Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(2): 1029-1031
Received: 13-01-2021
Accepted: 15-02-2021

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Influence of "N" inhibitors on nitrate nitrogen & yield of tomato under intensive cultivation

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DOI: https://doi.org/10.22271/phyto.2021.v10.i2n.13936

Abstract
Agricultural soils are responsible for formation of N_2O through nitrification and denitrification processes. Nitrification inhibitors reduces the rate at which ammonium is converted to nitrate either by killing or interfering with the metabolism of nitrifying bacteria. Synthetic nitrification inhibitors can efficiently inhibit nitrification. The present study was undertaken to observe the effect of Potassium thiosulfate (PTS) and neem coated urea on N_2O efflux under irrigated tomato cultivation to assess its suitability for decreasing N_2O emission to the atmosphere. The results depicted the reduction of nitrate nitrogen on third day after fertilizer application compared to zeroth day. The decreased NO_3-N was mainly due to the uptake by tomato for its growth and converted into N_2O as intermediate product during nitrification process. The yield of tomato (fruit yield) was significantly increased due to the application of various doses and types of N fertilizer application along with N inhibitors. The highest yield (63.2 t ha^{-1}) was recorded with the soil application of nutrients in STCR based recommendation of NPK with Neem coated urea which was on par with the STCR based recommendation of NPK with Normal urea (183:160:125kg ha^{-1}) along with Potassium thiosulfates @ 1% of applied N whereas blanket recommendation of NPK application recorded lower yield. The 38% lowest N_2O emission was found in the STCR based recommendation of NPK with Normal urea with Potassium thiosulfates @ 1% of applied N compared to Blanket recommendation of NPK with Normal urea, which was on par with the treatment of STCR based recommendation of NPK with Neem coated urea.

Keywords: tomato, nitrate nitrogen, STCR, N inhibitors

Introduction
Nitrous oxide (N_2O) is a trace gas responsible for global warming and depletion of ozone (O_3) in the stratosphere. It accounts for 5% of the total greenhouse effect and 250 times more effective than carbon dioxide (CO_2) on molecule-to-molecule basis in absorbing infrared radiation with its atmospheric lifetime of 150 years (Robertson, 1992) [12]. It indicates that it neither reacts with the atmospheric chemicals nor precipitated by the moisture in the atmosphere and moves uninterrupted to the stratosphere to damage O_3 layer, indirectly through NO formation. As with many greenhouse gases, the atmospheric concentration of N_2O has increased from about 285 ppbv (Khalil and Rasmussen, 2002) [4] in the pre-industrial era to about 310 ppbv in 1996 (Khalil, 1999) [5]. N_2O is biologically produced during the cycling of nitrogen in the ecosystem. Soil is reckoned to be a major source of atmospheric N_2O (Bouwman, 1990) [1]. Application of N fertilizers increases N_2O emissions (Bronson and Mosier, 1993) [2]. Emissions of N_2O from N-fertilized croplands vary considerably, ranging between 0.001% and 6.8% of applied N (Bouwman, 1990; Eichner, 1990) [1, 3]. From the agricultural soils, nitrification and denitrification are the two processes responsible for formation of N_2O. In both these processes, nitrite (NO_2^-) is formed as an intermediate compound. During the process of nitrification, NH_4^+, in aerobic condition, gets oxidized to NO_3^- via hydroxylamine and nitrite, releasing N_2O as a byproduct, while in denitrification, the NO_3^- gets completely reduced to N_2 evolving N_2O as an intermediate product. Therefore, the end product of nitrification works as substrate for denitrification. Hence, controlling the first process will certainly help in regulation of second process to some extent. Nitrification inhibitors are compounds that reduce the rate at which ammonium is converted to nitrate either by killing or interfering with the metabolism of nitrifying bacteria. Dicyandiamide (DCD) is one of the most widely used bacteriostatic nitrification inhibitors in the agriculture (Zacherl and Amberger, 1990) [14] and decomposes in soil to non-toxic products. Effect of DCD on N_2O emissions has been reported by Mosier *et al.* (1996) [9] in wheat and maize and McTaggart *et al.* (1997) [8] in ryegrass, grassland and spring barley.

