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FRACTIONS OF N (ORGANIC AND INORGANIC) INFLUENCE BY LONG TERM USE OF FERTILIZER AND MANURES IN A VERTISOL IN WHEAT UNDER RICE-WHEAT CROPPING SYSTEM

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ABSTRACT

The present investigation was carried out at Research Farm, College of Agriculture, IGKV, Raipur (C.G.) during *Rabi*season, 2012-2013. The experimental conducted in*Vertiso*l and laid out in a split plot design with four replications. Soil samples were analysed for available nitrogen, total nitrogen, ammonical nitrogen, nitrate nitrogen, total hydrolysable-N, amino acid-N, hydrolysable ammonium-N and amino-sugar N.Among the two forms of inorganic N, NH_4^+-N was the dominant fraction and varied from 17.25 to 31.45 mg kg^{-1} whereas, NO_3^--N varied from 8.44to 17.00 mg kg^{-1} under T_1(control) and T_8(100% RDF+FYM) treatment, respectively. In case of organic forms of nitrogen hydrolysable ammonium-N, amino acid-N, amino sugar-N and total hydrolysable-N increased significantly with the long term application of manure and fertilizers and its value ranged from 113.75 to 178.58 mg kg^{-1}, 147.00 to 199.50 mg kg^{-1}, 43.75 to 91.88 mg kg^{-1} and 447.13 to 686.88 mg kg^{-1} under T_1(control) and T_8(100% RDF + FYM) treatment respectively. The total-N and available-N ranged from 731.50 to 1053.50 mg kg^{-1} and 87.58 to 120.36 mg kg^{-1} under treatment under T_1(control) and T_8(100% RDF+FYM), respectively.

KEY WORDS
Fractions of Nitrogen, Wheat, spit plot design, Vertisol

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INTRODUCTION

Nitrogen is the key element among the major nutrients in crop production and most of Indian soils are deficient in these nutrients. In most of soils, N is mainly organic in nature; hence normally small portion of inorganic nitrogen in soil is present. Of all essential nutrients, nitrogen appears to have the most pronounced effect on plant growth and development (Ayeni, 2011). Nitrogen mainly enters the soil through the organic matter.The increase in soil N, P, K in the plots receiving both inorganic manures and amendments might be due to the consistent supply of organic matter and essential nutrients for plant growth (Nayak *et al*.). Plants and animal wastes decompose, adding nitrogen to the soil through action of bacteria that convert organic nitrogen into available nitrogen. The inorganic soil nitrogen component is usually small and easily depleted and hence cannot support plant growth for a long time. However release of organically bound nitrogen from manures and humus by the process of mineralization makes sure the unabated supply of nitrogen in available forms. The use of chemical fertilizers not only improves crop yield, but their application directly or indirectly causes series of changes in physical, chemical and biological properties of soil. These changes in long term have significant influence on the quality and productive capacity of the soil (Divya *et al*., 2012) The inorganic forms mainly include ammonium (NH_4^+) and nitrate nitrogen (NO_3^-) while organic soil nitrogen occur as protein, amino acid, amino sugars and other nitrogenous compounds. About one third of the fertilizer N applied to the soil is immobilized and retained in organic forms at the end of the growing season.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 There fore, evaluation of nitrogen mineralization is essential to have a rational basis for developing sound nitrogen management practice which has been presented dealt with.

MATERIALS AND METHODS

The present investigation was carried out at Research Farm, College of Agriculture, IGKV, Raipur (C.G.) during *Rabi* season, 2012-2013. The experimental conducted in *Vertiso*l and laid out in a split plot design with four replications. Experiment had 10 main plots as different combinations of fertilizers and manure (T) and two sub-plot (S) with before sowing of wheat crop (S_1) &after harvest of wheat crop (S_2). The physico-chemical properties of the soil under study before of long term fertilizer experiment (1999) were pH(1:2.5) 7.72, EC(dsm^{-1})0.20, Organic carbon (%)0.62, Available Nitrogen(mg kg^{-1}) 92.67, Total Nitrogen(mg kg^{-1}) 774.67, Ammonical Nitrogen(mg kg^{-1})8.87, Nitrate Nitrogen(mg kg^{-1}) 9.92, Total hydrolysable – N(mg kg^{-1}) 486.26, Amino acid – N(mg kg^{-1})158.67, Hydrolysable

