DICLOFOP (Hoelon) FOR WILD OAT AND GREEN FOXTAIL CONTROL

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Diclofop (Hoelon) is a new postemergence herbicide which selectively controls wild oat, green foxtail and certain other weedy grasses in barley and hard red spring and durum wheat. Weed control and crop tolerance have been good to excellent with diclofop at 12 to 16 oz/A. Weedy grass control has been reduced with diclofop when mixed with certain herbicides for broadleaf weed control.

INTRODUCTION

Wild oat (*Avena fatua* L.) and green foxtail (*Setaria viridis* (L.) Beauv.) are weedy grasses which infest small grain crops in North Dakota. Wild oat can be controlled effectively by preemergence applications of triallate (Far-go) or postemergence applications of barban (Carbyne) or difenzoquat (Avenge); however, these herbicides do not control green foxtail. In many cases, control of wild oat may result in more vigorous growth of associated green foxtail because of reduced competition for light, moisture, and nutrients. Thus, a herbicide which selectively controls both foxtail and wild oat in small grains would reduce losses due to weeds and increase crop production. Diclofop (Hoelon) has given selective postemergence control of wild oat and green foxtail in field crops (1,2,3). Experiments have been conducted throughout North Dakota since 1974 to evaluate diclofop for wild oat and green foxtail control in barley and spring seeded wheat. This report summarizes some of the results of those experiments.

MATERIALS AND METHODS

Wild oat and green foxtail control in barley and wheat. A total of 23 experiments were conducted at experiment stations in North Dakota from 1974 through 1978 on land moderately to heavily infested with wild oat (40 to 150 plants per square yard) and moderately infested with green foxtail (60 to 100 plants per square yard). Site location, soil texture, seeding date, and crop cultivar seeded are presented in Table 1. Diclofop was applied with a bicycle wheel plot sprayer delivering 8.5 gallons per acre (gpa) water at 35 pounds per square inch (psi) at the 1.5- to 2- or 3.5- to 4-leaf stage of wild oat. The crop plants generally had 0.5 to 1 more leaves than the wild oat plants when treatments were applied. Green foxtail ranged from 0.5 to 1.5 inches and 0.75 to 2 inches in height, respectively when the early and late treatments were applied. Visual ratings for wild oat and green foxtail control and crop injury were made after the crop had headed. Grain yields were determined by harvesting 4 by 20 to 24 feet from each plot. The grain was cleaned, weighed, and all yields expressed at 12% moisture.

Diclofop in combination with several herbicides for broadleaf weed control. Olaf wheat was seeded at Fargo in a silty clay May 25 and April 13 in 1975 and 1976, respectively. Herbicide treatments were applied to wild oat in the 2.5- to 3-leaf and wheat in the 3-leaf stage. Diclofop plus broadleaf herbicide combinations were applied as a tank mixture in 8.5 gpa water at 35 psi. Visual weed control ratings were made after the crop headed. Grain yields were determined by harvesting 4 by 24 feet from each plot.

Barley and wheat variety response. The herbicide reaction of varieties of hard red spring and durum wheat and barley was evaluated at Fargo on a silty clay. Hard red spring and durum wheat varieties were seeded June 1, 1974, and barley varieties April 15 and 25 in 1976 and 1977, respectively. Treatments were applied in 8.5 gpa water at 35 psi when the plants were in the 2- to 3-leaf stage. Plant height was an average of five measurements per plot and grain yield was determined from a 4 by 12 foot area harvested from each plot.

RESULTS

Wild oat and green foxtail control in barley and wheat. Diclofop at 12 and 16 oz/A gave good to excellent control of wild oat (89 to 94%) and green foxtail (92 to 95%) at both the 2- and 3.5-leaf stage of application in barley (Table 2). Diclofop at 16 oz/A applied at the later stage of growth caused barley injury, rated visually at 10%. The visual injury was mainly a slight height reduction. Diclofop at 12 and 16 oz/A increased barley yields 10.7 and 10.9 bu/A from applications at the 2-leaf stage, and 6.9 and 6.2 bu/A from applications at the 3.5-leaf stage respectively, when compared to the yield from the untreated control plots. Barley yields generally were higher when diclofop was applied at the 2- than at the 3.5-leaf stage probably attributable to the earlier removal of weed competition and/or reduced crop injury.

