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Plant response to wind erosion damage

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Wind erosion has damaged or destroyed crops on erodible soils in many regions of the United States. Wind damage to vegetables has been reported in Virginia (*9*), Michigan (*10*, *11*), Georgia (*4*), Wisconsin (*3*), and Texas (*6*). Blowing sand has damaged cotton in North Carolina (*14*) and the High Plains of Texas (*1*, *8*). Nematodes (*12*) are moved with windblown dust, and plant diseases can be transmitted by blowing soil or abrasive leaf contact during strong winds (*5*, *13*).

Evidence that wind alone can damage plants has been shown on many crops. Wind retarded early plant growth of marigolds, increasing water use per gram of dry matter produced and delaying maturity about 10 days (*7*). Sunflowers preconditioned by low levels of available soil moisture at one-eighth field capacity, however, withstood 10 times more exposure to wind before plants were killed than plants actively growing in soil with moisture at field capacity (*15*).

Plant cells may be damaged as the blowing sand strikes the plants. If soil movement is very slight, the injury may not be readily detectable, but usually the damage is very apparent and the plants will suffer. A crop severely damaged early in the growing season may be replanted or replaced by a different crop, depending on market potentials and the availability of water and the length of the growing season.

As production costs continue to skyrocket and the need for maximum food and fiber production increases, decisions concerning replanting damaged crops become more important. By knowing the survival and growth potential of crops subjected to wind damage, the grower can avoid replanting crops with good survival potential. We have conducted numerous laboratory wind tunnel tests to determine physical and physiological responses of several crops damaged by wind and sand.

Data reported here on survival, growth rate, and dry matter production are from Big Spring; those on physiological changes, from Manhattan. We conducted the studies under controlled greenhouse and laboratory wind-tunnel conditions. The plant responses can be evaluated by many techniques.

Results

Resistance to wind damage is a function of wind velocity, amount of abrasive material carried by the wind, exposure time, plant age, and crop. We exposed 21-day old winter wheat plants to 20 minutes of 30-mph wind and sand. Photosynthesis decreased and respiration increased in sand-blasted leaves (Table 1). The wind- and sand-damaged plants had less photosynthetic production and used more stored products to repair damaged tissue, as evidenced by dry weight accumulations of 81 to 55 percent of the check plants.

Wind or wind plus sand reduced the activity of the nitrate reductase enzyme immediately after exposure, indicating shock to plants (Table 2). Enzyme activity increased dramatically 1 day later and remained high for 10 to 40 days. Exposure to wind and sand initially reduced both moisture content in leaf cells and enzyme activity. As plants took up water, they also took up nitrate, dramatically increasing enzyme activity.

Crop Survival

Survival of a damaged crop is a grower's first concern. Leaf tips reflect the first stages of injury. Gradually, the entire leaf and stem will darken until it becomes dark green. If damage is extensive, the plant stem will weaken or break, and the plant will die. If the plant lives, the grower wants to know how it will respond to injury. Survival of plants exposed to wind is closely related to crop type, plant age when damaged, duration of exposure, and quantity of sand in the windstream. As exposure time increased from 5 to 20 minutes, average plant survival decreased from 95 to 46 percent (Table 3). Extremely sensitive crops

Table 1. Physiological changes in wind- and sandblast-damaged winter wheat plants, Manhattan, Kansas (*2*).

Treatment	Photosynthesis	Respiration	Dry Weight Accumulation Days 1 to 7
	— % of controls —		
Wind + 5 kg sand[a]	94	124	81
Wind + 10 kg sand[a]	87	150	60
Wind + 15 kg sand[a]	74	105	55

[a] Total sand on tray upwind from wheat plants before 20-minute exposure.

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Table 2. Nitrate reductase activity of soybean seedlings exposed to wind and sandblast damage, Manhattan, Kansas.

Treatment	Nitrate Reductase Activity Days After Exposure			
	IAE[a]	1	10	40
	— % of controls —			
Wind, 5 minutes	96	101	123	103
Wind + sand, 5 minutes	77	269	158	188
Wind, 10 minutes	15	108	101	123
Wind + sand, 10 minutes	17	267	254	209
Wind, 20 minutes	8	106	120	103
Wind + sand, 20 minutes	24	210	821	201
Wind, 40 minutes	45	177	100	210
Wind + sand, 40 minutes	50	1,746	555	744

[a] Immediately after exposure

Table 3. Crop survival as influenced by duration of exposure to a 33.6 mile per hour wind with 1 ton per rod width per hour sand flux on plants 9 or 10 days old (Big Spring, Texas, unpublished data).

Crop	Survival Exposure Time (minutes)		
	5	10	20
	— % —		
Peppers	75	8	0
Onions	100	100	100
Cabbage	100	87	56
Southern peas	100	94	72
Carrots	91	10	4
Cucumbers	100	100	46
Cotton	100	85	15
Sunflowers	91	88	72
Average	95	72	46

Table 4. Dry matter production (6-week-old plants) as influenced by crop and exposure time to a 33.6 mph wind and 1 ton per rod width per hour sand flux when plants were 9 or 10 days old (Big Spring, Texas, unpublished data).

Crop	Dry Weight Exposure Time (minutes)		
	5	10	20
	— % of controls —		
Peppers	73	8	0
Onions	53	53	14
Cabbage	53	24	15
Southern peas	70	43	16
Carrots	42	2	1
Cucumbers	112	86	24
Cotton	47	23	6
Sunflowers	105	94	22
Average	69	42	12

like peppers and carrots were totally destroyed by 20-minute exposures.