NH_4^+ -N(mg kg^{-1})128.26, Amino-sugar N(mg kg^{-1})42.36, Hydrolysable NH_4^+ -N + Amino-sugar N(mg kg^{-1}) 170.62, respectively. The experiment was conducted on 8000 m^2 area with plot size 10 m x 20 m (200 m^2). The treatments were 10 with 4 replications and recommended fertilizer Dose was100:60:40 Kg NPK ha^{-1}.The data obtained under various characters were tabulated and statistically analyzed for their significance. Where F value was found significant, the critical difference (CD) at 5 percent was calculated and used for the comparing individual treatment effect (Cochran and Cox 1957).

RESULTS AND DISCUSSION

Nitrogen fraction was estimated in soil samples (0-15cm) before sowing and after harvest of wheat crop and the results are discussed under following heads;

Inorganic fraction of nitrogen

Ammonical (NH_4^+) – N

The initial NH_4^+ -N value of soil was 8.87 mg kg^{-1} at the time of start of long term fertilizer experiment during 1999. The data presented in table (1) showed significant changes in the status of NH_4^+-N due to various treatments. The highest NH_4^+-N was recorded 31.45 mg kg^{-1} in the treatments receiving 100% RDF+FYM which was significantly superior over rest of the treatments. However, control plot showed significantly lower NH_4^+ -N (17.25 mg kg^{-1}) as compared with rest other treatments except treatment T_7. The ammonical nitrogen content was found in the order of $T_8 > T_4 > T_{10} > T_{3\ m} > T_5 > T_9 > T_6 > T_2 > T_7 > T_1$. The increase in NH_4^+-N in the various treatments may be ascribed due to continuous application of manure and fertilizer on long term basis. These results are in close conformity to the finding of Bhardwaj *et al.* (1994)and Santhy *et al.* (1998).

The data on NH_4^+ -N after each crop cycle showed significant increase due to application of different treatment levels and higher value of NH_4^+ -N at after harvest of wheat crop was observed as compare to before sowing of wheat crop. Interaction of treatment levels with sub plot treatment *i.e.* before sowing and after harvest of wheat crop was found to be non significant. These results corroborate with the finding of Guldekar and Ingle (2009).

Nitrate nitrogen (NO_3^-N)

While the long term fertilizer experiment was started in 1999, the initial NO_3^--N value of soil was 9.92 mg kg^{-1}. The data is presented in table (2) showed changes in the status of soil nitrate N over a period of 14 years due to various treatments. The highest nitrate N was recorded in treatments T_8(17.00 mg kg^{-1})100 % RDF +FYM which was significantly superior over rest of the treatments. However, control plot showed significant lower nitrate N (8.84 mg kg^{-1}) as compared to other treatments. The nitrate nitrogen (NO_3^-N) content was found in the order of $T_8 > T_4 > T_5 > T_3 > T_6 > T_{10} > T_9 > T_7 > T_2 > T_1$. The increased nitrate nitrogen in various treatments may be due to moisture, continuous cropping system and application of manures and

Table 1: Effect of long term use of fertilizers and manure on ammonical (NH_4^+)-N(mg kg^{-1}) in *Vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	16.53	17.97	17.25^ij^
T_2	50% NPK	19.43	22.14	20.78^gn^
T_3	100%NPK	23.98	25.88	24.93^de^
T_4	150% NPK	26.43	29.88	28.15^b^
T_5	100% NPK+ Zn	23.28	26.37	24.82^d^
T_6	100% NP	21.18	23.39	22.28^fg^
T_7	100% N	18.03	19.72	18.87^i^
T_8	100%NPK+FYM	30.80	32.11	31.45^a^
T_9	50%NPK+BGA	21.18	24.59	22.89^f^
T_{10}	50% NPK+GM	26.77	28.75	27.76^bc^
	Mean	22.75^b^	25.08^a^	
CD $_{at}$	5 %T =1.78	S = 0.46	T × S = NS	
Buffer	8.87			

