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AGRICULTURAL ECONOMIC REPORT NO.— 194

RESTRICTING THE USE OF PHENOXY HERBICIDES

- Costs to Farmers -

Economic Research Service
and
Agricultural Research Service

U.S. DEPARTMENT OF AGRICULTURE

ABSTRACT

Assuming that current levels of farm production are to be maintained, restricting the farm use of phenoxy herbicides would increase U.S. farmers direct production costs about $290 million. In addition, about 20 million more hours of family labor would be used.

Net reductions in farm income would total $107 million for corn, $51 million for wheat, $8 million for rice, $28 million for other small grain, $11 million for sorghum, $33 million for pasture, $36 million for rangeland, and $16 million for other crops on which the phenoxys were used in 1966. The estimates were determined for each of the above crops by partial budgeting using cross-sectional data from the ERS Pesticide and General Farm Survey, 1966; Agricultural Statistics, 1968; and from Agricultural Research Service weed scientists.

Key Words: Cost of restricting herbicides, phenoxy herbicides, 2,4-D, 2,4,5-T, herbicide, weed control herbicides, economics of herbicide use.

PREFACE

This report presents estimates of costs to U.S. farmers of prohibiting the use of phenoxy herbicides. It does not consider nonfarm uses such as herbicide applications to lawns, gardens, industrial sites, rights-of-way, and aquatic sites.

An important assumption of the analysis was that the current level of farm production would be maintained. The use of nonphenoxy herbicides, mechanical means, and other cultural practices were considered as alternatives for the phenoxy herbicides. For some crops, current yields would decline without use of phenoxy herbicides, so additional acres would be needed to maintain production. The additional land would be available from that currently diverted under various Government programs. It was assumed that through adjustments in the provisions of various Government programs, payments to farmers would remain the same.

Data on farm use of phenoxy herbicides used in the cost calculations are from the nationwide ERS Pesticide and General Farm Survey of 1966, the most recent available results of which are published in Quantities of Pesticides Used by Farmers in 1966. U.S. Dept. Agr., Agr. Econ. Rpt. No. 179, April 1970. Although total farm use of herbicides has increased since 1966, use of phenoxy herbicides in 1969 was not much above the 1966 level. All quantities of herbicides are expressed in pounds of active chemical ingredients. The data are quantities farmers indicated they had used in 1966 and do not necessarily mean that such uses are currently registered.

The report was prepared jointly by the Economic Research Service (ERS) and the Agricultural Research Service (ARS), U.S. Department of Agriculture. It was developed under the direction of Velmar W. Davis, Farm Production Economics Division, ERS, and William B. Ennis, Crops Research Division, ARS.

The policy of the Department of Agriculture is to continually review needs for herbicides and to register and use only those that are safe with respect to people, property, and the environment.

Washington, D.C. 20250 November 1970

CONTENTS

Use of trade names in this report is for identification only and does not constitute endorsement of these products or imply discrimination against other similar products. Chemical names and other designations of pesticides are shown in table 17.

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LIST OF TABLES

SUMMARY

Prohibiting the use of phenoxy herbicides (44 million pounds yearly) --primarily 2,4-D and 2,4,5-T on 62 million acres of cropland--would eventually increase costs substantially to consumers. The immediate effect would be an increase of $290 million in production costs to farmers. The estimates were based on use in 1966 and production levels, costs, and alternatives in 1969. In addition, farmers and their families would have to work 20 million more hours to control the weeds without these herbicides. For this extra labor, the farmers would obtain no additional income.

The increase in costs represents about 1 percent of the farm value of all crops or 5 percent of the value of the crops from the treated acres. The amount is nearly three times that spent for weed control with phenoxy herbicides, and constitutes an increase in costs of $4.64 per treated acre.

The impact of the ban would be more severe for some crops and farmers than for others. The total additional costs for maintaining production are distributed among crops as follows: corn, 37 percent; wheat, 17 percent; other small grains, 10 percent; sorghum, 4 percent; rice, 3 percent; other crops, 6 percent; pasture, 11 percent; and rangeland, 12 percent.

Alternative ways of maintaining production include the uses of other herbicides and changing cultural practices (e.g., handweeding, spot treatment, and increasing acreage). Dicamba could be used as an alternative herbicide to maintain production on half of the acres of corn, wheat, other small grain, and sorghum treated in 1966 with phenoxy herbicides. On the remaining acres of corn and sorghum, other herbicides could be used, along with some additional cultivations and spot chemical treatments or hoeing. Where yields could not be maintained by alternative herbicides and cultural practices at reasonable costs, more of the crop would be grown on acres previously diverted from farm production. For rice, the crop rotation would be changed to control most weeds and additional acreage planted to offset losses in production.

Of the $290 million additional costs, other substitutes for phenoxy herbicides would increase farm costs $61 million. Added cultural practices on land now being treated with phenoxy herbicides, and loss in quality of rice, would increase costs $138 million. Additional variable costs for producing some of these crops on diverted acres to offset yield losses would be $91 million.

For individual crops, estimates of additional costs to farmers are as follows:

Costs of restricting phenoxy herbicides in 1969, by crops

Crop	Costs of restricting phenoxy herbicide use				
	Reduced materials and application	Substitute herbicides and application	Additional cultural practices	Production on additional acres	Net additional costs
	Million dollars				
Corn	-37.0	122.5	21.2	----	106.7
Wheat	-21.9	15.3	12.1	45.0	50.5
Other small grain	-14.6	10.9	9.1	23.1	28.5
Sorghum	-5.6	14.5	2.4	----	11.3
Rice	-0.4	----	1/6.4	1.6	7.6
Other crops	-5.4	----	----	21.3	15.9
Pasture	-10.4	----	43.3	----	32.9
Range	-7.2	----	43.1	----	35.9
All crops	-102.5	163.2	137.6	91.0	289.3

1/ Includes $2.2 million for lower income from loss in quality.

Discontinuing farm use of phenoxy herbicides for noncrop areas such as fence rows would have little direct effect on productivity. But to control weeds on these areas without phenoxy herbicides would require much additional labor. If uncontrolled, these weeds would build up and reinfest cropland.

Farm costs of replacing the phenoxy herbicides are estimates of annual costs for 1969 under the assumption that present technology would be used. These costs assume that most weeds would be controlled. Ineffective weed control would increase costs considerably because of the rapid spread of weeds from seed. Costs do not include environmental damage such as erosion and effects of herbicide residues in soil from using more nonselective herbicide treatments for specific problems.

RESTRICTING THE USE OF PHENOXY HERBICIDES
-COSTS TO FARMERS-

by

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INTRODUCTION

Herbicides have become an increasingly important tool in farm production in the United States. They provide both selective and effective weed control in row crops, nonrow crops, pastures, fence rows, and rights-of-way.

Herbicides are an integral part of the production process that has evolved with increased specialization and more intensive farming. While many of the latest farm practices do increase production, they also provide a more favorable environment for certain weeds and, in turn, increase the need for effective herbicidal weed control. Herbicides, by providing more effective control of weeds, have helped to maintain farm production with an even smaller labor force.

The increased use of herbicides suggests benefits to farmers. However, the use of herbicides by individuals or groups sometimes may have undesirable side-effects. For example, herbicides may cause economic losses by drifting to nontarget crops and other plants. Or, they may be transported to other crops by water.

In general, the phenoxy herbicides, are highly selective, do not persist for more than 1 to 6 months in soil, are low in acute mammalian toxicity, and are effective at low rates and low volumes of application. These characteristics make them useful components in integrated systems of weed and brush control.

