



**Intrinsic™ Brand Fungicides
Plant Health Research**



The Chemical Company

SUMMARY

Intrinsic™ is the umbrella brand for turf and ornamental products that are labeled for disease control and plant health. The first initiative under the **Intrinsic** brand is based on the fungicidal active ingredient, pyraclostrobin. In the future, the **Intrinsic** brand of products will expand to include formulation enhancers and formulation technology.

Intrinsic brand fungicides such as **Insignia® SC Intrinsic™ brand fungicide** and **Honor® Intrinsic™ brand fungicide**, based on the active ingredient pyraclostrobin, improve disease control and plant health through inhibition of mitochondrial respiration in both fungal diseases and plants.

In fungi, inhibition of mitochondrial respiration prevents the breakdown of carbon required for production of energy to fuel fungal growth. This results in death of the fungi.

In plants, the inhibition of mitochondrial respiration causes a cascade of positive events that can result in improved tolerance to stresses and increased efficiency of plant physiological processes. Inhibition of mitochondrial respiration by pyraclostrobin results in:

- Less CO₂ lost by the plant, resulting in more carbon available for plant growth.
- Increased activity of nitrate reductase (NR), the enzyme that is important for making a form of nitrogen that can be used by plants. This results in more nitrogen available for plant growth.
 - The activation of nitrate reductase increases levels of nitric oxide. Nitric oxide triggers plant defense mechanisms. Plant defense mechanisms are important not only in defending against fungal diseases, but also bacterial and viral diseases.
 - Nitric oxide inhibits enzymes involved in the production of ethylene, a plant hormone produced in response to stress. Ethylene can cause a plant to drop energy containing leaves, to mature earlier than normal, and to abort flowers and seed in response to stress.
- Increased activity of enzymes like superoxide dismutase and peroxidases that remove harmful activated oxygen species. This can result in reduced oxidative stress in response to environmental disorders, such as physiological leaf spot, ozone damage, cold stress, and heat stress.

Intrinsic brand fungicides, **Insignia SC Intrinsic** and **Honor Intrinsic** improve plant health, not just through superior, broad spectrum control of fungal diseases, but also through improved tolerance to stress and increased efficiency of plant processes. This enables plants to better withstand disease and a multitude of environmental stresses, resulting in improved turf quality.

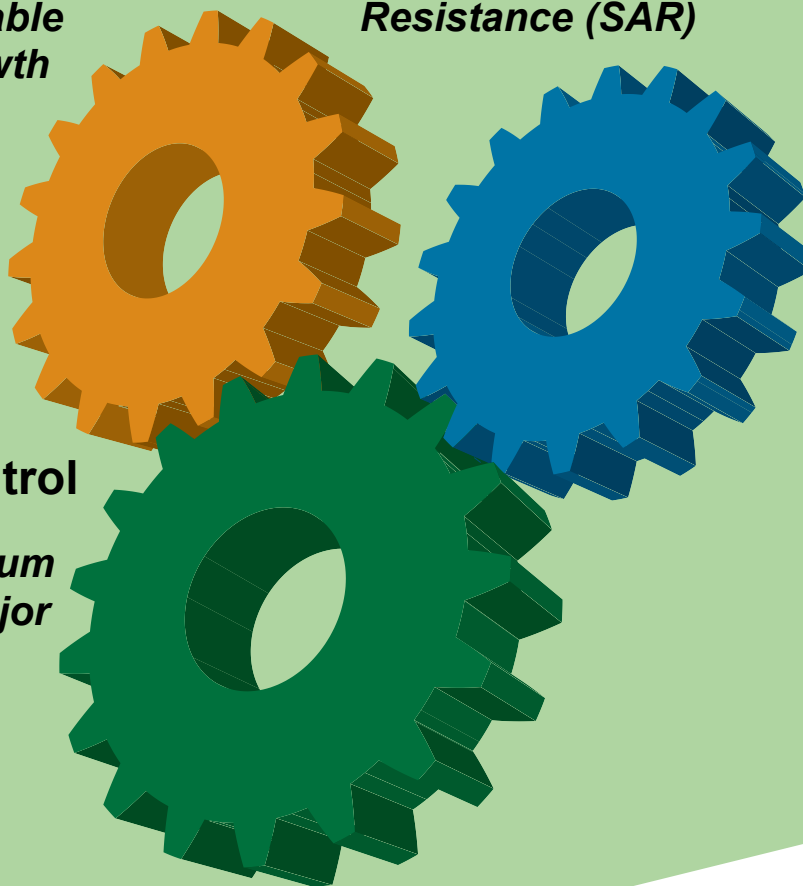
Although **Honor Intrinsic** and **Insignia SC Intrinsic** are labeled for disease control and plant health, BASF recommends using **Intrinsic** brand fungicides for preventative disease control first and foremost. **Intrinsic** brand fungicides are not labeled for use for plant health benefits in the absence of disease.

Increased Growth Efficiency

- *Reduced carbon/energy loss*
- *Increased nitrate reductase (NR) = more N available for plant growth*

Increased Tolerance to Stress

- *Reduced Ethylene*
- *Increased Antioxidative Activity*
- *Systemic Acquired Resistance (SAR)*



Disease Control

- *Broad spectrum control of major diseases*

Stress Management

- *Drought/Moisture*
- *Temperature Extremes*
- *Mechanical Stress*



INTRODUCTION

For superintendents to provide top quality turfgrass, the turf must make the best use of inputs like carbon and nitrogen while limiting energy wasted on preventing stresses caused by diseases, the environment, and other factors. Agronomic practices such as low mowing heights, reduced nitrogen rates, reduced irrigation inputs, and other cultural practices, such as aerification, can also cause stress to the turf. To maximize turf quality, superintendents focus on controlling factors they can impact to create an ideal environment for turf growth. These factors include agronomic practices to reduce stress, improve quality, and manage pests and diseases.



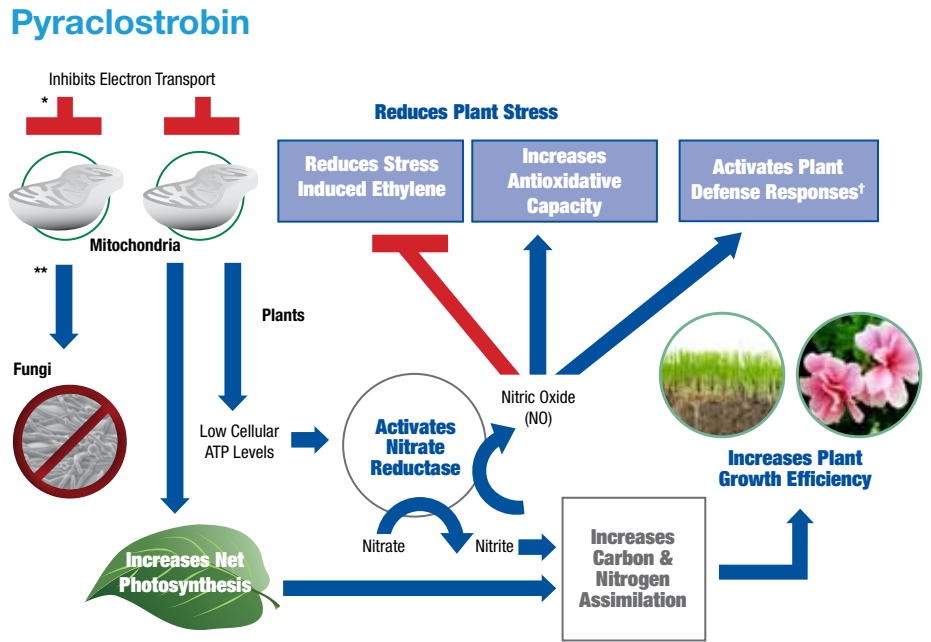
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PYRACLOSTROBIN-BASED FUNGICIDES PROVIDE DISEASE CONTROL AND PLANT HEALTH

Pyraclostrobin, an active ingredient in the **Intrinsic** brand fungicides **Insignia SC Intrinsic** and **Honor Intrinsic**, belongs to the strobilurin class of fungicides. In addition to excellent, broad spectrum disease control, research has shown pyraclostrobin-based fungicides also provide additional plant health benefits. Pyraclostrobin-based fungicides control foliar fungal diseases by inhibiting respiration in the mitochondria of fungi. This inhibition prevents the breakdown of energy-rich carbon compounds the fungus needs to produce energy for growth. Pyraclostrobin-based fungicides also have activity on plant mitochondria and reduce respiration in the plant. Since the plant's primary source of energy comes from sunlight through photosynthesis, this decrease in respiration can have a positive effect on growth. Decrease in respiration allows the plant to keep more stored carbon compounds for growth and triggers a chain reaction of positive physiological changes in the plant. These positive physiological changes may include an increase in nitrate reductase activity, elevated levels of antioxidants and defense signaling compounds, and a decrease in the stress hormone ethylene. The combination of disease control, stress reduction, and increased growth efficiency lead to the plant health benefits observed with the use of pyraclostrobin-based fungicides as described in this report (Figure 1).

