Wild Oats Seed Longevity and Production

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Wild oats (*Avena fatua* L.) continues to be the most troublesome weed in the Northern Great Plains of the USA and Canada. Since its introduction in seed grain by early settlers, wild oats has flourished and spread, currently infesting over 28 million acres of land in the USA plus another 20 million acres in Canada. Annual losses from wild oats are $300 to $500 million in the USA and $970 million in Canada. L.R. Waldron, as early as 1903, stated that wild oats was a "bad" weed. Modern weed control efforts have not removed wild oats from this "bad" category (7).

The major hinderance to long term control of wild oats is that a portion of wild oats seed is dormant and seeds can germinate for many years since the dormancy is slowly lost (1, 5). Research in Canada and Great Britian has indicated that wild oats may persist for up to six years in cultivated soils (2, 4, 6). Further, wild oats seed persistence was increased by burial in soil and depth of burial influenced wild oats emergence and seedling establishment (3). Information on wild oats seed longevity, seed population trends, and seed production is necessary for the development of more effective long term wild oats control programs.

METHODS AND MATERIALS

Seed Longevity. The objective of this experiment was to determine wild oats seed longevity in soil as influenced by burial depth, nitrogen fertilizer, and location. One hundred and fifty wild oats seeds were mixed with soil from the 0 to 1.5, 2 to 3.5, 4 to 5.5, 6 to 7.5, 8 to 9.5, and 10 to 11.5-inch depth, at Fargo and Williston, North Dakota. In addition, soil from the 2 to 3.5-inch depth was treated with 150 pounds per acre N (ammonium nitrate 34-0-0). The soil with wild oats seeds was placed in containers made from polyvinyl plastic pipe with a nylon screen bottom and top. The containers were buried with the screen horizontal at the same soil depth as the origin of the soil. The containers were removed at various intervals after burial, wild oats seed separated, and seed viability determined.

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Seed Reserves. The objective of this experiment was to determine the influence of crops on wild oats seed reserves in the soil over a three-year period. A control plot with normal seedbed preparation but no crop was included. One-half of each plot cropped with rye, soybeans, barley, wheat and flax was untreated and one-half was treated with triallate (Far-go) [S-(2,3,3-trichloroallyl)diisopropylthiocarbamate] preplant or preemergence incorporated depending on the crop. One-half of the control plots was treated with triallate and was black fallowed for wild oats control and one-half was untilled and untreated after seedbed preparation. All small grain plots received postemergence MCPA [[(4-chloro-o-tolyl)oxy]acetic acid] and soybean received preplant incorporated trifluralin (Treflan) [α,α,α-trifluoro-2,6-dinitro-N,-dipropyl-p-toluidine] plus cultivation if needed. Wild oats seed density was determined in the fall of each season. Three soil samples were taken from each plot to a uniform depth of 6 inches. The soil was bagged, weighed, and screened. Wild oats seed was removed, counted and seed density per acre to a depth of 6 inches was calculated.

Seed Production. The objective of this experiment was to determine the influence of wild oats herbicides alone and in combination on wild oats seed production in wheat. Triallate was applied and harrow incorporated twice immediately after seeding in 1982, 1983, and 1984. Barban (Carbyne) [4-chloro-2-butynyl-m-chlorocarbanilate] and diclofop (Hoelon) [2-[4-(2,4-dichlorophenoxy) phenoxy] propanoic acid] were applied to 1.5- to 2-leaf wheat and wild oats and difenzoquat (Avenge) [1,2-dimethyl-3,5-diphenyl-1H-pyrazolium] was applied to 3.5- to 4-leaf wheat and wild oats. Herbicide treatments were applied with a bicycle wheel plot sprayer delivering 17 gpa for triallate and 8.5 gpa for postemergence treatments both at 35 psi. Wild oats panicles were counted prior to harvest and 20 panicles were collected and hand harvested to determine seeds per panicle.