Table 2: Effect of long term use of fertilizer and manure on nitrate N (mg kg^{-1})in *Vertisol*under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	7.18	9.70	8.44^j^
T_2	50% NPK	8.58	13.08	10.83^ghi^
T_3	100%NPK	11.38	15.51	13.44^cd^
T_4	150% NPK	14.18	17.29	15.73^b^
T_5	100% NPK+ Zn	12.08	15.85	13.96^c^
T_6	100% NP	10.15	14.79	12.47^de^
T_7	100% N	9.28	13.48	11.38^fgh^
T_8	100%NPK+FYM	15.58	18.43	17.00^a^
T_9	50%NPK+BGA	10.15	13.14	11.65^efg^
T_{10}	50% NPK+GM	9.98	14.29	12.13e^f^
	Mean	10.85^b^	14.56^a^	
CD at 5 %	T = 1.04	S = 0.40	T × S = NS	
Buffer	9.92			

Table 3: Effect of long term use of fertilizer and manure on hydrolysableammonium N (mg kg^{-1}) in *vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	117.25	110.25	113.75^{j}
T_2	50% NPK	138.25	134.75	136.50^{gh}
T_3	100%NPK	159.25	152.25	155.75^{cd}
T_4	150% NPK	171.50	162.75	167.13^{b}
T_5	100% NPK+ Zn	162.75	154.00	158.38^{be}
T_6	100% NP	152.25	141.75	147.00^{def}
T_7	100% N	134.75	127.75	131.25^{hi}
T_8	100%NPK+FYM	180.25	176.75	178.50^{a}
T_9	50%NPK+BGA	145.25	140.00	142.63^{efg}
T_{10}	50% NPK+GM	152.25	145.25	148.75^{de}
	Mean	151.38^{a}	144.55^{b}	
CD at 5 %	T = 8.93	S = 3.53	T × S = NS	
Buffer128.26				

Table 4: Effect of long term use of fertilizer and manure on amino acid N (mg kg^{-1}) in *vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	150.50	143.50	147.00^{g-j}
T_2	50% NPK	168.00	157.50	162.75^{fgh}
T_3	100%NPK	199.50	171.50	185.50^{cde}
T_4	150% NPK	206.50	192.50	199.50^{ab}
T_5	100% NPK+ Zn	189.00	175.00	182.00^{bc}
T_6	100% NP	178.50	168.00	173.25^{cd}
T_7	100% N	157.50	147.00	152.25^{f-i}
T_8	100%NPK+FYM	203.00	196.00	199.50^{a}
T_9	50%NPK+BGA	171.50	164.50	168.00^{fg}
T_{10}	50% NPK+GM	189.00	178.50	183.75^{c-f}
	Mean	181.30^{a}	169.40^{b}	
CD at 5 %	T = 19.95	S = 5.71	T × S = NS	
Buffer 158.67				

Table 5: Effect of long term use of fertilizer and manure on amino sugar N (mg kg^{-1}) in *vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	45.50	42.00	43.75^{g-h}
T_2	50% NPK	54.25	50.75	52.50^{fgh}
T_3	100%NPK	68.25	65.50	66.88^{cde}
T_4	150% NPK	85.75	81.00	83.38^{ab}
T_5	100% NPK+ Zn	75.25	71.75	73.50^{bc}
T_6	100% NP	71.75	63.00	67.38^{cd}
T_7	100% N	59.50	42.00	50.75^{f-i}
T_8	100%NPK+FYM	91.00	92.75	91.88^{a}
T_9	50%NPK+BGA	56.00	49.00	52.50^{f-g}
T_{10}	50% NPK+GM	68.25	54.25	61.25^{c-f}
Mean	67.55^{a}	61.20^{b}		
CD $_{at}$ 5 %	T = 13.17	S = 3.20	T × S = NS	
Buffer 42.36				

fertilizers.

