TRADEMARK NITROGEN

SUBSTAIN-N® ASSIMILATION PROCESS

By: Micheal Hojjatie, Ph.D.

What is Urea Fertilizer?

- Urea is the most frequently used source of N fertilizer.
- Over 90% of world production is used as a nitrogen release fertilizer.
- Urea is a source of readily available N.
- Many soil bacteria possess urease which converts urea to NH_3 & CO_2.
- Urea, especially when surface banded, loses N as ammonia to environment
- Technologies have been devised (coating, chemical bonding, nitrification inhibition, urease inhibition, etc.) to prevent the loss of N from urea

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Triazone (Substain-N®) Production

Produced by combining urea, formalin (or UFC), and ammonia under regulated conditions to create a liquid urea-formaldehyde condensate product.

Total nitrogen content is 28-0-0.

This technology can also be applied to produce other grades such as 26-0-0, 30-0-0, and 32-0-0.

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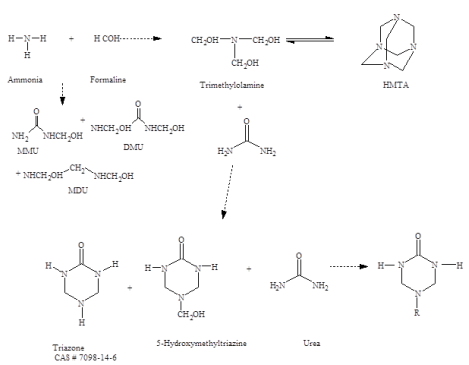
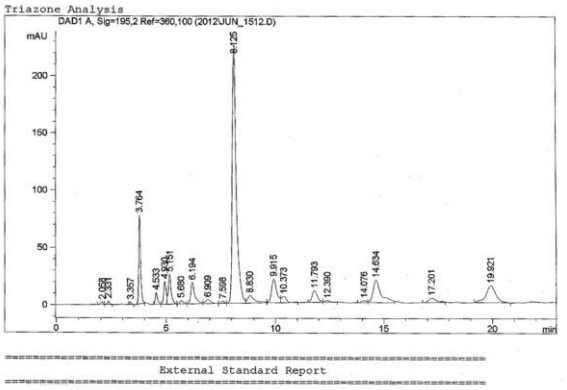
Sustain-N® (28-0-0) Composition

- Monomethylol urea (MMU) ≈ 2%
- Dimethylol urea (DMU) ≈ 0.3%
- Methylene diurea (MDU) ≈ 1.00%
- Biuret ≈ 0.02-0.3%
- HMT ≈ 1-2%
- Free Urea 28-40%
- Water 8-10%
- Traizone 60-75%





Overall, about 22% of N is from urea & about 78% of N is from SRN.

The minor components are about 5-8%.

What is this major component? The structure of the major component was determined by chemical analyses (NMR, X-Ray, and Chromatography) to be a substituted six-membered ring of triazone.

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Substain-N® (Triazone)

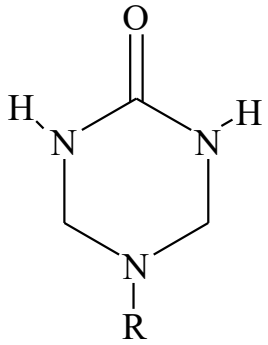
AAPFCO Definition (N-33, Official 1989)

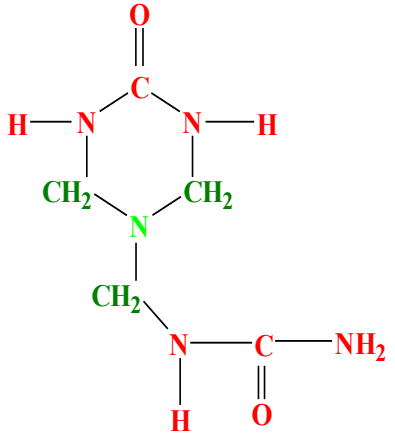
Triazone is a water -soluble compound of formula $C_5H_{11}N_5O_2$ which contains at least 40% total Nitrogen.

