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ManureHarms and Control of Ecological Pollution Issues

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ABSTRACT: Both the soil and fertilizers fulfill the nitrogen (N) needs for rice crops. Fertilizer N must be added to satisfy crop demand due to acute N deficiency in most rice soils. Via various processes, including ammonia volatilization, de-nitrification, and leaching, the N fertilizer added to rice crops is partially lost. These losses can lead to environmental issues, such as air emissions, marine environments and groundwater. It is not feasible to alleviate these issues fully. Nevertheless, they can be minimized to a large degree by different techniques. In order to minimize N fertilizer shortages, research has been undertaken worldwide. This paper examines this N fertilizer loss knowledge, indicating management practices to minimize these soil-water system losses.

KEYWORDS: inhibitors, phenylphosphorodiamidate (PPD), N-(n-butyl)thiophosphorictriamide (NBPT),International Rice Research Institute (IRRI).

INTRODUCTION

With the approximate 40 percent of the world's population, rice is the primary food crop. For its development and grain production, the rice crop removes significant quantities of N. For the development of one tonne of rough rice, including straw, the average amount of N removal varies from 16 to 17 kg. Complete N uptake per hectare per rice plant varies between varieties of rice. Much of the world's rice soils are deficient in N, and only a fraction of the N requirement can be met through biological nitrogen fixation by cyanobacteria and diazotrophic bacteria. Applications of Fertilizer N are therefore required to satisfy the demands of the crop. Generally urea is the most convenient N source for rice.In rice culture, the urea-N efficiency is very low, typically about 30-40 percent, even lower in some instances.

The poor productivity of N-use is primarily due to losses in ammonia volatilization, de-nitrification, leaching, and runoff. However, based on environmental factors and management methods, the degree of N failure differs in various ways. Via the release of gases like nitrous oxide, nitric oxide, and ammonia, volatilization and de-nitrification cause air emissions. Infrared emission is consumed by nitrous oxide, leading to greenhouse warming and stratospheric ozone layer loss[1]. Nitric oxide is a significant contributor to the production of tropospheric ozone, a major pollutant in the environment that impacts human health, crops, and natural habitats.Nitric oxide, a principal ingredient of acid deposition, is also a precursor to nitric acid. In terrestrial and marine environments, the accumulation of nitric oxide and ammonia can contribute to acidification, eutrophication, habitat composition changes and impacts on predators and parasite systems. Nitrate leaching creates groundwater contamination. Infant methemoglobinemia, lung disorder and reduced vitamin A content in the liver may be caused by excess levels of nitrates in drinking water and food[2]. This paper addresses these environmental challenges and alternative ways of mitigating these issues.

AMMONIA VOLATILIZATION

Around 85 percent of the rice-cropped area of the world is under the culture of wetlands. Rice plants take N predominantly as ammonium (NH_4) in wetland rice soils, taking less energy than nitrate to assimilate into amino acids. Ammonia volatilization losses in mildly to slightly acidic soils occur in flooded rice soils, while losses in alkaline soils are larger[3][4]. The utilization of carbon dioxide by algae and other marine biota for their photosynthetic activities raises the pH of the floodwater, resulting in significant ammonia volatilization losses of N. Ammonium fertilizers dissociate directly into NH_4, while urea can decompose to produce NH_4 ions by catalytic hydrolysis.Ammonium ions are strongly bound to the molecules of water and are converted to non-ionized ammonia (NH_3), which, as a gas, will detach from water. Ammonia volatilization losses vary from negligible to almost 60 percent of the added N in the flooded soils. The pH and temperature of the floodwater, algal and aquatic plant formation, crop growth, and soil properties are factors causing ammonia volatilization.

AMMONIA VOLATILIZATION REDUCTION TECHNIQUE

The soil-water method has many methods of reducing ammonia volatilization. This involves the application of calcium, potassium and magnesium soluble salts; the use of urease and algal inhibitors; the deep placing of nitrogen fertilizers; and the use of adapted urea and slow-release fertilizer types[5].

