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Field Windbreaks

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Agricultural producers face many challenges as they try to balance efficient production systems with increasing environmental demands. For these systems to be successful, they must optimize the balance between inputs and final production. Field windbreaks are one way to increase yields while at the same time reducing inputs and improving both environmental quality and production efficiency. Windbreaks reduce wind speed and alter the microclimate in sheltered areas. Field windbreaks reduce wind erosion and the damage to crops caused by wind-blown soil. They improve water use efficiency, reduce risks associated with drought, and manage blowing snow.

Field windbreaks provide positive economic returns to producers. For example, a 160-acre crop field can be totally protected within 20 years with four to six single-row field windbreaks spaced evenly across the field. These windbreaks will occupy about six acres and by the seventh year will begin to increase net yields and profits. In addition, field windbreaks provide opportunities to enhance natural controls of insects, provide valuable wildlife habitats, and add permanence and biological diversity to our agricultural systems.



Soybean yields are increased 12 to 17 percent in fields protected by windbreaks. The two-row field windbreak in the background is composed of a mix of hardwoods and conifers and has a density of about 60 percent.



Benefits of Field Windbreaks



Windbreaks can provide favorable microclimate conditions for pollinating insects, increasing yields of many vegetable and fruit crops.

Wind Erosion Control

Historically field windbreaks have been planted to control wind erosion and protect crops. As wind carries off fine soil particles containing organic matter and plant nutrients, soil productivity is lost. Additional fertilizer often is added to make up for the lost nutrients, increasing production costs.

Wind-blown soil can abrade young seedlings and, in severe cases, a crop may need to be replanted at considerable expense. Abrasion also can be a problem in vegetable and fruit production where appearance is a major factor in crop quality and market price.

Wind erosion occurs primarily on large, open fields where the soil is loose, dry and finely granulated and where the soil surface is smooth and vegetative cover is sparse or absent. These conditions most often occur

during the planting season when the soil has been prepared for planting. Conservation tillage systems help retain

vegetative cover but may limit crop selection, especially on more erosive soils or for crops producing low amounts of residue. Conservation tillage systems may require the use of additional herbicides which may be either economically or environmentally undesirable.

Windbreaks reduce wind erosion in three ways:

1. They reduce wind speed in the protected zone below the threshold for soil movement.
2. They reduce field width interrupting the flow of wind across the field.
3. They create a stable area where the erosion process is interrupted.

Snow Management

In many northern, semi-arid areas, snow is a critical source of soil moisture for crop and forage production. Over half of the snowfall may be blown off the field and deposited in road ditches, gullies or behind fence rows or it may simply evaporate. Field windbreaks with winter densities of 25 to 35 percent (for example, a single row of deciduous trees) help capture snow and distribute it across the field. Runoff from melting snow increases soil moisture and improves crop yields. For some fall-sown crops, field windbreaks offer protection against the drying effects of wind and reduce winter desiccation.

Improved Crop Yields

Numerous studies indicate the positive effect of windbreaks on crop yields (See *Table 1*). While results vary with year and weather conditions, crop yields are improved anywhere from 5 to 45 percent over the long term. Most of these yield increases can be attributed to better water use by the protected crop. The temperature increase in the protected area increases the rate of crop development and leads to earlier crop maturity and earlier marketing opportunities. Wind protection also improves crop quality. High quality fruits and vegetables bring a premium in the fresh food market while lower quality products often end up in secondary markets where the price paid to producers is considerably lower.

Table 1. Average, net yield increases of common grain and oilseed crops in response to shelter. (Based on world wide data.)	
Crop	Yield Increase (%)
Spring Wheat	6 to 10
Winter Wheat	20 to 25
Barley	23 to 25
Oats	5 to 7
Rye	18 to 20
Millet	40 to 45
Corn	10 to 15
Soybeans	12 to 17

One of the more common handicaps of field windbreaks is the impact of competition between the windbreak and the adjacent crop. There is no question that under conditions of limited moisture, competition between the windbreak and the crop results in a loss in yield in the area next to the trees. The degree of competition varies with crop, tree species and weather conditions. In most cases, yield increases in the rest of the protected field are great enough to compensate for these losses. Root pruning, the cutting of lateral tree roots between the windbreak and the crop, will reduce competition and increase crop yields within the zone of competition. In many cases, root pruning may be economical but must be repeated every three to five years if the benefits are to be maintained.



Numerous wildlife species use windbreaks as travel lanes, escape cover and shelter from bad weather. For more details on how to make your windbreak wildlife-friendly, see EC 91-1771, *Windbreaks and Wildlife*.

