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IMPACT OF DIFFERENT NUTRIENT MANAGEMENT STRATEGIES ON SOIL INORGANIC NITROGEN FRACTIONS IN GROUNDNUT AND THEIR RELATIONSHIP WITH CROP YIELD

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ABSTRACT

A field experiment was conducted during *Kharif* (2021) season to study soil nitrogen fractions in groundnut under different nutrient management approaches in the Central Dry Zone of Karnataka, using groundnut variety TMV-2 as test crop at Zonal Agriculture and Horticulture Research Station (ZAHRS), Hiriyur. The experiment was laid out in RCBD design with four treatments, five replications. This experiment comprises different nutrient management approaches as treatments *viz.*, Organic farming approach; Natural farming approach; POP (package of practice) and Farmer's practice. The findings show that there were notable differences in the soil's organic carbon content following the groundnut harvest. The primary (N, P and K) and secondary (Ca, Mg and S) nutrient fertility status of the soil varied significantly across treatment techniques. Organic farming showed higher soil biological characteristics, such as urease, phosphatase, and dehydrogenase activity. An inorganic of soil nitrogen fractions, specifically nitrate (NO_3^-), ammonical (NH_4^+), available and total nitrogen, showed notable variations during the growth stages (30, 60 and 90 DAS) as well as at harvest. Yield and yield attributes of groundnut positively correlated with various soil nitrogen fractions.

Key words : Nutrient approach, Biological properties, Yield attributes, Nitrate nitrogen, Ammonical nitrogen.

Introduction

Nitrogen is one of the important primary nutrient elements and essentially required for crop growth and development. It has been observed that nitrogen is most frequently deficient nutrient in crop production. Therefore understanding the behaviour of nitrogen in the soil is essential for maximizing agricultural production and profitability, while reducing the impact of nitrogen fertilization on the environment. Many nitrogen sources are available for use in order to supply nitrogen to crops. In addition to inorganic fertilizer nitrogen, organic nitrogen from animal manures, other waste products from nitrogen fixing leguminous crops can supply sufficient nitrogen for crop production.

The impact of modern agriculture on natural resources has become a major global concern. Population growth and expanding demand for agricultural products constantly increase the pressure on land and water resources. A major point of concern for many intensively managed agricultural systems with high external inputs is the low resource-use efficiency, especially for nitrogen. A high input combined with a low efficiency ultimately results in environmental problems such as soil degradation, eutrophication, and pollution of groundwater, emission of ammonia and greenhouse gases. Evidently, there is a need for a transition of current agricultural systems into highly resource-use efficient systems that are profitable, but at the same time ecologically safe and socially acceptable.

India is one of the major oilseeds grower and importer of edible oils. India's vegetable oil economy is world's fourth largest after USA, China and Brazil. The oilseed accounts for 13 per cent of the gross cropped area, 3 per cent of the gross national product and 10 per cent value of total agricultural commodities. This sector has recorded annual growth rate of area, production and yield @ 2.44 per cent, 5.47 per cent and 2.96 per cent respectively during last decade from 1999-2009.

The diverse agro-ecological conditions in the country are favourable for growing 9 annual oilseed crops, which include seven edible oilseeds *viz*., groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower and niger and two non-edible oilseeds *viz*., castor and linseed. Oilseeds cultivation is undertaken across the country in about 27 million hectares mainly on marginal lands of which 72 per cent is confined to rain, fed farming cultivation system.

Groundnut (*Arachis hypogaea*), is a specie in the legume family (*Fabaceae*) native to South America, Mexico and Central America. Groundnut is an important oil seed crop in India with 5.86 m ha and 8.26 m production. Though groundnut primarily used tonnes as oil seed crop, some of the groundnut varieties are recommend as table purpose for direct consumption because of its high nutrient value.

Organic farming is a production system which largely excludes or avoids the use of fertilizers, pesticides, growth regulators, preservatives, livestock feed additives and totally rely on crop residues, animal manures, legumes, green manures, off-farm wastes, mechanical cultivation, mineral nutrient bearing rocks and biological pest control to maintain soil health, supply plant nutrients and minimize insects, weeds and other pests.

Natural Farming (or ZBNF) involves the application of Jeevamritha, Beejamritha, mixed cropping system, home-made preparations for plant protection and seed/ planting materials, and mulching. Thus, it envisages complete freedom from chemicals from farming. Using at least Jeevamritha and not using any chemicals (fertilizers/pesticides/growth promoters). Both the conditions together were considered essential for terming as NF-adopter farmers.

Integrated nutrient management (INM) is an approach that seeks to increase production quality and protect the environment for posterity. It relies on nutrient application and conservation, new technologies to increase nutrient availability to plants, and the dissemination of knowledge between farmers and researchers (Palm *et al*., 2001). In the past, nutrient management was driven by the need to maximize production. However, sustainable nutrient management involves maximizing production, preventing on-site soil degradation and minimizing off-site involvement of applied nutrients (Tagliavini and Marangoni, 2002).

