Field Windbreaks for Row Crops

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

Herbert B. Schultz and Alan B. Carlton

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-

Concluded on next page

---

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 × 2 × 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.

T. W. Embleton is Associate Horticulturist, University of California, Riverside.

W. W. Jones is Horticulturist, University of California, Riverside.

The above progress report is based on Research Project No. 1632.

WINDBREAKS

Continued from preceding page

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—noninterplanted—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.

Herbert B. Schultz is Specialist in Agricultural Engineering, University of California, Davis.

Alan B. Carlton is Associate Specialist in Soils and Plant Nutrition, University of California, stationed at Stockton.

The above progress report is based on Research Project No. 1686.

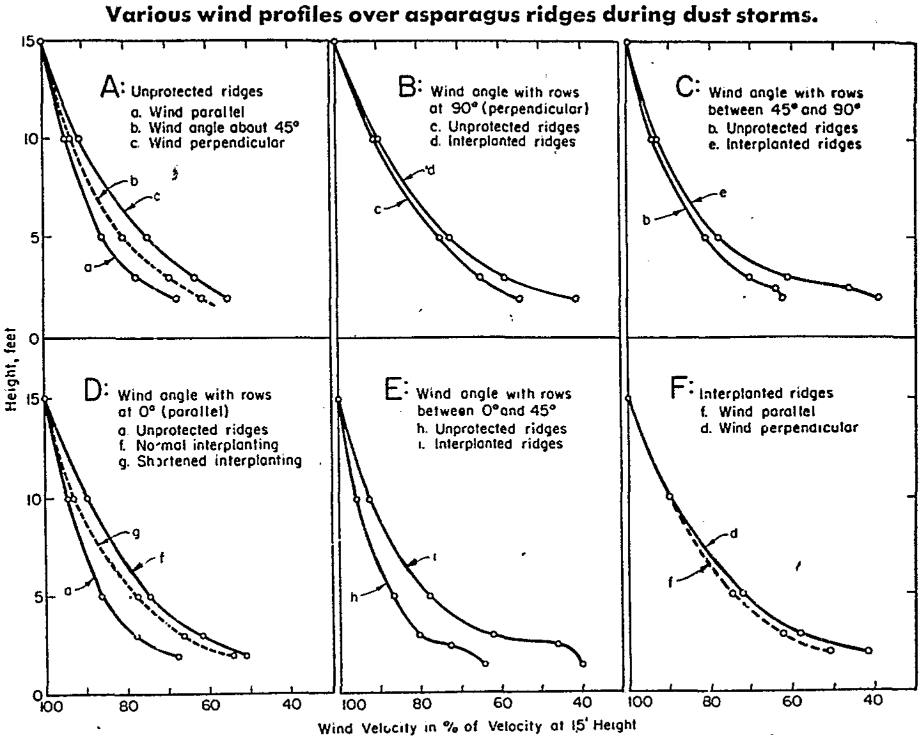
Wind Directions During Daily Periods with Wind Velocities over 10 Miles per Hour. March to September.
Percent of total number of readings.

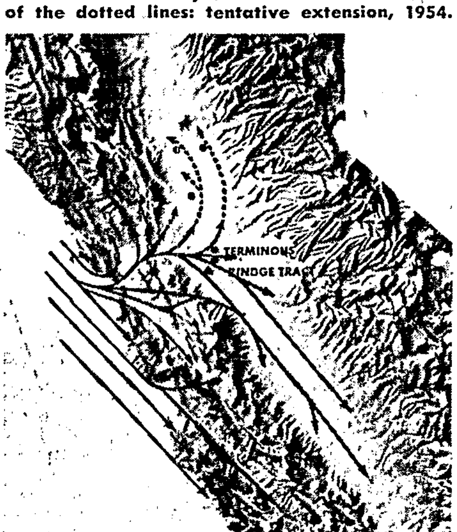
Station	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
Rindge Island 315 days, 1955–57	0	0	3	3	30	46	8	4	3	0	0	0	0	0	2	1	100
Terminous 141 days, 1958	0	0	0	13	64	2	6	5	1	0	0	0	0	1	5	3	100

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

Various wind profiles over asparagus ridges during dust storms.





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.

INTERPLANTING ROWS of asparagus with strips of grain, such as barley, for protection against wind erosion has gradually been accepted by most growers in the San Joaquin Delta area. Winter grain crops are used because physical characteristics of these plants are suitable and protection is needed most in May and June. The effectiveness of these interrow plantings was proven in 1958–1959 tests with elaborate installations which were also described in *California Agriculture.* A simpler method for analyzing interplanting effectiveness has been adopted recently which also presents the results in a more descriptive way. Wind velocities over the ridges are recorded by anemometers set into the ground so that the cups are only 1 inch above the surface, as shown in the sketch. Each anemometer is electrically connected to a California spot climate recorder for continuous recording.

