# Field Windbreaks for Row Crops

## inter-row plantings of grain in white asparagus fields gave protection against wind erosion during tests on peat soil

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**Inter-row planting** as a practical management practice for the protection of white asparagus fields from wind erosion has been intensively studied since 1955. Such erosion is sometimes costly to the growers and is an important factor in peat dust storms.

Interplanting asparagus ridges with rows of fast growing small grains does not take land out of production, as do tree windbreaks; lath fences—snow fences—appear to be too expensive under the conditions. Furthermore, investigations have shown that inter-row plantings of grain are highly effective even against winds moving parallel to the row directions. However, inter-row planting is restricted to row crops that are sufficiently spaced to permit a strip of taller, protecting plants in each row space. Also, inter-row plantings can give wind protection for a few months only.

Fortunately, on the islands in the San Joaquin Delta, these two restrictions do not exist for one of its important crops, white asparagus. This crop is planted in ridges 7′–8′ apart, providing space for one to three rows of grain between ridges. The need for protection against wind erosion is usually greatest during May and June, the months of optimum development for several varieties of barley and wheat.

A further factor supporting the preference for inter-row planting is the row orientation of many asparagus fields, which is unsuited for tree rows or snow fences with regard to the prevailing wind direction. At Terminous—the site of one of the two special wind survey stations used in these studies—the prevailing wind direction is straight west. From there on, the oceanic air masses fan out according to the valley shape. At Rindge Tract—the second survey station—the oceanic flow is just beginning to turn away from its west direction and is mostly between west and west-northwest. In such conditions, tree windbreaks or fences should be oriented in a north-south direction, and so should be, preferably, the asparagus rows to prevent the tree windbreaks and snow fences from interfering with the numerous cultivations and daily tractor harvesting of the crop. However, even when a new aspara-

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only one of magnesium nitrate, showed about 45% correction of the deficiency symptoms. Symptoms on the check trees had not improved.

The second experiment—in San Diego County—used only two applications of magnesium. The first spray was applied in the fall, on November 21, 1957, and the second on May 1, 1958. Single-tree plots were used, with the spray treatments and check replicated nine times. The fall application used five pounds of magnesium nitrate to 100 gallons of water and the spring application used 10 pounds to 100 gallons.

The second spray in this experiment was applied when the spring flush of growth was about two thirds expanded. Magnesium in leaf samples taken on May 22, 1958, three weeks after the spring spray, averaged 0.17% for the check and 0.23% for the sprayed trees. In each of the nine replications of the spray treatment, the concentration of magnesium in the leaves exceeded that of the check by more than 22%. The differences were highly significant.

The third experiment was a single application—in San Diego County, on May 1, 1958—using 10 pounds of magnesium nitrate per 100 gallons of water. The treatment was superimposed on a $3 \times 2 \times 2$—dolomite × potash × phosphate—factorial soil fertilizer experiment, replicated five times with two-tree plots. The plots in the factorial experiment that had received nitrogen, phosphorus, or potassium but no dolomite—that is, no magnesium—were split. One tree in each plot received a magnesium nitrate spray and the other was retained as a check. Additional plots, which had received a heavy mulch of steer manure every year since 1950, were split and sprayed in the same way. Leaf samples were gathered on May 22, 1958.

The trees of the factorial experiment had differential magnesium levels created in the leaves by past fertilizer treatments. Trees that had heavy applications of potash or manure in their prior fertilizer history had moderate to severe magnesium-deficiency symptoms. Regardless of previous fertilizer treatment, a single magnesium nitrate spray applied when the spring flush of growth was about two thirds expanded resulted in a substantial increase in magnesium concentration in leaves analyzed three weeks later.

When the spray was applied, deficiency symptoms had started to develop in leaves of the fall and winter flushes of growth. After two months, the sprayed trees had only about 40% as many leaves showing magnesium-deficiency symptoms as did the check trees. Apparently the sprays prevented further development of deficiency symptoms, but symptoms continued to develop in the check trees. The sprays did not correct symptoms that were present in the leaves at the time of spraying.

Magnesium nitrate spray at 10 pounds per 100 gallons of water applied to orange trees in San Diego County in August, 1958, gave little or no correction of the deficiency, suggesting that single summer applications are uncertain.

On some, but not all, light-textured citrus soils in California applications of Epsom salts—magnesium sulfate—have been effective, suggesting that a combination soil-spray program might be developed for such soils. No instance is known where applications of magnesium compounds to heavy-textured soils have corrected magnesium deficiency.

In earlier exploratory trials, foliage of orange trees was injured by magnesium nitrate at concentrations as low as 15 pounds per 100 gallons of water. Thus, 10 pounds of magnesium nitrate per 100 gallons approaches a maximum tolerable concentration. In Treatment 4, small quantities of zinc and manganese salts were combined with 10 pounds of magnesium nitrate per 100 gallons of water and no injury resulted from the treatment. However, as a precaution, magnesium nitrate sprays might be tested on a small number of trees before spraying an entire orchard.