The selectivity of phenoxy herbicides permits their use in controlling weeds and brush in some crops and noncropland areas without injuring desirable plants. This is important where alternative controls are not economically feasible.

Some consideration was given to restricting the use of phenoxy herbicides, particularly 2,4,5-T, in late 1969. It resulted from a laboratory study by a private research firm working under a Government contract with the Department of Health, Education, and Welfare. This study indicated that offspring of mice and rats given relatively large oral doses of 2,4,5-T during early stages of pregnancy had a higher than expected number of deformities.1/

This report focuses on the economic effects on U.S. farmers that would follow a prohibition on the use of all phenoxy herbicides. First, however, the report summarizes trends in the production and utilization of phenoxy herbicides, and briefly discusses possible alternative weed control practices and the extent to which these alternatives are already in use. Then, specific economic costs to U.S. farmers of prohibiting the use of phenoxy herbicides are estimated for individual crops and groups of crops on which the phenoxys are used.

The evaluation of costs of restricting phenoxy herbicides is based on the following assumptions: (1) farm production will be maintained at the level existing before the restriction, (2) brush and weeds will be controlled at 1966 levels, (the most recent year for which detailed data on the use of herbicides are available), and (3) Government payments to farmers will not change from present levels.

Although total farm use of herbicides has increased since 1966, the 1969 use of the phenoxys was not much above the 1966 level. Within the phenoxy group of herbicides, some changes have taken place, but they are mainly offsetting. For example, proportionately more 2,4,5-T and less 2,4-D are currently in farm use than in 1966 when the former was in short supply because of military purchases.

The cost estimates do not include an evaluation of losses that might occur on crops protected indirectly by the phenoxy herbicides. An example is cotton, a crop on which phenoxys are not generally used, but which is protected indirectly by treatment of weeds, such as cocklebur in corn, included in crop rotations with cotton. Neither does the report consider losses that would result from weeds and brush not controlled in noncrop areas on farms, nor losses from nonfarm uses.

PHENOXY HERBICIDES

The phenoxy herbicides 2,4-D and 2,4,5-T were first employed by farmers and ranchers in the mid-1940's and remain the most common synthetic organic herbicides. They are used in several situations. The largest use of 2,4-D is for broadleaf weed control in corn and other grains; the major use of 2,4,5-T is to kill brush. These materials are available as amine salts and esters, but include small amounts of acids and inorganic salts. Other lesser used phenoxy or related herbicides include erbon, fenac, 2,4-DEP, MCPA, MCPB, mecoprop, sesone, silvex, dichlorprop, and 2,4-DB.

Production and Domestic Use

Specific data on production and producers' domestic disappearance of the phenoxy herbicides are available only for 2,4-D and 2,4,5-T. However, these herbicides accounted for nearly 93 percent of all phenoxys used in farming. Total U.S. production and domestic disappearance of these herbicides from 1958 to 1968 varied as follows (table 1):

1/ News release by the Executive Office of the President, Office of Science and Technology, Washington, D.C., Oct. 29, 1969.

(1) The combined production of 2,4-D and 2,4,5-T increased steadily from 34.6 million pounds in 1958 to 96.8 million pounds in 1968.

(2) Production of 2,4-D stayed between 80 and 90 percent of the total. The percentage was slightly lower in some of the later years.

(3) Exports of 2,4-D and 2,4,5-T increased through 1964, accounting for about 20 percent of production until 1964. Since then, exports have dropped sharply and by 1968 were down to 4 percent of production.

(4) The combined domestic disappearance of 2,4-D and 2,4,5-T increased generally from 1958 through 1965. It increased from 25.1 million pounds in 1958 to about 58 million in 1965. The sharp increase in domestic disappearance to 81 million pounds in 1966 reflects the increased military purchases for use overseas.

(5) In earlier years, a higher proportion of the production of 2,4,5-T than of 2,4-D was used domestically. Since 1964, a higher proportion of the production of 2,4-D has been used domestically.

(6) The use of 2,4-D accounted for almost four-fifths of the combined domestic disappearance of 2,4-D and 2,4,5-T throughout the 1958-65 period. In 1966, the proportion of 2,4-D was considerably less because of the increased production and military purchases of 2,4,5-T which are included in the total domestic disappearance.

Farm Use

Uses of the phenoxy herbicides on farmland are primarily for selective control of annual and perennial broadleaf weeds in crops, and of broadleaf weeds and brush on grazing lands. They are also used, at relatively high rates (more than a pound an acre) for spot treatments on cropland and noncropland, and as general treatments on noncropland. Often they are used on crops as postemergence treatments following earlier use of other herbicides as preemergence treatments. When used for postemergence treatments they are applied as needed. Low cost, high selectivity, effectiveness at low rates of use, short persistence, and low acute oral toxicity to animal life make the phenoxys most desirable for broadleaf control.

Farmers take nearly half of all the 2,4-D and 2,4,5-T used in the United States. The remainder is used by industry, Government (Federal, State, and local) and by homeowners.

Farmers' use of phenoxy and other herbicides is summarized as follows (tables 2-5):

(1) Phenoxy herbicides account for a large share of all herbicides used by farmers--38 percent in 1966. Their proportion is declining because the use of other herbicides, such as atrazine and propachlor, is increasing more rapidly.

(2) The herbicide 2,4-D accounted for over 90 percent of the phenoxy herbicides used by farmers in 1964 and 1966.

(3) Nearly all the phenoxy and other herbicides were used on crops or grazing land. About 7 percent of all acres of crops, pasture, and rangeland was treated with phenoxys in 1966.

(4) Although the acreage treated was small, nearly 2 percent of the phenoxys and 3 percent of other herbicides were used extensively for treating fence rows, ditches, grounds around buildings, and other noncrop uses.

(5) In 1966, 84 percent of the farm use of phenoxy herbicides was on corn, wheat, other small grain, pasture, and rangeland. These crops accounted for 46 percent of the farm value of all crops, and occupied 78 percent of all crop acres, including pasture and rangeland. The largest use of phenoxys, 34 percent, was on corn.

(6) Herbicides other than phenoxys were used in largest quantities on cotton, corn, soybeans, fruits and nuts, and vegetables.

(7) In 1966, phenoxy herbicides accounted for 98 percent of all herbicides used on pasture and rangeland, 97 percent of those used on small grains other than wheat, 88 percent on wheat, and 33 percent on corn.

(8) The quantity used and extent of use of phenoxy herbicides varied among crops. In 1966, for example, almost 2 pounds of phenoxys were used on each of the 145,000 acres of rice treated. This compares with an average of less than 0.5 pound of phenoxys an acre on wheat and other small grains. Average applications on corn and grazing land were two-thirds and three-fourths of a pound of phenoxys, respectively.

(9) Corn and wheat accounted for nearly two-thirds of the acres treated with 2,4-D in 1966. Corn alone accounted for 39 percent. The largest use of 2,4,5-T was on pasture and rangeland.

ALTERNATIVES FOR MAINTAINING PRODUCTION

For some weed problems in some crops, no fully satisfactory weed control alternatives for the phenoxy herbicides are available. But for many crops, other herbicides and selected cultural techniques can be used to control some of the same weeds, although at higher cost. In still other situations, alternative herbicides are even more effective than the phenoxys.