CAS # : 146943-06-6

IUPAC Name: Urea, N-[(tetrahydro-4-oxo-1,3,5-triazin-1(2H)-yl)methyl]

Triazone is a Slow- Release Nitrogen Fertilizer: AAPFCO Definition (T-29, Official 1985) Slow or controlled release fertilizer means a fertilizer containing a plant nutrient in a form which delays its availability for plant uptake and use after application, or which extends its availability to the plant significantly longer than a referenced "rapidly available nutrient fertilizer" such as ammonium nitrate or urea Ammonium phosphate or KCl.





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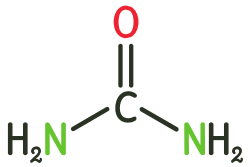
Urea vs. Substain-N®

Substain-N®

28-40%
QUICK RELEASE
1-2 WEEKS

60-75%
SLOW RELEASE
2 - 3 WEEKS on leaves | **4 - 12 WEEKS** on the ground

Urea



Mono, & Di-Methylol urea, other UF chains & Triazone

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Substain-N® Assimilation Process

Application processes of Substain-N® fertilizer

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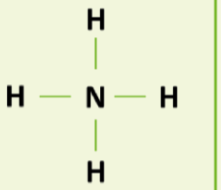
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes

Ammonium



Enzymes known as GOGAT,
Glutamine Synthetase (Glutamate Synthase)
permit the translocation of ammonium.

These enzymes permit its metabolization into amino-acids, proteins, sugar, lipids...

GRAIN FILLING

AtGLN1.2
OsGS1;3
OsNADH-GOGAT1
ZmGLN1.2/1.3
TaGS1.1/1.2/1.3
TaNADH-GOGAT1
AtASN1
TaSN2
ZmASN3/4

PHOTORESPIRATION

AtGLN2
AtGLN1
OsGS2
OsFd-GOGAT1
ZmGLN2
ZmFd-GOGAT1

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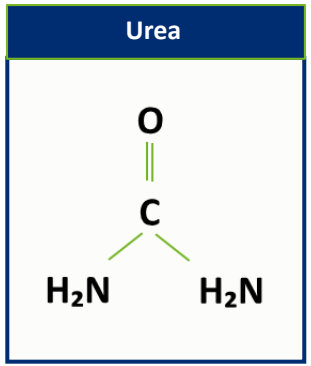
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



Urea penetrates the wax layer mainly via:

- **Polar pores** (aqueous pathways)
- **Cuticular cracks or imperfections**
- **Stomata** (less common route, mostly passive diffusion)

and is metabolized to **ammonium**.

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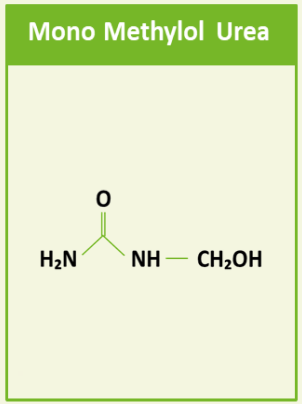
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



The hydrolyzes of Mono-Methylol Urea to **Urea plants available** is relatively fast and **takes between 3 to 12 weeks.**

The conditions affecting the fastness of hydrolyzes of the Mono-Methylol Urea are:

- Temperature (Best between 25 to 30°C)
- Leaf surface moisture
- Leaf surface pH (around 6).

