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How to Recognize Wind Damage on Leaves of Fruit Crops

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Summary. Plants respond to wind in a manner similar to drought, but, in addition, leaves suffer physical or mechanical damage. Long-term wind stress results in smaller plants, less total leaf area, skewed tree growth because most of the branches grow toward the leeward side, and less yield than plants protected from wind. A simple procedure to simulate abrasion damage to leaves helps growers recognize wind damage to several fruit crops.

Wind causes damage to plants in numerous direct as well as subtle ways. It can cause rubbing or abrasion damage, transpiration stress, and air temperature changes. Indirectly, wind carries particulates that wound plant cells, and wind may interfere with pollination. Effects of wind on plants have been reviewed by van Eimern et al. (1964), Grace (1977), and MacKerron and Waister (1985). Waister (1972) re-

viewed wind damage in horticultural crops. He reported that wind damage occurs under a diverse range of situations. The response of plants to wind is variable and distinct for each species. Differences in leaf cuticular waxes, pubescence, and stomatal placement all affect how leaves of similar species, and even cultivars, respond to wind. Several authors (Caldwell, 1970; Dixon and Grace, 1984; Grace and Russell, 1982; Martin and Clements, 1935; Wadsworth, 1960) suggest that plants under wind stress display short-term responses similar to plants under drought stress. Wind desiccates plants. The long-term effect of this drought-like response is limited growth. It is important to recognize wind damage to leaves because of the potential for long-term plant damage. Recognition of wind stress symptoms can help to explain poor plant growth, and encourage growers to take steps to prevent wind stress.

In orchards, trees under wind stress tend to be smaller, have less total leaf area, and have most of their branch growth toward the leeward side. In severe cases the entire tree trunk can lean away from the direction of prevailing winds. Less fruit is produced on trees under wind stress compared to those protected from wind. Wind can also affect low-growing fruit crops such as strawberries (*Fragaria* × *ananassa* Duchesne) (Newenhouse and Dana, 1989; Waister, 1972) and raspberries (*Rubus idaeus* L.) (Waister, 1970). Some fruit crops, such as kiwi (*Actinidia chinensis* Planch.), are especially sensitive to wind (McAneney and Judd, 1984), whereas wind-sensitivity in other fruit crops such as pear (*Pyrus communis* L.) depends entirely on cultivar selection (Proctor, 1982).

Wind-induced abrasion causes

wounds to form on leaf surfaces (MacKerron, 1976; Pitcairn and Grace, 1985; Thompson, 1974; Wilson, 1980). These openings create an opportunity for pathogenic bacteria or fungal spores to invade the leaf and cause damage. Plants such as strawberries, which have a propensity toward leaf diseases, may show increased symptoms of bacterial or fungal disease after exposure to wind. Wind damage on leaves is often mistaken for disease or herbicide damage.

A simple procedure can be used to simulate wind damage in the field or orchard. Although this discussion is concerned with fruit crops, the same procedure can be used to distinguish wind damage on any plant. This technique was tested under windy conditions in Tasmania, where wind stress is known to limit fruit plant growth (Newenhouse and Wilson, 1990). The key point is that wind causes abrasion, and it is this abrasion that damages leaves and fruit. When looking for wind damage one looks for signs of abrasion. While many plant diseases and stress reactions are caused by a direct change in the chemistry of plant tissues, wind stress is mainly caused by a physical force (sometimes termed "mechanical" stress). The procedure used to simulate wind damage involves applying physical force and abrasion to leaves.

This method to accurately simulate wind damage was developed after testing different techniques and comparing the resulting leaf blemishes to known samples of wind-damaged leaves. Apple, pear, apricot, peach, cherry, strawberry, raspberry, and grape plants in a sheltered location were chosen for this study. Some of the techniques tested included abrading leaves with paper towels, by hand, or by rubbing leaves together. Leaves were either allowed to remain on the plant or they were removed. Abraded leaves that were removed from the plant were either allowed to dry or they had their petioles immersed in water, and they were either kept at room temperature or refrigerated to 40F. Each treatment was composed of 10 leaves of various stages of maturity. Leaves were periodically checked for discoloration and signs of desiccation or abrasion. Treated leaves were compared to known samples of wind-damaged leaves from each species. The following procedure most accurately produces leaf blemishes

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that resemble those caused by wind abrasion.

