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Abrasive Action of Windblown Soil on Plant Seedlings[1]

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SYNOPSIS. Seedlings of El Reno sideoats grama were found to be more tolerant to windblown soil than Blackwell switchgrass, sand lovegrass, and Indiangrass. Buffalo alfalfa seedlings were not as resistant to soil abrasion as the range grasses studied.

ESTABLISHING adequate plant stands in the Great Plains is often difficult because of insufficient moisture at planting time and because serious windblown soil abrasion may occur while plants are in the seedling stage. While this problem is common to all crops, increased grass plantings for the Soil Bank and the use of vegetation to control blowing dust and sand on military installations in arid regions have intensified the need for information on the tolerance of grass seedlings to both drouth and abrasive action of wind blown soil.

Only a few studies have been reported of the effects of blowing soil on plants. Three studies (5, 6, 7) dealing with soil-borne mosaic, effect of removal of soil from root area of wheat by wind, and abrasive injuries to established winter wheat stands, respectively, have provided some information on soil movement damages to wheat. Another study[3] dealing with establishment of vegetative cover for airfield pavement shoulders indicated that blowing sand and grit cut off slow-growing grass seedlings adapted to dry regions.

This study was undertaken to provide some knowledge of the relative resistance of certain grasses and alfalfa to soil abrasion and of the recovery characteristics of the damaged plants. Two years' data are involved.

EXPERIMENTAL PROCEDURE

Equal weights of sandy loam soil were placed in a series of 18- by 6- by 5-inch flats and 4 rows of grass or alfalfa were seeded in the flats. Plants were thinned after emergence to obtain a constant plant population for each species. Four grasses and one alfalfa variety (Buffalo) were used. The grasses were sand lovegrass *(Erogrostis trichodes)*, Blackwell switchgrass *(Panicam virgatum)*, El Reno sideoats grama *(Bouiteloua curtipendula)* and Indiangrass *(Sorghastrum nutans)*. Each flat was exposed to 12 minutes of blowing dune sand in a laboratory wind tunnel. Rates of sand movement past the plants were determined by placing a known weight of sand in a 1½- by 12-foot metal tray at the beginning of this period and weighing the amount remaining after exposure. The downwind edge of the tray was placed adjacent to and level with the soil surface in the plant flats.

A completely random statistical design involved 5 wind velocities as different treatments with each treatment of each species replicated 4 times. In 1958, wind velocities were 0 (for check), 20, 23, 25, and 29 mph. The following year wind velocities were increased slightly to 22, 25, 28, and 31 mph.

Three days after exposure the plants in each flat were scored for damage by visual inspection and 3 weeks later they were rescored for an evaluation of recovery characteristics. After 1 to 2 months, depending on plant growth, the grasses and alfalfa were clipped, oven dried, and weighed to determine the dry weight of plant material.

In 1958, sand lovegrass, Indiangrass, and alfalfa were grown in the greenhouse. Sideoats grama and switchgrass were kept outside until exposure to the blowing soil and then placed in the greenhouse. All plants were grown outside through the entire time in 1959. A rain shade of clear polyethylene plastic was constructed to prevent soil splash during intense rainfall.

EXPERIMENTAL RESULTS AND DISCUSSION

Yield as Influenced by Abrasive Action

The results of analyses of variance for treatment effects on yield are shown in tables 1 and 2. Figures 1 and 2 show the relationship between the rate of soil movement past the plants and the reduction in yield of plant material. Linear or curvilinear regression procedures were used to derive trend lines that would best fit the data. Rate of soil movement in lieu of wind velocity was used in the regression analysis because of the different rates of soil movement obtained at the same wind velocity.

As was expected, the variance ratio was highly significant for treatment on the alfalfa. Data of both years were significant at the 0.1% level. The plants in 1958 showed considerably larger reductions in yield of dry plant material than those in 1959 (figure 1). This can probably be attributed to environmental conditions of growth. The greenhouse plants were not so vigorous and hardy as those grown entirely outside. Maximum reductions in yield on the average were 80% and 45% for 1958 and 1959, respectively.