RESULTS

Seed Longevity. The percentage of viable wild oats seeds buried at the various soil depths decreased rapidly during the first 13 months of burial in the soil at both Fargo and Williston (Table 1). Wild oats seed viability at burial was 99 percent but viability had decreased to 18 and 14 percent at Fargo and Williston, respectively, after 13 months burial in the soil averaged over burial depths.

Table 1. Percent viable wild oats seed as influenced by length of burial, burial depth, nitrogen fertilizer and location.

Burial depth	Length of burial (months)							
	13	25	33	48	60	84	108	Mean
(inch)	------(% viable seed - Fargo)[b]--------							
0-1½	11	13	6	6	2	1	0	6
2-3½	13	15	13	9	7	3	0	9
2-3½ + N[a]	9	9	9	9	3	1	0	6
4-5½	22	19	15	9	8	3	0	11
6-7½	24	23	13	18	14	7	2	14
8-9½	23	27	23	19	15	6	4	17
10-11½	26	27	26	29	16	11	4	20
Mean	18	19	15	14	9	5	1	
	---- (% viable seed - Williston)[b] ------							
0-1½	8	7	7	4	5	3	1	5
2-3½	13	12	13	11	11	14	7	12
2-3½ + N[a]	9	6	6	6	4	4	4	6
4-5½	16	12	14	16	16	16	10	14
6-7½	18	18	15	15	17	15	11	16
8-9½	17	17	19	15	16	18	15	17
10-11½	20	17	19	19	20	21	15	19
Mean	14	13	13	12	13	13	9	

a N = 150 lb/A N (ammonium nitrate 34-0-0).

b Viable seed are seed which germinated in water and seed which germinated in 1500 ppm GA_3. Initial viability was 99%.

Wild oats seed viability decreased more rapidly at Williston initially, but over the 108-month burial period, seed viability decreased more rapidly at Fargo than Williston. Wild oats seed viability was 4 percent less at Williston than Fargo after 13 months in the soil. However, after 60 months the percentage of viable wild oats seed was 4 percent greater, and by 108 months was 8 percent greater at Williston than Fargo when averaged over burial depths.

Differences in loss of seed viability between the two locations in this experiment were likely related to soil environment differences. The soil type was a silty clay and average annual precipitation is 19 inches at Fargo; the soil type was a sandy loam and average annual precipitation is 14 inches at Williston. Soil environment, particularly oxygen and moisture, has had a pronounced influence on wild oats seed persistence. The higher rainfall at Fargo may have reduced long term seed viability compared to Williston and the coarser textured soil at Williston may have caused the more rapid initial loss in seed viability compared to Fargo.

Loss of seed viability at both locations was greater at the shallow than at the deep burial depths. For example, 0 and 1 percent of the wild oat seed were viable at the 0 to 1.5-inch burial depth and 4 and 15 percent of the seed were viable at the 10 to 11.5-inch burial depth 108 months after burial at Fargo and Williston, respectively. Seed viability was lost more rapidly with nitrogen fertilizer than without nitrogen fertilizer in this study. Seed viability was reduced an average of 3 percent at Fargo and 6 percent at Williston by the addition of nitrogen fertilizer to soil from the 2 to 3.5-inch burial depth, averaged over sampling period.

Seed Reserves. The initial seed density in the experimental area at Fargo was 7.4 million seeds per acre. Wild oats seed reserves in the soil were reduced 98, 96 and 95 percent by three years of fallow, soybeans and rye when triallate was applied (Table 2). Three years of fallow, soybean, and rye treated with triallate reduced wild oats seed reserves in the soil over 95 percent, but sufficient wild oats seed was still present to cause a high infestation the following year. Wild oats seed reserves in the soil with these treatments ranged from 200 to 400 thousand seeds per acre.

Table 2. Wild oats seed reserves in the soil as influenced by crop when grown with or without triallate, a wild oats herbicide, at Fargo, North Dakota.