Given the above facts, the present study entitled "Impact of different Nutrient Management Strategies on Soil Inorganic Nitrogen Fractions in Groundnut and their Relationship with Crop Yield." was undertaken to know the best nutrient approach.

Materials and Methods

Experimental site

An experiment was conducted at ZAHRS, Babbur farm, Hiriyur, situated in Central Dry Zone (Agro-Climatic Region IV) of Karnataka. The geographical reference point of the experimental site was 13^0 57' North latitude and 75^0 38' East longitude, with an altitude of 606 meters above mean sea level (MSL).

The soil has clay loam texture and black in color. The analysis data indicated that soil was moderately alkaline in reaction with a normal electrical conductivity and low in organic carbon. Further, soil was low in available nitrogen status, medium status for available phosphorus and high in available potassium.

Field experiments was conducted in black soil (*Vertisol*) of ZAHRS, Babbur Farm, Hiriyur, using groundnut (Variety: TMV-2) as a test crop with four treatments replicated five times. The experiment was laid out in randomized complete block design, spacing 30cm x10cm and size of the plot is 20m × 10m.

Treatment details

Treatment	Farming system	Treatment details
T_1	Organic farming	Seed treatment with *Rhizobium* and PSB + Recommended dose of FYM (10 t ha^{-1}) + P equivalent basis of FYM
T_2	Natural farming	Seed treatment with Beejamrutha + Ghanajeevamrutha @ 1000 kg ha^{-1} before sowing + Jeevamrutha @ 500 L ha^{-1} @ 30 days interval + mulching
T_3	University Package of practices	Seed treatment with *Rhizobium* and PSB + Recommended dose of FYM (10 t ha^{-1})+NPK 25:75:37.5 kg

		ha^{-1} + $ZnSO_4$ $7H_2O$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Gypsum @ 500 kg ha^{-1}
T_4	Framer's practice	N:P_2O_5:K_2O::40:20:30 kg ha^{-1}

Note: Organic amendments like FYM, Beejamrutha, Ghanajeevamrutha and Jeevamrutha was characterized for total elemental composition before application.

Soil sampling and analysis

The treatment wise composite soil samples from each replication at harvest of crop were collected from of 0-15 cm depth at initial, 30, 60, 90 DAS and at harvest which were used for different chemical parameters analysis. The initial and at harvest samples were analyzed for different physical, chemical and biological properties and nitrogen fractions like exchangeable ammonical nitrogen, nitrate nitrogen, available nitrogen and total nitrogen. Samples collected at above mentioned intervals were analyzed for nitrogen fraction.

Table 1 : Initial soil characteristics of the experimental site.

S. no.	Parameter	Value
I	**Physical properties**	
	Bulk density (Mg m^{-3})	1.12
II	**Chemical properties**	
	pH (1:2.5)	8.85
	EC (dS m^{-1}@ 25 ºC)	0.53
	Organic carbon (g kg^{-1})	4.2
	Available macro nutrients	
	Available nitrogen (kg ha^{-1})	232.6
	Available phosphorus (kg ha^{-1})	27.7
	Available potassium (kg ha^{-1})	344.5
	Exchangeable calcium [cmol (p^{+}) kg^{-1}]	31.88
	Exchangeable magnesium [cmol (p^{+}) kg^{-1}]	13.15
	Available sulphur (mg kg^{-1})	29.33
III	**Biological properties**	
	Dehydrogenase (ìg TPF g^{-1} day^{-1})	84.87
	Phosphatase (ìg PNP g^{-1} h^{-1})	14.23
	Urease (NH_4^{+}-N g^{-1} soil 2h^{-1})	32.67

Soil samples collected were shade-dried and passed through 2 mm sieve before analysis. These processed samples were characterized for different physico-chemical and biological properties by using standard analytical protocols as detailed below.

Bulk density was determined by Keen's cup method (Piper, 1966). Soil pH was measured by potentiometric method using glass electrode (Jackson, 1973). The electrical conductivity (EC) of soil was determined in 1:2.5 soil : water suspension using Conductivity Bridge and the results were expressed in dSm^{-1} (Jackson, 1973).