The role of the phenoxy herbicides in weed and brush control is complex. The land area protected greatly exceeds that treated in any one year because the phenoxys are frequently part of a continuing weed control system. If the phenoxy treatments, or satisfactory alternatives, were not applied when needed, certain weeds would increase rapidly, and yearly treatments would soon become a necessity. Research has shown that species of weeds that escape control often become the predominant species. With poor control for only 2 to 3 years, the weed population can shift to a "hard-to-control" complex. Use of the phenoxys minimizes such shifts through their contributions to integrated systems of control.2/ These systems evolved from years of research and testing. Many of them are complex and delicately balanced. Removal of an essential component, such

2/ An integrated weed control system includes all production practices for the entire farm over time. Chemical, mechanical, and cultural practices used to control weeds are all considered as they affect and are affected by other farm practices such as seedbed preparations, and fertilizer practices.

as the phenoxy herbicides, without replacement with a satisfactory alternative, can make the entire system ineffective.

Dicamba is the best replacement for phenoxy herbicides in many situations. It gives better control than the phenoxys of some broadleaf weeds such as smartweed, wild buckwheat, and white cockle. It is currently recommended in mixtures with the phenoxys for control of these weeds in small grains. It is not a satisfactory alternative for many other broadleaf weeds and brush (e.g.,wild mustard, curly dock, milkweed, Russian knapweed, field bindweed, many species of oak, and mesquite). Only 2,4-D is registered for application to wheat in mature stages for control of weeds that interfere with harvest. Such use is particularly needed in the winter wheat areas. A low degree of tolerance by crops, hazards from drift and persistence, and higher costs limit the usefulness of dicamba on other field crops and grazing land.

Preemergence treatments with such herbicides as atrazine, amiben, diuron, fluometuron, linuron, trifluralin, nitralin, and propachlor control many of the same species of weeds controlled by the phenoxy herbicides. But these herbicides have only a limited value as alternatives to phenoxy herbicides. Their current use is often in conjunction with, rather than in place of, postemergence treatments with the phenoxy herbicides. Preemergence treatments with these herbicides are seldom feasible for rice, wheat, or other small grains. Preemergence use of diuron on small grains, for example, is limited to the Pacific Northwest. One or more of these herbicides are used extensively as preemergence treatments on corn, sorghum, sugarcane, and soybeans. Some use of these treatments is made on grazing lands, and on grasses and legumes grown for seed.

Postemergence treatments with atrazine, atrazine in oil-water emulsion, linuron, diuron, chloroxuron, and others also control many species of weeds controlled by the phenoxy herbicides. Such postemergence treatments can be considered as alternatives to phenoxys to a greater degree than similar preemergence treatments. Postemergence treatments with one or more of these herbicides can be used on corn, sorghum, sugarcane, soybeans, and on grasses and legumes grown for seed. Little or no use could be made of these treatments on grazing lands, rice, wheat, or other small grains. These treatments, however, have limitations. Some must be applied as directed sprays, and thus cannot be applied by aircraft. Few of these treatments are effective if the weeds are much beyond the seedling stage when treated. Many of these alternative herbicides are also applied as preemergence treatments, and the additional postemergence applications must not be enough to cause the total to exceed the amount that is registered for use within one crop season. Excessive residues in the soil may injure succeeding crops.

Postemergence treatments with certain other herbicides, such as propanil in rice, or bromoxynil in small grains, will control certain weeds in these crops. But such herbicides fail to control many broadleaf weeds that the phenoxy herbicides will control.

A number of organic herbicides such as picloram, prometone, diuron, and several inorganic herbicides such as sodium chlorate or sodium borate can be used to kill most plant life in noncrop areas. In this sense, they control the weeds controlled by the phenoxy group. But they are not satisfactory alternatives because of possible adverse effects on the environment, including erosion of soil from the denuded areas.

Some alternative herbicides, although considered satisfactory, are less desirable because of adverse effects on crop production. For example, barley has less tolerance for dicamba than for 2,4-D.

Cultivation and other kinds of mechanical control are alternatives to phenoxy herbicides in some situations. Additional cultivation of inter-row spaces after emergence of crops, additional tillage before planting, chain-dragging and bulldozing brush, killing weeds with flame, and intensive fallowing for extended periods (1 to 3 years) are examples.

Alternative cultural practices are seldom as effective as proper treatment with the phenoxy herbicides. These practices do not control weeds that reach above the crop; their use may result in soil erosion by wind and water; and they may also pollute the air with dust and smoke. For example, alternative methods of reducing stands of shinnery oak on certain sandy soils in Oklahoma, Texas, and New Mexico create wind erosion hazards that may do irreparable damage.

Increased farm use of higher cost alternative herbicides might be an incentive to the chemical industry to develop new herbicides that would be satisfactory alternatives for the phenoxys. But experience suggests that the development of new selective herbicides is relatively slow. It is not likely that effective materials, that are as selective as the phenoxys for controlling the broad range of weed species in many different crops, can be developed quickly.

ECONOMIC EFFECTS ON CROPS

This analysis gives estimates of costs from prohibiting all phenoxy herbicides used on crops and grazing lands. It does not consider such noncrop farm uses as treating fence rows, ditches, yards, gardens, and aquatic sites that make up about 2 percent of the farmland and represent less than 2 percent of the farm use of phenoxy herbicides.

The evaluation is based on the farm use of herbicides in 1966, the most recent available. The results are believed to represent 1969 economic effects of restricting the phenoxy herbicides. The only major change in phenoxy herbicide use patterns since 1966 involves spot treatments for control of such perennials as field bindweed. For practical purposes, 2,4-D is now the only herbicide that can be used for spot treating these weeds on almost 9 million acres of small grains and sorghum.3/

Although acreages and geographic distribution of crops, farm use of herbicides, and costs of herbicides per acre to farmers are for 1966, yields are averages for 1965-67. Data for recent years were used for estimates of use of alternative herbicides, cost of supplemental cultural practices, amount and productivity of land brought into production, and variable costs of producing crops on additional acres.

3/ In recent years, field bindweed has been held in check by a system of fallowing for 2 years followed by spot treatment with soil sterilants to control surviving plants. The recent cancellation of registration of soil sterilants for use on cropland has created new use for the phenoxys in 1969.

The most economical alternative herbicides and cultural practices were considered. It was assumed that additional acres of crops would be grown if total production of each crop could not be maintained by other alternatives. These acres are less productive than those treated with phenoxy herbicides.4/ Sufficient quantities of alternative herbicides were assumed to be available at 1966 prices. It was also assumed that additional land needed would be obtained through adjustments in Government wheat and feed-grain programs. Although such adjustments would not affect all farmers similarly, it was assumed that total Government payments to farmers would not decline.

Average variable costs, including hired labor plus a fifth of the usual charge for depreciation on added capital, were applied to the additional acres needed to maintain production. No charges were included in the analysis for the additional hours of operator and family labor needed to bring land back into production.

The only reduction in costs was the expenditure formerly made for phenoxy herbicides and their applications.

Corn

Corn valued at $5.1 billion was produced on 66.3 million acres in 1966. The majority of it was grown in 10 States--Illinois, Iowa, Indiana, Ohio, Missouri, Nebraska, Michigan, South Dakota, Minnesota, and Wisconsin.

Corn yields have risen significantly in the last 20 years. Much of the credit for this comes from such major technological developments as hybrid seed, improved fertilization practices, insecticides, and herbicides. One family of herbicides whose increase in use parallels these yield increases is the phenoxy compounds.

