

Identification and Management of Fusarium Wilt Race 4 of Cotton in Texas and New Mexico

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Fusarium wilt of cotton, caused by the fungus, *Fusarium oxysporum* f. sp. *vasinfectum* Race 4 (FOV4), was confirmed in numerous fields in El Paso and Hudspeth counties in Texas in 2017. Undoubtedly, it was present in those fields for several years, but how the disease entered the area remains unknown. FOV4 was first identified in the United States in a single county of the San Joaquin Valley (SJV) of California in 2003 and has since become widespread across the SJV.

FOV4 Threatens Cotton Production

Several races of FOV cause Fusarium wilt. FOV4 differs from other FOVs found in the U.S. because it is highly virulent on susceptible Pima and Upland varieties commonly grown in the Western U.S. FOV4 infects cotton without requiring the root knot nematode (*Meloidogyne incognita*). In California, the disease proliferates across all soil textures in cotton production areas, and in soils with pH values from neutral to alkaline. Once FOV4 is introduced into a field, it becomes a permanent resident. In California, crop rotation, summer fallow, and summer flooding have not eliminated the pathogen.

Weed-free summer fallow and long duration summer flooding have, however, reduced the adverse effects of FOV4 on a subsequent cotton crop. The fungus can also survive as a saprophyte on the roots of plants other than cotton without evidence of disease. Seed-applied and in-

furrow fungicides that have been tested to date have not provided acceptable levels of disease control in broadly infested cotton fields. While there has been significant success in developing moderate to high levels of tolerance in Pima cultivars, evaluations of Upland lines are not as advanced as are those of Pima.



Figure 1A. Bare spots within a field can indicate the presence of *Fusarium oxysporum* f. sp. *vasinfectum* Race 4. Photo credit: Tom Isakeit.

Infestation of Fields

FOV4 is introduced as spores into fields in four primary ways: **1.** infected seed; **2.** soil transported from infested fields on equipment, vehicles, and clothing and shoes of personnel who have been in infested fields; **3.** in plant debris carried from an infested field by equipment; and **4.** in irrigation or storm waters. It can take several years after FOV4 has been

introduced to notice the effects of the disease on susceptible cotton cultivars. Early observations are



Figure 1B. FOV4 can kill seedling cotton. Photo credit: Tom Isakeit.



Figure 1C. Early casualties of FOV4 can appear as dead plants at the 2-leaf stage. Photo credit: Mauricio Ulloa.

typically bare spots that occur randomly, indicating areas where young cotton plants were killed (**Fig. 1A**). When FOV4 is first observed, it may be mistaken for seedling damping-off caused by *Pythium* or effects of other early season pathogens, such as *Rhizoctonia solani* (**Figs. 1B and 1C**). Over a period of several years, the bare spots of dead or stunted plants will increase in size, and may be spread and enlarged via movement of soil and plant debris by tillage, furrow irrigation, or storm water flows.



Figure 2A. In Pima cotton, early symptoms may start as marginal leaf chlorosis in bottom leaves.
Photo credit: Mauricio Ulloa.



Figure 2B (left) and Figure 2C (right). FOV4 stunts and causes continuous root staining in Upland cotton. Photo credits: Mauricio Ulloa.

Symptoms of Susceptible Pima and Upland Cotton Cultivars

In California, the susceptible Pima cotton cultivars show severe disease symptoms and stand losses in early growth stages (1 to 6 leaf cotton). Many Upland varieties are susceptible to FOV4, but survival of small plants is typically better and early symptoms are less severe than those with susceptible Pima cultivars. However, both types of cotton can be infected when exposed to moderate to high soil inoculum levels, and FOV4 will reproduce in and around tissues of infected plants.

Symptoms differ between Pima (**Fig. 2A**) and Upland cotton (**Figs. 2B and 2C**). Severely impacted Pima cultivars tend to show leaf discoloration and necrotic areas as early as the 1-2 leaf stage, and may die at early stages (less than 6 leaves). Infected, susceptible Pima cultivars that survive may be severely stunted and show foliar symptoms; but damaged leaves often drop off during early development and may not be reliable indicators of infection. Many infected Upland cultivars

show fewer leaf symptoms and much less stand loss during early stages of the disease than do susceptible Pima cultivars. Symptoms on susceptible Pima varieties are more obvious than they are on Uplands as the disease progresses through the growing season. In contrast, for many Upland varieties, there may be few or no foliar symptoms for up to 10 to 12 weeks after planting. However, these Upland cultivars can show extensive root vascular staining (**Figs. 3A, 3B, 3C**), which indicates a plant is infected and inoculum is being produced.