Soil organic carbon was determined by using Walkley and Black's wet oxidation method (Walkley and Black, 1934). Available nitrogen was determined by alkaline potassium permanganate method (Subbaih and Asija, 1956). For analyzing ammonical nitrogen and nitrate nitrogen, soil samples were leached with 25 mL of 2M KCl solution, followed by adding 0.5 g of MgO powder for estimating NH^{4+}-N and NaOH was used, while estimating NO^{3-}-N by modifying Kjeldahl method (Bremner and Nelson, 1982). Total nitrogen was determined by using CHNS elementar analyzer (Vario EL CUBE model). Semi-macro analysis for CHNS is 40 mg of soil sample. Available phosphorus in soil was extracted by Olsen's extractant (0.5 M $NaHCO_3$) and the content of phosphorus was determined by ascorbic acid blue colour method at 660 nm (Jackson, 1973). Available potassium was determined by using flame photometer Jackson, 1973). Sulphate sulphur in the soil was extracted by using 0.15 per cent calcium chloride solution Jackson, 1973). Extraction of soil with 1N (pH

Table 2 : Chemical composition of the ghanajeevamrutha, jeevamritha, beejamrutha and FYM used in the experiment.

Elemental composition	Ghanajeevamrutha	Jeevamrutha	Beejamrutha	FYM
Nitrogen (%)	1.96	1.15	0.01	0.79
Phosphorus (%)	0.64	0.22	0.02	0.45
Potassium (%)	0.76	0.36	0.03	0.41
Sulphur (%)	0.56	0.32	-	0.32
Calcium (%)	0.80	0.75	-	1.09
Magnesium (%)	0.65	0.50	-	0.81
Zinc (ppm)	85.89	29.71	2.98	64.27
Manganese (ppm)	113.98	22.09	4.14	99.32
Copper (ppm)	49.34	7.93	0.59	44.01
Iron (ppm)	823.18	234.31	16.75	580.15

7) ammonium acetate followed by complexometric titration for estimation of exchangeable calcium and magnesium (Barua and Barthakur, 1997).

The dehydrogenase enzyme was analyzed following the procedure described by Casida *et al.* (1964). The phosphatase enzyme activity was analyzed following the procedure outlined by Eivazi and Tabatabai (1977). The urease enzyme activity was analyzed following the procedure outlined by Tabatabai and Bremner (1972).

The major nutrients such as nitrogen, phosphorus and potassium present in beejamrutha, jeevamrutha, ghanajeevamrutha were estimated by following microkjeldhal, vanadomolybdate and flame photometric methods respectively. Micronutrients present in beejamrutha were estimated using Atomic Absorption Spectrophotometer (AAS). Chemical composition of ghanajeevamrutha is presented in Table 2.

Statistical analysis and interpretation of data

The experimental data obtained were subjected to statistical analysis using Fisher's method of analysis of variance (Gomez and Gomez, 1984). Correlation analysis was carried out to assess the relationship among different soil nitrogen fractions and yield by Pearson correlation coefficient using IBM-SPSS statistics package software.

Results and Discussion

Soil physico-chemical and biological properties after harvest of the groundnut as influenced under different nutrient management approaches

Among the different nutrient approaches, the bulk density of soil was statistically non-significant and it ranged from 1.09 -1.13 Mg m^{-3}. However, numerically lower bulk density noted in the treatment following organic farming approaches. Where, the higher soil bulk density observed in treatment with farmer's approaches. The application of organic matter decreased the bulk density of soil and considerably increased the synthesis of polysaccharides and microbial gum, which served as a binding agent for soil particles (Kapoor *et al.*, 2015; Bhatt *et al.*, 2019; Kumar *et al.*, 2012) (Table 3).

The pH of the soil was statistically non-significant among the treatments after harvest of the crop. The pH value observed in, organic farming (8.35) was numerically lower than other treatments. Highest pH value (8.51). The soluble salt content was found statistically non-significant among different treatments after harvest of the crop. However, EC value observed in organic farming (0.52 dS m^{-1}) was numerically higher over other treatments. Least EC was recorded in farmer's practice (0.48 dS m^{-1}) after harvest. The generation of organic acids during the breakdown and mineralization of organic manures may be the cause of the small reduction in pH and EC values with the application of organic sources. The pH value decrease by one unit because of applying 7 tons of FYM during a four-year period (Singh *et al.*, 1980). Due to the application of organic manure, A considerable decrease in soil reactivity comparable to the application of fertilizer (Badanur *et al.*, 1990) (Table 3).

Table 3 : Effect of various nutrient management approaches on soil physico-chemical properties at post-harvest of groundnut.

Treatments	BD (Mg m^{-3})	pH	EC (dS m^{-1})	SOC (g kg^{-1})
Organic farming	1.31	8.35	0.52	4.8
Natural farming	1.31	8.41	0.49	4.8
POP	1.32	8.45	0.51	4.7
Farmer's practice	1.34	8.51	0.48	4.4
S.Em±	**0.01**	**0.04**	**0.01**	**0.01**
CD (p=0.05)	**NS**	**NS**	**NS**	**0.03**

Where, BD-Bulk density, pH- Soil reaction, EC- Electrical conductivity and SOC-Soil organic carbon.