The NO_3^--N content of soil was also studied at before sowing and after harvest of wheat crop. However higher values of nitrate N at before sowing of wheat crop observed to be significant than after harvest of wheat crop. Interaction of treatment levels with before sowing and after harvest was found to be non significant. Increase in NO_3^--N content may be ascribed to nitrification of NO_3^--N by soil microorganisms (Prasad *et al*. 1995 and Santhy *et al*. 1998).

Organic fraction of nitrogen

Organic fractions of nitrogen *viz*. total hydrolysable-N forms, hydrolysable ammonium-N, amino acid-N and amino acid-N + amino sugar was determined. However, amino sugar was calculated by subtracting hydrolysable ammonium-N from amino acid-N + amino sugar in soil.

Hydrolysable ammonium-N

The initial hydrolysable ammonium N value of soil was 128.26 mg kg^{-1}. The significant changes in the status of soil of hydrolysable ammonium due to various treatments over a crop cycle was due to continuous use of fertilizers and manure .The data is presented in table (3) showed significant difference for all the treatments. The highest hydrolysable ammonium N

Table 6: Effect of long term use of fertilizer and manure on total hydrolysableN (mg kg^{-1}) in *vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	453.25	441.00	447.13^{j}
T_2	50% NPK	519.75	505.75	512.75^{h}
T_3	100%NPK	586.25	575.75	581.00^{cd}
T_4	150% NPK	616.00	628.25	622.13^{b}
T_5	100% NPK+ Zn	588.00	584.50	586.25^{c}
T_6	100% NP	574.00	560.00	567.00^{ef}
T_7	100% N	511.00	498.75	504.88^{hi}
T_8	100%NPK+FYM	693.00	680.75	686.88^{a}
T_9	50%NPK+BGA	542.50	533.75	538.13^{g}
T_{10}	50% NPK+GM	589.75	553.00	571.38^{de}
Mean	567.35^{a}	556.15^{b}		
CD $_{at}$ 5 %	T = 12.78	S = 5.03	T × S = 15.9	
Buffer 486.26				

Table 7: Effect of long term use of fertilizer and manure on total N (mg kg^{-1}) in *vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T Mean
T_1	CONTROL	735.00	728.00	731.50^{ij}
T_2	50% NPK	812.00	833.00	822.50^{e-h}
T_3	100%NPK	854.00	861.00	857.50^{cde}
T_4	150% NPK	966.00	987.00	976.50^{b}
T_5	100% NPK+ Zn	868.00	896.00	882.00^{cd}
T_6	100% NP	826.00	847.00	836.50^{c-g}
T_7	100% N	728.00	749.00	738.50^{i}
T_8	100%NPK+FYM	1043.00	1064.00	1053.50^{a}
T_9	50%NPK+BGA	847.00	861.00	854.00^{cdef}
T_{10}	50% NPK+GM	882.00	896.00	889.00^{c}
	Mean	856.10^{b}	872.20^{a}	
CD $_{at}$ 5 %	T= 59.34	S = 6.06	T× S = NS	
Buffer 774.67				

was recorded for treatment T_8 (178.50 mg kg^{-1}) receiving 100% RDF+FYM which was significantly superior over rest of the treatments. However, content plot showed significantly lower hydrolysable ammonium N (113.75 mg kg^{-1}) as compared to rest of the treatments. The hydrolysable ammonium N content was found in the order of $T_8>T_4>T_5>T_3>T_{10}>T_6>T_9>T_2>T_7>T_1$. The increased hydrolysable ammonium N content was due to application of nitrogen either through inorganic or organic manures indicating possibility of buildup of hydrolysable ammonium N content of soil over a period of time. These findings are in general agreement with the findings of Bhardwaj *et al.* (1994) and Nayak *et al.* (2013).

