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Influence of Organics and Inorganics on Mineralization of Nitrogen in the Soil under Controlled condition

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ABSTRACT: Understanding nitrogen release patterns from decomposing organic manures will help in optimizing nitrogen use efficiency in crop production systems. In a pot-culture experiment of finger millet carried out for 10 weeks period, a significantly higher nitrate nitrogen (NO_3^--N) content (48.6, 47.51 and 48.52 mg kg^{-1}, respectively) was recorded with 100% RDN through FYM + 25% through inorganic fertilizers at 56, 63 and 70 DAI. The NO_3^--N content recorded in Only inorganics treatment was found significantly higher than NO_3^--N content recorded in treatments 100% RDN through FYM + 25% through inorganic fertilizers, 75% RDN through FYM + 25% through inorganic fertilizers and Only organics treatments at 14, 21, 28, 35, 42, 49 DAI. The significantly higher Ammonical nitrogen (NH_4^+-N)content (28.65, 40.80, 51.14, 55.46, 61.37, 69.01 and 62.92 mg kg^{-1}, respectively) was recorded in Only inorganics treatment at 7, 14, 21, 28, 35, 42, 49 DAI which decreased thereafter until 70 days followed by 100% RDN through FYM + 25% through Inorganic fertilizers (24.46, 30.69, 41.77, 48.48, 55.71, 59.25 and 59.24 mg kg-1, respectively) and 75% RDN through FYM + 25% through inorganic fertilizers(23.08, 25.40, 37.66, 44.60, 51.58, 55.75 and 56.94 mg kg^{-1}, respectively) and at 56, 63 and 70 DAI significantly higher NH_4^+-N content (61.88, 62.13 and 61.13 mg kg^{-1}, respectively) was recorded with 100% RDN through FYM + 25% through Inorganic fertilizers. Our pot-culture results suggest that the use of organic manures as the source ofN supply for crops for short and long term should be encouraged.

Keywords: Nitrate nitrogen (NO_3-N), Ammonical nitrogen (NH_4^+-N), Mineralization of Nitrogen, Manure Levels, Pot-culture, Finger Millet.

INTRODUCTION

FINGER MILLET commonly known as Ragi (*Eleusine coracana* (L.) Gaertn.) is one of the important traditional millets occupying the highest area under cultivation among the small millets and a predominant food crop of Southern Karnataka under rainfed conditions of *Alfisols.* In Karnataka, the average productivity of finger millet is 1800 kg ha^{-1} but the potential yield is more than 4000 kg ha^{-1} as recorded under on station experiments (Anon., 2019).

One of the problems faced by the farmers in the production of finger millet is the manure level for integrated nutrient management. Nitrogen (N) occupies a unique position among all the essential elements for crop growth and plays a fundamental role in various plant metabolic processes. It is one of the major components of many important molecules including proteins, nucleic acids, certain hormones and chlorophyll. Total nitrogen in soil generally varies from 0.02 to 0.44 per cent. Nitrogen in soils occurs both in organic and inorganic forms. Organic form of nitrogen, however, constitutes 95 per cent or more in the total nitrogen content. The major fractions of organic form of N are total hydrolysable-N, hydrolysable-NH_4^+-N, amino acid-N, hexose amine-N, amino sugar-N, acid insoluble N. The organic form of nitrogen made available only after mineralization. The total hydrolysable-N contributed more to the total-N compared to other fractions, thus indicating the existence of major portion of N in the organic forms and this hydrolysable nitrogen fraction was easily mineralizable and labile in nature. Transformation of nitrogen added through manures or fertilizers into different forms of nitrogen in the soil and their availability to crops depends on the soil properties and nature of nitrogen sources added to soils.

The information on the process of transformation and relationship among the different forms of N in the INM is very sparse. The movement of nitrogen between land, water and atmosphere define the cycling of the nitrogen on global scale. However, transformation of N from one form to another in soil represents internal N cycle. The movement/transformations of N in soil influence its availability and losses. Many researchers proved that available nitrogen status of the soils increased with increased supply of nitrogen either in the form of organic manures or fertilizers which ultimately increased the productivity of ragi. Further, they observed that due to its denitrification, volatilization and leaching losses only 30 to 40 percent of the nitrogen added was recovered by crops. The nitrate that is leached from fields causes environmental pollution by moving with water and contaminating either ground water or surface water bodies.

