Wind speed above and within sunflower stalks varying in height and population

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2 authors:

D.C. Nielsen
United States Department of Agriculture

Robert M. Aiken
Kansas State University

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D.C. Nielsen and R.M. Aiken

Interpretive summary

Low residue amounts following sunflower harvest in the central Great Plains appear to leave the soil unprotected against wind erosion. No quantitative data exist describing the effects of standing sunflower residues on wind speed within the standing stalks. The objectives of this study were to measure the effects of stalk height, population, and diameter (quantified as silhouette area index) on: 1) wind speed within sunflower residue, 2) friction velocity, and 3) erosion ratio of bare surfaces compared with surfaces covered with standing stalks. As the silhouette area index increases in response to increases in stalk height, population, or diameter, wind speeds near the soil surface decrease, friction velocity increases, and erosion potential decreases. Typical amounts of standing sunflower stalks cut to a height of 50 to 70 cm (20 to 38 in) would reduce erosion to less than 5% of the amount predicted for a bare soil surface.

Key words: friction velocity, silhouette area index, soil erosion, sunflower residue, wind speed.

ABSTRACT: Concerns about wind erosion during the summer fallow period following sunflower harvest arise from the assumption that low residue amounts following harvest provide inadequate protection for the soil surface. The objectives of this study were to: 1) measure the effects of standing sunflower silhouette area index (stalk height X diameter X population) on wind speed within and above standing sunflower stalks, and 2) compare the resultant changes in friction velocity and erosion ratio for residue-covered compared with bare soil surfaces. Sunflower (Helianthus annuus L.) stalks were either laid flat after harvest or left standing at one of two heights. Stalk densities were variable, from approximately 26,250 to 64,580 stalks/ha (10,620 to 26,140 stalks/a). Wind speed profiles within and above the standing stalks were measured with cup anemometers. Friction velocity increased linearly with wind speed and increased quadratically with the silhouette area index. Increasing the silhouette area index increased the critical friction velocity ratio in a manner similar to previously reported wind tunnel results. Predicted reductions in the wind erosion ratio based on these field-measured wind speeds are similar to values predicted from wind tunnel studies. Standing sunflower stalks should reduce the erosion potential to 0 to 12% of that predicted for bare soils.

Sunflower (*Helianthus annuus* L.) is an economically viable crop for dryland crop rotations in the central Great Plains. However, concerns about wind erosion during the summer fallow period following sunflower harvest arise from the assumption that low residue amounts following harvest provide inadequate protection for the soil surface.

Bilbro and Fryrear (1994), reiterating the finding of Siddoway et al. (1965), stated that standing residue is more effective than flat residue for controlling wind erosion because it absorbs more of the wind's energy and raises the zero-velocity point above the soil. They also noted that the height, diameter, and number of stalks per unit soil area determine the effectiveness of standing residue because these characteristics determine the silhouette area through which the wind must pass. Standing residues protect the soil from erosion by reducing wind speed near the soil surface, which prevents much of the direct wind force from reaching erodible soil particles. Standing residues also trap soil particles, which prevents the normal avalanching of soil material downwind (Woodruff et al. 1972; van de Ven et al. 1989). Smika (1983) measured a 74% reduction in wind speed at the soil surface when standing wheat straw height was increased from 30 to 61 cm (12 to 24 in).

Hagen (1996) stated that the friction

David C. Nielsen is a research agronomist and Robert M. Aiken is a soil scientist with the USDA-ARS, Central Great Plains Research Station, Akron, Colo. *They acknolwedge Steve Hinkle, Hubert Lagae, Gene Uhler, Bob Florian, Dee Webb, Kris Lindahl, Sharel Franke, Chad Kuntz, Dawn Scott, Karen Couch, and Mike Perry for assistance in plot preparation, data collection, and data analysis; Rick Lewton and Roger Ashley for use of their sunflower fields, and the National Sunflower Association for financial support of their research.*

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erosion ratio for residue-covered compared with bare soil surfaces.