Under dry and cool conditions, **the Hydrolyzes process will take longer.**

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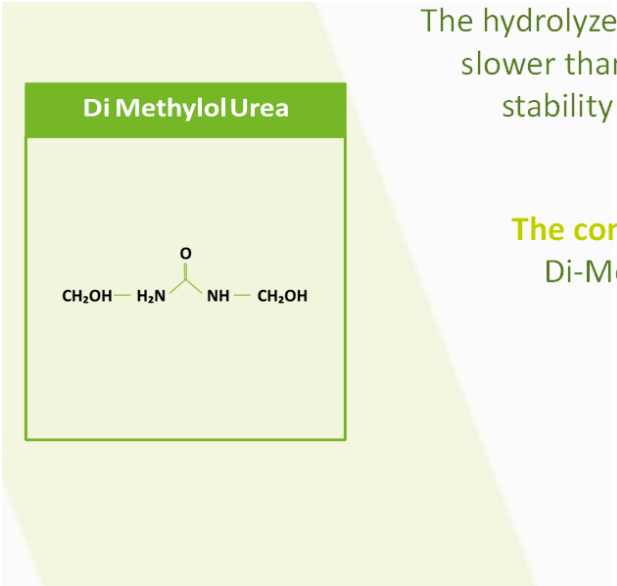
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



The hydrolyzes of Di-Methylol Urea to **Urea plants available** is slower than for Mono-Methylol Urea due to the increased stability from the 2 methylol groups and **takes Between Days or Weeks.**

The conditions affecting the fastness of hydrolyzes of the Di-Methylol Urea are:

- Temperature (Best between 25 to 30°C)
- Leaf surface moisture
- Leaf surface pH (Between 6 and 7).

Under dry and cool conditions, **the Hydrolyzes process will take longer.**
Other small chains UF adducts also go through the same processes.

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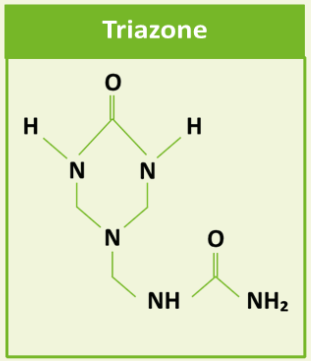
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



Triazone is a stable ring structure permitting to slow down the Nitrogen release.

Triazone is water soluble, but the release of Nitrogen is not immediate as for other forms of Nitrogen like Urea or Nitrate.

The Nitrogen is gradually released due to a gradual break down through chemical processes into Ammonium and is made plant-available.

Plants absorb Nitrogen from Triazone Several Weeks depending on:

- Humidity
- Temperature
- Leaf surface pH
- Presence of adjuvants

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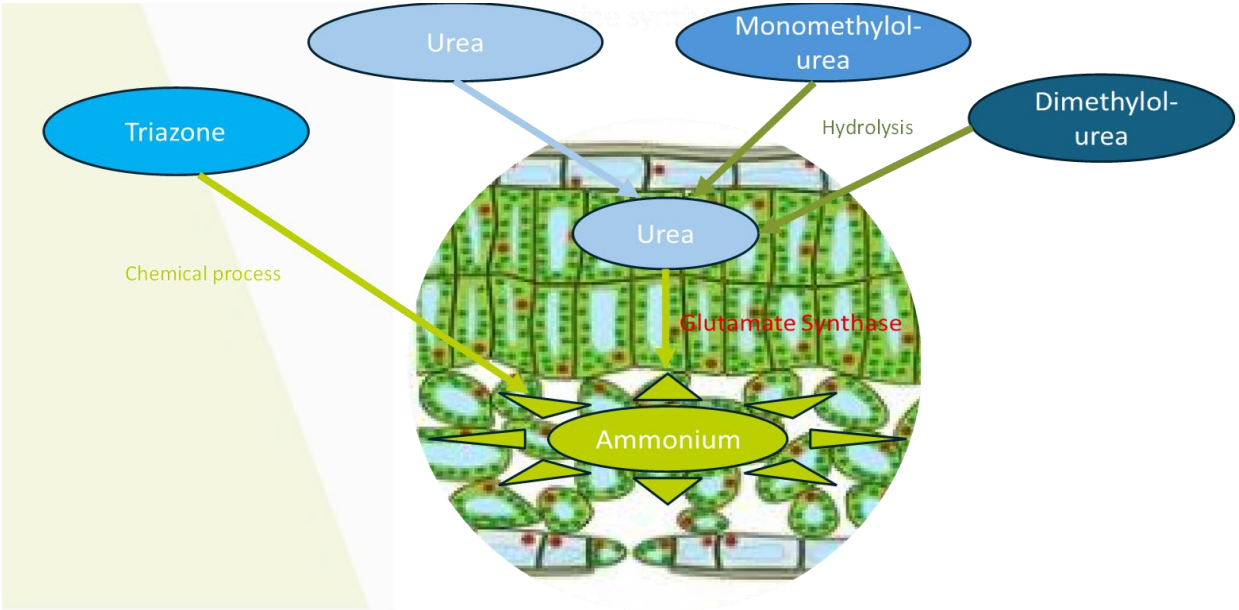
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