Diclofop at 12 and 16 oz/A gave good (86 to 92%) green foxtail control in wheat at both stages of application (Table 3). However, wild oat control with 12 oz/A diclofop was 10% higher at the 2- than 3.5-leaf stage of

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Table 1. Experimental site, soil texture, seeding date, and crop cultivar seeded in the wild oat and green foxtail control in barley and wheat experiments.

Experimental site	Soil texture	Seeding date	Cultivar Wheat	Cultivar Barley
Williston-1974	Loam	5/4	Ellar	—
Minot-1974	Loam	5/21	Waldron	—
Langdon-1974	Clay loam	6/6	Chris	—
Williston-1975	Loam	5/20	Olaf	Hector
Minot-1975	Loam	5/10	Waldron	Beacon
Langdon-1975	Clay loam	5/31	Olaf	—
Fargo-1975	Silty clay	5/25	—	Multum
Williston-1976	Loam	4/29	Olaf	Hector
Minot-1976	Loam	4/13	Ellar	Larker
Fargo-1976	Silty clay	4/13	Olaf	Beacon
Williston-1977	Loam	4/25	Ellar	—
Minot-1977	Loam	4/25	Waldron	—
Langdon-1977	Clay loam	5/24	Kitt	—
Fargo-1977	Silty clay	4/12	Olaf	—
Williston-1978	Loam	4/27	Olaf	—
Minot-1978	Loam	4/27	Olaf	—
Langdon-1978	Clay loam	6/1	Kitt	—
Fargo-1978	Silty clay	4/28	Kitt	—

Table 2. Barley injury, barley yield[2], and wild oat and green foxtail control with 12 and 16 oz/A diclofop, 1975 and 1976.

Wild oat leaf stage	Diclofop oz/A	Barley[1] % Injury	Barley[1] Yield, bu/A	% Control Wild oat	% Control Green foxtail
2	12	2 b[2]	43.4 a	91 a	92 a
2	16	3 b	43.6 a	94 a	95 a
3.5	12	5 ab	39.6 ab	89 a	94 a
3.5	16	10 a	38.9 b	92 a	94 a
Untreated control	—	0 b	32.7 c	0 b	0 b

[1]*Each value is the mean of six experiments each with four replications.*
[2]*Values followed by the same letter are not statistically different at the 5% level.*

Table 3. Wheat injury, wheat yield, and wild oat and green foxtail control with 12 and 16 oz/A diclofop, 1974 to 1978.

Wild oat leaf stage	Diclofop oz/A	Wheat[1] % Injury	Wheat[1] Yield, bu/A	% Control Wild oat	% Control Green foxtail
2	12	0	26.7 a[2]	87 a	86 a
2	16	0	26.6 a	89 a	87 a
3.5	12	0	21.9 b	77 b	88 a
3.5	16	0	23.6 ab	85 a	92 a
Untreated control	—	0	14.9 c	0 c	0 b

[1]*Wheat injury, wheat yield, and wild oat control are the mean of 17, and green foxtail the mean of 15, experiments each with four replications.*
[2]*Values followed by the same letter are not statistically different at the 5% level.*

application. Further, wild oat control with 12 oz/A diclofop at the 2-leaf stage was as effective as 16 oz/A at the 3.5-leaf stage. Wheat at both stages of application was not injured by diclofop at 12 and 16 oz/A. Diclofop at 12 and 16 oz/A increased wheat yields 11.8 and 11.7 bu/A from applications at the 2-leaf stage and 7.0 and 8.7 bu/A from applications at the 3.5-leaf stage, respectively, when compared to the yield from the untreated control plots. Wheat yields were higher when diclofop was applied at the 2- than 3.5-leaf stage probably attributable to the earlier removal of weed competition and/or better wild oat control.

Diclofop gave 6 to 7% better green foxtail and wild oat control in barley than wheat when averaged over stage and rate of application (Table 2,3). The better weed control with diclofop in barley than wheat may be attributable to better weed competition from barley than wheat.

