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TESTING WIND PROTECTING DEVICES IN THE FIELD BY MEANS OF VERTICAL WIND PROFILE MEASUREMENTS

One of the many aims of the peat land conservation project is the development of wind diminishing devices in the field, like windbreaks, fences, and interplantings. For testing their effectiveness a portable mast with five anemometers up to 15' height was used (see Fig. 3). Wind velocities at the various heights were recorded over asparagus ridges perpendicular and parallel to the wind, alternating open field conditions with areas between snow fences and later on between interplantings (rows of barley between asparagus ridges). Some data also were obtained under various wind angles between 0° and 90° to the ridges. All measurements were taken in conditions of "blowing dust", the velocities being higher than 13 mph at 6' height at the standard station on Bridge Island. A wind average for periods of 30 minutes was used for determining the velocities along each profile. Five (later 6) anemometers were selected after calibration of 15 on a horizontal bar. They were Bendix-Friez Type 339-A. After each test complete cleaning and lubrication was necessary due to infiltration of peat dust in the bearings and gears.

Figure 1 is an example of a comparison of wind speeds along the mast in the open and in 1½ acres protected by snow fences. Four 200' long rows of this lath-type fencing (4 feet tall) were erected on ridge tops, which means a total height of 5½' above surface. The measurements were taken downwind between the third and fourth row, 35' distant from each fence. The wind direction was right-angled to the fences. In Figure 1 it can be seen that the velocities—at 1½' height above surface incidentally being equal—are reduced between the fences with approach to the surface, but only by a small amount. The readings of the

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lowest anemometer which was beneath the ridge height unexpectedly showed about equal velocities at both locations. The explanation can be sought in the curving of the streamlines above and around the ridge. The snow fences installed on '70' distance obviously were not successful at the surface.

As no others of the 25 profiles obtained during 1957 were comparable closely all having different velocities during their observation periods, we can to base all further comparisons on the empirically found power law that increases with elevation.

$$u = u_1 + \left(\frac{z}{z_1}\right)^{1/n} \qquad u = \text{veloc} \quad z = ht$$

$$v = v_1 \times \frac{z}{z_1}$$

u = velocity
z = height

The exponent n is known to be dependent on temperature stratification. But considering daytime conditions alone (excluding night inversions) an additional strong dependence on surface roughness appears and some investigators used this exponent in order to determine the wind-diminishing effect of various ground covers (Sverdrup, Pasquill, K. Schultz). They obtained for daytime conditions:

sandy field	n = 2.4 to 3.0
short field	3.5
high grass	3.6-3.9
fallow field	4.0
stubble field	4.2
airport	4.3
snow	5.2

The highest figure n = 7, or p = $\frac{1}{7}$ = 0.143 was found by Pasquill in fully turbulent flow over a flat plate in the Göttinger Wind Tunnel, whereas the

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lowest figure ever observed was $s = 1.2$, or $p = \frac{1}{s} = 0.83$ by Best in England near strong inversion conditions at night. Lepus, Brown and Decker calculated for night conditions above citrus trees $p = 0.38$ to 0.43.

The determination of s can be made by plotting the observations on log-log paper, where the points should lie along a straight line, see Figure 1 right side. The tangent of the angle of the straight line with the ordinate determines the exponent s. This method was tried for all profiles. Figure 2 contains four more examples showing each of the curves bended very differently. Our calculated values for s fall in the same range of magnitude with the above mentioned as follows:

(4)	bare ridges, wind right-angled	s = 3.4	d = -11 cm
(3)	bare ridges, wind angles 45°	s = 4.1	d = -15 cm
(1)	bare ridges wind parallel	s = 2.4	d = -10 cm
(4)	between snow fences, wind right-angled	s = 5.6	d = -1 cm
(3)	between snow fences, topped by 1' fence	s = 2.4	d = 0 cm
(2)	interplantings, wind right-angled	s = 2.0	d = +13 cm
(1)	interplantings, wind angle 45°	s = 2.7	d = +47 cm
(4)	interplantings, wind angle 45° (with rows)	s = 2.8	d = +22 cm
(2)	interplantings, wind parallel with rows	s = 2.9	d = +5 cm
(1)	interplantings, heads chopped off, parallel with rows	s = 3.2	d = -6 cm

The figures in parentheses give the number of profiles available for the computation. As this power law is a statistical one, many more profiles will be needed to establish definite values of s in the present study. In these preliminary figures the higher values for unprotected areas are striking. The very

ion figures, however, for snow fences, which are even lower than for interplantings, say most verification. On the other hand, we might have to conclude that the determination of the exponent n is not the full answer to our problem. In the above mentioned investigations it served as parameter for wind structure only, but when looking for a parameter for the impact of the wind on the soil surface the determination of the zero-plane displacement seems to be more suitable.

