https://doi.org/10.29321/MAJ.10.A03800

# Comparative Nitrification of Urea and Urea Formaldehyde in Major Soils of South India

*by*

S. P. MUSTAFA [1] and R. NATARAJAN [2]

**Synopsis :** A study was undertaken to determine the rate of nitrification of urea formaldehyde, a waste product obtained from plastic industries analysing 19 per cent total nitrogen in comparison with urea. The results indicate that this product compares favourably with urea in the pattern of nitrification and it offers a promising source of organic nitrogen.

**Introduction :** Synthetic organic nitrogeneous fertilizers are usually preferred to ammoniacal and nitrate ones in places of high rainfall to inhibit leaching losses of nitrogen. In Madras State wherever a high analysis nitrogeneous fertilizer is to be used the choice is generally for urea. But of late, urea formaldehyde a synthetic product obtained by allowing urea and formaldehyde to react in various proportions has come into use. In countries like America where it is manufactured for fertilising the land, the product contains 37 per cent nitrogen. In India, it is obtained as a bye-product in plastic industries and the product analyses to 19 per cent total nitrogen. In the present work, fertilizer urea with 46 per cent nitrogen is compared with urea formaldehyde.

**Review of Literature :** Allison and Sterling (1949) observed that nitrate formation from soil organic matter was directly correlated with total soil nitrogen at different incubation periods with both limed and unlimed soils. Datta *et al* (1962) stressed the need for water insoluble nitrogenous fertilizers that would release available nitrogen at rates approximating to crop needs. Armiger *et al* (1948) working with a number of urea formaldehyde products of various solubilities found that the nitrogen from these sources was comparable to standard nitrogenous fertilizers. Hagin *et al* (1962) found that higher doses of urea formaldehyde markedly retarded nitrification in the early stages, but at later periods of incubation nitrification of urea formaldehyde was almost complete. Jacobson *et al* (1948) were of the view that nitrification was influenced to a marked degree by the kind and amount of nutrients available. Recently, Jung (1963) has reviewed the experimental results on the mineralisation of crotonylide as compared with other slow active nitrogen fertilizers such as urea form. Lyon and Buckman (1947) stated that lime stimulates nitrification in soil. Ostromecka (1963) found that nitrification at optimum temperature decreased with

[1] and [2] Assistants in Chemistry, Agricultural College and Research Institute, Coimbatore-3.

Received on 14—5—1965.

increasing acidity. Pereira and Smith (1963) in comparative nitrification studies of two urea forms successfully predicted the more rapid rate of nitrification and greater accumulation of nitrate nitrogen from the more soluble product. Winsor and Long (1956) established a significant correlation between nitrification and soil pH.

**Methods and Materials:** In the present investigation carried out at Agricultural College and Research Institute, Coimbatore during the period January to April 1964, urea and urea formaldehyde were applied at 0.1 per cent N level to major type of soils of South India *viz.* Black, Red, Laterite and Alluvial soils, each with and without $CaCo_3$.

The nitrification studies were conducted in 2 lb glass bottles with 300 gm air-dried soil. Urea and urea formaldehyde were added to give 0.1 per cent N level with and without lime. The addition of lime was at one per cent level as finely powdered $CaCo_3$. The soils were brought to optimum moisture conditions and incubated at laboratory temperature. Moisture was kept constant by periodical addition of water. Samples were drawn at regular interval of 30 days upto a period of 120 days and analysed for ammoniacal and nitrate nitrogen in duplicate (method of Bengtsson, 1924).

Portions of 20 gm of the soil were leached with 500 c. c. of 10 per cent KCL solution. Ammoniacal N was determined in a known volume of leachate by distilling with an excess of freshly ignited Magnesium oxide. The residue after ammonia determination was diluted with water and again distilled for determination of nitrate nitrogen using powdered Devadar's alloy. The particulars of treatment are given below:

*Treatment Particulars:* (1) Urea plus red soil (2) Urea plus red soil plus $CaCo_3$ (3) Ureaform plus red soil (4) Ureaform plus red soil plus $CaCo_3$ (5) Urea plus black soil (6) Urea plus black soil plus $CaCo_3$ (7) Ureaform plus black soil (8) Ureaform plus black soil plus $CaCo_3$ (9) Urea plus alluvial soil (10) Urea plus alluvial soil plus $CaCo_3$ (11) Ureaform plus alluvial soil (12) Ureaform plus alluvial soil plus $CaCo_3$ (13) Urea plus laterite soil (14) Urea plus laterite soil plus $CaCo_3$ (15) Ureaform plus laterite soil and (16) Ureaform plus laterite soil plus $CaCo_3$.

