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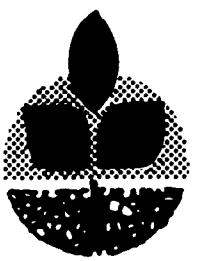

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Charles Stanger

ABSTRACT

Several herbicides were evaluated for crop selectivity and annual weed control in furrow-irrigated peppermint *(Mentha piperita* L.*)* and spearmint *(Mentha cardiaca* Baker*)*. The herbicide treatments were applied to fall-plowed and non-plowed mint. The soil was leveled, free of large clods, and the irrigation furrows established prior to the application of the herbicides. The better treatments were selected from the first year's screening trial and evaluated for 2 succeeding years. The combination of terbacil (3-*tert*-butyl-5-chloro-6-methyluracil) plus napropamide [2-(α-naphthoxy)-*N*,*N*-diethylpropionamide] consistently resulted in excellent season-long control of both the broadleaf and grassy annual weeds. Terbacil was effective in controlling the broadleaf weeds and the early emerging annual grasses but did not control the late-emerging grass. Napropamide was quite ineffective on most species of broadleaf weeds but persisted in the soil under furrow irrigation to control late emerging grass.

Three years of evaluation has shown fall applications of terbacil to be superior to spring-applied preemergence and postemergence treatments for annual weed control in furrow-irrigated mint.

Terbacil is currently registered for fall applications. Napropamide is not presently registered for use but efforts to obtain registration are underway.

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INTRODUCTION

How to control winter and summer annual weeds in peppermint *(Mentha piperita* L.*)* and spearmint *(Mentha cardiaca* Baker*)* grown under furrow irrigation is the most serious production problem in many mint-growing areas. Weeds are considered the most serious problem in mint fields because they not only reduce oil yields but also increase production costs and lower the quality of the extracted mint oil because of objectionable colors, odors, and flavors.

Mint growers in the area use a combination of practices in an effort to reduce weed populations. These include mechanical tillage, the application of herbicides and, occasionally, hand labor. Mechanical tillage is utilized in the spring on mint fields which were plowed in the fall when the mint was dormant. Spring tillage consists of a shallow cultivation, smoothing out the soil surface in preparation for making furrows for subsequent irrigations. This tillage operation usually eliminates the winter annuals and the early germinating summer annual weeds but the fields are left open to reinfestations by later germinating weeds.

The herbicides used commercially include Treflan (trifluralin) and Sinbar (terbacil). Trifluralin is applied in the spring and

incorporated during the normal spring tillage operation. If properly incorporated on the beds and in the irrigation furrows, trifluralin has been effective on early-season grasses and some broadleaf weeds but it is not effective on weeds in the *Cruciferae*, *Solanaceae*, and *Compositae* families at rates recommended for mint. Terbacil in combination with wetting agents or a crop oil is used extensively as a postemergence treatment in several mint-growing areas. In eastern Oregon and southwestern Idaho, the percent of weed control obtained from applying postemergence treatments has not been satisfactory and has generally resulted in many weedy mint fields at harvest time.

Terbacil is much more active as a herbicide when applied as a preemergence treatment. For optimum weed control it must be incorporated with the soil in that zone where weed seeds are germinating. Water applied through sprinkler irrigation or as rain or snow is an excellent means of incorporating and thus activating the herbicide.

In 1973, research was initiated in an effort to find an effective herbicide treatment that would selectively control annual weeds in mint produced under furrow irrigation in eastern Oregon and southwestern Idaho. The objective of this study was to evaluate herbicides for control of winter and summer annual broadleaf and grassy weeds when the herbicides are applied in late fall to both plowed and non-plowed mint and activated by winter moisture.

PROCEDURES

Procedures used to establish the trials and the results obtained at the various locations during the three years the research was conducted.

Procedure 1974

Materials and Methods

Plots were established in two commercial, non-plowed fields of Mitchum peppermint near Nyssa and Ontario, Oregon in early December. The mint was considered dormant, although the leaves were green and the plants were approximately 2 inches tall at the time of application. Weeds included seedling downy brome *(Bromus tectorum)* and prickly lettuce *(Lactuca scoriola* L.*)*. Some isolated plants of shepherds-purse *(Capsilla bursa-pastoris)* and tansy mustard *(Descurainia pinnata)* were also in the trial area. The downy brome ranged in size from just emerging to 2 inches tall. The largest prickly lettuce plants measured 3.5 inches across the rosettes. Summer annuals which emerged in the control plots during the growing season and in the plots of the non-effective treatments included Russian thistle *(Salsola kali* L.*)*, kochia *(Kochia scoparia)*, redroot pigweed *(Amaranthus retroflexus* L.*)*, barnyardgrass *(Echinochloa crus-galli* (L.) Beauv.*)*, and yellow foxtail *(Setaria glauca* (Weigel) Hubb.*)*.