In the plotting of Figures 1 and 2 the level of the soil surface in between the ridges was used as zero-plane. Actually, however, this zero-plane is more or less above the surface depending on height of ridges or kind of protective devices. For this reason, the various points of an individual profile do not lie exactly along the straight line, but are more or less grouped concave to the ordinate, see Figures 1 and 2. These points were, therefore, replotted by varying for each profile the zero-plane until they fitted a straight line. This "zero-plane-displacement" d is tabulated above. The values for d include an adjustment, as they were determined with respect to the ridge-height, in order to cancel out the influence of the latter as it was different at various locations. As it was mentioned for n, the obtained d-values also have to be considered as preliminary. They are negative for unprotected locations which means that the active surface is below ridge height. The locations between snow fences show some protection but intermediate by comparison with interplantings. For the latter ones especially, more measurements will be needed. For example, the final value for right-angled wind might turn out to be higher than +13 cm, and the value +47cm, which is based only on one measurement (profile 4 in Figure 1), might be too high for interplantings under a wind of 45°. However, the higher

value for the 45° angle -- vs. 13 cm for right-angled wind -- could be interpreted as caused by a greater amount of barley blades in the wind path. The barley rows having a width of only 3 to 4 inches offer a rather sparse population of blades to oppose a perpendicular air motion. Although another season's observations might call for some adjustment, the overall picture looks very promising for use of interplantings. Grown in rows of 6 ft. distance they reached a height of 14 to 16 inches above the ridges. The ability of the barley heads to bend is an extra advantage as the bending tends to prevent eddies on the lee side. Even in case of a parallel wind the obtained value d = 6 cm is satisfactory. For explanation might serve the unsteadiness of the wind direction due to turbulence, which always can be recognized by the unrest of the wind vane, especially in high velocities. An additional help might also in this case be the bending of the barley heads. Otherwise, with heads chopped off, only d = -6 cm was obtained. The height of these shortened barley blades was reduced to 6" above ridge height (for fear of weed problems in the following year).

Zero-plane displacement values can also be determined by the logarithmic law. But then a straight line on semi-log paper would be expected only in the absence of temperature effects. When a greater number of profiles has been accumulated, this method could also be used in the future.

Ridge

wind profile 4/4/57

4:30 to 5:30 pm

a between snow-fences

b outside " "