Substain-N® Assimilation Process

Degradation: Urease & Glutamine synthetase in the vegetal

VEGETAL APPLICATION

SUBSTAIN-N FERTILIZER physical capability to impregnate the leaf cuticule and to stick to the leaf permitting to resist to rain, sunlight, high/low temperature and wind, resulting in no N losses.

This permits also the FERTILIZER to remain **in contact with the cuticule** and to penetrate into the plants **progressively as urea or ammonium.**

When applied on the vegetal, **the process goes faster than in the soil as The FERTILIZER** is directly exposed to the sun rays and temperatures are higher. The Nitrogen assimilated is then made available in **ammonium** as this process is directly linked to the enzymes produced thanks to the **photorespiration activity of the plants**.

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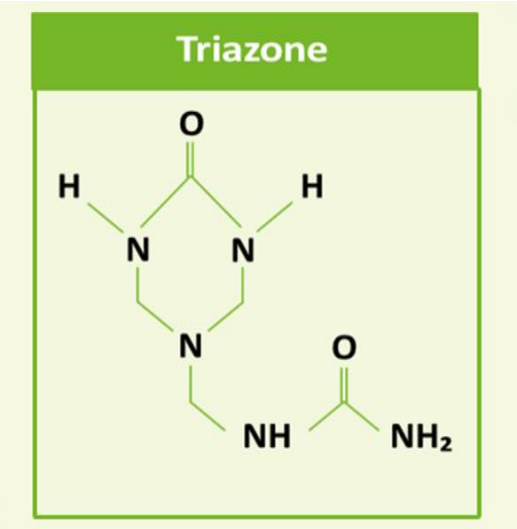
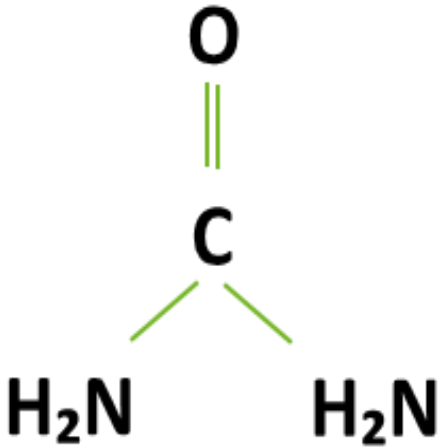
Substain-N® Assimilation Process

Application On/In The Ground





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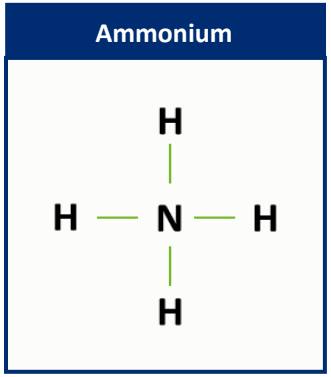
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



Through their rooting system, plants are able to uptake **Ammonium** in small quantity.

The excess of available **Ammonium** that plants cannot uptake through their rooting system will get degraded into **Nitrate** through the process.

Thanks to its slow-release pattern, the quantity available “daily” for the plants is relatively small permitting to limit/avoid the release of Nitrates.

