# Primary Tillage for Foxtail Barley (*Hordeum jubatum*) Control[1]

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**Abstract.** Primary tillage is an inexpensive method to control foxtail barley, a perennial bunchgrass which is an increasing concern to no-till cereal farmers in the Northern Great Plains. Moldboard plowing or chisel plowing in fall followed by field cultivation-harrowing in spring effectively controlled established foxtail barley on previously untilled sites before planting spring wheat. In contrast, chisel plowing in spring followed by field cultivation-harrowing did not control this weed completely. **Nomenclature:** Foxtail barley, *Hordeum jubatum* L. #[3] HORJU; wheat, *Triticum aestivum* L.

**Additional index words:** Chisel plowing, moldboard plowing, no-till weeds, tillage, HORJU.

## INTRODUCTION

Foxtail barley is a short-lived, shallow-rooted perennial bunchgrass which troubles no-till cereal producers in the Northern Great Plains (3, 8). This weed has a shallow fibrous root system. Individual plants persist from year to year and spread vegetatively through formation of new tillers and crown enlargement (3, 9). Foxtail barley lacks the root stocks, rhizomes, or root buds that make control of other perennial grasses so difficult.

A tank mixture of glyphosate[4] [*N*-(phosphonomethyl)glycine], surfactant, and ammonium sulfate applied in spring controlled established plants on no-till farmland or untilled wasteland (8).

Mechanical soil disturbance influences the prevalence of foxtail barley as a weed problem (3). In Canada, foxtail barley was more common on stubble land when a triple-disk drill was used for planting than when a disker planter was used (1). The disker planter probably controlled established foxtail barley plants better than the triple-disk drill because the former inverts soil and uproots the shallow foxtail barley crown while the triple-disk drill would compress the soil and slice through established plants without significantly uprooting the crown. The disk planter also incorporates seed with a disk harrow and clears the soil surface of most crop residue, incorporating surface-lying weed seed deeper than does the triple-disk drill.

In Alaska, as spring seedbed preparation was reduced progressively from two diskings to one disking to no-till, foxtail barley ground cover increased from 1% to 23% even though glyphosate was applied at planting (5). In a soybean [*Glycine max* (L.) Merr.]-corn (*Zea mays* L.) rotation in South Dakota, foxtail barley increased over 5 yr in no-till, but fall moldboard plowing plus spring disk harrowing for seedbed preparation or fall plus spring disk harrowing prevented its encroachment (13).

These studies showed that repeated annual tillage can prevent foxtail barley infestations from encroaching onto cropland or increasing once perennial plant establishment occurs on untilled farmland. Published information was not found on how effectively different primary tillage methods or the timing of tillage controlled established foxtail barley.

The objective of this research was to compare the efficacy of fall moldboard plowing, fall chisel plowing, and spring chisel plowing with no-tillage for controlling established foxtail barley. A 1979 survey of eastern North Dakota wheat growers showed that 21, 37, and 23% of them chisel plowed in fall, moldboard plowed in fall, and chisel plowed in spring, respectively, while 31% performed one cultivation plus harrowing in spring before planting wheat (11).

## MATERIALS AND METHODS

Research was conducted at two sites near North Dakota State University, Fargo, on a Fargo silty clay (fine, montmorillonitic, frigid Vertic Hapliquolls) with 2% sand, 44% silt, 54% clay, 3.6% organic matter, and a pH of 7.2 for Trial 1 (1986 to 1987) and 2.0% sand,

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available form WSSA, 309 W. Clark St., Champaign, IL 61820.

[4]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Dep. of Agric. and does not imply its approval to the exclusion of other products that also may be suitable.

