http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (4): 1184-1187, 1999 *Research Article*

Improvement of Nitrogen Fertilizer Efficiency with Nitrification Inhibitors in Lowland Rice

Arafat, S.M., A. Abd El-Gal* and M. Abu Seeda
Soil and Water Use Department, National Research Center, Dokki, Cairo, Egypt
*Soil Science Department, Faculty of Agriculture, South Vally University, Sohag, Egypt

Abstract
Rice is a very responsive crop to nitrogen, but the efficiency of the N-fertilizers is low. Greenhouse experiment has been conducted to evaluate some synthetic (N-serve) and natural (neem cake and waste tea) nitrification inhibitors to improve fertilizer efficiency and reduce N-losses in rice fields. Nitrogen was applied as urea and ammonium sulfate at a rate of 60 mg/Kg soil. Results revealed that addition of inhibitors with both N fertilizer caused a significantly increase in both grain and straw yields rice, addition of 0.04 percent neem cake with both urea and as gave the highest grain and straw yields of rice while the waste tea gave the lowest. The percentage increase of total yield with urea + inhibitor treatments ranged between 5.8 percent to 26 percent when compared with urea alone, 26 percent increase was recorded for 0.04 percent neem cake treatment and 22.4 percent for N-serve, while 5.8 percent was recorded for 0.04 percent waste tea treatment, Also, the percentage increase in total rice yield over AS alone was 14.4 percent and 25.6 percent for 0.02 percent and 0.04 percent neem cake treatments respectively, while was 8.8 percent for N-serve treatment. Results also showed that neem cake combined with both urea and AS was more effectiveness on N-uptake especially at applied rate (0.04 percent). The percentage increase in total N-uptake over urea alone was 31 percent , 29 percent and 5 percent for 0.04 percent neem cake, N-serve and 0.04 percent waste tea respectively. On the other hand, the percentage increase of total N-uptake over all as alone was 29 percent and 15 percent for 0.04 percent and 0.02 percent neem cake treatments respectively, while, the waste tea a very low increase in total N-uptake. N-recovery by rice plant increased from 285 to 513 mg N/pot as a result of addition of inhibitors, as well as an improved in the utilization efficiency of N from urea and AS fertilizers was recorded.

Introduction
Rice is noticed for its poor utilization of fertilizer nitrogen in comparison with other agronomic crops. Fertilizer nitrogen recovery is usually in the range of 30 to 40 percent using conventional application methods and even with the best agronomic practices seldom exceeds 60 to 65 percent (Craswell *et al.*, 1981; Vlek and Byrenes, 1986; Hammad, 1996). The flooded soil environment plays a significant role in N use efficiency because the mechanisms of N loss are so numerous various researchers have reported losses occurring from nitrification-denitrification, ammonia volatilization, immobilization by soil organic matter and inter lattice clay minerals, as well as by leaching and surface runoff. Nitrification inhibitors help stabilizing the added fertilizer in the form of NH_4^+, which as adsorbed by the soil exchange complex and this conserving it from being lost away from the soil system either through leaching or denitrification of NO_3^- form. The fore a response to nitrification inhibitors can only be expected where the conditions of the soil enhance both leaching and nitrification (Huber *et al.*, 1977). Urea is the major N-fertilizer for rice in Egypt some amended urea materials have recently been developed with intent of enhancing fertilizer use efficiency. Urea amended with either neem seed cake or begasse as a natural amends has been found promising however, studies on the extent of ammonia loss from these amended urea materials applied to flood rice field are limited (Rao, 1987; Abou Seeda, 1997). The objective of this study was to evaluate the effect of some natural nitrification inhibitors in neem cake and waste tea compared with the most known N-serve (nitrapyrin) as synthetic inhibitor under different N forms on N- uptake and rice yield production.

Materials and Methods
Greenhouse experiment was carried out at the National Research Center in randomized complete block design involving 13 treatments to fulfil the present study objectives. Nitrogen fertilizer at a rate of 60 mg Kg^{-1} was added either urea or ammonium sulfate. Nitrification inhibitors used were N-serve with a rate of 10 mg Kg^{-1} soil as synthetic inhibitors and neem cake (*Azadirachta indica juss*) and waste tea (the past of manufactured tea consisting of stalk and tluff) as a natural inhibitors. In case natural inhibitors the rates used were 0.02 percent and 0.04 percent of the soil. Rice seeds (*Oriza sativa* L., Giza 171) were soaked in water for 24 hours and then were sown in separated nursery beds. After 30 hours the seedling were transplanted into the experimental pots as four seedlings/pot. Each pot containing 10 Kg soil. Some

Table 1: Some characteristics of the studied soil.