The hydrolysable ammonium N content of soil was also studied at before sowing and after harvest of wheat crop. However, higher values of hydrolysable ammonium N at before sowing of wheat crop observed to be significant than after harvest wheat crops. Interaction of treatment levels with before sowing and after harvest was found non-significant. The continuous rice – wheat cropping system without any fertilization resulted in depletion of hydrolysable ammonium N at the initial status in soil. These findings are supported with the findings of Sekhon *et al.* (2011).

Amino Acid N (mg kg^{-1})

When the long term fertilizer experiment was started during 1999, the value of amino acid N of soil was 158.67 mg kg^{-1}. The data is presented in table (4) showed that significant changes in the status of soil amino acid N over a period of 14 years due to various treatments. The highest amino acid N was recorded 199.50 mg kg^{-1}in the treatments having 100% RDF+FYM (T_8) and 150 % RDF(T_4). Which was significantly superior over rest of the treatments except but significant over rest of other treatments. However, control plot showed significantly lower amino acid N (147.00mg kg^{-1}) as compared with rest of the other except treatments T_2 and T_7. The amino acid N content was found in the order of $T_8>T_4>T_3>T_{10}>T_5>T_6>T_9>T_2>T_7>T_1$. The increased amino acid N content may be due to combined application of manure and fertilizer or application of alone inorganic fertilizers. Nayak (2013) reported inorganic nitrogen fraction consisted of mostly of amino acids N which increased in soil due to addition of organic material in soil and fertilizer nitrogen. Similar result was also reported by Bharadawaj (1994).

The amino acid N content of soil was also studied at before sowing and after harvest of wheat crop. Higher values of amino acid N at before sowing of wheat crop was observed to be significant than after harvest wheat crop. Interaction of treatment levels with before sowing and after harvest was found to be non-significant. The continuous rice – wheat cropping system with out any fertilization resulting in depletion of amino acid N of their initial status in soil. These finding are in general agreement with the findings of sekhon *et al.* (2011).

Amino Sugar N (mg kg^{-1})

The initial amino sugar N value of soil was 42.36 mg kg^{-1}. The

Table 8: Effect of long term use of fertilizer and manure on available N (mg kg^{-1}) in *vertisol* under wheat crop

Symbol	Treatment	Before sowing	After harvest	T- Mean
T_1	CONTROL	89.60	85.55	87.58^{j}
T_2	50% NPK	109.20	100.80	105.00^{b-h}
T_3	100%NPK	114.80	107.80	111.30^{a-d}
T_4	150% NPK	116.20	109.20	112.70^{abc}
T_5	100% NPK+ Zn	117.60	112.00	114.80^{ab}
T_6	100% NP	112.00	107.10	109.55^{a-f}
T_7	100% N	107.80	98.00	102.90^{c-i}
T_8	100%NPK+FYM	123.20	117.53	120.36^{a}
T_9	50%NPK+BGA	112.00	103.60	107.80^{a-g}
T_{10}	50% NPK+GM	116.20	105.00	110.60^{a-e}
	Mean	104.66^{b}	111.86^{a}	
CD $_{at}$ 5 %	T = 14.07	S = 1.28	T × S = NS	
Buffer 92.67				

data is presented in Table 5 showed that significant changes in the status of soil amino acid N over a period of 14 years due to various treatments and highest amino sugar N was recorded 91.88 mg kg^{-1}in the treatments receiving 100 % RDF+FYM (T_8) which was significantly superior over rest of the treatments. However, control plot showed significantly lower amino sugarN (43.75 mg kg$^{-1)}$ as compared with rest of the other treatment except T_2, $T_7$and T_9. The amino sugar N content was found in the order of $T_8>T_4>T_5>T_6>T_3>T_{10}>T_9>T_2>T_7>T_1$. The increased amino sugar N content may be due to application of manure and inorganic fertilizers. Vidyavathi (2010) reported that the organic nutrient management practices had maximum value of amino sugar N and was significant over inorganic nutrient management practices.