Figure 1: Disease Control and Plant Health with Pyraclostrobin



*red lines indicate inhibition of pathway or process
 **blue arrows indicate activation of pathway or process
 †Increased tolerance to bacterial and viral infections

Proposed model of Plant Health benefits

DISEASE CONTROL AND PLANT DEFENSE

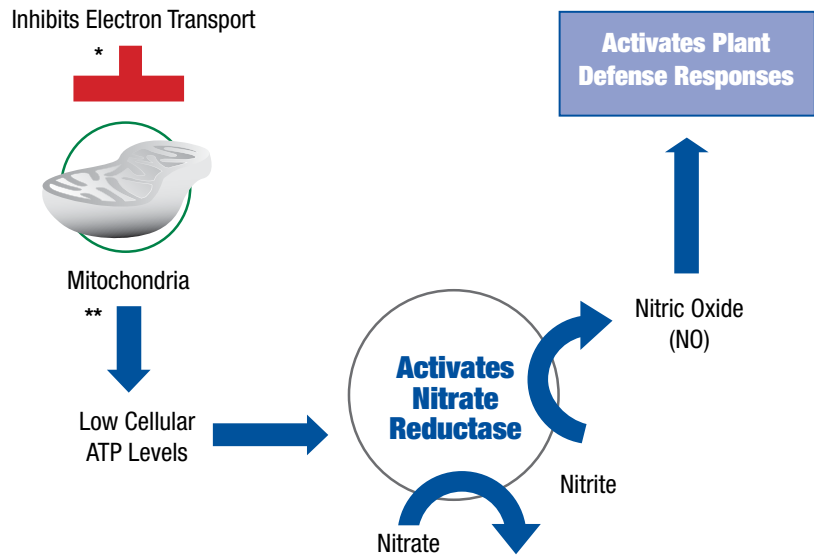
Intensively managed turfgrass on golf courses is susceptible to damage from diseases. Controlling diseases is especially important to superintendents to maintain playing conditions and turfgrass quality which meets the golfers' expectations. Disease control maintains turf quality and reduces the amount of energy used by the turfgrass to fight the disease. Pyraclostrobin-based fungicides are widely recognized as fungicides with excellent activity on a number of highly important diseases that infect many turfgrass species. The diseases controlled by pyraclostrobin in turf include: anthracnose, brown ring patch, gray snow mold, melting out, pythium blight, rapid blight, rust, and summer patch. See product labels for a complete list of diseases controlled.

Pre-treatment Activates Plant Defenses

Faster and/or improved defense responses by plants to pathogen attack reduce the impact of disease. Faster response helps reduce turf losses even when the turfgrass can fight off the disease. Pyraclostrobin-based fungicides have been shown to activate plant defenses so that turfgrass is better prepared to defend itself when pathogen attack occurs. One way plants respond to disease is by producing nitric oxide which triggers plants to defend against the disease. Pyraclostrobin-based fungicides promote the production of nitric oxide by reducing respiration in the plant mitochondria. The reduction in respiration activates the nitrate reductase enzyme, which in turn, increases the amount of nitrite. Together, activated nitrate reductase and increased levels of nitrite produce nitric oxide (Figure 2).

Figure 2: Activation of Plant Defense Responses, Proposed Model

Pyraclostrobin



*red lines indicate inhibition of pathway or process
**blue arrows indicate activation of pathway or process

PYRACLOSTROBIN-BASED FUNGICIDES IMPROVE GROWTH EFFICIENCY

Today's superintendents seek to maximize turf quality and health on their golf course as maintenance costs continue to rise. With these rising costs, superintendents want to know when they invest money into inputs like fungicides, those inputs will achieve the highest potential. Laboratory and field research have demonstrated pyraclostrobin-based fungicides improve nitrogen utilization in plants and improve photosynthetic efficiency. The result: turfgrasses treated with pyraclostrobin-based fungicides are healthier and stronger.

Improved Plant Utilization of Nitrogen

Nitrate reductase is an enzyme in plants required to convert nitrate to nitrite, used by the plant for growth and development. The activity of pyraclostrobin-based fungicides on plant mitochondria results in a reduction of respiration. This reduced respiration activates the nitrate reductase enzyme. This activation results in more rapid conversion of nitrate into nitrite for the plant to use. Thus nitrogen utilization is improved, and plant storage tissue (roots) can be increased to provide for better energy efficiency and improved plant growth potential (Figure 3).

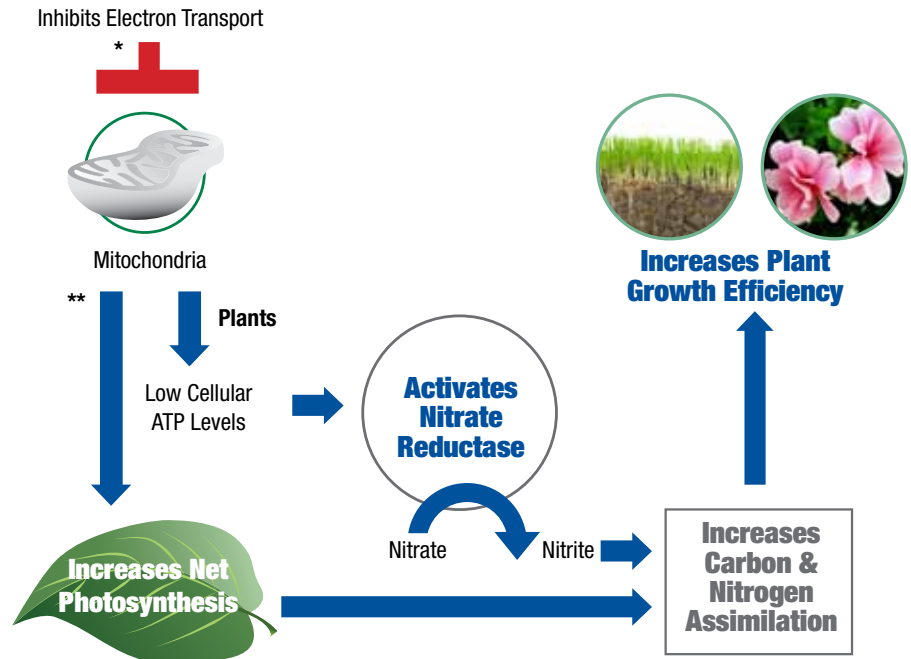
Greenhouse and laboratory results

A research study was conducted to determine the effect of pyraclostrobin on the enzyme, nitrate reductase. Within a few hours after a pyraclostrobin application to wheat leaves, the activity of nitrate reductase increased by more than 70%. The increased nitrate reductase activity was maintained for more than three nights after a single application of pyraclostrobin (Graph 1a, next page).

Nitrate uptake in vivo increased approximately 40%, seven days after pyraclostrobin treatment (Graph 1b, next page).

