



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(5): 1686-1691

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Received: 20-06-2020

Accepted: 18-07-2020

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Consequence of long-term balance nutrient management on soil nitrogen dynamics under groundnut-wheat cropping sequence in a calcareous clay Soils

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i5w.10541>

Abstract

The application of FYM maintained or increased nitrogen status of LTFE soils. In treatments of FYM (T₈, T₉), the status of nitrogen fractions increased. In case of all the fractions of nitrogen found significantly maximum in T₉. At initial stage of experiment (1st year) available nitrogen status of LTFE soils falls under lower range (<250 Kg N ha⁻¹), also after 5th, 10th, 15th and 20th year it decreased to lower range (<250 Kg N ha⁻¹) in most of the treatments, except treatments which received FYM (T₈ & T₉) which showed medium range in available-N status of LTFE soils. Further It was established here that for maintaining N fertility of soil at long run, addition of FYM is essential with inorganic fertilizers. Similar results were also recorded in case of all other fractions of nitrogen. In LTFE soils the percent depletion of different forms of nitrogen was interesting under all treatments. The total-N and O. C. showed positive depletion after a span of 20 year except T₁, T₅, T₆ and T₉ and available-N exhibited positive depletion except treatment T₁, T₅ and T₆.

Keywords: Nitrogen fraction, total nitrogen, ammonical nitrogen, nitrate nitrogen, O.C., available nitrogen, AICRP-LTFE soils, dynamics, fractions, haplustepts

Introduction

Nitrogen is an important element for plant life. In the importance it comes only next to carbon, hydrogen and oxygen as it figures in the composition of proteins, nucleic acid, growth hormones, vitamins etc. It is also one of the main structural components of a living organism. Only a small proportion of total N is present in the available forms (NH₄⁺ and NO₃⁻) in the soil. Nitrate is first reduced to ammonium level in a series of steps in order to be absorbed by the plants. The average Indian soil contains about 0.05 per cent nitrogen. Nitrogen occurs in soil as inorganic and organic compounds. Nitrates and nitrites of calcium, potassium etc. are the main inorganic forms of nitrogen while organic form chiefly the proteins. The mineral N of the soil exists as NH₄⁺, NO₃⁻ and sometimes NO₂⁻ either in soil solution, on exchange sites of soil particles or as NH₄⁺ held by clay minerals. Some gaseous nitrogen may also be found in the soils atmosphere and dissolved in soil solution. In most of the soils, the bulk of nitrogen is as an organic form and usually near the surface. The inorganic forms of nitrogen include nitrite which is usually a transitional stage between nitrate and ammonium, and is easily removed. Nitrogen also occurs as exchangeable ions, fixed forms and traces of gaseous forms such as dinitrogen and nitrogen monoxide and elemental nitrogen. Considering this fact, there is a urgent need to study the dynamics of different fractions of nitrogen under intensive cropping system and hence, the present investigation was planned.

Materials and Methods

Surface soil samples (0-15 cm) were collected from the AICRP-LTFE soils conducted on groundnut-wheat sequence in Randomized Block Design replicated four times at Instructional Farm Junagadh Agricultural University, Junagadh during the year 1999-2000 (1st year, after wheat), 2003-04 (5th year, after wheat), 2008-09 (10th year, after wheat), 2013-14 (15th year, after wheat) and 2018-19 (20th year, after wheat). The treatments were T₁- 50% NPK of recommended doses in G'nut-wheat sequence, T₂- 100% NPK of recommended doses in

G'nut -wheat sequence, T₃- 150% NPK of recommended doses in G'nut -wheat sequence, T₄- 100% NPK of recommended doses in G'nut -wheat sequence + ZnSO₄ @ 50 kg ha⁻¹ once in three year to G'nut only (i.e. '99, 02, 05 etc.), T₅- NPK as per soil test, T₆- 100% NP of recommended doses in G'nut -wheat sequence, T₇- 100% N of recommended doses in G'nut wheat sequence, T₈- 50% NPK of recommended doses + FYM @ 10 t ha⁻¹ to G'nut and 100% NPK to wheat, T₉- Only FYM @ 10 t ha⁻¹ to Groundnut and @ 15 t ha⁻¹ to wheat, T₁₀- 50% NPK of recommended doses + Rhizobium + PSM to G'nut and 100% NPK to wheat, T₁₁- 100% NPK of recommended doses in G'nut -wheat sequence (P as SSP) and T₁₂- Control. These soil samples were analyzed to determine the different forms of nitrogen on the basis of method mentioned below.

