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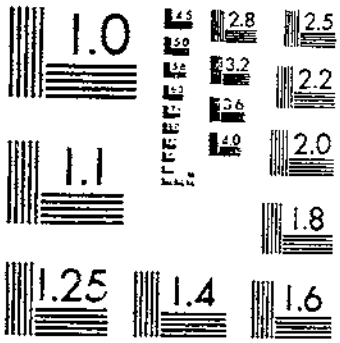

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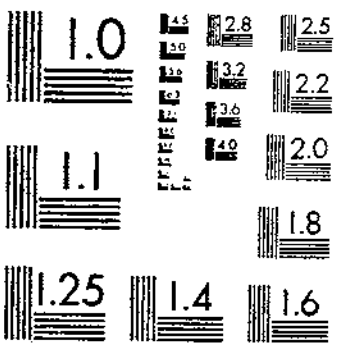

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THE BIOLOGIC AND ECONOMIC ASSESSMENT OF

DIALLATE

A report of the Diallate assessment team
to the rebuttable presumption against registration of Diallate

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Submitted to the Environmental Protection Agency
on September 12, 1977

UNITED STATES
DEPARTMENT OF
AGRICULTURE

IN COOPERATION WITH
STATE AGRICULTURAL EXPERIMENT STATIONS
COOPERATIVE EXTENSION SERVICE
OTHER STATE AGENCIES

TECHNICAL BULLETIN
NUMBER 1620

PREFACE

This report is a joint project of the U.S. Department of Agriculture and the State Land Grant Universities, and is the first in a series of reports recently prepared by a team of scientists from these organizations in order to provide sound, current scientific information on the benefits of, and exposure to, diallate.

The report is a scientific presentation to be used in connection with other data as a portion of the total body of knowledge in a final benefit/risk assessment under the Rebuttable Presumption Against Registration Process in connection with the Federal Insecticide, Fungicide, and Rodenticide Act.

This report is a slightly edited version of the report submitted to the Environmental Protection Agency on September 12, 1977. The editing has been limited in order to maintain the accuracy of the information in the original report.

Sincere appreciation is extended to the Assessment Team Members and to all others who gave so generously of their time in the development of information and in the preparation of the report.

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CONTENTS

ABSTRACT

Diallate is an important preplant, soil-incorporated herbicide for the control of wild oats in the geographical area from Minnesota west to the Pacific Ocean and south into California, Wyoming, Utah, and Colorado, with some less extensive infestations in Arizona, New Mexico, Texas, and Oklahoma.

Wild oats are estimated to infest 29 million acres of land in the United States. Economic returns beyond treatment costs occur on over 15 million acres.

Wild oats cost $319 million annually in yield losses and production expenses. One-half of these losses are reported to occur in North Dakota.

Wild oats is a major weed problem in sugarbeets, and is of economic importance in oats, soybeans, peas, dry beans, flax, lentils, corn, sunflower, and grass seed.

The total loss from wild oats, including both direct yield losses and indirect losses, exceeds $1 billion annually in the United States.

When diallate is used as directed on the registered label, contamination of water and air has not been found. Soil microflora rapidly degrade diallate when it is incorporated into the soil as directed. Human exposure is minimal because the herbicide is applied by machine and incorporated directly into the soil. No reference could be found relative to adverse health or environmental effects of diallate when used as directed.

Keywords: Diallate, wild oats control, herbicide, weed control, sugarbeets, flax, lentils, dry peas, alternatives to diallate, crop losses, pesticide registration, RPAR, economic impacts, human exposure.

INTRODUCTION

Title 40, 162.11, of the Code of Federal Regulations for the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended (86 Stat. 971, 89 Stat. 751, 7 U.S.C. 136 etseq.) provides that a rebuttable presumption against registration (RPAR) shall arise if the Environmental Protection Agency (EPA) determines that the pesticide meets or exceeds any of the risk criteria relating to acute or chronic toxic effects set forth in the Regulations (Section 162.11 (a)(3)). A notice of RPAR is issued when the evidence related to risk meets the criteria set forth.

The RPAR may be rebutted by proving that:

(1) In the case of a pesticide presumed against pursuant to the acute toxicity or lack of emergency treatment criteria, "that when considered with the formulation, packaging, method of use, and proposed restrictions on the directions for use and widespread and commonly recognized practices of use, the anticipated exposure to an applicator or user and to local, regional or national populations of nontarget organisms is not likely to result in any significant adverse effects"; and,

(2) In the case of a pesticide presumed against pursuant to the chronic toxicity criteria, "that when considered with proposed widespread and commonly recognized practices of use, the pesticide will not concentrate, persist or accrue to levels in man or the environment likely to result in any significant chronic adverse effects"; or,

(3) In either case, that "the determination by the Agency that the pesticide meets or exceeds any of the criteria for risk was in error."

The regulations also provide that evidence may be submitted as to whether the economic, social, and environmental benefits of the use of the pesticide subject to the presumption outweigh the risk of use. If the risk presumptions are not rebutted the Administrator (of EPA) will consider the information in determining the appropriate regulatory action.

In the Federal Register of May 31, 1977, the Environmental Protection Agency published a notice of rebuttable presumption against registration and continued registration of pesticide products containing diallate.

EPA has determined that pesticide products containing diallate meet or exceed the following criteria:

The reader is directed to the notice published in the Federal Register for detailed information used as the basis for the decision to issue a Rebuttable Presumption Against Registration (8).

Oncogenic Effects in Test Animals

The United Nations International Agency for Research on Cancer, after a review of the mouse feeding study conducted by Innes, concluded that diallate is carcinogenic when administered orally to mice. The Environmental Protection Agency Carcinogen Assessment Group (CAG) reviewed the Innes study and concluded that there were statistically and pronounced increases in hepatoma incidence in males of the two tested strains. There were small but statistically significant increases in the incidence of lung adenomas in both sexes of one strain of mice and in males only of the other strain.

The CAG concluded that the Litton Bionetics study showed a statistically significant increase in malignant tumors, as a whole only at the highest

dose in male rats and only at the lower dose in female rats. Industrial Bio-Test conducted a rat study in which they concluded that the neoplastic lesions noted in the test and controls were considered normal for rats of the age and strain. CAG evaluated the study and concluded that the rats showed a statistically significant excess of mammary carcinomas in females.

Neurotoxicity

Neurotoxic effects were observed in chickens administered diallate at 0.312 g/kg body weight by gavage twice daily for three consecutive days. This dosing was repeated for three more days beginning on the 21st test day. Evaluation of this study by EPA and by an EPA contractor concluded that this study provided adequate evidence of neurotoxicity.

Mutagenicity

A dominant lethal study on mice and a bacterial study have been reported. The dominant lethal study concludes that diallate produced no mutagenic effects. It is, however, limited because the investigator used only two dose levels instead of the three-four dose levels recommended as good protocol.

The negative result of the bacterial study is considered as tentative because no metabolic activation system was included.

Reproductive Effects

A 90-day dog study, submitted in 1960 in support of a request for a tolerance, reports that ovarian and testicular changes were noted during microscopic examination of the tissues. This study is under re-examination. An EPA contractor concluded that a study with albino rabbits demonstrated that diallate was not teratogenic or fetotoxic in rabbits.

This Cooperative Impact Assessment Report was prepared after contacting scientists in each State as to diallate usage and possible impact of the loss of the herbicide. Research data and use surveys were used when available as the basis for the impact assessment. The consensus of several scientists involved in research on wild oats or extension activities with growers in use areas was used when data were not available.

This report presents information on the biological, exposure, and economics related to the uses of diallate gathered by the U.S. Department of Agriculture, the State Agricultural Experiment Stations, and the Cooperative Extension Service.