Table 1—Summary of analysis of variance of treatment on yield.

Plant	Variance ratio	
	1958	1959
Alfalfa	42.713***	27.695***
Indiangrass	0.384 ns	3.788*
Sand lovegrass	3.937*	11.267**
Sideoats grama	2.523 ns	0.994 ns
Switchgrass	6.626**	5.992**

* Significant at 5% level. *** Significant at 0.1%
** Significant at 1% level. ns Nonsignificant.

Table 2—Summary of mean yields as a function of wind velocity and LSD* for plants that showed significant differences among treatments.

Plant	1958			1959		
	LSD*	Wind velocity	Mean yield	LSD*	Wind velocity	Mean yield
		mph	T./Acre		mph	T./Acre
Alfalfa	.186	0	1.25	.160	22	1.36
		20	1.11		0	1.35
		23	0.99		28	0.94
		25	0.49		25	0.91
		29	0.32		31	0.74
Indiangrass			--	.323	0	1.26
					22	1.23
					25	1.10
					31	0.86
					28	0.81
Sand lovegrass	.230	0	1.28	.370	0	1.99
		25	0.98		25	1.25
		29	0.96		22	1.20
		23	0.95		28	1.07
		20	0.90		31	0.91
Switchgrass	.250	0	1.70	.416	0	1.83
		23	1.62		22	1.61
		20	1.49		25	1.25
		25	1.37		28	1.24
		29	1.16		31	0.97

* Computed at 5% level of significance.
Vertical lines in mean yield column indicate no statistical difference among yields within the extremities of each line.

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[3] Jones, G. H. "Problems of airfield pavement shoulders in arid and semi-arid regions." Presented at the 51st annual meeting, American Society of Agronomy. 1958.

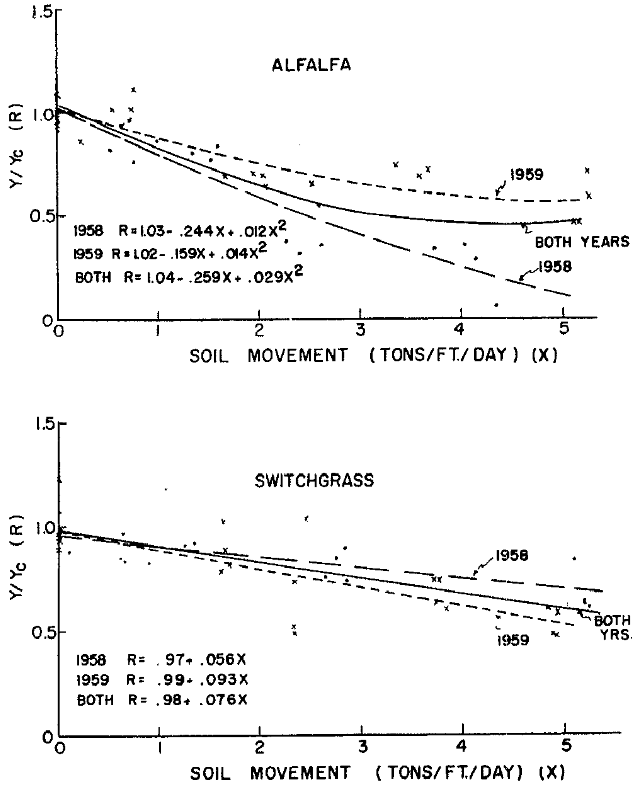

Figure 1—Relationships between rate of soil movement and yield of plant material for alfalfa and switchgrass. Y/Y_c is ratio of treatment and check yields.

