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Evil Effects of Overuse of Urea Fertiliser

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Introduction

Urea is an inexpensive form of high analysis nitrogen fertilizer having 46% nitrogen and 54% inert matter. Although urea is naturally produced in humans and animals (especially Animal urine which contains nitrogen % closer to 2-5% along with a variety of minerals and bacteria), synthetic urea is manufactured with anhydrous ammonia. H.M. Rouelle in 1773 discovered Urea in human urine. It was synthesized in 1828 by Friedrich Wohler. In 1870 urea was produced by heating ammonium carbamate in a sealed vessel (Kramer, 2004). This provided the basis of the current industrial process for its production.

In general, fertilizer urea will provide the most nitrogen at the lowest cost. It is easy to store and does not pose as a fire risk for long-term storage. Depending upon the compatibility, urea may be mixed with other fertilizers or may be applied on its own. For plants that love acidic soil, urea is one of the best fertilizers to acidify the soil. Additionally, urea generally causes little/ no damage when used through the soil test based application and mixed into the soil under appropriate soil moisture status.

What is the Advantage of using Urea as fertiliser for plants?

- Superior Nitrogen content, hence it requires in less bulk.
- Cost of production is low if natural sources are used.
- It is non-flammable and risk-free to storage.
- It has a wide application range and it can be used for all types of crops and soils.
- It has almost neutral pH and harmless to crops and soil if used in balanced quantity.
- Farmer's prefer it more compared to other fertiliser due to its immediate visualisation effect in plant foliage.
- Urea in prilled or briquette forms can be utelised even under flooded crop fields especially for rice cultivation.
- The coated urea has some beneficial effect over uncoated urea as the later undergoes transformation to nitrate by the activity of nitrifying bacteria NItrobactor and Nitrosomonas and further nitrate gets leached under ample moisture but due to coating (neem, sulphur or other chemicals) nitrification inhibition takes place thereby reducing the nitrogen loss.

Transformation of Urea in the soil

When applied as a foliar spray or even as granular spread above the soil layer, urea gets dissolved simultaneously owing

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to its reaction with air and water (Kissel and Cabrera, 2005). When used properly, urea can increase crop yields as it is the best source of nitrogen and nitrogen-containing compounds. When applied to soil, urea breaks down and converts to its ammonium form, a process that depends primarily on soil moisture (www.solverchem.com). Urea (46-0-0) transformations in soil (urea hydrolysis) :

$$CO(NH_2)_2 + H_2O \Rightarrow H_2NCOONH_4 \Rightarrow 2NH_3 + CO_2$$

The first step in this reaction requires an enzyme present in soil named urease. $H_2NCOONH_4$ (ammonium carbamate) is an unstable intermediary product that rapidly decomposes to ammonia and carbon dioxide. Hence the transformation of urea in soil could be written as :

$$CO(NH_2)_2 + H_2O \Rightarrow \Rightarrow 2NH_3 + CO_2$$

The above reaction requires moisture and is temperature dependent. This occurs within 2 to 4 days and becomes faster on high pH soils. Warm temperatures or high pH facilitate losses. Unless it rains, urea should be applied during this time to avoid ammonia loss. If the soil temperature is cold, nitrogen loss will be quite low. In crop growing favourable conditions the response is rapid. When urea dissolves in the soil, it creates a zone of high pH and ammonia concentrations around the soil, making the soil acidic and toxic at the same level (Kissel, 1988). Acidity of ammonium-based inorganic fertilizers obtained from the nitrification reaction, or direct absorption of the ammonium ions (NH_4^+) by plants. If the NH_4^+ is taken up by the plant before nitrification occurs (two moles of H^+ are released for every mole of NH_4^+ converted to nitrate) and its amount is greater than the accompanying anions, proton release from roots causes soil acidification (Naeem *et al.*, 2023). Although most soils eliminate toxicity by neutralizing them, this is partly because plants absorb anions such as NO_3^- and compensate by releasing equivalent amounts of alkaline HCO_3^- and OH^- in soil solution. Considering all these effects it is highly advisable to spread the urea into the soil immediately and certain isolation distance from the seeds should have be maintained.

Transformation of Urea in the flooded or rice soil

Urea transformation is difficult to model in flooded soil systems due to the complicated transformations it undergoes (Vanitha *et al.*, 2019). Inefficiency of recovering applied N fertilizer by rice in flooded soil is caused, in part, by N loss pathways in the soil and rice rhizosphere. Urea which is the main N fertilizer used by rice producers, also encounters an additional N loss because hydrolysis increases the pH of the surrounding environment which can cause high losses through NH_3 volatilization (Hongprayoon, 1992).