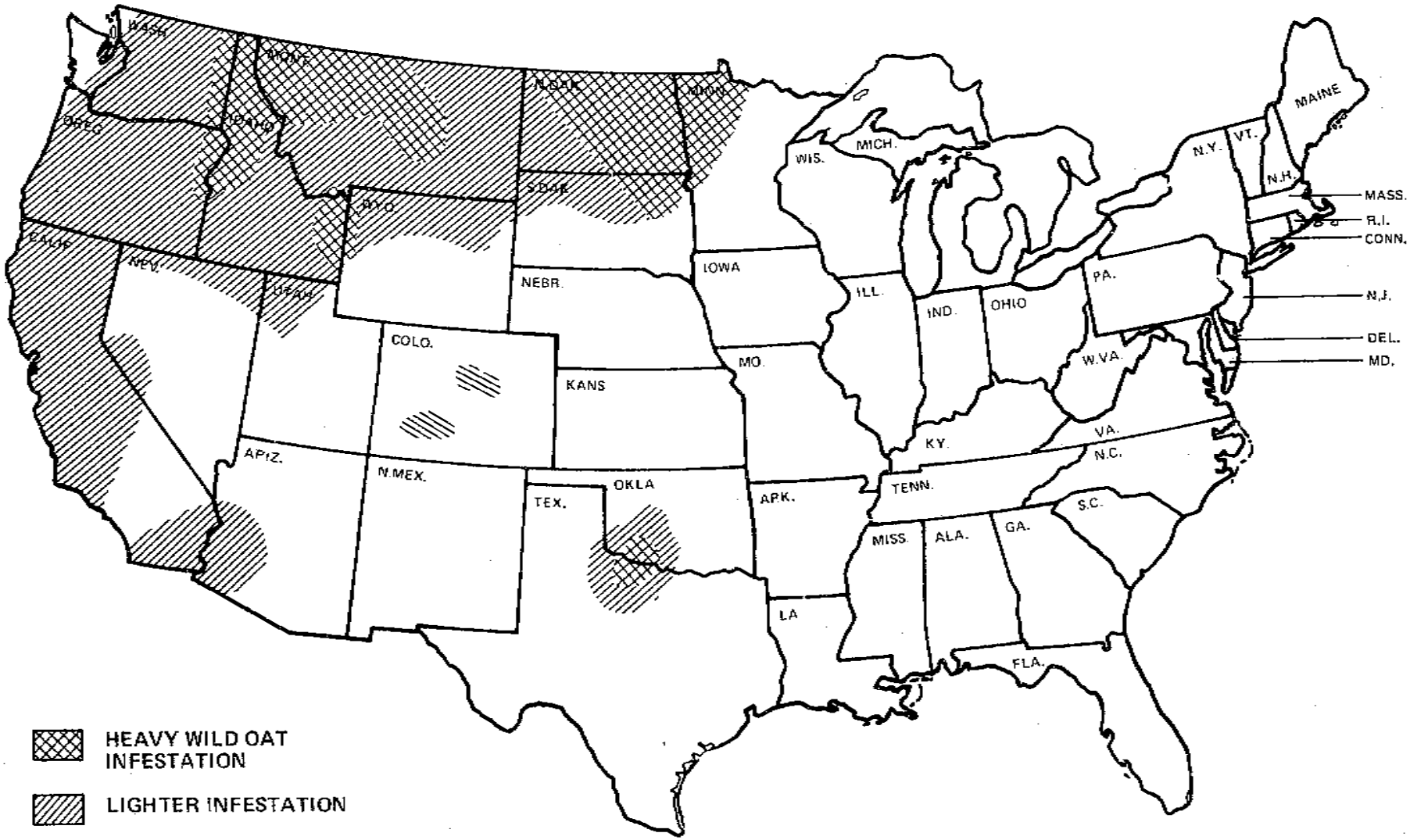
IMPORTANCE OF DIALLATE IN WILD OATS CONTROL

The major wild oats infestations in the United States occur in a geographical area from Minnesota west to the Pacific Ocean and south into California, Wyoming, Utah, and Colorado, with some isolated infestations in Arizona, New Mexico, Texas, and Oklahoma (Figure 1).

Wild oats was estimated recently by weed scientists in various States to infest 29 million acres of land (28) (Table 1). Wild oats infestations to the level that control methods would provide an economic return beyond the treatment costs were reported to occur on 14.6 million acres.

Wild oats cost $318.8 million annually in direct yield losses and production expenses as shown in Table 1. This value represents an average annual loss occurring between the late 1960's and 1973. Approximately one-half of this loss ($150,000,000) was reported by North Dakota.

The direct crop yield losses from wild oats are high, as indicated by competition experiments conducted in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HEAVY WILD OAT INFESTATION
LIGHTER INFESTATION

Table 1.--Extent of wild oats infestations and the associated estimated yield losses and production expenses (28).

Major States infested	Acres: Infested X 1,000	Acres: Economic infestation[a] X 1,000	Estimated loss X $1,000
Minnesota	1,000	400	35,000
North Dakota[b]	15,000	7,500	150,000
South Dakota	5,000	3,000	50,000
Montana	3,000	1,000	20,000
Wyoming	10	7	125
Colorado	250	100	1,000
Idaho	3,000	1,000	34,000
Washington[c]	750	750	13,000
Oregon	100	60	500
California[d]	900	750	15,200
Total	29,010	14,567	318,825

a/ Ten or more wild plants per square yard.
b/ Values for North Dakota are 3/4 those obtained from a survey when wild oats infestations were heavier than average (20).
c/ Economic infestation was not given on survey. Acres infested were used.
d/ Data from weed control specialists in California.

North Dakota (28). Wheat yields were reduced an average of 30% with an infestation of 100 wild oat plants per square yard. This level of infestation would normally be considered a moderate infestation. Barley is more competitive than wheat and yield losses from a given infestation of wild oats are less in barley than in wheat. Nevertheless, wild oats is still an important competitor with barley and caused a 20% yield loss with infestations of 100 plants per square yard.

Wild oats, even at low infestations, caused severe yield losses in flax. An infestation of only 10 plants per square yard caused a 20% yield loss and 80 plants per square yard caused a 65% yield loss (28).

Wild oats is considered to be equally as competitive in other areas, and some data indicated that yield losses may be even greater in the Northwestern U.S. and in irrigated crops than in North Dakota (a/).

Wild oats is assumed to be competitive in all crops, although precise competition data are not always available. In addition to the crops mentioned, wild oats is a major weed problem in sugarbeets and is considered of economic importance in oats, soybeans, peas, dry beans, flax, lentils, corn, sunflower, and grass seed.

In addition to the direct crop yield losses, expenses involving transportation, storage, cleaning, harvesting, and cultural and chemical control are also incurred from wild oats infestations.

a/ Lee, G. A. Personal communication, Univ. of Idaho, Moscow, Idaho, 1977.

Crop yields are reduced by delayed seeding for wild oats control, economic return from competitive crops sown for wild oats control is lower and extra tillage is required for wild oats control. In addition, some acres are replanted to the same or less profitable crops, other acres are cut for hay to prevent wild oats seed maturation, and some acres are abandoned. These indirect losses from wild oats plus the direct yield losses and production expenses were estimated by weed control specialists to exceed $1 billion annually in the wild oats infested area of the United States (28).

DIALLATE TECHNICAL DATA

A. Nomenclature
   1. Common name: diallate
   2. Chemical name: S-(2,3-dichloroallyl) diisopropylthiocarbamate
   3. Trade name: Avadex®
   4. Other names: CP-15336, DATC

B. Chemistry and physical properties

Diallate is a brown, oily liquid, soluble or miscible in most organic solvents, is slightly soluble in water (22 ppm at 24°C), and has a vapor pressure of 2.12×10^{-3} mm Hg at 25°C. Diallate consists of the cis and trans isomers (a/).

C. Herbicidal Uses

Diallate is primarily used as a preplant soil-incorporated herbicide for the control of wild oats in sugarbeets, flax, barley, lentils, peas, potatoes, corn, and soybeans. Diallate is labeled at 1.5 to 3.5 lb a.i./acre applied in 5 to 40 gallons of water or in a 10% granular formulation.

Diallate is an effective herbicide for wild oats control. Research results indicated that wild oats control in sugarbeets was 5 to 15% higher with diallate than with EPTC or barban. The primary usage of diallate is on sugarbeets (5,6).

D. Formulations
   1. Emulsifiable concentrate - 4 lb active ingredient per gallon.
   2. Granular - clay granule, 10% active ingredient.
   3. Mixture of one part diallate and two parts pebulate - a 6 lb per gallon emulsifiable concentration or 10% granules.
   4. Mixture of one part diallate and three parts cycloate - a 6 lb per gallon emulsifiable concentration or 10% granules.

E. Toxicological properties (12)
   1. Acute oral LD_{50} (rats), 395 mg/kg.
   2. Acute oral LD_{50} (dogs), 510 mg/kg.
   3. Sub-acute (rats), greater than 125 mg/day.
   4. Sub-acute (dogs), greater than 600 mg/day.
   5. Chronic toxicity (rats), 400 ppm in diet for 90 days resulted in weight loss.
   6. Chronic toxicity (beagle dogs), no effect at rates up to 125 ppm in diet for 90 days. At 600 ppm, food intake was erratic, weight gain decreased, and ovaries and testes were affected.

F. Uptake and translocation in plants (12)
   1. Absorption characteristics: In wild oats, primary absorption is through the emerging coleoptile.

a/ Personal communication--Monsanto Agricultural Products Co., St. Louis, Missouri, 1977.

2. Translocation characteristics: Extremely minor at early stages of seedling development.

G. Principal manufacturer

Monsanto Agricultural Products Co., 800 North Lindbergh Blvd., St. Louis, MO 63116.

H. Residue levels in crop samples

Residue determination on 49 samples of 13 crops (an average of 4 samples/crop) indicated less than 0.1 ppm diallate (17). Residues were not found at method sensitivity of 0.02 ppm when 17 samples of 5 crops were analyzed (18).