Total nitrogen

Total nitrogen was determined by the modified Kjeldhal method (Jackson, 1973) [6].

Available nitrogen

Available nitrogen was determined by alkaline permanganate method (Subbiah and Asija, 1956) [15].

Ammonical nitrogen

Ammonical nitrogen was determined by Richardson's method (Richardson, 1938) [13] N.B. - It's modification of Olsen method.

Nitrate nitrogen

Nitrate nitrogen was determined after Olsens extraction for ammonia (Olsen, 1929) [11].

Organic carbon

Organic carbon was determined by wet oxidation method

(Walkley & Black, 1935) [19]. Also detail information of analysis of the N fractions that I have been taken from the Comprehension Book of Soil Science Laboratory Analysis (Ashokkumar V. Rajani, 2018) [1].

Depletion (%): These nutrients depleted from soil by different cycles were calculated by the formula:

$$\text{Depletion of nutrient (\%)} = \frac{\text{Nutrient status of index year} - \text{Nutrient status of final year}}{\text{Nutrient status of index year}} \times 100$$

Results and Discussion

The results obtained from the present investigation have been discussed below

Available nitrogen

The Available nitrogen status of LTFE soils showed significant difference among the treatments in 1st year, 5th year, 10th year, 15th year, 20th year and pooled over the years. (Table 1) The significant highest value of available N content was recorded in treatments which received FYM (T₉) in pooled over years. During initial year (1st year), highest value observed in T₉ followed by T₈. This result was in confirmation with the finding of Varalakshmi *et al.* (2005) [17] who reported that available N significantly improved with the use of 100% recommended fertilizer + 7.5 t FYM ha⁻¹ in groundnut-finger millet cropping system and it was highest in T₉ during the 10th, 15th and 20th year except 5th year in which it was highest in T₈. There was slight increase in available-N content during 10th year and 20th year as compared to the initial year (1st year) value. The FYM having the positive surplus residual effect on the available-N content in the soil.

Table 1: Status of Available-N (kg ha⁻¹) in soils of LTFE in 1st, 5th, 10th, 15th and 20th year

Treat.	Available-N (kg ha ⁻¹)					
	1 st year	5 th year	10 th year	15 th year	20 th year	Pooled
T ₁	187.64	199.10	220.74	226.01	247.10	216.12
T ₂	233.01	219.60	205.62	215.43	221.25	218.98
T ₃	199.02	202.12	230.96	219.69	190.14	208.39
T ₄	210.29	191.39	191.22	197.08	184.92	194.98
T ₅	202.03	223.59	223.85	210.21	229.75	217.89
T ₆	217.27	214.43	214.95	224.31	234.59	221.11
T ₇	199.00	186.82	196.88	190.37	193.62	193.34
T ₈	258.89	281.91	273.49	151.22	257.31	244.56
T ₉	271.03	276.33	283.92	240.64	269.31	268.24
T ₁₀	223.81	189.34	240.12	243.26	206.67	220.64
T ₁₁	222.50	227.87	209.48	170.97	204.25	207.01
T ₁₂	166.43	167.92	190.45	183.42	162.11	174.07
Mean	215.91	215.03	223.47	206.05	216.75	215.44
S.Em.±	7.57	8.48	8.75	11.71	7.39	3.99
C.D. at 5%	21.78	24.40	25.17	33.71	21.25	11.14
C.V.%	7.01	7.89	7.83	11.37	6.82	8.28
Y * T	S.Em.±8.92			C.D. at 5% 24.89		

