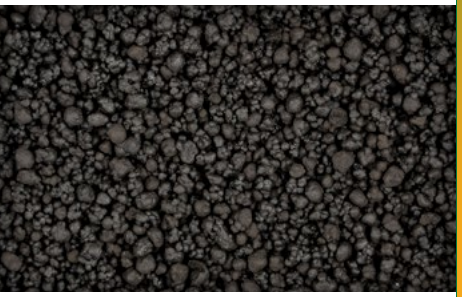
HUMIC **RESEARCH** TRIALS

The Andersons®



The Andersons works to ensure our products provide excellent and consistent performance in a variety of turfgrass management situations. We perform numerous greenhouse and in-field trials each year to evaluate and ground-truth our technologies by measuring product performance through an array of turfgrass growth parameters.

Our research trials are conducted in various locations across the United States with third-party and university collaborators. Locations are strategically selected, allowing us to study how product performance is impacted by diverse geographies, turfgrass species, pests, management conditions, and more. Our goal is to replicate precisely how our products will perform under the direction of turfgrass managers using standard turfgrass management practices for a given area.

Our Turfgrass Agronomy Team works closely with collaborators to ensure realistic research conditions and determine product application strategies that translate to real-world success. These collaborators are selected based on their ability to provide unbiased and reliable results. As one of the most trusted names in turfgrass management, we work hard to ensure that our research partnerships and the resulting deliverables generate that same level of confidence.

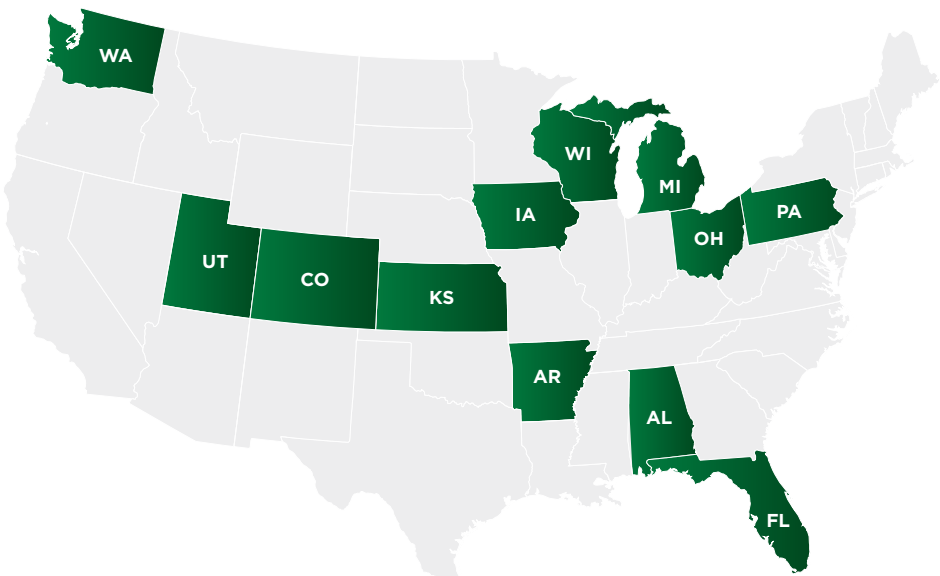
This guide highlights our humic acid and fertility research from the past few years. As the industry moves toward more sustainable turfgrass management, we are proud to be part of the solution, by continuing to develop innovative products and support them with applicable, relevant research for turfgrass managers.

- The Andersons Turfgrass Agronomy Team

RESEARCH PARTNERS

Our research partners are strategically selected to provide the most trusted data in the industry. With their assistance, we test our products in a variety of environmental conditions, soil types, and management practices throughout the country.

While our university and third-party relationships stretch far and wide, this guide is designed to provide a summary, including only the most relevant, humic-centric data from a handful of our featured partners.



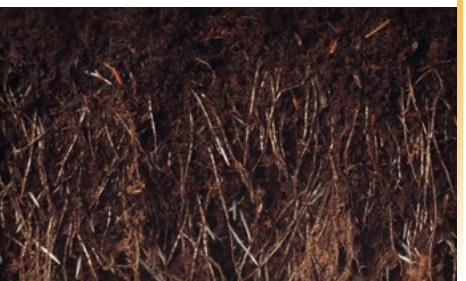
FEATURED PARTNERS

Delaware Valley University

Iowa State University

PennState

The Ohio State University



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PROUD MEMBER OF THE HUMIC PRODUCTS TRADE ASSOCIATION

The Andersons is a proud member of the Humic Products Trade Association (HPTA). The objective of the HPTA is to be the standard of excellence in humic trade. To accomplish this mission, the HPTA promotes commercial trade of humic products through scientific cooperation while addressing regulatory issues.

Members must conform to all the regulatory requirements of their respective federal, state, and local governments. Additionally, members must conduct business transactions in a fair and truthful manner with vendors and customers.

KEY FUNCTIONS OF HPTA

1. Provide guidelines and assistance in registration of humic products with state and federal agencies
2. Encourage the advancement of technology for producing humic products by standardizing analytical methods and reference material
3. Ensure businesses transact in a fair and truthful manner with vendors and customers

PRODUCT USE BASED ON SEASONAL GROWTH HABITS

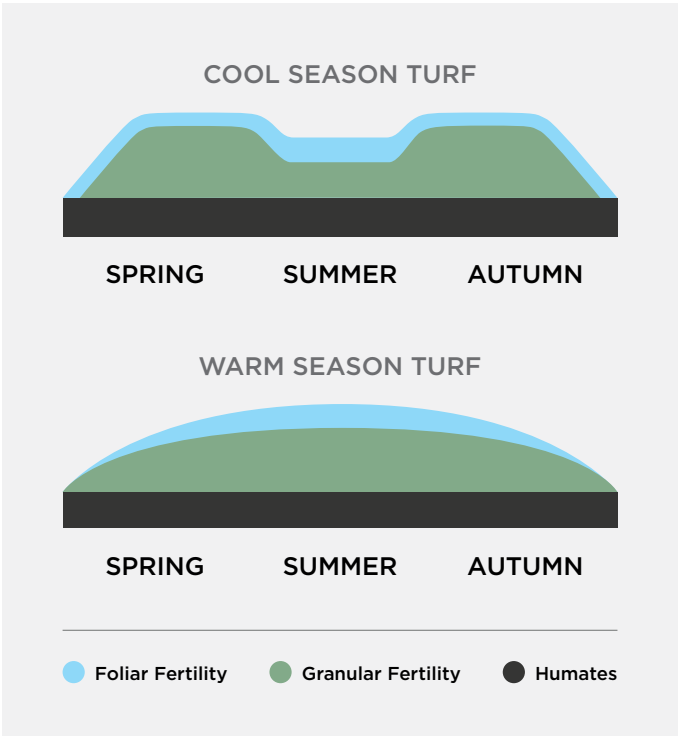
As an integral part of a high-performance turf nutritional program, humate-based products can be used throughout the growing season to improve soil health and increase the uptake and utilization of applied nutrients.