I. Residue levels in raw agricultural products

The Food and Drug Administration total diet program (Market Basket Survey) and the U.S. Department of Agriculture meat and poultry inspection program have never analyzed for diallate residues. Joint meetings of the World Health Organization and the Food and Agriculture Organization on pesticide residues have never reviewed residue data on diallate.

FATE IN THE ENVIRONMENT

Water

Information is currently not available on the fate of diallate in water; however, diallate use directions recommend incorporation into the upper 2 inches of soil as soon as possible after application to prevent loss due to photodecomposition and vaporization. Incorporation also places the herbicide in contact with emerging wild oat coleoptiles. Diallate adsorption to the soil would prevent runoff and leaching (11). Thus, diallate would not contaminate water unless transported by soil particles. Soil erosion from areas where diallate is used would not be sufficient to cause harmful contamination of water by diallate.

Air

Information is not available on the presence of diallate in the air. Diallate is not currently included in the EPA National Air Monitoring Program for Pesticides. The presence of diallate in the air would be minimal, because immediate soil incorporation is recommended and because the vapor pressure is 2.12×10^{-3} mm Hg at 25°C, 12,000 times less volatile than water (12).

Soil

Rapid desorption of diallate from soil has been reported (2, 3, 9, 14, 15, 16, 23, 24). Diallate disappears most rapidly from soils containing living microbial populations (2). In experiments with radio-labeled diallate, 50% of the diallate applied initially (2.5 ppm) disappeared after 1.5-4 weeks in non-sterile soils. Diallate disappearance was a result of degradation by soil microflora rather than by volatilization, adsorption, or retention by soil microflora. Other research results indicated degradation of diallate by soil fungi (14). All soils contain an abundance of soil microflora, and therefore diallate degradation would be rapid under use conditions. Analysis for diallate residues is not currently included in the EPA National Soils Monitoring Program.

Plants

Plant metabolism research with radio-labeled diallate on seedlings of barley, flax, and sugarbeets was submitted by Monsanto as part of the registration requirements. These experiments indicated that diallate was rapidly metabolized by the plants. The slowest degradation rate was in barley, where 74% of the radioactivity was released as labeled CO_2 within 11 days. The fastest degradation was in sugarbeets, where 87% of the radioactivity was released as CO_2 within 6 days.

HUMAN EXPOSURE

Exposure of applicators to diallate is low because of time (season) and method of application. Diallate applications for wild oats control are in the fall (October to freeze-up) or early spring (April-May) when temperatures are normally low. Diallate is less volatile at lower temperatures, and thus dermal and inhalation exposure to the applicator would be low. Diallate is applied to the soil surface and immediately incorporated, which limits the period of possible exposure. In addition, applicator exposure to diallate drift and vapors is minimized by the use of tractors with enclosed cabs. Available data indicate that 85% of the tractors sold in the United States have enclosed cabs (a/). Tractors used for diallate application in the Northern United States where wild oats is a problem commonly have had enclosed cabs for several years. Tractors with enclosed cabs are common in this region because temperatures are low when tillage operations are done, and because a cab is a small additional expense on large tractors. These large tractors are necessary for general farming operations and for applying and incorporating herbicides such as diallate in a single operation.

The average sugarbeet grower in North Dakota and Minnesota, treating his sugarbeet acreage, would have an exposure to spray vapors or drift of approximately 6 hours/year, assuming 20 acres treated/hour and an average of 115 acres/year. The 115 acres is based on 167,300 acres treated by 1450 growers (5). Sugarbeet grower exposure to diallate in irrigated regions would be less than in the non-irrigated regions because the average sugarbeet acreage per farm is less under irrigation than without irrigation. In the irrigated areas only 48,400 acres of sugarbeets were treated with diallate. The percentage of total sugarbeet acreage diallate-treated varied from a high of 62% in Montana to a range of 1-9% in the other States (Table 2). Sixty-five percent of the diallate usage on other crops (flax, dry peas, lentils, potatoes, barley, corn, soybeans, and forage legumes) is by farmers who do not grow sugarbeets. For sugarbeet growers who use diallate on other crops, however, the total exposure would probably not exceed an additional 6 hours over that for the sugarbeet operation. Also, in the non-irrigated areas, preliminary data from a survey (b/) indicated that 20% of the diallate is custom-applied. Thus, individual farmer exposure would be even less than indicated above.

Diallate residues have not been detected in raw agricultural commodities based on currently available levels of measurement. Method sensitivity in various crops is from .02-.05 ppm. Diallate has been registered as a selective herbicide for wild oats since 1960. No adverse health or environment effects have been reported over the years of diallate usage.

IMPACT OF DIALLATE NON-AVAILABILITY FOR CROPS

The economic impact of the non-availability of diallate as discussed in this report includes added costs of alternate herbicide purchase, application costs, and yield losses from less effective wild oats control from herbicides used as alternatives to diallate. Also included are losses from shifts to less profitable crops, yield losses due to delayed seeding, and costs of additional tillage, cultivation, and hand labor to control wild oats culturally. Diallate usage in this report was based on farmer surveys and on estimates by

a/ Personal communication, National Implement Dealers Association, 1977.

b/ Johnson, R. G., 1977. Unpublished survey data, North Dakota State University, Fargo, North Dakota.

Table 2.--Diallate usage on sugarbeets in wild oats-infested States, 1976.

Infested States	Planted acres in the wild oats areas[a/]	Treated acres[b/]	Percent treated	Average yield tons/acre
Non-Irrigated				
North Dakota-Minnesota	411,000	167,300	41	12.8
Irrigated				
Montana	46,500	28,900	62	21.0
Idaho	145,600	10,000	7	20.3
Wyoming	57,000	5,000	9	20.7
California	318,000	2,000	1	28.5
Utah	18,400	1,500	8	17.4
Oregon	14,600	1,000	7	25.1
Total	1,011,100	215,700	21	19.5

a/ (27).
b/ Based on farmer surveys and estimates by weed control specialists in each State.

Table 3.--Costs and method of application of diallate and alternative wild oats control in sugarbeets.

Control method	Rate lb a.i./acre	Cost $/acre[a/]	Time and method of application
Non-Irrigated			
A. Herbicides			
Diallate	1.25[b/]	5.30	Preplant incorporated, ground
EPTC-Fall	4.25	12.90	Preplant incorporated, ground
EPTC-Spring	2.50	7.60	Preplant incorporated, ground
Barban	0.75	12.20	Postemergence (1/2 air, 1/2 ground)
Dalapon	3.75	8.50	Postemergence (1/2 air, 1/2 ground)
B. Cultural			
Hand weeding	--	24.00-35.00	
Cultivation		2.00	
Irrigated			
A. Herbicides			
Diallate	1.25	5.30	Preplant incorporated, ground
Cycloate	4.00	23.50	Preplant incorporated, ground
Barban	0.75	12.20	Postemergence (1/2 air, 1/2 ground)
Paraquat	1.00	20.00	Post to weeds, Pre to crop
Dalapon	3.00	6.80	Postemergence (1/2 air, 1/2 ground)
Propham	6.00	13.00	Preemergence, ground
B. Cultural			
Hand weeding		24.00-65.00	
Cultivation		2.00	

a/ Based upon 1976 list prices, application cost not included. Costs for hand weeding and cultivation estimated by Assessment Team.
b/ Labeled rate is 1.5 to 2 lb/acre; however, 1.25 lb/acre represents an average use rate because approximately 5% is band-applied to one-third of the total area and diallate applied in combinations is often used at 1 lb/acre.

weed control specialists. Production losses from the unavailability of diallate were valued at 1975-76 average market prices.

Sugarbeets

Diallate was used on 215,700 acres of sugarbeets in 1976, which was 21.3% of the sugarbeet acreage in States that have a wild oats problem (Table 2). Farmers in the Red River Valley of North Dakota and Minnesota used more diallate on sugarbeets than did farmers in any other region - 167,300 treated acres or 41% of the planted acres.

Costs of diallate and alternatives for wild oats control are given in Table 3. EPTC, cycloate, and propham are preplant-incorporated herbicides that give fair to good wild oats control. EPTC gives the best wild oats control of these alternatives, but is used only in the Red River Valley because of injury to sugarbeets in other areas. EPTC was only 85-95% as effective as diallate (5).

Barban and dalapon are post-emergence herbicides that control wild oats. Barban gives 70-90% control of wild oats in the 2-leaf-stage, but larger wild oats are not effectively controlled and wild oats emerging after application are not controlled. Therefore, a single application of barban is not so effective as diallate for season-long wild oats control. Multiple application of barban is not registered; therefore, application to later emerged wild oats is not permitted. Barban is more effective than dalapon on 2-leaf-stage wild oats; however, dalapon will give fair control of larger wild oats (50-70%) (7). Dalapon causes sugarbeet injury under certain environmental conditions, but diallate has a good record of non-injury to plants.