More recently developed herbicides such as atrazine, CDAA, and linuron are used to complement, or replace, the phenoxy herbicides in some situations. Yet about 23 million acres--more than a third of all corn acreage--were treated with the phenoxys in 1966 (table 5). Atrazine, the next most popular herbicide, was used on 14 million acres that year.

The phenoxy compounds do not adequately control grasses in corn, but are extremely effective against broadleaf weeds and vines. Alternative herbicides do not control all broadleaf weeds under adverse conditions. However, dicamba will control many species but at higher cost and greater risk of damage to susceptible crops in adjacent fields.

Adjustments and costs. What would be the effect of prohibiting the use of phenoxy herbicides on corn? Dicamba could be used to control weeds on nearly half, or 11 million, of the acres treated with phenoxy herbicides in 1966 (table 6).

On the remaining acres, preemergence treatment with propachlor plus atrazine followed by postemergence treatment with herbicides such as atrazine or linuron could be used. This would need to be supplemented with cultivation and handweeding or spot treatment with herbicides. This

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4/ Estimates of lower productivity are from P. Weisgerber's Productivity of Diverted Cropland, U.S. Dept. Agr., Econ. Res. Serv., ERS-398, Apr. 1969.

treatment would be relatively effective for control of annual broadleaf weeds and grasses emerging with or soon after the corn. Once a postemergence treatment with the above materials had been made, they could seldom be reapplied for weeds that emerge later. They would not be effective for annual weeds more than 3 to 5 inches high and would not control perennial broadleaf weeds. Postemergence use of these materials would depend, in part, on whether the material had been used as a preemergence treatment. The total amount that can be used in one season is limited by registration and sometimes by crop tolerance. Because of these limitations, the acres treated with herbicides other than dicamba would require a net addition of one cultivation plus handweeding, or spot treatment with other herbicides. These would be needed to prevent populations of perennial broadleaf weeds (bindweed, horsenettle, honeyvine milkweed) or large-seeded annuals (morningglory, cocklebur) from increasing. These weeds, and others like them, would not be effectively controlled by postemergence applications of atrazine or linuron.

The total additional cost to farmers for producing corn, if the phenoxy herbicides were unavailable, is estimated at $107 million (table 6). This is almost three times the cost of weed control using phenoxy herbicides. It is about 2 percent of the 1966 farm value of corn and 6 percent of the farm value of corn from phenoxy-treated acres.

Wheat

Wheat valued at $2.1 billion in 1966 was produced on 54.5 million acres. Most of it was produced in the Plains areas and the Pacific Northwest.

Wheat growers treated 28 percent of the total wheat acreage with herbicides in 1966. About 90 percent of the herbicides used in wheat production were in North Dakota, South Dakota, Minnesota, Montana, Colorado, Idaho, Washington, and Oregon. Farmers in these States treated about 80 percent of their wheat acreage. Herbicide treatments go mainly on spring wheat. But in unusually wet years they are sometimes used extensively on hard red winter wheat in many areas. They are also widely used on winter wheat in the Northwest.

Wheat producers used more phenoxy herbicides than other types of herbicides. They treated more than 15 million acres of wheat with herbicides in 1966, and more than 14 million acres received phenoxy herbicides (table 5). The most widely used herbicides were 2,4-D, MCPA, and dicamba. Of these, 2,4-D accounted for 83 percent of 8.2 million pounds of herbicides applied.

Wheat producers began to use phenoxy herbicides in the 1940's with the discovery of 2,4-D. Use increased rapidly. The phenoxys, especially 2,4-D, are inexpensive and provide effective control of broadleaf weeds. Other herbicides that will control annual broadleaf weeds in wheat are more expensive, often are not as effective, and are less tolerated by crops.

Adjustments and costs. What would be the effect on wheat growers if the use of phenoxy herbicides were prohibited? Dicamba, diuron, or bromoxynil could substitute on about half of the wheat acres treated with phenoxys in 1966 (table 7). Wheat appears tolerant to dicamba before jointing. Later applications cause some crop injury. This lack of crop tolerance limits its use in much of the winter wheat area because wheat is often beyond the jointing stage when weed problems occur. Dicamba is not registered for application to mature wheat for control of late-season weeds. Dicamba is also more expensive and will not selectively control many weeds controlled by 2,4-D. Diuron or bromoxynil might also be used on some wheat acres but they are less selective and even more expensive. They do not control all of the problem weeds, and diuron is not registered for use except in the Pacific Northwest.

On about half of the wheat acres treated with phenoxy herbicides, there are no suitable substitutes. On these acres, wheat producers would have to accept an average loss of 30 percent in yield. In some areas, farmers might have a complete crop loss in some years.

For the acres where there are no suitable substitutes for the phenoxy herbicides, wheat producers could maintain production by planting 3.3 million more acres and by additional cultivations during fallowing to control such perennials as field bindweed on about 5 million acres (table 7). Adding acres now diverted under Government wheat and feed-grain programs would increase variable costs $40 million and machinery investment and depreciation costs another $5 million. Additional fallowing to control bindweed and other perennial weeds would increase costs $12.1 million.

Prohibiting the use of phenoxy herbicides would add $50.5 million to farm costs. This is more than twice the cost of controlling weeds with phenoxy herbicides. It is over 2 percent of the farm value of wheat and 8 percent of the value of wheat produced on acres treated with phenoxys. Also, these growers would need to provide about 5 million additional hours of operator and family labor.

Other Small Grains

Barley, oats, and rye valued at $977 million were grown on 35.6 million acres in 1966. These small grains were found in all regions of the United States. But 96 percent of the barley was grown in the Lake States, Northern Plains, Mountain, and Pacific Regions. And 86 percent of the oats was grown in the Corn Belt, Lake States, and Northern Plains Regions.

About 15 percent of the farmers growing small grains, other than wheat, used herbicides, but they treated 29 percent of the acres grown.

The phenoxys are the most important herbicides used on other small grains. In 1966, 97 percent of the 4.9 million pounds used were phenoxy herbicides. About 8.1 million acres or 83 percent of other small grain acres treated with herbicides were treated with 2,4-D (table 5).

Adjustments and costs. What would be the effect of restricting the use of phenoxy herbicides on other small grains? Dicamba could be used to control weeds on half of the 9.7 million acres that were treated with phenoxy herbicides in 1966 (table 8). However, dicamba is more expensive and the range of crop tolerance is narrower. On the remaining acres, no practical substitute exists for the phenoxy herbicides. Herbicides that are not phenoxys do not provide adequate control of certain weed pests. On these acres, small grain producers would sustain a loss in yield.

On acres where there is no suitable substitute herbicide for the phenoxys, it is estimated that prohibiting their use would reduce yields of other small grains by 30 percent. Farmers would need to increase the acreage of small grains planted by 1.8 million acres to maintain production. This additional acreage of small grains would increase farmers' variable costs $20.4 million and the average annual machinery investment and depreciation costs another $2.7 million. Necessary changes in cultural practices, including the substitution of fallow cultivation for phenoxys to control bindweed and other perennial weeds, would add $9.1 million more to farmers' costs.

Prohibiting phenoxy herbicides would add $28.5 million to farm costs. This is over twice the cost of using phenoxy herbicides for weed control. It is nearly 3 percent of the farm value of other small grains and 9 percent of the value of these small grains produced on phenoxy-treated acres. In addition, these growers would need to provide 2.8 million additional hours of operator and family labor.