The value of organic carbon among treatments ranged from 4.4-4.8 g kg^{-1}. The highest value of organic carbon was observed in a both organic farming and natural farming (4.8 g kg^{-1}), which was statistically on par with POP (4.7 g kg^{-1}). Significantly lower value of organic carbon was observed in farmer's practice (4.4 g kg^{-1}). The organic amendments increased soil organic carbon (Kaushik *et al.*, 1984; Kowaljow and Mazzarino, 2007; Chivenge *et al.*, 2009). After four years of the decomposition of organic manure over fertilizer treatment, a considerable rise in the organic carbon content of *Vertisol* (Bellakki and Badanur, 1997) (Table 2).

Among different treatments, significantly higher value of available nitrogen was recorded in POP (339.36 kg ha^{-1}) (Table 4), followed by farmer's practice (323.42 kg ha^{-1}) and organic farming (305.58 kg ha^{-1}). Significantly lower value of available nitrogen was recorded in natural farming (279.68 kg ha^{-1}). The higher soil microbial proliferation brought on by the addition of organic materials, which mineralize organically bound N to inorganic form, is also responsible for the increase in accessible nitrogen as a result of the application of organic matter (Adjei-Nsiah, 2012; Singh *et al.*, 2008; Rong *et al.*, 2016).

POP (29.88 kg ha^{-1}) recorded significantly higher value of phosphorus, which was statistically on par with farmer's practice (29.08 kg ha^{-1}), followed by organic

Table 4 : Effect of various nutrient management approaches on soil nutrient status at post-harvest of groundnut.

Treatments	**Primary nutrients**			**Secondary nutrients**		
	Available N (kg ha^{-1})	**Available P_2O_5 (kg ha^{1})**	**Available K_2O (kg ha^{-1})**	**Exch. Ca [cmol (p^{+}) kg^{-1}]**	**Exch. Mg [cmol (p^{+}) kg^{-1}]**	**Available S (mg kg^{-1})**
Organic farming	305.58	28.15	346.25	33.96	13.53	34.93
Natural farming	279.68	26.79	345.41	34.35	14.39	32.80
POP	339.36	29.88	347.82	34.97	15.53	35.86
Farmer's practice	323.42	29.08	346.70	30.95	10.60	27.75
S. Em. (±)	**0.32**	**0.27**	**0.33**	**0.16**	**0.12**	**0.07**
CD (p=0.05)	**0.98**	**0.83**	**1.02**	**0.51**	**0.38**	**0.22**

Table 5 : Effect of various nutrient management approaches on soil biological activity at post-harvest of groundnut.

Treatments	**Dehydrogenase (µg TPF g^{-1} soil day^{-1})**	**Phosphatase (µg PNP g^{-1} h^{-1})**	**Urease (NH_4^+-N g^{-1} soil 2h^{-1})**
Organic farming	97.38	22.46	41.69
Natural farming	93.06	19.20	38.54
POP	95.66	21.72	40.58
Farmer's practice	64.04	7.76	19.40
S.Em±	**0.33**	**0.29**	**0.15**
CD (p=0.05)	**1.01**	**0.90**	**0.48**

Table 6 : Relation between Soil nitrogen fractions and Yield of Groundnut.

Nitrogen fractions	**Yield and yield attributes**			
	Pod yield	**Haulm yield**	**Kernel yield**	**No. of pods per plant**
Total nitrogen	0.882	0.944	0.906	0.887
Available nitrogen	0.948	0.983*	0.977*	0.975*
NH_4^+-N	0.953*	0.969*	0.987*	0.998**
NO_3^--N	0.934	0.972*	0.971*	0.977*

Note: *Significant at 5 % level and **Significant at 1 % level.

farming (28.15 kg ha^{-1}). In natural farming (26.79 kg ha^{-1}), the available phosphorus value was found to be significantly lower. The value of available phosphorus is 11.5 percent higher in POP than natural farming. An increase in the amount of soil-available phosphorus following the incorporation of FYM alone or in combination with inorganic fertilizers and attributed it to improved phosphorus solubilization by the by product of organic manures' decomposition (Singh *et al.*, 1982; Tandon, 1987; Guo and Sims, 2002; Tognetti *et al.*, 2008; Khokle, 2016) (Table 4).

Among four treatments, application of recommended dose of fertilizer with FYM (347.82 kg ha^{-1}) recorded significantly higher concentration of available potassium in soil, followed by farmer's practice (346.70 kg ha^{-1}), which was statistically on par with organic farming (346.25 kg ha^{-1}). Lowest concentration of potassium was noticed in a natural farming (345.41 kg ha^{-1}). A continuous inorganic fertilizer treatment, FYM, and cropping over 41 years considerably raised the available K content [31]. The plots treated with FYM also had the highest levels of available K, which were followed by super-optimal doses of NPK fertilizers (Kaur and Benipal, 2006; Ebid *et al.*, 2007; Paradelo *et al.*, 2012) (Table).