An additional problem with the use of barban and dalapon is that they kill wild oat plants very slowly. Young sugarbeet plants must be thinned to prevent yield losses from competition among sugarbeet plants. Thinning is accomplished mechanically by using electronic sensors which do not distinguish between wild oats and sugarbeet plants. Therefore, if barban or dalapon is used, the thinning operation cannot be performed in a timely manner and yield losses will be incurred. On the other hand, diallate controls wild oat seedlings prior to emergence, so they do not interfere with the thinning operation.

Paraquat is a non-selective contact herbicide and must be applied after wild oats emergence but before sugarbeets emerge. Paraquat application reduces the wild oats population, but in many years most wild oats emerge after or along with the sugarbeets. Thus, paraquat is often not an effective herbicide for wild oats control. Hand labor for weeding and thinning still is commonly used in sugarbeets, but hand labor for wild oats control is expensive compared with diallate. Hand laborers generally charge by the acre rather than by the hour and charge more for weedy fields. The cost of hand hoe labor can exceed $100/acre in a field severely infested with wild oats or other weeds. Most farmers agree that sugarbeet profit margins do not justify this level of expense for hand labor. Even with the use of diallate, farmers typically spend $24-35/acre in the non-irrigated areas and $24-65/acre in the irrigated areas for hand labor (Table 3). If alternative herbicides were used in place of diallate, wild oats control would be less and additional hand labor would be needed. The hand labor costs are higher in the irrigated than in the non-irrigated region because irrigation promotes more late season emergence of wild oats. The use of hand hoe labor in a thick population of wild oats will often remove excessive numbers of sugarbeets along with the weeds, causing poor sugarbeet stands and yield losses. Sugarbeets are normally cultivated two to four times per year at a cost of $2.00/acre per cultivation. The absence of diallate would necessitate extra cultivations. Cultivation causes a direct cost for fuel and wear on machinery, but cultivation also can cause soil compaction and may damage sugarbeet roots.

Diallate was applied alone or in combination with other herbicides to 167,300 sugarbeet acres in the non-irrigated and 48,400 acres in the irrigated region (Table 4). Without diallate, multiple weed control practices on the same acreage would be used; therefore, the increase in acres treated with alternatives is greater than the diallate-treated acreage (Table 4). The increase in acres treated with diallate alternatives totaled 255,600 in the non-irrigated and 62,150 in the irrigated region.

The total increased production costs and loss of sugarbeet production due to the unavailability of diallate is estimated at $7.2 million with $3.5 million in the non-irrigated area and $3.7 million in the irrigated areas (Table 4). This amounts to $20.75/acre in the non-irrigated area and $76.13/acre in the irrigated areas for the acreage previously treated with diallate. With diallate available, the returns to land, labor, and management were estimated at $71.45/acre in the non-irrigated area and $241.76 in the irrigated areas (13, 22). With diallate unavailable, the per-acre returns to land, labor, and management would be $50.70 lower in the non-irrigated area and $165.63 lower in the irrigated areas, a reduction of about 30%.

Production losses from the unavailability of diallate were valued at 1975-76 average market prices. Under irrigation, several flushes of wild oats germinate in a year. Hand labor or postemergence herbicides are needed for each new flush of wild oats, but often adequate control by these methods is not possible. Diallate has usually given season-long wild oats control with one preplant application, thus controlling early as well as late germinating wild oats. In non-irrigated production, usually only one or two flushes of wild oats germinate, and good to excellent control is possible with hand labor and postemergence herbicides. Much of the added costs for hand labor and postemergence herbicides can be eliminated through the use of diallate. The average sugarbeet yield is higher from irrigated than from non-irrigated land (Table 2), and yield losses from wild oats competition under irrigation are also greater than with non-irrigated production.

In the non-irrigated region (Red River Valley of North Dakota and Minnesota) EPTC and diallate are commonly used in combination and barban or dalapon are commonly applied postemergence after preplant-incorporated EPTC or diallate to maximize wild oats control. Hand labor is used in addition to herbicides for weed control on most of the acreage in the Red River Valley. Without an effective and consistent preplant-incorporated herbicide, the use of postemergence herbicides and hand labor will increase.

The assumption in Table 4 for the non-irrigated area of the Red River Valley was that, in the absence of diallate, extra inputs of herbicides, cultivation, and hand labor would be made so that increased losses due to wild oats competition would be negligible. Of the 167,300 acres treated with diallate in the non-irrigated area in 1976, 42,000 acres were treated with diallate alone and 125,300 acres with a combination of diallate and EPTC. EPTC gives the best wild oats control of the alternatives and would be used on all acres treated with diallate alone. The loss of diallate in combination with EPTC would necessitate an increased use of the postemergence herbicides, barban and dalapon.

Because barban gives better wild oats control than dalapon and was used only on 6% of the acreage in 1976, barban would have the largest increase in usage, a projected increase of 94,000 acres. Much of the barban would be applied on acreage already treated with EPTC. Total wild oats control would be less in the absence of diallate; thus the average cost per acre for hand weeding would increase, additional cultivation would be needed, and very weedy fields would be summer-fallowed to

Table 4.--Increased costs to sugarbeet growers due to unavailability of diallate.

Control method	Affected acres[a/]	Costs: Herbicide	Costs: Application[b/]	Costs: Other	Yield loss: Tons	Yield loss: Value[c/]	Total value of costs and yield loss
				1,000			
NON-IRRIGATED							
Without diallate							
EPTC-Fall	21,000	$ 270.9	$ 73.5	--	0[d/]	--	$ 344.4
EPTC-Spring	21,000	159.6	73.5	--	0[d/]	--	233.1
Dalapon	24,000	204.0	34.8	--	0[d/]	--	238.8
Barban	94,000	1,146.8	136.3	--	0[d/]	--	1,283.1
Hand weeding	2,000	--	--	$1,721.0[e/]	0[d/]	--	1,721.0
Additional cultivation	80,000	--	--	160.0	0[d/]	--	160.0
Additional summer fallow[f/]	12,000	--	--	840.0	0[d/]	--	840.0
Additional replanting	1,600	--	--	48.0	3.2	$ 75.7	123.7
Total	255,600	$1,781.3	$ 318.1	$2,769.0	3.2	$ 75.7	$4,944.1
With diallate	167,300	886.7	585.6	--	--	--	1,472.3
Net change	--	894.6	(267.5)	2,769.0	3.2	75.7	3,471.8
IRRIGATED							
Without diallate							
Cycloate	11,100	260.8	38.8	--	9.6	227.0	526.6
Propham	400	5.2	1.4	--	2.4	56.8	63.4
Dalapon	2,500	17.0	3.6	--	2.5	59.1	79.7
Barban	2,500	30.5	3.6	--	7.2	170.3	204.4
Paraquat	2,500	50.0	3.6	--	7.8	184.5	238.1
Untreated	7,600	--	--	--	38.1	901.1	901.1
Hand weeding	11,100	--	--	410.7[g/]	19.8	468.3	879.0
Additional cultivation	14,500	--	--	29.0	7.4	175.0	204.0
Delayed seeding	1,250	--	--	--	2.5	59.1	59.1
Shift to other crops[h/]	8,700	42.0[i/]	22.9[i/]	890.5[j/]	--	--	955.4
Total	62,150	$ 405.5	$ 73.9	$1,330.2	97.3	$2,301.2	$4,110.8
With diallate	48,400	256.6	169.4	--	--	--	425.9
Net change	--	148.9	(95.5)	1,330.2	97.3	2,301.2	3,684.8
Total net change							
Non-irrigated and irrigated	--	$1,043.5	$(363.0)	$4,099.2	100.5	$2,376.9	$7,156.6

a/ Weed control practices may be used in combination or in sequence as well as alone, thus acres treated with alternatives exceed acres treated with diallate in 1976.

b/ Using application costs of $0.90/acre for ground spraying, $2.00/acre for aerial, and $2.60/acre for herbicide incorporation, application costs include only direct costs assuming the life of the equipment would not be significantly affected.

c/ Price of sugarbeets was assumed to be $23.65/ton (1975-76 average price).

d/ Assuming increased inputs sufficient to give no yield loss from competition.

e/ Includes an increased hand hoe labor cost of $10/acre on the 165,300 acres previously treated with diallate and an additional $34/acre on 2,000 acres that did not require hand hoeing when treated with diallate.

f/ Additional acreage of sugarbeets produced on land summer fallowed the previous year. A charge of $70/acre was made for land rental and tillage operations for summer fallow.

g/ An estimated 11,100 acres would require additional hand labor at an average cost of $37/acre.

h/ If diallate was not available, 8,700 acres of sugarbeets in Montana would be shifted to other crops. The acreages of these crops are shown in Table 5.

i/ Wheat and barley acres would be treated with triallate at 1 lb/acre and corn silage with atrazine at 2 lb/acre.

j/ Loss of income in shift of sugarbeet acreage to other crops (see Table 5).

reduce the wild oats problem sufficiently to allow sugarbeet production.