Wildlife Habitat

Windbreaks provide nesting habitat for squirrels, cottontail rabbits, small rodents and numerous bird species. They provide direct sources of food such as fruits and nuts, as well as habitat for insects and other invertebrates which in turn are a food source for other wildlife. Raptors such as hawks often use the high branches of a windbreak to perch and scan for prey. If one of your main goals in planting a windbreak is to increase habitat for upland game birds, consider using primarily shrubs or small trees in order to minimize predation by raptors. But remember, any reduction in windbreak height reduces the size of the protected area.

Global Climate Change

The buildup of atmospheric carbon dioxide is well known and efforts to reduce carbon dioxide emissions or to store carbon in wood are gaining attention. Planting trees in windbreaks contributes directly to the goal of storing carbon. In addition, field windbreaks contribute indirectly to our goal of reducing carbon dioxide emissions by reducing the number of acres farmed, thus reducing fuel, herbicide and fertilizer use while still improving total crop production. From a producer's perspective, getting more yield with reduced input costs makes economic sense.

How a Field Windbreak Works

As wind approaches a windbreak, some wind moves through the barrier, but most of it moves up and over the windbreak. This leads to a reduction in wind speed both windward (the side toward the wind) and leeward (the side away from the wind). On the windward side, the protected zone extends two to five times the height of the windbreak (2 to $5 H$, where H is the windbreak height). On the leeward side, the protected zone generally extends 10 to $20 H$ but may reach as far as 30 to $40 H$ downwind. Within these two protected zones the microclimate of the area is changed. Sheltered areas, within $10 H$ to the leeward, tend to be slightly warmer. Soil temperatures tend to be slightly higher, evaporation is reduced and humidity increased. Overall, crop growth conditions are improved, reducing plant stress and improving crop yields. A more complete discussion of how windbreaks affect microclimate can be found in EC 91-1763 *How Windbreaks Work*.

Field Windbreak Design

To design a field windbreak system it is critical to understand the purpose of the planting. Windbreaks designed for snow management are different from those designed to control wind erosion or to protect summer crops. Field windbreaks should be designed to accommodate the cultural practices, equipment and land situation of the individual farm operation. However, there are general principles that apply to the majority of situations.

Field windbreaks should be oriented perpendicular to the prevailing or problem winds to maximize the size of the protected zone. The most common location for a single field windbreak is at the edge of the field. This is a good location if you farm on both sides of the windbreak, but it is not the most efficient location if the windward protection falls on non-crop ground. Locating the windbreak within the field at a distance of 2 to $5 H$ takes advantage of the windward protection and increases economic return. In most cases, a single windbreak will not protect the entire field and additional windbreaks, parallel to the first, will need to be established at intervals across the field. Typically, the distance between windbreaks should range from 10 to $20 H$ depending on the degree of protection desired and the size of farm equipment.



In many areas, problem winds come from several directions and complete protection of a field may require a system of windbreaks to achieve full protection.

The ideal field windbreak designed for maximum crop production should consist of one or two rows and be composed of several tall, long-lived species with good rates of growth, deep root systems and similar growth forms. Individual species should be adapted to local growing conditions and native species often are a good choice. The overall windbreak should have a density of 40 to 60 percent during the growing season (*See cover photo*).

Field windbreaks designed to control wind erosion should have a density of 40 to 60 percent during the period when the soil is exposed. Most often this is at the time of planting when most deciduous trees are leafless. Typically, this means that the windbreak must contain either a coniferous species or a dense shrub understory. Spacing between windbreaks designed solely for wind erosion control, and without other conservation practices applied, should be 10 H or less to comply with USDA-Natural Resources Conservation Service technical guidelines. However, spacings of 10 to 15 H are much more economically efficient and do not significantly increase the risk associated with wind erosion. The proper spacing for field windbreaks designed to control wind erosion depends on climatic conditions, soil properties, residue management practices and the producer's willingness to accept the risks of wind erosion.

Field windbreaks designed exclusively for the uniform distribution of snow across the field should have a winter density of 25 to 35 percent. Planting a single row of tall deciduous trees on a wide spacing (16 to 20 feet between trees) perpendicular to the prevailing winter wind direction will provide good snow distribution across a field for a distance of 10 to 15 H. Snow blowing over the tops of the trees falls out of the air stream on the relatively still, leeward side of the windbreak. Wind passing through the relatively porous windbreak provides the mechanism to distribute the snow uniformly across the field. Field windbreaks that are too dense will cause snow to collect in narrow, deep drifts near the tree row and may limit field access in the early spring in northern areas.

