What's New in Downy Mildew?

With the emergence of downy mildew diseases over the past several years, what is your best approach to limiting possible threats?

BY A.R. CHASE

Over the past 15 years, a number of downy mildew diseases have "emerged," or maybe we are finally noticing them. The emergence of impatiens downy mildew has created quite a stir, leading to permanent changes in impatiens production and use. A similar situation with basil downy mildew has now led to all of the same changes.

There are many trials each year that evaluate fungicides for impatiens or basil and some trials on rose. There are few others for any other ornamental downy mildew. Other evaluations, with the exceptions of taxonomic work on the pathogens themselves are very rare.

Recently, we saw downy mildew on Red Apple ice plant (Aptenia) ground cover pop up a few winters ago in southern California. It wiped out 25-year-old plantings during the very wet winter. Downy mildew had previously been found on a few relatives of Aptenia including Mesembranthymum and Malabar spinach — also in the Aizoaceae family.

Generally speaking, the plants in a single family are susceptible to the same downy mildew pathogen. The impatiens downy mildew is only found a on few species in the impatiens genus. Basil downy mildew does not appear to attack other members of the mint family (like salvia and lamium, which do get downy mildew). However, there are many exceptions. For instance, there are a number of pathogens that affect different members of the Asteraceae family including: *Plasmopara halstedii* (osteospermum, rudbeckia and sunflower) and *Basidiophora entospora* (aster and callistephus). In addition, some plants can be attacked by multiple downy mildew pathogens. Pansy/viola can be attacked by *Peronospora violae* and *Bremia megasperma*.

EPIDEMIOLOGY

Knowing the factors that trigger an outbreak or stimulate sporulation are key elements of an effective control strategy. Two studies have reported on some specifics for temperatures and leaf wetness (basil and impatiens).

Epidemiology for impatiens downy mildew was reported in 2017 by Michigan State University (Harlan, Granke and Hausbeck). Optimal sporangial production occurred at 77° F. Development on plants incubated at 59 and 68° F was much lower. No pathogen sporulation was observed on plants incubated at 86° F.

Leaf wetness from a short three hours to 24 hours was evaluated for effects on sporulation. A leaf wetness period at least six hours yielded the highest level of sporangia, although three hours of leaf wetness did result in a good level of infection as well.

Researchers in Italy performed trials 10 years ago to determine factors that promote disease. Figure 1 shows the percentage of the leaf area with downy mildew sporulation after varying times of leaf wetness with the highest sporulation after 48 hours of leaf wetness. A follow-up trial was performed using shorter periods (0, 1, 2, 3, 6, 12 and 24 hours) and it demonstrated that a minimum of six hours of leaf wetness was needed for infection. Finally, the researchers tested the effect of 100 percent relative humidity (RH) on disease development after a 24-hour leaf wetness period. In this case, all times less than 12 hours resulted in no disease. At 12 hours of 100 percent RH, very slight disease developed. While at 24

Fungicide	Active Ingredient	FRAC Code	Level of Efficacy
Aliette	fosetyl Al	33	very good to excellent
Compass	trifloxystrobin	11	some to excellent
Daconil	chlorothalonil	M5	very good
FenStop	fenamidone	11	very good to excellent
Heritage	azoxystrobin	11	none to very good
Kocide	copper hydroxide	M1	good
Micora	mandipropamid	40	very good
Mural	azoxystrobin and solatenol	11 and 7	very good
Orvego	dimethomorph and ametoctradin	40 and 45	some to excellent
Pageant Intrinsic	pyraclostrobin and boscalid	11 and 7	very good
Segway O	cyazofamid	21	good to excellent
Stature	dimethomorph	40	very good to excellent
Subdue MAXX	mefenoxam	4	very good to excellent

Table 1. Fungicide summary for rose downy mildew.

hours of 100 percent RH, severity was moderate. *Peronospora belbahrii* requires at least six hours of leaf wetness to infect leaves and at least 12 hours of leaf wetness to cause severe infections.

The second series of trials evaluated effects of temperature. Overall, results showed that highest disease occurred when the temperature was 68° F, with no disease at 54° F or 81° F. Thus, basil downy mildew requires mild temperatures to develop.

Many downy mildew pathogens have similar temperature optima, but some actually are more severe in warmer conditions — for example, coleus downy mildew. Watch for disease, especially in spring and fall when temperatures are likely to be conducive to disease.

DOES PLANT TYPE AFFECT FUNGICIDE CHOICE?