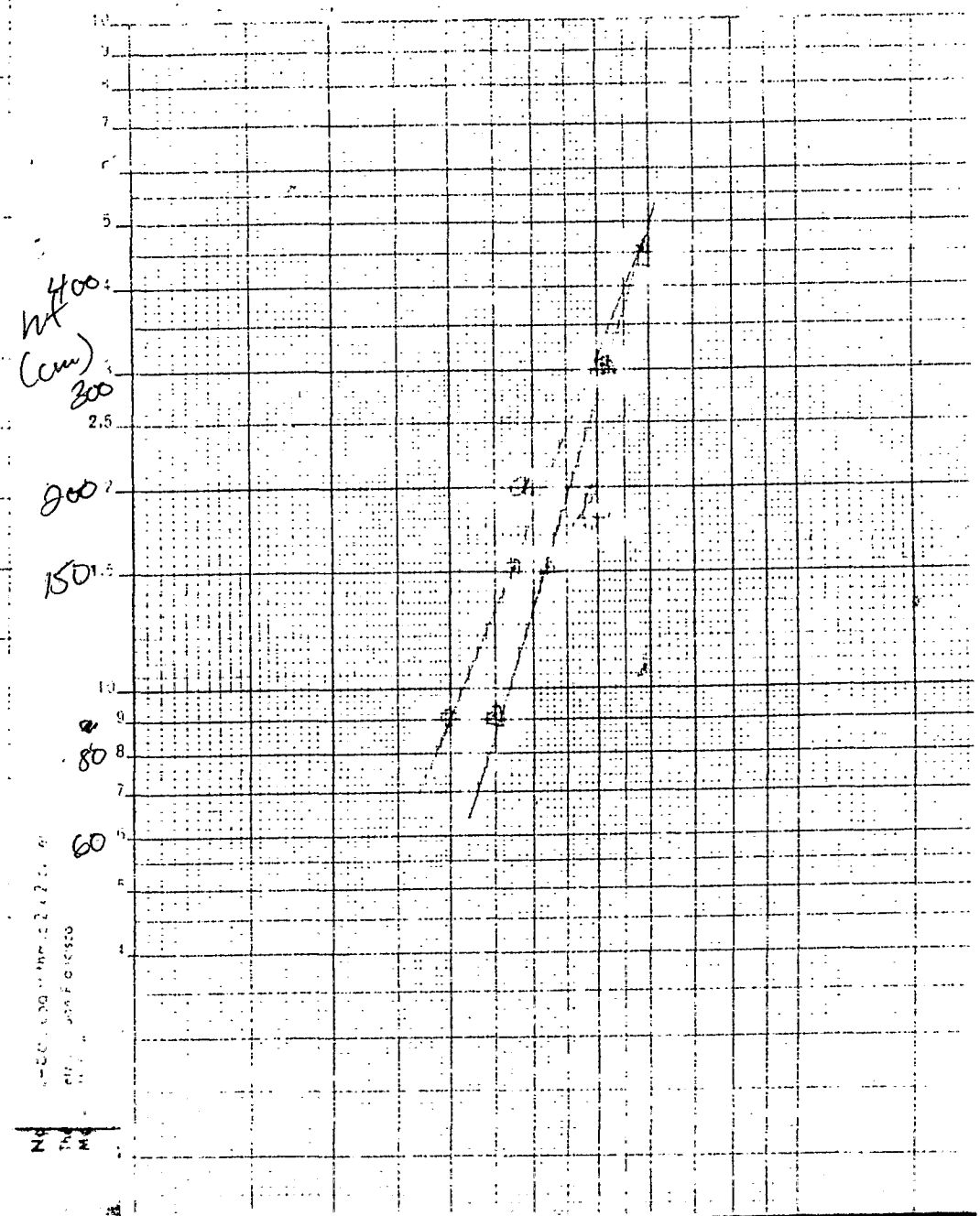
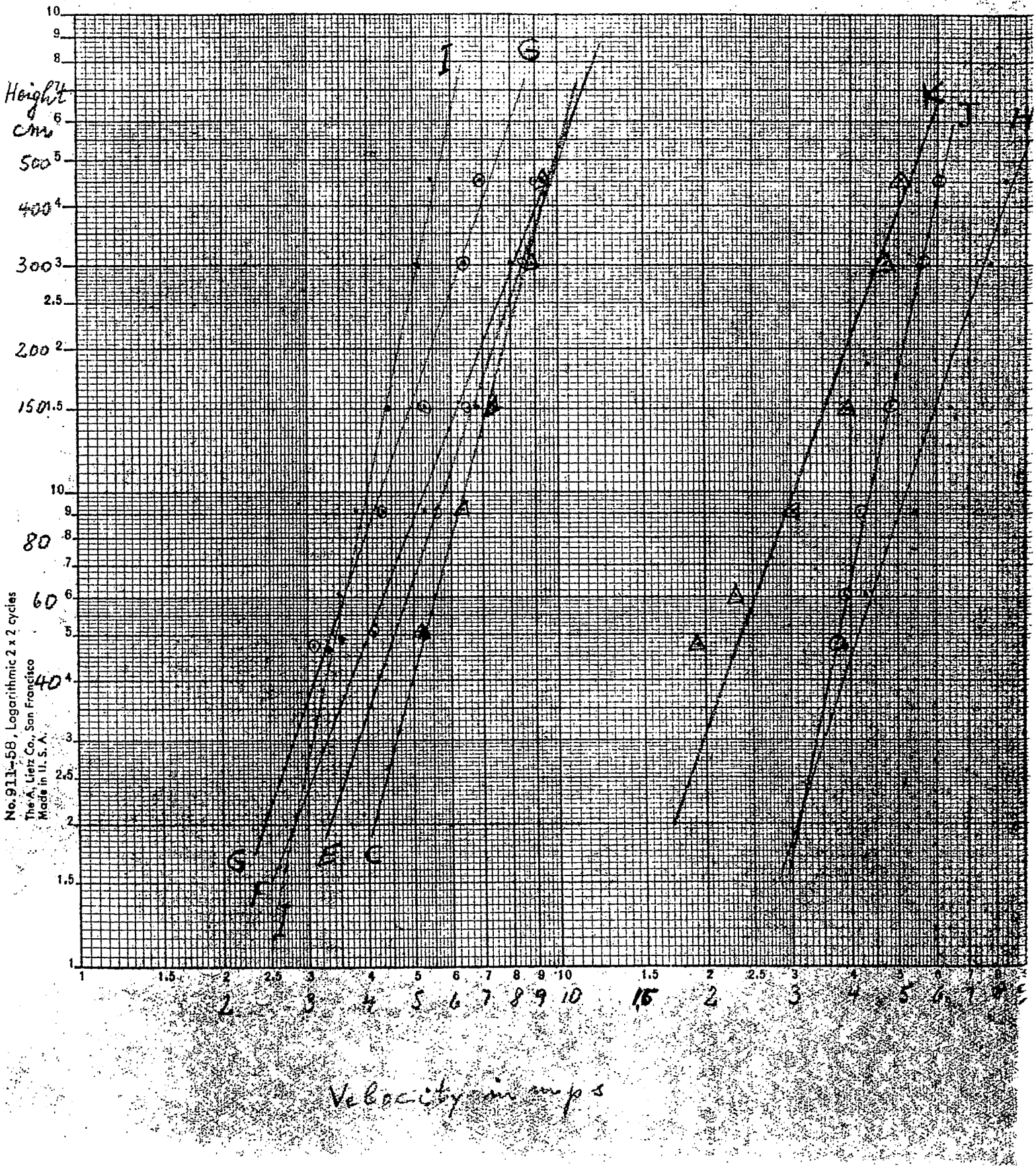


