AN EVALUATION OF HERBICIDES FOR BROADLEAF-WEED CONTROL IN RAPESEED

Efficacy, Phytotoxicity, and Soil Persistence Studies

by

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ABSTRACT

At the recommended rates (1.0 lb/A for trifluralin, ethalfluralin, EL-5261; 0.75 lb/A for dinitramine; 1.2 lb/A for nitrofen), none of the herbicides we evaluated in these studies reduced rapeseed stands, yields, or test weights. However, at higher rates (1.5, 3.0 lb/A), dinitramine reduced rapeseed stands, but this did not result in decreased yields. None of the other herbicides reduced rapeseed stand, yield, or test weights when applied at up to four times the recommended rate. No trifluralin residues were detected in rapeseed whole-plant or seed samples. All of the herbicides provided adequate control of common lambsquarters (*Chenopodium album* L.). Corn spurry (*Spergula arvensis* L.) was controlled by trifluralin, ethalfluralin, EL-5261, and nitrofen. All of the herbicides except nitrofen controlled chickweed [*Stellaria media* (L.) Cyrillo].

In 1979, 51 per cent of the trifluralin applied remained at the end of the growing season in one study while 26 per cent remained in another study. The rate of degradation at three sites in 1979 were as follows (greatest to least): Delta Junction, Matanuska Valley, Fairbanks. Degradation rates of trifluralin were not significantly different in three soil types or at two different application rates. Trifluralin showed no signs of leaching through the soil profile. In 1981, 25 per cent of the trifluralin, 8 per cent of the ethalfluralin, and 24 per cent of the EL-5261 applied remained at the end of the growing season. Despite the relatively long persistence of these preplant, incorporated herbicides, yields and test weights of barley planted in succeeding years were not reduced. A benefit of these persistent residues was control of broadleaf weeds in the succeeding barley crop.

INTRODUCTION

Rapeseed, *Brassica campestris* and *B. napus* grown primarily for its oil, is the major rotational crop with grains in western Canada. Its high cash value and adaptation to short growing seasons make it an attractive crop for rotation with barley in Alaska as well (Thomas and Lewis, 1981). However, the lack of a herbicide registered in Alaska for weed control in rapeseed has been a major obstacle to growing this crop in Alaska. Broadleaf weeds such as common lambsquarters (*Chenopodium album* L.) and chickweed [*Stellaria media* (L.) Cyrillo] can reduce yields, interfere with harvesting and reduce crop value.

Of the various herbicides that have been used in Canada for broadleaf weed control in rapeseed, nitrofen[a] (2, 4-dichlorophenyl p-nitrophenyl ether), trifluralin[b] (*a*, *a*, *a*-trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine), and dinitramine[c] (N^4, N^4-diethyl-*a*, *a*, *a*-trifluoro-3, 5-dinitrotoluene-2, 4-diamine) are the only ones which held promise of being used on rapeseed in the United States. Other herbicides that are used in Canada are precluded for use in the United States due to a lack of U.S. toxicology data. At present, nitrofen has been voluntarily withdrawn from the market by Rhom Haas Co. due to possible teratogenetic problems. We have collected efficacy, phytotoxicity, crop residue, and soil persistence data in an effort to register the remaining herbicides, trifluralin and dinitramine, for use in controlling broadleaf weeds in rapeseed. This was done in conjunction with the state of North Dakota through the USDA IR-4 minor-use registration process. While North Dakota received an IR-4 registration of trifluralin for

[a]Trade name: TOK (Rhom Haas Co.)
[b]Trade name: TREFLAN (Elanco Products Co.)
[c]Trade name: COBEX (U.S. Borax Co.)