Hence, practicing integrated nutrient management may be vital in increasing nitrogen use efficiency by crops and also to reduce the environmental pollution. This technology needs the scientific validation through intensive and in depth study to enhance the nitrogen use efficiency and productivity of finger millet.

MATERIAL AND METHODS

To investigate the influence of organics and inorganics on mineralization of nitrogen in the soil under controlled condition, a pot-culture experiment of finger millet was carried out for a period of 10 weeks during *Rabi* 2017 and 2018 at ZARS, UAS, GKVK, Bengaluru located in eastern dry zone of Karnataka. The centre is situated in the eastern dry zone of Karnataka at 12^{o} 58 North latitude and 77^{o} 35 East longitude with an altitude of 930 m above the mean sea level.

The soils of GKVK farm belong to Vijayapura series and are classified as *Oxichaplustalf.* Soils are reddish brown lateritederived from gneiss under subtropical semiarid climate. The soil of pot culture experiment was red sandy clay loam in texture having initial pH 7.32 and organic carbon content of soil was 0.31%.The fertility status of the experimental field was found to be medium in available nitrogen (325.46 kg ha^{-1}), high in available P_2O_5 (31.40 kg ha^{-1}) and medium in available K_2O (242.30 kg ha^{-1}). Physical and chemical characteristics of the experimental soil (ZARS, GKVK, Bengaluru) is given in Table 1.

Table 1: Physical and chemical characteristics of the experimental soil (ZARS, GKVK, Bengaluru).

Sr. No.	Properties	Mean value	Method employed
I.	**Physical properties**		
1.	**Particle size analysis** a. Coarse sand (%) b. Fine sand (%) c. Silt (%) d. Clay (%) Textural class	32.80 36.20 13.60 16.30 Red Sandy Clay loam	International pipette method (Piper, 1966)
2.	**Bulk density (g cc^{-1})**	1.43	Core sampler method (Piper, 1966)
3.	**WHC (%)**	39.31	Keen's cup method (Keen and Raczkowski,1921)
II.	**Chemical properties**		
1.	pH (1:2.5)	7.32	Glass electrode pH meter method (Piper, 1966)
2.	EC (dSm^{-1})	0.034	Conductometry method (Jackson, 1973)
3.	Organic carbon (%)	0.31	Wet oxidation method (Jackson, 1967)
4.	Available N (kg ha^{-1})	325.46	Alkaline permanganate method (Subbiah and Asija, 1956)
5.	Available P_2O_5 (kg ha^{-1})	31.40	Bray's method (Jackson, 1967)
6.	Available K_2O (kg ha^{-1})	242.30	Flame photometry method (Jackson, 1967)

The pot-culture experiment was laid out in completely randomized design (CRD) with five replications. After transplanting finger millet, soil samples were taken from each treatment at an interval of 7 days (On 7, 14, 21, 28, 35, 42, 49, 56, 63 and 70 days) and analyzed for nitrate and ammonical N. The collected data was statistically analyzed by following the method of Gomez and Gomez (1984).The treatments were as follows:

M_1: 100% RDN through FYM + 25% through Inorganic fertilizers

M_2: 75% RDN through FYM + 25% through Inorganic fertilizers

M_3: Only organics

M_4: Only inorganics.

RESULTS AND DISCUSSION

Transformation of added N through inorganics or organics into different forms of nitrogen in the soil and their availability to the crops depends on properties of soil and nature of nitrogen sources added to soils. According to the researchers, more than 90 per cent of nitrogen in the soil is present in organic form and the remainder is in inorganic forms that is readily available to the plants (Stevenson, 1982) and concentrations of inorganic form viz., nitrate N and ammonical N in soil at any given point of time is influenced by several soil factors. In the tropics, rarely available nitrogen is adequate for plant growth unless efficiently replenished from unavailable forms to available forms such as

NH_4^+-N and NO_3^--N. Fertilization, being the main practice of crop management, has great impact on the fractions of soil organic nitrogen, directly through changing the composition of the soil N and indirectly through affecting the crop growth (Bird *et al.* 2002; Kelley and Stevenson 1996). Singh *et al.* (2001) observed the decline in total hydrolysable N with the application of inorganic fertilizers and suggested that such a practice may not be successful in sustaining the soil productivity over a longer period.