Dry Matter Production

The crops tested varied considerably in type and growth habits. To compare all crops on an equal basis, we expressed dry matter, plant height, and growth rate as percentages of the control (undamaged) plants. Growth and development of damaged, but not killed plants, were delayed from 1 to 4 weeks (*1*). The more severe the injury, the longer the delay. As exposure time increased from 5 to 20 minutes, average dry weight of 6-week-old plants decreased from 69 to 12 percent of control plants (Table 4). Nine-day-old carrots and cotton exposed for 5 minutes produced less than 50 percent as much dry matter as control plants.

Growth Rate

Half the lightly damaged crops (5-minute exposures) grew more rapidly than controls, but growth rates of severely damaged plants (20-minute exposures) were reduced, except for cotton and sunflowers (Table 5). Only 15 percent of severely damaged cotton survived (Table 3). Accelerated growth indicates that cotton plants not destroyed recovered quickly, but the increased growth (Table 5) may have resulted from reduced competition because only a few plants survived (Table 3).

Plant Height

Plants exposed to severe wind and sand for 10 or 20 minutes were shorter than control plants, except sunflowers and cucumbers which showed a tolerance to 5- and 10-minute exposures. Onions had excellent survival (Table 3). Damaged onion plants, however, were smaller and recovered slower than damaged sunflowers (Table 6).

Conclusions

Wind erosion damage in a laboratory wind tunnel reduced plant survival, growth rate, and plant height of greenhouse plants by reducing plant photosynthesis and increasing respiration. Plant leaves were easily damaged and the loss of viable photosynthetic leaf area reduced energy production. The wind erosion damage also caused short-term, high-intensity, moisture stress because of impaired stoma control and epidermis damage. The increased moisture stress reduced the activity of soybean enzyme systems. As metabolic activity decreased, the plants naturally grew less, and dry matter production and plant height were reduced.

Plant survival decreased as exposure time to wind erosion damage increased. Peppers, carrots, and cotton were easily damaged by wind erosion while sunflowers, onions, and southern

Table 5. Crop growth rate[a] 4 weeks after exposure as influenced by length of exposure to wind and sand injury (Big Spring, Texas, unpublished data).

Crop	Growth Rate Exposure Time (minutes) 5	10	20
	% of controls		
Peppers	136	73	0
Onions	78	94	57
Cabbage	97	48	48
Southern peas	71	51	46
Carrots	73	33	8
Cucumbers	111	105	52
Cotton	211	139	168
Sunflowers	106	100	115
Average	110	80	62

[a] Growth rate is the average increase in height per day, expressed as a percentage of controls rate.

Table 6. Plant heights as influenced by duration of exposure to a 33.6 mph wind with 1 ton per rod width per hour sand flux on plants 9 or 10 days old (Big Spring, Texas, unpublished data).

Crop	Height Exposure Time (minutes) 5	10	20
	% of controls		
Peppers	89	47	0
Onions	90	85	58
Cabbage	84	66	54
Southern peas	72	63	64
Carrots	79	42	40
Cucumbers	120	99	41
Cotton	89	68	73
Sunflowers	102	95	81
Average	91	71	51

peas were fairly resistant. Severe wind erosion conditions destroyed all plants.

The growth rate and plant height of cucumbers and sunflowers increased after a 5-minute exposure to wind damage, which may indicate that a little damage can stimulate plant development of those two crops.

REFERENCES CITED

1. Armbrust, D. V. 1968. *Windblown soil abrasive injury to cotton plants.* Agron. J. 60: 622-625.
2. Armbrust, D. V., Gary M. Paulsen, and R. Ellis, Jr. 1974. *Physiological responses to wind- and sandblast-damaged winter wheat plants.* Agron. J. 66: 421-423.
3. Bubenzer, G. D., and G. G. Weis. 1974. *Effect of wind erosion on production of snap beans and peas.* J. Am. Soc. Hort. Sci. 99: 527-529.
4. Carreker, John R. 1966. *Wind erosion in the Southeast.* J. Soil and Water Cons. 21: 86-88.
5. Claflin, L. E., D. L. Stuteville, and D. V. Armbrust. 1973. *Windblown soil in the epidemiology of bacterial leaf spot of alfalfa and common blight of beans.* Phytopathology 63: 1,417-1,419.
6. Downes, J. D. 1973. *Reduction of sandstorm injury to vegetables under field conditions.* Texas Tech Univ. Agr. Sci. Tech. Rpt. No. T-4-114: 28-30.
7. Finnell, H. H. 1928. *Effect of wind on plant growth.* J. Am. Soc. Agron. 20: 1,206-1,210.
8. Fryrear, D. W. 1971. *Survival and growth of cotton plants damaged by windblown sand.* Agron. J. 63: 638-642.
9. Graves, Boyett. 1972. *Windbreaks for spring vegetable crops.* The Vegetable Growers News 27(6): 1.
10. Hill, Russell G. 1966. *Wind erosion control on upland soils.* Ext. Bul. 525. Extension Service, Washington, D. C. 6 pp.
11. Meredith, Deane. 1971. *An "ounce of prevention" can prevent wind damage.* Soil Cons. 36: 155.
12. Orr, C. C., and O. H. Newton. 1971. *Distribution of nematodes by wind.* Plant Disease Rpt. 55: 61-63.
13. Sill, W. H., Jr., A. E. Lowe, R. C. Bellingham, and H. Fellows. 1954. *Transmission of wheat-streak-mosaic virus by abrasive leaf contacts during strong winds.* Plant Disease Rpt. 38: 445-447.
14. Staff Report. 1968. *Field stripping curbs wind damage.* Cotton 4(5): 11.
15. Whitehead, F. H. 1963. *Experimental studies of the effect of wind on plant growth and anatomy. III. Soil moisture relations.* N. Phytol. 62: 80-85.