controlling weeds in rapeseed, Alaska did not, as Elanco Products Co., the manufacturer of TREFLAN, was concerned about persistence of trifluralin in the cold soils of Alaska and possible yield reductions in subsequent rotational crops. As a result, Elanco did not support registration of TREFLAN in Alaska. As a result, we have focused our research efforts on further determining the degradation rate of trifluralin in Alaskan soils and on evaluating the effects of trifluralin residues in the soil on barley, the crop expected to be grown in rotation with rapeseed. In addition, we have performed studies to determine the effects of ethalfluralin[d] [N-ethyl-N-(2-methyl-2-propenyl)-2, 6-dinitro-4-(triflouromethyl) benzenamine] and a 1:1 mixture[e] of trifluralin and ethalfluralin on weed control and yield in rapeseed. Ethalfluralin is similar in the spectrum of weed species it controls, but has the advantage of degrading faster in the soil than trifluralin. Currently, ethalfluralin is being reviewed by EPA for use in soybeans. If registration for soybeans is approved, then the USDA IR-4-minor use registration program could be used to register ethalfluralin for use in rapeseed. Work with dinitramine was dropped after 1978 because the manufacturers reported that they were not interested in registration of their product for rapeseed.

[d]Trade name: SONALAN (Elanco Products Co.)

[e]EL-5261, an experimental herbicide produced by Elanco Products Co.

MATERIALS AND METHODS

Efficacy-Phytotoxicity Experiments

Fairbanks 1978. Trifluralin, dinitramine, and nitrofen were evaluated in 1978 at Fairbanks on Tanana silt loam soil with pH 7.0 and 4.1 per cent organic matter. The three herbicides were applied to rapeseed fields at the Canadian (Saskatchewan Agriculture, 1977) recommended rate (1.0, 0.75, and 1.2 lb/A for trifluralin, dinitramine, and nitrofen, respectively), at twice the recommended rate, and at four times the recommended rate[f]. These treatments plus the control, which received no herbicide, totaled ten treatments. Each treatment was replicated four times in a randomized complete block design. Individual plots were 10 ft by 30 ft. The preplant herbicides, trifluralin and dinitramine, were broadcast sprayed on May 22 and immediately incorporated to 2-3-inch depth by disking twice. The plots received a uniform broadcast fertilizer application of 200 lb/acre 46-0-0 plus 300 lb/A 10-20-20.

'Torch' rapeseed was seeded in 8-inch rows at a rate of 6 lb/A. The seed germinated slowly due to dry weather, therefore 1 inch of water was applied June 12 as a sprinkle irrigation. Nitrofen, the postemergent herbicide, was applied to the appropriate plots after the crop emerged. Measurements of herbicide performance and phytotoxicity were made July 12. Weed-control measurements were obtained by counting the number of weeds (mostly common lambsquarters) in each of two randomly selected $4ft^2$ areas within each plot. Phytotoxicity ratings were made by making plant counts in 3 ft of row in each plot. The rapeseed was harvested with a combine October 6. Also at that time, whole-

[f]All herbicide rates are reported as pounds per acre of active ingredient.

plant samples and seed samples were collected from each plot and immediately placed in a freezer to prevent chemical degradation prior to laboratory analysis. The samples were shipped to the regional IR-4 laboratory at Michigan State University for residue analysis.

Delta Junction 1981. In 1981, the experiment was conducted at Delta Junction, Alaska on ground that had been planted to 'Galt' barley the previous year. The soil was a Nenana silt loam with a pH of 6.2 and an organic-matter content of approximately 4.5 per cent in the top 5 cm. The soil was broadcast fertilized on May 14, with 200 lbs/A urea (46 per cent N), 100 lb/A ammonium monophosphate (11-51-0), and 100 lbs/A potassium sulfate (0-0-51+17.6S) and then disked in one direction. The soil was then packed with a Brillion seeder. Preplant, soil-incorporated herbicides (trifluralin, ethalfluralin, and EL-5261) were applied with a bicycle plot sprayer calibrated to deliver 25.13 gal/A at 30 psi and were immediately incorporated using two perpendicular passes with a tandem disk. Each of these herbicides was applied at four rates: 0.5, 1.0, 2.0, and 4.0 lb/A. The experiment also contained weedy check plots.

