

PISTACHIO BUSHY TOP SYNDROME – Questions and Answers

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A new pistachio disease, Pistachio Bushy Top Syndrome (PBTS,) has been described and some information was presented at Pistachio Day. PBTS came to the attention of the California Pistachio Research Board in January 2014 and the discussion below is an attempt to bring growers up to date on rapidly emerging information.

What causes the disease?

The cause was widely discussed before scientific proof was obtained late in 2014. PBTS is caused by the infection of a bacterium, *Rhodococcus fascians* (Rf). Two strains have been identified and, while each is pathogenic, they act synergistically to cause more severe disease symptoms. Bacteria exchange DNA frequently so it is likely that new strains, probably derived from the initial two, will be found.

How widespread is the disease?

Thus far, it has only been found in clonally propagated UCB1 rootstock from a single nursery. In addition, it has only been found in rootstock produced in 2011 and after. This rootstock has been widely planted in California and Arizona, probably in all the major pistachio-producing counties. The percentage of rootstock exhibiting symptoms can vary widely among plantings but it seems likely that 20,000 acres have been affected to some extent.

What are the symptoms?

The most common symptoms are a consistent shortening of the internodes which leads to a bushy appearance of the rootstock. The shortened internodes also results in stunted plants. Leaves on affected rootstock will likely be smaller, a bit darker with perhaps some reddening, and a wavy leaf margin. More recently, a general lighter leaf color has been observed in some planting and experimentally inoculated rootstock, possibly due to poor nutrient uptake. These were the symptoms originally referred to as “chino” but the symptoms of Rf infection are more than the above. Affected plants are notoriously difficult to bud and, if successfully budded, the graft union can become swollen and cracked. Lateral buds on the rootstock below the graft union can become swollen and look like small blisters but without any liquid inside. These are much like what could be expected with crown gall. The area around the swollen buds becomes corky and if enough buds are affected, the rootstock can be girdled and the plant above will die. Infection can also stunt root growth and cause roots to be twisted. Young affected trees can be removed by a relatively gentle pull. The internode shortening, leaf symptoms, and stunted root system have been reproduced experimentally but the effects on grafting and graft unions have not yet been reproduced. Nevertheless, these graft symptoms have only been observed in PBTS affected plantings and it seems reasonable to attribute them to Rf infection by one or more strains of the bacteria. Photographs of the symptoms can be found in the Randall report and in the Pistachio Day presentation, posted and linked on the CPRB website (www.calpistachioresearch.org)

Are any of the pistachio rootstock immune?

Preliminary tests indicate that UCB1 seedling rootstock, UCB1 clonally propagated rootstock, and rootstock from *Pistacia integerrima* are all susceptible to infection and have developed symptoms similar to those described above. To my knowledge, *Pistacia atlantica* rootstock have not been tested but these would be susceptible to Verticillium wilt regardless.

The described symptoms are entirely from rootstock. What symptoms are there in the scion?

Given the difficulty experienced with budding and the relatively recent occurrence of PBTS, scion symptoms have not yet been described. At this point, we do not know if the scion will develop PBTS symptoms, or is capable of tolerating infection without developing symptoms. In a recent report, Rf was detected in or on a very limited number of trees in three orchards that showed premature and extreme nut drop while their immediate neighbors had neither the nut drop or detectable Rf. This is however a correlation, not cause and effect.

Can anything else cause these symptoms?

The short answer is yes. Internode elongation can be affected by nutrient deficiencies, herbicide damage, etc. Foliar symptoms could be mistaken for some micronutrient deficiencies, particularly zinc. Zinc deficiency is quite common in tree crops. Similar root symptoms can be induced by poor potting and field planting techniques. But the combination of all these symptoms (stunting, herbicide damage, poor potting, poor planting, budding difficulties, etc) in a single planting would be extremely unlikely and thus is also diagnostic.

Are symptoms always severe?

Symptoms can be variable and are not always severe. Disease symptoms may involve some environmental effects and we don't know if the most severe symptoms have both strains mentioned above while milder symptoms only involve one of the strains. Early on, plants can appear healthy, especially when small and upon initial receipt, but symptoms can develop over time, most typically within the first season prior to budding. However, some growers have had vigorous plantings which were budded and the swollen lateral buds on affected rootstock girdled the tree after budding. Incidence in affected plantings can also vary – I have heard of plantings with >75% affected rootstock and other plantings with <5%.

Are there any tests that can be done to determine if the rootstock are infected?

While there are diagnostic tests used in scientific studies, there aren't presently any diagnostically reliable and economical field tests. Part of the problem is that the Rf is not uniformly or consistently distributed – any test is only as good as your sample and you might have collected the leaves that have no Rf while it is in the rest of the plant.