COOL SEASON TURF

Cool season turf generally requires a higher percentage of its nutrition to be delivered in the spring and autumn, with moderate needs during the summer months. A baseline turf nutrition plan includes soil-based granular applications throughout the growing season. Foliar nutrition and humate-based products are then applied to complement granular baseline nutrition, especially during the summer when turf can be under stress.

WARM SEASON TURF

Warm season turf generally requires a higher percentage of its nutrition to be delivered during the period of late spring through early autumn. A baseline turf nutrition plan includes soil-based granular applications throughout the growing season. Foliar nutrition and humate-based products are then applied to complement granular baseline nutrition.



HUMIC SUBSTANCES

Humates, or humic substances, are a naturally-occurring, mined material that make up 60-80% of soil organic matter[1]. Like coal, humates occur as a result of the compression and degradation of nutrient-rich deposits of plant and animal remains. This produces a highly reactive, carbon-rich material that serves as a powerful addition to a turf management program.

WHY HUMIC ACID?

Humic acid is a natural soil conditioner, organic chelator, and microbial stimulator that provides the following benefits:

- Supplies an oxidized, soluble carbon source, leading to improvement in long-term soil pH
- Enhances efficiency and availability of applied nutrients
- Chelates soil micronutrients, increasing their availability
- Improves cation exchange capacity
- Enhances soil structure and biology
- Reduces water requirements by increasing water-holding capacity and enabling better water penetration in the soil

1. Brady, Nyle C, and Ray R Weil. The Nature and Properties of Soils. 14th ed., Pearson Education, 2008

THE THREE HUMIC FRACTIONS

NATURALLY DERIVED BIO-ORGANIC CARBON SOURCES

Humates are composed of three major fractions: fulvic acids, humic acids, and humins. Each of these fractions has some similar and some unique physical and chemical properties that contribute to their effectiveness and complement fertilizer programs. Our products contain all three forms of humic substances, maximizing the product benefits.

FULVIC ACIDS are highly soluble and readily absorbed by leaves, making them well-suited for foliar application. Fulvic acids enhance the absorption of nutrients and the efficiency of plant metabolic reactions.

HUMIC ACIDS are moderately soluble. They have a high cation exchange capacity (CEC), which helps increase a soil's nutrient holding capacity. Humic acid molecules chelate many essential nutrients and help stimulate soil microbiology.

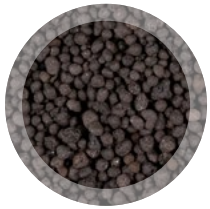
HUMINS are the least soluble form of humic substances. They contain high levels of carbon and have large nutrient holding capacity. Humins persist in soils for very long periods of time.

In addition to the three humic fractions, humic products utilizing The Andersons Dispersing Granule (DG) Technology contain a unique and powerful ingredient we call humic acid precursor. **HUMIC ACID PRECURSOR** contains a soluble form of organic carbon that releases into the soil as DG granules disperse. Through biochemical reactions, it is transformed into humic and fulvic acids, enhancing nutrient uptake and improving soil health.

HIGH-TECH HUMATES

We utilize the highest-quality humates in a complete range of products designed to improve plant nutrient uptake, efficacy, and rooting capacity, which yields an increased tolerance to environmental stressors like drought, temperature, and traffic.

Featuring innovative products and patented delivery systems, this unmatched portfolio of high-tech, humate-based solutions is built to perform, helping to build and maintain stronger, healthier turfgrass.



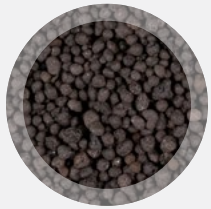
HUMIC DG™

Dispersing Granules

Dry Applied

70% Humic Acid
(A&L Method)

Year-Round



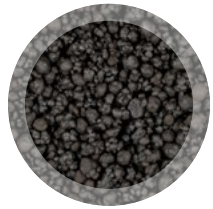
BLACK GYPSUM DG®

Dispersing Granules

Dry Applied

10% or 21% Humic Acid
(A&L Method)

Year-Round



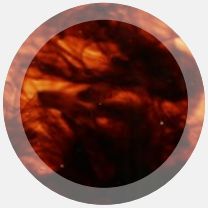
HUMIC DG™ CHARX®

Dispersing Granules

Dry Applied

30% Humic Acid
(A&L Method)

Year-Round



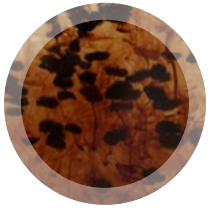
ULTRAMATE® LQ

Liquid

Spray Applied

12% Humic Acid
(A&L Method)

Year-Round



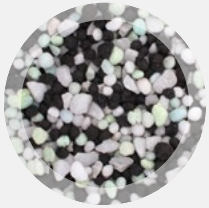
ULTRAMATE® SG

Soluble Granules

Spray Applied

70% Humic Acid
(A&L Method)

Year-Round



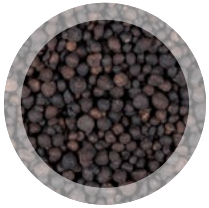
FERTILIZER + HUMIC BLENDS

Granules

Dry Applied

Humic Acid Varies

Growing Season



HCU® 44-0-0
(HUMIC COATED UREA)

Soluble Granules

Dry or Spray Applied

2% Humic Acid
(A&L Method)

Growing Season

PCHCU™ 40-0-0
(POLY-COATED HUMIC COATED UREA)

Soluble Granules

Dry Applied

2% Humic Acid
(A&L Method)

Growing Season

DISPERSING GRANULE (DG) TECHNOLOGY

Featured throughout our product line, our patented Dispersing Granule (DG) Technology creates spherical, dust-free, and ultra-dry particles, offering many advantages for turfgrass managers.

DISPERSIBLE

These granules rapidly disperse upon contact with soil moisture, creating tens of thousands of microparticles, which greatly increases surface area and allows for faster breakdown and availability of the humic substances.