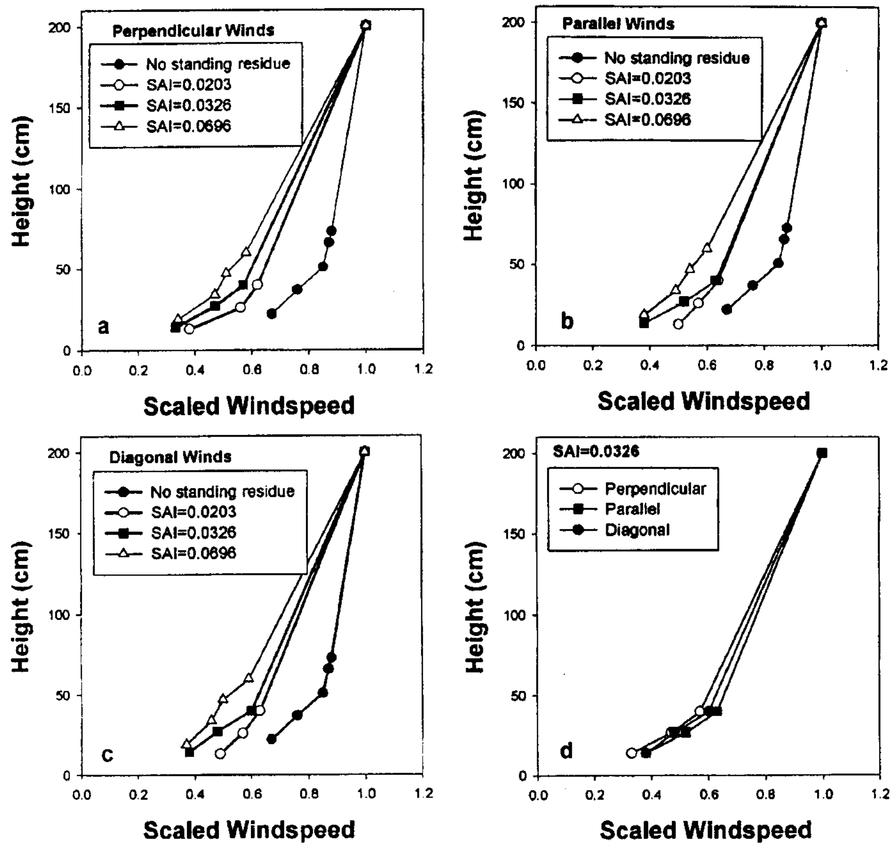

Figure 1. Scaled wind speed profiles for three levels of silhouette area index (SAI, m²/m²) from wind direction a) perpendicular, b) parallel, and c) diagonal to row direction; and d) wind direction effect for intermediate SAI

velocity at the soil surface drives the erosion process. Hagen and Armbrust (1994) derived a relationship from wind tunnel data of Lyles and Allison (1981) and van de Ven et al. (1989), which showed an exponential decline in the ratio of below-canopy to above-canopy friction velocities with increasing silhouette area index (SAI, which is residue height X diameter X population). The dowels used as simulated standing residue by van de Ven et al. (1989) were much shorter and smaller in diameter than typical sunflower stalks, but the characteristics of the actual sunflower residue used by Lyles and Allison (1981) were similar to some of the field residues used in this experiment (height = 43 cm, diameter = 1.57 cm, population = 44,600 to 166,300 stalks/ha, SAI = 0.0281 to 0.1123 m²/m²).

In evaluating data from wind tunnel studies, Hagen (1996) calculated erosion ratio (erosion from a standing residue-covered surface compared with a bare soil surface). The erosion ratio ranged from 0.10 to 0 for SAI of 0.02 to 0.05 m²/m².

Data regarding the effects of standing residues on near-surface wind speeds are specifically lacking for sunflower residues. The objectives of this study were to: 1) measure and quantify the effects of the standing sunflower silhouette area index on wind speed within and above standing sunflower stalks, and 2) compare the resultant changes in friction velocity and erosion ratio for residue-covered compared with bare soil surfaces.

Materials and methods

Six field experiments were conducted from the fall of 1992 through the early winter of 1995. Studies 2, 4, 5, and 6 (Table 1) were conducted at the Central Great Plains Research Station (6.4 km east of Akron, Colo.), while Studies 1 and 3 were conducted on cooperating farmers' fields near Akron. Soil types in the study areas were either Rago silt loam or Weld silt loam (both are fine montmorillonitic mesic Pachic Argiustoll). Row spacing was 76 cm (30 in) for all studies.