Total nitrogen

Status of total nitrogen in LTFE soils was almost same, but it was affected significantly and found significant differences due to various treatments in 1st, 5th, 10th, 15th, 20th year and when pooled over years (Table 2). The highest value of total nitrogen (%) recorded in T₈ (50% N P K of recommended doses + FYM @ 10 t/ha to G'nut and 100% NPK to Wheat)during 1st year, 5th year and 10th year, the results are supported by Meena *et al.* (2019) [10] investigated that the

highest total nitrogen was observed under application of 100% NPK + FYM 10 t ha⁻¹ in soil under long term maize-wheat cropping sequence. Khandagle *et al.* (2019) [8] also reported similar result under the same treatment. Kaur and Singh (2014) [7] also found that the increase in total N 23.1% more in FYM application than inorganic fertilizer alone. Total-N found highest in T₉ (Only FYM @ 10 t ha⁻¹ to Groundnut and @ 15 t ha⁻¹ to wheat) during 15th year and 20th year. Pooled value of treatments T₈ was highest followed by

T₉. The Year x treatment interaction was also found significant. The result are supported by Fengmin *et al.* (1998) [5] investigated the effect of organic matter on nitrogen content in soils derived from loess in NW China. The results indicated that Available N and Total N content were correlated

positively and significantly with organic matter content. But here it was interesting that in T₁₀ Total-N status of that soil improved in case of the pooled result, that might be due to fixation of atmospheric nitrogen by *Rhizobium* bacteria.

Table 2: Status of Total-N (%) in soils of LTFE in 1st, 5th, 10th, 15th and 20th year

Treat.	Total-N (%)					
	1 st year	5 th year	10 th year	15 th year	20 th year	Pooled
T ₁	0.0544	0.0588	0.0625	0.0666	0.0688	0.0622
T ₂	0.0647	0.0657	0.0585	0.0637	0.0612	0.0628
T ₃	0.0599	0.0602	0.0654	0.0608	0.0529	0.0598
T ₄	0.0635	0.0614	0.0526	0.0561	0.0510	0.0569
T ₅	0.0618	0.0608	0.0621	0.0580	0.0643	0.0614
T ₆	0.0598	0.0624	0.0603	0.0628	0.0652	0.0621
T ₇	0.0627	0.0590	0.0549	0.0633	0.0538	0.0587
T ₈	0.0768	0.0853	0.0818	0.0741	0.0750	0.0786
T ₉	0.0719	0.0837	0.0770	0.0804	0.0774	0.0781
T ₁₀	0.0663	0.0645	0.0672	0.0706	0.0577	0.0653
T ₁₁	0.0669	0.0646	0.0583	0.0626	0.0571	0.0619
T ₁₂	0.0550	0.0527	0.0530	0.0510	0.0543	0.0532
Mean	0.0636	0.0649	0.0628	0.0642	0.0616	0.0634
S.Em.±	0.0020	0.0016	0.0021	0.0021	0.0018	0.0009
C.D. at 5%	0.0059	0.0047	0.0061	0.0059	0.0053	0.0024
C.V.%	6.43	5.02	6.76	6.44	5.99	6.15
Y * T	S.Em.±0.0019		C.D. at 5% 0.0054			

Organic carbon (O.C.)

The Organic carbon showed significant difference in 1st year, 5th year, 10th year, 15th year, 20th year and pooled result and it was recorded higher under application of 50% NPK of recommended doses + FYM @ 10 t/ha to Groundnut and 100% NPK to Wheat (T₈) followed by (T₉) Only FYM @ 10 t ha⁻¹ to Groundnut and @ 15 t ha⁻¹ to wheat (Table 3) In case of pooled results and also higher in the treatment T₈ during 1st, 5th and 10th year result. The results are supported by Patel *et al.* (2018) [12] who observed that the significant increase in soil organic carbon was recorded with 100% NPK + FYM @ 15 t ha⁻¹ in the 41-year old LTFE in a *Vertisol* under soybean-wheat cropping system. Year x treatment interaction also

