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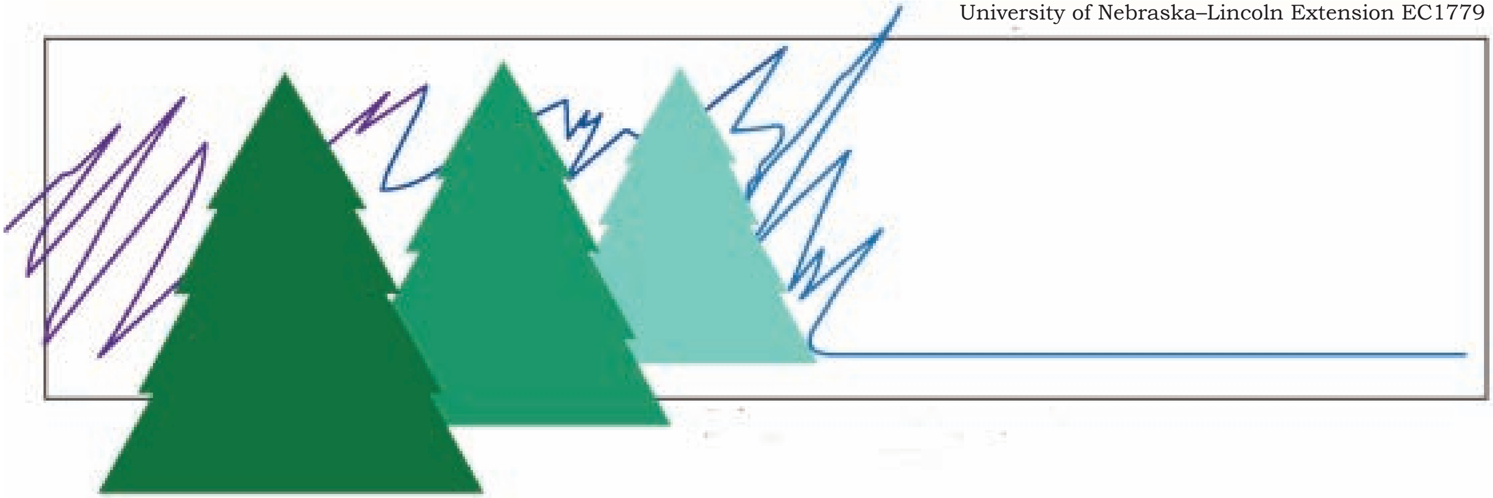

Windbreaks for Fruit and Vegetable Crops

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Windbreaks for Fruit and Vegetable Crops

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Fruit and vegetable growers face the challenge of producing high quality annual and perennial crops with a high percentage of marketable fruit under ever-increasing environmental standards. Many of these operations are located in areas subject to high winds, blowing soil and limited rainfall. To be successful, these operations must optimize the balance between inputs and final yields. Wind protection is one method to enhance growing conditions and improve yield and quality while contributing to improved environmental conditions. Tree or shrub windbreaks, tall annual crops or artificial barriers such as slat fence can provide wind protection. Windbreaks reduce wind speed, help control wind-blown soil and alter the microclimate in the sheltered area.

Windbreaks provide positive economic returns through improved water management, increased yield and quality and earlier crop maturity and marketing. Windbreaks composed of trees and shrubs contribute to landscape diversity, creating habitat for natural predators of pest insects and reducing insect infestations and thus pesticide applications. They improve the aesthetic appearance of the farm and farmstead, provide quality of life benefits for farm families and contribute to increased land values. By incorporating ornamental or fruiting shrubs, nut or fruit trees, or trees producing winter greenery into the windbreak, producers can market a secondary product and enhance revenue flows.

Sweet corn, tomatoes and cantaloupe growing in the protection of a two-row mixed species windbreak at the University of Nebraska–Lincoln Agricultural Research and Development Center.

Wind Effects on Vegetable Crop Production

Wind and Plant Growth

Wind has both direct and indirect effects on plant growth. Most people associate wind damage with dramatic changes in plant appearance, such as broken branches and lodging. In high winds, leaves can be stripped from plants, and under extreme conditions, plant stems may be broken or plants uprooted (Figure 1). However, low wind speeds (less than three to five miles per hour) have positive effects on many plants, leading to thicker and stronger stems. The simple movement of plants by wind can induce changes in plant morphology and crop yield. As wind speeds increase, plant development is slowed, growth is restricted and the form of the plant is altered.