I was recently asked to recommend fungicides for control of onion downy mildew. My first response was to find all of the recommendations and trials that were published on this disease. These trials showed that under most conditions, only a combination of mefenoxam and chlorothalonil (Ridomil Gold Bravo) and mancozeb (Maneb) were highly effective on this downy mildew. Some of the other fungicides we have seen provide excellent control on ornamental downy mildews worked well under low disease pressure for the onions.

Reviewing some trials on lettuce downy mildew performed at the University of Florida Everglades Research and Education Center by Raid and Sui in 2012 had dramatically different results than the onion work. On lettuce, rotations of very effective products with a less effective product were as effective as the use of effective products alone. This has not been the case with some diseases on other vegetables where using the best products on a longer interval was superior to alternation of them with a marginally effective product.

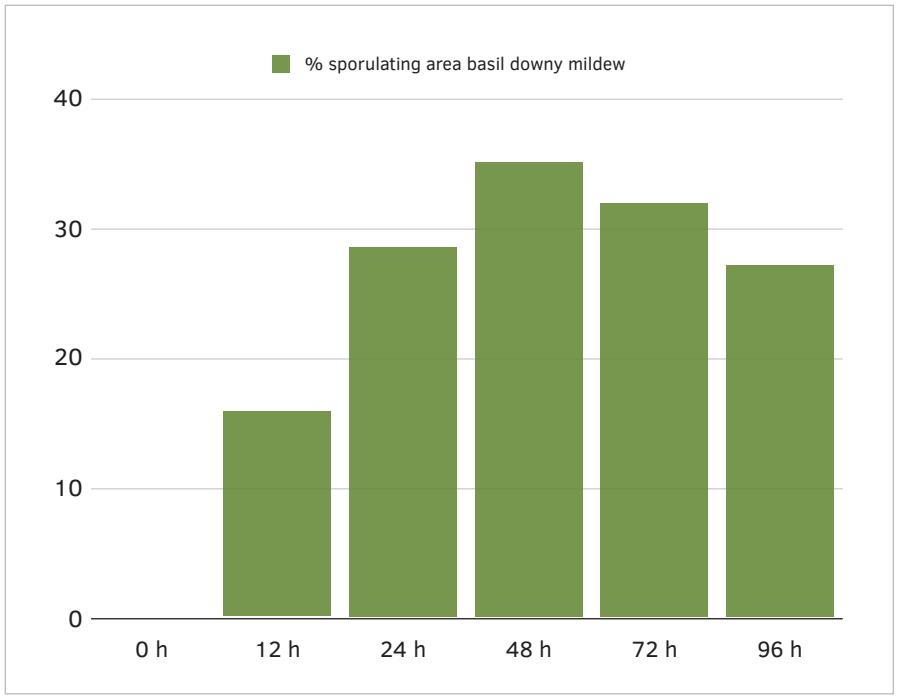

Figure 1. Percentage of leaf area with downy mildew sporulation after varying times of leaf wetness.

What does all of this have to do with downy mildew control on ornamentals? First, it confirms what I have seen in research on some crops where certain products are either not safe for a specific ornamental or the interaction is somehow not as effective. Alyssum downy mildew is very hard to control because the crop is so sensitive to fungicides. In our trials, only phosphites (like Aliette) were safe and effective on this alyssum.

I have noted that use of strobilurins on rose downy mildew does not consistently yield the very high degree of control seen with the same products on other crops. Impatiens downy mildew is uniquely controlled to a very high degree with a single seed drench of Subdue MAXX and Adorn. Once the impatiens are in the landscape use of Subdue G may be contraindicated due to widespread pathogen resistance (found in South Florida).

So, the picture is a lot more complicated than just finding a list of effective downy mildew products. You must see if specifics on the crop you are growing point you to or away from some of the registered products. Make sure to watch the crop carefully and make your own judgement based on your results. While you must adhere to product labels, that does not mean you have to use everything that is labeled for a crop to obtain a high degree of control. Using two or three FRAC groups is an effective way to prevent resistance, which is so common for most, if not all, downy mildew pathogens. Rotations are as effective as tank mixes and should actually be less costly and easier to interpret their efficacy.

So, what do you do about uncommon ornamental crops? If you were growing vegetables, you would have many resources. In ornamentals, however, the most common situation is that there are no trials on downy mildew specific to your crop. Resort to a generalized list (see Table 2).

Product	FRAC group
Adorn	43
Aliette (and others)	33
FenStop	11
Heritage	11
Micora	40
Orvego	40, 45
Pageant Intrinsic	7, 11
Segway O	21
Segovis	49
Stature SC	40
Subdue MAXX	4

Table 2. Some fungicides for downy mildew on ornamentals.