Each plot was 40 feet long and 8 feet wide with each treatment replicated either three or four times. Soil texture was sandy loam

at both experimental sites. The soils were wet at time of application from unusual amounts of rain during November. High daytime temperatures ranged from 45 to 50 degrees F. on the days the treatments were applied. During December, after establishment of the first experiment, 2.08 inches of rain fell on 12 days during a 26-day period; the largest amount on a single day was .45 inches.

Treatments were applied with a bicycle-wheel type plot sprayer using 8003 TeeJet nozzles (double overlap) at 35 pounds per square inch spray pressure and applying approximately 31 gallons of water per acre.

The application procedures were the same in all trials established during the three-year study unless otherwise described.

Results and Discussion

Terbacil, metribuzin (Sencor), cyanazine (Bladex), and GS 14254 (Sumital) were effective in controlling winter annual grasses and both winter and summer annual broadleaf weeds, but did not persist in these soils to control summer-emerging yellow foxtail and watergrass (Table 1). Pronamide (Kerb) effectively controlled downy brome but was not effective in controlling the broadleaf weeds in this trial. Devrinol (napropamide) effectively controlled all annual grasses throughout the growing season and for more than 30 days after the mint was harvested. The pronamide treatment caused mint injury with 50 to 60 percent stand reduction at the 1 pound active ingredient per acre rate. All other herbicides showed good mint tolerance.

The combination of terbacil plus napropamide gave excellent season-long broadleaf weed and grass control. Terbacil and napropamide, applied singly and in combination, were evaluated further under varying cultural practices during 1975 and 1976.

Procedure 1975

Materials and Methods

Selected rates of terbacil and napropamide were applied to both plowed and non-plowed Mitchum peppermint. The non-plowed field was recorrugated with a power rotary corrugator prior to the application of the herbicide treatments. The rotary corrugator left the field smooth and free of clods and in excellent condition for herbicide application. The treatments were applied December 3. Winter annual species of weeds present as seedlings at the time of application included prickly lettuce, tansy mustard *(Descurainia pinnata* (Walt) Brit.*)*, and downy brome. Summer annuals which emerged in the control plots during the growing season included kochia, lambsquarters, pigweed, barnyardgrass, and yellow foxtail.

The tilled field was moldboard-plowed in the fall after the peppermint was dormant. The soil was dry when plowed and large chunks of soil were turned up. The plot area was disked shallowly and harrowed to smooth the soil surface, It was then corrugated, using regular type corrugation shovels. Although the area appeared tilled and smooth after harrowing, the corrugator uncovered clods which were left exposed on the bed tops. The plots were sprayed December 4 and the plot area received no further tillage until after the mint was harvested.

Results and Discussion

Terbacil at rates of 1.5 and 2.0 pounds active ingredient per acre applied in the fall to non-plowed peppermint resulted in good, season-long control of both winter and summer annual broadleaf weeds (Tables 2 and 3). It also provided good control of the winter annual grass (downy brome) and early-season summer annual grasses (barnyardgrass and yellow foxtail).

However, by July, in areas within the plots where good peppermint ground cover was not obtained, barnyardgrass and yellow foxtail were emerging. The combination treatment of terbacil and napropamide at rates of 1.5 + 2.0 and 1.5 + 4.0 provided season-long control of both annual broadleaf and grassy type weeds. Napropamide, as expected, was not effective on the broadleaf weed species in this trial but was persistent and resulted in season-long annual grass control.

Weed control was not as good as expected in the fall-plowed plots. The unsatisfactory weed control was attributed to cloddy conditions prevailing in the trial area. The field was heavily infested with weed seeds which germinated and emerged from areas protected from the application of herbicide by the clods. These areas could be observed in the spring when high populations of weeds emerged from protected spots. In areas not protected by clods, excellent weed control was obtained with terbacil and the combination of terbacil plus napropamide.