Crop	Year		
	1	2	3
	(Million seed/A - No wild oat herbicide)[a]		
Rye	6.0	2.7	1.0
Soybeans	7.6	5.3	0.9
Wheat	10.8	11.7	16.1
Barley	8.6	10.9	11.0
Flax	11.9	13.9	19.3
Control	13.1	22.6	56.0
	(Million seed/A - Wild oat herbicide)[a]		
Rye	4.9	2.3	0.4
Soybeans	5.3	2.6	0.3
Wheat	7.5	6.3	4.6
Barley	6.3	4.9	1.9
Flax	8.7	8.0	5.7
Black fallow	5.5	2.5	0.2

a Initial wild oat seed density was 7.4 million seed/A.

Wild oats seed reserves in the soil increased over 650 percent in the non-fallowed non-cropped area over the three year period. Further, wild oats seed reserves in the soil increased over 160, 90 and 30 percent with three years of flax, wheat or barley without triallate, respectively. However, the respective seed reserves decreased over 30, 40 and 75 percent when flax, wheat or barley were treated with triallate for three consecutive years. Barley was more effective than wheat or flax in minimizing the increase in wild oats seed reserves without triallate or in reducing wild oats seed reserves when triallate was applied.

Soybeans were more effective in reducing wild oats seed reserves in the soil than flax, wheat or barley with or without triallate. The greater reduction is probably from soybean cropping practices, which included later seedbed preparation, additional tillage during preplant incorporation of trifluralin, and cultivation after soybean emergence.

Seed Production. Wild oats panicle production was reduced 51 to 98 percent and seed production 60 to 99 percent by the various herbicide treatments during the three-year period (Table 3). Wild oats panicle production and total seed production per acre were reduced more with a combination of triallate followed with postemergence herbicides than with only the individual herbicides. In addition, percent wild oats control was increased by up to 52 percent with a combination of triallate plus a postemergence herbicide rather than a single herbicide application. The combination of triallate preemergence with either diclofop or difenzoquat postemergence gave the greatest reductions in wild oats panicles and seed production per acre and the greatest wild oats control. Triallate plus diclofop was the most effective treatment for reducing wild oats seed production and providing the greatest per-

Table 3. Influence of herbicide treatment on wild oats panicles, seeds per panicle, total seed production, and wild oats control during 1983, 1984, and 1985.

Herbicide treatment	Stage	Rate	Wild oats panicles 1983	1984	1985
		(lb/A)	(No./A × 10^{-4})		
Triallate	PEI[a]	1.0	19.7	16.4	33.5
Barban	2-L	0.38	34.2	25.0	36.4
Diclofop	2-L	0.75	19.6	14.0	31.6
Difenzoquat	4-L	0.75	31.2	24.7	14.9
Triallate + barban	PEI + 2-L[a]	1.0 + 0.38	12.5	6.2	13.7
Triallate + diclofop	PEI + 2-L[a]	1.0 + 0.75	1.9	1.6	14.6
Triallate + difenzoquat	PEI + 4-L[a]	1.0 + 0.75	5.2	5.2	1.5
Untreated	---	---	72.6	51.4	102.6
			Wild oats seeds/panicle		
			1983	1984	1985
			(No.)		
Triallate	PEI[a]	1.0	36	35	36
Barban	2-L	0.38	27	30	29
Diclofop	2-L	0.75	32	33	33
Difenzoquat	4-L	0.75	23	32	28
Triallate + barban	PEI + 2-L[a]	1.0 + 0.38	34	31	33
Triallate + diclofop	PEI + 2-L[a]	1.0 + 0.75	25	28	27
Triallate + difenzoquat	PEI + 4-L[a]	1.0 + 0.75	28	36	32
Untreated	---	---	35	36	36
			Total wild oats seeds		
			(No./A × 10^{-6})		
Triallate	PEI[a]	1.0	7.0	5.7	12.1
Barban	2-L	0.38	9.2	7.5	10.6
Diclofop	2-L	0.75	6.3	4.6	10.4
Difenzoquat	4-L	0.75	7.2	7.9	4.2
Triallate + barban	PEI + 2-L[a]	1.0 + 0.38	4.3	1.9	4.5
Triallate + diclofop	PEI + 2-L[a]	1.0 + 0.75	0.5	0.4	3.9
Triallate + difenzoquat	PEI + 4-L[a]	1.0 + 0.75	1.5	1.9	0.5
Untreated	---	---	25.4	18.5	36.9
			Wild oats control		
			1983	1984	1985
			(%)		
Triallate	PEI[a]	1.0	66	66	28
Barban	2-L	0.38	60	46	64
Diclofop	2-L	0.75	81	58	59
Difenzoquat	4-L	0.75	63	43	85
Triallate + barban	PEI + 2-L[a]	1.0 + 0.38	88	93	91
Triallate + diclofop	PEI + 2-L[a]	1.0 + 0.75	94	98	90
Triallate + difenzoquat	PEI + 4-L[a]	1.0 + 0.75	91	94	95
Untreated	---	---	0	0	0