SPREADABLE

DG Technology creates uniform granules (left hand) that are clean and easy to handle. These granules can be spread evenly and consistently through all types of application equipment. Competitor's dry humic acid product (right hand) is dusty, non-uniform, and contains up to 20% moisture, making it hard to handle and difficult to spread.

BLENDABLE

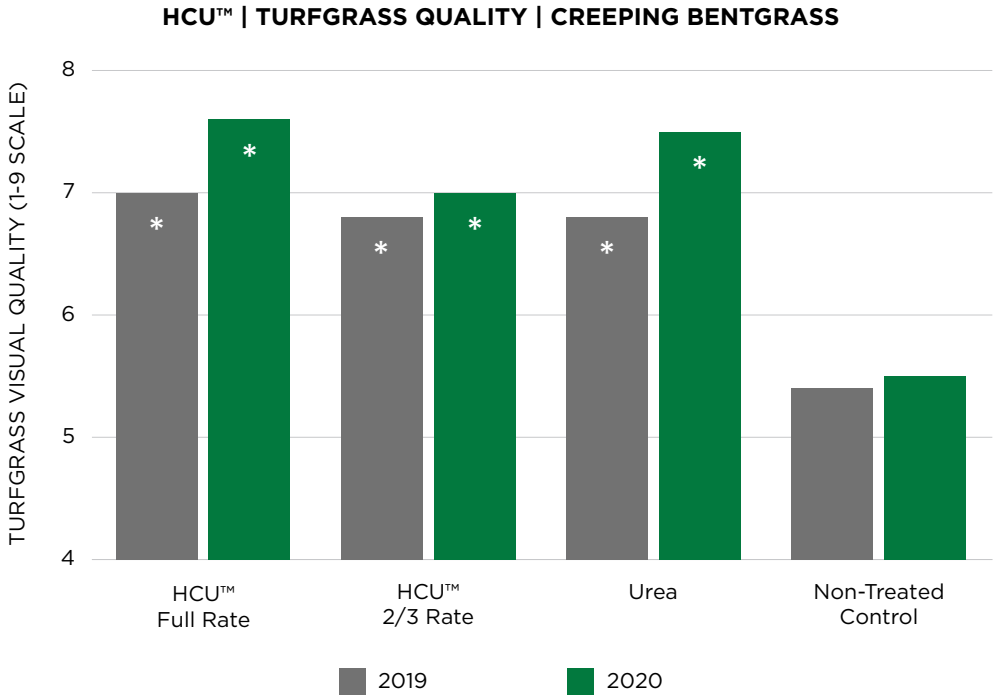
DG granules are designed to be ultra dry, which allows for successful blending with all types of dry fertilizers, including urea.

HUMIC **RESEARCH** TRIALS

In the following trials, you will sometimes find more treatments listed than are highlighted in the graphs/figures. When conducting replicated research, significant treatment differences do not always occur. Therefore we may only present treatments that are different from the untreated control or a treated standard control. Treatments yielding significant differences from the control/standard may also be indicated by asterisks (*) in the figures.

VARIABLE NITROGEN RATES OF HUMIC FERTILIZERS ON A SAND-BASED PUTTING GREEN

HCU™



DATES
2019 and 2020

LOCATION
Ames, IA, Iowa State University, field setting

TREATMENTS
HCU™ 44-0-0, full and reduced rates
Urea 46-0-0, full rate
Humic DG™
Black Gypsum DG®

SPECIES
Creeping bentgrass (0.130")

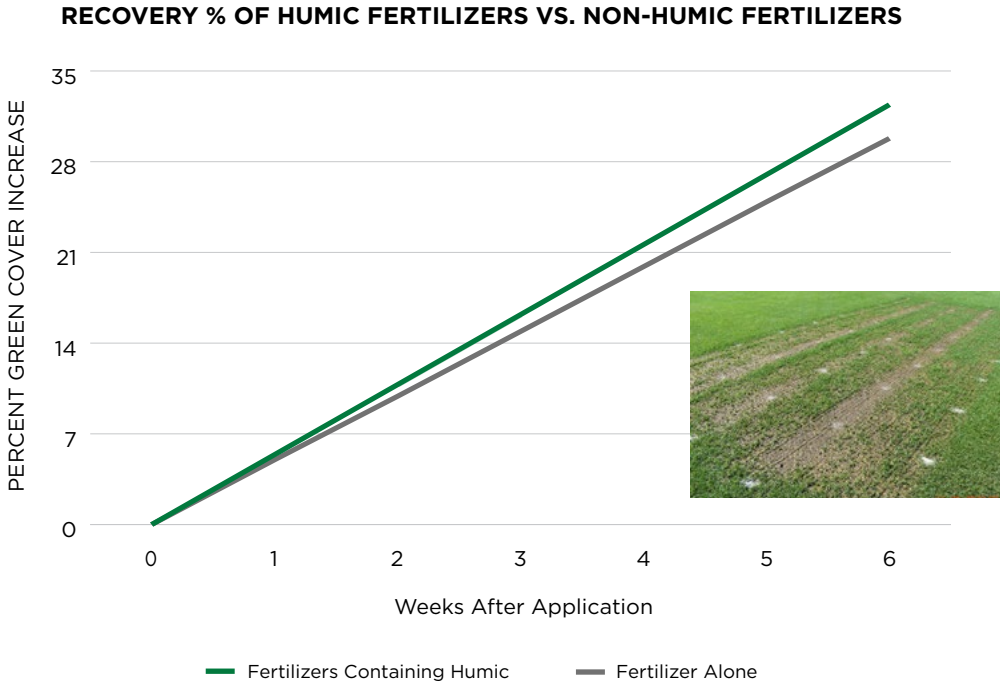
RATES
Fertility at 0.15 lb N per M every 2 weeks April-October (full). Reduced fertility rates at 66% of above Humic DG at 1.15 lb product per M in April, May, September, October. Black Gypsum DG at 1.15 lb product per M in April, May, September, October.

OBJECTIVE(S)
The objective of this trial was to determine if humic products could improve soil biological activity and allow for reducing nitrogen rates without compromising turfgrass quality and performance in a sand-based root zone setting. An additional goal of this trial was to compare our humic fertilizers to an industry-standard enhanced efficiency fertilizer (EEF).

SUMMARY
The reduced N rate treatment was equal in turfgrass quality and percent green cover to full N HCU rates (applied with or without HDG or BG).

