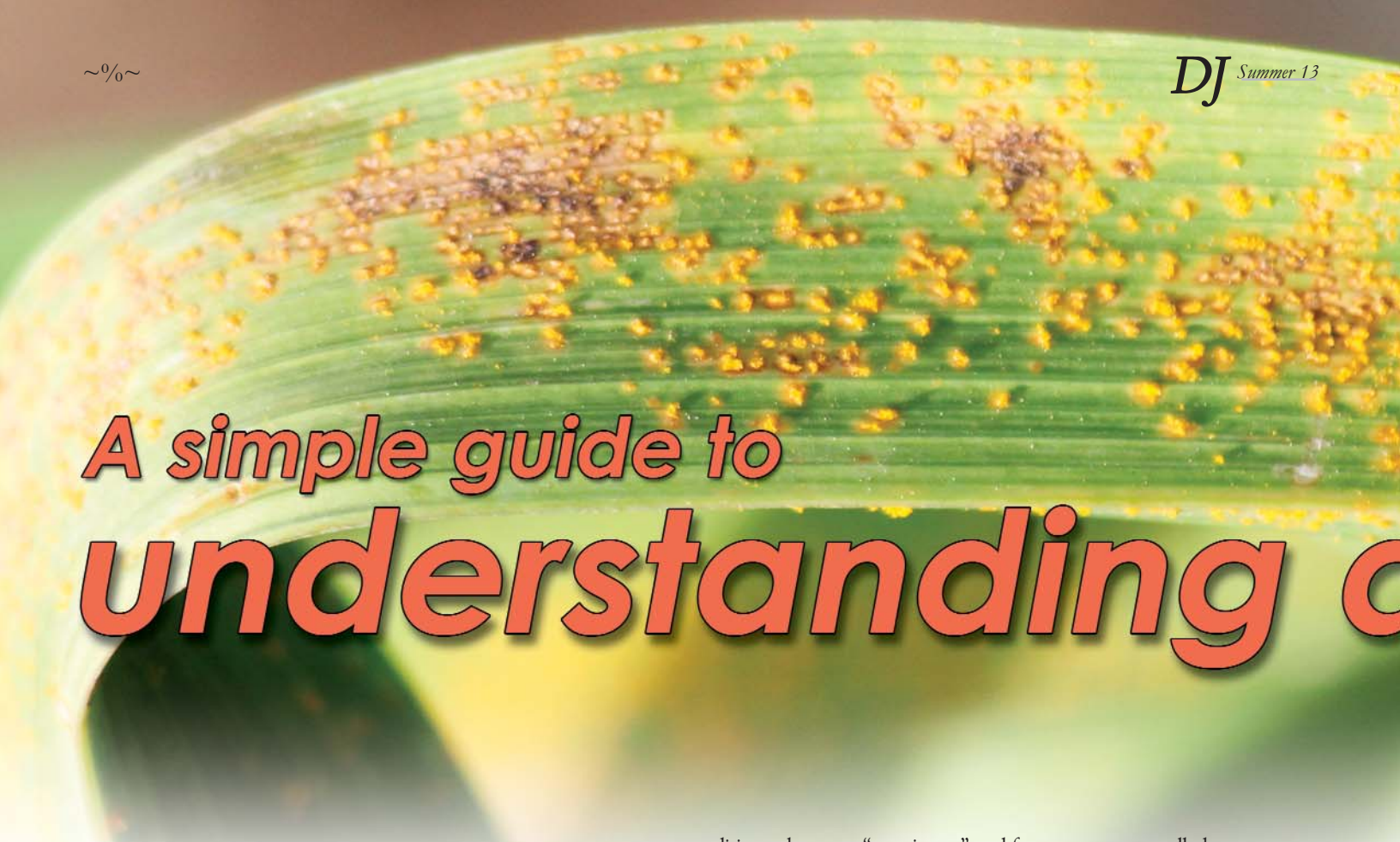

A simple guide to understanding c

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The number one question I am asked when doing programs around the country is: "How do I control rust in my garden?" Therefore, I have endeavored to present a simple guide to help the average daylily grower. This article's intent is to give a simplified explanation of the rust life cycle, and also to supply a sample guide for the treatment of rust, not to act as a comprehensive review of all fungicides effective against daylily rust. Doubtless, there are other classes of fungicides that are effective against daylily rust and other methods of control that are equally efficacious.