This new method was used for the first time in the 1960 tests, despite previous questions concerning reliability; first, as an opportunity for corroboration of prior results and second, in the case of agreement, this simpler method could be used confidently in further tests in modified interrow plantings.

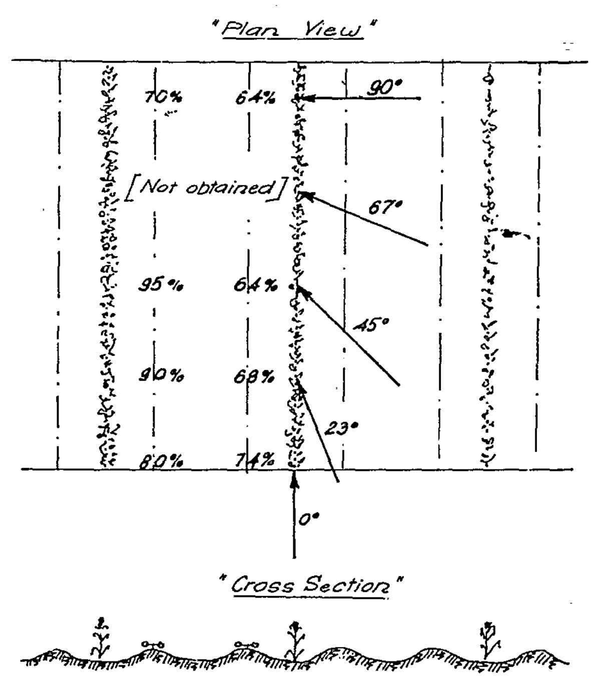
Under conditions tested so far, data comparable with 1958–1959 tests were obtained as plotted on the graph.

Measurements were made on 16-inch-high ridges with interplanted barley grown to about 33 inches high. The barley strips were spaced at the standard planting of about 8 feet. The solid curve in the graph shows that the wind was reduced to 55% of normal when blowing from a perpendicular direction (90° angle), and about as much or even a little more with angles near 45°. These reductions were to be expected because similar values were measured at a conventional wind break—a row of trees—downwind to a distance about five times the height of the trees. As the barley is about 17 inches higher than the ridges, five times this height would be 85 inches. The distance of the ridges from the barley strip is only 48 inches, however, and for a 45° wind, the path would be 68 inches, which is within the optimum protection zone.

The even somewhat greater protection in winds of about 45° can be caused by the greater compactness of the barley blades when looked at from an angle other than 90°. This may also explain the good protection noticeable for wind directions parallel to the ridges (0°-angle). As the damaging winds always are gusty, they are oscillating in direction as well as in velocity, so that they frequently depart from the parallel direction toward the 45° angle.

The scattering of plotted points is an indication of some of the difficulties inherent in this method. The various ridges can be differently shaped, for example, thus influencing the streamflow above. Blowing dust, entering the anemometer bearings, can change their calibration. Soil erosion during one recording period raised the height of the control anemometers in the non-interplanted sections to somewhat more than 1 inch and higher air-speeds were indicated there. About 50 hours of records could still be used, after elimination of such erroneous readings. On the other hand, a certain degree

PLAN VIEW of test plot showing wind velocity in per cent of normal over ridges in alternate interplantings for different wind angles.

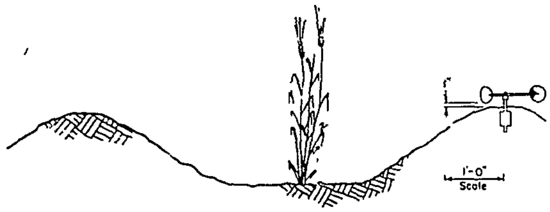


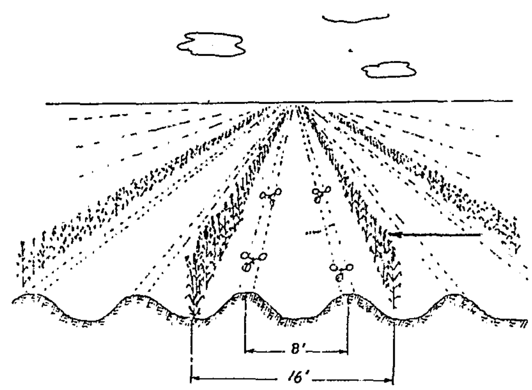
An alternate method for analyzing the effectiveness of wind erosion protection in asparagus fields of the San Joaquin Delta peat regions substantiated previous results proving the value of the practice of interplanting barley in every row, and showed success with alternate row planting mainly when done perpendicular to the critical winds.