'Candle' rapeseed was then planted at 6.0 lb/A using a Brillion seeder. Nitrofen was applied at 0.3, 0.6, and 1.2 lb/A on June 16 when the rapeseed was in the 4-6-leaf stage using the application pressure and rate used for the preplant herbicides. Each plot was 10 ft by 40 ft. The experiment was a randomized complete block with four replications. Rapeseed emergence was rated on June 15 by counting the number of plants in 30 feet of row in each plot. To measure the effects of the herbicides on seedling weight, five rapeseed plants were harvested at random from each plot on June 20. These plants were then oven dried and weighed. In order to measure the effects of the herbicides on dry weight of volunteer barley, all barley plants within a m^2 quadrat were collected from each plot on July 29. The number of plants collected was recorded and the dry weights determined. On August 28, the plots were rated for weed control. The only weed present was common lambsquarters. The scale shown in Table 1 was used for weed-control ratings. To determine rapeseed yield, plants from two 4-ft by 4-ft quadrats were collected from each plot, dried, threshed; the seed was then cleaned and weighed.

Table 1. Weed control rating system for 1981 efficacy-phytotoxicity study at Delta Junction.

Numerical Rating	Lambsquarter Characteristics	
	No./m^2	Size
1	>20	No control—large
2	>20	Big
3	>20	Medium
4	>20	Small
5	>20	Very small
6	11-20	----
7	6-10	----
8	3-5	----
9	1-2	----
10	0	----

Fairbanks 1982. In 1982, the experiments were conducted at the Fairbanks Experiment Farm. The soil was broadcast fertilized on May 10 with 400 lb/A 20:10:10 and disked in two directions. The preplant, soil-incorporated herbicides were applied at the same rates and incorporated as in 1981. Weed seeds were spread over the plot area prior to herbicide incorporation to ensure an even stand of weeds. 'Candle' rapeseed was then planted at 6.0 lb/A using a Brillion seeder. Nitrofen was applied at 0.6, 1.2, and 2.4 lb/A on June 18 when the rapeseed was in the 6-7- leaf stage using the same application pressure and volume as used for the preplant herbicides. Each plot was 10 ft by 40 ft. The treatments were replicated six times in blocks. To control volunteer barley, sethoxydin[g] [2-(1-[ethoxyimino] butyl)-5-(2-[ethylthio] propyl)-3-hydroxy-2-cyclohexen-1-one] was broadcast applied on June 25 at 0.3 lb/A with a CO_2 backpack sprayer calibrated to deliver 27 gal/A at 40 psi. The plots were surveyed July 6-7 to determine the

[g]Trade name: POAST (BASF Co.).

number of rapeseed and volunteer barley plants occurring in a 1 m^2 quadrat placed randomly in each plot and the per cent of rapeseed plants flowering in each plot. Similarly, on July 27-28, per cent weed cover was determined for each weed species in each plot using a 1 m^2 quadrat. A plot combine was used to harvest a 4.25-ft-wide strip the length of each plot on September 3.

Soil Persistence Experiments

Site effect experiment. A series of experiments was conducted to determine the degradation rate of herbicides for use in rapeseed under Alaskan conditions. These experiments were initiated in May 1979 at three sites: Delta Junction, Fairbanks, and Palmer, Alaska. At each site, plots were treated with trifluralin at 1.0 lb/A. The trifluralin was then incorporated with two tandem disking operations, and the plots were planted to 'Candle' rapeseed. Twenty soil samples were collected to a 6-in depth, using a 0.75-inch-diameter soil corer immediately after application, in the fall following harvest, and again in the spring a year after application. These samples were immediately frozen and shipped to Elanco Products Co. for gas-chromatographic determination of herbicide residues.

Effect of application rate and soil type. Another study was established at Delta Junction to determine whether (1) the degradation rate of trifluralin is influenced by application rate or by the different soil types found in the Delta Junction vicinity and whether (2) trifluralin is leached downward in the soil profile. Three research sites were selected for three different soil types representing a cross section of the soils in the Delta Junction area. Site Number 1 was selected on a Richardson silt loam. This site had been under cultivation for approximately 30 years and represented some of the more productive soils in the area. The Richardson series is characterized by approximately 4 feet of silt loam overlying very gravelly coarse sand. No permafrost was present at the this site, and the water table was at a depth of approximately 15 feet. Site Number 2 was selected on a Nenana silt loam soil. This site was located on land which had been cleared

