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Wind and Sandblast Injury to Field Crops: Effect of Plant Age[1]

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ABSTRACT

Most plant sandblast studies have been conducted with plants at only one age, which has varied from 3 to 21 days after emergence, depending on the plant species. This study was designed to determine if age of plants exposed to sandblast injury influences severity of damage. Plants of 'RS-626' grain sorghum [*Sorghum bicolor* (L.) Moench.], 'Williams' soybean [*Glycine max* (L.) Merr.], and 'Parker' winter wheat (*Triticum aestivum* L.) were exposed in a wind tunnel to a wind velocity of 13.4 m/s for 80 min and wind plus sand (0.297 to 0.42 mm diam) for 10, 20, 40, and 80 min at 3, 7, 14, 21, and 28 days after emergence and vernalization. Maximum reduction in dry weight measured 14 days after exposure and delay in appearance of first inflorescence or bloom occurred when plants were exposed 7 to 14 days after emergence, except for winter wheat exposed after vernalization where dry weight was not affected and inflorescence delay was greatest when exposed 21 days after vernalization. Spike weight and number in winter wheat were not affected by fall exposure but were reduced by exposures which occurred 2 to 4 weeks prior to spike emergence. The results indicate the need for cultural practices which will control wind erosion throughout the growing season for maximum crop yields.

Additional index words: **Wind erosion, Sandblast damage, Abrasive injury, Winter wheat, Grain sorghum, Soybean.**

LARGE areas of cropland in the Great Plains are damaged each year by wind erosion. Although most dust storms, reportedly 95% (8), occur between 1 November and 31 May, wind erosion can occur whenever wind velocities are high and soil surfaces are dry, loose, finely divided, and bare of vegetative cover.

Wind and windblown soil reduce survival, growth, yield, and quality of field crops (1, 2, 3, 4, 5, 7, 9, 10, 11, 13, 14, 15) and vegetables (4, 6, 12, 13). Most previous work was conducted in the seedling stage with exposure to wind and sandblast damage at a single age, except for studies on cotton (*Gossypium hirsutum* L.) (5, 9), tobacco (*Nicotiana tabacum* L.) (4), and winter wheat (*Triticum aestivum* L.) (15).

Both field-grown (5) and greenhouse-grown (9) cotton were exposed at several times after emergence—7, 14, and 21 days and 3 and 9 days, respectively. Both studies indicate that wind erosion damage was less severe as cotton plants aged. Tobacco (4) was exposed to sandblasting 7, 14, 21, and 28 days after transplanting. Total leaf dry weight was reduced on the plants exposed at 7 and 14 days when plants were harvested 14 and 48 days after exposure. Winter wheat was given one or two exposures to blowing soil in the fall and again in the spring after vernalization (15). Spring exposures caused more damage and reduced all yield indicators more than fall exposures. Yield reduction was related to amount of soil striking the plants and not to number of exposures.

This study was undertaken to determine the effect of plant age on resistance of grain sorghum [*Sorghum bicolor* (L.) Moench.], soybean [*Glycine max* (L.) Merr.], and winter wheat to soil abrasive injury.

MATERIALS AND METHODS

Crops of 'RS-626' grain sorghum, 'Williams' soybean, and 'Parker' winter wheat were grown in a greenhouse with a minimum temperature of 21°C and daylength extended to 12 h with a combination of fluorescent and incandescent lamps. Plants were seeded in 18-cm-diam plastic pots filled with masonry sand (sieved to remove all particles > 3.35 mm) and thinned to six plants 3 days after emergence. Watering was done daily with 0.2 strength Hoagland solution as needed.

The wind tunnel used in this experiment was a horizontally recirculating pull type, 9.14 m long, 0.76 m wide, and 1.02 m high. Three pots were located 7.62 m downwind from the honeycomb. The upwind tunnel floor, ceiling, and walls are plywood. Velocity distribution, both horizontally and vertically, is uniform throughout the test area. Wind velocities are measured with pitot tubes and pressure transducers.