In the irrigated areas (Table 4) the main substitute herbicide for diallate would be cycloate. Most of the acreage treated with diallate in 1976 was also treated with cycloate; the projected increase in cycloate usage was 11,100 acres. Barban, dalapon, and paraquat often would be used in addition to cycloate in the absence of diallate. The use of hand labor would increase and the acres not treated with a substitute for diallate would increase.

No shift to other crops would be expected in the non-irrigated Red River Valley; however, 18% of the acreage treated with diallate under irrigation would be shifted to other crops in the absence of diallate. Because the most logical alternative crops are not as profitable as sugarbeets, considerable lost income would result (Table 5).

In addition to the added direct costs as a result of diallate unavailability listed in Table 4, other losses should be considered. Because total wild oats control will be reduced in the absence of diallate, more wild oats seed will be produced and the wild oats problem in other crops in the rotation will increase. The extra hand labor needed in sugarbeets due to the absence of diallate would require approximately 1000 extra migrant laborers. Sugarbeet growers using migrant labor are required to supply housing. An extra 1000 migrant workers would require additional construction of housing or expensive motel or hotel rental. The extra cost for migrant housing is not included in the total additional cost figure; however, the extra cost of housing 1000 migrant workers is estimated at $250,000 annually (13). Further, migrant labor is heavily subsidized by government programs for day care centers, health services, legal aid, and food stamps. No extra cost for these programs is included in the total additional cost figure. Migrant labor availability may be limited in the future because of socio-economic factors. Diallate will be needed for sugarbeets in the future even more than now if migrant labor becomes less available. Triallate could substitute for diallate in sugarbeets with no loss of production or increase in cost. Triallate, however, is not labeled for use on sugarbeets in the United States and is currently listed as an RPAR candidate, which raises concern for the future availability of triallate.

Table 5.--Income lost in the shift from sugarbeets to other crops.

Crop	Acres	Total production[a/]	Value of production[b/]	Variable production cost[c/]	Return over variable cost
Sugarbeets	8,700	174,000 T.	$4,115.1	$2,657.9	$1,457.2
Alternative Crops					
Wheat	1,400	70,000 bu	213.5	156.6	56.9
Barley	4,400	264,000 bu	549.1	389.8	159.3
Corn Silage	2,900	58,000 T.	864.2	513.7	350.5
Sub-Total	8,700		1,626.8	1,060.1	566.7
Net Loss			2,488.3	1,597.8	890.5

a/ The yields used in calculating total production are as follows: Sugarbeets 20 tons, wheat 50 bu, barley 60 bu, and corn silage 20 tons/acre.

b/ The 1975-76 average prices for Montana used were sugarbeets $23.65/ton, wheat $3.05/bu, barley $2.08/bu, and corn silage $14.90/ton.

c/ Average production costs taken from (22). Herbicide costs for wild oats have been excluded because they have been included under herbicide costs in Table 4.

Flax

Diallate is applied to 28,900 acres of flax in Minnesota, North Dakota, and South Dakota, or to only about 3% of the flax acreage in the wild oats infested area (Table 6).

Barban, EPTC, and delayed seeding are the main alternatives to diallate for wild oats control in flax (Table 7). Barban is applied postemergence when the wild oats are in the 2-leaf stage. The limited time for the application is a deterrent to barban usage because adverse weather conditions during this 2-4 day period may prevent application. Further, barban has not given as effective wild oats control as diallate. Barban is often applied by air, which increases the cost of application compared with ground application. The cost values in this report for herbicide application and tillages performed by the farmer included only direct costs, assuming the life of the equipment would not be significantly affected (21).

EPTC was listed as a viable alternate only in North Dakota, where usage is presently in practice. The primary disadvantage of EPTC is marginal flax tolerance. Extreme precision in use rate relative to soil conditions is needed to give good weed control and acceptable crop injury; however, yields have been high with EPTC because of reduced competition from other annual weeds in addition to wild oats.

Table 6.--Current use of diallate on flax, 1976.

State	Planted acres[a/]	Treated acres[b/]	Percent treated	Average bu/acre[c/]
North Dakota	486,000	14,600	3.0	8.3
South Dakota	270,000	8,100	3.0	7.2
Minnesota	205,000	6,200	3.0	11.0
Total	961,000	28,900	3.0	8.8

a/ (27).
b/ Estimated by weed control specialists.
c/ 1974-76 average yield per harvested acre.

Table 7.--Costs of diallate and alternative wild oats control in flax.

Control method	Rate lb a.i./acre	Cost $/acre	Time of application	Yield bu/acre[d/]
Herbicide				
Barban	0.375	6.10	POST[c/]	11.3
EPTC[a/]	3.0	9.12	PPI	16.0
Diallate	1.25[b/]	5.30	PPI	14.4
Cultural				
Delayed seeding (extra tillage)		2.25		8.3

a/ Not recommended in Minnesota and South Dakota because of possible flax injury.
b/ Labeled rate is 1.5 lb/acre; however, flax growers often use only 1 lb/acre.
c/ POST = Postemergence; PPI = Preplant-incorporated.
d/ Estimated by weed control specialists.

Table 8.--Estimated weed control costs and yield losses in flax production, with the use of alternatives to diallate in North Dakota, South Dakota, and Minnesota, 1976.

Control method	Affected acres	Costs			Yield loss[b]		Total value of costs and yield loss
		Herbicide	Application[a]	Other	Bushels	Value	
Without diallate							
Barban	20,510	$125,111	$ 29,740	$ 34,760[c]	63,581	$428,536	$618,147
EPTC[d]	3,970	36,206	13,895		(6,352)	(42,812)	7,289
Delayed seeding	570			1,992[c]	3,477	23,435	25,427
Shift to other crops	3,850	19,687[e]	6,020[e]	72,087[f]			97,794
Total	28,900	$181,004	$ 49,655	$108,839	60,706	$409,159	$748,657
With diallate	28,900	153,170	101,150				254,320
Net change	---	$ 27,834	$(51,495)	$108,839		$409,159	$494,337

a/ Using application costs of $0.90/acre for ground spraying, $2.00/acre for aerial, and $2.60/acre for herbicide incorporation. Assumes that 50% of the barban is applied aerially and 50% ground. EPTC and diallate are applied by ground and incorporated.

b/ Yield loss based on individual State estimates and predicted treatment shifts with unavailability of diallate.

c/ Cost for removal of wild oats seed at $0.15/bu.

d/ Assuming 50% fall and 50% spring applications.

e/ Assumes that the wheat and barley acreage (Table 9) would be treated with 1 lb/acre of triallate at $4.25/acre and sunflowers with 3 lb/acre EPTC at $9.12/acre. EPTC is ground applied and incorporated and triallate is ground applied.

f/ Loss in income from shift of flax acreage to other crops (see Table 9).

Dalapon is listed in the sugarbeet section of this report as an alternate to diallate for wild oats control. Flax does not have tolerance to dalapon at rates needed for wild oats control.

Generally, wild oats is effectively controlled by delaying flax seeding into June when wild oats no longer emerge. Research data have indicated, however, that flax yields in North Dakota are reduced 0.28 bu/acre for every day of delay in seeding beyond May 1 (10). Delayed seeding is a common practice that is presently used, and probably accounts for the low average flax yields (Table 6). The practice requires 1-2 extra tillage operations for wild oats control and to enhance early weed seed germination.

The use of diallate for wild oats control in combination with other herbicides for annual broadleaf and grassy weeds makes possible early seeding, good weed control, and flaxseed yields of from 15-20 bu/acre.

The influence of diallate unavailability upon costs of weed control and yield losses in flax are presented in Table 8. The assumption was that all flax acres treated with diallate would either be treated with alternate herbicides, given cultural control, or shifted to other crops. Diallate assures growers of a better opportunity to maximize yields, and is used by growers who realize that large yield losses occur from delayed seeding and wild oats competition. Flax infested with uncontrolled wild oats would yield less than 5 bu/acre.

The 28,900 acres of flax presently treated with diallate would be influenced as follows: 20,510 treated with barban, 3,970 treated with EPTC, 570 delay-seeded, and 3,850 acres shifted to other crops.

The cost of alternative herbicides would increase about $28,000 compared with diallate, but application costs would decrease by about $51,500. The reduction in total application costs

Table 9.--Income lost in the shift from flax to other crops.