Properties	Values
PH (1:2.5 soil extract)	8.20
EC dsm^{-1} (soil paste)	1.93
$CaCO_3$ %	1.40
0.M %	1.70
Sand %	7.12
Silt %	29.10
Clay %	60.68
Texture class	Clayey
Total N %	0.11
Inorganic-N mg Kg^{-1} soil	215.00
Available-P mg Kg^{-1} soil	17.90
Available-K mg Kg^{-1} soil	512.00

physical and chemical properties of the studied soil were presented in Table 1.
Basal dose of 50 mg P_2O_5 Kg^{-1} soil and 50 K_20 Kg^{-1} soil in form of superphosphate and potassium sulfate were added to all pots before transplanting respectively.
After transplanting pots were provided with enough water to establish a water head of 2 cm above the soil surface. The waterlogging conditions was maintained throughout the growing season. At maturity stage, the plant parts were harvested and separated into grain and straw. Grain and rice straw yields recorded and biomass ground and prepared for analysis, Total N plant, soil inorganic N were determined by Kjeldahl method as described by Bremner and Mulvaney (1982). Soil analysis were conducted according to Cottenie *et al*. (1982) and Black (1982). The randomized complete block design was done according to Gomez and Gomez (1984).

Results and Discussion

Rice yield production in relation to nitrification inhibitors: Data in Table 2 represent the rice yield production under different treatments of N-sources with or without inhibitors. The application of urea and ammonium sulfate separately or in combination with nitrification inhibitors increased significantly both rice grain and straw yields compared to control treatment. However, it is noticed that N-sources and inhibitors differed widely from each other, 0.04 percent neem cake with both of urea and ammonium sulfate gave the highest rice grain and straw yields and waste tea inhibitors gave the least. Similar finding was observed by Singh *et al*. (1989), Panda *et al*. (1994) and Sharma and Prasad (1995). They found that application of neem cake with urea produced the highest yields. The percentage of increase in total rice yield in urea treatment ranged between 5.8 percent to 26 percent . This wide range reflects the specific effect of different inhibitor compare with urea treatment alone. 26 percent increase over urea alone was recorded for 0.04 percent neem cake and 22.4 percent in case of N-serve. Also, it is seen from data in Table 2 that both rates of neem cake applied with ammonium sulfate caused highly significant increased in rice grain and stew yields. However, the differentiation between the values of grain and strew yields were very closed for waste tea combined with both of urea and ammonium sulfate. The percentage increase in total rice yield over ammonium sulfate alone was 14.4 percent and 25.6 percent for 0.02 percent and 0.04 percent neem cake respectively, while was 8.8 percent for N-serve treatment.
Generally, the effect of N-serve as synthetic inhibitors more pronounced when combined with urea rather than with ammonium sulfate, while neem cake as natural inhibitor was the most effective with both of N-sources in this respect.

Nitrogen concentration and uptake: Table 3 represent the nitrogen concentration and related uptake by rice plants. The data reported show that the N-concentration differed slightly due to the N source and type of inhibitors. However, calculated N-uptake indicates a differential effect of the used inhibitory with different N sources. It could be noticed that neem cake combined with both urea and ammonium sulfate was more effectiveness on N-uptake especially at applied rate (0.04%). The percentage increase in total N-uptake over all urea alone was 31 percent, 29 percent and 5 percent for urea combined with 0.04 percent neem cake, N-serve and 0.04 .percent waste tea respectively. This increase in dry matter formation, meaning that the dilution effect is relevant too large extends. The results of N-uptake in ammonium sulfate treatments indicate superiority of neem cake over all other inhibitors. The effect is more evident with high rather than low neem cake rates. Where, the percentage increase in total N-uptake over all AS alone was 29 percent and 15 percent respectively. On the other hand, waste tea gave a very low increase in total N-uptake not more than 2 percent over all AS alone. Possible explanation of increasing N-uptake by rice due to application of inhibitors is that more N-accumulated in the soil organic fraction in the presence of inhibitors. This accumulation may be related to inhibitor maintaining more f$_i$ertilizer NH_4^+ form that is more readily utilized by microorganisms (Wilson *et al*., 1990).