FUNGICIDE RESISTANCE

There is little fungicide resistance proven for ornamental crops. The most glaring exception to this is impatiens downy mildew where resistance is rampant in some locations. In contrast, fungicide resistance in basil downy mildew that is treated at least as extensively as impatiens (in greenhouse production) has not been seen. One difference may be that the large amount of organic basil may never have resulted in overexposure of really effective products, which can aid in resistance development.

Although many of the same active ingredients are used in field production of basil in Florida, resistance has not developed. The best control for basil downy mildew in a recent trial was mefenoxam, OXTP, cyazofamid and dimethomorph. There appears to be something basically different about the pathogen since resistance to some of these fungicides in Florida impatiens does exist. Table 3 shows a short list of the active ingredients reported with impatiens downy mildew resistance.

Active ingredient	Location
Azoxystrobin	California
Cyazofamid	Florida
Dimethomorph	Florida
Fluopicolide	California, Florida, New Jersey
Fosetyl Aluminum	Florida, Holland, Illinois
Mefenoxam	California, Florida, Holland, Illinois, Michigan, New Jersey
Phosphorous Acids	Florida

Table 3. Impatiens downy mildew fungicide resistance.

ORGANIC BASIL PRODUCTION

A trial performed in 2016 to evaluate some newer biological/organic products for basil downy mildew was reported by McGrath and Sexton (LIHREC – Riverhead, New York – Cornell University). They included some biologicals like Double Nickel (*Bacillus amyloliquifaciens*, Triathlon BA), Howler (a combination of bacteria and fungi), Procidic (citric acid), Milagrum Plus (*Bacillus subtilis* strain IAB/BS03), a copper product Cueva, and a conventional standard.

The disease developed naturally over the course of the trial. Among the products tested for organic production, only Cueva (=Camelot O, copper octanoate) was able to provide control (44 percent) compared to the untreated control, and compared to the 96 percent control provided by the conventional grower standard treatment (data not shown).

Meanwhile, back in Florida, Raid (Everglades Research and Education Center) reported on efficacy of some of the same products. Raid found

Treatment/rotation	Large Leaf Basil	Eleanora Basil
Nontreated	72 a	55 ab
Regalia/Cueva	58 b	39 c
Sil-Matrix/Cueva	30 c	15 d
Double Nickel/Cueva	73 a	54 bc
Double Nickel/Regalia alt Cueva	64 ab	44 bc
Procidic/Cueva	27 c	15 d
Cueva (14 day interval)	73 a	64 a
Double Nickel/Regalia alt Cueva	28 c	19 d
Numbers in the same column followed by the same letter are not significantly different.		

Table 4. Florida trial on organic basil production.

that on two basil cultivars results were more or less the same (see Table 4). The most efficacious treatments were those containing Sil-Matrix (used every week), Procidic (alternated with Cueva) and the tank mix of Double Nickel and Regalia alternated with K-Phite (phoshonate). None of the products were clearly strong against this downy mildew in their own right. The use of somewhat effective products on a weekly interval was better than weekly applications of products with low if any efficacy. By the way, phosphonates like K-Phite and Aliette are excellent for downy mildew control on many crops.

You will have to try these on your own to decide if you can produce organic basil. Be sure to check fungicide labels (organic or conventional) for legal uses.

RECENT IMPATIENS DOWNY MILDEW TRIALS

Tom Freiberger (USDA-ARS, Rutgers University-IR-4 Ornamental Program) performed a couple of trials in 2016 for control of downy mildew on two impatiens cultivars.

Aptenia (ice plant) downy mildew.

Applications started on July 19, 2016, and continued at a seven, 14, 21 and 28 day interval depending on the fungicide. Plants were rated for sporulation on a 1 to 5 scale at various times and the graph below shows the final AUDPC (area under the disease progress curve).

Alude, Alude rotated with Orkestra Intrinsic, Segovis, and Segovis rotated with Inosco were very good on both cultivars. Adorn and Subdue were included in these experiments to monitor possible resistance development in this IDM population. As expected, the *Peronospora obducens* population was not affected by either product resulting in high levels of sporulation and subsequent plant decline. Prior to this year,