Within-residue wind profiles (Studies 1 to 5). Row direction was east-west in Studies 1 and 2, and north-south in the Studies 3 to 5. Plot size was 46 × 46 m (150 × 150 ft) within much larger sunflower fields such that there were no sharp discontinuities in surface residue conditions at the borders of the specified plot areas. Stalk densities were variable in the five studies, ranging from 26,250 to 64,580 stalks/ha (10,620 to 26,140 stalks/a). Variable seeding rates were used to establish variable stalk densities in Study 3; for the other four studies, stalk densities were whatever were found in the field after harvest. Stalks were cut at harvest to either 43 to 48 cm or 66 to 74 cm (17 to 19 in or 26 to 29 in). Study 1 also had a plot with stalks laid flat to the ground using a roller after sunflower harvest.

A mast was placed in the center of each plot with cup anemometers at various heights within the standing stalks. A reference cup anemometer and wind vane

Table 1. Dimensions of sunflower residue, calculated silhouette area index, and dates of wind speed measurements from six studies near Akron, CO

Study	Stalk height	Stalk diam.	Population	Silhouette area index	Dates of wind speed measurements	
	cm	cm	stalks/ha	m²/m²	begin	end
1	73	2.2	31397	0.0504	23 Oct 1992	30 Oct 1992
	43	2.2	30139	0.0285	30 Oct 1992	13 Nov 1992
	flat	——	——	0.0	13 Nov 1992	30 Nov 1992
2	63	1.8	46675	0.0529	19 Apr 1993	3 May 1993
3	70	1.2	64582	0.0543	3 Nov 1993	6 Dec 1993
	67	1.3	51666	0.0450	2 Nov 1993	8 Dec 1993
	68	2.0	34443	0.0468	1 Nov 1993	8 Dec 1993
	44	1.3	35521	0.0203	6 Dec 1993	28 Jan 1994
	47	1.7	30139	0.0241	8 Dec 1993	28 Jan 1994
	45	1.2	60278	0.0326	8 Dec 1993	28 Jan 1994
4	73	2.7	26247	0.0517	23 Mar 1994	10 May 1994
	45	3.0	26247	0.0354	25 Mar 1994	10 May 1994
5	68	2.8	36529	0.0696	27 Feb 1995	17 May 1995
6	50	2.3	27996	0.0315	4 Dec 1995	4 Dec 1995
	65	2.7	24972	0.0439	8 Dec 1995	8 Dec 1995

were placed at a height of 200 cm (79 in). In Studies 1, 2, and 5, wind speed was measured at 0.9, 0.7, 0.5, and 0.3 of stalk height. In studies 3 and 4, wind speed was measured at 0.9, 0.6, and 0.3 of the stalk height. Wind speed measurements in the flattened stalks of Study 1 were made at 67, 52, 37, and 22 cm (26, 20, 15, and 9 in). Anemometers were centered in the 76-cm (30-in) interrow space. Wind speed was measured every minute, and 15-minute average values were computed and saved by on-site data loggers. Scaled wind speeds were computed as U_z/U_{ref}, where U_z = wind speed at height z above the soil surface, and Uref = wind speed at the reference height [200 cm (79 in)]. Wind speed data were analyzed by wind direction relative to row direction.

Above-residue wind profiles (Study 6). Plot size for the two sites in this study were 152 × 91 m (500 × 300 ft) with the long direction running north-south, parallel to row direction. The anemometer mast was placed at the south end of the plot, in the middle of the east-west dimension, and data were analyzed when wind direction was north. Measurement heights were 240, 200, 160, 120, and 80 cm (94, 79, 63, 47, and 31 in) above the soil surface.