Crop	Acres	Total production[a/]	Value of production[b/]	Variable production cost[c/]	Return over variable cost
Flax	3,850	55,440 bu	$373,666	$ 97,983	$275,683
Alternative crops					
Wheat	1,530	36,567 bu	125,425	57,436	67,989
Barley	570	18,468 bu	44,877	19,471	25,406
Oats	570	23,655 bu	34,063	12,893	21,170
Sunflowers	1,180	11,800 cwt	129,800	40,769	89,031
Sub-Total	3,850		334,165	130,569	203,596
Net Loss			39,501	(32,586)	72,087[d/]

a/ The yields used in calculating total production are as follows: flax 14.4 bu, oats 41.5 bu, barley 32.4 bu, and sunflowers 1,000 lb/acre.

b/ The 1975-76 average prices for the three States of Minnesota, North Dakota, and South Dakota were used to calculate the value of production. The prices used are as follows: oats $1.44, wheat $3.43, barley $2.43, flax $6.74/bu, and sunflowers $11.00/cwt.

c/ Average production costs for 1975-76 were taken from: (25). Sunflower costs were unpublished costs of the Department of Agricultural Economics, North Dakota State University for 1975 and 1976. Herbicide costs for wild oats control have been excluded because they have been included under herbicide costs in Table 8.

d/ Flax returns compared with alternative crops.

occurs because barban application costs are estimated at $1.45/acre compared with $3.50/acre for diallate. The flax acres that would be shifted to other crops would be treated with triallate or EPTC for wild oats control, except those shifted to common oats. The increased wild oats infestations in the subsequent years following the untreated common oats could be significant and add to control costs in subsequent years.

The flaxseed production would be reduced 60,706 bushels from reduced wild oats control, which at $6.74/bu equals a $409,159 loss. In addition to the yield loss, the harvested seed would contain more dockage, increasing cleaning costs $.15/bu or $36,752. Alternate crop substitutions for diallate-treated flax would have a lower profit, causing a loss of $72,087 (Table 9). Although the cost of herbicides including application cost is sightly lower, the net loss from diallate unavailability equals $494,337 or $17.10 loss/diallate-treated acre.

With diallate available the farmer's return to land, labor, and management is estimated at $54.42/acre (a/); the loss of diallate would reduce these returns to $37.32/acre, or 31%.

Flax straw is used in the manufacture of quality paper. If weeds are present or flax growth poor, however, straw cannot be used for paper, which results in an economic loss. Flax straw decays slowly. Flax straw not used for paper is often burned or, if not burned, causes delays in tillage. Diallate unavailability would reduce the amount of straw acceptable for paper; however, this was not considered in the economic analysis. A yield of flax straw of 750 lb/acre at $12/ton has a value of $4.50/acre (1), and an estimated 25,000 acres (all diallate-treated minus EPTC alternate) would be lost for this use.

a/ Schaffner, L. W. 1977. Unpublished data. North Dakota State University, Fargo, North Dakota.

Table 10.--Acreage planted, average yields, and diallate-treated acres seeded to lentils, 1976.

State	Acres planted[a/]	Diallate-treated acres[b/]	Percent acres treated	Average yield lb/acre[a/]
Idaho	25,000	16,000	64	1,200
Washington	85,000	25,500	30	1,250
Total	110,000	41,500	38	1,239

a/ Personal communication - Howard Blain, Executive Secretary, Washington-Idaho Pea and Lentil Commission, 1977.
b/ Estimates by weed control specialists.

Table 11.--Costs (per acre) of diallate and three alternative herbicides for control of wild oats in lentils.

Herbicide	Rate lb a.i./acre	Herbicide cost $/acre	Time of application
Diallate	1.0[a/]	4.25	PPI[b/]
Triallate	1.0[a/]	4.25	PPI
Propham	4.0	8.75	PPI
Barban	0.33	5.20	POST

a/ Farmers generally use less than the labeled rate of 1.5 lb/acre.
b/ PPI = Preplant-incorporated; POST = Postemergence.

Table 12.--Estimated weed control costs and yield losses in lentil production, with the use of alternative herbicides to diallate in Idaho and Washington.

Control method	Affected acres	Costs		Yield loss		Total value of costs and yield loss
		Herbicide	Application	Cwt	Value[a/]	
Without diallate						
Triallate	38,440	$163,370	$134,540	(10,725)	$(144,787)	$153,123
Propham	2,660	23,275	9,310	426	5,751	38,336
Barban	400	2,080	360	520	7,020	9,460
Total	41,500	$188,725	$144,210	(9,779)	$(132,016)	$200,919
With diallate	41,500	176,375	145,250	--	--	321,625
Net increase	--	$ 12,350	$ (1,040)	(9,779)	$(132,016)	$(120,706)

a/ Yield losses valued at $13.50/cwt. Data from Idaho indicated slightly higher yields with triallate compared with diallate.

Diallate used on flax could easily be replaced with triallate at no extra cost or loss in wild oats control, but triallate is not labeled for use on flax.

Asulam, a postemergence herbicide, has shown promise for wild oats control in flax, and if labeled would help to reduce losses. Wild oats is susceptible to asulam at the 3- to 4-leaf stage, thus increasing the period for wild oats control beyond that of barban. Asulam is not as effective for wild oats control as diallate, however, and increased yield losses would occur due to wild oats competition.

Lentils

Wild oats infestations are common throughout the lentil-growing area of Washington and Idaho. During 1976, 110,000 acres of lentils were planted in the two States (Table 10). Washington accounted for 77% of the total acres and Idaho growers planted the remaining 23%. Approximately 41,500 acres, or 38%, of land seeded to lentils were treated with diallate for the control of wild oats infestations.

There are presently three alternative herbicides available for wild oats control in both States (Table 11). Research indicated that diallate was slightly more effective for wild oats control than was triallate on an equal active ingredient basis. Recent research data from Idaho, however, indicated slightly higher lentil yields with triallate compared with diallate. This was apparently due to lentils being more tolerant to triallate than to diallate. Triallate could be an effective alternative if its future availability were assured.

Growers use triallate on approximately 30% of the lentil acreage. Propham applied preplant-incorporated at 4.0 lb/acre is used on only 1% of lentil acreage because of rapid propham degradation by soil microorganisms. Propham cannot be applied to a field more than once in 4 years because specific soil microorganisms multiply to populations that degrade propham too rapidly for wild oats control. Barban at 0.33 lb/acre is the only postemergence herbicide available for wild oats control in lentils. Barban is used primarily to control wild oats that occur in sprayer skips in fields previously treated with diallate or triallate. Applications of barban must be very timely to be effective. Wild oats often emerge over a long period of time, which results in only partial control with barban.

In Washington and Idaho, 70% of the total lentil acreage receives diallate, triallate, or barban for the control of wild oats. Diallate is applied to 41,500 acres. Should diallate become unavailable, the shift in herbicide usage would be 93% to triallate, 6% to propham, and 1% to barban.

Herbicide cost to growers is estimated at $176,375 annually with diallate available (Table 12). With diallate unavailable, the total cost of herbicides for wild oats control would be $188,725, or an increase of $12,350 annually.

The lentil production areas in Washington and Idaho are contiguous, and production practices, climatic conditions, and weed problems are similar. Although no yield comparison data are available from Washington, the results from recent research conducted in Idaho have been used in the economic analysis.

Dry Peas

Wild oats is a major weed problem in the dry pea production areas of Washington and Idaho. These two States produce a majority of the dry peas for the United States. In 1976, 130,000 acres of dry peas were planted and an average of 1,542 lb/acre of crop was harvested (Table 13). Approximately 13,700 acres or 10% of the area seeded to peas were treated with diallate.

Three alternative herbicides are commonly used for wild oats control in dry peas (Table 14). Triallate at

Table 13.--Acreage planted, average yields, and diallate-treated acres seeded to dry peas, 1976.

State	Acres planted[a/]	Diallate-treated acres[b/]	Percent acres treated	Average yield lb/acre[c/]
Idaho	50,000	5,500	11.0	1,515
Washington	80,000	8,200	10.2	1,560
Total	130,000	13,700	10.5	1,542

a/ (26).
b/ Estimates by weed control specialists.
c/ (27).

Table 14.--Costs (per acre) of diallate and three alternative herbicides for control of wild oats in dry peas.

Herbicide	Rate lb a.i./acre	Herbicide cost $/acre	Time of application
Diallate	1.25	5.30	PPI[a/]
Triallate	1.25	5.30	PPI
Propham	4.00	8.75	PPI
Barban	0.375	5.90	POST

a/ PPI = Preplant-incorporated; POST = Postemergence.

1.25 lb/acre is a preplant soil-incorporated treatment applied to 40-45% of the dry peas grown in Idaho and 30% of the dry peas grown in Washington. Ninety-two percent of the acres now treated with diallate for wild oats control will be shifted to triallate if diallate becomes unavailable. Idaho data indicate that diallate gives slightly better control of wild oats than does triallate.

Propham at 4 lb/acre as a preplant soil-incorporated treatment is utilized on approximately 2% of the total dry pea acreage. If diallate is unavailable, approximately 2% of the diallate-treated acres would be treated with propham. Propham cannot be applied to a field more than once in 4 years, because specific soil microorganisms multiply to levels that degrade propham too rapidly to permit wild oats control.

