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Neem (*Azadirachta indica*) seed kernel powder retards urease and nitrification activities in different soils at contrasting moisture and temperature regimes

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Abstract

A laboratory experiment was conducted to examine the potentiality of a natural resource neem (*Azadirachta indica*) seed kernel powder (NSKP) to reduce the urease and nitrification activities in different soils (*viz.*, normal, acid, and sodic) at contrasting moisture (1:1 soil to water and field capacity) and temperature regimes (10 °C and 37 °C). Results have revealed that application of NSKP with urea did not exhibit any urease inhibitory property in normal and sodic soils, but in acid soil it had maintained higher concentration of urea than the urea alone treated samples for two weeks after application. At 37 °C and under field capacity moisture level, urea hydrolysis was more rapid than at 10 °C and under waterlogged (1:1) conditions. The NSKP has showed variable effects (4–28%) to inhibit nitrification during 7–21 days after application, depending upon the soil types, temperature and moisture regimes. The nitrification activity was significantly low in acid soil followed by normal and sodic soils. The present study suggests that NSKP has the potential to retard the urease activity in acid soil, and nitrification in all the soils, and thus it may be used along with urea for the better use of applied –N.

Keywords: Nitrogen; Nitrification; Neem (*Azadirachta indica*) seed kernal powder; Urea hydrolysis; Nitrogen losses

1. Introduction

In 2003–2004, about 11.15 million tones of fertilizer N (i.e., about 65% of total fertilizer consumption) were applied onto the Indian soils. Of the total N, 82% was through urea (FAI, 2005). Being a high analysis (46% N) fertiliser, urea is cheaper than other N fertilizers in India; its favourable physical properties make it convenient for the farmers to use it safely, either as dry or through solution. But the major disadvantage still associated with urea is that it can be lost up to 30% or more (i.e., 3.34 million tones or more in the Indian context during 2003–2004) if not properly managed. At 30%, the cost of this loss is estimated approximately Rs. 67 billion (or $1.5 billion). Nitrogen losses not only drains exchequer of a developing country like India but also it has serious socio-environmental implications. A recent report by the Central Ground Water Board (India) has revealed that nitrate contents in several localized pockets of Indo-Gangetic belt is in excess of desirable limit ($50\ mg\ l^{-1}$) (Chattopadhyaya, 2005). Emission of nitrogenous gases, particularly N_2O, which contributes to stratospheric ozone depletion and greenhouse effect, is another problem. Cost of the remediation of these socio-environmental side effects of N losses is never been worked out.

Minimising nitrogen losses is thus a priority area of research to prevent atmosphere and groundwater pollution besides saving in the fertilizer cost to the farmers. In order to reduce these losses of nitrogen and increase its efficiency, one of the mechanisms is to apply urease and nitrification inhibitors. A number of urease and nitrification inhibitors have been developed and used for slowing the urea hydrolysis and bacterial oxidation of NH_4^+ to NO_3^-–N in the soil

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(Prasad and Power, 1995; Varel, 1997) and reducing N_2O emissions.

However, in spite of several advantages, on a global scale, only two chemical nitrification inhibitors have so far gained importance for practical use; these are DCD (dicyandiamide) in Europe and, to a limited extent, nitrapyrin [2-chloro-6 (trichloromethyl) pyridine] in the US. These two compounds have also specific problems associated with them, besides being too expensive for large-scale use in agriculture. Moreover, in the present time when emphasis is increasingly being given on minimising the use of chemicals in agriculture for environmental and economic reasons, it is necessary to find out natural urease and nitrification inhibitors, which will function efficiently in all types of soils under various moisture regimes both in upland and in flooded conditions. At the same time they should be easy to produce, easy-to-use and also be inexpensive.