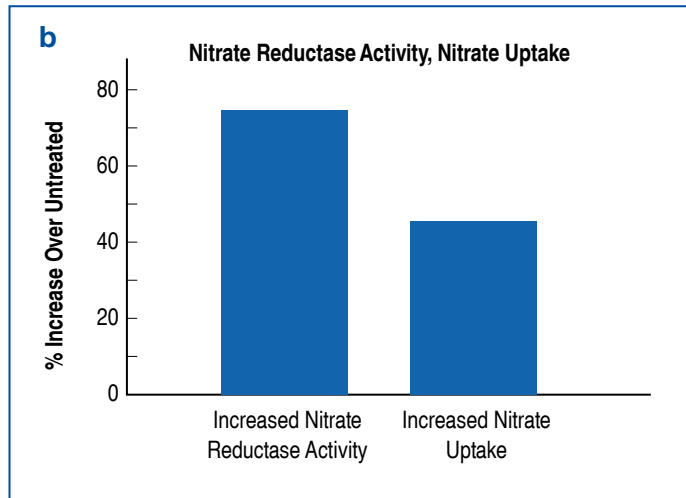
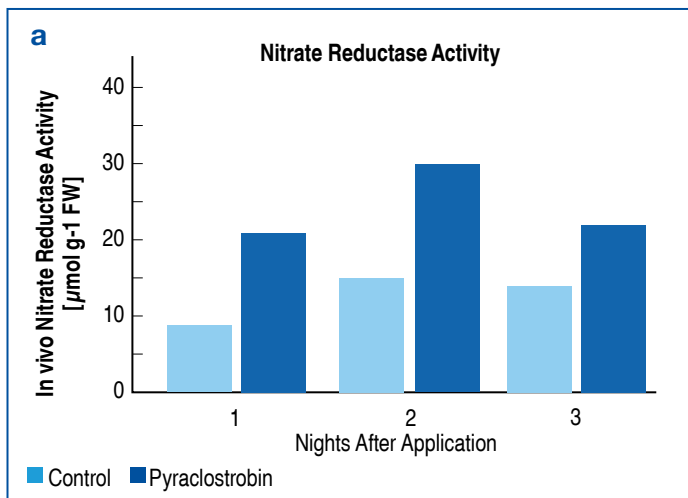
Figure 3: Improved Nitrate Reductase Activity and Photosynthetic Efficiency, Proposed Model

Pyraclostrobin



*red lines indicate inhibition of pathway or process
**blue arrows indicate activation of pathway or process

Graph 1 a & b: Applications with Pyraclostrobin Increased Nitrate Reductase Activity and Nitrate Uptake in Wheat, Resulting in Increased Plant Growth



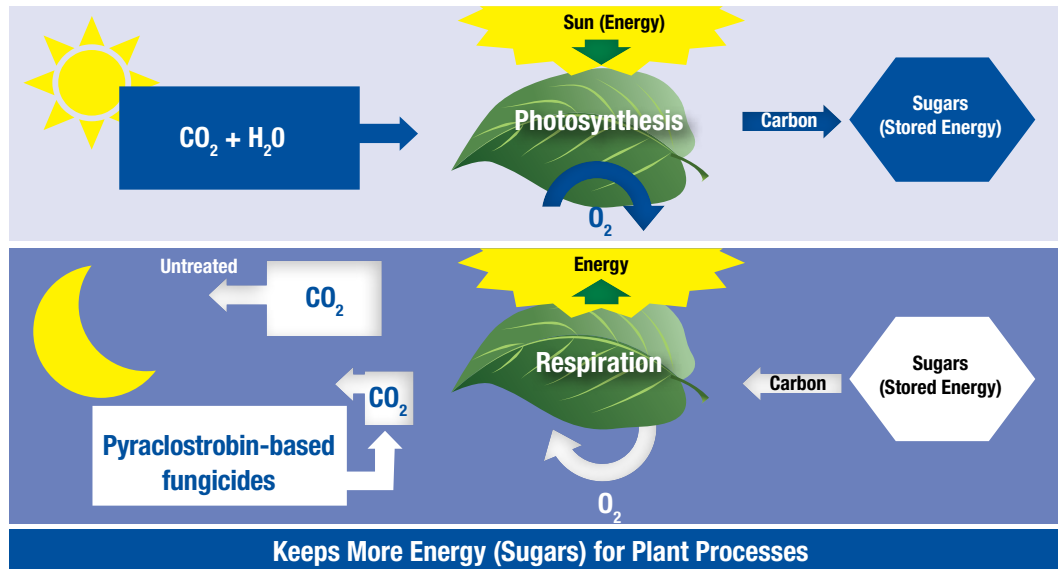
Köhle et al. 2002 in *Modern Fungicides and Antifungal Compounds III*, Eds. Dehne, Gisi, Kuck, Russell and Lyr

Nitrate reductase determined 14 hours after application; nitrate uptake measured 7 days after application.

Pyraclostrobin-based Fungicides Improve Photosynthetic Efficiency

Increasing the efficiency of photosynthesis also allows a plant to make the best use of available inputs. The activity of pyraclostrobin-based fungicides on plant mitochondria reduces respiration in plants. This reduction in respiration reduces the amount of CO_2 given off when stored carbon compounds are broken down. Reducing the amount of CO_2 given off can mean more carbon (stored energy) remains available for growth and development (Figure 4).

Figure 4: Reduction of Respiration/Increased Photosynthetic Efficiency



INCREASED TOLERANCE TO ENVIRONMENTAL STRESS

A turfgrass growing season is never the same for the entire year. Even short periods of mild stress can affect turf quality. Reducing the impact of environmental stresses allows the turfgrass to remain healthier. When a plant experiences stress, it produces several compounds in response. Two of these compounds are ethylene and activated oxygen species.

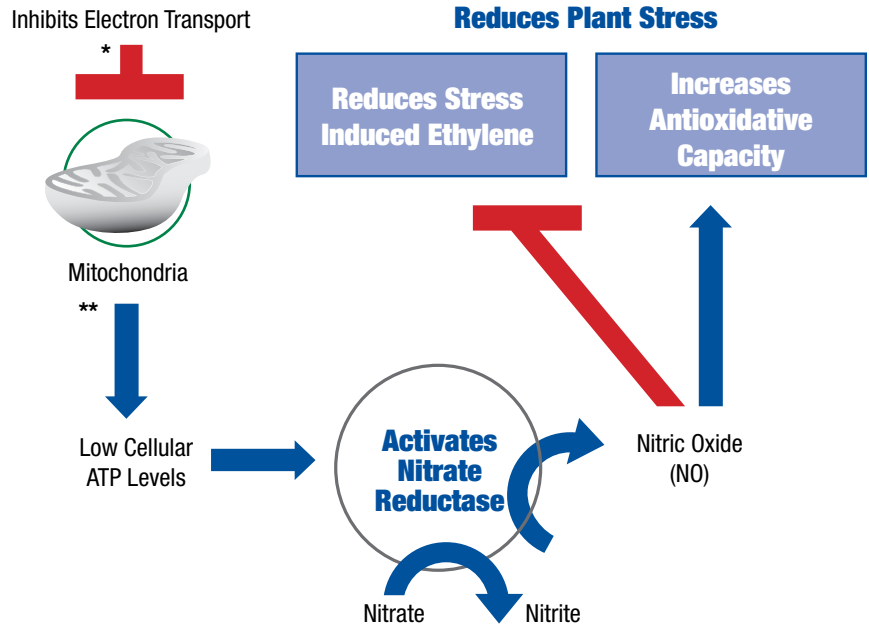
Improved Tolerance to Drought

Ethylene is a hormone plants produce in response to many stresses, including drought stress. Plants also produce ethylene in response to injury, when they mature, prior to leaf loss, and before pathogen triggered cell death. Nitric oxide inhibits the enzymes involved in the production of ethylene. The more nitric oxide, the less ethylene produced. Since nitric oxide levels in a plant are often increased after a pyraclostrobin-based fungicide application, the amount of ethylene in treated plants is also reduced (Figure 5).

The inhibition of ethylene production by pyraclostrobin was compared to other strobilurins. Forty-five hours after the stress started, pyraclostrobin reduced ethylene production by 33% more than strobilurin 2 and by 67% more than strobilurin 1 (see Graph 2 on next page).

Figure 5: Pyraclostrobin Reduces Plant Stress by Inhibiting Ethylene Production and Increasing Antioxidative Capacity, Proposed Model

Pyraclostrobin



*red lines indicate inhibition of pathway or process
**blue arrows indicate activation of pathway or process

Pyraclostrobin-based Fungicides Improve Tolerance to Heat

Heat stress is linked to increased superoxide dismutase (SOD) activity. Nitric oxide is also linked to increased tolerance to heat. As discussed earlier, pyraclostrobin applications increase SOD activity and increase the production of nitric oxide by increasing the activity of nitrate reductase. Thus pyraclostrobin applications can improve plant tolerance to heat.