during the winter of 1978-79 and was cultivated for the first time in the spring of 1979. The Nenana series is representative of a majority of the tillable soils in the Delta-Clearwater area and is characterized by a mantle of silty soil approximately 20 inches thick overlying very gravelly sand. Permafrost was present within a foot of the soil surface at the time of the site selection. The water table in this area was at approximately 160 feet. Site Number 3 was selected to represent some of the poorest agricultural soils in the area. The surface soil was almost pure sand and was initially classified as a Beales soil. However, later core drilling revealed that it was a Nenana silt loam soil, complete with an organic moss layer, buried underneath a surface layer of sandy outwash. For this study, we identified this soil as simply *sand*. This site was cleared in 1978 but was cultivated for the first time in 1979. It was relatively close to Site Number 2 and had similar permafrost and groundwater conditions. Following initial cultivation in late May, each of two rates of trifluralin was applied to three plots at each location: 1.0 lb/A or 4.0 lb/A. The herbicide was then incorporated using two passes with a tandem disk, and 'Candle' rapeseed was planted at 6 lb/A. In late September, following harvest, three 2-in-diameter soil cores were collected from each plot using a Giddings hydraulic soil probe. The cores were divided into 6-inch increments to a depth of 1 foot and 1-foot increments to the underlying gravel layer. These samples were immediately frozen and shipped to Raltech Scientific Service, Inc. for trifluralin analysis.

1980 Field bioassey. In 1980, five barley fields were selected near Delta Junction where trifluralin had been applied in 1979. Soil samples were collected in August and shipped to Elanco for residue analysis. Yield data were collected in three of these fields to determine if the barley yields were reduced below the 1980 Alaskan average of 30 bu/A.

1981-1982 persistence. In 1981, soil samples were collected from the rapeseed-herbicide efficacy-phytotoxicity plots located at Delta Junction. Four 4-inch deep soil samples were collected and composited on the following dates: May 16 (immediately after incorporation), June 2, August 5, and October 7 from each trifluralin, ethalfluralin, and EL-5261 plot in which 1.0 lb/A had been applied. These samples were frozen after collection and sent to Elanco for gas-chromatographic analysis. On May 21-22, 1982, these plots were fertilized with 500 lb/A 20:10:10 and planted with 72 lb/A of viable 'Galt' barley seed. To estimate residual weed control, the per cent cover of weeds (all common lambsquarters) was measured in the center 1 m^2 of each plot on June 24. Following this weed-control measurement, bromoxynil[h] (3,5-dibromo-4-hydroxybenzonitrile) at 0.4 lb/A was broadcast applied to control common lambsquarters. The plots were harvested on September 13 using a 4.25-ft-wide plot combine.

[h]Trade name: BUCTRIL (Rhone-Poulenc, Inc.)

RESULTS

Efficacy-Phytotoxicity Experiments

Fairbanks 1978. Table 2 shows the results of the experiments conducted at Fairbanks in 1978. The rapeseed stand was not reduced below the level of the control in any of the trifluralin or nitrofen plots. Although stand reductions were not noted at the recommended rate of 0.75 lb/A of dinitramine, the rapeseed stand was reduced 21 per cent and 54 per cent by the 1.5-lb/A and

Table 2. The effect of herbicide treatments on weed control, rapeseed stand, and rapeseed yield in 1978 at Fairbanks.

		Rapeseed		
Treatment	Rate (a.i.)	Stand Reduction	Yield	Weed Populations
	(lb/A)	(%)	(bu/A)	(No./m^2)
dinitramine	0.75	0	55.6	6
dinitramine	1.5	21	52.2	5
dinitramine	3.0	54	47.7	0
trifluralin	1.0	0	44.9	6
trifluralin	2.0	0	44.0	5
trifluralin	4.0	0	41.6	2
nitrofen	1.2	0	44.7	12
nitrofen	2.4	0	53.4	9
nitrofen	4.8	0	58.8	6
control		0	38.0	40
LSD[a]		3.6	----	2.3
r^2		0.98	0.46	0.91

[a]LSD values ($p < .05$) were calculated for variables with a significant treatment effect.