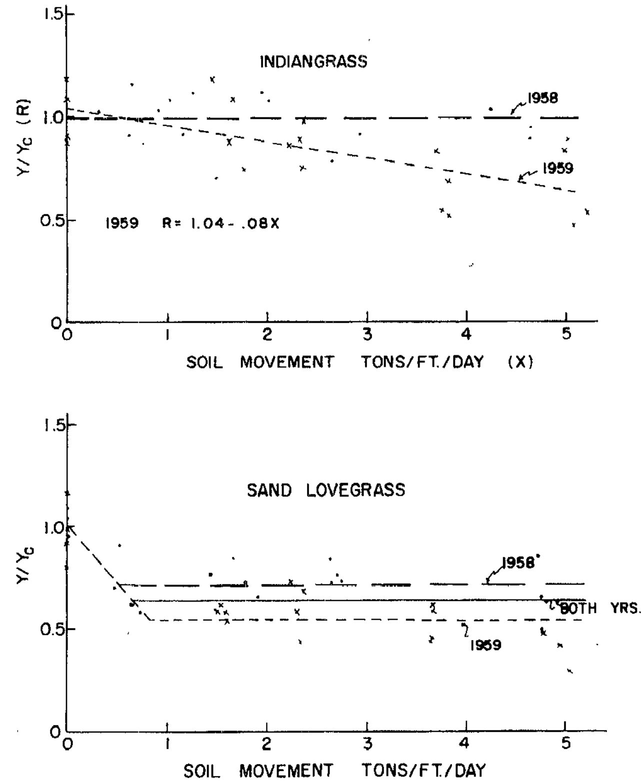

Figure 2—Relationships between rate of soil movement and yield of plant material for Indiangrass and sand lovegrass. Y/Y_c is ratio of treatment and check yields.

Switchgrass showed a rather uniform decrease in plant material with increasing soil movement (figure 1). The variance ratio for treatment was significant at the 1% level for both years. The grass in 1958 showed less reduction in yield than that in the following year, however, it was about 10 days older at time of exposure. Maximum average reductions in yield were approximately 30% and 50% for the two years.

No significant differences for treatment of Indiangrass were found the first year, but the variance ratio was significant at the 5% level in 1959. Several factors may have influenced the results in 1958. The seedlings were exposed September 22, and were not clipped until the first week in December. Growth was very slow and had apparently ceased at the time of clipping. Some unknown seasonal factor, perhaps the length of day, appears to adversely affect the growth of warm season grasses in a controlled-temperature greenhouse. Average maximum reduction in yield was approximately 35% at the highest rate of soil movement (figure 2).

Sand lovegrass reacted somewhat differently from other species to the blowing soil. Although the variance ratios were significant at the 5% and 1% levels for the 2 years, table 2 shows that differences for both years are due to the checks only, i.e., no differences among rates of soil movement were evident (figure 2). This furnishes evidence that sand lovegrass is susceptible to low wind velocities and corresponding low rates of soil movement, and is not damaged appreciably more over the higher range wind velocities and soil movement studied. Less reduction in yield was obtained in 1958 than in 1959. Conditions of growth in 1958 were the same as for Indiangrass, i.e., growth occurred during the fall months and a long growing period. Also the seedlings were about one week older at time of exposure than those in 1959. Maximum average reductions in yield at all rates of soil movement were 30% and 45% for 1958 and 1959, respectively.

Sideoats grama was the only species studied that showed no significant difference for treatment either year. This does not mean that it is completely resistant to windblown soil abrasion. By averaging all the treatments and comparing with the average for the checks, yields were reduced about 18%. Except for Indiangrass in 1958, this was the smallest reduction noted.

Visual Observations

Figure 3 shows the plants 3 days after exposure; figure 4 shows plants just prior to clipping compared with un-

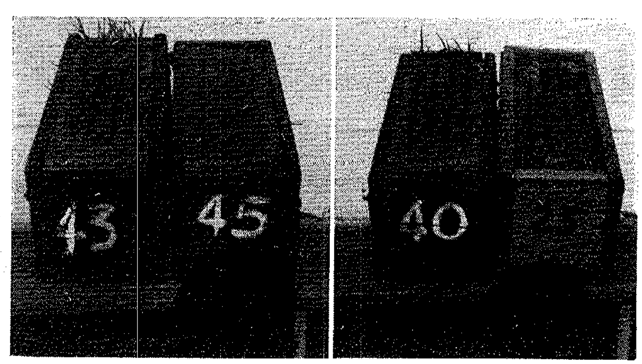

Figure 3—Appearance of plants 3 days after exposure: 43 and 45, Indiangrass; 40 and 25, switchgrass. Flats 43 and 40 are untreated checks.