Stalk diameter, population, and silhouette area index. In all six studies, stalk diameters were measured at the time of anemometer installation. The measurements were made with a micrometer 4 to 6 cm (1.5 to 2.5 in) below the top of the stalk, on 10 stalks in each of the four rows surrounding the anemometer mast. A silhouette area index (m^2/m^2) was calculated as stalk diameter X stalk height X number of stalks per m^2. The number of stalks per m^2 was determined from the number of stalks in 3-m (9.8-ft) lengths of 4 rows surrounding the anemometer mast. Measurement of stem diameter near the cutoff point produces a conservative estimate of the silhouette area index. Measurement dates and stalk characteristics for the six studies are given on Table 1.

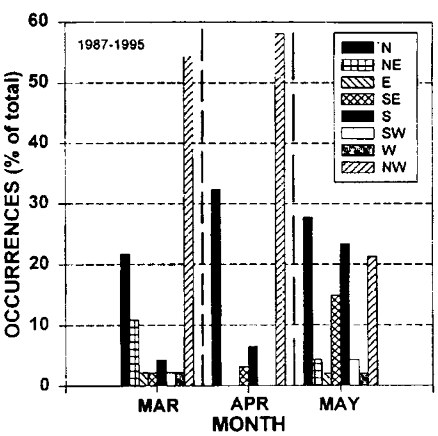

Figure 2. Average frequency of winds greater than 13 m/s (29 mph) by direction for March, April, and May at Akron, CO

Stability. Although simultaneous measurements of temperature gradients in any of the studies were not made, the small temperature gradients typical of the times of year (fall, winter, spring) and times of day (usually evening or early morning), and the high wind speeds (Table 2) minimize the chances of non-neutral conditions affecting the results.

Theory. The wind speed profile in the log-law region above the canopy is generally expressed as:

$$U_z = \frac{u_*}{0.4} \ln\left[\frac{(z-d)}{z_o}\right] \quad (1)$$

where
U_z = wind speed (m/s)
u_* = friction velocity (m/s)
z = measurement height above soil surface (m)
d = zero-plane displacement height (m)
z_0 = aerodynamic roughness length (m)

The values of u_*, d, and z_0 can be found by plotting wind speed against ln (z-d), where d is fit first by a trial-and-error procedure (Rosenberg et al. 1983) and then the values of u_* and z_0 are determined from the slope and intercept, respectively, of the regression of wind speed vs. ln (z-d).

The ratio of below-canopy to above-canopy friction velocities, u'_{*0}/u_{*v}, was shown by Hagen and Armbrust (1994) to be modeled well by:

$$\frac{u'_{*o}}{u_{*v}} = 0.86\exp\left[\frac{-SAI}{0.0298}\right] + 0.25\exp\left[\frac{-SAI}{0.356}\right] \quad (2)$$

Raupach et al. (1993) and later Musick et al. (1996) calculated a similar quantity, Rt, the ratio of the threshold friction velocity of a surface without standing residue to the threshold friction velocity of a surface with standing residue, as:

$$R_t = \left(\sqrt{(1-m\sigma SAI)(1+m\beta SAI)}\right)^{-1} \quad (3)$$

where
σ = ratio of roughness element basal to frontal-silhouette areas

$$= \frac{\pi}{4}\frac{1}{AR} \; where \; AR = \frac{h}{D}$$

β = ratio of isolated-element (c_r) and bare ground surface (c_s) drag coefficients

$$= \frac{c_r}{c_s}$$

m = empirical factor accounting for the increased difference between maximum and mean shear stress on the erodible surface resulting from the flow around roughness elements (= 0.5)
h = roughness element height (cm)
D = roughness element diameter (cm)

In the current analysis, the value of c_r was obtained from tabulated data given by Campbell (1977) for cylinders. The value of c_s (= 0.002512) was calculated from the wind profile data in Study 1 (flattened residue) from the relationship

$$c_s = (u_*/U_{ref})^2$$

Following the method of Hagen (1996), the erosion ratio (ratio of erosion from residue-covered and bare soil surfaces) is calculated as:

$$Rv = \frac{q_r}{q_b} \quad (4)$$

where
q_r = average saltation discharge for residue covered surfaces, computed from equations 5-8 (below) with u_* from residue-covered surfaces
q_b = average saltation discharge for a bare surface, computed from equations 5-8 (below) with u_* from the surface with stalks flattened (Study 1).