Figure 2

Various Wind Profiles near Terminous, 1957, under different wind conditions, over asparagus ridges with and without interplantings



No. 911-58, Logarithmic 2 x 2 cycles
The A. Lietz Co., San Francisco
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PROJECT NO. 1686 PG. ~~84~~ 81

REPORTED BY H. G. Schulte

Davis - Ag Engineering
Campus and Department

DATE January 13, 1958

For the third consecutive year a spot climate station was operated on Bridge Island. The evaluation of the obtained wind data was done as in the preceding years, and tables 1 to 4 were arranged as previously for the season March to September.

Only 171 days with wind recordings were available, whereas the previous year furnished 193 recorded days. For this reason, some figures in this year's tables turned out to be somewhat smaller than in the previous year (especially in table 2), which should not be interpreted as the 1957 season being "less windy" than 1956. However, it can be stated that the 1957 wind season was rather on the quiet side as was 1956, when compared with 1955. In table 3 of each year's report the number of hours with velocity equal or greater than 15 mph disclose this fact:

	March	April	May	June	July	August	September	
1955:	---	---	(85)	87	10	0	1	hours
1956:	59	25	52	34	6	3	0	hours
1957:	(18)	31	59	32	0	0	0	hours

This comparison also shows that the highest frequency of these strong velocities which appears to be in May, was even more pronounced in 1957, and the quick decline of such winds thereafter still faster than in the two previous years. An attempt was made to break the monthly compilation up into 10-day intervals, beginning with May 22, and using the three years together:

Form B-30m-1,'53(B8800)

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Ave. date of decade:	May 26	June 5	June 15	June 25	July 5	July 15	July 25
No. of hours with 15 mph wind or more:	86	72	63	29	11	5	0

This presentation reveals that after the peak-occurrence in May, the decrease of strong winds is little during the first two decades in June, but starts to be sharp thereafter. In case the following years corroborate this result, soil protection methods should very strictly be recommended to be applied until June 20.

The prevailing directions of the strong winds again were established as WNW (Table 2). The balance is a scatter over a great number of other directions. These occasionally different directions mostly occur in the spring months and are caused by storm passages. From May on, the monsoon-regime with W or WNW-directions becomes predominant as explained in previous reports. This influence can best be seen in Table 1, fourth line, where only 27 percent of all strong winds came from W or WNW in April, but 91 percent in May, the percentage remaining high for the rest of the season.

D-029660

Form R-15m-10,'57(171)

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Table 1. Number of days with at least one hourly velocity of 10 mph or more from March 1 to September 30, 1957.

	March	April	May	June	July	August	September	Total
Number of available recorded days	11	28	24	25	27	27	27	171
Number of days having vel. 10 mph or more	8	22	21	22	15	6	8	102
Number of days vel. 10 mph or more from W or WNW	3	6	19	19	13	5	6	71
Same in percent of all days	37	27	91	86	87	83	75	70

Table 2. Occurrence of directions for velocities of 10 mph or more from March 1 to September 30, 1957

Directions	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
No. of days	0	0	5	4	11	60	9	5	4	0	0	0	0	0	2	2

Table 3. Totals of hours of high velocities for the various months

	March	April	May	June	July	August	September	
Number of hours of 10 or more mph	(161)*	134	165	161	58	25	15	
Number of hours of 15 or more mph	(48)*	31	59	32	0	0	0	
Ave. duration of one daily period of winds of 10 mph or more	7.2	6.1	8.8	7.3	3.9	4.2	1.9	hours

*extrapolated to full month

Form R-25m-20,'57(971)

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Table 4. Frequency of velocities of 10 and more mph for the various hours of the day, March to September 1957

PST	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
AM	8	7	8	6	5	4	6	11	19	22	24	29
PM	32	41	54	60	72	71	63	41	18	15	10	8
						same for velocities of 15 mph and more						
AM	0	1	2	2	0	0	1	0	1	3	7	10
PM	10	11	11	21	22	22	13	1	1	1	0	0