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RESEARCH PAPER

Effect of urea modified hydroxyapatite nano fertilizer on nitrogen release pattern in red soil

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Abstract : A laboratory incubation study was conducted during 2018 at College of Agriculture V.C. Farm, Mandya using CRD design with eight treatments and three replication. Treatments included were T_1:100% Nitrogen-Urea (NU), T_2 to T_4: NU: UHA @ 75:25, 50:50 and 25:75 per cent, respectively and T_5 to T_7: UHA @ 50, 75 and 100%, respectively, T_8: Absolute control. Results revealed that application of 100 per cent N through nano UHA increased the content of ammonical-N at 5 DAI (653.3 $\mu g\ g^{-1}$) but the content decreased at 10 DAI (583.3 $\mu g\ g^{-1}$) and increased to 716.7 $\mu g\ g^{-1}$ at 15 DAI and maintained it upto 20 DAI while, it decreased at 45 DAI. The nitrate –N release was highest (596.7 $\mu g\ g^{-1}$) at 10 DAI in T_7 treatment and maintained it upto 20 DAI and decreased at 45 DAI. Similar pattern was observed with the application of 75 and 50 per cent N-UHA treatments (T_6 and T_5, respectively). The amount of release of ammonical and nitrate N was proportional to the amount N added through UHA at any sampling interval.

Key Words : UHA: Urea modified hydroxyapatite nano fertilizer, Tomato, NU: Nano urea, DAI: Days after incubation, Nitrate –N and Ammonical – N.

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INTRODUCTION

The extent of world food production depends on fertilizer use invariably increase in future due to increase in population, without fertilizers the world would produce only about half as much staple food and forest lands would have to be put into production (Roberts, 2009). Mineral fertilizers are the main source of nutrients applied to soils to overcome the deficiency in native nutrient supply. On the other hand the mineral fertilizer use has created some environmental hazards. It has been documented by several researchers that nitrate loss from the soil have toxicological implications for animals and humans (Oves *et al.,* 2013) and the loss of N in the form NO_x may increase global warming potential (Park *et al.,* 2012). Nitrate along with P also have detrimental impact on the environment leading to the eutrophication of freshwater (Mishra *et al.*, 2014) and marine ecosystems. In this context manage fertilizers and soils in sustainable way so that, not only food demands are met, but soil remains healthy to meet food and nutritional

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security of future generation with minimum environmental impact. Employing nanotechnology in synthesis and formulations of nano fertilizers and their subsequent use is regarded as a break through in achieving higher nutrient use efficiency with minimum environmental risk due to the slow release nature of nanoparticles. Nanotechnology refers to controlling, building and restructuring materials and devices on scale of atoms and molecules (1-100 nm). The development of nanotechnology in conjunction with biotechnology has significantly expanded the application domain of nanomaterials in various fields including agriculture. So, use of nano fertilizers in place of conventional urea nitrogen fertilizers lessen the nitrogen losses to environment as it releases nitrogen slowly thus coinciding with plant uptake as a result the quantity of fertilizers application can be reduced and reduces the environmental risk associated with conventional N fertilizers.

Material and Methods

Laboratory incubation study details:

Laboratory experiment was conducted to study the release pattern of nitrogen from the applied urea modified hydroxyapatite nano fertilizer at different intervals for 45 days.

Experimental set up:

Small plastic cups, which can hold 50 g soil was used for conducting incubation study. In the beginning soil sample collected was treated with FYM (as per the recommended dose for tomato crop). Exactly 50 g FYM treated soil was transferred to cups. Calculated quantity of urea, UHA, SSP and MOP were dissolved in distilled water as per the treatment details given below were added to soil. Separate set of containers were used (Fig.A) for different interval of sampling (0, 5, 10, 15, 20, 25, 30 and 45 days). The samples were maintained at field capacity moisture. Cups holding soil were weighed at two days interval and based on the weight loss the water was added to bring the samples to field capacity.

Treatment details:

T_1: RDF (NPK) + FYM
T_2: RD (PK) + 75% N-U + 25%N-UHA + FYM
T_3: RD (PK) + 50% N-U + 50% N-UHA + FYM
T_4: RD (PK) + 25% N-U+ 75% N-UHA + FYM
T_5: RD (PK) + 50% N-UHA + FYM
T_6: RD (PK) + 75% N-UHA + FYM
T_7: RD (PK) + 100% N-UHA + FYM
T_8: Absolute control.

Note:

– RDF: Recommended dose of conventional fertilizers.

– RD (PK): Recommended dose of phosphorus and potash fertilizers

– Recommended fertilizer (250: 250: 250 N: P_2O_5: K_2O kg ha^{-1}) and FYM (39.75 t ha^{-1}) dose for tomato crop was used

– Hundred per cent of N was supplied through urea (N-U) and urea modified hydroxylapatite nano fertilizer (N-UHA) or in combination of both as per the treatment details. However, the recommended P and K which were common to all the treatments were supplied through SSP and MOP, respectively.