Briefly, for a simple field with sandy soil, the saltation discharge (q) can be modeled as:
where

$$q = q_c \frac{C_{ens}}{C_{ens}+T}\left\{1-\exp\left[-(C_{ens}+T)L\right]\right\} \quad (5)$$

q_c = saltation discharge transport capacity without stalk interception
C_{ens} = emission coefficient with standing residue

T = interception coefficient of standing residue
L = field length

The emission coefficient with standing residue is given as:

$$C_{ens} = C_{en}\left(1 - \frac{0.0023DSAI}{h}\right) \qquad (6)$$

where
Cen = emission coefficient for bare sand = 0.06 m^{-1}
D = stalk diameter (mm)
h = stalk height (m)

$$T = C_t \frac{SAI}{h} \qquad (7)$$

The interception coefficient for standing residue with the bulk of the saltation below the residue height is:
where C_t = interception coefficient of individual stalks (value about 1).
The saltation discharge transport capacity, q_c, is given by:

$$q_c = C_s u_*^2 (u_* - u_{*t}) \qquad (8)$$

where
C_s = saltation discharge coefficient (value not important when calculating erosion ratio because it cancels from both the numerator and denominator)
u_* = friction velocity of residue-covered surface
u_{*t} = soil surface dynamic threshold friction velocity = 0.291 m/s

Table 2. Scaled wind velocity (U_z/U_{ref}) profiles and reference wind speeds (U_{ref}) in standing sunflower residue

Data are separated into three categories: wind direction perpendicular, parallel or diagonal to row direction

Study	Stalk Height (z)	Population	Anemometer Height	(U_z/U_{ref})		
	cm	stalks/ha	fraction of z	Perp.	Paral.	Diagonal
1	73	31397	1.0	0.72	0.66	0.69
			0.9	0.63	0.66	0.64
			0.7	0.59	0.55	0.56
			0.5	0.49	0.50	0.49
			0.3	0.47	0.41	0.39
			U_{ref} (m/s)	5.27	4.44	7.32
	43	30139	1.0	0.61	0.60	0.61
1			0.9	0.56	0.59	0.58
			0.7	0.50	0.52	0.50
			0.5	0.53	0.49	0.50
			0.3	0.42	0.33	0.42
			U_{ref} (m/s)	10.75	6.41	10.45
1	73(flat)	———	1.0	0.88	0.88	0.88
			0.9	0.87	0.87	0.87
			0.7	0.85	0.85	0.85
			0.5	0.76	0.75	0.75
			0.3	0.67	0.67	0.67
			U_{ref} (m/s)	9.30	9.30	9.30
2	63	46675	1.0	0.68	0.65	0.69
			0.9	0.64	0.64	0.65
			0.7	0.57	0.55	0.55
			0.5	0.48	0.51	0.48
			0.3	0.44	0.43	0.43
			U_{ref} (m/s)	10.37	9.27	10.98
3	70	64582	0.9	0.66	0.64	0.64
			0.6	0.50	0.48	0.45
			0.3	0.37	0.43	0.35
			U_{ref} (m/s)	9.32	10.20	11.07
3	67	51666	0.9	0.65	0.63	0.64
			0.6	0.53	0.50	0.51
			0.3	0.44	0.43	0.44
			U_{ref} (m/s)	9.49	10.90	11.19
3	68	34443	0.9	0.66	0.70	0.63
			0.6	0.55	0.54	0.50
			0.3	0.4	0.36	0.36
			U_{ref} (m/s)	7.34	10.41	9.75

Results and discussion

Within-residue wind profiles. Scaled wind speeds (wind speed at given height divided by wind speed at U_{ref} = 200 cm) are given in Table 2. All scaled wind speed profiles were from the fastest recorded wind speed period in each study (U_{ref} also is given in Table 2 for each data set). Typical scaled wind speed profiles from three of the studies and three wind directions (Figures 1a, b, c) show the effect of SAI increases on reduction of wind speed within the standing sunflower stalks. This effect holds for all wind directions relative to row direction. Wind speeds were slightly reduced as winds blew diagonally across or perpendicular to row direction, compared with winds blowing parallel to the row direction (Figure 1d), as shown for the Study 3 data with SAI = 0.0326 m^2/m^2. This was not observed consistently in all data sets at all heights within the standing stalks.