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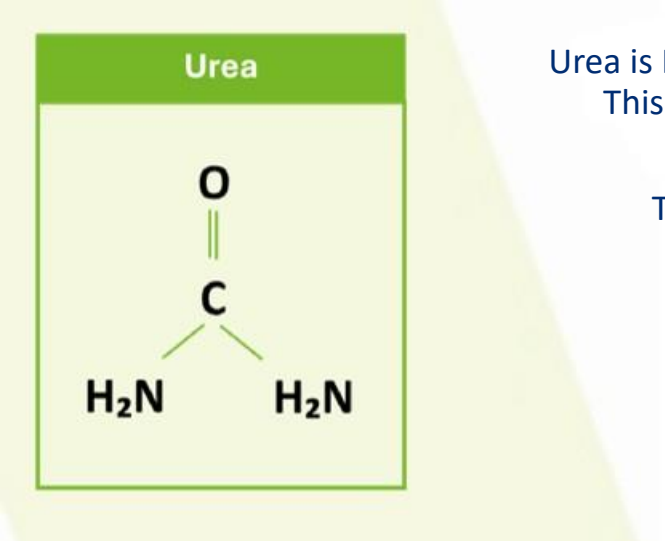
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



Urea is Hydrolyzed by **Urease** Produced by soil bacteria.
This hydrolysis permits the release of **Ammonium**.

The release of **Ammonium** is very progressive as it starts a few hours after the application of the Substain-N ® on or in the ground can last up to 90 days depending the soil temperatures and the soil micro-organisms activity.

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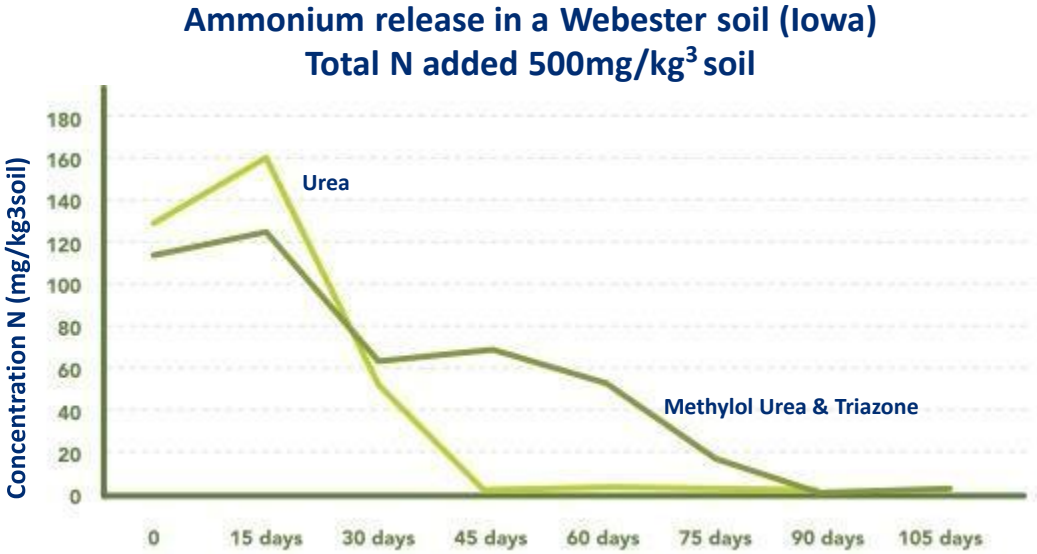
Substain-N® Assimilation Process

Degradation Process: Hydrolysis in the soil

SOIL APPLICATION



By : R. Garcia, and J.D. Hernandez, N. Central Extension -Industry, Soil Fertility Conference, 2005, Vol. 21