Synthetic nitrification inhibitors, though expensive, can efficiently inhibit nitrification. Certain allelochemicals released by plants are also reported to have an inhibitory effect. Rice postulated that because inhibition of nitrification results in conservation of both energy and nitrogen, vegetation in late succession or climax ecosystems contains plants that release allelochemicals that inhibit nitrification in soil (Rice, 1984) [12]. Some natural products from neem (*Azadirachta indica*, A. Juss), karanja (*Pongamia glabra*, Vent.), mint (*Mentha spicata, Mentha arvensis* L.), and mahua (*Madhuca longifolia*, L.) are reported to inhibit the activity of nitrifiers (Prasad *et al.*, 1995; Kumar *et al.*, 2016; Majumdar, 2008) [11, 6, 7].

The present study was undertaken to observe the effect of PTS and neem coated urea on N_2O efflux under irrigated tomato cultivation to assess its suitability for decreasing N_2O emission to the atmosphere.

Materials and Methods

This investigation was carried out to assess the influence of "N" inhibitors on nitrate nitrogen under tomato cultivation. A field experiments were conducted at two different places *viz.*, Mr. Ponraj, Kallapuram, Kinathukadavu, Elur post, Coimbatore District & Mr. R. Tamil Selvan, Mathampatty, Thondamuthur block of Coimbatore District with two seasons of Nov. – Dec. 2019 & June – July 2020 with hybrid Sivam. The pooled analysis were performed with both the seasons data and interpreted. The experiment was laid out in randomized block design with six treatments and four replications. A uniform plot size of 25 m^2 was adopted for all the treatments and replications. Nitrogen was applied as per treatment schedule through normal urea, neem coated urea while phosphorus and micronutrient mixture were applied entirely as basal and nitrogen and potassium in four equal splits (basal, 30, 45 & 60 days intervals). The potassium thiosulfate (PTS) was applied at the rate of one per cent of applied N. STCR value has been calculated by using NPK value of experimental field soil with the standard equation developed by STCR unit of Dept. of SS&AC, DNRM, TNAU, Coimbatore.

The details of the treatments are as below.

Treatment structure

T_1: Blanket recommendation of NPK with Normal urea (200:250:250 kg ha^{-1})

T_2: STCR based recommendation of NPK with Normal urea (183:160:125kg ha^{-1})

T_3: Blanket recommendation of NPK with Neem coated urea

T_4: STCR based recommendation of NPK with Neem coated urea

T_5: T_1 + Potassium thiosulfates @ 1% of applied N

T_6: T_2 + Potassium thiosulfates @ 1% of applied N

The soil nitrate nitrogen were assessed during the 0, 1st, 2nd & 3rd day after "N" based fertilizer application of basal, first and second top dressing. In order to compare the effect of various treatments, the standard statistical procedure were used on nitrate nitrogen and yield. The cultivation practices and plant protection measures were adopted as per crop production guide 2020.

Results and Discussion

Characterization of soils of experimental field

The experimental field is red sandy clay loam. Representative soil samples at 0-30 cm depth were collected and analyzed for the physio-chemical properties. The pH of soil was recorded 6.81 and EC was recorded 0.31 $dSm^{-}1$. Considering the nutrient status, the experimental soil recorded available nitrogen (173.20 kg ha^{-1}), and phosphorus (27 kg ha^{-1}) where as potassium content recorded (336.50 kg ha^{-1}). The Nitrate reductase (NR) activity was found 69.53 µg NO_2 g^{-1} h^{-1} in the experimental soil (Table 1.).