Neem (*Azadirachta indica*) is one of the most promising trees, having potential uses in the management of pests and diseases in soil and plant systems, is a part of India's genetic biodiversity. Being a tropical tree it is very well suited to the arid and semiarid climate of India. Neem trees are found in all parts of India, in plains as well as in areas up to a height of 1850 m above the mean sea level, and it is tolerant to adverse soil conditions. The agricultural and medicinal importance of this multi-purpose tree was known to Indians since centuries. In addition to various insecticidal properties, neem cake has been found as an effective nitrification inhibitor (Prasad and Power, 1995; Parmar and Singh, 1993). Nimin (an alcohol extract of neem) has been reported to increase N use efficiency (Usha Kiran and Patra, 2003). In India, neem seeds are abundantly available at the time of fruiting. Though neem cake or its extract has been proved to have nitrification inhibition property (Prasad and Power, 1995; Usha Kiran and Patra, 2003), it has not been widely used due to various reasons. Being processed, these materials are still not easily available and costlier to farmers than the extra benefit of N saving or enhanced crop yields. To make the technology simpler, convenient and inexpensive, it was thought if neem seed kernal powder (NSKP) could be used along with urea instead of neem cake or its extracts. The neem seed kernels are rich in neem oil (45%) as well as oleo chemicals (Parmar and Singh, 1993). It has also not been clearly understood whether neem seed has any property to reduce urease activity in soil. In a preliminary study, Chhonkar (1984) has reported that crushed neem seed did not slow down urea hydrolysis, whereas Patra et al. (unpublished data) have observed lower urea hydrolysis in red soil (alfisol, pH 6.6) due to application of neem cake when applied at 20% of urea–N and compared with urea alone. Such possibility has been also indicated by Prasad and Power (1995). Thus there is a need to investigate whether neem seed possesses urease inhibition property or not. In addition, the efficiency of NSKP as a nitrification inhibitor in contrasting soil and moisture regimes is largely unknown. If it is found that NSKP, which is easy to access and less costly to make powder, is effective, then instead of neem cake or oil, NSKP can be a better alternative option for direct application along with urea.

The present investigation was therefore, undertaken to study the potentiality of NSKP on the rates of urea hydrolysis and nitrification in three different soils (*viz.* normal soil, acid soil and sodic soil) at two different moisture (waterlogged and field capacity) and temperature (10 °C and 37 °C) regimes.

2. Methods

This experiment was conducted in a laboratory condition at the Indian Agricultural Research Institute (IARI), New Delhi using three different soils (0–15 cm depth); normal, acid and sodic soils. Normal soil (*Typic ustochrept*) collected from IARI (New Delhi) research farm, acid soil (*Aeric haplustalf*) from the farmland of Orissa University of Agriculture and Technolgy, Bhubaneswar (India), and the sodic soil (*Typic natrustalf*) was collected from the Central Soil Salinity Research Institute, Karnal (India). Soil samples were air-dried, gently ground and sieved (2 mm) before using for this experiment. Some of the physico-chemical properties of these soils and their methods of analyses are presented in Table 1.

2.1. Laboratory study

Ten grams of soil was taken in polyethylene reagent bottles of 150 ml capacity. Urea was added at a rate equivalent to 1000 μg N per g soil (Douglas and Bremner, 1971). In half of the bottles NSKP was added at the rate of 20% of urea–N. The amount of NSKP was purposefully taken high to test its potential as a nitrification and/or urease inhibitor. Two moisture regimes, i.e. water logged (1:1) (WL) or field capacity (FC), were maintained, and the soils were kept at 10 °C or 37 °C through out the incubation period. Loss of soil moisture, if any, was compensated by adding distilled water, everyday. Analysis of urea concentration in soil samples was done on day 1, 2, 3, 4, 6, 10, 14 and 18 after applications. The difference between the

Table 1
General characteristics of experimental soil (average of three replicated determinations, on air dry weight basis)

Property	Normal soil	Acid soil	Sodic soil	Methods of analyses
Texture	Loam	Sandy loam	Silty loam	Bouyoucos (1962)
pH (1:2 soil to H_2O)	7.8	5.3	9.1	Jackson (1967)
EC (dS m^{-1}) (1:2)	0.2	0.2	2.8	Jackson (1967)
Org-C (%)	0.35	0.48	0.92	Walkley and Black (1934)
NH_4^+–N	3.6	3.2	4.1	Yuen and Pollard (1952)
NO_3^-–N	7.5	5.1	10.5	Bremner (1965)