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## WINDBREAKS

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gus field is planted, the direction of water drainage often governs row orientation, which therefore is not always perpendicular—at right angles—to the prevailing wind. The practice of inter-row planting does not have to cope with this difficulty.

During the 1957 and 1958 dust storm seasons, wind measurements were taken —by anemometers attached at predetermined heights along a portable mast— in bare asparagus fields and in fields interplanted with rows of barley. The field measurements have yielded 41 vertical wind profiles—graphs of velocities at varying heights—which were used to compare the air flow over bare—non-interplanted—and interplanted fields under various angles of the wind to the ridges. In preparing the graphs, the velocity of the top anemometer, at 15′ height—usually around 20 miles per hour—was set as 100% for each profile, and the speeds at the lower heights were plotted in percentages.

Vertical profiles of wind conditions over unprotected ridges—diagram A of the graph on this page—show the velocity of a crosswind to be retarded to 79% at the 3′ height—in comparison to a field with wind parallel to the ridges— because in itself the cross-orientation of ridges and wind acts as a considerable windbreak. Interplanting under such conditions seems to add only a modest amount of protection, but at the lowest anemometer, the one at the 2′ height— Diagram B, curve d—the interplanted barley strip cut the speed down to 75% of the value in the curve c.

Very striking, however, are the results in diagram D. A vertical profile of a wind parallel to ridges interplanted with rows of barley shows the windbreak effect of barley to be very good, even from a low stand. Actually, the wind reduction for parallel wind was almost as good as when the wind was perpendicular to the ridges—Diagram F. The reason for this very satisfactory performance appears to be that the angle between a parallel wind and the ridges never is exactly 0°, but somewhere between 0° and 45°. This is true especially in the hours of maximum erosion during the highest daytime gustiness, which is always accompanied by an unsteadiness of direction.

Other vertical profiles showed that interplantings under wind directions other than 90°—and 0°—gave the greatest amount of wind reduction at the lowest— most important—height, with wind speed only 60%–65% of that over bare ridges. A similar result was obtained in 1958 from calculations using an analytical expression for wind increase with height. The explanation may lie in the greater apparent density of the barley strips when viewed obliquely as compared with that observed at right angles.

A comparison of the effectiveness of inter-row planting with the protection given by rows of tall trees shows that a perpendicular wind usually decreases to 40%–60% of normal, downwind at a distance of five times the tree height; to 60%–80% of normal at 10 times tree height; and to 80%–95%, at 15 times tree height. This means that protection against such winds by inter-row planting is equivalent to the 20%–40% reduction in wind velocity provided by a tree windbreak at a downwind distance of 10 times the tree height. At wind angles other than perpendicular, protection by tree windbreaks becomes poorer, but protection by inter-row planting apparently becomes even better. Still more striking is the substantial protection provided by inter-row planting against parallel winds where tree windbreaks would be useless.

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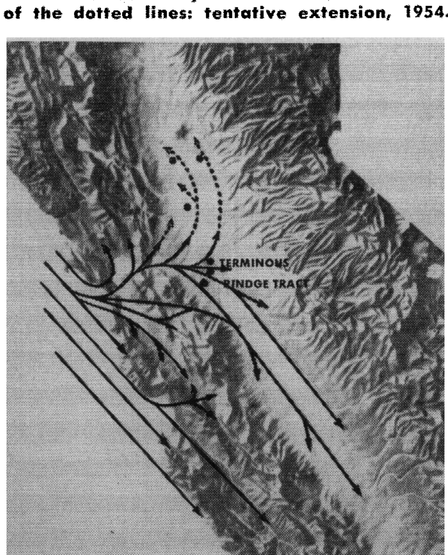
**Wind Directions During Daily Periods with Wind Velocities over 10 Miles per Hour. March to September. Percent of total number of readings.**

| Station | S | SSW | SW | WSW | W | WNW | NW | NNW | N | NNE | NE | ENE | E | ESE | SE | SSE | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rindge Island 315 days, 1955–57 | 0 | 0 | 3 | 3 | 30 | 46 | 8 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 100 |
| Terminous 141 days, 1958 | 0 | 0 | 0 | 13 | 64 | 2 | 6 | 5 | 1 | 0 | 0 | 0 | 0 | 1 | 5 | 3 | 100 |

**Wind Directions for Velocities of 15 Miles per Hour and More on Rindge Island During May and June; Average of Four Years (1955–58) Percent of Total Number of Readings**

| SW | WSW | W | WNW | NW | NNW | N | Others | Total |
|---|---|---|---|---|---|---|---|---|
| 5 | 2 | 35 | 50 | 6 | 0 | 2 | 0 | 100 |

**Streamlines of oceanic air masses in the California valleys in summer. After Byers, 1930. The 6 dots show locations of California spot climate recorders used for wind and temperature survey. Stations shown in the northern half of the Central Valley served in the construction of the dotted lines: tentative extension, 1954.**




**Various wind profiles over asparagus ridges during dust storms.**