Among various treatments, POP (package of practices) recorded the maximum exchangeable magnesium (15.53 cmol (p+) kg^{-1}), followed by natural farming (14.39 cmol (p+) kg^{-1}) and organic farming (13.53 cmol (p+) kg^{-1}). Significantly lower value of exchangeable magnesium was observed in farmer's practice (10.60 cmol (p+) kg^{-1}). The significantly higher value of exchangeable calcium after harvest of the crop was recorded in POP (34.97 cmol (p+) kg^{-1}), followed by natural farming (34.35 cmol p(+) kg^{-1}) and organic farming (33.96 cmol (p+) kg^{-1}). The significantly lower value of exchangeable calcium was observed in farmer's practice (30.95 cmol (p+) kg^{-1}). The value of exchangeable calcium and magnesium significantly decreased in farmer's practice. Higher availability of calcium in POP may be attributed to the application of gypsum. Further application of organic residues increased the cation exchange capacity of the soil. Improved cation exchange capacity is important since it leads to increased availability of plant nutrients and hence improves the fertility status of the soil. Organic anions released from

FYM retard the phosphorus fixation in soil by complexing with organic ligands and chelation of it with cations like Ca, Mg, Fe, Al, Zn, Mn and Cu (Thirunavukkarasu and Balaji, 2015; Ramakrishna *et al*., 2016; Gogoi *et al*., 2015) (Table 4).

Among four treatments, the significantly higher value of sulphur was recorded in POP (35.86 mg kg^{-1}), followed by organic farming (34.93 mg kg^{-1}) and natural farming (32.80 mg kg^{-1}). The significantly lower value of available sulphur was recorded in farmer's practice (30.95 mg kg^{-1}). The release of organically bound sulphur during mineralization is what caused the increase in available sulphur content (Vadiraj *et al*., 1992). The increase in accessible sulphur in such soils was probably caused by the addition of larger amounts of organic manures and a longer duration of organic farming noticed higher SO_4-S content in the soils (Swarup and Ghosh, 1980) (Table 5).

Among four treatments significantly higher dehydrogenase activity was observed in organic farming (97.38 µg TPF g^{-1} soil day^{-1}), followed by POP (95.66 µg TPF g^{-1} soil day^{-1}), and natural farming (93.06 µg TPF g^{-1} soil day^{-1}). Significantly lower dehydrogenase activity was observed in farmer's practice (64.04 µg TPF g^{-1} soil day^{-1}) at harvest of the crop. Dehydrogenase activity in organic farming (T_1) and POP (T_3) was 4.6 per cent and 2.8 per cent higher than natural farming. Dehydrogenase activity may be higher in organic farming due to the direct addition of organic matter through farmyard manure and an increase in root biomass, both of which aided in the growth and development of soil microorganisms and had a favorable impact on dehydrogenase activity compared to control (Meshram *et al*., 2016; Krishnakumar *et al*., 2005; Katkar *et al*., 2012) (Table 5).

Among four treatments, the significantly higher phosphatase activity was observed in organic farming (22.46 ìg PNP g^{-1} h^{-1}), which was statistically on par with POP (21.72 ìg PNP g^{-1} h^{-1}) followed by natural farming (19.20 ìg PNP g^{-1} h^{-1}). The significantly lower value of phosphatase activity was recorded in farmer's practice (7.76 ìg PNP g^{-1} h^{-1}). Phosphatase activity in organic farming (T_1) and POP (T_3) was 16.9 per cent and 13.1 per cent higher than natural farming (T_2). Alkaline phosphatase activity increased, which showed that organic matter considerably raised soil enzyme activity. The addition of organic materials to the soil acted as a carbon source that increased microbial biomass and phosphatase activity, demonstrating that these enzymes are of microbial origin. The crop growth stage also significantly influenced the soil enzyme activities (Sriramachandrasekharan and Ravichandran, 2011; Bohme *et al*., 2005; Sheng *et al*., 2005).

Among four treatments, the highest urease activity was observed in organic farming (41.69 NH^{4+}-N g^{-1} soil 2h^{-1}), followed by POP (40.58 NH^{4+}-N g^{-1} soil 2h^{-1}) and natural farming (38.54 NH^{4+}-N g^{-1} soil 2h^{-1}). The significantly lower value of urease activity was recorded in farmer's practice (19.40 NH^{4+}-N g^{-1} soil 2h^{-1}) (Table 5). The increase in activity of urease enzyme in organic farming maybe due to application of FYM. Further, the activity of urease enzyme directly depends upon total nitrogen in soil. The impact of organic fertilizers, especially organic-mineral fertilizers, on soil enzyme activity is typically greater than that of mineral fertilizers. Combined usage of organic manures boosted the enzyme activity of the soil rather than single organic manure application (Krishnakumar *et al*., 2005; Goyal *et al*., 1993).