Plants were exposed in the tunnel to a wind velocity of 13.4 m/s for 80 min and to wind plus sand (0.297 to 0.42 mm diam) for 0, 10, 20, 40, and 80 min at a sand flux of 31 g/cm width/min at 3, 7, 14, 21, and 28 days after emergence and also at the same intervals after vernalization for winter wheat. Actual plant ages at exposure were 3, 7, 14, 21, and 28 days for grain sorghum, soybeans, and fall-exposed winter wheat and 90, 94, 101, 108, and 115 days for spring-exposed winter wheat. Sand was introduced into the wind stream at the beginning of the wind period. Plants were returned to the greenhouse after exposure.

Winter wheat was vernalized by placing the plants in a constant temperature room (45 days at 3°C with constant illumination from four fluorescent lamps) 42 days after emergence. Plants did not become dormant but growth ceased.

Three plants from each exposure treatment were harvested 14 days after exposure. Plant height, survival, number of live leaves, fresh weight, and dry weight were recorded. Due to high water demand, grain sorghum was harvested after all plants headed, and soybeans after all plants had bloomed. Winter wheat was harvested 136 days after emergence. Number of spikes and total weight of spikes were recorded.

RESULTS AND DISCUSSION

All measurements taken 2 weeks after exposure followed the same trends, so only dry weight (expressed as percent of control dry weight) will be discussed. Increasing the length of exposure to sandblast damage increased the dry weight reduction in soybeans (Table 1). Wind alone damaged the grass species seedlings (grain sorghum and winter wheat) more than the broadleaf (soybean). This may be due to the reaction of the leaf shape to the wind. Grass species leaves tend to whip when placed in a windstream and the leaf tips are physically removed by this whipping action. Older and larger plants (spring exposed winter wheat) tend to protect the leaves better due to larger bulk.

Analysis of variance (ANOVA) for this study indicates that exposure treatment was more important in reducing dry weight than age of the plant when exposed to wind and sandblast damage, except in the

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Table 1. Effect of exposure treatment to wind and sandblast damage on dry weight 2 weeks after exposure.

Exposure treatment	Grain sorghum	Soybean	Winter wheat Fall exposure	Winter wheat Spring exposure
	% of control			
Control	100	100	100	100
Wind only	85	97	78	96
Wind plus 10 min sand	67	83	52	79
Wind plus 20 min sand	73	66	64	92
Wind plus 40 min sand	57	43	52	79
Wind plus 80 min sand	63	37	47	82
$LSD_{0.05}$†	13	10	11	11
$s_{\bar{x}}$	4.63	3.48	3.80	4.03

† LSD = Least significant difference, $s_{\bar{x}}$ = Standard error of mean of sample.

Table 2. The F ratios for dry weight 2 weeks after exposure to wind and sandblast damage.

Source	df†	Grain sorghum	Soybean	Winter wheat Fall exposure	Winter wheat Spring exposure
Exposure treatment	5	11.92**	60.09**	28.24**	5.13**
Age at exposure	4	12.90**	5.82**	13.04**	0.25

** Significant at the 0.01 level.
† df = Degrees of freedom.

case of grain sorghum where the effect was about even (Table 2).

Exposure of grain sorghum, soybean, and winter wheat seedlings to windblown sand 7 to 14 days after emergence reduced the dry weight more than when plants were younger or older (Table 3). This probably is the age where the plant has exhausted the energy supply in the seed and has become totally dependent on its own ability to produce photosynthate. Any loss of photosynthetic tissue at this time places an added burden on the plant's energy supply, as energy must be diverted from growth to the repair of cells damaged by sandblasting. Exposure of winter wheat after vernalization reduced dry weight 10 to 15%, regardless of the age at exposure.