HUMIC FERTILIZERS ON TURFGRASS SUBJECTED TO SIMULATED TRAFFIC

PCHCU™ | HumicDG™ | Black Gypsum DG®



DATES
2019 and 2020

LOCATION
Ames, IA, Iowa State University, field setting

TREATMENTS
HCU™ 44-0-0
PCHCU™ 40-0-0
22-0-3
Urea 46-0-0
Black Gypsum DG®
Starter fertilizer
Stabilized nitrogen

SPECIES
Kentucky bluegrass (2.0")

RATES
Fertility at 1.0 lb N per M
Black Gypsum DG at 3.0 lb

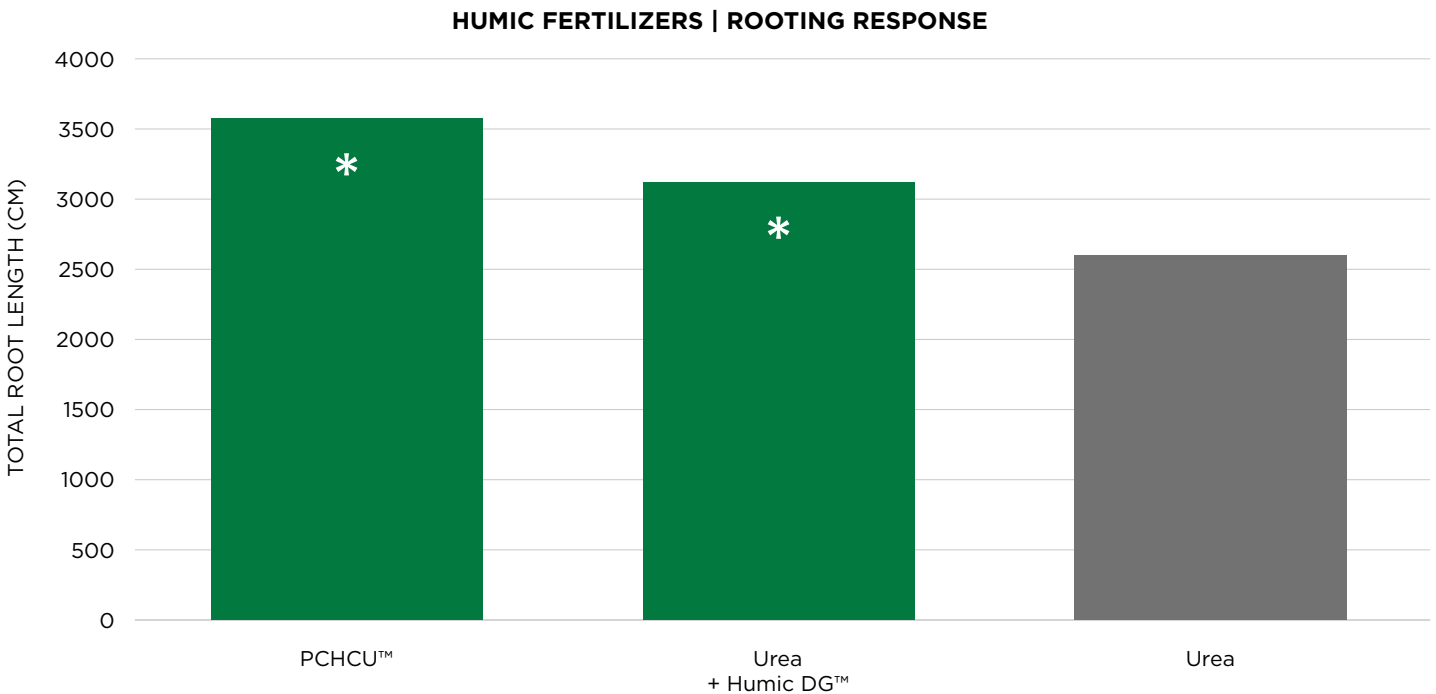
OBJECTIVE(S)
The objective of this trial was to investigate if incorporating humic substances with fertilizer will improve turfgrass traffic tolerance, performance, and recovery after traffic.

SUMMARY
Percent green cover: Fertilizer treatments incorporating humic substances (HCU and PCHCU) improved recovery on average by 9% relative to just fertilizer.

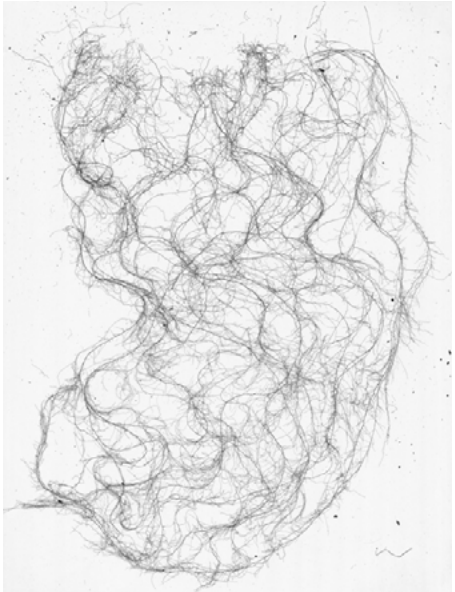
Application timing: When applying synthetic fertilizer + Black Gypsum DG, 4 applications spaced throughout the growing season performed better than just 2 applications (with total nitrogen applied equal).

ROOTING RESPONSE TO HUMIC FERTILIZERS *(TRIAL INFO ON PAGE 15)*

PCHCU™ | HumicDG™



PCHCU™ | KENTUCKY BLUEGRASSS ROOTING RESPONSE



PCHCU™

UREA ONLY

DATES
2018 and 2019

LOCATION
Ames, IA, Iowa State University, greenhouse setting

TREATMENTS
22-0-3
PCHCU™ 40-0-0
Urea 46-0-0
Humic DG™
Starter fertilizer
Stabilized nitrogen