Procedure 1976

Materials and Methods

Late fall treatments of terbacil and napropamide were applied to fall-plowed and non-plowed Mitchum peppermint at three locations and to fall-plowed Scotch spearmint at one location. The plowed fields were leveled after plowing and before corrugation and both the plowed and non-plowed fields were corrugated in the fall before the herbicide application. The fields were not worked again until after harvest. Equipment used to make furrows consisted of a power rotary corrugator and regular furrowing type shovels mounted on a cultivator bar. In both cases, soil on the surface was left free of clods and of a fine tilth. In the non-plowed fields, the original corrugates were re-established with a power rotary corrugator. The water furrows were shaped narrow and only deep enough to facilitate proper irrigation. The narrow corrugates confined the irrigation water to a small area, thus reducing the amount of soil surface leached free of herbicide and vulnerable to late-emerging summer annual grasses and broadleaf weeds. The stands of peppermint and spearmint during the summer growing season were moderately dense and uniform at all locations.

The herbicide treatments, including rates and application information unique to each location, are listed in Tables 4, 5, 6, and 7.

Results and Discussion

Terbacil and napropamide were selected from a herbicide screening trial in 1973 as the most promising materials to continue experiment work with as fall-applied treatments under furrow irrigation. Terbacil is registered for use in peppermint and spearmint. Napropamide is not registered but indications are that registration is forthcoming.

In these trials, terbacil at rates of 1.5 and 2.0 active ingredient per acre was effective in controlling the following winter annuals: prickly lettuce, tansy mustard, tumbling mustard *(Sisymbrium altissimum* L.*)*, shepherdspurse *(Capsella bursa-pastoris* (L.) Moench.*)*, and volunteer wheat *(Triticum* species*)*. It was also effective in controlling most summer species of annual weeds which emerged prior to mid-season (Tables 4, 7). Late-emerging summer annual broadleaf weeds were usually not a problem in terbacil-treated plots. However, late-emerging barnyardgrass and foxtail were not effectively controlled with 2 pounds active ingredient per acre of terbacil and can be a problem in mint fields. These grasses occurred primarily in the water furrows.

It was noted that neither terbacil nor napropamide were effective in controlling western salsify *(Tragapogana dubius* Scop.*)*. Salsify should be eliminated by hand-weeding to prevent this weed from becoming a serious problem in terbacil-treated mint fields.

Napropamide at rates of 2 and 4 pounds active ingredient per acre did not adequately control the broadleaf weed species in these trials. At these rates, it was effective in controlling downy brome, barnyardgrass, and foxtail for the length of the growing season.

Terbacil in combination with napropamide has consistently been the better treatment where grassy weeds are present, resulting in good control of most species of annual broadleaf and grassy type weeds.

GENERAL DISCUSSION AND CONCLUSIONS

Three years of field trials have shown that a late fall application of terbacil to both spearmint and peppermint at rates of 1.5 to 2.0 pounds active ingredient per acre will result in good control of most species of winter and summer annual broadleaf weeds. Terbacil at these rates has given good control of annual summer grasses until mid-season but has not controlled later emerging grasses along the furrow edge. When napropamide (1) at rates of 2.0 to 4.0 pounds active ingredient per acre is used in combination with terbacil as a fall treatment, season-long annual broadleaf and grassy weed control has been obtained. Napropamide is not effective by itself on broadleaf weeds.

These treatments have been effective in both plowed and non-plowed mint. In both plowed and non-plowed mint, the irrigation furrow must be formed and the soil surface free of clods before the herbicide is applied. The winter moisture will activate the herbicide. Further tillage after the herbicide is applied usually will reduce weed control because of interference with the herbicide-treated layer. The furrows should be shaped as narrow as possible and only as deep as necessary to facilitate proper irrigation during the growing season.

Better weed control from fall-applied treatments can be expected on non-plowed mint. The non-plowed mint usually has earlier ground cover with denser mint stands which reduce weed emergence and growth by competition.

The number of herbicides registered for use in mint crops is limited to terbacil and trifluralin. Those weeds which are tolerant to these herbicides should be removed by hand labor to prevent a shift to populations of tolerant weed species.

Salsify is not easily controlled by terbacil and is increasing in population in mint fields.

Both peppermint and spearmint were tolerant to fall applications of terbacil and napropamide. The terbacil injury symptoms which have occurred in spearmint from postemergence treatments were not evident in the treatments applied during the fall.

Table 1. Winter and summer annual weed control in peppermint grown under furrow irrigation, Ontario, Oregon, 1974.