Areas or fields vulnerable to wind erosion where snow distribution is also important present additional challenges. As windbreak densities drop below 40 percent, wind erosion control decreases but snow distribution is enhanced. In contrast, as windbreak densities are increased above 40 percent, erosion control increases but problems associated with large snow drifts become more common.

This type of conflict is common in many windbreak design situations in which two objectives have different design requirements. In these cases it is necessary to decide between the alternatives. Which problem is more common or severe? What is the **primary** objective of your windbreak? What other management practices can be included to further minimize one of the problems? For example, residue management may help control wind erosion and allow windbreak densities to be in the 25 to 35 percent range for snow distribution.

Field Windbreak Economics

While many producers recognize the increase in yields associated with wind protection, the question remains: "Do they make economic sense?" For a windbreak system to be profitable, the financial return from the long-term average yield increase from the protected zones must be large enough to compensate for the land occupied by the windbreak, for the crop losses associated with competition, and for the costs associated with planting and maintaining the windbreak.

A financial analysis of the impacts of an investment in a field windbreak system on grain producers in the Great Plains indicates positive returns over the life of the windbreak. The analysis includes the costs of windbreak establishment and maintenance, the loss of crop acres due to acres planted to trees, the loss of productivity associated with the zone of competition, the length of time required to grow the windbreak and the cost of removal at some point in the future. These costs are more than offset by the reduced input costs on acres not farmed and the increase in yields from the protected acres.

For example, if a corn/soybean farmer from the Midwest with a 160-acre field established four single-row, parallel field windbreaks equally spaced across the field, the cost of establishment and the costs associated with land planted to the windbreak would be recovered within 10 years. By year 15, the net return on the windbreak investment would be several thousand dollars. By year 30, the return on the original windbreak investment would be over \$30,000. The windbreaks would be expected to live an additional 20 years or more, providing additional income to the producer.

These returns are based on the reduced production costs and the increased yield from sheltered acres. In many cases, cost share programs and other conservation programs are available to help offset the establishment costs and may provide annual payments for acres planted to the windbreak. If these programs are available, the returns from a field windbreak investment would be even higher. Although hard to quantify, wind erosion control, wildlife habitat and carbon storage provide additional economic values.

Financial benefits for specialty crops such as fruits and vegetables are even higher. These crops are much more sensitive to microclimate conditions and thus tend to respond more positively than grain crops to wind protection. Producers can expect premium prices for higher quality produce and for earliness to market. For example, a two-year study on fresh market snap beans showed a 40 to 50 percent increase in marketable yield and returned, on average, \$900 more per acre per year from sheltered fields than from unsheltered fields. In both of these examples, the magnitude of the dollar return is highly dependent on the wholesale price at the time of harvest.

Another important economic benefit of field windbreaks is the opportunity for a greater diversity in crop choice. Because of the microclimate created by the windbreak, a producer may be able to choose from a wider range of crops. Greater crop diversity reduces the risks of growing only one crop and has the potential to increase natural control of insect pests and contribute to the ecological stability and resilience of the farm ecosystem. A windbreak also contributes to greater habitat diversity, providing homes for a wider range of microbes, insects, plants and wildlife. With careful planning and management, field windbreaks can improve economic return by enhancing insect predators and reducing the need for pesticides.

Windbreak Management and Maintenance

Windbreaks are living systems and, as such, require care and management to function at their best. Regular attention to weed control, corrective pruning, monitoring for insect and disease problems, replanting if necessary, and proper use of chemicals on adjacent fields will help ensure an effective windbreak for many years. More details on windbreak management are available in the publication, *Windbreak Management*, EC 96-1768.

Agroforestry

Field windbreaks are one of many agroforestry-related practices that can increase overall productivity and environmental quality on the farm or ranch. With a bit of imagination, a field windbreak can incorporate various species and management practices that will return additional dollars to the producer.



In arid areas where trees are difficult to grow, shrubs or tall native grasses may be used to provide crop protection, to control wind erosion, and to capture snow for crop production.

The management of existing multiple-row field windbreaks for timber or fuel wood is similar to that of a small woodlot. Larger trees, such as ash, cottonwood, and other poplar species can provide lumber for crates and pallets. Eastern redcedar and Osage Orange resist decay and can provide posts and poles as well as other specialty wood products. Many juniper species may be chipped for animal bedding and bring a premium when packaged for the small animal or pet market. For those with a long-term outlook, new windbreaks also can be designed to produce timber crops. High quality hardwoods such as walnut, oak and possibly ash can be included in field windbreaks to provide potential future income. Fruit and nut trees also may be incorporated into field windbreaks and may provide valuable products for home use or for sale at local farmers' markets. Shrubs that produce cuttings for the decorative floral market are another potential source of additional income.

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



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