A branch (or on an herbaceous plant, a stem or crown) is selected with about four to six mature leaves and is marked with a string or tape for later identification. Another branch with four to six young, newly formed leaves is also selected and labeled. Without removing the leaves from either branch, two leaves from each branch are crushed by hand, being careful not to rip or tear the leaves. Another leaf from each branch is selected and folded in half so that the upper surface folds on top of itself. The folded leaf is held between the thumb and middle finger and rubbed by moving the fingers back and forth, rubbing one part of the leaf against the other. This rubbing action is continued for at least 30 sec, taking care to keep the leaves attached to the branch. With some rough leaves it may be necessary to use both hands to rub the leaf against itself. This procedure is repeated with another leaf from each branch, but this time the leaf is folded in half so that the lower leaf surface folds on top of itself. When finished, there should be two groups of leaves (mature and young) with several different types of abrasion damage: 1) crushed, 2) upper leaf surfaces rubbed together, and 3) lower leaf surfaces rubbed together. After 6 h, the tree or plant should show early effects of abrasion, and after 12 to 24 h, the total effect of abrasion will be apparent, which is similar to wind damage. Young, succulent leaves are usually more susceptible to abrasion or wind damage than older leaves. Aside from signs of direct crushing, damage from the abrasion technique will resemble damage from wind. Descriptions of wind-induced leaf blemishes are similar to descriptions of abrasion-induced blemishes.

On apple leaves (*Malus domestica* Borkh.), crushed areas will appear as shiny, dark-brown lines. Rubbed or abraded areas will look slightly purple, then glossy brown or black. By holding the leaf at different angles and looking closely, one may see discoloration, almost like a shadow. On the underside of the apple leaf, an orange-red color appears. Surface hairs are detached in abraded areas, so parts of the underside of the leaf will look shiny. As abraded areas of the leaf dry, these shiny parts die and turn brown. In the orchard, these brown necrotic areas occur where one leaf has rubbed against another, or where a branch or a wire has rubbed against a

leaf. Apple leaves tend to show most wind effects on the upper leaf surface. The following descriptions of leaf damage on other species focus on those aspects that differ from this basic description of apple leaves.

Abraded areas of pear leaves first show a glossy red-brown, then may turn black. Almost all discoloration appears on the upper leaf surface. Sometimes the midrib can become pink or red. Crushed areas on pear leaves have a similar appearance to crushed areas on apple leaves.

On apricot (*Prunus armeniaca* L.) leaves, crushed areas appear as fine white lines or cracks on the upper leaf surface, with corresponding brown or black lines on the lower surface. Rubbed or abraded areas have a silvery-white dusty look where surface waxes have been disturbed. Light-green flattened areas appear, which later turn brown. Initially, this damage appears on the upper leaf surface.

Peach (*Prunus persica* L.) leaves tend to show very little damage from wind or abrasion. After crushing the leaves, some white lines or cracks may appear on the upper leaf surface with corresponding brown or black lines underneath, similar to crushed apricot leaves. Abraded peach leaves also may resemble abraded apricot leaves.

Cherry (*Prunus avium* L.) leaves are even more resilient than peach leaves. They show very little discoloration from abrasion or wind. Some cherry species are used as windbreak trees to protect orchards.

Strawberry leaves are especially wind-sensitive. They show abrasion and wind rub on the lower leaf surfaces first, appearing as light-brown areas that can turn black. On the upper leaf surface, wind rub is glossy dark green or purple. These lesions will later turn brown as they dry. In the field, this wind damage occurs where one leaflet touches another, or where two leaves rub together. Often wind damage occurs where the edge of one leaflet rubs or flaps against the underside of another leaflet. Leaf stalks can also show brown wind-rub lines or patches.

Raspberry leaves are also wind-sensitive and show signs of damage similar to strawberry leaves. They have brown mottled patches on the upper leaf surfaces. These areas later change to glossy purple. Damage occurs where the edge of one leaflet rubs or flaps against another. Canes and petioles can also show brown areas of damage.

Abraded grape leaves turn light brown or reddish-brown on the upper surface. They may also turn purple.

Many growers overlook wind as a cause of plant stress. Other growers see wind-induced lesions on leaves, but mistake them for herbicide drift damage or disease. It takes very little wind to cause a plant response. Even moderate winds [15 mph (24 kph)] have been shown to cause leaf damage (Newenhouse and Dana, 1986). This technique for recognizing wind damage on leaves allows growers to see what response wind elicits in fruit crops.

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