Soil chemical analysis at different days after incubation:

NH_4^+ - N and NO_3^+ – N

Out of 50 g soil 10 g soil sample was drawn from each plastic cup at 0, 5, 10, 15, 20, 25, 30 and 45 days after incubation (separate cups were kept for each interval). The NH_4 and NO_3 content were extracted using 100 ml of 2 M KCl solution. The concentration of NO_3^- - N and NH_4^+ - N in the extract was determined by taking 50 ml of extract in the distillation tube to which 0.5 g of MgO was added and steam was passed and 50 ml of distillate is collected in the receiving flask containing 4 per cent boric acid with mixed indicator. The content of NH_4 was determined by titrating against 0.1N HCl and expressed as NH_4 - N. After NH_4-N distillation is completed 0.5 g of Devarda's alloy was added to the same distillation tube and again distillation was done to trap ammonia in the 4 per cent boric acid which was titrated against 0.1 N HCl and expressed as NO_3 - N (Rowell, 1993).

Statistical analysis:

The data collected from incubation experiment was analysed statistically following the procedure as described by Gomez and Gomez (1984). The level of significance used in 'F' test was P=0.01. The critical differences were calculated wherever 'F' test was significant.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Release pattern of NH_4^+ and NO_3^- from UHA treated red soil:

Application of 100 per cent N through nano UHA with RD (PK) + FYM (T_7) increased the content of ammonical-N at 5 DAI (653.3 µg g^{-1}) and decreased at 10 DAI (583.3 µg g^{-1}) and increased to 716.7 µg g^{-1} at 15 DAI and sustainable maintenance was upto 20 DAI while, it decreased at 45 DAI Whereas, nitrate –N release was highest (596.7 µg g^{-1}) at 10 DAI in T_7 treatment and maintained it upto 20 DAI and decreased at 45 DAI. Similar pattern was observed with the application of 75 and 50 per cent N-UHA + RD (PK) + FYM treatments (T_6 and T_5, respectively). The amount of ammonical and nitrate N was proportional to the amount N added through UHA during all sampling intervals. The release of NH_4^+ - N and NO_3^- -N five days after incubation in urea treated soil was lower than that recorded with UHA.

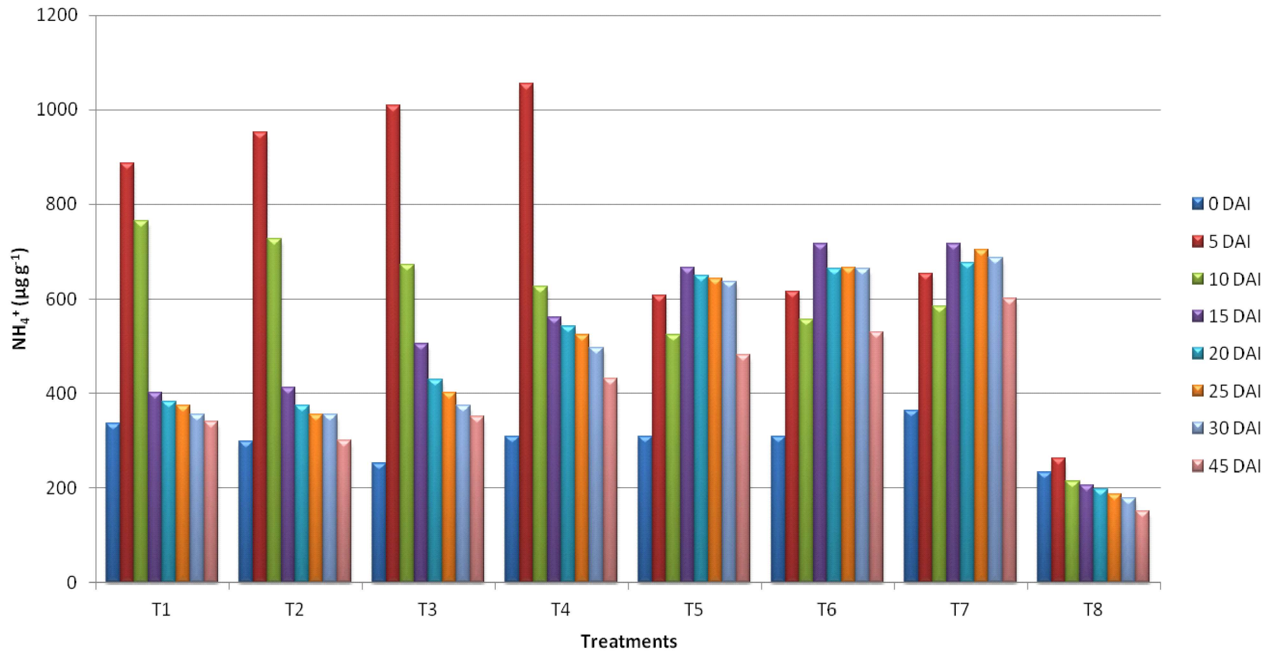
The data presented in Table (1 and 2) and Fig. (1 and 2) indicated that the conversion of amide form of nitrogen (urea) to NH_4^+ - N and NO_3^- -N form was quicker than the treatment which received N in the form of UHA. Further, it was observed that the amount of NH_4^+ - N and NO_3^- -N was higher in the treatment that received N-UHA as compared to urea treated soil. Urea-HA nano hybrids, released nitrogen twelve times slower compared to pure urea. In evidence with this Kottegoda *et al.* (2017) reported that it took 3820 s to release 86 per cent (or 0.79 g) of the N in urea in the 6:1 urea- HA nanohybrid. The rest of the 0.13 g (14%) of urea in the nanohybrids is released over a significantly longer period of time up to 1 week. For the urea-HA nanohybrids, the rate of release of N was 12 times slower compared to pure urea. The release profile of the nanohybrid is in agreement with the bonding mechanism suggested by

