HOST PLANT RESISTANCE

an untapped weapon in the fight against fusarium

With fusarium incidence on the rise, lisianthus growers may want to start fighting infection before symptoms even occur. Starting with naturally resistant cultivars would be the first step in a truly integrated disease management program.

By Brent K. Harbaugh and Robert J. McGovern

While lisianthus has become an extremely important cut flower in the last decade, it certainly is not an easy crop to produce. Lisianthus seems to be plagued with a number of diseases, and *fusarium* crown and stem rot is one of the most damaging. It has been reported as a disease of lisianthus produced both as potted plants and cut flowers, but it has been especially devastating in cut flower production. For example, in 1997 we surveyed three Florida and four California cut flower production sites for crown and stem rot incidence; plant mortality was as high as 70 percent.

The causal agent of this disease, *Fusarium avenaceum* (Fr.; Fr.) *Sacc.*, primarily attacks the crown and stems of lisianthus, but may also rot the taproot and large feeder roots near the soil line. The first above-ground symptom is a gradual loss of green coloration in leaves, which is followed by tan leaf flecks, browning of leaf veins and a tan discoloration of entire leaves. Wilting and a brown stem rot occur as the disease progresses, and infected plants rapidly die. Orange spore masses form on the bases of rotted stems and are diagnostically very important.

Research on several fronts has led to the development of chemical and cultural control measures that have given some relief in the management of *fusarium* in recent years. However, one approach to disease management that has received inadequate attention is the evaluation of resistance in existing lisianthus cultivars and the development of resistant cultivars. There has been an explosion of new cultivars released within the last decade, with over 85 cultivars available in the United States in 1999, but we are not aware of breeding efforts specifically aimed at developing resistance to *F. avenaceum*. We initiated a research project to evaluate 46 cultivars of lisianthus to determine if resistance exists that could either be used in current control strategies or as a first step toward the breeding of resistant cultivars.

Symptoms of crown and stem rot of lisianthus caused by Fusarium avenaceum. *(Photos courtesy of Brent Harbaugh.)*

RESEARCH METHODS

Sixteen blue/purple, 15 pink and 15 white flowering cultivars of lisianthus were selected from five different breeding programs: American Takii Inc., Salinas, Calif.; PanAmerican Seed Company, Elburn, Ill.; Fukukaen Seed Company, Japan; Sakata Seed America Inc., Morgan Hill, Calif.; and University of Florida, Bradenton, Fla. In this preliminary study, we were interested in examining a representative sample from many sources in order to develop an understanding of the gene pool that may contain resistant genes.

Each color group was evaluated separately due to space limitations in the growth chamber, and, as a result, there were differences in certain production practices that necessitated analyzing each color group as a separate experiment. Seeds

Table 1. Percentage of 40 plants of blue/purple flowering lisianthus cultivars showing symptoms of crown and stem rot 55 days after inoculation with Fusarium avenaceum *(top to bottom, most to least susceptible).*

Cultivar	Seed source	Plants with symptoms (%)
Mermaid Blue	Sakata	100
Tiara Purple	Takii	93
Maurine Blue	U.Fla.	85
Florida Blue	U.Fla.	80
Flamenco Purple	Sakata	59
Laguna Deep Blue	PanAm.	58
Echo Blue	Sakata	56
Lisa Blue	PanAm.	50
Heidi Deep Blue	Sakata	49
Tyrol Blue	Sakata	45
Mariachi Blue	Sakata	40
Yodel Blue	Sakata	38
Royal Purple	Takii	33
Bridal Violet	Takii	30
Ventura Deep Blue	PanAm.	25
Hallelujah Purple	Fukukaen	25

Table 2. Percentage of 40 plants of pink flowering lisianthus cultivars showing symptoms of crown and stem rot 55 days after inoculation with Fusarium avenaceum *(top to bottom, most to least susceptible).*

Cultivar	Seed source	Plants with symptoms
Maurine Pink	U.Fla.	98
Florida Pink	U.Fla.	90
Lisa Pink	PanAm.	85
Mermaid Pink	Sakata	85
Echo Pink	Sakata	83
Royal Pink	Takii	80
Tiara Pink	Takii	78
Tyrol Rose Pink	Sakata	73
Flamenco Rose Pink	Sakata	58
Hallelujah Pink	Fukukaen	53
Ventura Rose	PanAm.	50
Heidi Rose Pink	Sakata	40
Laguna Pink	PanAm.	40
Mariachi Pink	Sakata	40