N-recovry and N-utilization efficiency: Plant recovery of applied N as affected by nitrification inhibitors is presented in Table 4. Results indicated that application of inhibitors increased nitrogen recovery by rice from about 285 to 513 mg N/pot. The application of neem cake at a rate of 0.04 percent with both of urea and ammonium sulfate gave the highest values of N-recovery. N-serve inhibitors came the second in this respect. The highest increment in N-recovery was observed with urea + 0.04 percent neem cakes treatment, while the application of waste tea slightly improved the N-recovery by rice plants. Also data in Table 4 show the calculated apparent utilization efficiencies of applied nitrogen with/or without nitrification inhibitors. It was observed that, increasing neem cake rates had markedly improved the utilization efficiency of N from both urea and AS fertilizers. This means that the neem cake inhibitor contributed to the efficiency of both urea and AS nutrition increasing it to reach 85.5 percent and 83.7 percent compared to 47.5 percent and 47.8 percent for urea and AS without inhibitors respectively. While the increment in N utilization efficiency was 82.8 percent and 63.8 percent for urea and AS with N-serve respectively. The inhibitory effect of neem cake on nitrification of urea may be due to (a) the initial inhibition of the activity of urease enzyme (Fernando and Roberts, 1976) and\or (b) the inhibition of the nitrification process of the ammonium ions liberated from urea. The chemical nature of the inhibition by neem cake may be attributed to the protective action of its polyphenolic substances and their ability to chemically combine with extra-cellulose enzymes of microorganisms (Basaraba, 1964).

The residual available inorganic N, phosphorus and potassium in soil after harvesting: The available inorganic-phosphorus and potassium in soil after harvesting of rice yield (Table 5) were affected by the addition of inhibitors. The addition of inhibitors resulted in an increased of the total inorganic-N in soil. Results also showed that high values of available inorganic-N in the studied treated soil were obtained with urea (and/or AS + N-serve) and urea (and/or 0.04 percent neem cake) treatments. This meaning that additions of these inhibitors stimulate

Table 2: Effect of nitrification inhibitors on rice production and grain/straw ratio

Treatments	Grain g/pot	Straw g/pot	Total g/pot	Grain/Straw ratio
Control	26.60	37.50	67.1	0.79
Urea	49.40	53.90	103.3	0.92
Urea + N serve	62.10	64.30	126.4	0.97
Urea + 0.02% neem cake	52.00	56.20	108.2	0.93
Urea + 0.04% neem cake	63.70	66.60	130.3	0.96
Urea + 0.02% waste tea	50.70	59.20	109.9	0.86
Urea + 0.04% waste tea	51.30	58.00	109.3	0.88
$L.S.D_{0.05}$	1.22	2.75		
$L.S.D_{0.01}$	1.72	3.85		
Ammonium sulfate	51.20	55.10	106.3	0.93
AS + N-serve	59.80	55.90	115.7	1.06
AS + 0.02 neem cake	59.00	62.60	121.6	0.94
AS + 0.04 neem cake	64.60	68.90	123.5	0.94
AS + 0.02 waste tea	50.40	57.80	108.2	0.87
AS + 0.04 waste tea	49.90	56.20	106.1	0.89
$L.S.D_{0.05}$	1.58	2.53		
$L.S.D_{0.01}$	2.22	3.62		

Table 3: Nitrogen content in rice plants and its uptake as affected by N-source and nitrification inhibitors

Treatments	N-content (%)		N-uptake mg/pot		Total
	Grain	Straw	Grain	Straw	
Control	0.79	0.57	234	214	448
Urea	0.84	0.59	415	318	733
Urea + N serve	0.87	0.63	540	405	945
Urea + 0.02% neem cake	0.84	0.59	437	332	769
Urea + 0.04% neem cake	0.85	0.63	541	420	961
Urea + 0.02% waste tea	0.79	0.62	401	367	768
Urea + 0.04% waste tea	0.81	0.61	416	354	770
Ammonium sulfate	0.81	0.58	415	320	735
AS + N-serve	0.83	0.60	496	335	831
AS + 0.02 neem cake	0.79	0.61	466	382	848
AS + 0.04 neem cake	0.84	0.59	543	407	950
AS + 0.02 waste tea	0.79	0.59	398	341	739
AS + 0.04 waste tea	0.78	0.64	389	360	749

Table 4: N-recovery and utilization efficiency (%) as affected by nitrification inhibitors

Treatments	N-recovery mg/pot	Utilization efficiency (%)
Urea	285	47.5
Urea + N serve	497	82.8
Urea + 0.02% neem cake	321	53.5
Urea + 0.04% neem cake	513	85.5
Urea + 0.02% waste tea	320	53.3
Urea + 0.04% waste tea	322	53.7
Ammonium sulfate	287	47.8
AS + N-serve	383	63.8
AS + 0.02 neem cake	400	66.7
AS + 0.04 neem cake	502	83.7
AS + 0.02 waste tea	291	48.5
AS + 0.04 waste tea	301	50.2

Added N 600 mg/pot

N recovery = total N uptake (fertilizer) - total N uptake (control)

N utilization efficiency = N recovery/N applied by fertilizer X100

Table 5: Effect of nitrification inhibitors on rice nutrients content in soil after harvesting Available nutrients mg/Kg soil