H. B. SCHULTZ • A. B. CARLTON • F.

Interplanting Methods for WIND EROSION PROTECTIO *in*

SKETCH BELOW details recording anemometer placement on asparagus ridge in interrow planting of one row of barley per strip. **SKETCH TO RIGHT,** shows field installation of recording anemometers on asparagus ridges interplanted with barley in alternate rows.





: inaccuracy was allowable because wind elocities below 15 mph at a 6-foot height ·ere not found critical under usual field onditions. Wind speeds of more than 20 ph were seldom registered. Therefore, wind reduction to 75% of normal ppears to be sufficient.

Under these circumstances, however, w stands of interplantings (6 inches gher than the ridges) are considered arely sufficient. The dashed line in the raph is based on tests of two methods of iis kind of modification. One low stand as the result of late planting intended to iminate interference with earlier ground ork needed at the ridges. The other low and was caused by cutting off the barley eads before maturation in order to avoid eed problems in succeeding years. he graph also shows that, under these onditions, the wind protection decreases or winds departing from the perpendicu- .r direction—in contrast to the curve for ie standard planting.

Further tests with modified interplant- igs were carried out in the 1963 season, hen a plot was made available for test- ig wind flow over barley strips planted every other row. Wind velocities were ieasured over both ridges. As can be seen the sketch, a dual installation was hosen for the purpose of checking and s a guard against sudden change of con- ition of one anemometer. As a further recaution for protection against erosion at the anemometer spots, the ridges were covered with sheets of paper.

Similar installations, as seen in the sketch (recorders are not shown), were placed on ridges without interplantings (controls), on ridges with standard interplantings of barley, as well as oats. Unfortunately, the barley was diseased and developed poorly, reaching a height of only 28 inches. The protection provided by the standard interplanting was, therefore, 10% weaker than in previous years, and no differences resulted from the test comparing barley with oats. These results should not be considered final. More data is needed for a year when better developed interplantings are available.

For the same reason, data obtained on four test days for the alternate planting method, shown on the plan view, should be considered as tentative. However, it can clearly be seen that wind protection is much superior on the ridges which are close to the windward barley strip. If plotted into the graph, data from this ridge would occupy a position in between the two curves. The other ridge appears to be nearly unprotected in wind angles around 45°, but a perpendicular wind direction seems to give a fair amount of shielding. Some wind reduction could also be obtained for parallel wind. Here again the strong oscillations caused the direction to deviate so much that both ridges received some shielding. The benefit was a little greater at one ridge, because the wind was not exactly parallel and included a component of about 5 to 10° from that side more often than the other.

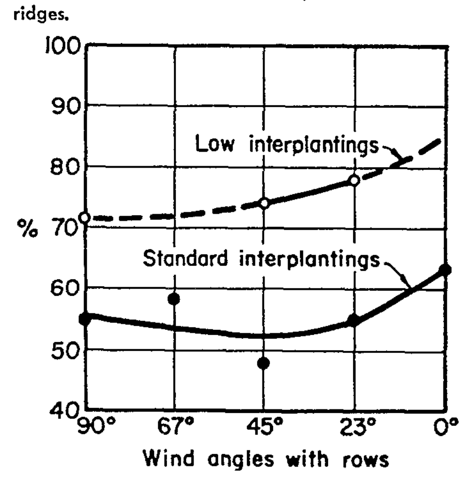
The data obtained so far indicates that the practice of interplanting in alternate asparagus rows is feasible with rows perpendicular to the critical winds. This should be north-south in the northern part of the peat soil region where the winds are directly from the west. Toward the southern edge of this region—southwest of Stockton—most of the winds with critical velocities are from west to northwest, and asparagus rows planted northeast–southeast could be protected in a great number of cases by barley strips in every other row. Fields planted in other directions can obtain only partial protection from this method. Further verification of these results will be tested next season if better plantings and higher wind velocities are available. In previous years, testing, winds of 15 mph occurred, as compared with 5 to 12 mph winds in 1963.

Interplanting in alternate asparagus rows, if feasible, would allow easier harvesting, and reshaping of ridges, which is necessary several times during harvest, and a reduction of winter problems with volunteer barley.

H. B. Schultz is Specialist in the Experiment Station, Department of Agricultural Engineering, University of California, Davis; A. B. Carlton is Specialist in the Experiment Station, Department of Soils and Plant Nutrition, Stockton; and F. Lory is Laboratory Technician, Dept. of Soils and Plant Nutrition, Davis.

Dell Aringa Bros., asparagus growers on King Island, San Joaquin County, assisted with this study by planting and managing the interrow grain crops.

GRAPH of wind velocity over interplanted asparagus ridges in per cent of velocity over non-interplanted ridges. Anemometer cups 1 inch above ridges.



quin Asparagus