*Table 1.* Dates of field operations testing tillage for foxtail barley control.

| Event | Date | |
|---|---|---|
| | Trial 1 | Trial 2 |
| Fall moldboard plowed | 10/23/86 | 9/27/88 |
| Fall chisel plowed | 10/16/86 | 9/27/88 |
| Spring chisel plowed | 4/20/87 | 4/21/89 |
| Field cultivated | 4/21/87 | 4/28/89 |
| Planted and fertilized | 4/28/87 | 5/1/89 |
| Crop emerged on chiseled plots | 5/11/87 | 5/12/89 |
| Herbicides applied | ... | 6/1/89 |
| Weed control evaluated | 6/15/87 | ... |
| Foxtail barley seedhead density determined | 6/22/87 | 6/29/89 |
| Shoot dry weight harvested | 6/24/87 | 6/29/89 |

47% silt, 51% clay, 3.9% organic matter, and a pH of 7.7 for Trial 2 (1988 to 1989).

The experiment was arranged as a randomized complete block design with three blocks and was repeated (Trials 1 and 2). Primary tillage treatments were fall moldboard plowing, fall chisel plowing, spring chisel plowing, and no-tillage. In both trials, plots were fall moldboard plowed about 20 and 18 cm deep, respectively, and fall chisel plowed about 15 cm and 9 cm deep, respectively. Spring and fall chisel plowing was done with the same implement at approximately the same depth for each trial.

The chisel plow was equipped with 12-cm-wide chisel points that were spaced 60 cm apart on two parallel tool bars spaced 43 cm apart. Three chisel points were offset on one tool bar from four points on the other tool bar so that the points disturbed the soil in parallel lines 30 cm apart. The moldboard plow was equipped with three reversible 45-cm-wide bottoms spaced 40 cm apart.

Except for the no-tillage plots, seedbeds were prepared with one pass of a combined field cultivar-harrow (secondary tillage) just before spring planting. The field cultivator had winged shovels that were 16.3 cm wide offset on three parallel tool bars so that they cut the soil in rows spaced 12.5 cm apart. The harrow had numerous straight tines spaced 20 cm apart offset on three parallel tool bars.

The dates of each field operation are presented (Table 1). Trial 1 was conducted from the fall of 1986 to 1987 and Trial 2 was conducted from the fall of 1988 to 1989 on untilled fallow sites that were heavily and uniformly infested with established foxtail barley and had not been cropped in the previous 3 yr. Perennial foxtail barley was one of the first weeds to resume growth in spring and was growing at the time of spring chisel plowing. Plots measured 3.3 by 18.3 m in Trial 1 and 3.3 by 9.2 m in Trial 2.

'Wheaton' hard red spring wheat was planted at 90 kg/ha 3.8 to 5 cm deep with a double-disk grain drill[5] in rows spaced 17.5 cm apart (Table 1). Wheat seed was treated with carboxin (5,6-dihydro-2-methyl-*N*-phenyl-1,4-oxathiin-3-carboxamide) at 75 to 100 g/100 kg seed. Nitrogen as urea was deep banded approximately 6 cm deep in 35-cm rows half-way between wheat rows at 67 and 100 kg N/ha in Trials 1 and 2, respectively, at planting. Enough N was applied each year for a 2690 kg/ha wheat yield goal as recommended by North Dakota State University from soil tests conducted on samples collected in late fall. No other mineral nutrients were recommended. Wheat in the plots was not harvested because of either competing weeds (Trial 1) or bird and insect damage (Trial 2).

Postemergence herbicides were applied with a bicycle sprayer equipped with 8003 flat fan nozzles[6] spaced 50 cm apart on a 3-m boom and operated at 5.5 km/h and 170 kPa generated by pressurized air. Diclofop {(±)-2-[4-(2,4-dichlorophenoxy)phenoxy]propanoic acid} at 1.1 kg ai/ha and thifensulfuron {methyl 3-[[[[(4-methoxy - 6 - methyl - 1,3,5-triazin-2-yl)amino]carbonyl]amino] sulfonyl]-2-thiophenecarboxylic acid} at 20 g ai/ha were applied with added nonionic surfactant[7] at 0.25% (v/v) to the entire experiment after spring wheat began tillering to control annual grasses and broadleaf weeds in Trial 2. In Trial 1, common dandelion (*Taraxacum officinale* Weber. in Wiggers # TAROF), Canada thistle [*Cirsium arvense* (L.) Scop. # CIRAR], and perennial sowthistle (*Sonchus arvensis* L. # SONAR) were present but were not controlled.