But, very little information is available with respect to the influence of integrated nutrient management practices on distribution of different forms of nitrogen in the soils. Further, the mineralization pattern of the nitrate and ammonical nitrogen in the soil.

The knowledge of distribution of various nitrogen forms in soil attains greater importance in understanding the potential of a soil in supplying them to the crops and also to understand the N use efficiency by crops. In soils of sandy clay loam texture, the availability of N in soils is low owing to their low organic matter status and leaching loss of N from these soils and this becomes a limiting factor for crop production. Therefore, to understand the transformation of applied N into different fractions and their availability to plants becomes an essential part of integrated nitrogen management in order to increase the productivity and also to maintain the soil health. The outcome of the pot-culture experiment is elaborated using tabular and graphical representation.

Inorganic fractions - Nitrate nitrogen (NO_3^--N). The NO_3^--N content in the soil at any given point of time depends upon the rate of formation, crop removal, volatilization, leaching, denitrification, rate of mineralization and addition of NO_3^--N through inorganic and organic manures (Giesenking, 1975).

The NO_3^--N and NH_4^+-N are the major inorganic nitrogen fractions in soil. The data presented (Table 2 & Fig. 1) revealed that in general, among all the treatments NO_3^--N content increased with incubation time up to 70 days in all the treatments except M_4(Only inorganics) where in it increased up to 42 days and steadily declined after 42 days up to 70 days.

In Only inorganics treatment the significantly higher NO_3^--N content (25.54, 38.74, 44.38, 50.84, 55.88 and 52.41 mg kg^{-1}, respectively) was recorded at 14, 21, 28, 35, 42, 49Days After Incubation (DAI) which decreased thereafter until 70 days followed by M_1(23.94, 29.26, 41.38, 46.06, 51.46 and 49.62 mg kg^{-1}, respectively) and M_2(20.98, 26.31, 38.17, 40.98, 47.26 and 46.43) and at 56, 63 and 70 DAI significantly higher NO_3^--N content (48.6, 47.51 and 48.52 mg kg^{-1}, respectively) was recorded with M_1(100% RDN through FYM + 25% through Inorganic fertilizers.). The NO_3^--N content recorded in the treatment M_4(Only inorganics) was significantly higher than NO_3^--N content recorded in treatments M_1(100% RDN through FYM + 25% through Inorganic fertilizers.), M_2(75% RDN through FYM + 25% through Inorganic fertilizers.)and M_3(Only organics) treatments at 14, 21, 28, 35, 42, 49 DAI (Table 2 and Fig. 1).

The significantly lower NO_3^--N content (9.25, 12.41, 17.76, 24.11, 28.16, 33.83, 35.58, 33.83 and 32.43 mg kg^{-1}, respectively) was recorded with M_3(Only organics) at 7, 14, 21, 28, 35, 42, 49, 56, 63 DAI and with M_4(Only inorganics) at 70 DAI (34.36 mg kg^{-1}).

This might be due to the much slow release of nitrogen from organics, resulting in the smaller losses of nitrogen and building up of a higher concentration of nitrogen. Similar observations were made by Karamjit*et al.* 2011 and Mahbubeh and Mohsen, 2012. Further, integrated treatments with combined application of inorganics and organic recorded higher NO_3^--N compared to the treatments which received N only through fertilizers without organics. This could be correlated to the increase in soil pH due to increased microbial activity might have hastened nitrification process with a reduction in leaching losses (Udaysoorian *et al.,* 1989). In case of only inorganics treated plots without organics, the conversion of NH_4^+-Nto NO_3^--N was rapid as observed by Benbe *et al.* (1991) and this might have led to more leaching loss of NO_3^--N.

Inorganic fractions –Ammonical nitrogen (NH_4^+-N). Crop residues or organic manures rich in nitrogen are important in maintaining adequate level of available nitrogen and through mineralization can release the large amounts of mineral nitrogen (De Neve and Hofman 1998). During mineralization of organic manures, the released nitrogen can contribute to nutrient requirements of subsequent crops (Schröder *et al.* 1997), or become a pollutant. Organic manures can have large effect on N leached (Rahn *et al.*, 2003). Nitrogen in organic manures is made available to crops majorly by the process of mineralization and is regulated by organic manure's chemical composition.