Although all the races of FOV can cause wilt symptoms, vascular damage from FOV4 is distinctive in most cultivars. FOV race 1 (FOV1) typically shows vascular staining that in later stages extends from the roots into stem tissues. In comparison, FOV4 enters the tap and lateral roots and produces vascular staining that often is restricted mostly to the tap and lateral roots. Vascular staining from FOV4 is dark and continuous, rather than streaked, and can be found in the core (central portion or pith) of infected cotton tap roots and lateral roots (**Fig. 4**). Such vascular staining of infected plants can be seen as early as the 1-2 leaf stage, or can appear later in plant development. Typically, the infection starts during early root development. With FOV4, staining is generally limited to the roots and not always evident in above-ground stem tissue. As the fungus continues to grow, more tissues decay. Eventually, in seriously affected plants, damage is seen as stunting, wilting, and death; while other infected plants may only be stunted and still survive the growing season.



Figure 3A. Continuous root staining in Upland cotton showing no above-ground symptoms. Photo credit: Mauricio Ulloa and Robert Hutmacher.



Figure 3B. Continuous staining in taproot of Upland cotton. Photo Credit: Mauricio Ulloa.



Figure 3C. Continuous staining in taproot of late season Upland cotton. Photo Credit: Mauricio Ulloa.

Scouting for FOV4

Look for symptoms between the seedling and first flower stages. Weak areas with stand losses become more difficult to see when scouting in mid-season. Symptoms might be obscured later in the season, particularly if Verticillium Wilt or other races of Fusarium wilt are present.

It is essential to check the roots for vascular staining (Fig. 4).

In cases of unexplained stand loss, collect several intact plants, put them in a paper bag, place them in a cooler or air-conditioned space, and bring them to your county extension office. At the office, they will be photographed and the photos electronically transmitted to the extension plant pathologist who will evaluate them, offer a diagnosis, or recommend that the samples be sent (preferably overnight) to a plant disease diagnostic laboratory.



Figure 4. An example of black streaking in the center of the root. Photo credit: Tom Isakeit.

How the Fungus Spreads

FOV4 can survive in soil, in plant debris, and in infected seed beneath the seed coat, even after acid delinted and treated with fungicide seed treatments. The fungus produces multiple types of spores and some types can survive in soil for many years. Spread within a field occurs when infested soil is moved by implements, vehicles or personnel, or when water carries infested soil or plant debris in irrigation or storm water to other fields. Local spread by soil movement can be reduced with practices of segregating or thoroughly cleaning equipment by power washing with detergents.

Spread by Seed

- **Infected seed is a means to disseminate FOV4 over great distances.**
- **Planting seed from infested fields poses significant risk of spreading infection.**
- **Do not plant seed produced in infested fields; for example, replanting of so-called “brown bag” from fields known to have FOV4.**
- **Do not plant seed from fields that are suspected to have been exposed to FOV4.**

What Farmers Can Do If Contaminated Seed or Soil May Have Infested Their Fields

- Walk fields and pull random and symptomatic plants, cut roots, and inspect.
- Highly tolerant cultivars, when available, should be planted.
- In California, a full summer, dry, weed-free fallow has reduced damage to a succeeding cotton crop.
- Crops other than cotton can be planted; they will not become diseased with FOV4. However, at this time no crop rotation is known that will eliminate the pathogen from the soil. Replanting of susceptible cotton cultivars will bring the disease back and likely expand the FOV4 infestation.

What Farmers Can Do to Prevent or Restrict Infestation

- Do not plant seed originating from an area with FOV4. In Texas, the documented infested area is El Paso and Hudspeth counties. Not all fields in the area are infested, but at this time there is no verified test to ensure seed is free of FOV4. Plant only seed grown in areas where FOV4 has not been identified.
- Clean soil and plant material from farming equipment that has been in infested fields before moving to other fields. Use a pressure washer and a detergent soap, chlorine, or quaternary ammonia product when possible to increase spore kill.
- Limit tail water movement coming out of infested fields.
- Do not apply gin trash from infested fields or manure from cattle fed cottonseed from infested fields.
- Do not allow livestock from infested areas into uninfested fields.
- Investigate the cause of randomly distributed bare spots and seedling death in fields. Submit plant samples to your county agent, extension specialist, or plant disease diagnostic clinic. A qualified laboratory should be used to confirm the diagnosis of FOV4 in plant samples. There are currently no easy to utilize, cost-effective soil tests for detecting FOV4. There are many types of Fusarium present in plant tissue and soils. Tests need to be specific to confirm FOV4 infestation.



Figure 5. Pencil-line staining of pith, characteristic of FOV4. Photo credit: Tom Isakeit.

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