Effect of nutrient management approaches on soil nitrogen fractions at different growth stages of groundnut

Total nitrogen : Among four treatments, the significantly higher concentration of total nitrogen at 30 DAS (Figure 1a) was observed in organic farming (805.93 mg kg^{-1}), followed by POP (795.91 mg kg^{-1}) and natural farming (784.79 mg kg^{-1}). The significantly lower value of total nitrogen was recorded in farmer's practice (775.82 mg kg^{-1}). Among four treatments, the significantly higher concentration of total nitrogen at 60 DAS was observed in organic farming (811.17 mg kg^{-1}), followed by POP (800.90 mg kg^{-1}) and natural farming (791.14 mg kg^{-1}). The significantly lower value of total nitrogen was recorded in farmer's practice (782.62 mg kg^{-1}). Among four treatments, the significantly higher concentration of total nitrogen at 90 DAS was observed in organic farming (825. mg kg^{-1}), followed by POP (820.79 mg kg^{-1}) and natural farming (808.77 mg kg^{-1}). The significantly lower value of total nitrogen was recorded in farmer's practice (791.11 mg kg^{-1}). Among four treatments, the significantly higher concentration of total nitrogen after harvest was observed in organic farming (840.73 mg kg^{-1}), followed by POP (832.79 mg kg^{-1}) and natural farming (825.75 mg kg^{-1}). The significantly lower value of total nitrogen was recorded in farmer's practice (795.62 mg kg^{-1}). The increase in total nitrogen in organic farming maybe attributed to increase in level of organic carbon in organically treated soils. Total nitrogen followed the organic carbon level because the soil-internal cycling is linked to organic carbon. The increase in organic carbon and total nitrogen, has been observed in organically managed soils compared to conventionally managed soils receiving chemical fertilizers only (Reganold, 1988; Drinkwater *et al.*, 1995). Also found the increase in total nitrogen, 23.1 percent more in FYM application than organic fertilizer alone (Kaur and Singh, 2014).

Available nitrogen : Among four treatments, the significantly higher value of available nitrogen at 30 DAS was observed (Fig. 1b) in farmer's practice (140.65 mg kg^{-1}), followed by POP (138.81 mg kg^{-1}) and organic farming (136.67 mg kg^{-1}). The significantly lower value of available nitrogen was recorded in natural farming (134.74 mg kg^{-1}). At 60 DAS, the significantly higher value of available nitrogen was observed in POP (142.59 mg kg^{-1}), followed by farmer's practice (141.17 mg kg^{-1}), and organic farming (138.73 mg kg^{-1}). The significantly lower value of available nitrogen was observed in natural farming (136.88 mg kg^{-1}). At 90 DAS, the significantly higher value of available nitrogen was observed in POP (158.84 mg kg^{-1}), followed by farmer's practice (153.95 mg kg^{-1}) and organic farming (141.04 mg kg^{-1}). The significantly lower value of available nitrogen was observed in natural farming (138.07 mg kg^{-1}). After harvest of the crop, the significantly higher value of available nitrogen was observed in POP (169.68 mg kg^{-1}), followed by farmer's practice (161.71 mg kg^{-1}), and organic farming (152.79 mg kg^{-1}). The significantly lower value of available nitrogen was observed in natural farming (139.84 mg kg^{-1}). The significantly higher value of available nitrogen was recorded in treatment receiving fertilizers and FYM, maybe due to lower C:N ratio of FYM, which hastens mineralization of nitrogen in soil. It is likely that the same factors that contributed to the rise in organic C also contributed to the rise in soil-available N in the soil that had organic manure added to it (Puranik *et al.*, 1978; Kher and Minhas, 1992; Ayuso *et al.*, 1996).

Ammonical nitrogen : At 30 DAS, the significantly higher value of NH^{4+}-N (Fig. 1c) was observed in farmer's practice (12.80 mg kg^{-1}) followed by POP (11.62 mg kg^{-1}), and organic farming (10.67 mg kg^{-1}). The significantly lower value of NH^{4+}-N was observed in natural farming (8.73 mg kg^{-1}). At 60 DAS, the significantly higher value of NH^{4+}-N was observed in farmer' practice (13.20 mg kg^{-1}), followed by POP (12.79 mg kg^{-1}) and organic farming (11.54 mg kg^{-1}). Significantly lower value of NH^{4+}-N was observed in natural farming (9.72 mg kg^{-1}). At 90 DAS, the significantly higher value of NH^{4+}-N was observed in POP (14.84 mg kg^{-1}), followed by farmer's practice (13.86 mg kg^{-1}), and organic farming (11.91 mg kg^{-1}). Significantly lower value of NH^{4+}- N was observed in natural farming (10.64 mg kg^{-1}). After harvest of the crop, the significantly higher value of NH^{4+}-N was observed in POP (16.68 mg kg^{-1}), followed by farmer's practice (14.81 mg kg^{-1}), and organic farming (12.76 mg kg^{-1}). The significantly lower value of NH^{4+}-N was observed in natural farming (11.26 mg kg^{-1}). Because gypsum includes sulphur and encourages plants to grow roots more effectively, the buildup of NH^{4+}-N was higher in POP, suggesting that more nitrogen was perhaps being fixed there. The application of FYM and urea together reduced ammonic volatilization losses (Yaduvanshi, 2001; Rajput *et al.*, 1984; Thakur *et al.*, 1992; Mikha and Rice, 2004; Venugopal *et al.*, 2017; Kushwaha, 2011).