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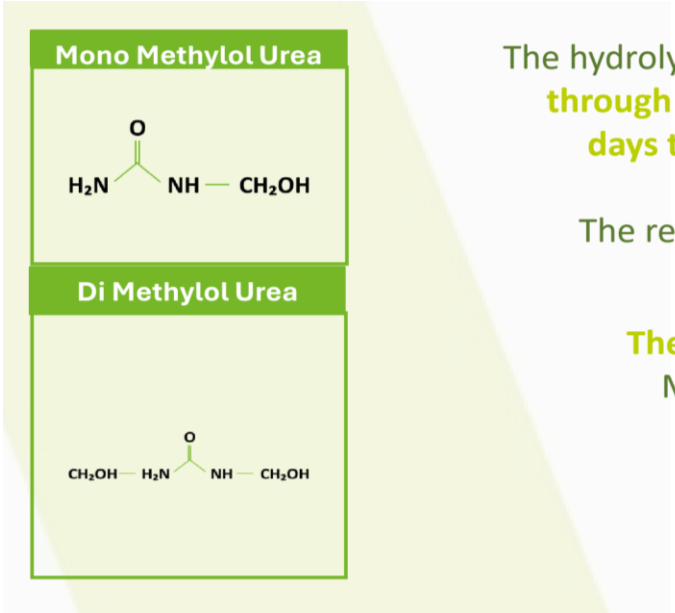
Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes



The hydrolyzes of Mono Methylol and Di Methylol Ureas **through a non enzymatic hydrolysis within few days to 3 weeks.**

The result of this hydrolysis is the release of **Urea.**

The conditions affecting the fastness of hydrolyzes of the Mono and Di Methylol Urea are:

- Temperature (>20 °C)
- Soil relative humidity
- No water excess

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Substain-N® Assimilation Process

Vegetal Application, Degradation Process: Moisture, light, temperature and enzymes

Triazones are hydrolyzed by **urease** produced by soil bacteria. This hydrolysis permits the release of **Urea**.

The release of **Urea** from **Triazones** is slow and can last up to 12 weeks, depending on the following parameters:

- Temperature (>20°C)
- Relative soil humidity
- Soil micro-organisms activity
- Soil pH (optimum between 6 to 7,5)

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Substain-N® Assimilation Process

Degradation Process: Urease

Urease *(urea amidohydrolase, EC 3.5.1.5)* is a nickel containing enzyme produced by plants, fungi, and bacteria that **catalyzes the hydrolysis of urea** into ammonia andcarbamate.

Nitrates (NO_3^-)

Nitrification process

Ammonium (NH_4^+)

Enzymatic Hydrolysis

Urea ($CO(NH_2)_2$)

NonEnzymatic Hydrolysis

MMU ($H_2NC(O)NHCH_2OH$)

Enzymatic Hydrolysis

DMU ($C_3H_8N_2O_3$)

Triazone ($C_3H_7ON_3$)

TRADEMARK NITROGEN

Substain-N® – Application and Efficiency

Overview

Substain-N® is a specialized nitrogen fertilizer developed to deliver optimal performance across a variety of application methods. Its advanced formulation is designed to ensure that plants consistently receive the essential nitrogen required for robust and healthy growth. By adapting to different application techniques, Substain-N® provides versatility for growers seeking reliable solutions for plant nutrition.

Guaranteed Efficiency

Each application of Substain-N® comes with a guarantee of efficiency. This means that regardless of the way it is administered, Substain-N® reliably supplies nitrogen to plants, supporting their development and vitality. The consistent delivery of nitrogen enables plants to thrive and reach their full potential, ensuring dependable results for growers in diverse agricultural settings.

Limiting Nitrogen Loss

Beyond its role in nourishing plants, Substain-N® is engineered to minimize nitrogen loss. By retaining nitrogen within the soil and making it continuously available for plant uptake, the fertilizer maximizes its effectiveness and helps to reduce potential environmental impacts. This approach ensures that more of the applied nitrogen is utilized by plants, promoting both agricultural productivity and sustainability.

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Substain-N® - Gradual Degradation Process

A key feature of Substain-N® lies in its “Gradual Degradation Process,” which involves various chemical forms of nitrogen within the fertilizer. This process enables a sustained nutrient effect, providing a steady supply of energy to plants and supporting their physiological activities over time. As a result, Substain-N® ensures a lasting benefit to plant growth, maintaining consistent nutrition throughout critical stages of development.

TRADEMARK NITROGEN

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