Sorghum

Sorghum has become an important feed crop. Planted acres exceeded 16 million in 1966, about a fourth that of corn. Most of this was in the Southern and Northern Plains, and in parts of the Corn Belt. In some of these areas, where moisture is insufficient or poorly distributed during the growing season, sorghum will produce more total digestible nutrients (TDN) than corn.

The phenoxy herbicides have helped make possible efficient production of sorghum. They are especially useful for controlling broadleaf weeds and vines. This reduces the competition from weeds for needed moisture and in some areas, the amount of fallowing required.

In 1966, farmers applied phenoxy herbicides to 3.6 million acres of sorghum, almost a fourth of all sorghum acres (table 5). The triazines, the second most popular group of herbicides, were used on fewer than a million acres and almost no other herbicides were used on sorghum.

Adjustments and costs. What would be the effect on sorghum producers if the phenoxy herbicides were prohibited? Of the 3.6 million acres treated with phenoxys, dicamba could be used to replace nearly half of the phenoxys (table 9). For the acreages treated with dicamba, the effect would be limited to increased herbicide costs.

On the remaining acres, production could be maintained using other herbicides if additional cultural practices were used. Atrazine and oil could be used as a postemergence treatment for control of grasses and some broadleaf weeds but this replacement costs more and crop tolerance is less than with corn. Currently, it is registered only for use in New Mexico, Oklahoma, and Texas. Additional cultural practices would be required in lieu of phenoxy herbicides in programs for control of bindweed and other perennial pests in certain areas. In these areas, a 2-year fallow program, involving 16 cultivations, could be substituted at the beginning of each 10-year production cycle for periodic spot-treatments (or general treatments in crops) with phenoxy herbicides. This substitution would raise costs by about $1 million.

The additional costs to farmers of these alternative practices would total more than $11 million per year--about twice the cost of using phenoxy herbicides for weed control. This is about 1.4 percent of the farm value of sorghum and more than 6 percent of the value of production from acres treated with phenoxy herbicides.

Rice

Farmers produced rice valued at $421 million in 1966. This production was primarily in four States--Arkansas, Louisiana, Texas, and California. Production was almost equally divided among the four.

About two-thirds of the rice growers applied herbicides. They treated a little more than half of 2 million acres of rice grown in 1966. About 145,000 of these acres were treated with phenoxy herbicides (table 10).

The use of propanil, which accounted for 90 percent of the herbicides used on rice in 1966, effectively controls one of the major weeds--barnyardgrass. Propanil also controls several species of broadleaf weeds. It does not effectively control curly indigo, redstem, purple ammania, or many aquatic species.

The phenoxy herbicides complement propanil in the control of broadleaf weeds. Those not controlled by earlier applications of propanil, as well as the midseason and late season broadleaf weeds, are effectively controlled by the phenoxys. These weeds are major problems on almost 500,000 acres. Control is maintained by treating about a third of these acres each year with phenoxy herbicides.

Use of the phenoxy herbicides also helps to maintain the quality of the grain. Broadleaf weeds growing in rice during harvest will increase the moisture content and contaminate the grain with weed seeds and plant parts. The greater the contamination, the lower the quality and price of the rice.

Adjustments and costs. What would be the effect of prohibiting the phenoxy herbicides? If no suitable substitutes are available for the phenoxy herbicides, farmers would sustain a 15 percent reduction in yield on the acres now treated with phenoxy herbicides.

To offset losses in quality and to maintain production, 24,000 additional acres of rice would have to be planted. These added acres would be in place of some of the soybeans now included in the crop rotation. The shift from soybean to rice production would add $65.70 per acre to variable costs.6/ The result would be a $1.6 million increase in farmers' costs.

In addition to offsetting a yield reduction from current infestations, farmers would change their crop rotation and initiate a program of mechanical fallowing to prevent the infestations of broadleaf weeds from increasing and spreading. To do this, they would need to substitute summer fallow for soybeans on 145,000 infested acres. This change in the crop rotation would decrease costs by $1.4 million since the costs of summer fallowing land are less than the variable costs incurred in the production of soybeans by $9.85 per acre.7/ However, the shifting of 145,000

6/ Variable costs for rice ($79.45) less those for soybeans ($13.75).

7/ Almost 500,000 acres of rice land are infested with broadleaf weeds. The phenoxy herbicides control this infestation if used every third year. If they are unavailable, these acres must be fallowed and cultivated every third year. Thus, 145,000 acres of land in the rice and soybean rotation must be summer fallowed each year. Acres to be fallowed are in the crop rotation that would have been planted to soybeans.

acres of soybeans to summer fallow and another 24,000 acres to rice production would reduce the quantity of soybeans produced by 3.9 million bushels.8/ This decline in soybean production could be offset by additional fertilizer applied to 1.7 million acres of soybeans. The increased use of fertilizer would add $5.6 million to costs.

If phenoxy herbicides are not available to control weeds on the 145,000 acres treated in 1966, the rice produced would be contaminated with weed seeds and plant parts. The resulting loss because of the decline in quality is estimated at $2.2 million.9/

The net loss to rice producers because phenoxy herbicides would not be available is $7.6 million. This is about 19 times the cost of using phenoxy herbicides to control the weeds. It is nearly 2 percent of the farm value of rice and 25 percent of the value of production from acres treated with phenoxys. In addition, these growers would need to provide an additional 142,000 man-hours of operator and family labor.

Other Crops

The phenoxy herbicides are used to control weeds and regulate growth of a wide variety of crops. Some of the crops--corn, small grains, sorghum, and rice as well as pasture and rangeland--on which the phenoxys are used extensively are discussed separately. Other crops on which smaller amounts of phenoxys are applied are grouped together for analysis. These include cotton, soybeans, peanuts, sugarbeets, vegetables, fruits, nuts, land being fallowed, and all other crops. The smallness of the acreages treated and also the minuteness of the quantities used conceal the tremendous impact of the phenoxy herbicides on these crops.

For instance, 2,4,5-T used as a growth regulator to thin fruit in the spring and to hold it on the tree until harvest in autumn, saves a large labor expenditure, insures a better quality product, and leads to a more orderly harvest. On cotton, the phenoxy herbicides are sometimes used as desiccants for killing the foliage. This facilitates mechanical harvesting. Wax bars impregnated with phenoxys suspended on cultivators are used in soybean fields to control weeds rising above the soybean plants. Grass seed contaminated with weed seed because of poor weed control cannot be certified and its value can be reduced more than 50 percent. Phenoxy herbicides are important parts of effective weed control programs in the grass seed crops.

8/ To offset the 3.9 million bushels of soybeans lost from these acres, 1,746 thousand additional acres would have to be fertilized using 1964 practices. The cost of applying the average quantities of fertilizer when used on soybeans in this area was $3.23 per acre for materials and application. It has been estimated that the application of additional fertilizer would increase average yields about 2.2 bushels per acre.

9/ A loss in quality valued at $0.40 per hundredweight would occur when production from the 145,000 acres formerly treated with phenoxy herbicides was marketed. It also would occur on 2,000 weed infested acres or 7 percent of the 24,000 additional acres brought into production. It is assumed that the average yield on these 147,000 acres would be 37.2 hundredweight per acre. The loss in quality would be $14.88 per acre.

The phenoxy herbicides are used on about 3.6 million acres of other crops, some of which were devoted to the production of high value crops. Thus, a loss in productivity could cause serious losses (table 5).