Diclofop at 12 or 16 oz/A gave consistent green foxtail control at both stages of application, however, wild oat control with diclofop was more consistent at the 2- than 3.5-leaf stage (Table 4). Wild oat control exceeded 80% with 12 oz/A diclofop applied at the 2-leaf stage in 20 of 23 experiments and at the 3.5-leaf stage only in 15 of 23 experiments. Further, wild oat control exceeded 80% with 12 oz/A applied at the 2-leaf stage as often as 16 oz/A applied at the 3.5-leaf stage.

Table 4. Number of experiments in wheat and barley where wild oat and green foxtail control exceeded 80% with 12 and 16 oz/A diclofop, 1974 to 1978.

Wild oat leaf stage	Diclofop oz/A	Number of experiments exceeding 80% control[1]	
		Wild oat	Green foxtail
2	12	20 (23)	19 (21)
2	16	21 (23)	21 (21)
3.5	12	15 (23)	19 (21)
3.5	16	19 (23)	20 (21)

[1]*Values in ( ) indicate the number of experiments involved*

Diclofop in combination with several herbicides for broadleaf weed control. Broadleaf herbicides applied with diclofop as a tank mixture reduced wild oat control 0 to 59% compared to diclofop applied alone (Table 5). Tank mixtures of broadleaf herbicides with diclofop would control both broadleaf weeds and weedy grasses with one application, however, bromoxynil (Buctril or Brominal) was the only herbicide which did not reduce wild oat control when applied with diclofop. Dicamba (Banvel) reduced wild oat control 59%, 2,4-D 42%, MCPA 30%, and bromoxynil plus MCPA (Bronate or Brominal Plus) 22% when applied in combination with diclofop compared to diclofop alone. Wheat yields generally were lower when wild oat control was reduced by adding a herbicide for broadleaf control with diclofop.

Barley and wheat variety response. Varieties of barley and hard red spring and durum wheat had excellent tolerance to 16 oz/A diclofop (Table 6). Visual injury ratings taken 2 weeks after treatment ranged from 0 to 7% in barley and 0 to 3% in hard red spring or durum wheat, however, plant height or yield were not affected by 16 oz/A diclofop.

Table 5. Wild oat control and wheat yield with diclofop alone or in combination with herbicides for broadleaf weed control at Fargo, 1975 and 1976.

Treatment	Rate oz/A	% Wild oat control	Wheat yield bu/A
Diclofop	12	87 a[1]	27.8 a
Diclofop + bromoxynil	12+4	91 a	28.2 a
Diclofop + bromoxynil + MCPA	12+4+4	65 b	22.0 b
Diclofop + MCPA (DMA)[2]	12+4	57 b	21.4 bc
Diclofop + 2,4-D (DMA)[2]	12+4	45 c	20.1 bc
Diclofop + dicamba	12+2	28 d	18.3 bc
Untreated control	—	0 e	16.8 c

[1]*Values followed by the same letter are not statistically different at the 5% level.*
[2]*DMA = dimethylamine formulation.*

Table 6. Barley and wheat cultivar response to 16 oz/A diclofop at Fargo.

Cultivar[1]	% injury	Plant height, inches	Yield, bu/A
Barley			
Beacon	7	24.8 (25.6)[2]	46.1 (47.4)
Larker	5	25.6 (25.2)	45.6 (44.6)
Manker	0	24.1 (25.2)	41.3 (41.2)
Bonanza	4	24.8 (25.2)	50.5 (52.8)
Hector	5	24.4 (24.8)	63.8 (60.3)
Hard red spring wheat			
Olaf	0	27.7 (28.8)	38.3 (39.9)
Waldron	0	31.2 (31.8)	36.0 (35.9)
Ellar	3	30.5 (31.6)	37.8 (36.9)
Era	0	26.9 (27.5)	40.0 (40.1)
Durum wheat			
Botno	0	30.8 (31.7)	32.1 (32.7)
Ward	0	34.0 (34.8)	34.5 (35.0)
Rugby	0	31.3 (31.4)	33.8 (34.1)
Leeds	3	34.8 (35.4)	34.1 (33.9)

[1]*Barley data are the means of 2 experiments, 1976 and 1977, and wheat data the means of 1 experiment, 1974, each with four replications.*
[2]*Values in ( ) indicate the plant height or yield of the untreated control plots.*

DISCUSSION

Diclofop at 12 and 16 oz/A provided excellent selective postemergence control of wild oat and green foxtail in barley and wheat, resulting in significant wheat and barley yield increases compared to the untreated control plots.