Table 3. Percentage of 40 plants of white flowering lisianthus cultivars showing symptoms of crown and stem rot 55 days after inoculation with Fusarium avenaceum *(top to bottom, most to least susceptible).*

Cultivar	Seed source	Plants with symptoms
Florida White	U.Fla.	100
Malibu White	PanAm.	100
Maurine White	U.Fla.	100
Tiara White	Sakata	100
Yodel White	Sakata	100
Royal White	Takii	98
Ballet White	Takii	93
Tyrol White	Sakata	90
Flamenco White	Sakata	88
Maurine White/Blue	U.Fla.	88
Mermaid White	Sakata	85
Mariachi Pure White	Sakata	83
Ventura White	PanAm.	60
Lisa White	PanAm.	55
Heidi Pure White	Sakata	53

were germinated at 72°–75° F (22°–24° C) in germination trays in a growth room with approximately 200 foot-candles of light from cool-white fluorescent lamps. The soil medium used in all aspects of these studies was, by volume, a 3 Canadian peat : 2 vermiculite: 1 perlite mix with a 6.7 (± 0.2) starting pH. Germination trays were moved to a glass greenhouse two weeks after sowing. Temperatures were maintained between 60° F (15.5° C) and 95° F (35° C). Seedlings were fertilized twice per week with a water soluble fertilizer (15-16-17) solution containing N at 250 ppm.

Seedlings were transplanted into 128-cell plug trays with eight plants of each cultivar per tray. Each cultivar was randomly placed in five trays making a total of 40 plants evaluated per cultivar. Seedlings at this stage were fertilized twice per week with a water soluble fertilizer (15-5-15) solution containing N at 500 ppm.

Before inoculation with *F. avenaceum*, and for the rest of each study, seedlings were moved to a growth chamber maintained at 66˚ F ± 2˚ F (18.9˚ C ± 1° C). This is the temperature we found to be ideal for *fusarium* infection and disease development. Cool-white fluorescent lamps provided approximately 950 foot-candles for 16 hours per day. Plug trays were placed in individual 1-inch deep trays, and plants were provided water and fertilizer solution via subirrigation.

Inoculum was prepared by blending carnation leaf agar plates of 5–7 day old cultures of a highly virulent isolate of *F. avenaceum* in tap water at a ratio of one plate per 100 mL of water. Ten mL of the *F. avenaceum* inoculum was applied to the soil around each plant, which saturated the soil medium in each plug. A method for uniform inoculation is essential when screening for resistance, and we developed this technique over several years so that we could ensure a high infection rate.

The frequency of plants expressing characteristic well-developed symptoms of *F. avenaceum* (browning of leaf veins, stem lesion and/or crown rot) was recorded at 25, 40 and 55 days after inoculation. Although seedlings often have a slight chlorosis before fully developed symptoms are expressed, this chlorosis is similar to that caused by *pythium* or nutritional imbalances and thus is not definitive for signaling infection by *F. avenaceum*. Symptomatic plants were randomly sampled throughout all tests to confirm infection by *F. avenaceum* by re-isolation of the pathogen on Komada's medium.

CULTIVAR SUSCEPTIBILITY

Blue Cultivars. The frequency of diseased plants (i.e., percentage of plants with characteristic symptoms caused by infection with *F. avenaceum*) ranged from a low of 10 percent for 'Ventura Deep Blue' to a high of 55 percent for 'Tiara Purple' 25 days after inoculation. By day 40, Ventura Deep Blue continued to have the lowest percentage of disease (18 percent), while 100 percent of 'Mermaid Blue' plants were diseased. The frequency of diseased plants at day 55 (see Table 1) ranged from 25 percent for Ventura Deep Blue and 'Hallelujah Purple' to 85 percent for 'Maurine Blue', 93

Ventura Deep Blue (far left) and Bridal Violet (second from left) lisianthus released from different seed companies exhibited partial resistance to fusarium *crown and stem rot. Mariachi Pink (second from right) and Echo Pink (far right) double-flowering lisianthus cultivars expressed different levels of susceptibility for* fusarium *crown and stem rot.*

percent for Tiara Purple and 100 percent for Mermaid Blue.