SPECIES
Kentucky bluegrass

RATES
Fertility at 1.0 lb N per M
Humic DG at 0.9 lb product per M

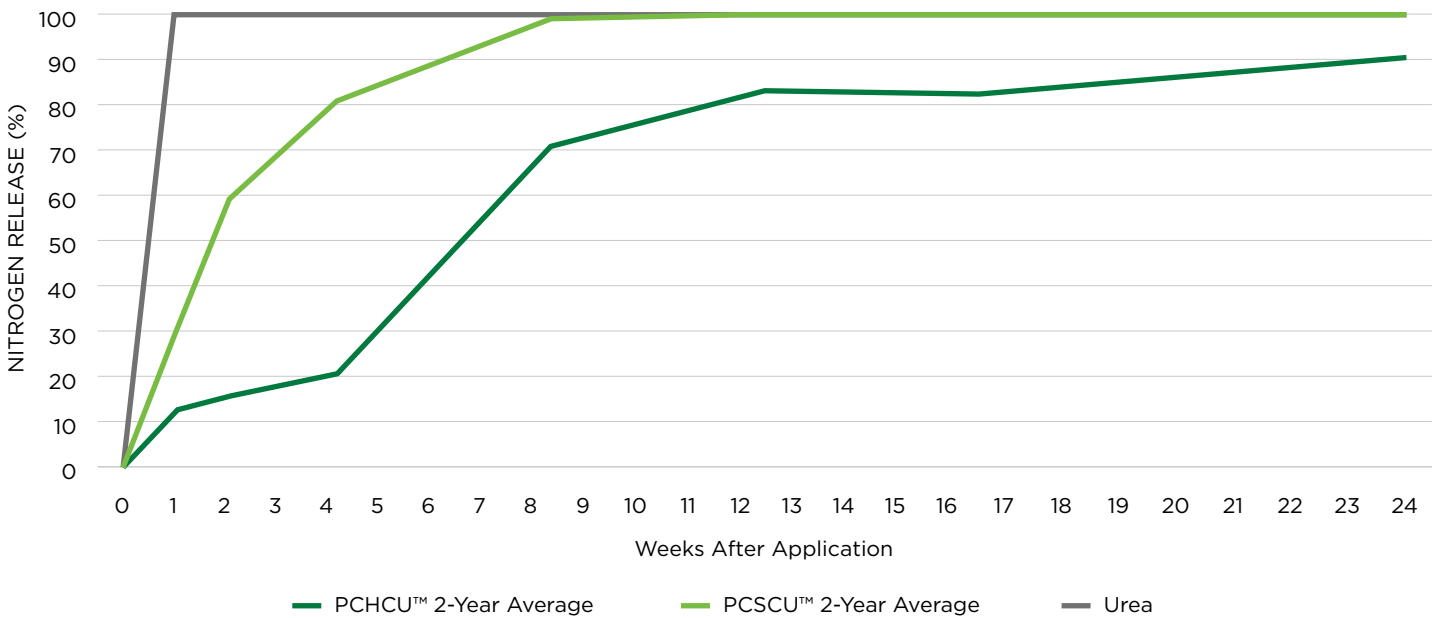
OBJECTIVE(S)
The objective of this trial was to further investigate the benefits of humic acid when used on Kentucky bluegrass by measuring root and shoot morphological parameters.

SUMMARY
Bluegrass: PCHCU and urea + HDG had greater total root length (37% and 20%, respectively) than urea alone. This suggests that the addition of humic products increases KBG root branching and hairs. PCHCU also had increased root surface area and root volume (42 and 46%, respectively) compared to urea alone.

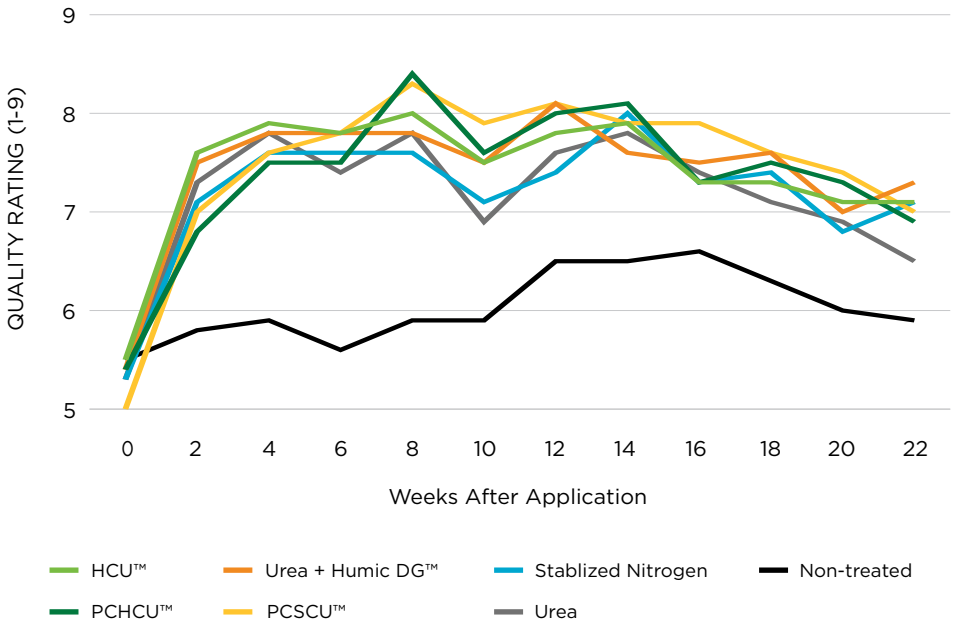
POLY-COATED HUMIC FERTILIZER NITROGEN RELEASE CURVES *(TRIAL INFO ON PAGE 17)*

PCHCU™ | PCSCU™ | HCU™ | HumicDG™

POLY-COATED HUMIC FERTILIZERS | NITROGEN RELEASE CURVES



POLY-COATED HUMIC FERTILIZERS | AVERAGE TURF QUALITY



DATES
2019 and 2020

LOCATION
Ames, IA, Iowa State University, field setting

TREATMENTS
PCHCU™ 40-0-0, full and reduced rates

HCU® 44-0-0

Urea 46-0-0

Humic DG™

Poly-coated sulfur-coated urea (PCSCU) 43-0-0

Stabilized nitrogen

SPECIES
Kentucky bluegrass (3.0")