Pyraclostrobin-based Fungicides Improve Recovery from Mechanical Stress

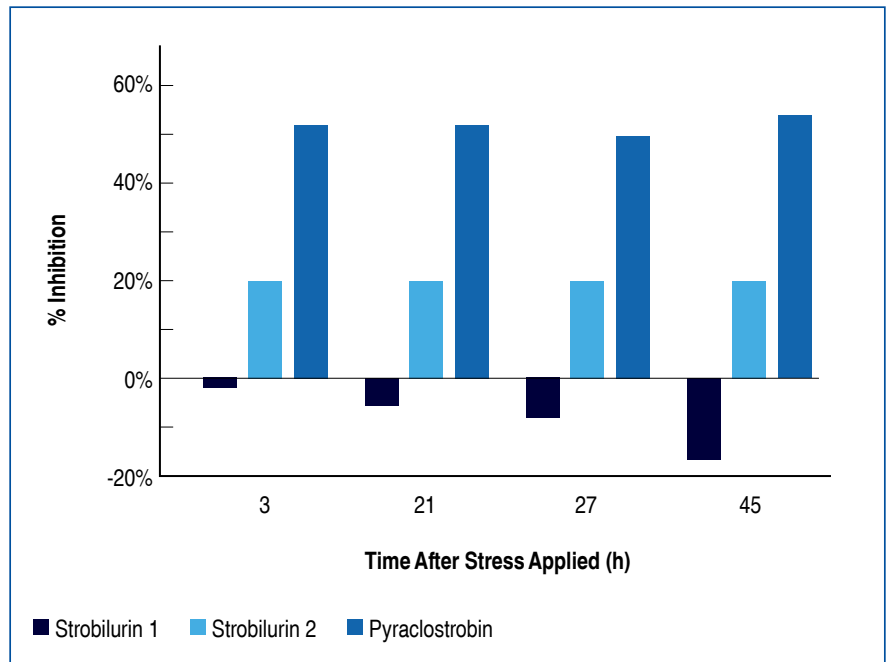
Superintendents routinely perform agronomic practices on their golf course such as aerification, verticutting, spiking, and mowing. These practices cause injury to the turf and require additional time for turfgrass to heal. Minimizing recovery time is very desirable to provide ideal playing conditions.

Summary

Maintaining high quality turf is very challenging for superintendents due to numerous stresses which can reduce turf quality. Superintendents have been suggesting for years that the turf's ability to tolerate stress is improved following a pyraclostrobin application, resulting in higher turf quality.

Pyraclostrobin-based fungicides, including **Insignia SC Intrinsic** and **Honor Intrinsic**, are helping superintendents not only control diseases, but also reduce the effects of stresses on their turfgrass. This allows superintendents to meet golfers' expectations by providing ideal playing conditions.

Graph 2: Pyraclostrobin Inhibited the Production of Ethylene in Wheat After Stress



BASF Global Ag Research, 2001

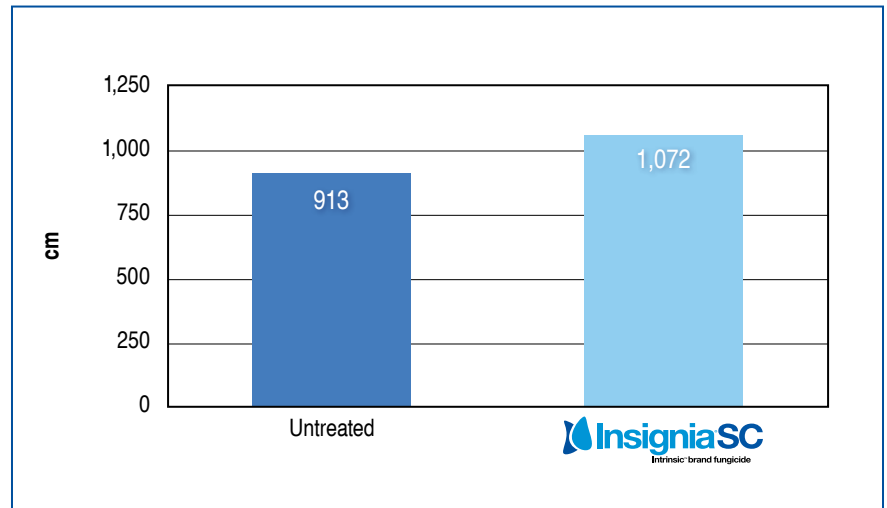


Plant Health Research in Turf

CREEPING BENTGRASS ROOT RESPONSE TO IRRIGATION REGIMES

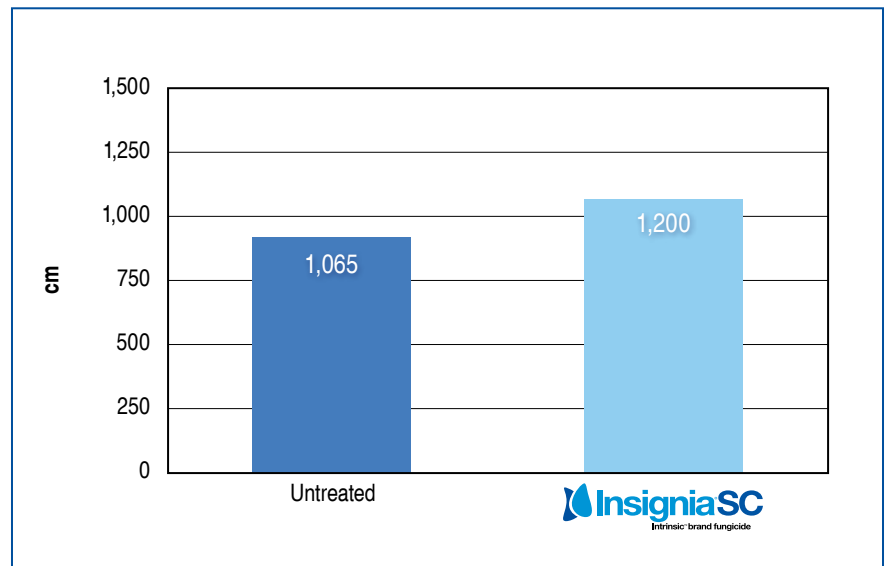
Greenhouse research was conducted to evaluate the effects of pyraclostrobin on the rooting of creeping bentgrass managed under two irrigation regimes during high temperature conditions in a greenhouse. The light and frequent (LF) regime was irrigated daily to replace 100% of evapotranspiration, and the deep and infrequent (DI) regime was irrigated to a 30 cm. depth at leaf wilt. Plants were maintained in a greenhouse which averaged a maximum daily temperature of 31° C. Total root length (the total length of all individual root segments added together with the aid of a group scanning device and a computer program) was calculated from each soil sample. Plants treated with pyraclostrobin showed an increase in total root length (Graph 3 & 4), when compared to non-treated grass total root length under LF and DI irrigation regime.

Graph 3: Bentgrass Total Root Length (cm) with Deep and Infrequent Irrigation



*N= 6 trials: A-1, Pennncross, Colonial and SR1119 data was combined across creeping bentgrasses (CA, IL, TN, 2009). Root measurements taken 90 days after treatment. Turf treated with **Insignia SC Intrinsic** at 0.7 oz. rate.*

Graph 4: Bentgrass Total Root Length (cm) with Light and Frequent Irrigation



*N= 6 trials: A-1, Pennncross, Colonial and SR1119 data was combined across creeping bentgrasses (CA, IL, TN, 2009). Root measurements taken 90 days after treatment. Turf treated with **Insignia SC Intrinsic** at 0.7 oz. rate.*