The scaled wind speeds were regressed against the anemometer height, residue height, wind direction relative to row direction, and silhouette area index. The regression coefficients, p values, and coefficient of determination are given in Table 3.

The regression equation defined by the coefficients given in Table 3 predicts the effect of management practices, such as changing stalk population and cutting height at harvest, on wind speeds within the standing stalks. For example, with stalks of a 1.9-cm (0.75-in) diameter at a population of 39,550 stalks/ha (16,000 stalks/a), doubling the cutting height from 35 to 70 cm (14 to 28 in) would change the silhouette area index from 0.0263 to 0.0526 m^2/m^2, thereby cutting wind speeds at 30 cm (12 in) above the soil surface by 19%. This equation also predicts that wind speeds near the soil surface would be reduced by 3 to 4% with winds blowing perpendicular to the row direction, compared with winds blowing parallel to the row direction. More than 70% of winds at Akron with speed greater than 13 m/s (29 mph) come from the north, northwest, or south (Figure 2). Consequently, there may be a small advantage with respect to wind reduction near the soil surface with an east-west row orientation.

Above-residue wind profiles and erosion ratio. In the current experiment, only two data sets (Study 6) had above-residue wind profiles. These two profiles were matched to within-residue profiles

Table 2. (continued) Scaled wind velocity (U_z/U_{ref}) profiles and reference wind speeds (U_{ref}) in standing sunflower residue

Data are separated into three categories: wind direction perpendicular, parallel or diagonal to row direction

Study	Stalk Height (z)	Population	Anemometer Height		(U_z/U_{ref})	
	cm	stalks/ha	fraction of z	Perp.	Paral.	Diagonal
3	44	35521	0.9	0.62	0.64	0.63
			0.6	0.56	0.57	0.57
			0.3	0.38	0.50	0.49
			U_{ref} (m/s)	10.55	12.85	13.79
3	47	30139	0.9	0.59	0.63	0.63
			0.6	0.55	0.54	0.53
			0.3	0.38	0.48	0.43
			U_{ref} (m/s)	10.05	12.90	13.57
3	45	60278	0.9	0.57	0.63	0.60
			0.6	0.47	0.52	0.48
			0.3	0.33	0.38	0.38
			U_{ref} (m/s)	9.84	11.38	13.18
4	73	26247	0.9	0.60	0.66	0.61
			0.6	0.49	0.53	0.50
			0.3	0.37	0.48	0.41
			U_{ref} (m/s)	7.83	11.83	9.76
4	45	26247	0.9	0.58	0.62	0.62
			0.6	0.48	0.50	0.50
			0.3	0.39	0.47	0.41
			U_{ref} (m/s)	7.81	11.78	9.91
5	68	36529	0.9	0.58	0.60	0.59
			0.7	0.51	0.54	0.50
			0.5	0.47	0.49	0.46
			0.3	0.34	0.38	0.37
			U_{ref} (m/s)	9.23	10.43	10.49

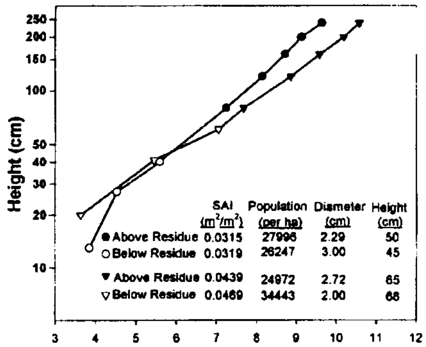

Figure 3. Wind speed profiles above and within standing stalks varying in height and silhouette area index (SAI)

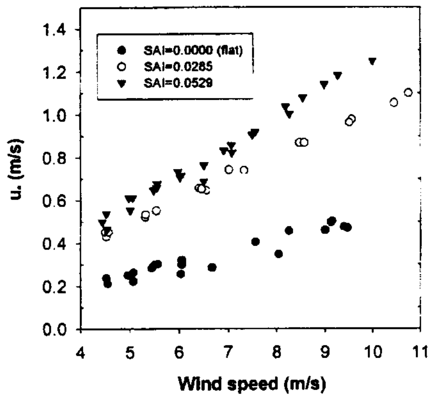

Figure 4. Increase in friction velocity (u*) with wind speed at reference height (200-cm) for three levels of silhouette area index (SAI, m²/m²)