Adjustments and costs. Losses on acres of other crops formerly treated, but left untreated if phenoxy herbicides are restricted, are estimated at 15 percent. To offset these losses, about 538,000 additional acres must be brought into production (table 11). The average variable cost of production for acres needed to replace the phenoxy loss was estimated to be $39.67 an acre. For the 538,000 additional acres required, this amounts to $21.3 million added costs. However, after subtracting savings from not applying phenoxys, farmers would have $16.0 million of additional costs. This is less than one-fourth of 1 percent of the total farm value of these other crops but it is 7 percent of the value of production from phenoxy treated acres. In addition, these growers would need to provide 3.6 million additional hours of family labor.

This method of analysis is not fully valid for maintaining production on crops in this grouping which require long periods of time to bring in new production. In these instances, where the phenoxys had been used as herbicides, handweeding and cultivation would probably be the best alternatives. For growth regulator purposes, other, sometimes more expensive, materials such as 2,2-dimethyl hydrazide 10/ and carbaryl would be used. Phenoxys used for cotton desiccation probably could be omitted without loss provided recently introduced desiccants are available.

Pasture and Rangeland

There were about 630 million acres of pasture and rangeland in farms in 1964, including about 58 million acres of cropland used for pasture and 82 million acres of woodland pasture. Thus, in terms of acres, pasture and range is the largest farm and ranch enterprise. These lands provide much forage for dairy and beef cattle, sheep, horses, and some for hogs and poultry.

Much of the pasture and most of the rangeland is untillable because of shallow soils, and steep, rocky, or rough terrain. Much of it is also unsuitable for cultivated crops because of low average annual precipitation. Weeds on much of the pastureland may be partially controlled by mowing, but most of the weeds and brush on rangeland must be controlled by a combination of managed grazing, and mechanical and herbicide treatment. If control programs are not used, then broadleaf weeds and shrubs compete strongly with grasses and legumes for sunlight, moisture, and nutrients. Mechanical control of weeds and brush on much of the rangeland appears to be expensive, and in many instances farmers and ranchers have resorted to less costly herbicide treatments.

At present, the phenoxy herbicides are the only group of herbicides used to any extent on pasture and rangeland. Weeds and brush infesting pasture and rangeland are most widely controlled by 2,4-D and 2,4,5-T, respectively. In 1966, nearly 8 million acres (more than 1 percent) of pasture and rangeland were treated with phenoxy herbicides (table 5). The phenoxy herbicides have several advantages for use on pasture and rangeland. They are effective, selective, and inexpensive; they do not

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10/ (B-Nine(R), Alar(R))

harm grasses at the rates used; and they can be effectively and economically applied by aerial equipment. Fewer chemical substitutes for the phenoxy herbicides used on weeds and brush in pasture and rangeland are available than for other crops.

Of the 7.8 million acres treated with phenoxys, 5.2 million acres were pasture and 2.6 million acres were rangeland (tables 12 and 13).

Adjustments and costs. What would be the economic costs if the phenoxy herbicides were not used on these lands? Mowing and land renovation are the primary alternative control methods on pasture. This land would be renovated at intervals by disking, fertilizing, and seeding to maintain productivity.

Mowing is not a satisfactory alternative to the phenoxy herbicides for most of the rangeland because much of it is covered with woody shrubs. The major alternatives for removing shrubs are bulldozing, chopping, root plowing, shredding, root grubbing, or chain dragging with crawler tractors. These methods are expensive when measured against benefits received. In many cases, the brush must be chopped with a heavy disk, raked, or burned. Seeding, fertilizing, and deferred grazing are common practices accompanying hand clearing for successful control. Mowing, if the land is not too uneven and rocky, will control weeds for a few years following brush removal and seeding.

Although a relatively small percentage of the pasture and rangeland acreage is involved, the additional costs are very high, about $69 million --almost four times the cost of using phenoxy herbicides for weed and brush control. This is about 2 percent of the value of all range and pasture production, and more than the value of production on phenoxy herbicide treated acres. Eight million additional hours of family labor would also be needed.

Producers of feed from pasture and rangeland, particularly rangeland, would face exceptionally high additional costs in relation to the value of forage if phenoxy herbicides are prohibited. They might find such outlays for improving rangeland unprofitable.

Summary of Effects

Stopping the use of phenoxy herbicides would add about $290 million to farm costs (table 14). When phenoxy herbicides are used to control weeds on 62.5 million acres, costs per acre for these herbicides and their application are $1.64 per acre. Alternative methods that could replace phenoxy herbicides on these acres would add $4.64 per acre. This would increase the total cost to $6.28 an acre--nearly four times that of the phenoxy herbicides. The increase in cost is about 1 percent of the farm value of all crops or 5 percent of the value of crops from the treated acres.

The herbicides substituted for phenoxys on 38.7 million acres would increase farm costs for materials and application $60.7 million above those for phenoxys. The cost of substitute herbicides and application ($163 million) would be $4.22 per acre for nearly 39 million acres treated. Corn production would account for 75 percent of the increase in the cost of purchasing and applying substitute herbicides.

Over 5.7 million additional acres of cropland, not including rice, would be needed to maintain production and offset yield losses. Additional variable costs of $90 million would be incurred in adding these acres. The average variable costs on the additional acres are $15.79 per acre added. About 90 percent of the added acres would be needed to maintain the production of wheat and small grains.

Range renovation and seeding, mowing to control weeds, and other cultural practices on crops other than rice would add $131 million to farm costs. These cultural practices would be needed on 30.6 million acres at an average cost of $4.28 per acre. Pasture and rangeland would account for 66 percent of the added costs of cultural practices.

Lowered quality of rice would add another $2 million to the cost of restricting the use of phenoxy herbicides. Also, net additional costs for cultural practices on rice and the added variable costs of substituting rice for soybeans add $6 million to costs.

The total additional costs for maintaining production would be distributed among crops as follows: corn, 37 percent; wheat, 17 percent; other small grains, 10 percent; sorghum, 4 percent; rice, 3 percent; other crops, 6 percent; pasture, 11 percent; and rangeland, 12 percent.

In addition to the costs resulting from the prohibition of phenoxy herbicides, farm operators and their families would need to provide nearly 20 million hours of additional labor to maintain current production and marketings.

NONCROP USES

Large quantities of phenoxy herbicides are now used for noncrop purposes. These include treatment of fence rows, road banks, and ditches, but data on acreages so treated are not available. Hence, no estimates on the impact of banning phenoxy herbicides on costs of controlling weeds in these situations were made. These uses would have little direct immediate effect on productivity, but would require more mechanical work and labor. Labor used for these purposes would probably increase at least 10-fold. Also, uncontrolled weeds in fence rows and along ditches and roads would provide reservoirs of weeds to reinvade cropland.

Table 1.--Production, exports, and domestic disappearance of 2,4-D and 2,4,5-T (acid basis), United States, 1958-68

Year	Production 1/		Exports	Domestic disappearance 2/	
	2,4-D	2,4,5-T	2,4-D and 2,4,5-T	2,4-D	2,4,5-T
	Million pounds				
1958	30.9	3.7	6.8	21.3	3.8
1959	29.3	5.5	5.8	34.1	5.5
1960	36.2	6.3	8.8	31.1	5.9
1961	43.4	6.9	9.1	31.1	5.4
1962	43.0	8.4	10.2	35.9	8.1
1963	46.3	9.1	14.7	33.2	7.2
1964	53.7	11.4	13.0	44.0	8.9
1965	63.3	11.6	6.9	50.5	7.2
1966	68.2	15.5	5.4	63.9	17.1
1967	77.1	14.6	4.4	3/	3/
1968	79.3	17.5	3.4	3/	3/

1/ Does not include the acid equivalent of esters and salts produced from precursors other than the acid form of the phenoxy herbicide. Production of other precursors was relatively minor before 1967.