The data on amino sugar N after long term fertilization practices showed significant effect with the application of different treatment levels. However, higher values of a amino sugar N at before sowing of wheat crop observed to be significant than after harvest wheat crops. Interaction of treatment levels with before sowing and after harvest was found to be non significant.

Total Hydrolysable N (mg kg^{-1})

During 1999 when the experiment was started, the initial total hydrolysable N value of soil was 486.26 mg kg^{-1}.The data is presented in table (6) revealed that significant changes in the status of soil total hydrolysable N due to various treatments over a period of 14 years. The highest total hydrolysable N was recorded in treatment T_8 (686.88 mg kg^{-1})100 % RDF +FYM. However, control plot showed significant lower total hydrolysable N (447.13mg kg^{-1}) as compared with rest other treatments. The total hydrolysable N content was found in the order of $T_8>T_4>T_5>T_3>T_{10}>T_6>T_9>T_2>T_7>T_1$.

The data on total hydrolysable N after long-term fertilization practices showed significant effect with the application of different treatment levels. Higher values of total hydrolysable N before sowing were observed to be significant comparing to the value after harvest of wheat crops. Interaction of treatment levels with before sowing and after harvest was found to be significant. The results obtained higher total hydrolysable-N content due to addition with organic and inorganic fertilizer. Similar results were reported by Martin and Kachhave (2009).

Total Nitrogen

The long term fertilizer experiment was started in 1999, the total N value of soil was 774.67 mg kg^{-1}.The data on total N content in various treatments is presented in table (7) showed that significant changes in the status of soil total N over a period of 14 years due to various treatments. The highest total nitrogen was recorded in treatment T_8 (1053.50 mg kg^{-1}**)** 100 % RDF +FYM which was significantly superior over rest of the treatments. However, control plot showed significantly lower total nitrogen (731.50 mg kg^{-1}) as compared with rest of other treatments except treatment T_7. The total nitrogen content was found in the order of $T_8>T_4>T_{10}>T_5>T_3>T_9>T_6>T_2>T_7>T_1$.The increased total nitrogen content may be due to application of manures & fertilizers. This finding is in general agreement with the findings of Sarawad *et al.* (2001), Nayak (2013) and Babita (2010).

The data on total N after long term fertilization practices indicated significant increase with the application of different treatment levels after each crop cycle and higher values of total N at after harvest of wheat crop was observed as compare to before sowing of wheat crop. These results correlate with the findings of Dan *et al.* (2010). Interaction of treatment levels with before sowing and after harvest was found to be non significant.

Available Nitrogen (mg kg^{-1})

The Initial available N value of soil was 92.67 mg kg^{-1} at the time of start of long term fertilizer experiment during 1999.The data presented in table (8) showed significantly changes in the status of soil available N over a period of 14 years due to various treatments. The highest available nitrogen was recorded in treatment T_8 (1053.50 mg kg^{-1})100 % RDF+FYM which was significantly superior over rest of the treatments. However, control plot showed significantly lower available nitrogen (87.58 mg kg^{-1}) as compared with rest of other treatments. The total nitrogen content was found in the order of $T_8>T_5>T_4>T_3>T_{10}>T_6>T_9>T_2>T_7>T_1$.The increased total nitrogen content may be due to application of manures & fertilizers.

The data on available N after long term fertilization practices showed significant variable increase with the application of different treatment levels except control. Significant values of available N after harvest of wheat crop was observed as compared with before sowing of wheat crops. Similar results were reported by Singh *et al*. (2001) and Hemalatha& Chellamuth (2013). Interaction of treatment levels with before sowing and after harvest was found to be non significant.

REFERENCES

Aveni, L. S. 2011. Integrated plant nutrient management: *A panacea for sustainable cropproduction in Nigeria.Int. J. Soil Sci.* **6:** 19-24.