Foxtail barley shoots were harvested and seedhead density was determined in four random 0.21- or 0.25-$m^2$ quadrats/plot in Trial 1 or 2, respectively (Table 1). Shoots were clipped at the soil surface, and shoot dry weight was determined after oven drying at 70 C for at least 3 days. All seedhead density data and shoot dry weight data were standardized on a "per $m^2$" basis for comparisons. In addition, foxtail barley con-

[5]Haybuster 107 double-disk grain drill with deep-banding fertilizer attachment, Haybuster Manufacturing, Box 1950, Jamestown, ND 58401.

[6]TeeJet nozzles, Spraying Systems Co., North Ave., Wheaton, IL 60188.

[7]Surfactant was Ortho X-77 spreader (Principal agent: alkylaryl polyoxyethylene glycols, free fatty acids, and isopropanol 90%) from Chevron Chemical Co., 940 Hensley St., Richmond, CA 94801.

*Table 2.* The effect of tillage on control of established foxtail barley.

| Treatment | Shoot dry weight | | Seedhead production | |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 1 | Trial 2 |
| | ($g/m^2$)[a] | | ($no./m^2$)[a] | |
| Fall moldboard plowed (FM)[b] | 0 | 0 | 0 | 0 |
| Fall chisel plowed (FC)[b] | 0 | 8 ± 7.5 | 0 | 18 ± 20 |
| Spring chisel plowed (SC)[b] | 14 ± 11 | 106 ± 21 | 13.7 ± 8.3 | 265 ± 11 |
| No tillage | 1.2 ± 2.1 | 310 ± 42 | 0.5 ± 0.8 | 884 ± 193 |

[a]Means ± standard errors of the mean.

[b]Seedbed prepared by field cultivation-harrowing just before spring wheat planting.

trol was evaluated visually from 0 = no control to 100 = complete control for Trial 1. Descriptive statistics are presented. Analysis of variance was not conducted because two of four treatments had many zero values in both trials, a violation of the ANOVA assumption of homogeneity of variance which could not be rectified by data transformation.

## RESULTS AND DISCUSSION

Differences between trials in foxtail barley density and the presence of perennial broadleaf weeds in Trial 1 likely caused foxtail barley to respond differently to no-tillage in the two trials. In Trial 1, tillage suppressed perennial broadleaf weeds early in the growing season compared to no-till, probably preventing broadleaf weeds from reducing foxtail barley growth in tillage plots.

In both trials, moldboard plowing in fall drastically reduced both shoot dry weight and seedhead density of foxtail barley and completely controlled foxtail barley 2 months after spring wheat planting (Table 2). Fall chisel plowing controlled foxtail barley better in Trial 1 than in Trial 2 probably because shoot growth was much less in Trial 1 than in Trial 2. Chisel plowing in spring partially controlled foxtail barley but was inferior to either moldboard or chisel plowing in fall in both trials. Visually evaluated foxtail barley control substantiated the shoot growth measurements for Trial 1 (data not presented).

The results demonstrate that fall moldboard plowing can effectively control established foxtail barley (Table 2). However, moldboard plowing exposes the soil surface to wind and water erosion and is incompatible with conservation goals. Fall chisel plowing was nearly as effective as moldboard plowing and allows less soil erosion than does moldboard plowing.

Spring chisel plowing of the Fargo silty clay left large clods containing entire foxtail barley plants on the soil surface, even after spring field cultivation-harrowing for seedbed preparation and planting (Figure 1). These uprooted, established foxtail barley plants may have been able to reroot and regrow during soil consolidation after spring rains in Trial 2 (May, 1989, in Figure 2). While it did not rain for 2 weeks after fall tillage (October, 1988) in Trial 2, it rained 0.6 cm within 4 days following spring chisel plowing (May, 1989). This may have been enough rain following spring chiseling in Trial 2 for rerooting of clod-bound plants. In Trial 1, it did not rain for at least 3 weeks after any primary or secondary tillage operation (October, 1986, and April, 1987, in Figure 2).