Nitrate nitrogen : At 30 DAS, the significantly higher value of NO_3^--N (Fig. 1d) was observed in farmer's practice (9.82 mg kg^{-1}), followed by POP (8.74 mg kg^{-1}) and organic farming (7.54 mg kg^{-1}). The significantly lower value of NO_3- -N was recorded in natural farming (5.74 mg kg^{-1}). At 60 DAS, the significantly higher value of nitrate nitrogen was observed in POP (10.59 mg kg^{-1}), followed by farmer's practice (10.10 mg kg^{-1}) and organic farming (8.63 mg kg^{-1}). The significantly lower value of NO^{3-}-N was observed in natural farming (7.60 mg kg^{-1}). At 90 DAS, the significantly higher value of NO_3- -N was observed in POP (12.48 mg kg^{-1}), followed by farmer's practice (11.34 mg kg^{-1}) and organic farming (10.57 mg kg^{-1}). The significantly lower value of NO_3^--N was observed in natural farming (9.38 mg kg^{-1}). After harvest of the crop, the significantly higher value of NO^{3-}-N was observed in POP (14.35 mg kg^{-1}), followed by farmer's practice (12.84 mg kg^{-1}), and organic farming (11.62 mg kg^{-1}). The significantly lower value of NO_3^- -N was observed in natural farming (9.64 mg kg^{-1}). The impact of constant manuring and fertilisation on the soil nitrogen fractions during a seven-year period in an *Alfisol* intensive cropping system and found that the total, ammonia, nitrate and organic nitrogen contents significantly increased (Udaysoorian *et al.*, 1989). All nitrogen components in the soil rose while using organic manures at a rate of FYM @ 25 t ha^{-1} per crop (Verma and Bhagat, 1994; Basumatary and Taluldar, 1998; Santry *et al.*, 1998).

Correlation coefficient between nitrogen fractions and yield as influenced under different nutrient management approaches

Correlation studies showed that there was positive correlation between total nitrogen and pod yield, haulm yield, kernel yield and no. of pods per plant after harvest (Table 6). Available nitrogen had positive correlation with pod yield and significant positive correlation with haulm yield (r=0.983*), kernel yield (r=0.977*) and no. of pods

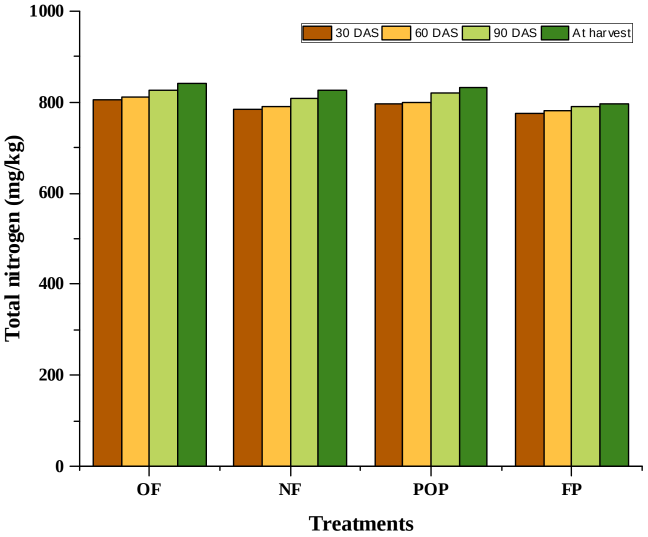

Fig. 1a : Effect of different nutrient management strategies on soil total nitrogen.

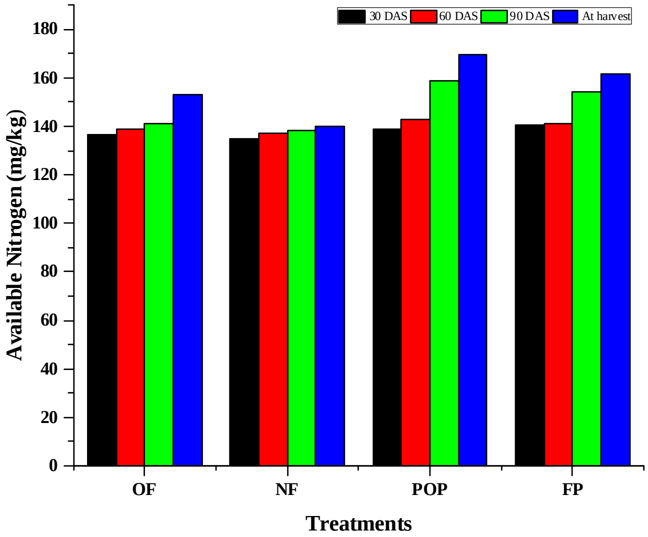

Fig. 1b: Effect of different nutrient management strategies on soil available nitrogen.