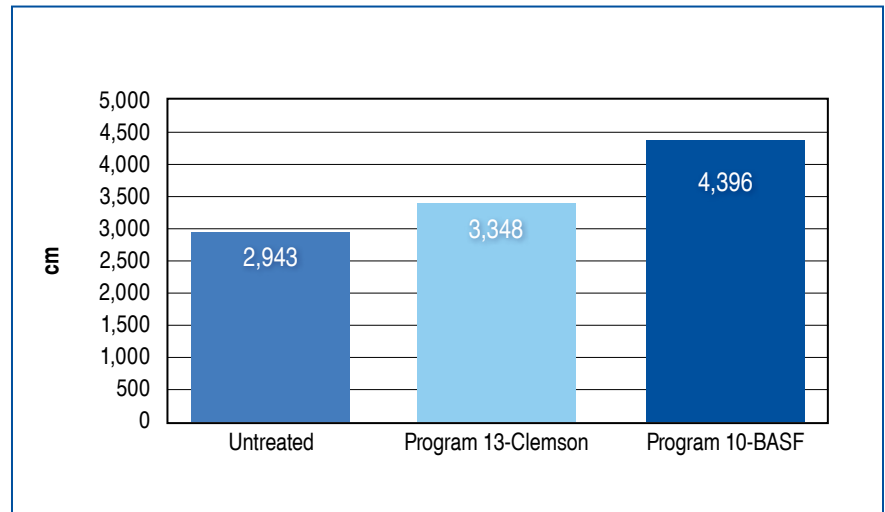
SUMMER STRESS OBSERVATIONS FROM DR. BRUCE MARTIN (CLEMSON UNIVERSITY)

Field observations from Summer Stress Programs in 2007 at Clemson University Turfgrass plots (Florence, SC) showed the ability of A-1 bentgrass to tolerate extended periods of high heat and humidity with the use of pyraclostrobin-based fungicides. Temperatures at or greater than 100° F were recorded for numerous days during the trial period. Table 1 (next page) shows programs that included pyraclostrobin showed higher turfgrass quality for the entire season as well as recuperative growth through the winter and into the spring of 2008 (Dr. Bruce Martin communications). Root cores were sampled from the untreated plots, BASF, and Clemson's treatments the following spring, and analyzed with WinRHIZO® tron for root length (cm.) (Graph 5).

University turfgrass plant pathologists develop spray treatment programs to show golf course superintendents and other turfgrass professionals how to manage disease and appropriately rotate products for resistance management.

Clemson University Turfgrass plots located outside of Florence, SC at the Pee Dee Research and Education Center has established an example using summer bentgrass programs to demonstrate these uses. The summer of 2007 was one of the hottest and driest on record for many parts of the Southeastern U.S. including the Florence area.

Graph 5: Total Root Length (cm) of Clemson Summer Stress Trials



Clemson Univ. A1 Bentgrass Summer Stress Trials 2007. Root core samples were taken early spring 2008.

Shown here in Table 1 is a portion of the number of programs that were evaluated that summer by Dr. Bruce Martin, Clemson turfgrass plant pathologist. Here we see Dr. Martin's Clemson Program 13 is compared to untreated plots and top performing programs from BASF. The dates in the table indicate when the products were sprayed and the number below the product is a rating for turf

quality at the time of the spray during the summer stress. The scale is 1-9 with 1 being brown or dead turfgrass and 9 representing quality turfgrass with high color, density, and texture and is absent of disease. All programs reflect labeled rates for all products. In addition, these programs include **Insignia® WDG fungicide**, another pyraclostrobin-based fungicide from BASF.

Table 1: Turf Quality Rating of Clemson Summer Stress Trials
(Selected Treatments – 2007)

Program	May 22	June 5	June 19	July 3	July 17	July 31	Aug 14	Aug 28
Untreated	6	6	4	3	2	2	1	2
10-BASF	Honor Intrinsic brand fungicide 8	Trinity® fungicide 8	Insignia WDG fungicide 8	Daconil® Ultrex fungicide 8	Insignia 8	Curalan® fungicide + Dac 8	Insignia 8	Honor Intrinsic 7
13-Clemson	Tartan® fungicide 8	Insignia 8	Spectro™ 90 fungicide 8	Chipco® Signature™ fungicide + Dac 8	Insignia 8	Chipco Sig + Dac 8	26GT™ fungicide 8	Tartan 7

Turf quality data points are not rounded.

Courtesy of Dr. Bruce Martin, Clemson University, 2007

Number under the product treatment is Turf Quality Rating (Scale 1-9)

Abbreviations are: Dac = Daconil Ultrex, Chipco Sig = Chipco Signature

The following tables detail the rates and intervals of the products used in both Program 10 and Program 13.

BASF Program 10 at Clemson 2007 Bentgrass Trial

Honor Intrinsic brand fungicide - spray 1	1.1 oz./1000 ft ²	14 day interval
Trinity fungicide - spray 2	1.0 fl. oz./1000 ft ²	14 day interval
Insignia fungicide - spray 3	0.9 oz./1000 ft ²	14 day interval
Daconil Ultrex fungicide - spray 4	3.2 oz./1000 ft ²	14 day interval
Insignia - spray 5	0.9 oz./1000 ft ²	14 day interval
Curalan fungicide +	1.0 oz./1000 ft ²	14 day interval
Daconil Ultrex - spray 6	3.2 oz./1000 ft ²	14 day interval
Insignia - spray 7	0.9 oz./1000 ft ²	14 day interval
Honor Intrinsic - spray 8	1.1 oz./1000 ft ²	14 day interval

Clemson University's Program 13 in 2007 Bentgrass Trial

Tartan fungicide - spray 1	2.0 fl. oz./1000 ft ²	14 day interval
Insignia - spray 2	0.9 oz./1000 ft ²	14 day interval
Spectro 90 fungicide - spray 3	5.76 oz./1000 ft ²	14 day interval
Chipco Signature fungicide +	4.0 oz./1000 ft ²	14 day interval
Daconil Ultrex - spray 4	3.2 oz./1000 ft ²	14 day interval
Insignia - spray 5	0.9 oz./1000 ft ²	14 day interval
Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
Daconil Ultrex - spray 6	3.2 oz./1000 ft ²	14 day interval
26 GT fungicide - spray 7	4.0 fl. oz./1000 ft ²	14 day interval
Tartan - spray 8	2.0 fl. oz./1000 ft ²	14 day interval