[a] PEI was triallate application after wheat seeding with shallow harrow incorporation, 2-L and 4-L were herbicide application at the 2- and 4-leaf wild oats stage, respectively.

cent wild oats control in 1983 and 1984; triallate plus difenzoquat was the most effective treatment in 1985. This indicates that the wild oats response to these herbicides was influenced by environment and that prediction of the most consistently effective treatment is dependent on environment.

SUMMARY

The principal goal of this research was to develop information on wild oats seed longevity and seed production under several cropping and herbicide systems. Factors that influenced wild oats seed longevity in the soil included depth of burial, tillage practices, soil fertility and environmental conditions. Wild oats seed longevity generally was greater with deep burial and drier environmental conditions and less with high levels of nitrogen fertilizer or shallow burial.

These data indicate that fields densely infested with wild oats will require intensive control inputs combining competitive crops, reduced plowing, and herbicides to reduce seed reserves in the soil to levels where intensive control measures are not needed. Intensive systems which effectively controlled high wild oats infestations were summer fallow, warm season crops such as soybeans treated with herbicides, fall seeded crops such as rye which are extremely competitive with spring germinating wild oats, or small grains treated with pre- and postemergence herbicides for wild oats control. Intensive control practices for two to three years generally reduced wild oats infestations to levels where less intensive systems would adequately control wild oats in subsequent years.

The short term economic advantage of eliminating control measures when a wild oats population is low must be weighed against the risk of wild oats producing seeds that will cause a larger population of wild oats the following year as well as dormant seeds that will germinate over several years. Wild oats seed persisted in the soil at least nine years under North Dakota conditions, particularly at the deeper burial depths, which indicates that eradication would be extremely difficult even under an intensive management system.

LITERATURE CITED

1. Banting, J.D. 1962. The dormancy behavior of *Avena fatua* in cultivated soil. Can. J. Plant Sci. 42:22-39.
2. Banting, J.D. 1966. Studies on the persistence of *Avena fatua*. Can. J. Plant Sci. 46:129-140.
3. Thurston, J.M. 1961. The effect of depth of burying and frequency of cultivation on survival and germination of seeds of wild oats (*Avena fatua* L. and *Avena ludoviciana* Dur.). Weed Res. 1:19-31.
4. Thurston, J.M. 1966. Survival of seeds of wild oats (*Avena fatua* L. and *Avena ludoviciana* Dur.) and charlock (*Sinapsis arvensis* L.) in soil under leys. Weed Res. 6:200-206.
5. Wilson, B.J. 1972. Studies on the fate of *Avena fatua* seeds on cereal stubbles as influenced by autumn tillage. Proc. Brit. Weed Contr. Conf. 11:242-247.
6. Wilson, B.J. and G.W. Cussans. 1972. The effect of autumn cultivations on the emergence of *Avena fatua* seedlings. Proc. Brit. Weed Contr. Conf. 11:234-241.
7. Waldron, L.R. 1903. Noxious weeds and how to kill them. N.D. Exp. Sta. Bull. No. 56, pp 200-243.