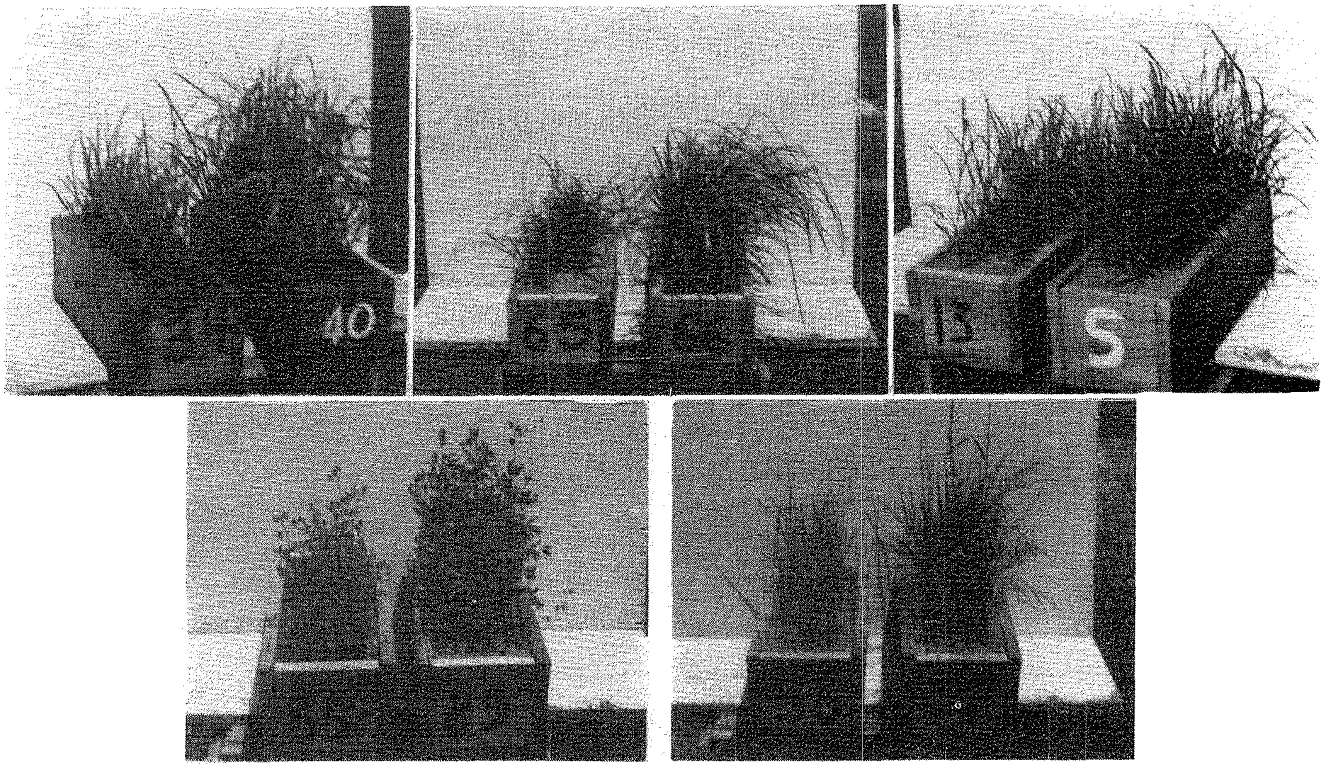

Figure 4—General appearance of grasses and alfalfa just prior to clipping. Top row, left to right: switchgrass, sand lovegrass, and sideoats grama; Bottom row, left to right: alfalfa and Indiangrass. Flat on right in each pair is untreated check.

treated checks. Visual estimates of damage were made using the scoring system in table 3. Also presented in this table is the relationship between damage score and average reduction in yield for each species. The relationship was good for alfalfa, fair for switchgrass, and rather poor for the other grasses. It appears that visual estimates of abrasive damage shortly after treatment indicate yield reduction for alfalfa, but reductions in yield for grasses are less closely related to appearance after treatment.