**Results:** The addition of lime does not influence mineralisation of nitrogen in all the four types of soils. The nitrification is greater than ammonification in all the soils studied. Maximum mineralisation was noticed at the 6th day after incubation and afterwards decreased. Ammonification was found to be more or less steady throughout the period compared to nitrification which increased markedly upto 90 days beyond which it decreased abruptly. In black and laterite soils nitrate nitrogen was significantly greater than ammoniacal nitrogen. In red and alluvial

soils, it was not significant. Ammonification was the same in all the soil types. Nitrification was found to vary from soil to soil and it was observed to be more in black and laterite soils than in red and alluvial soils. Lime is found to be beneficial in the case of urea formaldehyde. The rate of mineralisation both in urea and urea formaldehyde was statistically the same.

**Discussion :** The differences in the nitrogen mineralised due to soil types were not significant. These findings were in contrast to those of Winsor and Long (1956) who stated that the rate of decomposition of urea formaldehyde compounds varied greatly from soil to soil depending upon the pH. Limed and unlimed soils behaved similarly. There was also no significant difference between different forms of nitrogen, placing urea and urea formaldehyde on a par. Armiger and his associates (1948) observed a similar trend. These authors working with a number of ureaformaldehyde products of various solubilities found that the nitrogen from these sources was comparable to standard sources of nitrogen fertilizer.

TABLE I

*Mean values of Nitrate & Ammoniacal nitrogen in soils.*

| Forms of N | Mean value | S. E. | C. D. |
|---|---|---|---|
| $NO_3$. N | 11·10 | 0·65 | 2·41 |
| $NH_4$. N | 6·79 | | |

Conclusion : $NO_3$, $NH_4$

From table I, it would be seen that there was a marked difference between the amounts of ammoniacal and nitrate nitrogen formed, the latter being greater in amount. This was because, the ammoniacal nitrogen produced on hydrolysis, got quickly converted into nitrate nitrogen due to the increase in pH on account of the formation of ammonium carbonate which is alkaline in reaction.

TABLE II

*Mean value of ($NO_3$ N plus $NH_4$. N) at different periods.*

| Period | Time | Mean value | S. E. | C. D. |
|---|---|---|---|---|
| I | At 30 days | 7·809 | | |
| II | At 60 days | 12·037 | 0·92 | 3·2 |
| III | At 90 days | 9·506 | | |
| IV | At 120 days | 6·431 | | |

II III I IV

Within the periods studied, there was a significant difference in the mineralisation from time to time. Maximum mineralisation was noticed at the 60th day after incubation and thereafter, there was a gradual decline

with time. This is in conformity with the observation of Datta and co-workers (1962) who reported that ureaformaldehyde products can release nitrogen upto a period of three months and afterwards they become resistant to further decomposition. The variation in the total amount of nitrogen mineralised with lime was similar for both urea and ureaformaldehyde, but the relative amounts of ammoniacal and nitrate nitrogen varied significantly with lime.

TABLE III

*Mean values of $NH_4$. N plus $NO_3$. N in soils.*

| Period | Time | $NH_4$. N Mean Value | $NO_3$. N mean Value | S. E. | C. D. |
|---|---|---|---|---|---|
| I | 30 days | 7·5 | 8·2 | | |
| II | 60 days | 8·7 | 15·4 | | |
| III | 90 days | 5·1 | 13·3 | 1·3 | 4·2 |
| IV | 120 days | 5·9 | 6·3 | | |

$NH_4$ II I IV III

$NO_3$ II III I IV

I $NO_3$ $NH_4$

II $NO_3$ $NH_4$

III $NO_3$ $NH_4$

IV $NO_3$ $NH_4$

There was no significant difference in the ammoniacal nitrogen formed from time to time. The nitrate nitrogen content increased markedly with time upto 90 days beyond which there was an abrupt decrease. The ammonical nitrogen produced appeared to be quickly transformed into the nitrate form. The trend was similar for all soil types either with or without lime.

TABLE IV

$NH_4$. N and $NO_3$. N in different soil types.

| Soil | Forms of N $NH_4$ Mean value | $NO_3$ Mean value | S. E. | C. D. |
|---|---|---|---|---|
| Red | 8·2 | 6·9 | | |
| Black | 5·4 | 14·7 | 1·3 | 4·2 |
| Alluvial | 7·3 | 9·5 | | |
| Laterite | 6·1 | 13·4 | | |

$NH_4$ Red Alluvial Laterite Black

$NO_3$ Black Laterite Alluvial Red

Red $NH_4$, $NO_3$

Black $NO_3$, $NH_4$

Alluvial $NO_3$, $NH_4$

Laterite $NO_3$, $NH_4$

The variation of $NH_4$. N and $NO_3$. N formed in the soil types was not significant. In the case of black and laterite soils there was a significant difference between the amount of ammoniacal and nitrate nitrogen produced. In both cases, nitrate nitrogen was found to be higher than the ammoniacal nitrogen. In red and alluvial soils, the amount of ammoniacal and nitrate nitrogen produced differed significantly. Ammoniacal nitrogen formed was the same in all the soil types, but the amount of nitrate nitrogen differed significantly from soil to soil. The black and laterite soils recorded the maximum nitrate nitrogen compared to alluvial and red soils, the latter two being on a par. This general trend of results was noticed in the two types of fertilizers at all stages of study as the higher order of interaction of these factors were not significant. The presence or absence of lime seemed to have no effect on these trends as it was evident from the absence of higher order interaction.