3.0-lb/A application rates of dinitramine, respectively. Both trifluralin and dinitramine reduced weed populations by more than 85 per cent as compared to the weedy control, with per cent control increasing with increasing application rates. Nitrofen provided 70 per cent weed control at the lowest rate and 85 per cent control when applied at 4.0 lb/A. Alhough there was no significant ($p<.05$) effect of the weed-control treatments on rapeseed yield, several patterns in the data deserve mention. First, the lowest yield was produced in the weedy control plots. Yields were highest where low rates of dinitramine (0.75, 1.5 lb/A) and high rates of nitrofen (2.4, 4.8 lb/A) were used. Where trifluralin or dinitramine were used, yields decreased with increasing application rates. The opposite trend occured with nitrofen. No trifluralin residues were detected in rapeseed whole plant and seed samples that were sent to the IR-4 regional laboratory at Michigan State University for gas-chromatographic analysis.

Delta Junction 1981. Table 3 shows the results of the 1981 efficacy-phytotoxicity studies at Delta Junction. None of the three herbicides, trifluralin, ethalfluralin, and EL-5261, significantly affected the number of rapeseed plants per meter of row or the mean seedling weight. Similarly, rapeseed yields and test weights were not significantly affected by the herbicide treatments. Herbicide treatment did significantly affect the number and total weight of volunteer barley, however. There were significantly more volunteer barley plants occurring in the plots treated with trifluralin at 0.5 lb/A than in most other herbicide and control plots. In general, plots treated with the lowest herbicide rates (1.0 lb/A) had as many or more volunteer barley plants as the control plots. The total plant weight of volunteer barley in plots treated with trifluralin at 1.0 lb/A was significantly greater than that in plots treated with 2.0 lb/A of ethalfluralin. Volunteer barley weight was greatest for low rates of the herbicides, and most equaled or exceeded the control, although there was no significant ($p< .05$) effect of herbicide treatment on the average plant weight of volunteer barley. However, herbicide treatment did have a highly significant effect on weed control. Weed control

Table 3. The effect of herbicide treatments on control of volunteer barley and broadleaf weeds and on mean rapeseed emergence, yield, and test weight at Delta Junction in 1981.

Treatment	Rate (a.i.)	Rapeseed: Stand	Rapeseed: Avg. Seedling wt.	Rapeseed: Yield	Rapeseed: Test Weight	Volunteer Barley: Population	Volunteer Barley: Total Weight	Volunteer Barley: Weight per plant	Broadleaf Weed Control
	(lb/A)	(plants/m row)	(g/plant)	(bu/A)	(lb/bu)	(plants/m^2)	(g/m^2)	(g/plant)	(%)
trifluralin	0.5	24.5	0.75	12.4	48.1	40.3	42.4	1.92	20
trifluralin	1.0	25.4	0.44	9.5	44.8	23.0	52.7	2.50	53
trifluralin	2.0	29.7	0.60	10.7	45.0	7.5	10.0	1.46	73
trifluralin	4.0	28.2	0.68	14.5	46.8	8.5	5.1	0.53	80
ethalfluralin	0.5	26.4	0.67	12.3	49.3	12.5	25.5	2.39	15
ethalfluralin	1.0	26.6	0.60	12.5	48.7	10.0	7.1	1.29	35
ethalfluralin	2.0	31.0	0.53	13.4	47.7	2.0	2.4	1.01	68
ethalfluralin	4.0	31.7	0.35	11.1	46.9	4.0	7.7	1.44	88
EL-5261	0.5	26.5	0.50	13.5	47.2	18.5	13.1	1.69	25
EL-5261	1.0	28.6	0.71	11.6	45.5	7.8	27.7	1.51	58
EL-5261	2.0	25.7	0.60	15.7	46.6	5.5	12.2	1.85	73
EL-5261	4.0	27.8	0.46	12.5	46.4	2.0	4.1	3.31	78
nitrofen	0.3	29.4	0.51	8.7	46.3	10.0	21.1	2.21	43
nitrofen	0.6	26.9	0.88	13.5	49.6	21.3	30.7	2.23	28
nitrofen	1.2	29.6	0.64	9.9	47.4	7.0	13.0	2.07	63
control		27.0	0.69	11.2	47.6	8.0	14.3	1.56	
LSD[a]		- - -	- - -	- - -	- - -	19.8	27.5	- - -	24
r^2		0.75	0.32	0.32	0.52	0.45	0.46	0.56	0.78

[a] LSD values ($p< .05$) were calculated for variables with a significant treatment effect.

was much greater for all herbicides at the recommended rate or higher compared to the untreated control, except, for ethalfluralin.