Table 1: Initial soil characteristics of experimental field soil

S. No.	Parameters	Value
1	pH	6.81
2	EC (dSm^{-1})	0.31
3	Organic carbon (%)	0.58
4	Available nitrogen (kg ha^{-1})	173
5	Available phosphorus (kg ha^{-1})	27
6	Available potassium (kg ha^{-1})	337
7	Exchangeable Ca (c mol (P^+) kg^{-1})	1.14
8	Exchangeable Mg (c mol (P^+) kg^{-1})	0.56
9	Exchangeable Na (c mol (P^+) kg^{-1})	1.63
10	Nitrate nitrogen (mg kg^{-1})	38.8
11	Nitrate reductase (µg NO_2 g^{-1} h^{-1})	69.53
12	Bacteria (x10^6 CFU g^{-1} of soil)	20
13	Fungi (x10^4 CFU g^{-1} of soil)	13
14	Actinomycetes (x10^2 CFU g^{-1} of soil)	03

Influence of "N" inhibitors on Nitrate Nitrogen under tomato cultivation

The nitrate nitrogen content during the different nitrogen application periods was higher in 0th day in all the treatments. The mean nitrate nitrogen content in 0th day of soil was recorded 34.47, 44.68 & 40.23 mg kg^{-1} of NO_3-N in basal, first & second top dressing, respectively. The lowest nitrate nitrogen was observed on third day after fertilizer application (Fig. 2). The decreased NO_3-N was mainly due to the uptake by tomato for its growth and converted into N_2O as intermediate product during nitrification process.

Table 2: Influences of "N" inhibitors on Nitrate Nitrogen (mg/kg) under tomato cultivation

Treatments	Basal Application				1st Top Dressing				2nd Top Dressing			
	0 day	1st day	2nd day	3rd day	0 day	1st day	2nd day	3rd day	0 day	1st day	2nd day	3rd day
T_1	45.7	41.5	37.5	32.5	55.7	33.2	24.5	18.8	50.3	30.6	22.5	17.9
T_2	41.1	36.9	31.9	28.8	50.5	30.9	22.5	17.3	46.6	27.8	20.9	16.2
T_3	32.2	28.3	27.0	25.4	40.8	32.9	25.8	17.2	36.7	30.9	20.8	17.7
T_4	30.0	28.0	26.0	24.7	40.0	30.9	22.7	16.3	35.0	30.1	18.9	15.0
T_5	30.0	27.6	24.0	24.0	42.5	35.2	26.5	17.7	37.8	31.5	26.0	17.0
T_6	27.8	25.6	22.0	20.5	38.6	27.5	21.0	16.0	35.0	30.0	17.9	15.4
Mean	34.47	31.32	28.07	25.98	44.68	31.77	23.83	17.22	40.23	30.15	21.17	16.53
CD	1.25	0.96	1.26	1.19	1.81	1.09	0.93	0.87	1.19	1.33	0.74	0.73
SEd	0.58	0.45	0.58	0.55	0.84	0.51	0.43	0.40	0.55	0.62	0.34	0.34

Influence of "N" inhibitors on Yield status of tomato

The yield of tomato (fruit yield) was significantly increased due to the application of various doses and types of N fertilizer application along with N inhibitors. The highest yield (63.2 t ha^{-1}) was recorded with the soil application of nutrients in STCR based recommendation of NPK with Neem coated urea which was on par with the STCR based recommendation of NPK with Normal urea (183:160:125kg ha^{-1}) along with Potassium thiosulfates @ 1% of applied N where as blanket recommendation of NPK application recorded lower yield (Table 3). The findings is in accordance with the Olasantan (1991) [10] found that the fruit yield of tomato plant was reduced at higher rates of N application.

Table 3: Influence of "N" inhibitors on yield of tomato

Treatments	Yield (t ha^{-1})
T_1	54.3
T_2	60.9
T_3	57.5
T_4	63.2
T_5	56.8
T_6	62.4
Mean	59.2
CD (0.05)	1.441
SEd	3.139

Conclusion

The 38% lowest N_2O emission was found in the STCR based recommendation of NPK with Normal urea with Potassium thiosulfates @ 1% of applied N (1.28, 1.91 & 1.78 mg m^{-2} day^{-1} of N_2O at basal, first and second top dressing, respectively on third day after fertilizer application) when compared to Blanket recommendation of NPK with Normal urea, which was on par with the treatment of STCR based recommendation of NPK with Neem coated urea.

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