found significant. During 15th and 20th year the Organic carbon was higher in T₉ (Only FYM @ 10 t ha⁻¹ to Groundnut and @ 15 t ha⁻¹ to wheat) and that might be increase in LTFE surface soil after 20th year due to FYM. The results are supported by Balaguravaih *et al.* (2005) [3] investigated that application of FYM or groundnut shells alone improved the O. C. status marginally. There was increase in O. C. status of LTFE soils at 5th and 15th year as compared to initial status of soil (1st year). FYM application improved soil physical condition, ultimately root growth increases and more biomass added to the soil, seems to increase organic carbon status of the particular soil.

Table 3: Status of O.C. (%) in soils of LTFE in 1st, 5th, 10th, 15th and 20th year

Treat.	O.C. (%)					
	1 st year	5 th year	10 th year	15 th year	20 th year	Pooled
T ₁	0.625	0.673	0.718	0.763	0.790	0.714
T ₂	0.745	0.755	0.665	0.730	0.703	0.720
T ₃	0.690	0.690	0.748	0.698	0.598	0.685
T ₄	0.728	0.705	0.603	0.643	0.580	0.652
T ₅	0.710	0.698	0.713	0.665	0.733	0.704
T ₆	0.688	0.718	0.688	0.720	0.748	0.712
T ₇	0.723	0.678	0.625	0.725	0.613	0.673
T ₈	0.885	0.983	0.940	0.853	0.858	0.904
T ₉	0.828	0.963	0.885	0.925	0.880	0.896
T ₁₀	0.763	0.740	0.768	0.810	0.653	0.747
T ₁₁	0.770	0.740	0.665	0.713	0.648	0.707
T ₁₂	0.633	0.603	0.603	0.580	0.613	0.606
Mean	0.732	0.745	0.718	0.735	0.701	0.726
S.Em.±	0.024	0.019	0.024	0.024	0.021	0.010
C.D. at 5%	0.068	0.055	0.069	0.069	0.061	0.028
C.V.%	6.46	5.13	6.70	6.51	6.06	6.19
Y * T	S.Em.±0.023		C.D. at 5% 0.063			

Ammonical nitrogen

The Ammonical nitrogen showed significant difference due to treatments in 1st year, 5th year, 10th year, 15th year, 20th year and pooled result, the Y x T interaction was also found

significant. In first year, the highest value was recorded in plot of T₈ followed by T₉, T₂ and T₁₁. The results are supported by earlier works of Venugopal *et al.* (2017) [18] investigated that the application of FYM along with NPK

resulted in higher $\text{NH}_4\text{-N}$ (28 mg kg^{-1}) than application of only NPK, while in 5th year, 10th year, 15th year and 20th year the highest value was recorded in treatment T_{11} , T_8 , T_{10} , and T_5 respectively. In case of T_{10} (50% NPK of recommended doses + *Rhizobium* + PSM to G'nut and 100% NPK to Wheat) high result might be due to nitrogen fixation by microorganism. In case of T_{11} (100% NPK of recommended doses in G'nut - Wheat sequence P as SSP) which include sulphur in SSP which help the plant to grow their roots more efficiently and so more nitrogen fixation might be done and T_5 (NPK as per Soil Test) having more ammonical-N might be due to low crop yield.

Here the treatment (T_8 , T_9) received FYM having higher ammonical-N content in the pooled value. The results are

supported by earlier work by Kushwaha (2011)^[9] the highest value of inorganic-N 188 kg ha^{-1} was recorded with 100% NPK+FYM treatment. As a result of fertilizer application in these treatments in surface and subsurface soil positive effect of FYM. FYM is the food for the microorganism which help to growth of nitrogen fixing organism and also release organic acid upon decomposition which might be release unavailable form of nitrogen. There was a slight decrease in Ammonical nitrogen status of the LTFE soil as compared to the initial status (Table 4.1.3 & Fig. 4.1.3). The results are supported by earlier works of Sihag *et al.* (2005)^[14], Balagopalan *et al.* (1986)^[2], who observed that surface soil samples showed decrease in $\text{NH}_4\text{-N}$.

