Effects of "Dirting" on Strawbreaker Foot Rot of Winter Wheat

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ABSTRACT

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Soil or volcanic ash placed around the base of winter wheat (dirting) in the spring increased the severity of strawbreaker foot rot incited by *Pseudocercosporella herpotrichoides*. The effects of volcanic ash and soil were similar. In some cases dirting reduced yield, in some cases it increased yield, and in some cases it did not affect yield.

Pseudocercosporella herpotrichoides (Fron) Deighton attacks winter wheat (*Triticum aestivum* L.) at the soil line, resulting in weakened straw. When severe, the stem collapses (= strawbreaker), lodges, or if the wheat remains standing, the heads blight prematurely (= whiteheads) or the grain shrivels.

More than 15 yr ago, observations in the dryland wheat, summer-fallow portion of central Washington indicated that spring tillage of growing wheat increased the severity of foot rot (1). Anhydrous ammonia applied through shanks beneath the growing wheat in early spring or tilling with a rotary hoe to dislodge cheat grass (*Bromus tectorum* L.) were abandoned as cultural practices because of this observed effect. Experiments at the Dryland Research Unit, Lind, Adams County, WA, demonstrated increased losses from foot rot with shanking or with the rotary hoe in March (1).

Wheat is seeded with deep-furrow drills beneath a dust mulch in the dryland area. A ridge as high as 10 cm remains between the wheat rows throughout the winter. Tillage in the spring dislodges soil from the ridges, placing it on and around the plants. The hypothesis was that this soil maintained moisture around the basal tissues, favoring the continued development of foot rot in tissues already infected.

On 18 May 1980, Mt. St. Helens erupted and volcanic ash was deposited on winter wheat in depths ranging from 1 to 5 cm over much of central Washington. Did this deposition increase foot rot? The present work was done to determine the effects of volcanic ash and soil on the incidence and severity of foot rot of winter wheat. Cultivation that resulted in soil about the basal parts of peanut (*Arachis hypogaea* L.) plants is called "dirting," and we adopted this terminology (2).

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MATERIALS AND METHODS

Experiments were conducted at the Dryland Research Unit on Ritzville fine sandy loam, which receives an average of 24 cm of precipitation annually, and at Pullman, Whitman County, on Palouse silt loam, which receives an average of 51 cm of precipitation annually.

At Lind, 67 kg of N/ha as anhydrous ammonia was applied before planting, and at Pullman, 60 kg of N/ha as ammonium nitrate was applied broadcast by a cyclone spreader on the soil surface in a split application, half in autumn and half in early spring. All experiments were on summer fallow and weed control was by hand cultivation.

Seeding was done with a deep-furrow drill at both locations, 50 kg of seed per hectare, on 9 September 1980 and 2 September 1981 at Lind and 24 September 1981 and 16 September 1982 at Pullman. All these dates are considered reasonably "early" for the two sites. Plots were 1.8 × 4.0 m, each containing four rows 35 cm apart.

Conidia of *P. herpotrichoides* were washed from infested oat kernels incubated outdoors, adjusted to 200,000/ml and applied with a knapsack sprayer directly on the wheat to runoff. Inoculations were made on 13 November 1980, 6 November and 3 December 1981, and 19 February and 16 March 1982 at Lind and on 17 November 1981 and 15 November 1982 at Pullman.

Volcanic ash collected near Ritzville, Adams County, in March 1981 was stored in 113.6-L galvanized, covered garbage cans (30-gal.). Ash and soil from the experimental sites were used in dirting.

On 13 April 1981, dirting was done by placing ash or soil from the experimental site around the bases of wheat plants within aluminum cylinders. The cylinders, 7 cm high and 10 cm across, were placed around individual plants in the row and pressed 2–4 cm into the soil. Some cylinders were left empty, some filled with ash, and some with soil.

Aluminum cylinders were unsatisfactory because after the plants attained some height, wind blew the plants so forcefully that many cylinders were dislodged and the soil or ash escaped from the bottom during rains. Data presented are from cylinders that remained in place. In subsequent trials, aluminum lawn edging was inserted on each side of a row, 7.5 cm from the row, and ash or soil was placed 3 cm deep in this 15-cm band around the bases of the plants on 20 April and 19 May 1982 at Lind and on 18 May 1982 and 14–15 April 1983 at Pullman. Plants were large at the time of dirting, with an average of 11 tillers per plant and an average height of 26 cm from soil to tip of the leaf of Sprague wheat at Lind by 10 April 1981.

All experiments were in a randomized block design, except that when lawn edging was used, ash or soil and no ash (= check) or no soil (= check) data were obtained from 1-m portions of the same rows (ash, check; soil, check, in the same row).