Figure 1. High wind events can lead to severe plant damage. Muskmelon vines were blown to one side of the row and in some cases uprooted by winds of 20 mph.

Wind stress results in smaller plants with shorter internodes, thicker stems and smaller leaf areas. Wind desiccates flower parts, making them less attractive to pollinating insects and reducing receptivity of the pistil to pollen. The result is lower rates of fertilization and a subsequent reduction in fruit set, leading to reduced yield. More visible injuries, such as leaf tearing or abrasion, can lead to increased water loss from the leaves, plant water stress and reduced yields.

How Windbreaks Work

Windbreaks work by providing a barrier to surface winds. As the wind approaches the barrier, most of the wind is forced up and over the windbreak, creating a zone of reduced wind speed behind the windbreak. Maximum wind speed reduction occurs at a distance between five to eight times the height of the windbreak (H) while smaller wind speed reductions extend up to 15 H. The size of the protected area and the degree of wind speed reduction depend on windbreak structure. Dense windbreaks tend to give greater wind speed reductions, but the length of the protected area is slightly less. The density also determines how much of the wind passes through the windbreak, with less dense windbreaks allowing more wind to pass through and extending the protected zone farther downwind. Finally, a portion of the approaching wind moves around the ends of the windbreak, creating two small zones of increased wind speed near the ends of the windbreak. For more information see EC 02-1763, ***How Windbreaks Work.***

Microclimate Effects

As a result of the wind speed reduction adjacent to a windbreak, the microclimate in the sheltered areas is altered. Actual microclimate modifications for a given windbreak depend on windbreak height, density, orientation, time of day, topography and local weather conditions, but some general trends are apparent. Within 8 H downwind of the windbreak, daytime air temperatures are several degrees warmer than unsheltered areas due to the reduction in turbulence. Further downwind (8 to 24 H), turbulence increases and daytime air temperatures tend to be slightly cooler than unsheltered areas due to a greater amount of air mixing.

Nighttime temperatures downwind and near the ground (to approximately three feet) tend to be several degrees warmer. In contrast, temperatures six feet above the surface tend to be cooler. On nights when wind speeds are very low, the reduction in wind speeds in shelter may lead to greater levels of radiation cooling and sheltered areas may be several degrees cooler than open areas. In early spring and late fall, these conditions may lead to frost in sheltered areas.

Soil temperatures also tend to be several degrees warmer in sheltered areas. Humidity levels in sheltered areas increase, and evaporation and plant water loss decrease, contributing to conservation of soil moisture, improvement of crop water use efficiency and an increase in crop yields in the protected zones. In areas where snow is an important source of soil moisture, windbreaks can be used to trap snow and increase soil moisture (See EC 96-1770, ***Windbreaks for Snow Management).***

Soil Erosion and Abrasion

Historically windbreaks have been planted to control wind erosion and protect crops from abrasion by wind-blown soil particles. Wind erosion and wind-blown soil particles reduce germination success of small seeded crops, damage young seedlings (Figure 2) or transplants, and cause abrasion of older crops, reducing appearance and lowering market value (Figure 3). In most cases, yields are reduced. In severe cases, the crop may need to be replanted, which increases the cost of production.

Figure 2. Many crops are damaged by abrasion from wind-blown soil, see Table 1. Here wind-blown soil has damaged a field of corn (Ohio) and will require replanting at additional expense.

Crop tolerance to wind-blown soil abrasion is defined as the maximum amount of wind erosion the crop can withstand without economic loss. It is expressed in terms of tons of wind-blown soil/acre/year. Vegetable crops tend to have low tolerance to soil abrasion (Table 1), yet vegetable production fields tend to be located on lighter, sandy soils, which are prone to wind erosion. Conservation tillage practices used in many grain production systems are not always applicable to vegetable production systems due to the need for a well-prepared

Figure 3. Wind protection reduces rubbing and bruising of sensitive fruit crops such as the papaya, shown here protected by a tall, narrow tree windbreak. (Hawaii)

seedbed. It is during this early spring planting period when the soil is bare that the potential for damage from wind erosion is greatest. Incorporating wind protection into the cropping operation provides additional flexibility in the choice of cultivation practices available to the producer.