As urea is added to the soil, it is converted to ammonium carbonate following hydrolysis by the urease enzyme. This conversion leads to the presence of high concentrations of ammonium ions in the floodwater, which are lost by ammonia volatilization as the pH of the floodwater increases due to the photosynthetic behavior of algae. Application of urease inhibitors reduces the activity of urease on the soil surface and enables urea to pass before hydrolysis into the deeper soil layer. The released ammonium then remains in the soil in the cat-ion exchange complex.In several laboratory and greenhouse studies, the urease inhibitors phenylphosphorodiamidate (PPD) and N-(n-butyl)thiophosphorictriamide (NBPT) worked successfully in minimizing ammonia volatilization failure. Laboratory and field experimental findings demonstrated that application of urease inhibitors including hydroquinone and phenylendiamine improves agronomic production of urea-N due to decreased ammonia volatilization loss in flooded rice soils. Algal inhibitors may delay the growth of algae, leading to an increase in soil pH, thus reducing the loss

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of volatilization of ammonia[6].Freney et al. observed that the use of an algal inhibitor (copper sulphateterbutryn) minimized the loss of ammonia volatilization resulting in a rice yield increase of 0.3-0.6 t ha21. Rawluk, Grant, and Racz recorded that, due to NBPT application with granular urea, ammonia volatilization loss was reduced by 28-88 percent. Similar findings were also recorded by Phongpan and Byrnes. At the International Rice Research Institute (IRRI), experimental findings show that the addition of the urease inhibitor PPD along with urea decreased the loss of ammonia by 12-22 kg N ha21. There have also been studies of positive effects of other urease inhibitors (thiourea, hydroquinone, 2-4 dinitro phenol and boric acid).

DENITRIFICATION

De-nitrification takes place after the nitrification of ammonium into nitrate in the flooded rice soils (NO_3). Nitrification takes place between 0 and 2 mm from the root surface, while de-nitrification happens between 1.5 and 5.0 mm from the root surface. In this process, NO_3 is reduced to nitric oxide (NO), nitrous oxide (N_2O) and nitrogen (N_2) gases by a series of steps which are then released into the atmosphere. De-nitrification mainly occurs in the reduced soil layer without oxygen in wetland rice soils (O_2). NO_3 is used by optional anaerobes as an electron acceptor during the degradation of soil organic matter and other organic materials in the absence of O_2[7].As determined by the 15N tracer technique at IRRI, the magnitude of de-nitrification loss can vary from marginal to 46 percent of the N applied depending on the application of urea and methods of crop establishment [8]. In continuously flooded rice-cropped soils, Fillery and Vlek recorded that de-nitrification losses of fertilizer N were 5 to 10 percent, while the loss in the fallow soil was around 40 percent of the applied N. 15N research show that in underground saturated soils under rice cultivation, the de-nitrification rate is higher relative to soils under wheat cultivation.

DECREASING DENITRIFICATION LOSSES

Decreasing the loss of ammonia volatilization by various methods, as discussed in the previous section, may not be successful in reducing the loss of nitrogen. Via the nitrification process, the ammonium ion stored in the soil-water system is readily converted to nitrite, then to nitrate. By de-nitrification and leaching, the nitrate ion is susceptible to degradation. The method of nitrification follows de-nitrification. Therefore, if nitrification of ammonium into nitrate is delayed or decreased, the loss of de-nitrification would decrease.As a consequence, the use of nitrification inhibitors such as dicyandiamide (DCD), iron pyrite, nitrapyrin, phenylacetylene, encapsulated calcium carbide, terrazole, etc., can minimize de-nitrification losses. Field experimental findings performed using 15N as the tracer at Griffith by CSIRO (Commonwealth Science & Industrial Research Organization) revealed that the use of encapsulated calcium carbide greatly decreased de-nitrification. By deep positioning of urea fertilizer, de-nitrification losses can also be decreased. Slow-release fertilizers such as urea coated with sulphur will

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significantly decrease de-nitrification losses[9].One of the three main greenhouse gases is nitrous oxide released from agricultural soils due to de-nitrification losses (methane, carbon dioxide, and nitrous oxide). Nitrous oxide emissions can be minimized by the application of plant residues with high polyphenol content and high protein binding ability.

CONCLUSIONS

Losses of nitrogen fertilizer by volatilization, de-nitrification, and leaching of ammonia can cause environmental contamination and health problems. While these issues should not be entirely alleviated, there are ample empirical results to show that some management strategies can mitigate these problems. Volatilization losses from ammonia can be minimized by:

- applying soluble calcium, magnesium, and potassium chloride or nitrate salts;
- the use of algal and urease inhibitors;
- deep placement of N fertilizers and use of modified forms of urea; and
- use of fertilizers with gradual release.

De-nitrification losses can be minimizedby:

- use of nitrification inhibitors,
- deep placement of N fertilizers,
- use of slow-release fertilizers, and
- Application of plant residues having high polyphenol content and high protein binding capacity.

Leaching losses can be minimized by:

- application of inhibitors for nitrification,
- deep positioning of N fertilizers,
- the use of fertilizers with slow release, and
- The application of plant residues with a high content of polyphenols and a high binding capacity of proteins.

By utilizing plant-growth-promoting micro-organisms in rice cultivation, the need for N fertilizer can be minimized by the effective usage of N by the rice crop, thus reducing environmental emissions due to N losses.

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