Foot rot is judged on a scale of 0–4, where 0 = no lesions, 1 = light lesions, 2 = moderate lesions, 3 = rather severe lesions, and 4 = severe lesions or dead stems. Economic losses require a reading of 2 or higher. Disease is rated at maturity by stripping away all basal leaf sheaths to reveal the stem. In the 1980–1981 season, dry weight of shoots was recorded; in subsequent trials, grain per meter of row was recorded.

RESULTS

1980–1981 (Lind). Disease was so severe in inoculated rows (Table 1) that dirting on 13 April 1981 made no difference. Dirting the controls, which were subject to light natural inoculum, however, increased disease severity. Ash and soil affected disease severity equally.

1981–1982 (Lind). Foot rot severity was lightest in the uninoculated plots and most severe with the early November inoculation, decreasing as the time of inoculation was delayed (Table 2). The March inoculation did not differ from the uninoculated controls.

Dirting on 20 April increased disease severity, and soil and ash were equal in

effect; dirting on 19 May did not increase disease severity (Table 2).

The severity of the November inoculation is underestimated by the above data because of missing stems. The total number of stems counted from the November inoculation was 2,504; in all other inoculation dates, the number of straws varied between 3,110 and 3,367. Some tillers died early in the November-inoculated plots, and they deteriorated to such an extent that they were lost before harvest.

Dirting on 20 April decreased yield (Table 3). Yields were affected by poor seedbed preparation, but dirting the plant in early spring (20 April) reduced yield, both of healthy and of inoculated plants (Table 3). In contrast, dirting later in the spring (19 May) increased the yield (Table 4), except after the November inoculation.

The overall effects of inoculation and of dirting, whether with soil or ash, were significant. The difference between soil and ash was not significant.

1981–1982 (Pullman). The effect of dirting, both with soil and ash, was significant as indicated by disease scores of 2.36 with soil and 2.35 with ash compared with 1.98 with no dirting ($LSD_{0.05} = 0.21$). Dirting with either ash or soil increased foot rot severity equally. Yields were not influenced by dirting.

1982–1983 (Pullman). Dirting in the spring increased foot rot severity of all three wheats (Table 5). Stephens was more susceptible than Daws or Nugaines, but there were no interactions between cultivars and dirting.

Foot rot reduced the yield of Stephens by 25%, of Daws by 19%, and of Nugaines by 10%. Dirting in this trial did not reduce yields. The three cereal rusts (stripe, leaf, and stem) were present and they attacked the three wheats to some extent. Adding soil to the bases of the wheat plants did not significantly reduce yields at Pullman in the 1982–1983 season.

DISCUSSION

Farmers were concerned, after the volcanic eruption on 19 May 1980, that the ash around the base of the wheat would aggravate strawbreaker foot rot and depress yields. There were no nonashed controls, but yields were high in the dryland region for the season of the volcanic eruption. Farmers concluded, and subsequent experiments (R. E. Allan and C. J. Peterson, *unpublished*) proved them right, that volcanic ash is an effective mulch, reducing water loss from the soil.

At Lind, in the dryland region, ash applied on 20 April decreased yield and ash applied on 19 May increased yield. Earlier experiments in the 1962–1963 season (1) showed that pulling the fertilizer applicator with shanks through the soil in November decreased the yield

Table 1. Severity of strawbreaker foot rot at maturity and total dry weight (excluding roots) of winter wheat for controls or after inoculation with *Pseudocercosporella herpotrichoides*, with and without volcanic ash or soil (dirting) placed around the crowns on 13 April 1981 at Lind, WA

Treatment	Disease indices (Sprague)	Dry weight (g)	
		Sprague	Stephens
Control	1.46[a]	91.3	71.5
Control + ash	2.37	65.0	56.8
Control + soil	2.34	81.6	55.8
Inoculated	3.98	24.9	25.2
Inoculated + ash	3.95	20.4	19.5
Inoculated + soil	4.00	14.0	34.7
$LSD_{0.05}$	0.44	24.2	

[a] Foot rot severity index: 0 = lesions, 1 = light lesions, 2 = moderate lesions, 3 = rather severe lesions, and 4 = severe lesions or dead stems.