Table 1: Ammonium content (µg g^{-1}) in soil at different days after incubation as influenced by urea and UHA application

Treatments	0 DAI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI
T_1: RDF (NPK) + FYM (100% N-U)	336.0	886.7	765.3	401.3	382.7	373.3	354.7	340.0
T_2 : RD (PK) + 75% N-U + 25% N-UHA + FYM	298.7	952.0	728.0	410.7	373.3	354.7	354.7	300.3
T_3 : RD (PK) + 50% N-U + 50% N-UHA +FYM	252.0	1008.0	672.0	504.0	429.3	401.3	373.3	350.0
T_4 : RD (PK) + 25% N-U + 75% N- UHA +FYM	308.0	1054.7	625.3	560.0	541.3	522.7	494.7	430.0
T_5: RD (PK) + 50 % N- UHA + FYM	308.0	606.7	522.7	666.7	650.0	643.3	636.7	480.0
T_6: RD (PK) + 75% N- UHA + FYM	308.0	616.0	556.7	716.7	663.3	666.7	663.3	530.0
T_7 : RD (PK) + 100% N- UHA + FYM	364.0	653.3	583.3	716.7	676.7	703.3	686.7	600.0
T_8 : Absolute control	233.3	261.3	214.7	205.3	196.0	186.7	177.3	149.9
S.E.±	04.17	08.34	15.84	12.45	10.32	09.32	13.25	1.51
C.D. (P=0.01)	16.79	33.59	63.75	50.10	41.53	37.50	53.35	6.07

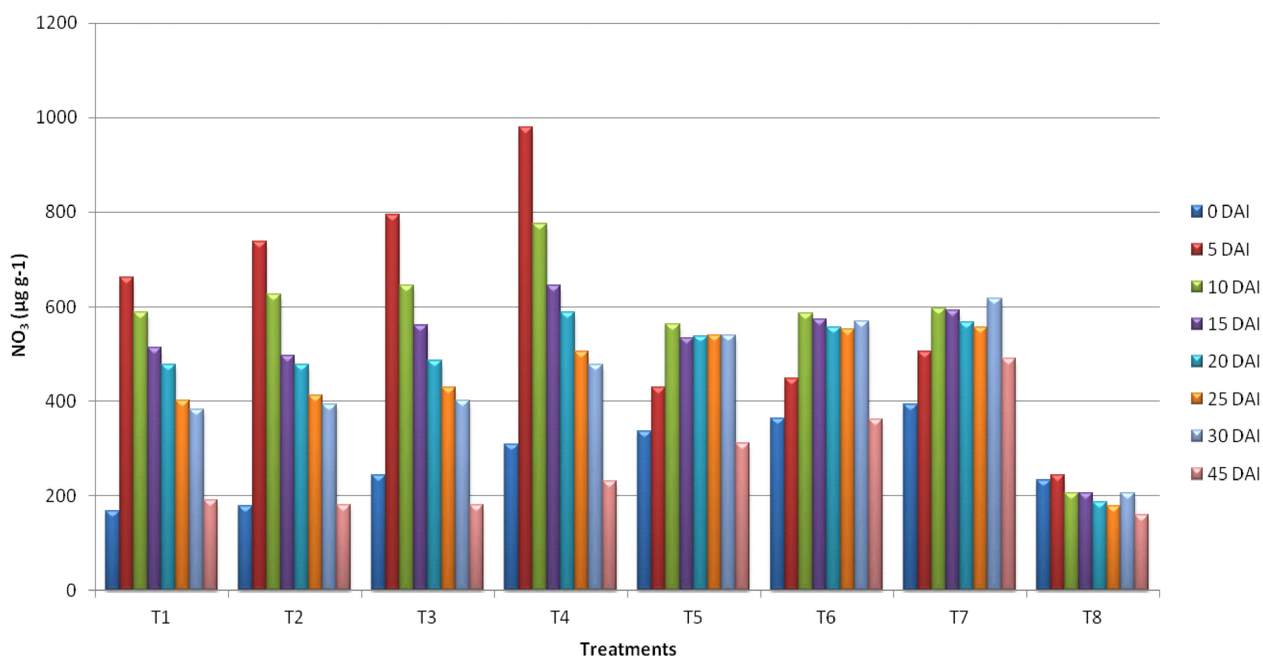
Table 2: Nitrate content (µg g^{-1}) in soil at different days after incubation as influenced by urea and UHA application