The Negative impacts of urea as a fertilizer

The negative impacts exerted by urea are

i) Urea induces rapid growth which pushes plants to grow too fast. In some crops the increased vegetative growth by the overuse of urea hampers the reproductive growth.

ii) Plants grow fast but are very weak and promotes stress

iii) Destroys soil organisms.

iv) Increases pest & disease activities.

v) Urea breaks down into various compounds some of which can inhibit plant growth- Eventually decreases plant production.

vi) Urea impurities/derived chemical toxicity.

vii) Decreases nutritional values of plants to humans while increases nutritional value to pests.

viii) The carbon in Urea based fertilizers is chemically converted to CO_2 and lost to the atmosphere. Carbon is energy to plants and soil micro-organisms.

Excess urea causing stresses in plant and soil microorganism

Plants absorb urea derived nitrogen directly from the soil. Natural sources provide nitrogen as and when needed by plants whereas the chemical nitrogen such as urea which is absorbed by the plants in very large amounts irrespective of plant need (Mahajan Seeds and Nursery. 2016) and as a result may impose stress in plant when urea is excess applied. Urea application in excess initially poses oxidative stress to the plants that is immediately counteracted by enhanced scavenging of reactive oxygen species via enhanced glutathione reductase activity (Zhang, 2024). Kong *et al.* (2017) observed that excessive N application decreased the ability to scavenge reactive oxygen species (ROS), increased lipid peroxidation and caused significant metabolic changes disturbing N metabolism, secondary metabolism and lipid metabolism, which led to reduced grain filling in wheat. Stress is also caused by the fact that excess urea upon hydrolysis form ammonia, and if ammonia is not converted by the nitrifying bacteria into nitrite and nitrate because of high pH then the ammonia kills off all beneficial soil bacteria which are needed to breakdown the nutrients needed by plants. Bacteria are sensitive to ammonia and are affected by this to a greater extent than fungi. Since urea is a much more concentrated source of nitrogen, the bacteria are not fed instead destroyed leaving behind other mutated form of bacteria which may not be beneficial to plants. Investigation of Sun *et al.* (2019) revealed that long-term intensive urea fertilization may increase the risk of N loss through ammonia volatilization and increase the risk of soil degradation due to the collapse of soil microbial diversity. Since the microbial transformation of nutrient gets hampered by the reduction of soil microbial diversity, the plants slowly find themselves weakening and stressed out. Their root systems no longer function as they should and eventually depend more & more on external nutrition. (Mahajan Seeds and Nursery. 2016). Like all the nitrogenous fertiliser, If urea is overdosed, the plants will grow too fast and become soft and sappy – an invitation to pests (Mahajan Seeds and Nursery. 2016).

How excess urea induces insect attack in crop plants?

Farmers believe that if they apply more urea then there will be maximum production. Due to more nitrogenous fertilizer doses the plant tissues become more succulent and hence crops are easily digested by insect pest (Singh and Sarkar,

2021). Especially leaf folder attack in rice was high with high doses of nitrogen fertilizer (Subbaih and Morachan 1974). Higher nitrogen more specifically urea fertilizer application (1) increases the preference of infestation behaviors (feeding and oviposition), (2) extends infestation time (adult lifespan), and (3) shortens generation reproduction time (nymph, pre-oviposition, and egg period) of rice pests specifically rice plant hopper. This infestation is also facilitated by the increase in rice physical indexes (plant height, leaf area, and leaf width) and physiological indexes (chlorophyll content, water content, dry matter mass, and soluble protein content) and decrease for leaf thickness resulting from excess urea or nitrogen fertilisation (Li, 2021). In general, insects namely hoppers, leaf folders, some borers, aphids, moths and beetles infestation got accentuated by excess nitrogen fertilizer application (Bala *et al.*, 2018).

What Urea does to favour plant diseases?

The very same bacteria that are normally present in the soil dies and is replaced by a different type of bacteria. Some of the bacteria are of the "bad" type. The long term urea application greatly increased soil urease activity and ureolytic bacterial abundance, but decreased ureolytic bacterial diversity (Sun *et al.*, 2019). The high activity of ureolytic bacteria increases the amount of ammonia in the soil via fast urea degradation. As a result, plants are damaged due to lack of necessary nutrients and the toxicity of ammonia and carbon dioxide released from urea degradation, they said. High nitrogen also mutates bacteria into rapid growth cycles. There are many instances where N fertilization can increase plant disease incidence, for example, with downy mildew, powdery mildew, leaf rust, stem rot and rice blast diseases. These infestation increased as the increased N or urea availability impacted on the degree of lignification of woody plant tissues, delay in lignin deposition on the xylem cell wall, reduction in the thickness of the secondary cell wall as well as major biopolymer components (cellulose and lignin) in plants (Sun *et al.*, 2020). Bremner (1990) observed the leaf-burn symptom after foliar fertilization of soybeans with urea which had resulted from the accumulation of toxic amounts of urea in the soybean leaves rather than formation of toxic amounts of ammonia through urea hydrolysis by leaf urease.