Wind Effects on Vegetable Crops

Vegetable crops are extremely responsive to wind protection. Field studies in Nebraska showed positive responses for snap bean, muskmelon, cabbage and bell pepper. Muskmelon grown in the protection of a windbreak produced heavier fruits five to seven days earlier than muskmelon grown in an open field. Yields of marketable melons were 70 percent greater from sheltered fields. Similarly, cabbage yields increased 14 to 18 percent in shelter. A study of snap beans showed larger leaf areas on protected plants and greater total and

Tolerant >2 tons/acre/year	**Moderate tolerance** 1 to 2 tons/acre/year	**Low tolerance** 0.5 to 1 tons/acre/year	**Very low tolerance** 0 to 0.5 tons/acre/year
Barley	Alfalfa (mature)	Broccoli	Alfalfa seedlings
Buckwheat	Corn	Cabbage	Asparagus
Flax	Onion (>30 days)	Cucumber	Cantaloupe
Grain sorghum	Orchard crops	Garlic	Carrot
Millet	Soybean	Green/snap bean	Eggplant
Oat	Sunflower	Lima bean	Cut flowers
Rye	Sweet corn	Peanut	Kiwi fruit
Wheat		Potato	Lettuce
		Sweet potato	Muskmelon
		Tobacco	Onion seedlings
			Pepper
			Spinach
			Squash
			Strawberry
			Sugarbeet
			Table beet
			Tomato
			Watermelon

Table 1. Crop tolerance to wind-blown soil. (Adapted from National Agronomy Manual, USDA-NRCS)

marketable yields, especially early and late in the season when prices tend to be higher. The average gross value of the protected snap beans was 47 to 63 percent higher than beans grown without wind protection. Bell pepper plants were larger, flowered earlier and had almost five times more flowers per plant 30 days after transplanting. Due to higher flower numbers and less bacterial leaf spot in the sheltered peppers, marketable yields were two times greater in sheltered areas than in unsheltered areas. Yield and quality improvements for these and other selected vegetable crops from numerous studies are summarized in Table 2.

Crop	Response to wind protection
Broccoli	Increased leaf area
Pepper	Reduced bacterial leaf spot Yield improvement in dry years Larger plants, earlier flowers, greater yields
Potato	Earlier sprouting and ripening, increased yield and quality
Snap bean	Reduced disease, earlier ripening, larger leaf area Increased yield of marketable beans
Tomato	Reduced sandblast injury, less flower abortion, greater fruit set Increased yield of high quality fruit
Cabbage	Greater yield and improved tenderness
Melon	Longer vines, earlier flowering and fruit maturity, increased yield
Carrot	Improved germination, reduced sandblasting
Cucumber	Reduced vine damage, increased yield
Lettuce	Reduced sandblasting, increased yield
Paprika	Earlier harvest, increased yield
Tobacco	Reduced sandblasting and leaf damage, increased nicotine content
Jojoba	Reduced sandblasting
Okra	Increased yield

Table 2. Effects of wind protection on vegetable crops.

Wind Effects on Fruit Crops

Windbreaks provide many benefits to orchard and vineyard crops (Table 3). Reductions in wind speed reduce the amount of mechanical damage caused by the whipping of leaves, branches, buds, flowers and fruit, which improves fruit quality and increases economic returns. Under sheltered conditions, trees and vines

Figure 4. Providing protection for pollinating insects is critical to many pollinated crops. For some, a secondary operation of honey production can add another source of income to the farm operation.