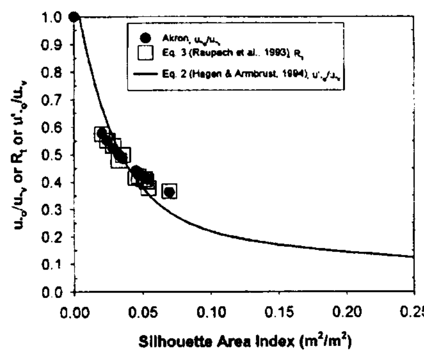

Figure 5. Friction velocity ratios as affected by silhouette area index

from residue with similar height and SAI and wind speed at 200 cm to construct combined profiles of within-and above-residue wind speeds (Figure 3). From the linearity of these two profiles, it can be concluded that d is near 0. The friction velocity was calculated for each profile using the full above-residue profile (heights 80-to-200 cm), and, alternatively, using only the wind speeds at 200 cm and at the top of the standing stalks (40 cm for stalks 45 cm tall, and 61 cm for stalks 68 cm tall). The friction velocities for the short stalks were 0.8528 m/s for the full profile and 0.8773 m/s for the 2-point profile (2.9% error). The friction velocities for the tall stalks were 1.0582 m/s for the full profile and 1.0510 m/s for the 2-point profile (0.7% error). From this comparison it was concluded that wind speeds at 200 cm and at the top of the residue could be used to adequately calculate the friction velocity for the standing residue (u_{*v}) for each of the data sets in Studies 1 to 5. U_{*v} was calculated for a range of wind speeds (always greater than 4 m/s) for each data set from wind directions of 0o, 45°, and 90° relative to row direction. An example of the relationship

Table 3. Linear regression coefficients, p values, and coefficient of determination for regression model U_z/U_{ref} = a + b*ht + c*stalk ht +d*dir + e*SAI + f*SAI²

Variable†	Coefficient	p‡	r²
a (constant)	0.5357	<0.0001	0.93*
b (ht)	0.00582	0.0191	
c (stalk ht)	-0.00125	0.0001	
d (dir)	-0.000179	0.0036	
e (SAI)	-4.9109	0.0195	
f (SAI²)	32.9498	<0.0001	

* regression significant at the 0.001 level
† ht = anemometer height above soil surface (cm)
stalk ht = sunflower stalk height (cm)
dir = wind direction relative to row direction (degrees)
SAI = silhouette area index (m2/m2)
‡ p = probability of coefficient=0 when all other variables are already in model

between u_{*v} and Uref is shown in Figure 4 for three data sets. The relationships are linear, and there was no effect of wind direction on the relationships. U_{*o} was computed as the value of the friction velocity over the soil surface where the stalks had been laid flat (Study 1).

A relationship to predict u_{*v} for a given SAI and Uref was determined with curve-fitting software (Table Curve 3D, SPSS, Inc., Chicago, IL.) applied to combined data from all of the studies:

$$u_{*v} = \exp[-2.9864 + 0.03853 \cdot SAI^{0.5} + 1.01167 \cdot \ln(U_{ref})] \quad r^2 = 0.96 \qquad (9)$$

This relationship was used to calculate u_{*o}/u_{*v} for the SAI recorded in Studies 1

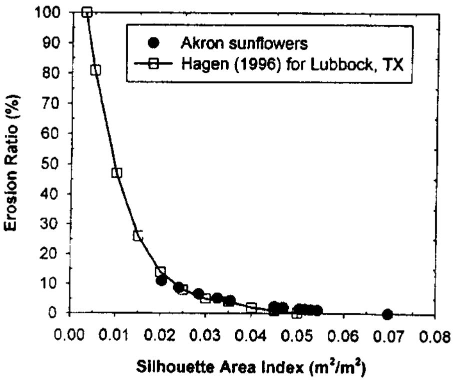

Figure 6. Ratio of erosion from covered and bare soil surfaces as affected by silhouette area index of standing sunflower stalks; calculated from changes in friction velocity measured in the field at Akron, CO and calculated from wind tunnel relationships for a sandy soil in Lubbock, TX