Table 4: Status of Ammonical-N (ppm) in soils of LTFE in 1st, 5th, 10th, 15th and 20th year

Treat.	Ammonical-N (ppm)					
	1 st year	5 th year	10 th year	15 th year	20 th year	Pooled
T_1	43.25	45.25	52.00	53.25	57.25	50.20
T_2	56.00	56.25	47.00	49.25	51.00	51.90
T_3	43.00	46.25	52.75	44.75	43.75	46.10
T_4	48.00	33.25	61.00	44.25	41.75	45.65
T_5	48.00	55.25	45.50	49.50	59.75	51.60
T_6	46.50	50.00	49.50	53.75	54.00	50.75
T_7	43.50	36.50	42.00	28.75	40.25	38.20
T_8	58.75	66.00	61.25	33.25	59.00	55.65
T_9	56.75	58.50	56.75	48.00	58.75	55.75
T_{10}	37.50	41.25	54.00	55.75	31.50	44.00
T_{11}	51.75	73.50	50.75	48.25	36.75	52.20
T_{12}	34.25	37.75	41.50	22.25	24.50	32.05
Mean	47.27	49.98	51.17	44.25	46.52	47.84
S.E.m. \pm	2.44	2.00	2.79	2.74	1.87	1.07
C.D. at 5%	7.02	5.77	8.03	7.87	5.39	2.99
C.V.%	10.32	8.02	10.90	12.36	8.06	10.02
Y * T	S.E.m. \pm 2.39			C.D. at 5% 6.69		

Nitrate nitrogen

The data presented in table-5 depicted that there were significant differences found in status of Nitrate-N in LTFE soils at initial (1st year), after 5th, 10th, 15th and 20th year, due to various treatments but, that was non significant for the pooled data. The Y x T interaction showed significant difference among treatments. Initially (1st year) and in 5th year the highest value recorded in plot of T_{11} (100% NPK of recommended doses in G'nut -Wheat sequence P as SSP), that add sulphur to the soil due to SSP and it was best for the root growth and nitrogen fixation, after that it was highest in T_9 , T_{10} and T_8 during the year 10th year, 15th year and 20th year respectively. High nitrate-N in (50% NPK + *Rhizobium* +

PSM to groundnut and 100% NPK to wheat (T_{10}), it might be due to fixation of atmospheric nitrogen by *Rhizobium* bacteria. The treatment T_8 which receive FYM having high nitrate-N due to effect of FYM. The results are supported by earlier work by Venugopal *et al.* (2017)^[18] Found that the application of FYM along with NPK resulted in higher $\text{NO}_3\text{-N}$ (19.7 mg kg^{-1}) than application of only NPK. Kushwaha (2011)^[9] also studied Positive effect of FYM.

There was marginal increase after 1st year upto 5th year but after that overall decrease in status of Nitrate-N in 10th, 15th and 20th year as compare to initial value and Balagopalan *et al.* (1986)^[2] also reported similar results *i. e.* overall decrease of nitrate nitrogen in surface soil samples.

Table 5: Status of Nitrate-N (ppm) in soils of LTFE in 1st, 5th, 10th, 15th and 20th year

Treat.	Nitrate-N (ppm)					
	1 st year	5 th year	10 th year	15 th year	20 th year	Pooled
T_1	21.25	22.25	24.00	24.50	27.50	23.90
T_2	26.75	29.75	20.25	23.75	21.00	24.30
T_3	25.25	22.25	24.75	21.75	19.25	22.65
T_4	23.00	13.25	23.50	21.50	18.25	19.90
T_5	22.25	26.00	27.25	18.00	20.25	22.75
T_6	28.25	28.25	21.75	19.00	26.25	24.70
T_7	20.75	19.25	20.75	13.00	12.25	17.20
T_8	27.25	33.75	29.25	15.75	28.00	26.80
T_9	30.00	30.50	32.00	23.00	7.00	24.50
T_{10}	19.75	18.25	27.00	30.75	21.00	23.35
T_{11}	31.50	39.00	22.50	12.00	21.25	25.25
T_{12}	16.50	17.50	16.25	19.50	14.00	16.75
Mean	24.38	25.00	24.10	20.21	19.67	22.67