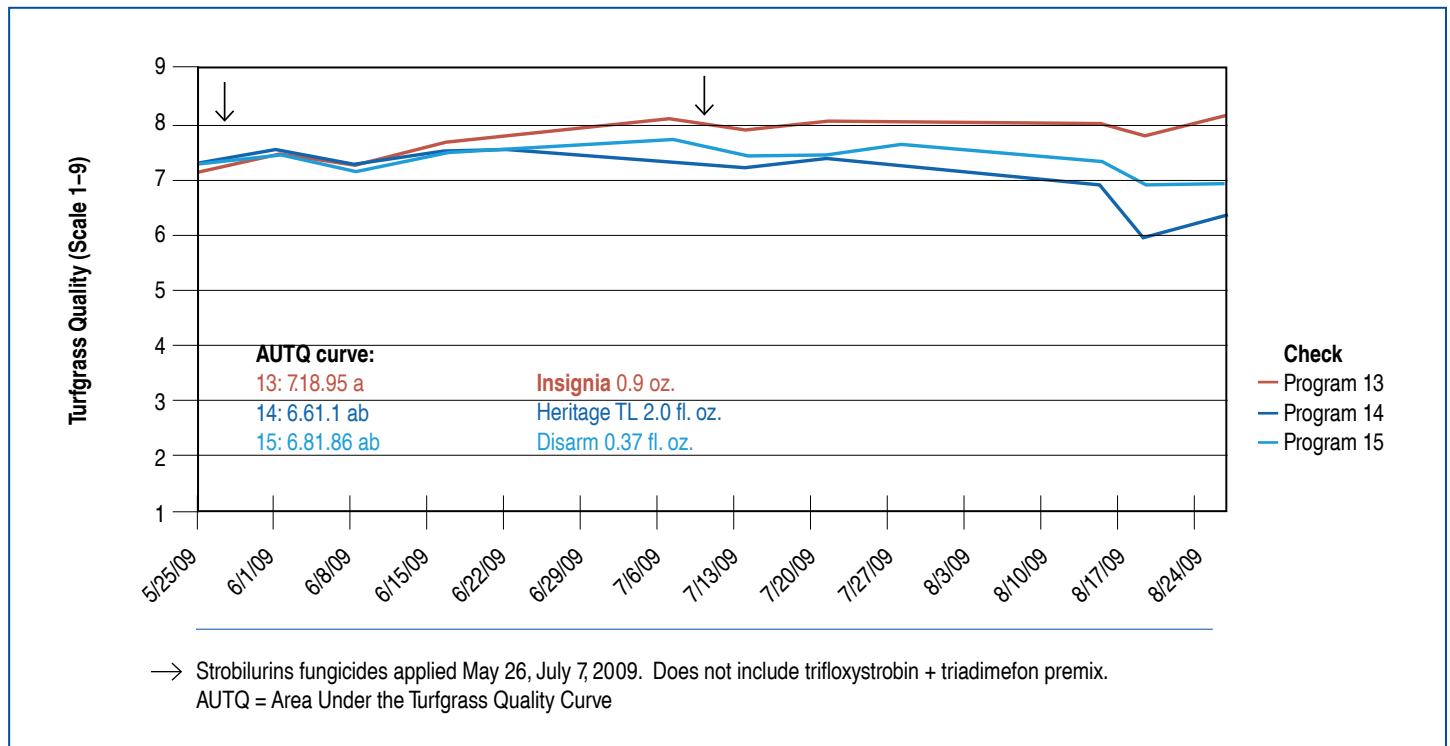
TURF QUALITY RATINGS SHOW EFFECTS OF STROBILURINS IN SUMMER BENTGRASS PROGRAMS

We noted earlier that in 2007 Dr. Martin had tested Clemson Program 13 which featured **Insignia WDG**, another pyraclostrobin-based fungicide. In 2009, Martin and Clemson again tested Program 13 and also tested two other strobilurins that summer: Program 14, which featured Heritage® TL fungicide, and Program 15 which featured Disarm® fungicide. What we are looking at here is the performance of those two strobilurin fungicides vs. **Insignia** which contains the strobilurin pyraclostrobin and the resulting turfgrass quality for the entire summer season.

Graph 6 reflects results from 2009 and examination over two summers of comparing strobilurin products applied as a single active on the Turf Quality Under the Curve (Scale of 1-9) — as an accumulative value for all quality ratings to turfgrass during a defined period of May through August. The ratings are based on the recognized agronomy scale of 1-9, where 1 represents brown or dead turfgrass and 9 represents excellent quality turfgrass with high color, density, and texture and is absent of disease. This chart is courtesy of Dr. Bruce Martin from his research program on bentgrass at the Clemson University Pee Dee REC, Florence, SC.

Graph 6: Effects of Strobilurins in Program 13

(Courtesy of Dr. Bruce Martin)



Note: In Program 13, 14, and 15, the combination of trifloxystrobin & triadimefon was applied in all programs at the beginning and end. Since trifloxystrobin & triadimefon is a combination fungicide formulation, it was not included in this analysis to allow for direct strobilurin to strobilurin comparison. Results above compare solo strobilurins on the same schedule: **Insignia** vs. Heritage vs. Disarm. The arrows indicate where the strobilurins were applied twice through the summer stress months. (Dr. Bruce Martin's Research Rpt.)

The following tables detail the rates and intervals of the products used in both Programs 13, 14, and 15, which feature **Insignia**, Heritage TL, and Disarm respectively.

In 2009 the Spray Dates were the following:

- spray 1 - May 12
- spray 2 - May 26
- spray 3 - June 9
- spray 4 - June 23
- spray 5 - July 7
- spray 6 - July 21
- spray 7 - August 4
- spray 8 - August 18

13	Tartan - spray 1	2.0 fl. oz./1000 ft ²	14 day interval
	Insignia - spray 2	0.9 oz./1000 ft ²	14 day interval
	Spectro 90 - spray 3	5.76 oz./1000 ft ²	14 day interval
	Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
	Daconil Ultrex - spray 4	3.2 oz./1000 ft ²	14 day interval
	Insignia - spray 5	0.9 oz./1000 ft ²	14 day interval
	Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
	Daconil Ultrex - spray 6	3.2 oz./1000 ft ²	14 day interval
	26 GT - spray 7	4.0 fl. oz./1000 ft ²	14 day interval
	Tartan - spray 8	2.0 fl. oz./1000 ft ²	14 day interval

14	Tartan - spray 1	2.0 fl. oz./1000 ft ²	14 day interval
	Heritage TL fungicide - spray 2	1.0 fl. oz./1000 ft ²	14 day interval
	Spectro 90 - spray 3	5.76 oz./1000 ft ²	14 day interval
	Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
	Daconil Ultrex - spray 4	3.2 oz./1000 ft ²	14 day interval
	Heritage TL - spray 5	1.0 fl. oz./1000 ft ²	14 day interval
	Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
	Daconil Ultrex - spray 6	3.2 oz./1000 ft ²	14 day interval
	26 GT - spray 7	4.0 fl. oz./1000 ft ²	14 day interval
	Tartan - spray 8	2.0 fl. oz./1000 ft ²	14 day interval

15	Tartan - spray 1	2.0 fl. oz./1000 ft ²	14 day interval
	Disarm fungicide 480SC - spray 2	0.36 fl. oz./1000 ft ²	14 day interval
	Spectro 90 - spray 3	5.76 oz./1000 ft ²	14 day interval
	Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
	Daconil Ultrex - spray 4	3.2 oz./1000 ft ²	14 day interval
	Disarm - spray 5	0.36 fl. oz./1000 ft ²	14 day interval
	Chipco Signature +	4.0 oz./1000 ft ²	14 day interval
	Daconil Ultrex - spray 6	3.2 oz./1000 ft ²	14 day interval
	26 GT- spray 7	4.0 fl. oz./1000 ft ²	14 day interval
	Tartan - spray 8	2.0 fl. oz./1000 ft ²	14 day interval

BERMUDAGRASS RESPONSE TO COLD: INTRINSIC BRAND FUNGICIDES EFFECTS

Excerpts from Dr. John Cisar's 2009
Research Report:

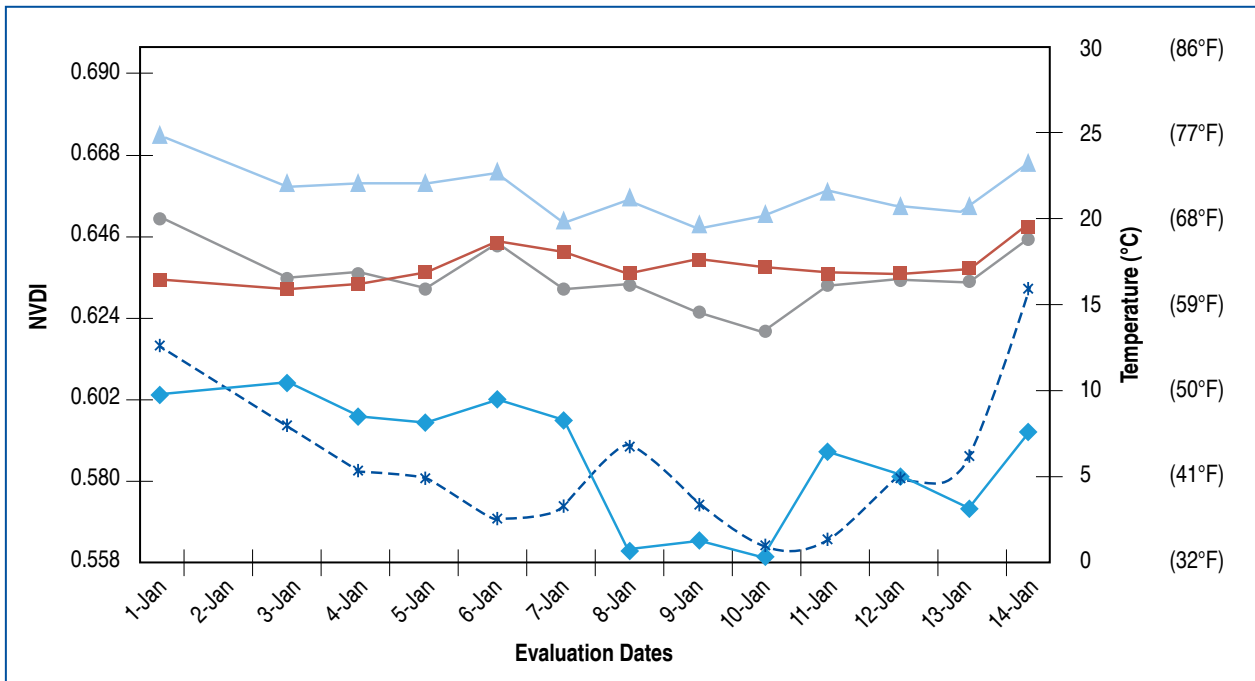
In some areas of the U.S., golf greens are over-seeded with cool-season grasses during the fall and winter playing seasons. Bermudagrass putting surfaces can often be off-colored during brief cold weather patterns. However, this overseeding practice does present other negative agronomic conditions for spring transition and bermudagrass vigor. It could be desirable to have a treatment that minimizes the discoloration of bermudagrass due to chilling stress.