What effect does urea have on environment?

Urea is a popular fertilizer that produces ammonia gas and causes acid rain, groundwater pollution, and ozone layer depletion due to the release of nitrous oxide during the denitrification process (Hazra, 2016). With increasing use and projected future use, this problem is likely to grow further over the next decade. NH_3 released from urea is further oxidized and converted to nitric acid and sulfuric acid from the industrial source. Acid rain can damage vegetation. Urea emits harmful gases during production. The manufacturing process involves releasing pollutants into the air. It creates more ammonia content in the soil, making it more acidic and affecting the natural fertility of the soil. Nitrogen based synthetic fertilizers like urea when converted to nitrate [*Ammonium nitrogen (NH_4^+) is positively charged and*

adsorbed to the soil. No nitrogen leakage occurs in this formulation; However, NH_4+ is converted to NO^{3-} form by bacteria. This process occurs very quickly (starting within 2 to 3 days) when soil temperatures are above 50° F. Complete conversion of NH_4^+ to NO^{3-} takes approximately one month after application. Nitrate nitrogen (NO^{3-}) is negative and will not be adsorbed on soil particles; It can drain freely from the soil. When the soil is saturated with water, nitrate nitrogen is lost to the environment through denitrification (Sawyer, 2007).], leach into groundwater and increase its toxicity, causing water pollution. Urea derived nitrate entering streams, rivers, lakes and other bodies of water can harm the aquatic ecosystem. When plants grown from this nitrate enriched soil are eaten by animals, they turn into poisonous nitrites in the intestines. These harmful nitrites interact with hemoglobin in the blood, causing methemoglobinemia, which causes circulatory and respiratory problems and in severe cases (when methemoglobin in the blood increases to 80% or more) can lead to death. Perhaps one of the scariest effects of chemical fertilizers is something called methemoglobinemia. In infants it is alternatively known as Blue Baby Syndrome (Hazra, 2016). The risk most often occurs when infants are given formula reconstituted with nitrate contaminated water. The condition causes a decrease in oxygen in the blood and results in a blue-grey skin color, causes lethargy and/or irritability and can lead to coma or death.

What happens if urea is mixed with other fertilisers?

Urea should not be blended with superphosphates unless applied shortly after mixing. Urea will react with superphosphates, releasing water molecules and resulting in a damp material which is difficult to store and apply. Further urea is also non compatible with nitrate fertilisers namely ammonium nitrate/calcium ammonium nitrate, etc and triple super phosphate.

How urea derivatives or impurities are toxic to plants?

Heat is normal in the urea production process, the urea will slightly convert to biuret if the temperature exceeds 200°F, but this only happens during production. (extension.umn.edu). This change does not occur in the warehouse or on the ground. Most urea manufacturers keep the biuret content low by keeping the pressure low. Biurea content is usually around 0.3%, but foreign origin urea tends to have higher. Biuret in urea can cause agricultural problems when placed near seeds or added even before planting in the strip where the seeds will be planted later. At high concentrations, biuret can interfere with protein synthesis and nitrogen metabolism in plants. Nitrogen concentrations are generally lower in biuret-damaged leaves than in healthy urea-treated leaves. Biuret also interferes with the normal activity of many important enzymes, causing some enzymes to be reduced relative to healthy leaves. Although biuret in urea can harm plants at high altitudes, modern production methods have reduced the severity of this problem. Biuret converts to ammonia, but at a slower rate than urea. Since biuret remains in the soil for several weeks, the potential for seed damage remains for a short time when the urea converts to ammonia. The main danger of biuret is the

germination of seeds (Mikkelsen, 2007). Although some citrus plants are affected, the damage absorbed by the plant is minimal. There is little damage in citrus crops through plant absorption.

Conclusion

Urea application in balanced amount is necessary for crops to maintain plant growth and yield, but its overuse can adversely affect plant health and yield. It is therefore advocated to use urea only after judging the nitrogen status of soil though soil testing which will not only improve the crop health and yield but also will be economic for the farmers.

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