Babita, 2010. Nitrogen dynamics in soil-plant system as influenced by long-term use of chemical fertilizers and amendments in an acid Alfisol. M.Sc. Thesis, Department of Soil Science, CSK Himachal Pradesh KrishiVishvavidyalaya, Palampur.

Bhardwaj, V. and Omanwar, P. K. 1994. Long-term effects of continuous rotational cropping and fertilization on crop yields and soil properties-II.Effects on EC, pH, organic matter and available nutrients of soil.*J. the Indian Society of Soil Science* **.42(3):** 387-392.

Cochran, W. D. and Cox, G. M. 1957. Experimental Designs. **2nd edition** Wiley, New York

Dan, W.,Xingzhu, M., Wang, S. and Zhou, B. 2010. Effect of long-term fertilization on organic matter, total nitrogen and microbe characteristic of black soil. World Congress of SoilScience, Soil Solutions for a Changing World.pp. 44-47.

Divya, J. and Belagali, L. 2012. Effect of chemical fertilizers on

physico- chemical Characteristics of agricultural soil samples of Nanjangud taluk, Mysore district, Karnataka, India.*The Ecoscan.***6(3&4):** 181-187

Guldekar, V. D. and Ingle, S. N. 2009. Dynamics of nitrogen forms in soil under long-term fertilization to sorghum-wheat sequence in Vertisols. *PKV Research J.* **33(1):** 21-24.

Hemalatha, S. and Chellamuthu, S. 2013. Impacts of long term fertilization on soil Nutritional quality under fingerMillet : maize cropping sequence.*J. Environ. Res. Develop*.**7:** 1571-1576.

Martin, N. R. and Kachhave, K. G. 2009. Nitrogen fractions and their relationship under sorghum sunflower cropping sequence in a typichalustert.*An Asian J. Soil Sci.* **49(1):** 11-14.

Nayak, T., Patel, T., and Bajpai, R. K. 2015.Influence of organic and inorganic fertilization on soil physical properties in a vertisol under rice.*The Ecoscan.* **9(1&2):** 71-74.

Nayak, V. N., Gatav, G. K. and Bhagat, R. K. 2013. Different N fractions and their relationship with available Nitrogen, yield and nutrient uptake in safflower (*Carthanmustinctoroius*) in *vertisol.Current Advances in Agriculture Science.* **5(1):** 135-137.

Prasad, B. and Sinha, S. K. 1995. Nutrient regulating through crop

residues management for sustainable rice and wheat production in calcareous soil.*Fert.News.* **40:** 15- 25.

Prasad, B. and Sinha, S. K. 1995. Nutrient regulating through crop residues management for sustainable rice and wheat production in calcareous soil.*Fert.News.* **40:** 15- 25.

Santhy, P., Sankar, S. J., Muthuvel, P. and Selvi, D. 1998. Long term fertilizer experiments-Status of N, P and K fractions in soil.*J. Indian Soc. Soil Sci.* **46(3):** 395-398.

Sarwad, I. M., Singh, D., Rana, D. S. and Kumar, K. 2001. Nitrogen fractions and their relationships with mineralizable N and its uptake by crops in a long-term fertilizer experiment. *J. Indian Soc. Soil Sci.* **49 (4):** 691-694.

Sekhon, K. S., Singh J. P. and Mehla, D. S. 2011. Long term effect of manure and mineral fertilizer application on the distribution of organic nitrogen fractions in soil under rice –wheat cropping system.*Archives of Agronomy and Soil Sci.* **57:** 705-714.

Singh, K. and Milkha, S. A. 2001. Nitrogen immobilization-mineralization in a sandy loam soil amended with crop residues at varying moisture regimes. *J. Indian Soc.Soil Sci.* **49(1):** 198-202.

Vidyavathi, G. S., Dasog, H. B., Babalad, N. S., Hebsur, S. K., Gali, S. G., Patil and Alagawadi,A. R. 2012. Nutrient status of soil under different nutrient and crop management practices. Karnataka *J. Agric. Sci.***25(2):** (193-198).