WHAT ARE RUSTS?

Rusts are members of the Fungus kingdom. As such, they have certain characteristics common to that kingdom. Fungi are heterotrophs, in that they rely on other organisms as a source of carbon (food) for metabolism, i.e., they get their nutrients from other organisms. Daylily rust, *Puccinia hemerocallidis*, in particular, is an obligate parasite, which means that it requires living plant tissues to grow, feed and reproduce. The spores, however, can live for an unknown period of time independently of plants. Daylily rust is also heteroecious, a term that means it is only capable of completing part of its life cycle solely on *Hemerocallis* species, but requires an alternate host plant to complete its entire life cycle.

RUST REPRODUCTION.

Rust reproduction can be a very complex process. Daylily rust is able to reproduce by both sexual and asexual (cloning) means. Part of the sexual life cycle must take place on an Asian plant known as *Patrinia*. Luckily for us, *Puccinia hemerocallidis* has not yet been observed to infect *Patrinia* species in North America. However, it is possible that *Puccinia hemerocallidis* will eventually infect *Patrinia* species here. This means that, at this time, in order to eliminate or control daylily rust, we need only concentrate on disrupting the asexual life cycle that occurs exclusively on daylilies. By the same token, it would also be safer not to grow *Patrinia*, just in case.

Most commonly, a daylily plant's first infection starts when a spore, known as a urediospore, also called a summer spore or repeating spore, is spread by the wind and lands on a living daylily leaf. Under proper conditions, the spore "germinates" and forms a structure called an appressorium over a stomate, through which it enters the interior of the leaf. Once inside, the rust begins feeding in the plant tissues, eventually forming a network of mycelium (fungal strands) inside the leaf. Under ideal conditions, usually seven to ten days, (may be much longer under non-ideal conditions) depending on temperature and other environmental factors, the rust produces a new mass of urediospores that erupt through the epidermis capable of infecting more daylily leaves[1]. As with many fungi, the only part of the organism that we normally see is the reproductive structure or the spores themselves. This is the part of the life cycle that we recognize as "rust" on our plants. These new spores are then spread by the wind, direct contact with other leaves, insects, or the careless gardener, and the process begins again. These cycles of infection by urediospores can continue indefinitely as long as conditions are favorable, as can occur in USDA Zones 7 and higher. Typically, in Zone 6 and lower, rust (the urediospore) is "killed off" in the winter.

However, a different spore type known as the teliospore, or winter spore is typically more durable and able to survive cold winters. When temperatures again warm up in the spring, teliospores can germinate on dead daylily leaves and produces basidiospores. Basidiospores cannot directly infect daylilies but must infect the alternate host plant, *Patrinia spp.*, where the sexual stage of the life cycle takes place[1]. The rust would then, in theory if *Patrinia* could be infected in North America, be able to infect a daylily. For this reason, rust is much less prevalent in colder climates in North America at this time. However, this does not necessarily mean that all the rust is gone because rust may still survive within living leaves as mycelium through the winter. Thus, plant leaves that remain green and alive may still harbor an existing infection that has not yet sporulated.

STOPPING THE SPREAD OF RUST

Because the main method of rust spread is by means of wind blown spores, and the fact that we are unlikely to limit the effects of blowing wind, we must focus our control efforts on other areas.

1. Preventing rust from germinating. One method is to make conditions difficult for the spores to "germinate" and infect new plants. In order for a spore to infect a plant two conditions must be met; there must be adequate moisture and temperatures. When temperature conditions

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— Ice Money photo

and treating rust in daylilies

are optimal, usually around 72-75 degrees F, a new spore requires that a host leaf remains wet for at least four to six hours. At lower temperatures, longer periods of leaf wetness may be required[2]. By reducing the factors that allow a leaf to remain wet for long periods of time, we can significantly reduce the germination of new spores. Eliminating overhead watering can greatly decrease the chances that the leaves remain wet long enough for germination to occur. In instances where this is not practicable, changing watering times to just before dawn, when the leaves are likely already wet from dew, can help decrease the "wet time" available for rust spore germination. Another effective method for reducing wet time is to increase plant spacing. This allows for greater airflow between plants and also has the benefit of reducing direct contact between adjacent plants. However, in my garden, and most other gardens I have visited, this is not a realistic option. If there is enough room to increase the spacing of the plants, there is enough room to fill that space with another daylily, rather than create a space grabbing "rust inhibition zone."