Chilling stress has been shown to induce metabolic activity which increases ethylene concentrations. In turn, elevated ethylene is associated with chlorosis and senescence of leaves. Research conducted by BASF AG indicates that pyraclostrobin inhibits the activity of ACC-synthase and as a result limits synthesis of ethylene.

The winter of 2010 provided the perfect conditions to observe bermudagrass treated with pyraclostrobin-based fungicides as compared to untreated or an industry standard and determine if leaf discoloration can be moderated. During this time of year the use of fungicides for the control of bermudagrass "leaf spots" is considered normal maintenance. Pyraclostrobin-based fungicides, **Insignia SC Intrinsic** and **Honor Intrinsic**, have previously been shown to be good treatments for this disease.

In response to chilling stress (i.e., temperature minimums below the cardinal base of 10° C for warm-season grasses), only turf treated with pyraclostrobin responded with an increase in Normalized Difference Vegetation Index (NDVI) readings as compared to the untreated turfgrass and an industry standard (Graph 7). An NDVI reading measures the light reflectance of plants. The higher the NDVI, the healthier the turf.

Graph 7: Chill Stress Tolerance of TifEagle Bermudagrass in Response to Plant Protectant Application
(Furnished by: Dr. J. Cisar, N. Young, K. William; Univ. of Florida, Ft. Lauderdale, FL, 2010.)



One application made one day prior to cold event. NDVI = higher NDVI the greener or more chlorophyll the plant has

- Untreated
- ◆ Tartan @ 1.5 fl. oz.
- Insignia SC Intrinsic @ 0.7 fl. oz.
- ▲ Honor Intrinsic @ 0.84 oz.
- * Temp. Min

Excerpt from Dr. John Cisar's
Research Report:

Significant differences were observed for turf quality and absence of winter leaf spot infections throughout the rating period through April 30, 2010, that encompassed a very cold winter which affected the results shown in Graph 8. Initial quality was sub-standard (ratings below TQ of 6) and improved differentially by treatment (BASF Program vs. The University of Florida Program vs. Untreated turf). Disease stress was very obvious in untreated check during cooler weather and BASF Preventative Program had the best ratings and generally had high quality ratings through April 30, 2010, demonstrating both turfgrass protection from disease as well as the impact from the cold weather.

BASF & The University of Florida Program

BASF Preventative Program:

Honor Intrinsic 1.11 oz.

Curalan + Fore® fungicide 1.0 + 8.0 oz.

Chipco Signature + Fore 4.0 + 8.0 oz.

Honor Intrinsic 1.11 oz.

Chipco Signature + Fore 4.0 + 8.0 oz.

Insignia SC Intrinsic 0.7 oz.

UF (University of Florida) Curative Program:

Heritage 0.4 oz.

Chipco Signature + Daconil 4.0 + 3.2 oz.

Heritage 0.4 oz.

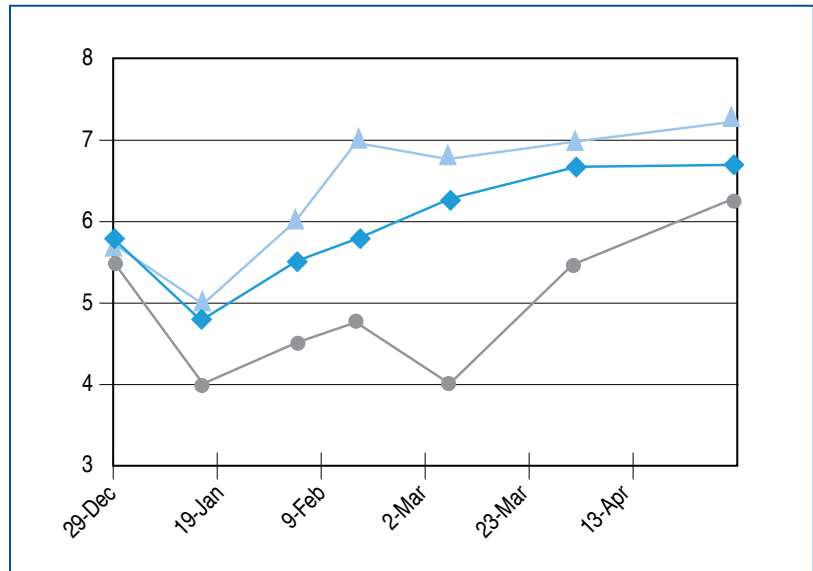
Chipco Signature + Daconil 4.0 + 3.2 oz.

Heritage 0.4 oz.

Chipco Signature + Daconil 4.0 + 3.2 oz.

Graph 8: Turfgrass Quality and Color of Champion Bermudagrass Green
(FL, 2010, Cisar)

Scale of 1-10, 1=dead brown turf; 6=minimally accepted turf



- Untreated
- ▲ BASF Preventative Prog
- ◆ UF Curative Prog

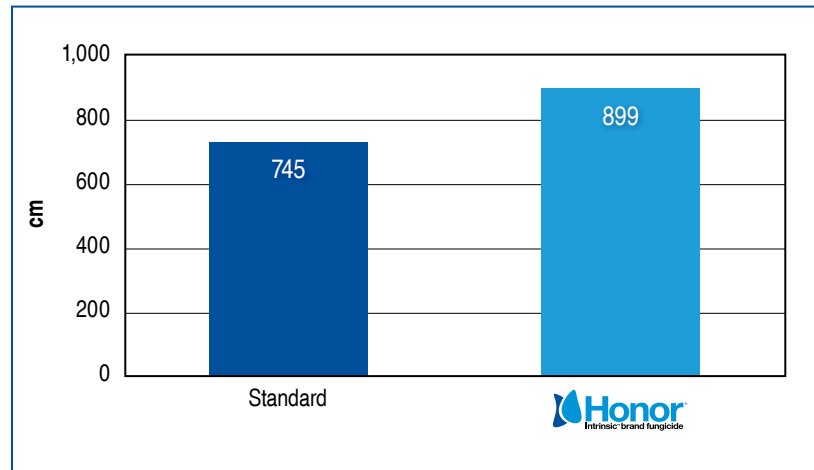
N=1, Champion Bermudagrass, Several days of exposure to temperatures below 50°F (record lows) Jan. - Mar. 2010 were recorded in Ft. Lauderdale, FL. All treatments applied 14-d interval; 6 applications.

ROOT GROWTH AFTER AERIFICATION ON BOTH COOL AND WARM SEASON GREENS WHEN TREATED WITH INTRINSIC BRAND FUNGICIDES

Trials were conducted on golf courses to determine if **Honor Intrinsic** applied pre- and post-aerification could result in healthier root systems after aerification. **Honor Intrinsic** was applied 7 days pre-aerification and 7 days post-aerification at 1.1 oz./1000 sq ft. Root cores were harvested 14 days after the second application and analyzed utilizing a root scanning computer program. The program generates total root length data which is the combined length of all root segments in the core samples. Results show increased total root length over the standard fungicide application for the course.

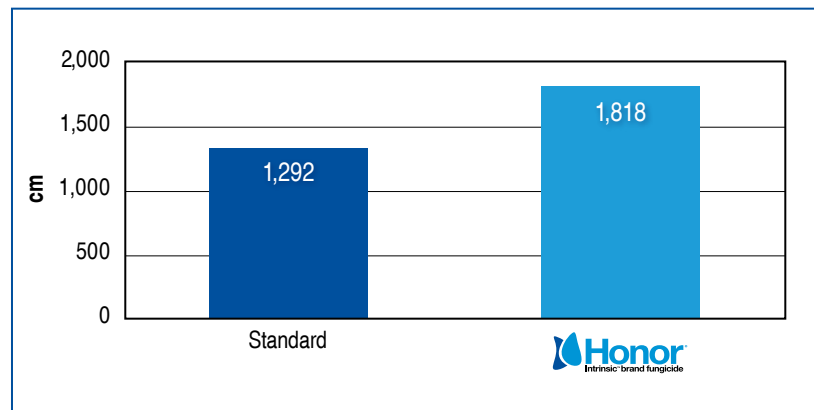
Individual demonstrations indicate that the increase in root growth can occur in both cool and warm season turfgrass species. When TifEagle ultradwarf bermudagrass greens were aerified in South Florida during late spring of 2010, **Honor Intrinsic**-treated greens showed a 154 cm. (20.7%) increase in total root length as compared to the golf course's standard spring fungicide treatment (Graph 9). Cool season turfgrass at Pilgrim's Oak Golf Course showed a 526 cm. (40.7%) increase in total root length as compared to the golf course's standard spring fungicide treatment as shown in Graph 10.