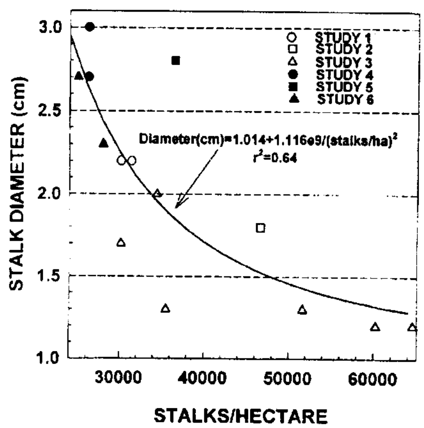

Figure 7. Reduction in sunflower stalk diameter with increasing stalk population

to 5, setting SAI equal to 0 to obtain u_{*0}. For comparison, these values are presented with those computed by Equation 3 (Raupach et al. 1993) in Figure 5. The similar ratio, u'_{*0}/u_{*v}, computed by Equation 2 (Hagen and Armbrust 1994) also was included. The values of u_{*0}/u_{*v} computed from the Akron data are very nearly the same as computed by Equation 3, but systematically different from u'_{*0}/u_{*v} calculated by Equation 2. Equation 2 overpredicts u_{*0}/u_{*v} for SAI < 0.035, and underpredicts for SAI > 0.035.

Using the u_{*0}/u_{*v} values computed by Equation 9 for each of the SAIs measured in Studies 1 to 5, the erosion ratio from Equations 4 to 8 was computed. For SAI in the range of those normally observed for sunflowers in the field, Equation 9 provides estimates of u_{*v}, which predict similar reductions in erosion ratio (Figure 6) to those presented in the revised Figure 6 of Hagen (1996) (personal communication) for conditions in Lubbock, Tex., using relationships derived from wind tunnel studies. The data shown in Figure 6 indicate that even sparse stands of sunflower stalks (SAI = 0.0200 m^2/m^2) can reduce saltation discharge to 15% of what it would be for surfaces without residue cover. Standing sunflower stalks producing SAI in the more normally-observed range of 0.035 to 0.045 m^2/m^2 can reduce saltation discharge to less than 5% of that predicted for bare surfaces.

Stem diameters and silhouette area index. As farmers consider sunflower residue management options such as increasing cutting height and plant populations, they should be aware that higher populations may not necessarily increase the silhouette area index, due to the reduction in stalk diameter that may occur with the higher densities (Table 1, Study 3; Figure 7). Some of the variability in the relationship shown in Figure 7, especially in the 25,000 to 40,000 stalk/ha (10,120 to 16,190-stalks/a) range, is likely due to differences in growing season water availability among the 6 studies. Studies 1, 2, and 6 received approximately 35 mm (1.4 in) more growing season precipitation than Studies 3 and 4, while Study 5 was irrigated. Also, Study 3 was located on soil with much lower stored soil water at sunflower planting than the other five studies. The smaller diameter stalks appear to be less durable and less able to remain standing throughout the entire winter and spring following sunflower harvest. Visual estimates of fallen stems in the high population treatments of Study 3 in the spring following harvest were near 80%, while the low population of Study 4 showed nearly all stems still standing in the spring. Producers may want to plant at lower populations to ensure stalks of sufficient strength to remain standing throughout the winter and spring following sunflower harvest, especially since previous research in Kansas and Nebraska has shown no significant increase in yield with increasing plant population (Alessi et al. 1977; Mikesell 1994; Schneiter 1992; Sunderman and Lawless 1994).

Conclusions

Sunflower residue can be managed to reduce soil erosion potential by choosing plant densities that result in large sturdy stalks, then cutting those stalks at harvest as tall as possible. The effect of stalk diameter, stalk density, and stalk height on wind speed profiles within standing stalk residues can be predicted with the silhouette area index. The effect of increasing the silhouette area index is to decrease wind speeds within the standing stalk residue and increase friction velocity, thereby reducing the potential for wind erosion.

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