S.Em.±	1.85	1.46	2.06	1.80	1.23	0.76
C.D. at 5%	5.32	4.20	5.91	5.18	3.54	NS
C.V.%	15.18	11.69	17.05	17.81	12.50	15.04
Y * T	S.Em.±1.70		C.D. at 5% 4.76			

Depletion percent of different forms of nitrogen

In LTFE soils after a span of twenty year the Total nitrogen showed positive depletion that means it decreased (Table 6) except in T₁, T₅, T₆ and T₉ were negative depletion was noted, Similar results were also found in case of O. C. percent depletion. These results were also in agreement with the finding of Tomar (2003) [16] in his studies in *Typic Haplustert* clay soil following soybean-wheat crop sequence receiving inorganic fertilizers either or with FYM continuously for 31 years had observed that organic carbon content was 1.02% (100% NPK + FYM) as compared to 0.58% in control. Among various N fractions, amino acid nitrogen was dominant N fraction. Whereas Ammonical nitrogen showed positive trend in percent depletion, except in T₁, T₃, T₅, T₆, T₈ and T₉ were negative depletion was noted, the highest percent depletion of Ammonical N was noted in T₁₁. In case of Nitrate nitrogen, all treatments exhibited positive depletion, except T₁, T₈ & T₁₀, this might have been attributed to leaching losses and crop uptake mostly this form of nitrogen. In case of Available nitrogen, where the highest positive depletion was noted in treatment which 100% NPK of recommended doses in G'nut -Wheat sequence + ZnSO₄ @ 50 kg ha⁻¹ once in three year to G'nut only (T₄) that was might be due to more uptake by the crop, negative depletion noted in treatment T₁, T₅ and T₆. These results were also in agreement with the finding of Brar and Dheri (2016) [4] Application of fertilizers improved available N in soil. Integrated use of organic manures and inorganic fertilizers improved the N fractions in the soil. Treatment T₈ and T₉ which include FYM having good result as compared to the control.

Table 6: Percent depletion of different forms of nitrogen after ground nut-wheat sequence in LTFE soils

Treat.	Total-N	O.C.	Amm.-N	Nitr.-N	Av.-N
T ₁	-26.40	-26.40	-32.37	-29.41	-31.69
T ₂	5.33	5.70	8.93	21.50	5.05
T ₃	11.78	13.41	-1.74	23.76	4.47
T ₄	19.68	20.27	13.02	20.65	12.06
T ₅	-3.99	-3.17	-24.48	8.99	-13.72
T ₆	-8.94	-8.73	-16.13	7.08	-7.97
T ₇	14.27	15.22	7.47	40.96	2.70
T ₈	2.29	3.11	-0.43	-2.75	0.61
T ₉	-7.63	-6.34	-3.52	76.67	0.63
T ₁₀	12.88	14.43	16.00	-6.33	7.66
T ₁₁	14.60	15.91	28.99	32.54	8.20
T ₁₂	1.37	3.16	28.47	15.15	2.59

Conclusion

It can be concluded from the Long Term Fertilizer Experiment (LTFE) in Junagadh constituting medium black calcareous soil derived from Trap basalt that the soil available forms of the nitrogen ascribed depletion over time irrespective of fertilizer treatments, except in treatments which received FYM along with inorganic fertilizers. An application of FYM not only sustains fertility, but also increases soil fertility status as like here in N status of the LTFE soil. In treatments which received FYM, increased available-N status in LTFE soils. The combined application of FYM and inorganic fertilizers in continuous manner, have sustained the crop yield. The dynamics of nitrogen along with their forms exhibited variable trend, in general some forms exhibited negative trend

and some of them ascribed positive trend with varying magnitude according to the soil.

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