Graph 9: Total Root Length (cm) of TifEagle Ultradwarf Bermudagrass



*Hawk's Nest GC in Vero Beach, FL, 2010. Root measurements taken 14 days after treatment. Turf treated with **Honor Intrinsic** at 1.1 oz. rate.*

Graph 10: Total Root Length (cm) of Bentgrass/Poa annua Greens



*Pilgrim's Oak GC in Peach Bottom, PA, 2010. Root measurements taken 14 days after treatment. Turf treated with **Honor Intrinsic** at 1.1 oz. rate.*



Frequently Asked Questions for Intrinsic Brand Fungicides

1) What are **Intrinsic** brand fungicides?

A: **Intrinsic** brand is the family of fungicide products labeled for disease control and plant health. The launching pad of **Intrinsic** brand fungicides is based on the active ingredient pyraclostrobin. The first two products in this category are **Insignia SC Intrinsic brand fungicide** and **Honor Intrinsic brand fungicide**. In the future, BASF will launch other products under this brand that will include formulation enhancers and formulation technology.

2) How can you now say that pyraclostrobin has disease control and plant health benefits after six years in the marketplace?

A: Like many other products in the agricultural industry, once a product has widespread use, new observations are made that require further evaluation. This has been the case with pyraclostrobin in the turf market. Improved plant health was documented on golf courses that had been treated for diseases prior to a significant stress event and turf quality was improved vs. untreated turf.

Observed benefits include improved root development while above-ground effects can sometimes appear to be subtle. These benefits are more subtle when turfgrass is growing under ideal conditions, but express themselves more when turfgrass is stressed.

3) Does boscalid in **Honor Intrinsic brand fungicide** contribute toward the disease control and plant health benefits of pyraclostrobin when the product is used according to label directions?

A: Boscalid, the active ingredient, is part of the known synergy with pyraclostrobin for improved control of many diseases, resulting in better turf quality. Specific trials that focused on boscalid response in turf to stress factors such as drought, temperature, and mechanical stress were not conducted. These disease control and plant health trials looked solely at the response of the combination product.

4) What kind of scientific evidence do you have to demonstrate that **Intrinsic** brand fungicides do something in the plant to help combat stress?

A: We have researched disease control and plant health with pyraclostrobin in crops for over 10 years and in turf for over three years. Our findings show that several plant physiological processes are affected when pyraclostrobin is applied. These include: reduced CO₂ production, increased nitrate reductase activity, reduced ethylene production, and increased activity of stress-reducing enzymes.

5) How are the benefits from these products different than benefits from Bayer products containing StressGard®?

A: StressGard-containing products affect turf by filtering UVB radiation. In other words, it acts as a protectant to the turf. Pyraclostrobin, the active ingredient contained in **Insignia SC Intrinsic brand fungicide** and **Honor Intrinsic brand fungicide**, affects physiological (internal) processes in the plant which trigger protection from diseases and stresses, delivering more comprehensive stress tolerance.

6) Do other QoI fungicides exhibit similar plant health responses?

A: In BASF and university research, other QoI's which include azoxystrobin, have been compared in a number of studies and did not show the complete plant health effects observed from **Intrinsic** brand fungicides. Laboratory data has shown differences in the level of enzyme activity generated with azoxystrobin as compared to pyraclostrobin (SOD or nitrate reductase). BASF also manufactures several QoI fungicides and research has shown that pyraclostrobin is the most metabolically active for disease control and plant health benefits.

7) With pyraclostrobin being classified as a localized penetrant vs. azoxystrobin having acropetal systemic activity, how do **Insignia SC Intrinsic brand fungicide** and **Honor Intrinsic brand fungicide** provide a higher degree of disease control and plant health benefits?

Systemic activity does not necessarily result in better disease control or impart plant health benefits. **Insignia SC Intrinsic brand fungicide** and **Honor Intrinsic brand fungicide** control specific diseases (Pythium Root Dysfunction, Rapid Blight, Dollar Spot) that azoxystrobin does not control despite small translocation differences. There are also other active ingredients that have high mobility (such as fosetyl-al) but do not deliver broad spectrum control or greater efficacy on certain diseases solely because of that characteristic.

8) Explain the difference between plant health benefits from foliar fertility nutrition vs. **Intrinsic** brand fungicides.

A: Foliar fertility provides nutrients that turfgrass requires. Benefits from foliar nutrition are excellent turf color and normal growth characteristics. **Intrinsic** brand fungicides can help plants protect themselves from diseases and other stresses by utilizing their internal physiological processes to fight disease and mitigate stress, such as increased SOD activity. Fertilizer is the food for the turf to grow while **Intrinsic** brand fungicides are the medicine for turf to fight off diseases and stress.

9) How many applications does it take to see the plant health benefits?

A: We typically see benefits following one application that is applied for disease control and prior to the stress event. Priming the plant (in other words, treatment prior to a stress event) appears to be the best way to maximize on plant health benefits as well as disease control vs. treating after or during the stress event.

10) How long does the plant health effect last after an application?

A: Our turf studies have focused on showing plant health benefits days to weeks after application. Plant health effects gained from pyraclostrobin treatments, such as larger root growth, may benefit the plant even after the active ingredient eventually disappears. Future research will be focused to learn more about the long-term plant health benefits of pyraclostrobin treatments.

11) Can an end user expect this plant health effect at the lower end of the labeled rates?

A: **Insignia SC Intrinsic brand fungicide** and **Honor Intrinsic brand fungicide** were tested at mid and high labeled rates for disease control that results in plant health benefits; the lower rates for disease control have not been tested for plant health benefits.

12) Can I use **Intrinsic** brand fungicides to get plant health benefits if there are no diseases present?

A: The use directions on the product labels are specific for disease prevention and control. The products may only be applied to labeled use sites when disease is expected. You should apply any fungicide first as a preventative for disease control.

13) In terms of plant health benefits resulting from superior disease control, what are the pre-aerification timelines to achieve the best results for different turf species?

A: While we continue to determine pre-treatment timelines, our initial research indicates that applying **Insignia SC Intrinsic brand fungicide** or **Honor Intrinsic brand fungicide** for disease control around seven days prior to the stress event (aerification) will help provide plant health effects on Bermuda and bentgrass. Results are pending for Poa annua.

14) What other stress related performance benefits have been shown with **Intrinsic** brand fungicides?

A: **Intrinsic** brand fungicides like **Insignia SC Intrinsic brand fungicide** and **Honor Intrinsic brand fungicide** have been shown to provide disease control as well as protection from stresses like drought and temperature extremes.

15) Can foliar nutrition be utilized by the plant more efficiently after an **Insignia SC Intrinsic brand fungicide** or **Honor Intrinsic brand fungicide** application?

A: At the cellular level, significant increases in nitrate reductase enzyme activity have been measured. This enzyme converts nitrate to nitrite, the nitrogen source plants use to build proteins. Direct benefits from foliar/soil fertility changes and pyraclostrobin applications have not yet been investigated in turf.

16) Are there any products that may be used in a spray rotation, either before or after **Insignia SC Intrinsic brand fungicide** or **Honor Intrinsic brand fungicide** that would deter or alter the development of any measurable plant health benefits?

A: We have not observed any antagonism to **Intrinsic** brand fungicides with regard to performance with the use of other products prior to or after use.

17) The product label for **Headline® fungicide**, which also contains pyraclostrobin and is sold to the agricultural market, states that preventive applications of **Headline** can result in greater yields at harvest when used according to label directions for preventive disease control. Is this observed in turf?

A: In research trials, we have observed increased root development with **Insignia SC Intrinsic brand fungicide** or **Honor Intrinsic brand fungicide** but did not note any yield or growth enhancement in turf (faster growth rate, higher clipping yield, more seed heads).

Always read and follow label directions.

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