Table 2. Effect of date of inoculation and date of application of ash or soil (dirting) to the crowns of Nugaines wheat at Lind, WA, during the 1981–1982 season on severity of strawbreaker foot rot at maturity

Treatment	Check	Inoculation date				Mean
		6 Nov.	3 Dec.	19 Feb.	16 Mar.	
No dirting	0.16[a]	2.38	1.10	0.28	0.12	0.81
Ash (20 April)	0.15	2.98	1.51	0.77	0.30	1.14
Soil (20 April)	0.23	3.11	1.99	0.46	0.11	1.18
Mean	0.18	2.83	1.53	0.51	0.18	···
$LSD_{0.05}$ for means			0.29			0.22
No dirting	0.09	2.46	1.13	0.33	0.09	0.82
Ash (19 May)	0.07	2.77	1.09	0.37	0.11	0.88
Soil (19 May)	0.06	2.63	1.09	0.21	0.12	0.82
Mean	0.07	2.62	1.11	0.30	0.11	···
$LSD_{0.05}$ for means			0.17			NS[b]

[a] Foot rot severity index: 0 = no lesions, 1 = light lesions, 2 = moderate lesions, 3 = rather severe lesions, and 4 = severe lesions or dead stems.
[b] NS = not significant.

Table 3. Yield of Nugaines wheat (g/m) uninoculated or inoculated with *Pseudocercosporella herpotrichoides*, with or without ash or soil (dirting) placed around the crowns on 20 April 1982, at Lind, WA

Treatment	Check	Inoculation date				Mean	
		6 Nov.	3 Dec.	19 Feb.	16 Mar.		
No dirting							
Check for ash	109	55	85	117	121	97.3	
Check for soil	117	73	103	110	117	103.9	
Mean							100.6
Dirting							
Ash	79	37	96	96	116	84.5	
Soil	105	33	84	101	101	84.9	
							84.7
Mean	103	49	92	106	114		
$LSD_{0.05}$ for means			16.3			14.6	10.3

Table 4. Yield of Nugaines wheat (g/m) uninoculated or inoculated with *Pseudocercosporella herpotrichoides*, with or without ash or soil (dirting) placed around the crowns on 19 May 1982, at Lind, WA

Treatment	Check	Inoculation date				Mean	
		6 Nov.	3 Dec.	19 Feb.	16 Mar.		
No dirting							
Check for ash	108	54	90	114	103	94.0	
Check for soil	93	48	92	119	91	89.0	
Mean							91.5
Dirting							
Ash	130	55	93	133	115	105.0	
Soil	134	54	109	120	110	105.0	
							105.0
Mean	116	53	96	121	105		
$LSD_{0.05}$ for means			13.3			11.9	8.4

Table 5. Effect of soil (dirting) placed around the crowns of winter wheat on 14–15 April 1983 on severity of strawbreaker foot rot at Pullman, WA

Treatment	Cultivar			Mean
	Daws	Nugaines	Stephens	
No dirting	2.75[a]	2.74	2.94	2.80
Dirting	3.35	3.43	3.65	3.47
$LSD_{0.01}$				0.22

[a]Foot rot severity index: 0 = no lesions, 1 = light lesions, 2 = moderate lesions, 3 = rather severe lesions, and 4 = severe lesions or dead stems.

of inoculated wheat slightly but pulling it through wheat with strawbreaker foot rot in March decreased yield substantially. In our experiments, dirting was not done in March, but the April dirting (Table 3) decreased and the May dirting (Table 4) increased yield. Evidence indicates that dirting in early spring is harmful but dirting late in spring is not.

Shanking and rotary tilling add a degree of mechanical injury in addition to dirting. We dirted plants with no mechanical injury. It appears likely that dirting early in the spring may induce a type of shock to the plant, resulting in increased susceptibility of the tissues to *P. herpotrichoides* and that dirting later (without physical injury as with a deposition of volcanic ash) has little adverse effect or is offset by the beneficial effects of conserving water.

The increased susceptibility to *P. herpotrichoides* in these experiments appears to be a small part of the adverse effect of early dirting. Yields of the controls and of very lightly diseased wheat (the February and March inoculations, Lind, 1981–1982) were reduced. It is hard to believe that ash or soil 3–4 cm deep around the crowns of wheat with several tillers results in significant loss of photosynthetic area. The leaves were not covered.

In theory, if volcanic dust fell in late autumn, foot rot would be decreased or eliminated. The fungus sporulates on refuse on the soil surface and the spores are splash-dispersed. Ash before significant spore dispersal would bury the source of inoculum. If ash fell in February or March, after early infections had occurred, losses would be maximum; in April, losses from foot rot would be increased moderately; and in May or later, the effect would be neutral or beneficial.

The apparent equality of dirting with volcanic ash or soil is evidence that whatever the effects of cover, they are the result of physical factors rather than microorganisms. The volcanic ash was totally devoid of organic matter and must have been very nearly free of microorganisms.

Farmers no longer use a rotary hoe to dislodge grassy weeds in the wheat in early spring. Herbicides play a more important role in weed control than before. The standard practice in dryland areas is to inject the fertilizer into the summer-fallowed soil before seeding or to inject it beneath the drill row at planting. Advances in technology have removed the need for practices that result in placing soil around the bases of growing wheat plants.

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