Table 4 shows data for recovery scores taken 3 weeks after treatment and average reductions in yields. There is general agreement between the score and yield reduction; however individual variation at the same score was quite large. Such estimates made by visual inspection lack the confidence of quantitative measurement data and are subject to differences in individual judgment.

Interpretation of Results

This was a laboratory study wherein abrasive injuries were accelerated by exposing alfalfa and grass seedlings to very high concentrations of moving sand for short periods. Interpretation of the results in terms of field conditions is dependent on factors affecting the rates of soil movement and the intensity-frequency of winds. Limited information is available on these factors. Some speculation seems appropriate.

Over long, level areas of dune sand maximum rates of soil movement can be as much as 2.9 tons per foot per day (1, 2, 4). Wind velocity, soil texture, and the length downwind determine the rates of movement on farm fields, increasing from zero at the leading edge of field to a maximum some distance downwind.

As a hypothetical example, consider a field of grass seedlings 40 rods long. The maximum rates of soil movement in tons per foot per day would occur at 40 rods downwind and would be about 0.07 on a silty clay loam, 0.39 on a silt loam, and 2.6 on a loamy sand (3). All of these rates are less than the maximum 5 tons per foot per day used in the laboratory study.

Intensity-frequency studies of winds (8) indicate that at Dodge City, Kansas, a sustained wind of 40 miles per hour would occur and last for a period equal to the laboratory testing period (12 minutes) once every year during the March, April, and May period.

A combination of the rate of soil movement for loamy sand, the intensity-frequency data, and results of this study indicate that about once a year there could be sufficient soil movement to reduce alfalfa seedling growth following

Table 3—Percent yield reduction as related to damage score immediately after abrasion (means of 2 years data).

Damage score*	Percent reduction in yields				
	Alfalfa	Indiangrass	Sand lovegrass	Sideoats grama	Switchgrass
1		2 ± 5	20 ± 15	15 ± 20	3 ± 15
2	9 ± 15	13 ± 25	30 ± 15	19 ± 17	15 ± 15
3	26 ± 10	25 ± 30	40 ± 27	21 ± 16	37 ± 20
4	52 ± 12	36 ± 20	--	--	--
5	--	-	-		--

* 1. No bleaching or firing of leaf tips.
2. Slight: Obvious bleach of leaf tips.
3. Medium: Rather severe bleaching of leaves but little damage to stems.
4. Severe: Complete bleaching of leaves and considerable damage to stems.
5. Extreme: Tops killed to ground line.

Table 4—Percent yield reduction as related to recovery score 3 weeks after abrasion (means of 2 years data).

Recovery score*	Percent reduction in yields				
	Alfalfa	Indiangrass	Sand lovegrass	Sideoats grama	Switchgrass
1	0	0	30	15	16
2	13	13	28	20	32
3	37	33	27	24	49
4	72				
5	-	-	-		-

* 1. Full. 2. Good. 3. Medium. 4. Poor. 5. Very poor.

damage by 45%, switchgrass 25%, sand lovegrass 35%, and Indiangrass 20%.

Since information on wind occurrences and soil movement rates is limited, the above example serves primarily to show how the information obtained in this study could be used.

SUMMARY

El Reno sideoats grama, Blackwell switchgrass, sand lovegrass, Indiangrass, and Buffalo alfalfa seedlings were exposed to blowing soil carried by 7 different wind velocities between 20 and 31 miles per hour in a wind tunnel. Measurements of damage were made by visual inspection and by weighing the plant material 1 to 2 months after exposure.

Average maximum reductions in yield of plant material for 2 years data were 18% for sideoats grama, 40% for switchgrass, 37% for sand lovegrass, 35% for Indiangrass (one year results), and 55% for alfalfa. Sand lovegrass was susceptible to low rates of soil movement.

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