2. Removing infected plant tissues. Once a plant has been identified as being infected with rust, the first line of defense is the prompt removal and proper destruction of all infected foliage. The infected leaves should be removed in a manner that minimizes any contact with nearby plants. Keep in mind that disturbing the leaves will release spores into the air, necessitating the use a fungicide immediately after removal to protect the remaining stubs and other plants. It is not advisable to spray immediately before removal of infected plant tissue. This exposes the user to increased risk of toxic exposure. If spraying beforehand is determined to be absolutely necessary, read the label on your chosen fungicide to determine the Restricted Entry Interval (REI: the time after a pesticide application during which entry into the treated area is restricted) to avoid possible personal injury. Care should also be taken to properly disinfect hands and tools before touching any other daylilies. Infected leaves should not be used for mulch, but should be destroyed by burning or proper disposal in a landfill. Simply removing the leaf from the plant does not kill the spores present. An infected leaf that is left lying around the yard is capable of harboring rust spores and infecting healthy plants. Additionally, plants that consistently have problems with rust need to be eliminated from the garden and — even more importantly — any hybridizing program. That being said, however, the presence of a few "rust buckets" in the garden can be helpful to enable a hybridizer to more adequately test the rust resistance of new hybrids or to indicate when another round of fungicide application might be necessary.

3. Fungicides. Fungicides are the next line of defense for preventing and curing rust infections. However, because most fungicides act to prevent the disease from becoming established, rather than eliminating (curing) the disease, fungicides should not be used in place of proper cultural practices, but as an adjunct to a total rust control program only when proper cultural practices alone are insufficient to control rust.

CAUTIONARY STATEMENTS

1. READ THE LABEL. To avoid possible severe injury to your daylilies and other plants, **always read the entire label of any fungicide before applying** to your plants to determine the suitability of the product to your individual situation. If you have not used a product before, it is a good idea to perform a small test on some extra plants to determine the safety and efficacy of any product.

2. AVOID INJURY TO OTHER PLANTS. Spray drift management is of utmost importance. Do not apply any fungicide when conditions are favorable for drift, including when winds are gusty or greater than 10 mph, high temperatures-generally above 85 degrees F, and low humidity. Drift can be further reduced by using larger droplet sprays and applying as close to target plants as possible.

CHOOSING THE CORRECT FUNGICIDES

The task of choosing the correct fungicides to use can be daunting; there are literally hundreds of fungicides commercially available. A large number contain identical, or similar, active ingredients sold under numerous different trade names. Thankfully, the Fungicide Resistance Action Committee (FRAC) has sorted all the fungicides by their mode of action and decided on a convention known as a FRAC Code. (A FRAC Table can be accessed at www.frac.info/) All together there are 64 different FRAC Codes and only about a dozen different modes of action. Out of these, only a few have been proven to have a significant level of effectiveness on *Puccinia hemerocallidis*. Some of these code groups, with an example or two of the trade names of appropriate formulations effective specif-

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ically against *Puccinia hemerocallidis*, are:

Code 1 – Cleary's® 3336;
Code 3 – Banner Maxx®, Strike®;
Code 11 – Heritage®, Compass® O;
Code M3 – Dithane®;
Code M5 – Daconil®.

Another Code group that contains fungicides stated on the product label to be effective against rusts, in general, is:

Code NC (Not Classified) – Double Nickel 55®, Triact® 70 (a neem oil product)

Now that we have a list of potentially effective fungicides, how do we choose which ones to use? Just having a list and choosing products randomly, is not sufficient.