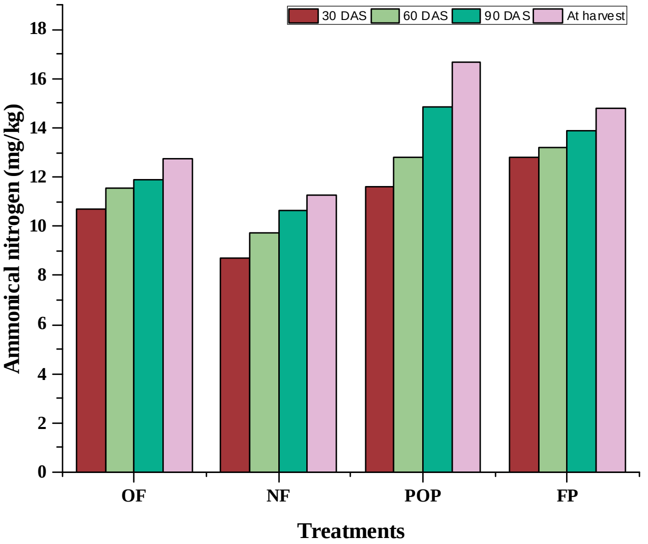

Fig. 1c : Effect of different nutrient management strategies on soil ammonical nitrogen.

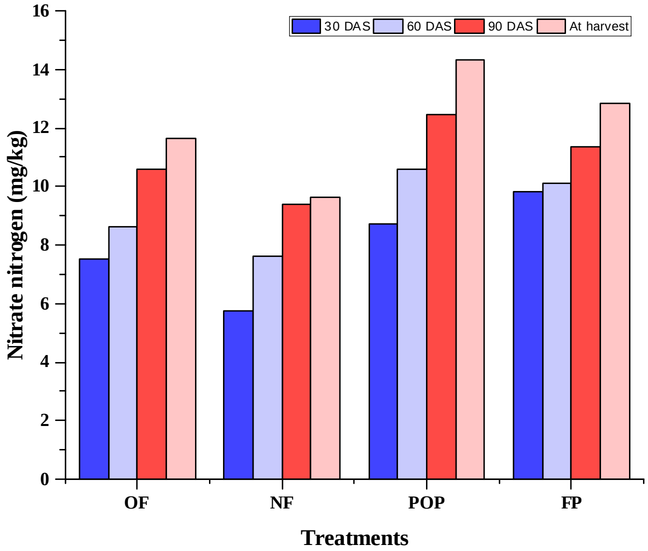

Fig. 1d : Effect of different nutrient management Strategies on soil nitrate nitrogen.

per plant (r=0.975*). NH$_4$+-N had positive and significant correlation with pod yield (r=0.953*), haulm yield (r=0.969*), kernel yield (r=0.987*) and no of pods per plant(r=0.998**). NO$_3$- -N showed positive correlation with pod yield, but positive and significant correlation haulm yield (r=0.972*), kernel yield (r=0.971*) and no. of pods per plant (r=0.977*).

The correlation coefficient (r values) emerged out suggest that pod yield, haulm yield, kernel yield and no. of pods per plant were predominantly dependent on total nitrogen, available nitrogen, NH^{4+}-N and NO$_3^-$-N. They noticed a substantial relationship between the available nitrogen, ammonia, and nitrate-nitrogen and the wheat yield (Prasad *et al.*, 2016). Nitrate and ammonia together contributed most to maize biomass production, whereas greatest biomass accumulation with NO^{3-}-N was recorded for wheat (Dinev and Stancheva, 1995; Prasad and Rokima, 1991; Srivastava, 1975; Srivastava and Srivastava, 1993).

Conclusion

Initial soil properties like bulk density, pH, EC and OC did not change significantly among the treatments. However, the highest nutrients status *i.e.* nitrogen, phosphorus, potassium, calcium, magnesium and sulphur were recorded in POP practice. Among nitrogen fractions, total nitrogen was found significantly higher in organic farming system at all growth stages of groundnut. Moreover, the other fractions like available nitrogen, ammonical and nitrate were highest in POP practice, followed by farmer's practice. Correlation studies proved that nitrogen fractions like available nitrogen, NH$_4^+$-N and NO_3^--N were positively correlated with yield.

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