Fall chisel plowing plus spring field cultivation-harrowing may control established foxtail barley less expensively than either moldboard plowing or herbicide treatment (8). In North Dakota in 1986, the average custom costs[8] for moldboard plowing ($6.25) followed by field cultivation ($3.63) was $9.88; the cost for chisel plowing ($4.96) followed by field cultivation ($3.63) was $8.59; and the cost for ground sprayer application ($2.02) and glyphosate at 0.5 kg ae/ha, surfactant at 0.25% (v/v) (assuming 94 L/ha spray volume applied), and ammonium sulfate at 2.8 kg/ha was $13.86.

Most foxtail barley seedlings emerge in fall (7, 12). Few foxtail barley seedlings were observed in spring in either fall- or spring-plowed plots herein. Subsequent seedling growth was extremely slow. Seedling emergence of foxtail barley is quickest and greatest from the soil surface and decreases with increasing seed burial depth down to 5 cm in the soil profile (2, 10). Thus, foxtail barley is adapted to establishment on no-till land. The preceding season's seed crop was suggested

[8]Cost estimates are from T. L. Reff. 1987. Custom farm work rates on North Dakota Farms, 1986, by North Dakota Farming Regions. Coop. Ext. Serv. EC-499 Revised.

*Figure 1.* Uprooted clods of soil containing perennial foxtail barley plants that reroot following spring chisel plowing and field cultivation-harrowing for seedbed preparation.

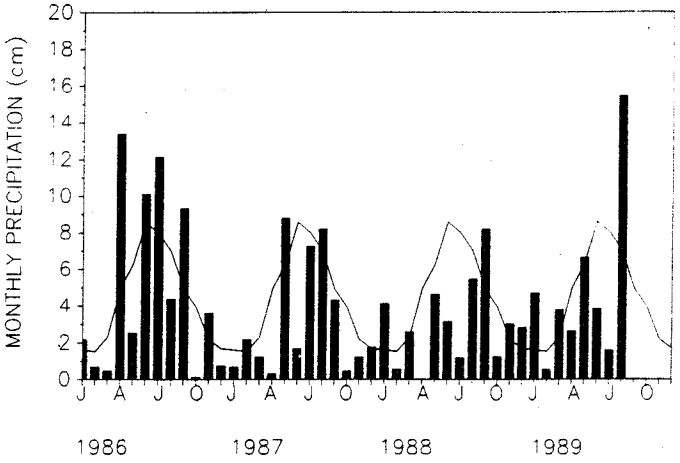


*Figure 2.* Monthly precipitation (bars) from 1986 to 1989 and the 30-yr average monthly precipitation (line) for Hector Airport weather station, Fargo, ND.

as a major source of new foxtail barley infestations (7) because foxtail barley seed are nonpersistent in soil (2, 4, 6).

In this study, fall moldboard or chisel plowing not only killed established plants (Table 2), but it probably prevented successful seedling establishment, further limiting foxtail barley encroachment onto cultivated land (5, 13). Deep primary tillage may bury most surface-lying seed too deeply for successful seedling emergence (2). Also, spring seedbed preparation by field cultivation-harrowing likely kills germinating seedlings that emerged after fall tillage before establishment. Wheat emerged a few days earlier in spring on moldboard plowed and chisel plowed plots than on no-till plots, but this probably did not influence established foxtail barley regrowth which preceded planting.

This research provides no-till farmers with an effective, less costly alternative to herbicides (8) to control established foxtail barley. Periodic moldboard or chisel plowing in fall followed by field cultivation-harrowing in spring for seedbed preparation may have a place for killing established foxtail barley (Table 2) and slowing its encroachment on no-till farmland.

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