Treatments	Inorganic N	P	K
Control	23.1	11.1	223
Urea	37.3	19.4	458
Urea + N serve	65.1	24.2	489
Urea + 0.02% neem cake	43.1	21.1	578
Urea + 0.04% neem cake	55.9	23.6	455
Urea + 0.02% waste tea	36.6	17.5	535
Urea + 0.04% waste tea	34.4	18.3	431
Ammonium sulfate	33.2	20.2	428
AS + N-serve	54.2	26.4	473
AS + 0.02 neem cake	46.5	24.3	471
AS + 0.04 neem cake	52.9	26.1	485
AS + 0.02 waste tea	30.2	18.5	489
AS + 0.04 waste tea	36.3	18.4	473

utilization as a result of a better management of N-fertilizer, while the other ones had no significant effect on increasing the available N in soil. Similar finding were obtained concerning the available-P in soil, the greatest values were obtained with urea and/or AS combined with N-serve and 0.04 percent neem cake treatment. Results also, revealed that the application of inhibitors caused a highly significant increase in a available potassium in soil after harvesting of rice yield. Addition of urea combined with 0.02 percent neem cake and 0.02 percent waste tea was more effective than other inhibitors in its increasing effect on available K in soil. On the other hand addition of AS combined with 0.04 percent neem cake and 0.02 percent waste tea was more effective than the other ones. It may be concluded that urea and ammonium sulfate amended with inhibitors, especially 0.04 percent neem cake, might offer potential yield increase of rice through reduction of N-loss. The addition of this amendment can prevents N-transformation which reflect on increase in nitrogen use efficiency by rice plant, more over provides more residual N for following crop.

References

Abou Seeda, M., 1997. N-effeiciency as affected by natural inhibitors addition in rice ecosystems. J. Agric. Sci. Mansoura Univ., 22: 1787-1997.

Basaraba, J., 1964. Influence of vegetable tannins on nitrification in soil. Plant Soil, 31: 8-16.

Black, C.A., 1982. Methods of Soil Analysis, Part 2. American Society of Agronomy, Wisconsin, USA.

Bremner, J.M. and C.S. Mulvaney, 1982. Nitrogen-Total. In: Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties, Page, A.L., R.H. Miller and D.R. Keeney (Eds.). ASA and SSSA, Madison, WI., USA., pp: 595-624.

Cottenie, A., M. Verloo, L. Kiekens, G. Velghe and R. Camerlynck, 1982. Chemical Analysis of Plants and Soils. Laboratory of Analytical and Agrochemistry, State University-Ghent, Belgium.

Craswell, E.T., S.K. De Datta, W.N. Obcemea and M. Hartantyo, 1981. Time and mode of nitrogen fertilizer application to tropical wetland rice. Nutr. Cycling Agroecosyst., 2: 247-259.

Fernando, V. and G.R. Roberts, 1976. The partial inhibition of soil urease by naturally occurring polyphenols. Plant Soil, 44: 81-86.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agriculture Research. 2nd Edn., John Wiley and Sons, New York, USA., ISBN-13: 9780471870920, Pages: 680.

Hammad, S.A., 1996. Status and behavior of nitrogen in soils under different conditions-a review. J. Agric. Sci. Mansoura Univ., 21: 1559-1587.

Huber, D.M., H.L. Warren, D.W. Nelson and C.Y. Tsai, 1977. Nitrification inhibitors-new tools for food production. BioScience, 27: 523-529.

Panda, M.M., A.R. Mosier, S.K. Mohanty, S.P. Chakravorti, A.B. Chalam and M.D. Reddy, 1994. Nitrogen utilization by lowland rice as affected by fertilization with urea and green manure. Nutr. Cycling Agroecosyst., 40: 215-223.

Rao, D.L.N., 1987. Slow-release urea fertilizers-effect on floodwater chemistry, ammonia volatilization and rice growth in an alkali soil. Fertil. Res., 13: 209-221.

Sharma, S.N. and R. Prasad, 1995. Use of nitrification inhibitors (neem and DCD) to increase N efficiency in maize-wheat cropping system. Fertil. Res., 44: 169-175.

Singh, M., T.A. Singh and M. Singh, 1989. Comparison of neem (*Azadirachta indica*) oil coated urea with some other coated urea fertilizers on an alkaline calcareous soil. J. Indian Soc. Soil Sci., 37: 314-318.

Vlek, P.L.G. and E.H. Byrenes, 1986. The Efficiency and Loss of Fertilizer-N in Lowland Rice. In: Nitrogen Economy of Flooded Rice Soils, De Datta, S.K. and W.H. Patrick Jr. (Eds.). Martin Nijhoff Publication, The Hague, pp: 131-147.

Wilson, C.E., B.R. Wells and R.J. Norman, 1990. Dicyandiamide influence on uptake of preplant-applied fertilizer nitrogen by rice. Soil Sci. Soc. Am. J., 54: 1157-1161.