Crop	Response to wind protection
Raspberry	• Reduced desiccation of canes, improved yields and fruit quality
Strawberry	• Increased yield and quality of fruit
Plum	• Increased yield and more marketable fruit
Anjou pear	• Improved quality of fruit
Grape	• Reduced desiccation of young vines, improved growth rates and yields • Reduced leaf damage and rubbing of grape bunches, improved quality
Kiwi fruit	• Improved yield of marketable fruit
Valencia orange	• Improved yield of marketable fruit
Navel orange	• Decreased premature fruit fall
Prostrate lemon	• Increased winter survival
Citrus	• Increased total sugar, Vitamin C and yield • Decreased premature fruit fall • Decreased fruit damage and improved fruit quality
Banana	• Reduced fruit loss due to wind damage

Table 3. Effects of wind protection on orchard and vineyard crops.

use water more efficiently, reducing plant stress as well as irrigation costs. The improved microclimate within the orchard reduces desiccation of pollen and floral parts and improves pollination, fertilization and subsequent fruit set. Pollinating insect activity is enhanced due to the reduced wind speed and slightly higher temperatures (Figure 4).

Timing of spray applications and potential spray drift are serious concerns for fruit growers. Windbreaks provide a more favorable spraying environment and reduce drift while increasing the opportunities for application due to reduced wind speeds. Improved orchard microclimate reduces evaporation of spray droplets, promotes a more uniform distribution of sprays and increases the efficiency of spraying, especially for low-volume applications.

Windbreaks influence both pest and beneficial insect species (Figure 5). Care must be exercised in selecting windbreak species to minimize potential host plants. Species selection and management practices can influence the use of the windbreak by bird species, reducing bird damage to developing fruit. Windbreaks filter blowing soil, which may carry inoculum for bacteria or fungal diseases. Sandblasting injures leaf surfaces and may provide entry points for various diseases. By controlling wind erosion and wind-blown soil, windbreaks reduce abrasion and thus reduce incidence of some diseases.

Figure 5. Providing habitat for insect predators such as lady beetles can help keep pest species below the economic threshold and help reduce the need for insecticide applications. In organic systems, habitat biodiversity is critical to maintaining a natural balance between crop pests and natural predators.

Windbreak Design

Each farm operation is different and windbreaks should be designed with site conditions and cultural practices in mind. For maximum effectiveness, windbreaks should be oriented perpendicular to problem winds, have no gaps or openings, and be at least 10 times longer than they are tall. For those areas with problem winds from more than one direction, a windbreak network may be necessary to achieve the desired level of protection required by sensitive fruit or vegetable crops. These types of crops are extremely sensitive to direct wind damage and to abrasion by wind-blown soil, thus the distance between windbreaks should be no more than 10 times the height of the windbreak.

Windbreaks for vegetable crops should have a density of 40 to 60 percent early in the growing season in order to provide protection to emerging seedlings or transplants. This can be accomplished in several ways. A single row of tall, native evergreens is most efficient. A single row of densely planted shrubs will also provide excellent protection but will require more windbreaks across the field due to the shorter height. Shrubs have an added advantage in that they are compatible with many irrigation systems. Orchards require taller windbreaks and this is best accomplished with a tall, deciduous tree species. Again, native species are the best choice as they are adapted to local conditions.

Species diversity in the windbreak is another desired characteristic. Diversity offers a number of advantages. It reduces the chance that a single disease or insect problem will destroy the windbreak. Diversity creates a wide array of micro-habitats, which in turn offers opportunities for a variety of biological control organisms and reduces the need for chemical controls. Additionally, incorporating decorative woody florals and fruit or nut trees into the windbreak may offer an additional source of income.

Various annual crops can be used as windbreaks. Two or three rows of sweet corn or sunflowers can offer good protection to a fall crop of cool season vegetables. Annual rye grass strips (Figure 6) planted early in the season will provide protection for most warm season crops. For early cool season crops, several rows of sorghum stubble or tall, perennial grasses will provide protection for a newly prepared seedbed, young seedlings or transplants. The key to any successful windbreak system is understanding the needs of the crop and providing protection during critical growing periods.

Designing a windbreak that meets your needs requires careful consideration of all aspects of your operation, as well as an understanding of basic ecological principles and a working knowledge of local growing conditions. For help in designing your windbreak, contact your local forester, NRCS district conservationist or extension educator. Taking advantage of the many benefits windbreaks offer can improve the profitability of your operation and enhance the environment.

Figure 6. Narrow strips of tall grasses can be used to control wind erosion and provide protection to newly seeded crops.