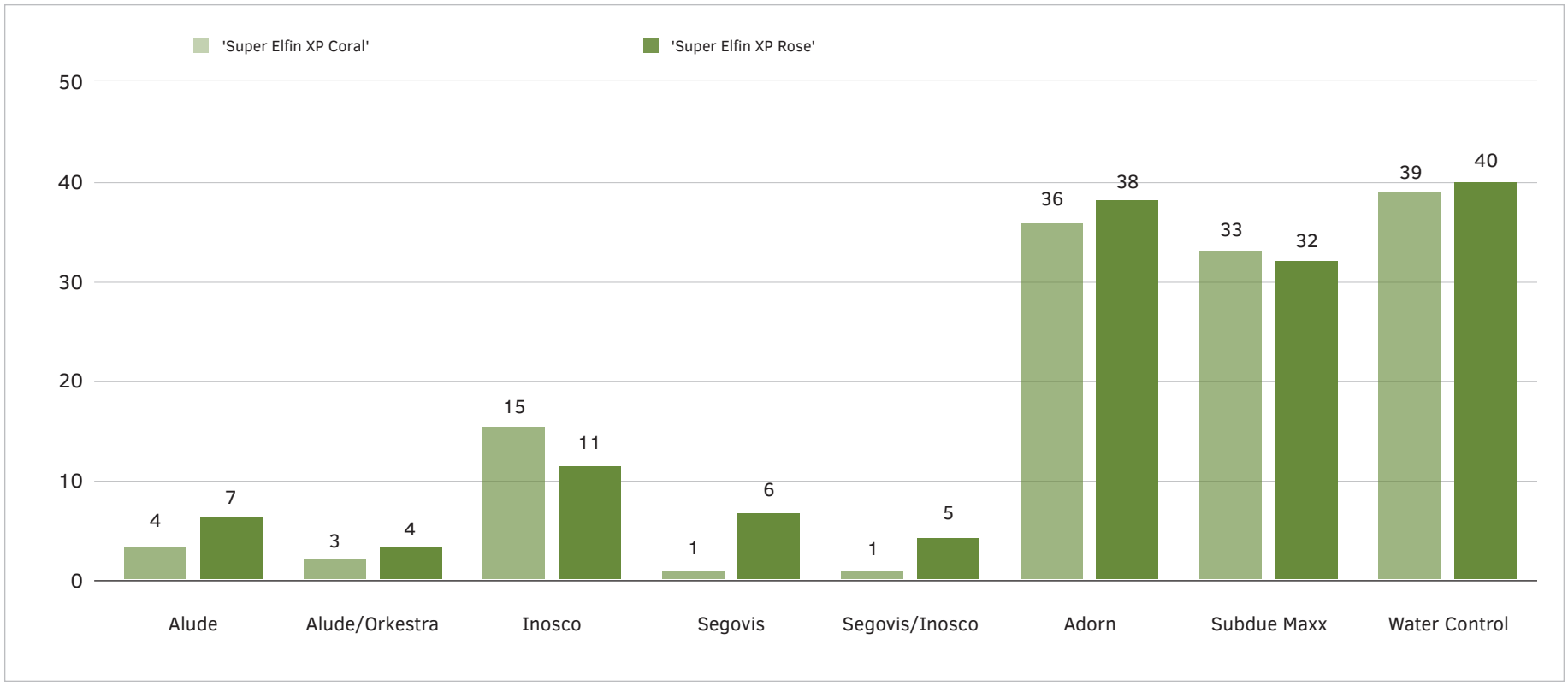

Figure 2. Severity of impatiens downy mildew on two cultivars of impatiens as affected by various fungicides. Plants were rated for sporulation on a 1 to 5 scale at various times. Graph shows the final AUDPC (area under the disease progress curve).

Alude treatments typically had high quality with heavy sporulation, but during 2016 very little sporulation occurred with Alude-treated plants.

These results show that IDM populations are not always consistent from year to year, making the choice of effective products challenging. Always rotate between effective FRAC groups or use tank-mixes of effective FRAC groups. These include FRAC 49 (Segovis), FRAC 11/7 combinations (Pageant Intrinsic and Orkestra Intrinsic are two examples), and FRAC 40 (Stature and Micora).

The picture for downy mildew control on ornamentals and other greenhouse-produced crops is changing very fast.

In some parts of the U.S., older products like FRAC 4 (Subdue Maxx), FRAC 43 (Adorn), FRAC 21 (Segway O) and many members of FRAC 33 (Aliette, Alude and Inosco for example) remain effective rotational partners. In the case of impatiens downy mildew, make sure you pay attention to your results since what works this year may not be the same as what worked last year.

SEGOVIS FUNGICIDE

Segovis is a systemic fungicide containing the active ingredient oxathiapiprolin (FRAC 49) delivering long-lasting control at low use rates. Foliar and drench applications have shown long-lasting protection at low

Downy mildew on buddleia cuttings.