Barban at 0.375 lb/acre is the only postemergence herbicide commonly used for wild oats control in dry peas. Barban must be applied at the two-leaf stage of wild oats. Irregular emergence of wild oats and adverse climatic conditions often contribute to poor control with barban. The primary use of barban has been to control wild oats that escaped preplant treatment. Approximately 6% of the areas treated with diallate will be treated with barban if diallate becomes unavailable. Barban is not as effective as diallate for wild oats control, and therefore yields will be reduced about 35%.

Diallate is applied to 13,700 acres of dry peas in Washington and Idaho at a cost of $120,560 -- $72,610 for herbicides and $47,950 for application (Table 15). The greatest impact will be on the yield reduction of dry peas,

Table 15.--Estimated weed control costs and yield losses in dry peas production with the use of alternative herbicides to diallate in Idaho and Washington.

Control method	Affected acres	Costs		Yield loss		Total value of costs and yield loss
		Herbicide	Application	Cwt	Value[a/]	
Without diallate						
Triallate	12,605	$ 66,806	$ 44,117	5,798	$ 52,762	$ 163,685
Propham	247	2,161	864	761	6,925	9,950
Barban	848	5,003	763	3,926	35,727	41,493
Total	13,700	$ 73,970	$ 45,744	10,485	$ 95,414	$ 215,128
With diallate	13,700	72,610	47,950	--	--	120,560
Net increase	—	$ 1,360	$ (2,206)	10,485	$ 95,414	$ 94,568

a/ Yield losses valued at $9.10/cwt (1975-76 average price).

resulting from increased competitive influence of wild oats. The total yield loss from the alternate herbicides will be 10,485 hundredweight, with a value of $95,414 (Table 15). The value of the yield loss minus the lower herbicide costs equals a net loss of $94,568 from the unavailability of diallate for dry peas.

Diallate is the most effective herbicide available for wild oats control in dry peas based on Idaho data. The substitution of an alternative herbicide, including triallate, will result in reduced wild oats control and subsequent yield reductions. The total impact of allowing more wild oats plants to produce seed and thus more heavily infest the soil cannot be predicted; however, intensified wild oats infestations will increase wild oats problems in other crops in the rotation.

Crops with Minor Diallate Usage

Soybeans: Diallate is applied to approximately 8,000 acres of soybeans in the United States, which is a small percentage of the total acreage (Table 16). The usage is restricted to North Dakota and Minnesota, States with wild oats in soybeans. Usage in these States is also small because only part of Minnesota has wild oats, the late planting for soybeans reduces wild oats problems, and other herbicides give partial control.

Data are not available on yield losses from wild oats or the yield increases from wild oats control in soybeans in the United States; however, the estimated yield loss from wild oats if not controlled would equal 20-50% based on data from Canada (4).

Sixty percent of the diallate-treated soybean acres would be treated with barban for wild oats control; 30% converted to wheat, barley, or flax; and 10% would be left untreated if diallate were not available.

The estimated yield loss per acre with barban treatments compared with diallate would be 5-15%, assuming normal cultivation practices for weed control. Diallate is usually used in combination with other soil-applied herbicides for more complete weed control. The partial wild oats control obtained from these herbicides used without diallate would limit yield losses to 10-20%. The long-term effect, however, would be an increase in the wild oats seed supply, which would increase the future wild oats infestation. One approach to integrated wild oats control is complete control for several years to reduce the need for intensive herbicide usage in

Table 16.--Crops with minor diallate usage.

Crop	U.S. planted acres (1,000)	Diallate-treated acres[a/]	States using diallate
Potatoes	1,400	6,500	ND, MN, MT
Barley	9,296	10,500	ND, MN, MT, ID
Soybeans	50,327	8,000	ND, MN
Corn	84,121	8,000	ND, MN
Alfalfa	26,556	Negligible	

a/ Estimated by weed control specialists.

subsequent years. The loss of diallate in soybeans would not allow the desired excellent control needed to reduce wild oats seed production and indirectly to reduce the soil seed reserve.

Corn: The majority of corn grown in the United States is not in areas having wild oats infestations. Diallate is used only on about 8,000 acres, mainly in Minnesota and North Dakota.

Data on yield losses from wild oats in corn or the increased yields from the use of diallate are limited; however, estimates are that yield losses of 30-60% would be likely with no wild oats control (19). Atrazine, cyanazine, butylate, and EPTC also give control of wild oats as well as many other weeds in corn, which probably accounts for the low diallate usage. Atrazine, however, often leaves a soil residue that will damage most other crops in a rotation. Cyanazine has limited corn safety in certain situations, and butylate and EPTC do not consistently give complete wild oats control and require deep incorporation immediately after application. Thus, diallate is needed as an option to farmers with heavy wild oats infestations who wish to maximize wild oats control in corn.

Barley: Only a small percentage of the barley acreage is treated with diallate, because triallate is registered for use in barley. Barley has more tolerance to triallate than to diallate, with equal wild oats control. Diallate is used in barley because of certain individual preferences or because farmers using diallate in other crops may wish to use only one herbicide. The use of only one product has many advantages, e.g., less storage of partially used containers, reduction of possible misapplications, reduction of herbicide inventory, and less sprayer cleaning.

Potatoes: Diallate is registered for use in potatoes only in North Dakota, Minnesota, and Montana. In 1976, 6,500 acres of the 203,600 acres of potatoes in these three States were treated with diallate.

Diallate usage in potatoes was limited, as tillage and other herbicides are used for wild oats control. EPTC gives good wild oats control in potatoes, which can be treated with rates up to 6 lb/acre. EPTC at 6 lb/acre is costly and must be incorporated more deeply than diallate. Metribuzin, linuron, and paraquat also are used for wild oats control in potatoes, but give less wild oats control than diallate or EPTC.

Alfalfa: Information on diallate usage in alfalfa is not available, but the assumption was that very few acres of alfalfa are treated with diallate.

ECONOMIC IMPACT AND DISCUSSION

Dillate is used principally for wild oats control in sugarbeets; it has limited usage in flax, lentils, peas, barley, soybeans, corn, potatoes, and alfalfa. Diallate is applied annually to 215,700 acres of sugarbeets and to 117,100 acres of the other crops combined (Table 17).

Diallate unavailability would have a small effect on the overall United States crop production (Table 18). The loss of income, however, due to the unavailability of diallate would be substantial to individual farmers and localized areas.

The total annual direct economic impact of diallate unavailability on sugarbeets, flax, lentils, and peas was estimated at $7,624,900 (Table 17). This estimate of economic impact does not include any losses that occur in potatoes, barley, soybeans, corn, and alfalfa because of the limited diallate usage in these crops. Further, the economic impact estimate does not include any possible effects on long-term market prices or indirect losses.

The major economic impact of diallate unavailability would be to producers of sugarbeets both in the non-irrigated areas of North Dakota and Minnesota and the irrigated areas in the Western United States, mainly Montana, Idaho, and Wyoming.

The major losses from diallate unavailability are from additional costs for wild oats control (mainly hand hoe labor) in the non-irrigated area and from a loss of sugarbeet yield from reduced wild oats control with alternatives to diallate in the irrigated area. The total annual economic loss from the unavailability of diallate for wild oats control in sugarbeets was estimated at $7,156,600 (Table 17).

The economic losses from diallate unavailability are a small percentage of the total United States sugarbeet production; however, individual farmers and local farming areas in the wild oats-infested areas would be affected significantly. Sugarbeet production is concentrated near processing facilities. Therefore, the impact would be

Table 17.--Summary of annual economic impact of unavailability of diallate, U.S. totals.

Crop	Acres treated	Percent of total	Losses if diallate not available: Value of yield loss (gain)	Other[a/] (gain)	Total (gain)
			1,000		
Sugarbeets	215,700	14.1	$ 2,376.9	$ 4,779.7	$ 7,156.6
Flax	28,900	2.8	409.2	85.2	494.4
Dry peas	13,700	10.5	95.4	(0.8)	94.6
Lentils	41,500	37.7	(132.0)	11.3	(120.7)
Potatoes	6,500	0.5			
Soybeans	8,000	b/	(Economic losses would		
Barley	10,500	0.1	be small and were not		
Corn	8,000	b/	calculated.)		
Forage legumes	--	b/	--	--	--
Total	332,800		$ 2,749.5	$ 4,875.4	$ 7,624.9

a/ Includes added costs of alternative control methods and losses due to shift to other crops.

b/ Less than one-tenth of one percent.

Table 18.--Effect of diallate unavailability on total crop production.