Treatment	Rate ai/A	% Crop injury	% Winter annual weed control		% Summer annual weed control		
			Downy brome	Prickly lettuce	Foxtail	Russian thistle	Kochia
terbacil	0.8	0	100	100	47	59	74
terbacil	1.2	0	100	100	74	95	92
napropamide	4.0	0	100	14	100	37	38
napropamide	6.0	0	100	20	100	50	47
metribuzin	0.5	0	100	100	17	34	22
metribuzin	0.75	15	100	100	50	70	60
GS 14254	1.6	0	100	100	74	94	90
asulam	1.5	0	30	40	0	14	10
asulam	3.0	0	70	30	0	20	28
pronamide	0.75	27	100	33	35	10	0
pronamide	1.0	54	100	20	50	14	7
napropamide + terbacil	3.0 + 0.75	0	100	100	100	75	97
cyanazine	1.5	5	100	91	0	40	53
cyanazine	3.0	9	100	100	44	82	85
Check	-	0	0	0	0	0	0

Evaluated June 22 - Percent weed control and crop injury ratings are an average from three replications.

Table 2. Annual weed control in non-plowed peppermint, Nyssa, Oregon, 1975

Treatment	Rate ai/A	% Crop injury	% Weed control[1] Prickly lettuce	Tansy mustard	Downy brome	Lambs-quarter	Pig-weed	Kochia	Barnyard-grass	Yellow foxtail
terbacil	1.0	0	96	98	98	94	93	95	75	75
terbacil	1.5	0	100	100	100	97	96	100	70	75
terbacil	2.0	0	100	100	100	100	100	100	85	87
terbacil plus napropamide	1.0 + 2.0	0	98	100	100	96	96	95	94	93
terbacil plus napropamide	1.5 + 2.0	0	100	100	100	100	100	100	98	98
terbacil plus napropamide	1.0 + 4.0	0	100	100	100	96	95	94	100	100
terbacil plus napropamide	1.5 + 4.0	0	100	100	100	100	100	100	100	100
Check	-	0	0	0	0	0	0	0	0	0

[1]Average of three replications

Date of evaluation: August 13, 14, 1975
Stage of weed growth at time of application:
1. prickly lettuce - 2-3" rosette
2. tansy mustard - 1-2" rosette
3. downy brome - 2-3 leaves

General Information
Crop: Peppermint (var. Mitchum)
Plot size: 17' x 50'
Irrigation: Furrow
Soil texture: Silt loam

Table 3. Annual weed control in fall-plowed peppermint, Ontario, Oregon, 1975

Treatment	Rate ai/A	% Crop injury	% Weed control[1]							
			Prickly lettuce	Tansy mustard	Downy brome	Lambs-quarter	Pig-weed	Kochia	Barnyard-grass	Foxtail
terbacil	1.5	0	80	88	84	67	80	77	78	73
terbacil	2.0	0	87	93	93	80	77	83	87	80
napropamide	4.0	0	35	43	97	72	72	67	93	92
terbacil plus napropamide	1.0 + 1.0	0	75	83	96	85	72	83	77	76
terbacil plus napropamide	1.0 + 2.0	0	80	90	98	91	83	88	88	87
terbacil plus napropamide	1.0 + 3.0	0	83	93	100	92	90	92	93	92
terbacil plus napropamide	1.5 + 1.0	0	86	97	98	96	93	95	97	97
Check	-	0	0	0	0	0	0	0	0	0

[1]Average of three replications

Date of evaluation: August 15, 1975

General Information
Crop: Peppermint (var. Mitchum)
Irrigation: Furrow
Soil texture: Silt loam

Table 4. Annual weed control in fall-plowed peppermint, Nyssa, Oregon, 1976

Treatment	Rate ai/A	% Crop injury	% Weed control[1]					
			Prickly lettuce	Sun flower	Kochia	Lambs-quarter	Wild oats	Foxtail
terbacil	1.0	0	87	70	82	92	58	76
terbacil	1.5	0	96	81	98	98	89	89
terbacil	2.0	2	99	98	99	100	93	95
terbacil plus napropamide	1.0 + 2.0	0	89	75	85	90	62	82
terbacil plus napropamide	1.0 + 4.0	3	82	72	79	92	68	84
terbacil plus napropamide	2.0 + 2.0	4	97	95	99	100	94	97
terbacil plus napropamide	2.0 + 4.0	8	100	98	99	100	91	99
terbacil (split)[2]	1.0 + 1.0	0	85	74	80	91	73	81
napropamide	4.0	0	10	40	10	20	80	92
Check	-	0	0	0	0	0	0	0