Pink Cultivars. The frequency of diseased plants ranged from a low of 3 percent for 'Echo Pink', 'Heidi Rose Pink' and 'Ventura Rose' to a high of 58 percent for 'Maurine Pink' 25 days after inoculation. By day 40, cultivars with the lowest percentage of disease were 'Mariachi Pink', 'Bridal Pink', 'Laguna Pink' and Ventura Rose (8 to 13 percent), while the greatest number of diseased plants occurred with Maurine Pink (90 percent). The percentage of diseased plants at day 55 (see Table 2) ranged from 23 percent for Bridal Pink to 98 percent for Maurine Pink.

White Cultivars. Only a few cultivars expressed disease symptoms by 25 days after inoculation, with the highest frequency at 28 percent for 'Royal White'. By day 40, only 'Lisa White' and 'Tyrol White' did not show symptoms, while 'Maurine White-on-Blue' reached 33 percent diseased plants. However, by day 55 (see Table 3), the lowest percentage of diseased plants was 53 percent for 'Heidi Pure White' and five cultivars had 100 percent diseased plants ('Florida White', 'Malibu White', 'Maurine White', 'Tiara White' and 'Yodel White').

ADDITIONAL RESEARCH NEEDED

The white cultivars appeared to respond differently than the blue/purple or pink cultivars because the disease development was slower. However, direct comparisons cannot be made between color groups since the plant production conditions were not the same for all three tests. Additional experiments will be designed to compare the best blue and pink cultivars with the best white cultivars in order to determine if the white cultivars have a genetic basis for delayed disease development. The genetic basis for this delayed symptom development or partial resistance needs to be studied in order to take advantage of these findings for breeding more resistant cultivars.

We evaluated less than half the cultivars sold in the United States at the time of the test. There are probably hundreds more on a worldwide basis. Our goal was to begin the process of looking for resistance and to see if varieties could be categorized according to susceptibility. It is evident from these studies that differences in susceptibility to *fusarium* do exist, and these differences exist within the gene pool of each of the breeding sources selected. Thus, there appears to be a good opportunity to improve lisianthus through breeding efforts. Other cultivars need to be screened to expand the knowledge base for breeding for resistance and for categorization of susceptibility among cultivars to aid management of the disease in the short term.

A percentage of all cultivars tested became infected and are consid-

ered susceptible to *F. avenaceum*. However, distinct differences occurred between cultivars within a flower color group in the length of time for symptom development and in the frequency of diseased plants, indicating different degrees of susceptibility. It is important to remember that the test methods favored disease development. Thus, for example, one would not expect 100 percent of a cultivar in a grower's field to become infected with *fusarium*, and these cultivars may perform very well in areas without disease pressure.

In production areas with a known history of *fusarium* crown and stem rot, growers would have a broad choice of cultivars within and between the color groups and different seed companies. For example, Hallelujah Purple, Ventura Deep Blue and Bridal Violet, representing three seed companies, were the least susceptible blue cultivars. In addition, there were differences within double-flowering — as well as within single-flowering — cultivars from the same seed company. For example, the double-flowering Mariachi Pink had about half as many diseased plants compared to double-flowering Echo Pink. The single-flowering Heidi Pure White had 53 percent plants showing symptoms compared to 90 percent for single flowering Tyrol White.

Incorporation of resistance to *F. avenaceum* into breeding efforts could significantly improve control measures and potentially reduce fungicide use. The method we developed for screening lisianthus cultivars for their response to infection by *F. avenaceum* would be valuable in a breeding program to develop resistant cultivars. Growers currently experiencing severe losses from *F. avenaceum* may benefit from this research by using cultivars found to be less susceptible to *F. avenaceum* as an aid to management of this disease.

Heidi Pure White (left) and Tyrol White (right) single-flowering lisianthus cultivars expressed different levels of susceptibility to fusarium *crown and stem rot.*

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