Crop	Unit	Wild oat-infested areas: Production loss[a/]	Wild oat-infested areas: Total production[b/]	Wild oat-infested areas: %	For the U.S.: Total production[b/]	For the U.S.: %
Flax	Bu	116,146	6,796,000	-1.7	7,356,000	-1.6
Sugarbeets	Tons	274,500	19,677,000	-1.4	29,427,000	-0.9
Dry peas	Cwt	13,011	2,150,000	-0.6	2,150,000	-0.6
Lentils	Cwt	+9,779	1,362,900	+0.7	1,362,900	+0.7

a/ Based on previous tables.
b/ (27) except lentils which was a personal communication from Howard Blain, Executive Secretary, Washington-Idaho Pea and Lentil Commission, 1977.

concentrated in a few sugarbeet producing counties having wild oats infestations. Sugarbeet production is a major enterprise for nearly all the producers. Thus, the unavailability of diallate will have a severe impact upon individual farmers. The per-acre returns to land, labor, and management would decline approximately 30% on the diallate-treated acres should diallate be unavailable. A shift of sugarbeet acreage to other crops could result in poor utilization of refining facilities and place them at a competitive disadvantage in the sugar market. Sugarbeets are considered a minor crop by most herbicide manufacturers. Thus, the chance of developing and registering a new substitute for diallate in sugarbeets is remote.

The second most important economic impact from diallate unavailability is in flax, with a loss of $494,400 in North Dakota, Minnesota, and South Dakota (Table 17). The loss of flax production if diallate were unavailable would be 1.7% of the total flax production in North Dakota, Minnesota, and South Dakota (Table 18). Flax is a major crop for individual farmers who would be severely affected by diallate unavailability. The per-acre returns to land, labor, and management from flax would decline 31% on the diallate-treated acres should diallate be unavailable.

The impact of diallate unavailability for potatoes, soybeans, barley, corn, and legumes was not determined as usage was small; however, diallate in these crops is important to the individual using diallate as part of an integrated wild oats control program across all crops in a rotation.

Triallate is an alternative on dry peas, but is slightly less effective than diallate. A loss of $94,568 was estimated for dry peas due primarily to yield losses.

For lentils, recent Idaho research indicates slightly less wild oat control with triallate compared with diallate, but yields were slightly higher, apparently because of more lentil injury from diallate. These higher yields translate into a gain of $120,706 if triallate is used to replace diallate.

Diallate cancellation could have many indirect economic influences which are not evaluated easily. Wild oats not controlled produce seed which falls to the soil to infest subsequent crops in the rotation. Wild oats seed is dormant upon maturity and will continue to emerge for up to 7 years, depending upon environmental conditions.

The cancellation of diallate would require the availability of 1,000 more migrant laborers with an estimated

$250,000 annual housing cost and social benefit expenses, which are not included in the per-acre cost of hoeing. Wild oats causes flax straw of poor quality, which is not acceptable for paper production. Flax straw not used for paper is often burned, causing pollution, or if not burned it causes delays in tillage. Flax straw decays slowly and causes clogging of tillage equipment.

Diallate is an effective preemergence-incorporated herbicide for wild oats control and available alternatives usually do not give equal control. Barban, which is the main postemergence alternate herbicide, has restrictions as to time of application, which makes application difficult. Further, barban is applied early postemergence and has no residual wild oats control, thus allowing infestation by late emerging wild oats. EPTC and cycloate are preplant soil-incorporated alternatives to diallate in sugarbeets and EPTC is an alternative in flax; however, wild oats control and crop safety is less with EPTC and cycloate than with diallate.

Exposure to diallate is very limited, as the applicator is usually in an enclosed cab and the herbicide is incorporated into the soil immediately after application, which limits exposure to humans and wildlife. Available information indicates that diallate is degraded rapidly in crops and soil, reducing the probability of a residue in the harvested commodity. No diallate residues have been detected in raw agricultural products with currently available analytical techniques.

LITERATURE CITED

1. Anderson, D. E.
   1975. An economic and agronomic evaluation of flax straw availability in North Dakota. North Dakota Research Report No. 59.
2. Anderson, J. P. E., and K. H. Domsch.
   1976. Microbial degradation of the thiocarbamate herbicide, diallate, in soils and by pure cultures of microorganisms. Archives Environmental Contamination and Toxicology 4:1.
3. Beck, T.
   1970. The microbial degradation of herbicides and their effect on soil microflora. [In German] Zentr. Bakteriol. Farasitenk. Abt. II. Naturu 124(3/4): 304-313. Pesticide Abstracts 71-1770.
4. Chow, P. N. P.
   1975. Control of wild oats and other weeds with preplanting soil incorporated and post emergence applied herbicides in soybeans. Research Report Canadian Weed Committee, Western Section, p. 156-157.
5. Dexter, A. G.
   1976. Control of wild oats and other weeds with preplant incorporated herbicides in sugarbeets. Research Report, North Central Weed Control Conference 33:176-177.
6. _____
   1976. Sugarbeet Research and Extension Reports. North Dakota State University, University of Minnesota, American Crystal Sugar Company, U.S. Department of Agriculture, and Minnesota-North Dakota Farmers Cooperative, p. 1-65.
7. _____
   1976. Wild oat control with postemergence herbicides in sugarbeets. Research Reports, North Central Weed Control Conference 33:172-173.
8. Environmental Protection Agency.
   1977. Rebuttable presumption against registration and continued registration of pesticide products containing diallate. Federal Register 42(104):27669-27674.

9. Fang, S. C.
1969. Thiocarbamates. In Kearney, P. C., and D. D. Kaufman (Eds.) Degradation of Herbicides. Marcel Dekker, Inc. New York. p. 147-164.
10. Hammond, J. J.
1972. A flax production system analysis. Flax Institute of the United States 42:1-5.
11. Helling, C. S.
1971. Pesticide mobility in soils. Soil Science Society Proceedings 35:732-748.
12. Hilton, J. L., Chairman.
1974. Herbicide Handbook Committee. Herbicide Handbook of the Weed Science Society of America, Champaign, Illinois.
13. Johnson, R. G.
1976. Sugarbeet Research and Extension Reports. North Dakota State University, American Crystal Sugar Company, United States Department of Agriculture and Minnesota-North Dakota Farmers Cooperative, p. 79-80.
14. Kaufman, D. D.
1967. Degradation of carbamate herbicides in soil. Journal of Agriculture and Food Chemistry 15(4):582-591.
15. _____, and J. Blake.
1973. Microbial degradation of several acetamide, acylanilide, carbamate, toluidine, and urea pesticides. Soil Biology Biochemistry 5:297-308.
16. Koern, E., C. L. Foy, and F. M. Ashton.
1968. Phytotoxicity and persistence of four thiocarbamates in five soil types. Weed Science 16:172-175.
17. Monsanto Agricultural Products Company.
1967. Pesticide petition number 607. St. Louis, Missouri.
18. _____
1969. Pesticide petition number 832. St. Louis, Missouri.
19. Moyer, J. R.
1975. Control of weeds in field corn with postemergence herbicides. Research Report, Canada Weed Committee, Western Section. p. 164.
20. Nelewaja, J. D.
1973. Wild oats infestation of field crops in 1973. North Dakota Farm Research 31:3-5.
21. _____, and L. W. Mitich.
1976. Weed control in flax. North Dakota State University Circular, W-617.
22. Schaefer, J., J. F. Guenther, and L. Luft.
1976. Enterprise costs of irrigated crops, Lower Yellowstone Valley. Bulletin 1162, Cooperative Extension Service, Montana State University, Bozeman, Montana.
23. Smith, A. E.
1971. Degradation, adsorption, and volatility of diallate and triallate in prairie soils. Weed Research 10:331-339.
24. _____, and A. Fitzpatrick.
1970. The loss of five thiocarbamate herbicides in non-sterile soils and their stability in acidic and basic solutions. Journal of Agriculture and Food Chemistry 18(4):720-722.
25. U.S. Department of Agriculture, Economic Research Service.
1976. Costs of producing food grains, feed grains, and cotton, 1974-76. Agriculture Economics Report No. 338, Washington, D.C., June 1976.
26. _____, Economic Research Service.
1976. Vegetable situation, TVS-201. August 1976.
27. _____, Statistical Reporting Service.
1976. Crop Production, 1976 Annual Summary, CrPr 2-1 (77). January 17, 1977.
28. Wax, L. M., Chairman.
1976. Wild Oat - A Situation report. Wild Oats ad hoc Research Working Group. North Dakota State University, Bulletin Room, Fargo, North Dakota.

DEPARTMENT OF AGRICULTURE
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Federal Register Section
Technical Services Division (WH-569)
U.S. Environmental Protection Agency
401 M Street, S.W. Rm. 401 E. Tower
Washington, D. C. 20460

Gentlemen:

Reference: OOP-30000/15

Attached are three (3) copies of a report containing information accumulated by the diallate USDA/State Impact Assessment Team and USDA staff. This response to the RPAR announcement is being forwarded within the 105-day period provided for risk rebuttal.

This is an initial draft report containing most of the current information that was available to the team. However, with distribution of this draft to contributors, other interested parties, and to EPA, no doubt additions and changes will be made before the final report is approved.

Sincerely,

ERRETT DECK
Coordinator
Office of Environmental Quality Activities

Enclosures: 3 copies of
"Assessment of the Need for Diallate
in Agriculture"

* U.S.G.P.O. 624-134/1302-1594

END