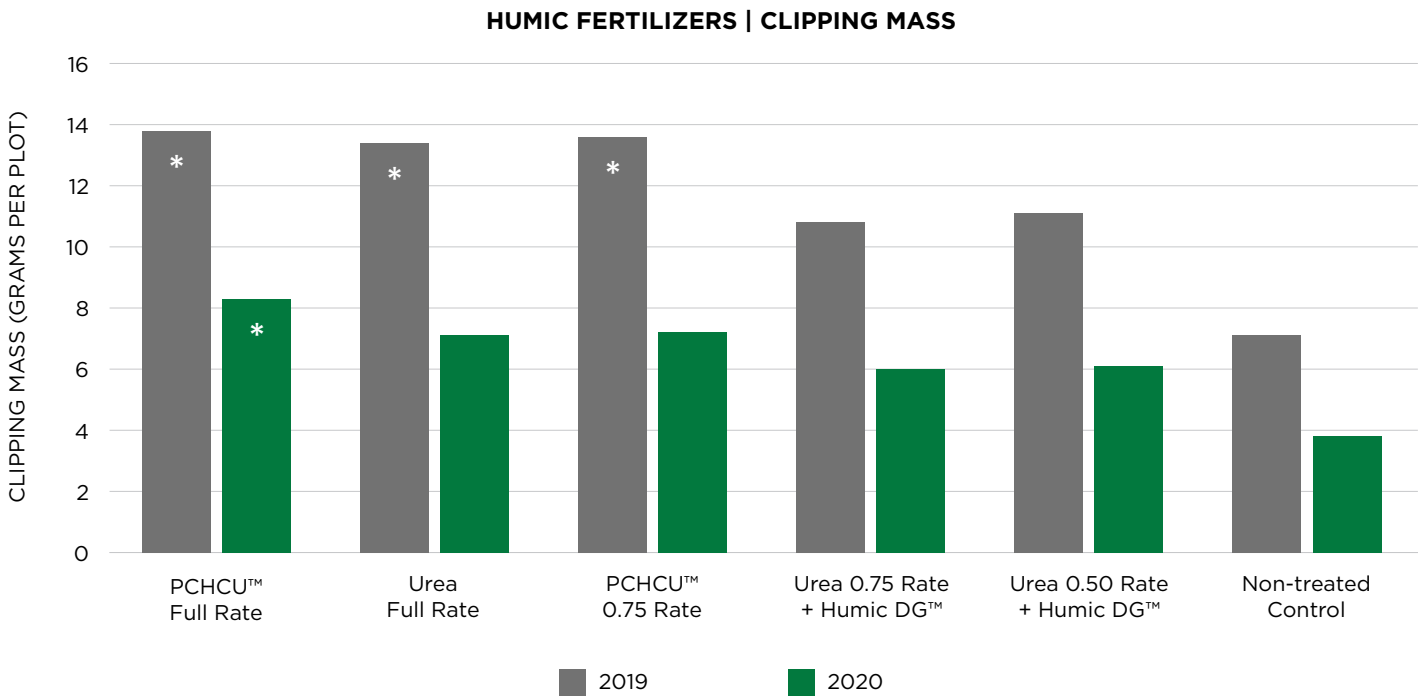
RATES
Fertility at 1.0 lb N per M, four applications per year
Humic DG at 0.9 lb product per M, four applications per year

OBJECTIVE(S)
The objectives were to determine if humic substances will increase the plant-available nitrogen (N) and to determine the nitrogen release curves of the fertilizers.

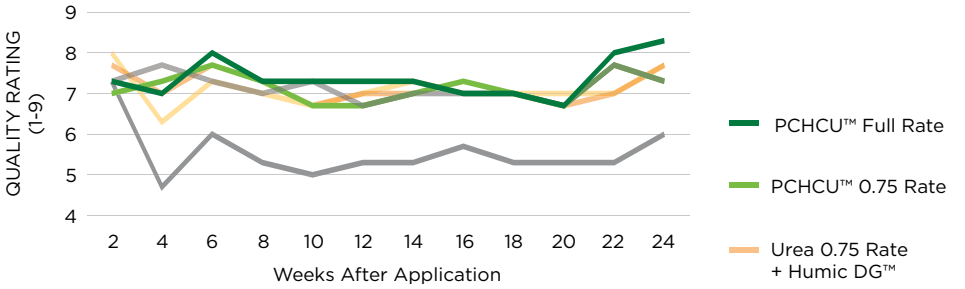
SUMMARY
PCHCU had 25% more inorganic N captured than all other treatments, showing more plant-available N. PCHCU and PCSCU had the longest N release curves, showing potential for the longest duration of plant-available N with these treatments. Overall, PCHCU and PCSCU have similar release curves to other current enhanced efficiency fertilizers.

QUALITY RESPONSE TO POLY-COATED HUMIC FERTILIZERS APPLIED AT REDUCED NITROGEN RATES *(TRIAL INFO ON PAGE 19)*

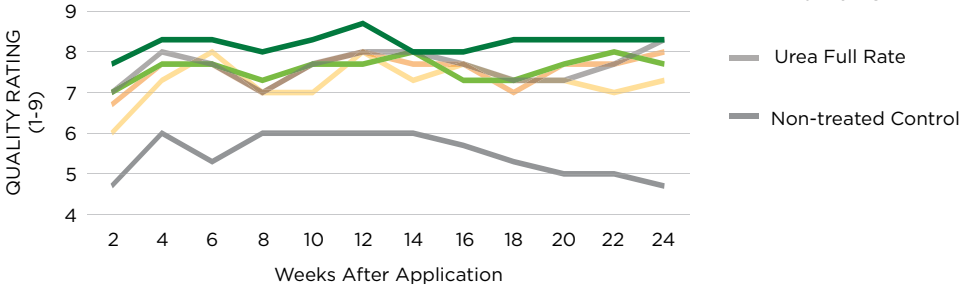
PCHCU™ | HumicDG™



HUMIC FERTILIZERS | AVERAGE TURF QUALITY | 2019



HUMIC FERTILIZERS | AVERAGE TURF QUALITY | 2020



DATES
2019 and 2020

LOCATION
Ames, IA, Iowa State University, field setting

TREATMENTS
PCHCU™ 40-0-0, full and reduced rates
22-0-3
Urea 46-0-0, full and reduced rates
Humic DG™
Stabilized Nitrogen

SPECIES
Kentucky bluegrass (3.0")

RATES
Fertility at 1.0 lb N per M (full); reduced rates of 0.75 and 0.50 lb N per M
Humic DG at 0.9 lb product per M

OBJECTIVE(S)
The objective of this trial was to investigate if humic substances incorporated into fertilizers could meet the need for reduced management inputs.