Fairbanks 1982. In 1982 the herbicide treatments had a significant effect ($p<.05$) on: rapeseed stand (no./m^2); the number of rapeseed plants flowering on July 6-7; the number of volunteer barley plants (Table 4); and per cent control of common lambs-

Table 4. The effects in 1982 of herbicide treatments on control of volunteer barley and on rapeseed population, yield, test weight, and flowering at Fairbanks.

Herbicide	Rate (a.i.)	Rapeseed Stand	Rapeseed Yield	Rapeseed Test Wt.	Rapeseed Plants Flowering[a]	Volunteer Barley
	(lb/A)	(No/m^2)	(bu/A)	(lb/bu)	(%)	(No/m^2)
trifluralin	0.5	99	9.0	40.1	39	61
	1.0	107	10.8	42.7	47	79
	2.0	84	12.7	34.4	66	45
	4.0	75	12.2	42.4	50	26
ethalfluralin	0.5	95	11.1	40.1	58	62
	1.0	93	14.8	42.6	46	49
	2.0	159	12.2	42.3	58	20
	4.0	90	10.5	40.3	68	15
EL-5261	0.5	125	8.6	40.5	53	54
	1.0	112	11.1	39.5	50	56
	2.0	115	12.8	42.1	49	36
	4.0	90	12.8	35.3	66	37
nitrofen	0.6	88	11.3	43.7	15	99
	1.2	82	13.6	42.4	47	79
	2.4	190	11.4	44.4	43	85
No herbicides		75	9.3	37.2	19	101
LSD[b]		64	----	----	34	47
r^2		0.34	0.23	0.20	0.36	0.37

[a]Rating performed July 6-7, 1982.

[b]LSD values ($p<.05$) were calculated for variables with a significant treatment affect.

quarters, common chickweed and cornspurry (Table 5). Rapeseed stands were greater in all of the herbicide-treated plots than in control plots although this difference was significant only between the control and plots with ethalfluralin applied at 2.0 lb/A. All of the preplant-incorporated herbicides appear to prolong rapeseed flowering since a higher percentage of the rapeseed individuals were flowering in these plots than in the control. In addition, these herbicides reduced the number of volunteer barley plants when applied at greater than 0.5 lb/A for ethalfluralin and 1.0

Table 5. The effect of various herbicides in 1982 on per cent control of various weed species in rapeseed at Fairbanks.

Herbicide	Rate (a.i.)	Common Lambsquarters	Common Chickweed	Corn Spurry
	(lb/A)	(% Control)		
trifluralin	0.5	56	67	100
	1.0	85	84	100
	2.0	95	95	100
	4.0	99	95	100
ethalfluralin	0.5	82	51	100
	1.0	88	76	100
	2.0	96	93	100
	4.0	98	98	100
EL-5261	0.5	88	75	100
	1.0	87	76	100
	2.0	97	89	100
	4.0	98	98	100
nitrofen	0.6	47	-40[b]	100
	1.2	86	-213[b]	100
	2.4	69	-163[b]	100
weedy control		0	0	0
LSD[a]		34	118	45
r^2		0.54	0.53	0.36

[a]LSD values ($p<.05$) were calculated for variables with a significant treatment effect.