Another important inorganic nitrogen fraction is NH_4^+-N. The content of NH_4^+-N content in all the treatments increased up to 70 DAI except M_4(Only inorganics) where in it increased up to 42 days and gradually decreased thereafter up to 70 days.

The significantly higher NH_4^+-N content (28.65, 40.80, 51.14, 55.46, 61.37, 69.01 and 62.92 mg kg^{-1}, respectively) was recorded in M_4 (Only inorganics) treatment at 7, 14, 21, 28, 35, 42, 49 DAI which decreased thereafter until 70 days followed by M_1(24.46, 30.69, 41.77, 48.48, 55.71, 59.25 and 59.24 mg kg^{-1}, respectively) and M_2(23.08, 25.40, 37.66, 44.60, 51.58, 55.75 and 56.94 mg kg^{-1}, respectively) and at 56, 63 and 70 DAI significantly higher NH_4^+-N content (61.88, 62.13 and 61.13 mg kg^{-1}, respectively) was recorded with M_1(100% RDN through FYM + 25% through Inorganic fertilizers.). The NH_4^+-N content recorded in the treatment M_4(Only inorganics) was significantly higher than NH_4^+-N content recorded in treatments M_1(100% RDN through FYM + 25% through Inorganic fertilizers.), M_2(75% RDN through FYM + 25% through Inorganic fertilizers.) and M_3(Only organics) treatments at 7, 14, 21, 28, 35, 42, 49 DAI (Table 3 and Fig. 2).

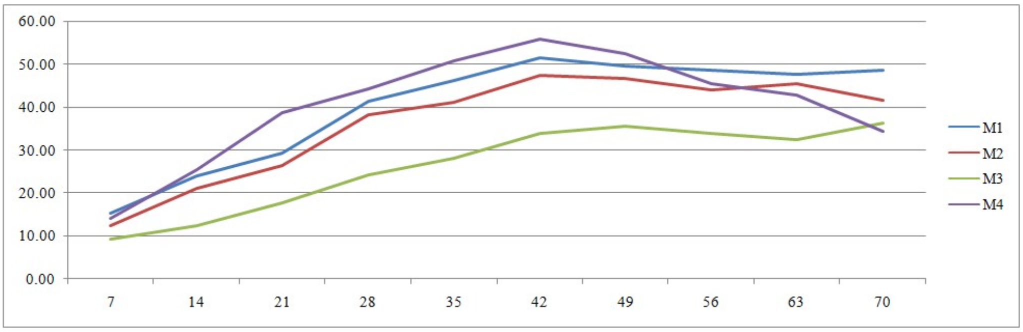
The significantly lower NH_4^+-N content (17.67, 20.93, 29.90, 33.10, 38.02, 41.02, 41.95, 43.13 and 45.57 mg kg^{-1}, respectively) was recorded with M_3(Only organics) at 7, 14, 21, 28, 35, 42, 49, 56, 63 DAI and with M_4(Only inorganics) at 70 DAI (43.26 mg kg^{-1}) (Table 3).

These results are in consonance with that of Kamat *et al.* (1982), who observed an increase in different forms of nitrogen with combined application of inorganics along with organic sources. Similarly, Sharma and Verma (2001) observed an increase in different forms of nitrogen with continuous application of inorganic fertilizers and green manuring. Huang *et al.* (2009) concluded that organic manure had a more significant effect on soil nitrogen than inorganic fertilizer alone. Santhy *et al.* (1998) also observed a positive effect on the build-up of the nitrogen fractions in soil with the application of farm yard manure along with inorganic fertilizers.

Table 2: Influence of organics and inorganics on mineralization of nitrogen in the soil (NO_3-N release (mg kg^{-1})) Pooled.