First it is important to understand some population genetics. In any instance where large populations of any organism exist, the possibility of individuals that are tolerant of different chemical control measures exists. This may be as few as one in a billion or greater. Organisms, in this case rust, become resistant when the same fungicide, or class of fungicide, is used repeatedly allowing only those few resistant rust organisms to survive. These selected rust organisms quickly reproduce and become the dominant strain that is partially or completely resistant to the fungicide that at one time was very effective. For this reason, fungicides should always be used in a regular program that relies on a rotation of products with different modes of action, from different FRAC Codes, not just different brands within a FRAC Code. The greatest danger of resistance formation and fungicide failure occurs when rotating or alternating between products with the same mode of action in the high-risk categories of Code 1 and Code 11 fungicides. The least chance of resistance formation and the greatest success comes from a program that uses a regular rotation of products from as many different FRAC Codes as possible and combines products from two or more FRAC Codes in each treatment.

Rust is present in a whole daylily bed.
— MaryAnn Pruden photo

Before we begin choosing products for our rotation, it is important to understand that there are two major classifications of fungicides based upon where they work: the systemic fungicides and the contact fungicides.

Codes 1, 3 and 11 are the systemic fungicides. This means that they are absorbed into the plant tissues and act to protect, and to some extent eliminate rust from, the tissues, from the inside out. For this reason some are considered to be curative as well as protective. This sounds great. Why would we need anything else? The problem is that there are two limitations. First, while the "protective" activity is present whenever the fungicides are in place, the "curative" activity only occurs if the active fungicide ingredients are present within the plant tissues prior to infection or in the first 72 hours after infection, but they are not effective against more advanced latent infections[3]. Second, these are the same fungicides with the greatest risk of resistance formation, and, therefore, failure. The labels on many of these fungicides recommend that they be used no more than one time in succession in a rotation before using at least one, if not two different classes of fungicides. To further decrease the chance of failure with the systemic fungicides, it is often recommended that a combination of systemic and contact fungicides be employed in each treatment.

The contact fungicides especially active against *P. hemerocallidis* are found in Codes M3 and M5, and NC (specifically, Triact® 70). This group of fungicides acts mainly by establishing a barrier, either chemical, as in the case of M3 and M5, or physical, as in the case of Triact® 70. All three of these classes of contact fungicides have the advantage of having a very low risk of resistance formation. However, the Code M3 and M5 fungicides have two serious limitations that can reduce their usefulness, or require additional steps to be taken to ensure their overall effectiveness. First, these fungicides are not generally considered to have curative properties, rather they can only prevent rust from becoming established. Additionally, they are only effective when actually present on the leaf surface. After application, these fungicides tend to wash off of the leaves the when it rains or the overhead sprinklers come on, reducing or completely eliminating their effectiveness. Fortunately, we can use the Triact® 70 from Code NC to combat this problem. While the use of neem oil has long been established as a plant leaf polish, it also has the beneficial effect of killing rusts, mainly by dehydration, and works wonderfully as a spreader-sticker when the Triact® 70 formulation is used and added to rust spray mixtures[4,5,6]. Therefore, using Triact® 70 in combination with a contact fungicide from Codes M3 or M5 helps ensure that the fungicide remains in place, while at the same time, helping to prevent the rust. It should be noted that it is not recommended that neem oils be used in conjunction with chlorothalonil (Daconil®) on hot days to prevent burning of the leaves. From my own experience, Triact® 70 is safe to use with all the other fungicides listed in this article. However, care should be taken to follow the label directions carefully and to test a small area first to confirm the safety of this product in your individual situation. The use of pure neem oil extracts, other than Triact® 70 is not encouraged due to the increased chance of phytotoxicity.

Microbial disruptors. Double Nickel 55® is a formulation containing *Bacillus amyloliquefaciens* strain D747 (Double Nickel 55® does not contain any nickel). According to the product label[7], this is a broad-spectrum preventative biofungicide for control or suppression of fungal and bacterial plant diseases. The active ingredient of Double Nickel 55® is the naturally occurring strain, D747, of the beneficial rhizobacterium *Bacillus amyloliquefaciens*, which colonizes roots, leaves, and other plant surfaces. D747 rapidly colonizes plant root hairs, leaves, and other surfaces, preventing establishment of disease-causing fungi and bacteria. It can be applied alone, or in combination with other fungicidal applications. Double Nickel 55® also has the added advantage of being certified by the National Organic Program (NOP) and listed/approved by the Organic Materials Review Institute (OMRI). Double Nickel 55® is safe to apply to vegetable crops up to and including the day of harvest. The Restricted Entry Interval (REI) is only until the product is dry on the leaves. Double Nickel 55® is used at the rate of ¾ teaspoon to ½ tablespoon per gallon every seven to ten days, per 1,000 square feet.