SUMMARY

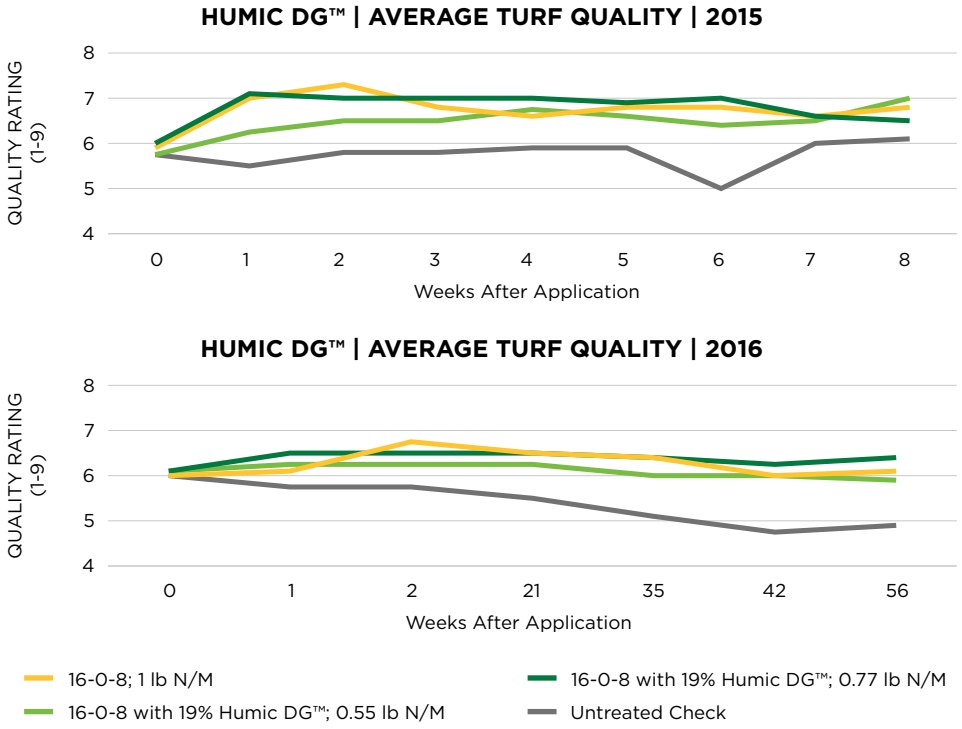
Turfgrass quality: Treatments with reduced N rates and a humic component (PCHCU @ 0.75, urea @ 0.75 + HDG, urea @ 0.50 + HDG) were similar in turfgrass quality and percent green cover to full N rate treatments (PCHCU @ 1.0, urea @ 1.0).

Clipping biomass: Clipping mass slightly reduced as N rates decrease. Nitrogen rate drives the growth rate but N rate not directly tied to turfgrass quality when a humic component is involved.

Soil microbial biomass and activity: Differences were noted relative to N rate but not relative to inclusion of a humic component.

THE IMPACT OF HUMIC DG ON NITROGEN EFFICACY

Humic DG™



DATES
2015 and 2016

LOCATION
State College, PA, Penn State University, field setting

TREATMENTS
16-0-8 at 1.0 lb N per M

16-0-8 at 0.77 lb N per M
+ 19% Humic DG™ at 0.92 lb per M

16-0-8 at 0.55 lb N per M
+ 19% Humic DG™ at 0.65 lb per M

SPECIES
Kentucky bluegrass (3.0")

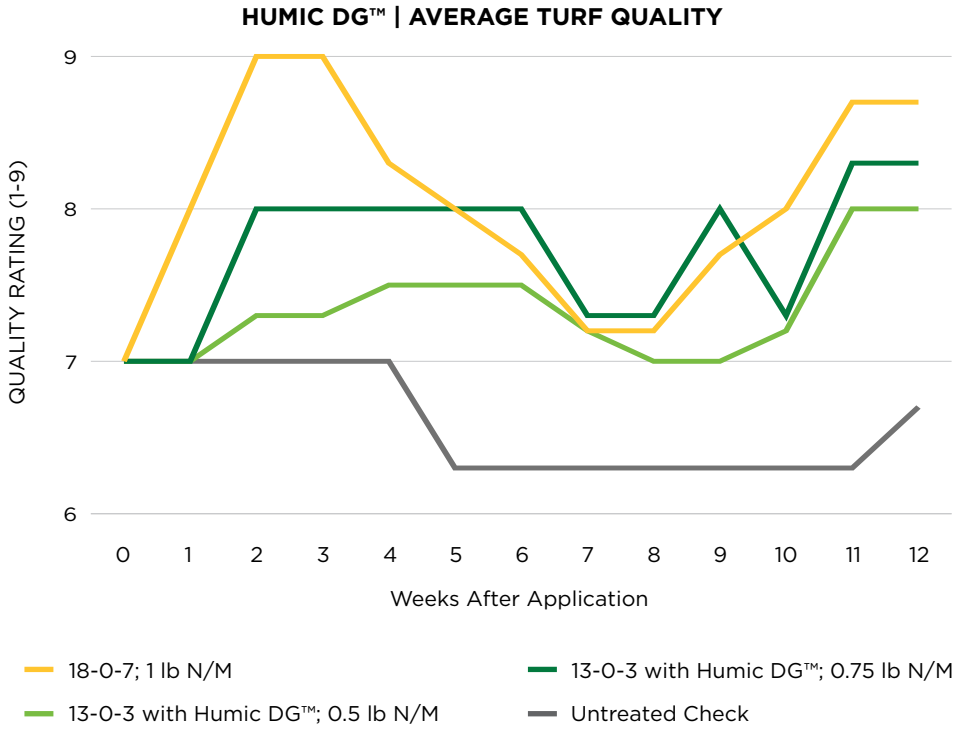
RATES
See above

OBJECTIVE(S)
The objective was to determine the effect of Humic DG on nitrogen efficiency when applied with full and reduced rates of nitrogen.

SUMMARY
No differences were observed in turf quality between the 16-0-8 at 1.0 lb N/M rate and the 16-0-8 at 0.77 lb N/M + Humic DG over two years. The same level of quality was achieved when less N was used in conjunction with Humic DG compared to a higher N rate applied without Humic DG.

THE IMPACT OF HUMIC DG ON NITROGEN EFFICACY

HumicDG™



DATE
2015

LOCATION
Doylestown, PA, Delaware Valley University, field setting

TREATMENTS
18-0-7 at 1.0 lb N per M

13-0-3 at 0.75 lb N per M
+ 11.5% Humic DG™ at 0.92 lb per M

13-0-3 at 0.50 lb N per M
+ 11.5% Humic DG™ at 0.65 lb per M

SPECIES
Kentucky bluegrass (3.0")