Green foxtail control with 12 and 16 oz/A diclofop was excellent at both stages of application, however, wild oat control with diclofop generally was better with applications at the 2- than 3.5-leaf stage. Data on wild oat control with diclofop indicate that the 12 oz/A rate could be applied at the 2-leaf stage for equal or better control than 16 oz/A at the 3.5-leaf stage. Thus, the stage of wild oat would be important to determine the application rate of diclofop.

Wheat and barley tolerance to postemergence applications of diclofop generally was good, however, in several experiments, slight barley injury was observed with diclofop at the 3.5-leaf stage of application. Hard red spring and durum wheat and barley varieties did not differ in tolerance to diclofop.

Diclofop applied as a tank mixture with bromoxynil controlled broadleaf weeds and weedy grasses with one application. However, diclofop tank mixed with several other herbicides reduced wild oat control with diclofop by 20% or more. Other research conducted at North Dakota State University indicates that applications of diclofop and 2,4-D or MCPA should be separated by more than 1 day (5).

Climatic and soil factors which promote plant growth generally have enhanced wild oat and green foxtail control with diclofop in glasshouse and growth chamber experiments (4). Field observations have confirmed that adequate moisture and fertility enhance wild oat and green foxtail control with diclofop in wheat and barley. These conditions not only enhance diclofop activity, but also promote greater crop competition with weeds.

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Approaches of this kind would keep transportation problems at a minimum.

Most existing oil extraction plants include auger-type expeller units. These machines are designed with an auger in a perforated housing. The center shaft of the auger increases in size from the inlet to the outlet until at the outlet end the shaft is the same diameter as the flighting. As seed moves through the auger, it is compressed until it is forced between this outlet shaft and the auger housing. Oil is forced out of the seed as it is compressed and flows from the machine through the perforations in the housing. Friction caused by the process provides heat so the oil will flow better. Seventy-five percent of the oil from sunflower seed has been extracted by this process.

In most commercial extraction plants, the meal from the auger expeller is exposed to a spray of hexane. This is a solvent that dissolves the remainder of the oil and removes it from the meal to increase the oil yield. Over 99 percent of the oil can be removed from the seed when this process is used. Hexane is then evaporated from the oil and reused.

The complexity of the solvent extraction process makes it undesirable for small on-farm processing plants. Filtration is a necessary step in processing oil as a fuel for diesel engines. The filtration is necessary to prevent fouling of engine fuel systems. Filtering the oil through a 4-micron filter has been recommended as a final process.

Further refining may be desirable to alter the oil characteristics so it will perform well in engines. Commercial extraction plants remove gums by treating the oil with water and then processing it in a centrifuge. Waxes are removed by cooling the oil. Treating the oil with methyl alcohol will produce a methyl ester which also may be used as a fuel. Engine testing is needed to determine if these or other treatments would improve the sunoil as a fuel.

Oil from hybrid varieties of sunflower is commonly 40 percent of the seed including the hull. This compares to 18 percent for soybeans, 17 to 22 percent for cottonseed, 31 percent for peanuts including shells, 36 percent for flax, 30 to 36 percent for safflower and 35 to 44 percent for rapeseed. As a result of the high oil content of sunflower seed, oil yield per acre from sunflower is good.

Meal from processed sunflower shows promise of being a useful feed supplement for livestock. Dr. W. E. Dinusson is conducting a research program in the Department of Animal Science to evaluate this meal. He reports that the protein content for solvent extracted dehulled seed is above 40 percent. This compares favorably with that of other oilseeds such as soybean meal, cottonseed meal, and rapeseed meal.

Dr. Edward J. Deibert is evaluating the meal for possible use as a fertilizer. The nutrient content (nitrogen, phosphorus, and potassium) of the whole seed meal and dehulled seed meal would have an approximate value, based on current fertilizer prices, of $29.40 and $51.72 per ton respectively. He has suggested that the meal could be effectively utilized as a supplemental fertilizer source when other means of disposal are not available.

Dr. D. L. Helgeson and Prof. L. W. Schaffner are conducting economic analyses on processing sunflower