Treatments	0 DAI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI
T_1: RDF (NPK) + FYM (100% N-U)	168.0	662.7	588.0	513.3	476.0	401.3	382.7	190.0
T_2 : RD (PK) + 75% N-U + 25% N-UHA + FYM	177.3	737.3	625.3	494.7	476.0	410.7	392.0	180.0
T_3 : RD (PK) + 50% N-U + 50% N-UHA +FYM	242.7	793.3	644.0	560.0	485.3	429.3	401.3	180.0
T_4 : RD (PK) + 25% N-U + 75% N- UHA +FYM	308.0	980.0	774.7	644.0	588.0	504.0	476.0	230.0
T_5: RD (PK) + 50 % N- UHA + FYM	336.0	429.3	563.3	533.3	536.7	540.0	540.0	310.0
T_6: RD (PK) + 75% N- UHA + FYM	364.0	448.0	586.7	573.3	556.7	553.3	530.0	360.0
T_7 : RD (PK) + 100% N- UHA + FYM	392.0	504.0	596.7	593.3	566.7	556.7	516.7	490.0
T_8 : Absolute control	233.3	242.7	205.3	205.3	186.7	177.3	205.3	160.0
S.E.±	05.1	06.6	12.4	12.2	11.7	11.8	12.1	06.3
C.D. (P=0.01)	20.6	26.6	49.9	48.9	46.9	47.5	48.7	26.5



T_1: RDF (NPK) + FYM, T_2: RD (PK) + 75% N-U + 25%N-UHA + FYM, T_3: RD (PK) + 50% N-U + 50% N-UHA + FYM
T_4: RD (PK) + 25% N-U+ 75% N-UHA + FYM, T_5: RD (PK) + 50% N-UHA + FYM, T_6: RD (PK) + 75% N-UHA + FYM
T_7: RD (PK) + 100% N-UHA + FYM, T_8: Absolute control

Fig. 1: NH_4^+ content (µg g^{-1}) in soil at different DAI as influenced by urea and UHA application



T_1: RDF (NPK) + FYM, T_2: RD (PK) + 75% N-U + 25%N-UHA + FYM, T_3: RD (PK) + 50% N-U + 50% N-UHA + FYM
T_4: RD (PK) + 25% N-U+ 75% N-UHA + FYM, T_5: RD (PK) + 50% N-UHA + FYM, T_6: RD (PK) + 75% N-UHA + FYM
T_7: RD (PK) + 100% N-UHA + FYM, T_8: Absolute control

Fig. 2: NO_3^- content (µg g^{-1}) in soil at different DAI as influenced by urea and UHA application

several characterization techniques. More than 70 per cent N was released from urea in two weeks time period while only 39 per cent N was released from UHA in the incubation study under upland moisture condition (Weerasinghae *et al.,* 2016). Results were in agreement with the results of Manikandan *et al*. (2013); Rajendran *et al.* (2016) and Giroto *et al.* (2017).

Conclusion:

Application of 100 per cent N through nano UHA with RD (PK) + FYM increased the content of ammonical-N at 5 DAI (653.3 $\mu g\ g^{-1}$) but the content decreased at 10 DAI (583.3 $\mu g\ g^{-1}$) and increased to 716.7 $\mu g\ g^{-1}$ at 15 DAI and maintained it upto 20 DAI while, it decreased at 45 DAI and Nitrate –N release was highest (596.7 $\mu g\ g^{-1}$) at 10 DAI in T_7 treatment and maintained it upto 20 DAI and decreased at 45 DAI. Similar pattern was observed with the application of 75 and 50 per cent N-UHA + RD (PK) + FYM treatments (T_6 and T_5, respectively). The amount of ammonical and nitrate N was proportional to the amount N added through UHA at any sampling interval. use of urea modified hydroxyapatite nano fertilizers in place of conventional urea nitrogen fertilizers lessen the nitrogen losses to environment as it releases nitrogen slowly thus, coinciding with plant uptake as a result the quantity of fertilizers application can be reduced and reduces the environmental risk associated with conventional N fertilizers.

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