TREATMENTS	Incubation time (days)									
	7	14	21	28	35	42	49	56	63	70
M_1:	15.27	23.94	29.26	41.38	46.06	51.46	49.62	48.61	47.51	48.52
M_2:	12.25	20.98	26.31	38.17	40.98	47.26	46.43	43.91	45.21	41.47
M_3:	9.25	12.41	17.76	24.11	28.16	33.83	35.58	33.83	32.43	36.27
M_4:	14.15	25.54	38.74	44.38	50.84	55.88	52.41	45.59	42.83	34.36
S.Em±	0.29	0.45	0.31	0.62	0.51	0.31	0.28	0.36	0.26	0.32
CD @ 5%	0.88	1.34	0.93	1.86	1.52	0.92	0.83	1.08	0.77	0.97

M_1: 100% RDN through FYM + 25% through Inorganic fertilizers. **M_2:** 75% RDN through FYM + 25% through Inorganic fertilizers. **M_3:** Only organics. **M_4:** Only inorganics.



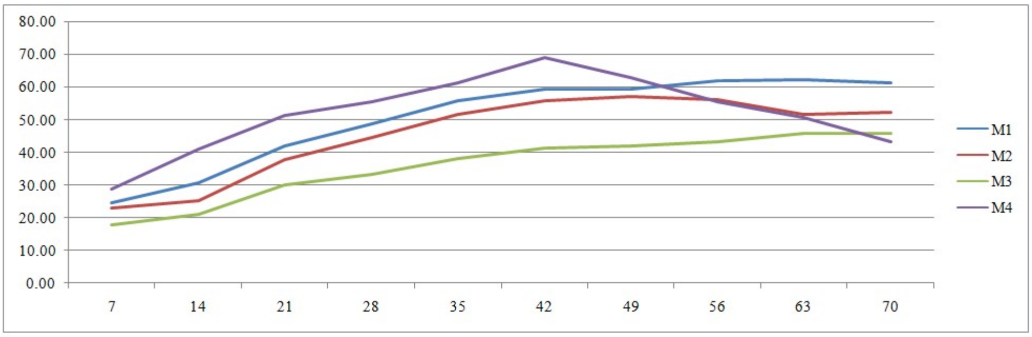
M_1: 100% RDN through FYM + 25% through Inorganic fertilizers; **M_2:** 75% RDN through FYM + 25% through Inorganic fertilizers; **M_3:** Only organics; **M_4:** Only inorganics.

Fig. 1. Influence of organics and inorganics on mineralization of nitrogen in the soil (NO_3-N release (mg kg^{-1})) Pooled.

Table 3: Influence of organics and inorganics on mineralization of nitrogen in the soil (NH_4-N release (mg kg^{-1})) Pooled.

TREATMENTS	Incubation time (days)									
	7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**
M_1:	24.46	30.69	41.77	48.48	55.71	59.25	59.24	61.88	62.13	61.13
M_2:	23.08	25.40	37.66	44.60	51.58	55.75	56.94	55.83	51.43	52.15
M_3:	17.67	20.93	29.90	33.10	38.02	41.02	41.95	43.13	45.57	45.67
M_4:	28.65	40.80	51.14	55.46	61.37	69.01	62.92	55.41	50.70	43.26
S.Em±	0.37	0.57	0.48	0.69	0.67	0.35	0.44	0.40	0.32	0.38
CD @ 5%	1.12	1.70	1.45	2.08	2.02	1.04	1.33	1.21	0.97	1.14

M_1: 100% RDN through FYM + 25% through Inorganic fertilizers; **M_2:** 75% RDN through FYM + 25% through Inorganic fertilizers; **M_3:** Only organics; **M_4:** Only inorganics.



M_1: 100% RDN through FYM + 25% through Inorganic fertilizers; **M_2:** 75% RDN through FYM + 25% through Inorganic fertilizers; **M_3:** Only organics; **M_4:** Only inorganics.

Fig. 2. Influence of organics and inorganics on mineralization of nitrogen in the soil (NH_4-N release (mg kg^{-1})) Pooled.

Plate 1: Advisory committee visit to field and Pot culture experiment.

CONCLUSION

From this study, it can be concluded that the integrated use of inorganic fertilizers with organic manures represents the sound practice for sustaining the nitrogen reserves in soil and this will be a more beneficial proposition than the application of inorganics alone in improving the soil nitrogen status and enhancing nutrient availability to the crop during the critical stages of nutrient requirement and yield under an intensive cropping system.

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Conflicts of Interest: None.

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