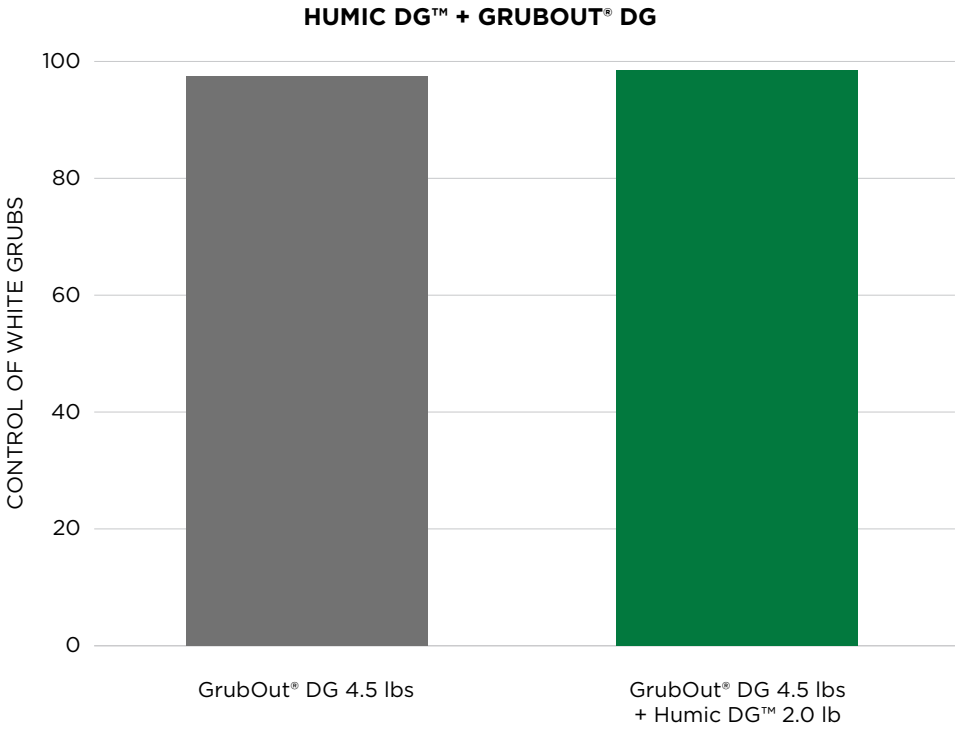
RATES
See above

OBJECTIVE(S)
The objective was to determine the effect of Humic DG on nitrogen efficiency when applied with full and reduced rates of nitrogen.

SUMMARY
Turfgrass color and quality of 18-0-7 at 1.0 lb N/M and 13-0-3 at 0.75 lb N/M + Humic DG were statistically similar. Reduced nitrogen rates can be used in conjunction with Humic DG to obtain the same level of quality and color of full nitrogen rates. Half rate of N results in lower quality and is not recommended at this time.

GRUB CONTROL WITH AND WITHOUT HUMATES

Humic DG™



DATE
2021

LOCATION
Denver, CO, third-party cooperator, field setting

TREATMENTS
GrubOut® DG
ANDE Humic DG™

SPECIES
Creeping bentgrass (0.130")

RATES
GrubOut® at 4.5 lb product per M
Humic DG™ at 2.0 lb product per M

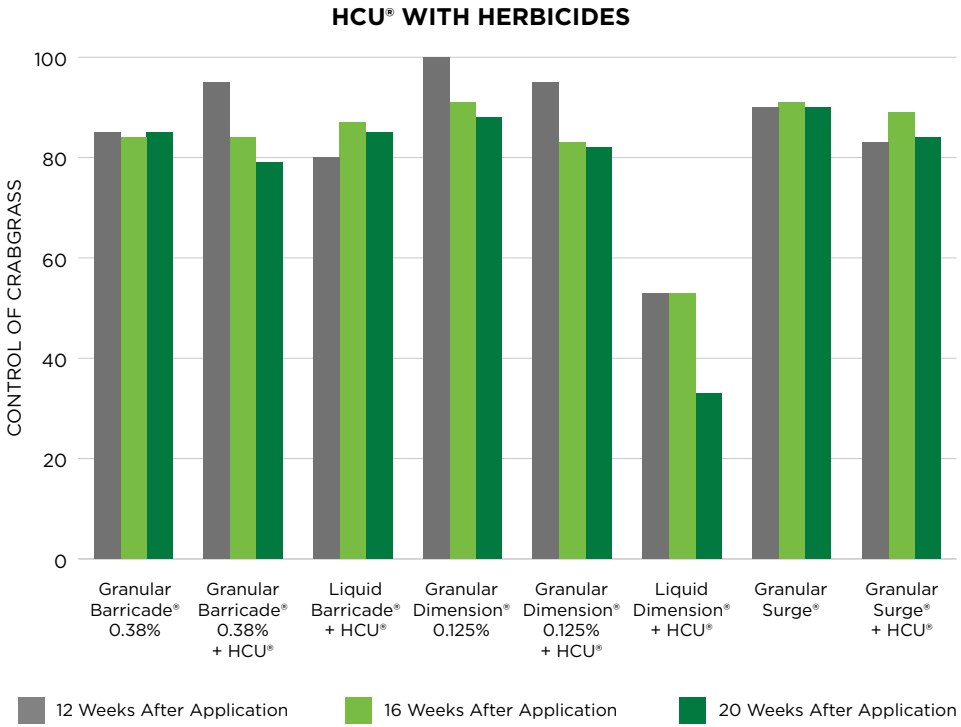
CHEMICALS
Imidacloprid (0.2%)

OBJECTIVE(S)
The objective was to determine the effect of adding humic products to insecticide applications without compromising turfgrass quality and performance in a sand-based root zone setting. An additional goal of this trial was to compare our humic fertilizers to an industry-standard enhanced efficiency fertilizer (EEF).

SUMMARY
GrubOut® DG provided 97.5% control of Japanese beetle larvae even after being applied in late-July. The addition of Humic DG did not statistically increase or decrease control, making it suitable for use in blended insecticide combination products.

THE IMPACT OF HCU ON HERBICIDE EFFICACY

HCU™



DATE
2017

LOCATION
Columbus, OH, Ohio State University, field setting

TREATMENTS
Granular Barricade® 0.38%
Granular Barricade® 0.38% + HCU®
Liquid Barricade® + HCU®
Granular Dimension® 0.125%
Granular Dimension® 0.125% + HCU®
Liquid Dimension® + HCU®
Granular Surge®
Granular Surge® + HCU®

SPECIES
Mixture of Kentucky bluegrass, tall fescue, and crabgrass (3.0")

RATES
Rates vary by treatment

CHEMICALS
Prodiamine, dithiopyr

OBJECTIVE(S)
The objective was to determine the effect of adding humic products to herbicide applications. Comparisons are made between granular herbicides and liquid herbicides, with and without addition of humic coated urea (HCU).

SUMMARY
All treatments except Liquid Dimension® + HCU provided acceptable control of crabgrass (≥80%). The addition of HCU® to granular fertilizer+herbicide blends did not impact herbicide efficacy on crabgrass. The addition of HCU did not negatively impact herbicide efficacy, making it suitable in fertilizer+herbicide blends as a value-added addition.

The Andersons®

AndersonsPlantNutrient.com/Turf | 800-253-5296

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