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***Fusarium* in Tulips: Ethylene, Gum, and Aborted Flowers**

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Tulip forcing in 2002 was difficult. In many greenhouses, tulip crops were uneven, and overall, very short. Upon flowering, many pots had one or more stems with blind shoots, where the bud may have been aborted at a relatively late stage (perhaps when it was 1/2" long), or at a much earlier stage, where only a blackened stump and tiny remnants of a very small flower were present (Figure 1). In either case, the value of the product was severely compromised. These kinds of problems were seen in both pot and cut crops, and in landscape plantings as well. A major culprit in all these problems is *Fusarium*, an important disease in many bulb crops, but one that poses special problems for tulips.

In an earlier article ("A Bulbs Journey", August, 2001 GPN), the relationships of *Fusarium* infection, ethylene production, and forcing problems were introduced. In this article, we'll review some of the known information on *Fusarium* infection in tulip bulbs and describe some non-chemical remedies for its management.

Recognizing *Fusarium* infection

The most common fusarium in tulips is *Fusarium oxysporum* Schlecht. *f. sp. tulipae*, and it can be a problem wherever tulip bulbs are produced. Tulips bulbs infected with *Fusarium* are easily recognized (Figures 2 and 3). Another easy way to detect *Fusarium* is to smell the bulbs. Infected bulbs have a distinct sour smell as a result of the fungus degrading the bulbs' tissue. Infected bulbs may also have white mycelium (mold) growing on the surface, and this is usually concentrated on the basal part of the bulb (Figures 2 and 3). Still other bulbs may be very lightweight, as a result of the starches and other scale components being consumed by the fungus. Bulbs with a severe infection might show a somewhat opened bulb tip, with the protruding leaves dried out (Figure 4). Multiple fungi can be present on a tulip infected with *Fusarium*, for example *Penicillium*. This fungus is distinguishable from *Fusarium* as it is a bluish-green fungus. With only superficial growth on the bulb's surface, *Penicillium* is not a major problem.

Field and production factors

Infection of tulip bulbs by *Fusarium* is more likely during growing seasons with high soil temperatures from the period of flowering (i.e., early May) until digging in late June to mid-July. Thus, *Fusarium* is exacerbated in warmer growing seasons. Past research has indicated that later digging tends to increase *Fusarium* infection due to the normal increase in soil temperature in late spring. On the other hand, early harvesting to avoid warm soil temperatures is not an answer as bulbs are not properly mature with early digging. In the case of Dutch production, there are many suggestions as to the sudden increase in *Fusarium* over the past two seasons,

including changes in farming practices and bulb handling equipment, regulatory changes affecting fungicide availability, buildup of spore and inoculum in the soil, and possibly the appearance of one or more “new” *Fusarium* strains that could be more resistant to fungicides and/or generally more aggressive in their infection and spread.

Fusarium, gummosis, and ethylene

Aside from direct effects of the fungus on a bulb, a much larger problem comes from the fact that the *Fusarium* fungus produces a large quantity of the plant hormone, ethylene. This ethylene can have several negative effects or consequences, including flower abortion, uneven, stunted growth, reduced rooting, and gummosis (external or internal blobs of a clear to brownish-tan substance that ultimately hardens like peanut brittle (without the peanuts, of course, see Figures 5 and 6). In severe cases, the external “gum” can cement numerous bulbs together into a cluster (more like peanut brittle?!). Often, the gummosis is only produced inside the bulb (“internal gummosis”), filling up the spaces between the bulb scales. The bulb must be cut open to see internal gummosis.

Another confounding factor in the diagnosis of ethylene problems is the timing of ethylene exposure. Gummosis is more commonly expressed in tulips exposed to ethylene shortly after digging, that is, in mid to late July. The same cultivars exposed to ethylene late in the season (for example, after shipment to the United States) will often not develop any gummosis at all, but may still show 100% flower abortion upon forcing.

While most of the symptoms of tulip ethylene exposure are deleterious (e.g., flower abortion), others (e.g., gummosis) are not specifically problematic. If the flower of a tulip cultivar aborts due to ethylene exposure, the bulb is obviously worthless. On the other hand, the presence of some gummosis is not an indication the shipment should be refused. Cultivars vary in their sensitivity to ethylene and their expression of gummosis symptoms. For example, certain tulip cultivars may exhibit gummosis upon ethylene exposure, but are somewhat immune to flower abortion from the same ethylene. Thus, the presence of gummosis in a cultivar in a shipment only indicates that *that cultivar* was exposed to ethylene (which probably occurred well before shipment), but it does not *specifically* indicate that the *entire shipment* was exposed, nor does it *specifically* mean that the affected bulbs will show problems upon forcing.

Due to the complex interaction of cultivar, symptom expression, and varying times after digging when these problems can occur, you should immediately contact your supplier if you receive a shipment with a substantial proportion of *Fusarium* or gummosis tulips. Long standing advice has been to seriously consider discarding the lot if more than 10% of the bulbs are infected by *Fusarium*. This is, again, due to injury from the large quantity of ethylene that can be produced from the infected bulbs.

What to do?

Since *Fusarium* infected bulbs continue to produce ethylene after planting, such bulbs can injure bulbs within a pot or a cut flower forcing crate. Thus the old adage that one bad apple spoils the batch applies equally well to planted tulips. During planting operations, bulbs should be inspected and bulbs showing any signs of *Fusarium* infection should be discarded. Also discard any bulbs that are “light” (having been consumed already by the fungus), and any with a sour smell (sure evidence of *Fusarium* actively working on the bulb). It cannot be emphasized how

important this step can be to help with uniformity of the pot of cut flower crate during forcing. The utility of dipping or drenching with fungicides by US forcers is questionable, as the injury resulting from ethylene exposure has already mainly occurred.

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Figure 1. 'All Seasons' tulip with one stem showing an aborted flower bud (lower right). This is an example of "kernrot", a disorder involving mite injury on the primordial flower bud. Bulbs that are exposed to ethylene react with a small amount of shoot growth, enough to open the tip of the bulb. This opening gives an entry point for mites to crawl in and begin feeding on the young bud, leading to its death. Injury is expressed as a blackened stump at the time of flowering.



Figure 2. Tulip bulbs showing severe *Fusarium* infection. Note progression of the disease from the base.



Figure 3. The bottom of tulip bulbs showing well developed *Fusarium* infections. In both cases, but especially on the bulb on the right, injury to the root collar is evident. If cut open, the basal plate of the right bulb would be seen to be severely injured, and the bulb would not flower properly.



Figure 4. Tulips with *Fusarium* infection, and exhibiting the characteristic opening on the top of the bulb due to ethylene generated from the *Fusarium*.



Figure 5. “Gummosis” of tulips. These bulbs (3 different cultivars) show symptoms of external gummosis, or leakage of polysaccharide-like material from the bulb. These symptoms indicate the bulbs have been exposed to ethylene. Gummosis is a clear indicator that the bulbs have been exposed to ethylene. However, in some cases, ethylene *does not* lead to gummosis.



Figure 6. Close-up of gummosis on a tulip bulb.