[1]Average of 4 replications

Date of application: November 20, 1975
Date of evaluation: July 21, 1976

[2]Date of application of split treatment:
November 20, 1975 and May 21, 1976

General Information
Crop: Peppermint (var. Mitchum)
Plot size: 16' x 38'
Soil texture: Silt loam
Irrigation: Furrow

Table 5. Annual weed control in non-plowed peppermint, Ontario, Oregon, 1976

Treatment	Rate ai/A	% Crop injury	% Weed control[1]					
			Volunteer wheat	Prickly lettuce	Mustard	Downy brome	Summer broadleaf[2]	Summer grasses[3]
terbacil	1.0	0	88	87	100	100	87	82
terbacil	1.5	0	100	99	100	100	96	94
terbacil	2.0	0	100	100	100	100	100	97
terbacil plus napropamide	1.0 + 2.0	0	100	100	100	100	87	94
terbacil plus napropamide	1.0 + 4.0	0	100	100	98	100	87	96
terbacil plus napropamide	2.0 + 2.0	0	100	100	100	100	100	99
terbacil plus napropamide	2.0 + 4.0	0	100	100	100	100	100	99
terbacil (split)[4]	1.0 + 1.0	0	100	100	100	100	92	92
Check	-	0	0	0	0	0	0	0

[1] Average of three replications

[2] Summer annual broadleaf weeds included pigweed, puncture vine *(Tribulus terrestris* L.), and lambsquarter

[3] Summer annual grasses included sandbur, green foxtail, and watergrass

[4] Split treatment applied:
November 13, 1975 and May 21, 1976
Date of application: November 13, 1975
Date of evaluation: July 21, 1976

General Information
Crop: Peppermint (var. Mitchum)
Soil texture: Sandy loam
Irrigation: Furrow

Weed size at time of application (fall):
Volunteer wheat - 6 inches tall (tillering)
Tansy mustard - 1-6 inch rosette
Tumbling mustard - 1-6 inch rosette
Shepherdspurse - 1-2 inch rosette
Downy brome - 2-4 leaves

Table 6. Annual weed control in plowed spearmint, Eagle, Idaho, 1976

Treatment	Rate ai/A	% Crop injury	% Weed control on two dates of evaluation[1]			
			Lambsquarters		Foxtail	
			June 25, 1976	Aug. 12, 1976	June 25, 1976	Aug. 12, 1976
terbacil	1.0	0	92	91	50	30
terbacil	1.5	0	96	96	72	60
terbacil	2.0	0	98	98	85	70
terbacil plus napropamide	1.0 + 2.0	0	91	89	74	70
terbacil plus napropamide	1.0 + 4.0	0	90	87	89	87
terbacil plus napropamide	2.0 + 2.0	0	99	99	90	92
terbacil plus napropamide	2.0 + 4.0	0	100	100	97	98
terbacil (split)	1.0 + 1.0	0	99	97	82	76
napropamide	4.0	0	31	20	87	89
Check	-	0	0	0	0	0

[1]Average of 4 replications.

Date of application: December 31, 1975
Split treatment applied:
December 31, 1975 and March 10, 1976

General Information:
Crop: Spearmint (var. Scotch)
Plot size: 9' x 38'
Soil texture: Sandy clay loam
Irrigation: Furrow

Table 7. Annual weed control in non-plowed peppermint, Meridian, Idaho, 1976

Treatment	Rate ai/A	% Crop injury	% Weed control[1]					
			Prickly lettuce	Tansy mustard	Downy brome	Lambsquarters	Pigweed	Summer grasses[2]
terbacil	1.5	0	100	100	100	98	96	79
terbacil	2.0	0	100	100	100	99	99	85
terbacil plus napropamide	1.5 + 2.0	0	100	100	100	99	95	82
terbacil plus napropamide	1.5 + 4.0	0	100	100	100	100	96	92
terbacil plus napropamide	2.0 + 2.0	0	100	100	100	100	97	94
terbacil plus napropamide	2.0 + 4.0	0	100	100	100	100	100	100
napropamide	2.0	0	30	35	94	35	30	89
napropamide	4.0	0	40	50	98	45	38	96
Check	-	0	0	0	0	0	0	0

[1] Average of 4 replications

[2] Summer grasses include both barnyardgrass and green foxtail

Date of application: November 26, 1975
Date of evaluation: August 12, 1976

General Information
Crop: Peppermint (var. Mitchum)
Soil texture: Clay loam
Irrigation: Furrow

Weed size at time of application (fall):
Prickly lettuce - 1-2 inch rosette
Tansy mustard - 1-2 inch rosette
Downy brome - 2-5 leaves