[b]Growth of chickweed was stimulated over that of control plots due to lack of control of this species and good control of competitive weeds.

lb/A for trifluralin and EL-5261. All of the herbicide treatments significantly reduced the populations of common lambsquarters and corn spurry compared to the control. Common lambsquarters control tended to increase with increased rates of trifluralin, ethalfluralin, and EL-5261. These same herbicides displayed a similar trend with respect to control of chickweed. In plots where pineappleweed (*Matricaria matricarioides* L.) and Shepherdspurse (*Capsella bursa-pastoris* L.) occurred, neither trifluralin, ethalfluralin, or nitrofen provided any control of these species. Herbicide had no effect on rapeseed yield or test weight. However, the yields and test weights of rapeseed grown in treated plots were generally as great or greater than those in the control.

Soil Persistence Experiments

Site effect experiment. The results of the herbicide-degradation experiments conducted during 1979-1980 at three Alaskan locations (Table 6) indicate that an average of 51 per cent of the applied trifluralin remained in the soil in the fall following the cropping season, and approximately 41 per cent was present the

Table 6, Soil degradation of trifluralin following application in 1979 at three Alaskan locations.

			Trifluralin Remaining		
Location	App. Date	App. Rate	Imm. After App.	Fall 1979	Spring 1980
		(lb/A)	(%)	(%)	(%)
Delta Jct.	6/15/79	1.0	53	41[a]	32[c]
Fairbanks	6/20/79	1.0	69	59[a]	50[d]
Palmer	6/22/79	1.0	64	53[b]	- - -
Mean			62	51	41

[a] Samples collected 90 days after application.

[b] Sample collected 77 days after application.

[c] Sample collected May 23, 1980.

[d] Sample collected May 27, 1980.

following spring at planting time. Degradation appeared fastest at Delta and slowest at Fairbanks, though a lack of plot replication prohibits a test of statistical significance.

1980 field bioassay. Despite slow degradation, barley yields from three fields at Delta Junction in which trifluralin had been used the previous year averaged 50.7 bu/A (Table 7). This yield was considerably better than the 1980 statewide average barley yield of 30 bu/A (Alaskan Agricultural Action Council, 1980).

Effect of application rate and soil type. In another degradation experiment conducted at Delta Junction in 1979, analysis of variance indicates no significant differences in trifluralin degradation rates due to application rate or soil type. Over all treatments, 26 per cent of the trifluralin applied remained at the end of the growing season (Table 8). None of the trifluralin was found below

Table 7. Trifluralin residues fifteen months after application in May 1979 and subsequent barley yields at Delta Junction.

Field Number	Field	Application Rate	Remaining After 15 Months	1980 Barley Yield
		(lb/A)	(%)	(bu/A)
1	Brazier's Field No. 1	1.0	51	50
2	Brazier's Field No. 2	1.0	29	55
3	Brazier's Field No. 3	1.0	73	47

Table 8. Trifluralin degradation in three soil types and at two application rates over the 1979 growing season at Delta Junction.

	Soil Type		
Application Rate	Richardson Silt Loam	Nenana Silt Loam	Nenana Silt Loam (sandy)
(lb/A)	- - - - (% of Applied Herbicide Remaining) - - - -		
1.0	26	25	14
4.0	23	37	30

the 6-inch depth, indicating that trifluralin did not leach through the soil profile.

1981-1982 persistence-carryover study. Shown in Table 9 are the results of the degradation study conducted in 1981 at Delta Junction. On August 5, 23 per cent of the trifluralin, 10 per cent of the ethalfluralin, and 11 per cent of EL-5261 (trifluralin and ethalfluralin, combined) applied still remained. No additional degradation of trifluralin and EL-5261 could be detected between August 5 and October 9. However, during the same time period, another 2 per cent of the ethalfluralin had disappeared. These residues had no significant effect on the yield and test weight of 'Galt' barley planted the next spring (Table 10). Except for plots in which trifluralin and ethalfluralin had been applied at 4.0 lb/A or nitrofen applied at 0.6 lb/A, all the herbicide treatments had higher average yields than the control. All of the herbicide treatments except trifluralin and EL-5261 at 0.5 lb/A provided residual control of common lambsquarters, with the per cent cover of this weed significantly less than the weedy control.

Table 9. Degradation rates of three dinitroaniline herbicides at Delta Junction, Alaska in 1981.

