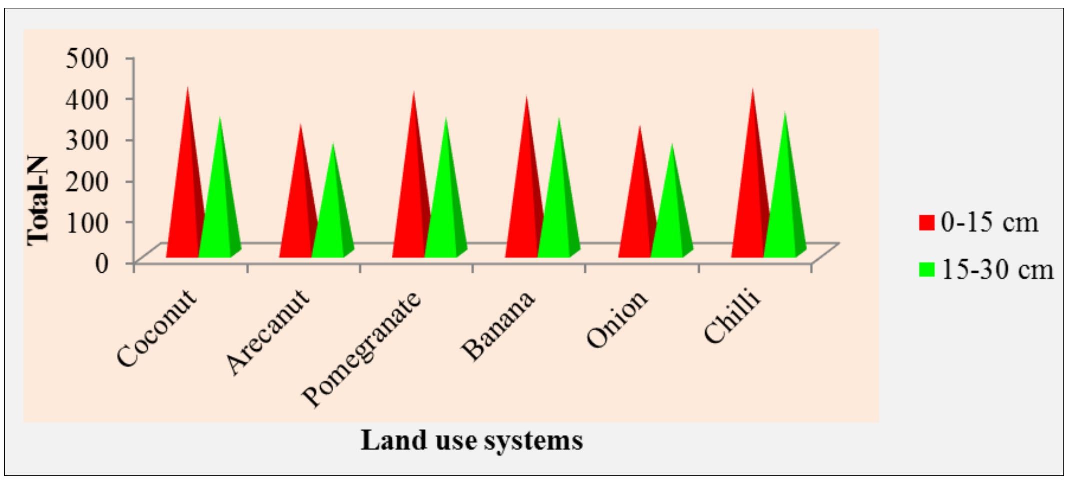

Fig 7: Total hydrolysable nitrogen

available phosphorus as compared to sub surface status which might be due to its higher removal than replenishment and phosphorus fixation capacity of soil (Satisha and Badrinath, 2001) [11]. The surface soils contained higher potassium than sub surface soils. This could be attributed to more intense weathering, release of potassium from organic residues, application of potassium fertilizers and upward translocation of potassium from lower depth along with capillary rise of ground water. Similar findings are made by Varaprasad Rao *et al*. (2008) [15]. The decrease in the total nitrogen content with increase in depth may be related to the close link with organic carbon and due to association of nitrogen with organic matter and adsorption of ammonical nitrogen on humus complex in the soil (Verma *et al*. 1980) [16]. The exchangeable ammonical nitrogen showed a decreasing trend with depth due to low rate of mineralization in the subsurface soils. Similar findings also are reported by Kaistha *et al*. (1990) [5]. Nitrate nitrogen content showed a zone of maximum concentration at the surface than the subsurface due to rapid mineralization of organic matter in surface layer compared to subsurface soils. Similar results were reported by Singh *et al*. (1998) [13, 14]. Amino acid nitrogen gets mineralized at a faster rate and its contents decreased with increase in soil depth (Fig. 5) similar results were reported by Mohapatra and Khan (1987). The status of hydrolysable ammonical nitrogen and hexsamine nitrogen content is dominantly controlled by clay content and to some extent by micro organisms. (Aggarwal *et al*., 1990) [1].

Conclusion

Soils under different horticultural land systems of Hiriyr taluk, Chitradurga district, showed the low to medium available N, P and K. Soil reaction was alkaline in nature. Due to high soluble salts content EC range was higher. Sandy loam to clay textured soil was observed. Among the different forms of nitrogen total hydrolysable nitrogen was the dominant fraction and NO_3^--N was the least fraction. The dynamic status of different nitrogen forms in these soils appeared to be low that frequent N fertilization with a small amount but multiple times so that nitrogen concentration in soil solution may be maintained at a higher and more stable value for sustainable production of horticultural crops.

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