2/ Production and initial carryover stocks plus imports less exports and end-of-year carryover stocks. Producers' domestic disappearance includes military shipments abroad; these are not considered exports.

3/ Not available.

Source: The Pesticide Reviews, 1968 and 1969. U.S. Dept. Agr., Agr. Stabil. and Conserv. Serv.

Table 2.--Quantities and percentages of phenoxy and other herbicides used in farm production, by type of herbicide, United States, 1964 and 1966 1/

Item	1964 2/		1966 3/	
	Million pounds	Percent	Million pounds	Percent
Phenoxy herbicides:				
2,4-D	34.4	41	40.1	35
2,4,5-T	1.7	2	.8	1
MCPA	1.5	2	1.6	1
Other phenoxy herbicides	.8	1	1.5	1
All phenoxy herbicides	38.4	46	44.0	38
Others:				
Atrazine	10.9	13	23.5	20
Dicamba	4/	5/	.2	5/
Linuron	.2	5/	1.4	1
Propachlor	6/	6/	2.3	2
Picloram	4/	5/	.1	5/
Cacodylic acid	7/	7/	4/	5/
Other herbicides 8/	34.5	41	43.8	38
All others	45.6	54	71.3	62
Total herbicides 9/	84.0	100	115.3	100
Defoliants and desiccants 10/	16.1		6.1	

1/ Does not include Alaska and Hawaii.
2/ Revised estimates based on Quantities of Pesticides Used by Farmers in 1964, U.S. Dept. Agr., Agr. Econ. Rpt. No. 131, Jan. 1968.
3/ Based on Quantities of Pesticides Used by Farmers in 1966. U.S. Dept. of Agr., Agr. Econ. Rpt. No. 179, April 1970.
4/ Less than 50,000 pounds.
5/ Less than 0.5 percent.
6/ Data not available.
7/ None reported.
8/ Those used in largest quantities include: diuron, propanil, CDAA, and other carbamates, amiben, 2,3,6-TBA, trifluralin, chlorpropham and propham, naptalam, and some arsenicals, dinitros, and inorganic herbicides.
9/ Does not include petroleum.
10/ Includes some materials used as herbicides. Includes primarily arsenic acid, chlorates, and borates, Folex(R), and DEF(R).

Table 3.--Acres grown, farm value of production, and quantities of phenoxy herbicides used, by crops and other uses, United States, 1966 1/

Crop and other use	Acres 2/ grown		Farm value 3/		Phenoxy herbicides 4/	
	Million acres	Percent	Million dollars	Percent	Million pounds	Percent
Corn	66.3	7	5,106	20	15.0	34
Wheat	54.5	6	2,141	8	7.2	16
Other small grain	35.6	4	977	4	4.8	11
Sorghum	16.4	2	807	3	2.0	5
Rice	2.0	5/	421	2	.2	1
Other crops	171.5	19	12,729	49	3.7	8
Pasture and range-land	544.5	61	6/3,539	14	10.3	23
Noncrop use	7/	7/	---	--	.8	2
Total	890.8	100	25,720	100	44.0	100

1/ Does not include Alaska and Hawaii.
2/ Calculated from acres reported in Crop Production, 1967, U.S. Dept. Agr., CrPr 2-2 (7-67) and from estimates based on 1964 Census of Agriculture.
3/ Calculated from farm value reported in U.S. Dept. Agr., Agricultural Statistics, 1968.
4/ Based on Quantities of Pesticides Used by Farmers in 1966. U.S. Dept. Agr., Agr. Econ. Rpt. No. 179. April 1970.
5/ Less than 0.5 percent.
6/ Estimated $6.50 per acre. Based on the weighted average feed value of cropland pasture ($27.00 per acre) and grassland pasture and rangeland ($4.70 per acre).
7/ Data not available.

Table 4.--Quantities and percentages of phenoxy and other herbicides used, by crops and other uses, United States, 1966 1/

Crop and other use	Active ingredients					
	Phenoxy herbicides 2/		Other herbicides		Total	
	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent
Corn	15.0	34	31.0	43	46.0	40
Wheat	7.2	16	1.1	2	8.3	7
Other small grain	4.8	11	.1	3/	4.9	4
Sorghum	2.0	5	2.0	3	4.0	4
Rice	.2	1	2.6	4	2.8	2
Other crops	3.7	8	32.2	45	35.9	31
Pasture and rangeland	10.3	23	.2	3/	10.5	9
Noncrop use	.8	2	2.1	3	2.9	3
Total	44.0	100	71.3	100	115.3	100

1/ Based on Quantities of Pesticides Used by Farmers in 1966. U.S. Dept. Agr., Agr. Econ. Rpt. No. 179, April 1970. Does not include Alaska and Hawaii.

2/ Includes acids, amine salts, high-volatile esters, low-volatile esters, and inorganic salts of 2,4-D and 2,4,5-T. Also includes other phenoxy herbicides and related herbicides such as erbon, fenac, 2,4-DEP, MCPA, MCPB, mecoprop, sesone, silvex, dichlorprop, and 2,4-DB.

3/ Less than 0.5 percent.

Table 5.--Acres treated with phenoxy and other herbicides, by types of herbicide and by crops and other uses, United States, 1966 1/

Herbicide	Crops and other acres treated 2/							
	Corn	Wheat	Other small grain	Sorghum	Rice	Other crops	Pasture and rangeland	Total
	Million acres							
Phenoxy herbicides:								
2,4-D	22.4	13.7	8.1	3.4	0.1	2.4	6.7	56.9
2,4,5-T 3/	.3	.1	.1	4/	4/	.2	.9	1.6
MCPA	.3	.8	1.5	.2	---	.1	4/	2.9
Other phenoxy	.1	4/	4/	---	---	.9	.1	1.1
Others: 5/								
Atrazine	13.7	4/	4/	.8	---	.4	4/	15.0
Dicamba	.1	1.2	.2	---	---	4/	4/	1.6
Linuron	.5	---	---	4/	---	.7	---	1.3
Propachlor	1.5	---	4/	---	---	.1	---	1.6
Picloram	4/	4/	---	---	---	.1	4/	.1
Cacodylic acid	---	---	---	---	---	.1	---	.1

1/ Based on Quantities of Pesticides Used by Farmers in 1966. U.S. Dept. Agr., Agr. Econ. Rpt. No. 179, April 1970. Does not include Alaska and Hawaii.

2/ Does not include noncropland acreages such as fence rows and ditch banks nor nonfarm uses. Acreages cannot be added to get land area treated because more than one herbicide may be applied to the same acres. For example, 2,4-D and 2,4,5-T may be applied to the same acres for weed control.

3/ Acres treated were down from 3.1 million in 1964 because of increased military purchases in 1966.

4/ Less than 50,000 acres.

5/ Selected substitutes for phenoxy herbicides. Other herbicides can be used to control many of the same weeds controlled with phenoxy herbicides.