Herbicide	Herbicide remaining at indicated interval following application [a]		
	One Day	80 Days	145 Days
	(%)		
trifluralin	44 ± 34[b]	23 ± 7	25 ± 11
ethalfluralin	27 ± 5	10 ± 3	8 ± 3
EL-5261	23 ± 7	11 ± 5	24 ± 4

[a] All herbicides were applied at 1.0 1b/A (active ingredient) in May.
[b] Average of four plots and standard deviation.

Table 10. The effect of various herbicides applied for control of weeds in rapeseed in spring 1981 on the yield of 'Galt' barley at Delta Junction in 1982.

Treatment	Rate (a.i.)	Barley Grain Yield	Barley Test Weight	Common Lambsquarters
	(lb/A)	(bu/A)	(lb/bu)	(% cover)
trifluralin	0.5	80.5	38.1	5.8
	1.0	71.8	38.9	10.0
	2.0	72.7	37.9	6.8
	4.0	63.1	38.1	2.9
ethalfluralin	0.5	68.9	37.0	16.3
	1.0	78.7	37.2	11.3
	2.0	70.4	39.3	7.8
	4.0	54.2	36.5	0.8
EL-5261	0.5	69.6	37.0	21.3
	1.0	66.9	38.1	12.5
	2.0	76.1	37.5	3.3
	4.0	74.2	37.7	2.9
nitrofen	0.6	63.1	38.1	11.3
	1.2	73.4	37.4	8.8
	2.4	72.0	38.7	16.3
control		64.7	39.6	26.3
LSD		----	----	10.0

DISCUSSION

The results of studies conducted between 1978 and 1982 indicate that dinitramine, trifluralin, ethalfluralin, and EL-5261 would be suitable for control of broadleaf weeds in rapeseed. None of the herbicides, at the recommended rates, reduced rapeseed stands, yields, or test weights. At higher rates, trifluralin, ethalfluralin, EL-5261, and nitrofen produced no detrimental effects to rapeseed. While dinitramine applied at 1.5 and 3.0 lb/A (two and four times the recommended rate) reduced rapeseed stand, this did not affect yield. All of the herbicides controlled common lambsquarters, the predominant weed in rapeseed grown in Alaska. In addition, trifluralin, ethalfluralin, EL-5261, and nitrofen controlled corn spurry, while only the first three herbicides controlled chickweed.

The persistence of trifluralin appears to be greater in Alaska than in the rapeseed-producing areas of Canada. At the end of the growing season in Alaska, 25-51 per cent of the trifluralin applied in the spring still remains. This compares to 10-23 per cent remaining after 5 mo. in Saskatchewan (Smith and Hayden, 1976) and 17-26 per cent remaining after 50 weeks in Manitoba (Prichard and Stobbe, 1980). Rate of degradation of trifluralin appears to be independent of application rate as has been shown by Prichard and Stobbe (1980) and Savage (1973). Trifluralin persistence has been shown to increase with lower soil temperatures (Hamilton and Arle, 1972; Horowitz et al., 1974; Probst et al., 1967). The cool summer temperatures and long period of time during which soils are frozen in winter must be largely responsible for the slow degradation rates experienced in Alaska. Low soil moisture has also been found to decrease breakdown rates of dinitroanaline herbicides (Harvey, 1973; Savage, 1978).

During the 1979 growing season (May-September), the period in which the research was conducted, the Matanuska Valley,

experienced a rainfall shortage of 2.79 inches while Fairbanks experienced a 0.87-inch deficit and Delta a 0.43-inch increase over the average rainfall during this period. Season totals for these locations were 6.74 in, 5.37 in, and 9.21 in, respectively. This suggests that persistence in 1979 was related to rainfall as persistence was greatest at the Fairbanks site which received the smallest amount of rainfall and least at Delta Junction which received the most rainfall.

Despite the slow degradation of the dinitroanaline herbicides reported here, no detrimental carryover effects were noted for barley grown the following year. Barley appears to be quite tolerant of trifluralin and ethalfluralin residues in the soil. In fact, trifluralin is registered for spring barley in Canada and North Dakota. A 3-year rotational sequence of rapeseed followed by barley and then fallow should allow sufficient time for trifluralin residues to break down prior to the next application.

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