Treatment interval	Average # infected leaves	Mean incidence (%)
Non-treated	13.9 a	15.1 a
7 days	1.1 b	0.9 b
14 days	1.8 b	1.5 b

Table 5. Effect of timing on rose downy mildew using a fungicide program.

use rates. Drench applications also can be used to effectively control downy mildew in various plant systems such as impatiens, roses and other herbaceous crops. Against impatiens downy mildew, a single drench application of Segovis at 1.2 ounces/100 gallons provided complete disease control for up to 52 days after treatment.

In 2016, two studies on rose downy mildew control were conducted on 'Pink Double Knockout' roses by Baysal-Gurel (Tennessee State University). In the first trial, fungicide applications were initiated when the first signs of downy mildew appeared. The initial spray was a tank mix of Subdue Maxx (2 ounces/100 gallons) and Micora (4 ounces/100 gallons). Then plants were split into two treatments and the following alternation was applied either weekly or every other week: Mural (7 ounces/100 gallons) and Segovis (2 ounces/100 gallons). Results are shown in Table 5. Clearly the spray rotation worked very well whether it was applied on a seven or 14-day interval. Disease incidence was relatively low in the trial and the seven-day interval may have been necessary had disease pressure been higher.

In another trial using the same cultivar of rose, plants were drenched instead of sprayed. They were planted in a 3-gallon container and irrigated from overhead daily. Pots were drenched with about 20 ounces per pot after the first signs of symptoms appeared. Rates in the graph are per 100 gallons. The average number of infected leaves and the mean percentage incidence showed the same trends with statistically significant control using any of the drenches compared to the non-treated control. Downy mildew severity in this trial was higher than in the first trial.

Applications of Segovis as a drench are showing very long residual activity on downy mildew control. It might be a good idea to mix Subdue Maxx or Micora with Segovis when used for downy mildew to maintain

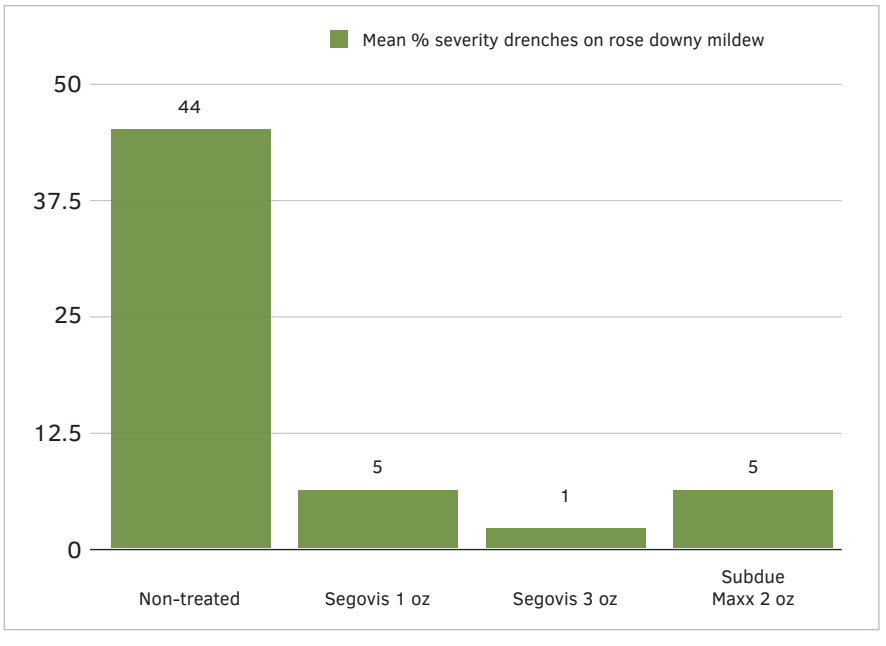

Figure 3. Effects of fungicide drenches on rose downy mildew.

efficacy of this new fungicide for as long as possible. Resistance is all too easy for the downy mildew fungi to develop.

CONCLUSIONS

The picture for downy mildew control on ornamentals and other greenhouse-produced crops is changing very fast. Organic production is nearly impossible on crops like basil, but the public desire for this product remains high. The best approach will be to change the environment to limit the time the disease is favored. Creating an environment that does not favor downy mildew is costly, but it may be the only long-term solution for this organic crop, unless basil breeding provides a resistant cultivar that has good culinary characteristics.

For ornamentals, our worst problem is the very low number of researchers available to identify new downy mildew threats before they are realized. We are still getting new fungicide FRAC groups registered that are increasingly effective as well as maintaining usefulness of older FRAC groups in some crops. So far (today at least) we are winning the downy mildew war with new conventional and organic choices on most of our crops. gpn

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