However, lime had a beneficial effect in the case of urea formaldehyde as shown in Table V.

TABLE V

Mean values of $NH_4$. N and $NO_3$. N with and without lime.

| Lime | Form of fertilizers: Urea Mean value | Ureaformaldehyde Mean value | S. E. | C. D. |
|---|---|---|---|---|
| Without lime $W_1$ | 9.7 | 6.8 | 0.92 | 3.2 |
| With lime $W_2$ | 8.3 | 11.1 | | |

$W_1$ Urea Ureaformaldehyde

$W_2$ Ureaformaldehyde Urea

Urea $W_1$, $W_2$

Ureaformaldehyde $W_2$, $W_1$

In the case of urea there was a slight decrease in the mineralisation due to the addition of lime, though not statistically significant. But in the case of urea form there was a marked increase in the mineralisation due to the addition of lime, the reason being that urea form on hydrolysis give urea and formic acid. The lime added neutralised the formic acid formed and rendered the urea formed free for further mineralisation. This trend of results was found to hold good for all the four types of soils as well as for both variations in ammoniacal and nitrate with lime.

**Summary and Conclusions:** A laboratory study was undertaken to compare the rate of nitrification of urea and ureaformaldehyde, a waste product from plastic industries. Urea and ureaformaldehyde at 0·1 per cent

N level were tried on different soils, each treatment having lime and no lime. Samples were drawn at intervals of 30 days for a period of 120 days. The ammoniacal and nitrate nitrogen were estimated in the soils.

The rate of mineralisation both in urea and in ureaformaldehyde was statistically the same. Addition of lime was found beneficial only in the case of ureaformaldehyde and not in urea. In the soils tested, more of nitrate nitrogen was found during the different periods of incubation than ammoniacal nitrogen. Maximum mineralisation was found at the 60th day.

The study revealed that on equal nitrogen basis and in combination with lime, ureaformaldehyde can be used on a commercial scale in all the major soil groups of South India. However, more detailed experiments have to be carried out preferably under field conditions with various crops and under different climatic conditions to establish the utility of ureaformaldehyde as a fertilizer.

**Acknowledgement:** The authors are grateful to Dr. A. Mariakulandai, Former Professor of Agronomy, Dr. D. John Durairaj, Professor in Soil Science and Sri K. S. Nair, Bacteriologist for their valuable guidance and suggestive criticism. The help rendered by Sri V. Ranganathan, Assistant Soil Chemist is gratefully acknowledged.

## REFERENCES


| | | |
|---|---|---|
| Allison, F. E. and Luann D. Sterling | 1949 | Nitrate formation from soil organic matter in relation to total $N_2$ and cropping practices. *Soil Sci.*, **67**: 239—252 |
| Armiger, W. H., R. E. Wagner and F. O. Lundstorm | 1948 | 'Ureaform-A nitrogeneous fertilizer of controlled availability' *J. Amer. Soc. Agron.* **40**: 342 |
| Datta, S. N., M. A Idrani, V. Iwaran and A. K. Rishi | 1962 | 'Ureaformaldehyde products as manures for agricultural crops. *Indian J. Appl. Chem.* **25**: 42–46 |
| Hagin, J., J. Morin and S. Dasberg | 1962 | Experiments with ureaformaldehyde on a loess soil. *Israel J. Agric. Res.* **12**: 141—144 |
| Jacobson, H. Q. M., C. L. W. Swanson and E. Smith | 1948 | 'Effect of various fertilizer cations and anions on soil reaction, leaching nitrification of urea and related characteristics in an uncropped soil' *Soil Sci.* **65**: 437—460 |
| Jung, J. | 1963 | 'Slow acting nitrogeneous fertilizer of synthetic origin' *Soils and Fert.*, **27**: 1964 Abs. No. 420 |
| Lyon, T. L and H. O. Buckman | 1947 | '*The Nature and properties of Soils*'. The Macmillon and Co., New York, 4th Edition, P. 377. |
| *Ostromecka, M | 1963 | 'Trial on evaluating the rate of urea transformation in certain mineral soils. *Soils and Fer.* **26** No. 5 (1963) Abst. No. 2564 |
| Pereira, R. L. and J. B. Smith | 1963 | 'Nitrification of urea form fractions insoluble in hot or cold water'. *J. Assoc. Agric. Chem., Wash.* **46**: 565—569 |
| Winsor, G. W. and M. I. E. Long | 1956 | 'Mineralisation of the nitrogen of ureaformaldehyde compounds in relation to soil pH' *J. Sci. Food. Agri.*, **7**: 560—564 |


* Original not seen