The greatest reduction in development noticed 2 weeks after exposure in the 7- to 14-day-exposed plants continued through to heading or blooming for fall-exposed winter wheat and soybean (Table 4). Fall-exposed winter wheat heading was delayed 3 to 7 days and soybean first bloom was delayed 7 to 14 days. Maximum heading delay in sorghum and spring-exposed winter wheat occurred when plants were exposed 2 to 4 weeks before inflorescence began emerging. First inflorescence or bloom appeared 61, 40, and 111 days after emergence for grain sorghum, soybean, and winter wheat, respectively. It appears that physical damage at this stage of plant development diverts photosynthate from inflorescence development to repair of abrasive injury, thereby delaying inflorescence emergence by 9 to 11 days. This delay in maturity may increase the chance of water stress or, in the case of winter wheat, exposure to hot, dry winds which may further reduce yields.

Fall exposures of winter wheat at 7 to 14 days after emergence reduced dry weight at harvest and delayed heading but did not significantly alter spike weight or number (Table 5). The lightest and the least number of spikes, however, were produced on plants exposed 7 days after emergence. Spring exposures reduced spike weight and number more when plots were exposed 21 and 28 days after vernalization or 1 or 2 weeks before spikes emerged. Spring-exposed plants produced significantly fewer spikes, 8.6 vs. 12.0, which were significantly lighter, 1.02 vs. 1.16 g. These results agree with those of Woodruff (15) for fall and spring exposures.

Although wind erosion is not as likely to occur when plants are maturing as when they are seedlings (8), these results indicate the need for cultural practices that will control wind erosion throughout the year for maximum crop production.

Table 3. Effect of plant age at exposure to wind and sandblast damage on dry weight 2 weeks after exposure.

Age at exposure	Grain sorghum	Soybean	Winter wheat Fall exposure	Winter wheat Spring exposure
days	% of control			
3	67	77	77	89
7	56	73	62	89
14	69	58	46	87
21	87	70	69	85
28	92	77	74	90
$LSD_{0.05}$†	12	9	10	8
$s_{\bar{x}}$	4.22	3.18	3.47	2.85

† LSD = Least significant difference, $s_{\bar{x}}$ = Standard error of mean of sample.

Table 4. Effect of plant age at exposure to wind and sandblast damage on delay in heading or blooming relative to unexposed plants.

Age at exposure	Grain sorghum	Soybean	Winter wheat Fall exposure	Winter wheat Spring exposure
days	days after control			
3	5.2	12.0	3.9	5.8
7	7.7	12.0	6.9	5.9
14	2.1	14.6	5.3	7.4
21	2.4	10.5	3.1	11.2
28	9.2	7.0	3.9	6.8
$LSD_{0.05}$†	3.4	1.5	1.9	1.8
$s_{\bar{x}}$	1.21	0.52	0.68	0.62

† LSD = Least significant difference, $s_{\bar{x}}$ = Standard error of mean of sample.

Table 5. Effect of plant age at exposure to wind and sandblast damage on number and weight of spikes of winter wheat.

Age at exposure	Fall exposure Spike weight	Fall exposure Number	Spring exposure Spike weight	Spring exposure Number
days	g		g	
3	1.11	13.3	1.17	10.5
7	1.01	10.7	1.21	10.2
14	1.23	11.7	1.11	8.6
21	1.21	11.9	0.81	6.3
28	1.23	12.5	0.80	7.6
$LSD_{0.05}$	NS	NS	0.17	1.3
$s_{\bar{x}}$	0.05	0.52	0.06	0.46
Avg.	1.16†	12.0††	1.02†	8.6††

† Spike weight $LSD_{0.05}$ = 0.06 $s_{\bar{x}}$ = 0.02. LSD = Least significant difference, NS = Not significant, $s_{\bar{x}}$ = Standard error of mean of sample.
†† Spike number $LSD_{0.05}$ = 0.6 $s_{\bar{x}}$ = 0.2.

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