Summary. A complete rust prevention program incorporates two main areas of focus. The first is the implementation of proper cultural

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practices. These practices include making it more difficult for rust to germinate by decreasing wet time and increasing plant spacing, and by decreasing the spread of rust spores by the proper handling, disposal and/or complete removal of infected plants and foliage. The second is the implementation of a fungicide rotation program that includes fungicides from as many different appropriate FRAC Codes as practical, with no duplication of codes in successive treatments, and combining a systemic and a contact fungicide in each treatment. In addition, products containing neem oil (Triact® 70) and certain bacteria can be added to increase the effectiveness of the fungicides.

A SAMPLE SPRAYING PROGRAM

The following is a sample of the fungicide rotation program that we have used with great success in the "Rustbelt" of Southeast Georgia. The minimum spray interval is seven to ten days, but was modified, as needed, depending on factors such as temperature, humidity, rain, and the presence or absence of rust on a known indicator plant or rust bucket. If rust is under control in the garden, the interval can be increased greatly. Spraying should begin before good rust growing conditions occur in your area. In Southeast Georgia this will be as early as February. The rule we go by is: When the daylilies begin to grow it is time to begin spraying. Note that in each case, a systemic fungicide is paired with a contact fungicide.

	Systemic Fungicide Code	Contact Fungicide Code	Microbial disruptor
Treatment 1	3	M3	Double Nickel 55
Treatment 2	1	M5	
Treatment 3	11	M3	
Treatment 4	3	M5	
Treatment 5	1	M3	Double Nickel 55
Treatment 6	11	M5	
Treatment 7	3	M3	
Treatment 8	1	M5	
Treatment 9	11	M3	Double Nickel 55
Treatment 10	3	M5	
Treatment 11	1	M3	
Treatment 12	11	M5	

Code group	Active ingredient (product)
Code 1	Thiophanate-methyl (Cleary's® 3336F)
Code 3	Propiconazole (Banner Maxx®)
Code 11	Pyraclostrobin (Compass® O)
Code M3	Mancozeb (Dithane® 75DF)
Code M5	Chlorothalonil (Daconil® 500ZN)
Code NC	Triact® 70, Double Nickel 55®

Note: Triact® 70 was added to all spray solutions at the rate of five tablespoons per gallon as a spreader-sticker/fungicide.

Note: The Double Nickel 55® (Code NC), although labeled for use as a weekly or biweekly application, appears to only require one to three treatments per growing season in our area for effective control.

For more information, please feel free to go to www.scottelliottdaylilies.com where more in depth information can be found. Or, email me at scottelliottdaylilies@yahoo.com. ■

References

1. Daylily Rust Information Page. Sue Bergeron. http://web.ncf.ca/ah748/rust.html
2. Effects of Light, Temperature, and Leaf Wetness Duration on Daylily Rust, 2003. D. S. Mueller and J. W. Buck, University of Georgia, Department of Plant Pathology, Georgia Station, Griffin 30223.
3. Preventative vs. Curative Fungicides by Daren Mueller and Alison Robertson, Department of Plant Pathology, Iowa State University Extension. http://www.extension.iastate.edu/CropNews/2008/Preventative+or+curative+fungicides.htm
4. Update on Rust Diseases and Their Control. A. R. Chase. Chase Horticultural Research, Inc. 8031 Mt. Aukum Rd., Suite F, Mt. Aukum, CA 95656-0529 www.chasehorticulturalresearch.com.
5. Fungicides On The Horizon. Ann Chase. 2003. Greenhouse Chemical Trends. http://www.gpnmag.com/sites/default/files/02%20Fungicides.pdf
6. Triact® 70 Product Description http://www.ohp.com/Products/triact_70.php
7. Double Nickel 55® Product Label. http://www.cdms.net/LDat/ldAIE004.pdf

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