I have an affected planting. Is there any danger of the disease spreading to the non-symptomatic plants? How about to my other pistachio plantings?

In the greenhouse, the disease is relatively easily spread by sprinklers and water droplets. At this point we don't know if it can be spread in the field by pruning implements, hand contact, etc.. While experiments are underway, they are unlikely to be complete until 2016 or 2017. We assume the disease could be spread by root to root contact but the root systems are so stunted it likely won't happen for at least a few years. The risk of moving a bacterium on budding knives or pruning shears seems much greater. These questions are currently being researched.

Is there anything I can treat the rootstock with to cure it?

Because Rf is a bacterium, antibiotics spring to mind but there are none registered for pistachios and the history of antibiotic use to control bacterial diseases in plants is not encouraging. Thus, there are none and there aren't likely to be any, at least not in the foreseeable future. You should not expect the plant to recover - they will most likely remain stunted, difficult or impossible to bud, unlikely to support a vigorous scion when budded and grown to maturity due to a stunted root system, and will not have good prospects for high production.

What are my options if I have an affected planting?

This disease is a very unique one and there are few if any other crop diseases we can use for informed decisions. While we have research in progress, we won't know much for more than a year or two and this is outside your decision window if you already have an affected planting. With this level of ignorance on our part, none of the options are good. What you choose to do will depend on your ability to accept risks and what will allow you to sleep at night without second guessing your decision. Decisions will likely be painful but some decisions may be less painful to you, depending on your situation.

Having said that, there are things that should be considered:

- Take precautions to reduce risk of moving the pathogen to unaffected plantings by applying a surface sterilant to budding knives, pruning shears, and shovels.
- Survey your planting and determine what percent/how many plants are affected.
- Remove the affected plants.
- Decide if and how to replant. This is discussed more thoroughly below.

How do I keep it from moving to unaffected planting?

Do not move implements and people from affected plantings to unaffected ones without taking some disinfection precautions. We haven't documented Rf movement on implements/people but other bacteria and pathogens can be moved on budding knives, pruning shears, hands, and contaminated clothing including gloves. It may be too late for some of these actions – that means you need to monitor the potentially exposed planting for symptoms. Because we don't know how easily spread this bacterium is, do what you can practically do to reduce the risk of contaminating other orchards.

How should I survey the planting?

The hardest part is being able to identify affected plants. Currently, the only method that is fast enough is visual identification. Work with your county farm advisor, your nurseryman, or other experts to learn how to identify the symptoms. You might get different advice from different people so document the criteria you use to identify the affected plants. Depending on the size of the planting, you may choose to examine all the plants or choose a path thorough the planting and examine a sample of random plants on the path. Starting with a random path will help you determine the presence and/or incidence of PBTs in your planting. Some growers faced with high infection rates have elected to remove entire plantings. Others have replanted only the affected trees. The decision is unique to every orchard and grower. If you decide to remove only the affected trees, you will need to walk the entire orchard to mark trees for removal.

How should I use the survey?

Looking carefully at your survey, you have your next painful decision. Is the incidence so high and/or the risk of transmission to adjacent plants due to budding attempts/pruning so great that you need to remove most or all of the planting? Removing a portion of the plants will mean some management headaches – at what point does it make sense to remove all the plants and start over? Can you get rootstock for replanting?

How should I remove the plants?

The Rf bacterium can occur throughout the plant, including the roots, so when pulling plants, get as much of the roots as possible. The bacterium doesn't survive long on dead tissue nor does it survive as a free-living soil bacterium. So you want to create conditions that kill the remaining roots **and keep the area weed-free to guard against the Rf colonizing weed roots**. We don't know if Rf will persist in weed roots but it is prudent not to run the risk. Some growers have removed affected rootstock and planted into the same spot immediately. They run a risk of transmitting the Rf from the remaining infected roots to the replant; we don't know how great that risk is so if it doesn't happen or is rare, the decision was good but if it does happen, it was an unfortunate decision.

What can I do about replanting?

If you have removed a portion of the original planting, you are committed to replanting in the same spot. How long should the spot remain fallow to permit remaining roots to die? That question can't be answered with certainty but longer is less risky than shorter. Some growers are allowing the spot to fallow for about 3-4 months including summer weather, keeping it completely dry. Others have fallowed for up to a year.

If you have removed the entire planting, you can replant in the same spot or shift the planting by planting midway between the two old sites. This is of course a lot of work, moving stakes and irrigation lines. Growers have done both but we don't yet have any information to decide if one option is better than the other.

Rootstock may be in short supply and your choices may be limited by when you can get rootstock for replanting.