Table 6.--Corn: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre			Total costs
		Materials	Application	Total	
	1,000 Acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	23,136	0.60	1.00	1.60	37.0
Substitute practice 2/					
Dicamba 3/	11,000	1.85	1.00	2.85	31.4
Other herbicides					
Preemergence 4/ 5/	12,136	4.30	0.50	4.80	58.3
Postemergence 6/	12,136	1.70	1.00	2.70	32.8
Additional cultivation 7/	12,136	----	0.75	0.75	9.1
Other cultural practices 8/	12,136	----	1.00	1.00	12.1
Total	----	----	----	----	143.7
Additional costs					
Substitute practice	----	----	----	----	106.7

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.
2/ Allocation of acres based on ARS estimates.
3/ Assumes weeds being controlled with 2,4-D on 11 million acres can also be controlled with dicamba without a loss in production or the need for additional cultural practices.
4/ On the 12,136 thousand acres not treated with dicamba, a preemergence treatment would be applied consisting of propachlor at 3 pounds an acre plus atrazine at 1.5 pounds an acre. Costs are indicated only for the atrazine portion of this treatment because propachlor is used primarily to control grasses not adequately controlled with phenoxy herbicides.
5/ Other herbicides (amiben, butylate, CDAA, linuron, simazine) could also be used in programs similar to that described, but the cost would be equal or greater.
6/ A banded application of postemergence treatment with atrazine to the acres not treated with dicamba at the broadcast rate of 1.5 pounds an acre in oil-water emulsion.
7/ One additional cultivation of acres not treated with dicamba.
8/ Where needed, follow herbicide treatment and mechanical cultivation with spot treatments using herbicides or handweeding to suppress weeds not controlled by earlier treatments. The cost for this practice assumes widely scattered and limited infestation over all acres not treated with dicamba.

Table 7.--Wheat: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practices	Acres	Costs per acre: Materials	Costs per acre: Application	Costs per acre: Total	Total costs
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	14,577	0.50	1.00	1.50	21.9
Substitute practice 2/					
Dicamba 3/	7,000	1.18	1.00	2.18	15.3
Additional acres 4/	3,335	----	----	13.50	45.0
Cultural practices 5/	5,039	----	----	2.40	12.1
Total	----	----	----	----	72.4
Additional costs					
Substitute practices 6/	----	----	----	----	50.5
				Hours per acre	Million hours
Additional family labor	3,335	----	----	1.5	5.0

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.

2/ Allocation of acres and yield losses based on ARS estimates.

3/ Assumes weeds on 7,000 thousand acres can be controlled with dicamba.

4/ Acres needed to offset loss in production on the remaining 7,577 thousand acres where no satisfactory alternative herbicide is available. Based on 1965-67 average yield of 24.5 bushels per acre on presently used land, 22.0 bushels on additional acres, 80 percent of additional acres infested, and 30-percent loss in yield on acres not treated. 3,335= (14,577-7,000) (24.5) (0.30) /22.0-(0.30) (0.80) (22.0). Yields are for States where most of the herbicides were used. Variable costs are per planted acre (table 15).

5/ Acres infested with bindweed. The control is additional cultivations during a 2-year fallow period. The $2.40 cost per acre is for 16 cultivations in 2 years out of a 10-year period at $1.50 per acre prorated over 10 years.

6/ Cost of substitute practice less cost of using phenoxy herbicides.

Table 8.--Other small grains: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre			Total costs
		Materials	Application	Total	
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	9,692	0.51	1.00	1.51	14.6
Substitute practice 2/					
Dicamba 3/	5,000	1.18	1.00	2.18	10.9
Additional acres 4/	1,838	----	----	12.54	23.1
Cultural practices 5/	3,806	----	----	2.40	9.1
Total	----	----	----	----	43.1
Additional costs					
Substitute practice 6/	----	----	----	----	28.5
				Hours per acre	Million hours
Additional family labor	1,838	----	----	1.5	2.8

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.
2/ Allocation of acres and yield losses based on ARS estimates.
3/ Assumes weeds on 5,000 thousand acres can be controlled with dicamba.
4/ Acres needed to offset loss in production on the remaining 4,692 thousand acres. Based on 1965-67 weighted average yield of barley, oats, and rye (44.0 bushels) on presently used land, 37.0 bushels on additional acres, 30 percent of additional acres will need to be treated and 30 percent loss in yield on acres not treated. 1,838= (9,692-5,000) (44.0) (0.30) / 37.0-(0.30) (0.30) (37.0). Variable costs are per planted acre (table 15).
5/ Acres infested with bindweed. The control is additional cultivations during a 2-year fallow period. The $2.40 cost per acre is for 16 cultivations in 2 years over a 10-year period at $1.50 per acre prorated over the 10 years.
6/ Cost of substitute practice less cost of using phenoxy herbicides.

Table 9.--Sorghum: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre: Materials	Costs per acre: Application	Costs per acre: Total	Total costs
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	3,558	0.56	1.00	1.56	5.6
Substitute practice 2/					
Dicamba 3/	1,700	1.85	1.00	2.85	4.8
Atrazine and oil 4/	1,858	4.24	1.00	5.24	9.7
Tillage practices 5/	1,858	----	----	.75	1.4
Fallow cultural practices 6/	430	----	----	2.40	1.0
Total	----	----	----	----	16.9
Additional costs					
Substitute practice	----	----	----	----	11.3

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.
2/ Allocation of acres based on ARS estimates.
3/ Assume weeds controlled with 2,4-D on 1,700 thousand acres can also be controlled with dicamba without a loss in production or the need for additional cultural practices.
4/ Assume weeds being controlled with 2,4-D on 1,858 thousand acres can be generally controlled with atrazine and oil. All acres so treated require an additional cultivation.
5/ One additional cultivation at $0.75 per acre on land treated with atrazine and oil.
6/ Acres infested with field bindweed and other perennial weeds must receive 16 cultivations in 2 fallow years out of each 10-year period at $1.50 per acre per cultivation prorated over the 10 years of effectiveness. This amounts to $2.40 per acre.

Table 10.--Rice: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre			Total costs
		Materials	Application	Total	
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	145	1.72	1.00	2.72	0.4
Substitute practice 2/					
Additional acres 3/	24	----	----	65.70	1.6
Loss in quality 4/	147	----	----	14.88	2.2
Added fertilizer on soybeans 5/	1,746	----	----	3.23	5.6
Changing rotation 6/	145	----	----	(9.85)	(1.4)
Total	----	----	----	----	8.0
Additional costs					
Substitute practice	----	----	----	----	7.6
				Hours per acre	Million hours
Additional family labor 7/	24	----	----	5.9	.1

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.

2/ Allocation of acres and yield losses based on ARS estimates.

3/ Acres needed to offset loss in production on the 145 thousand acres where no satisfactory alternative is available. Based on 1965-67 average yield of 43.8 hundredweight per acre and a 15 percent lower yield due to weeds. 24 = 145 (0.15) (43.8) / 43.8 - (0.15) (0.52) (43.8). The additional land taken out of soybeans has the same productivity. Variable costs are per planted acre with nonphenoxy herbicides used on half the added acres (table 15). Farmers will increase their costs $65.70 an acre by growing rice rather than soybeans.

4/ The cost of a loss in quality is associated with the production from all of the acres treated with phenoxy herbicides plus 2,000 additional acres.

5/ Additional fertilizer was applied to 1,746 thousand acres of soybeans to offset the loss in production on 145 thousand acres shifted to summer fallow and 24 thousand acres shifted to rice production.

6/ The substitution of fallow for 1 year of soybeans reduces farmers costs on these acres because the variable costs of summer fallowing ($3.90 per acre) are $9.85 an acre less than the variable costs of producing soybeans ($13.75 an acre).

7/ Hours of family labor required on acres added to maintain rice production. Hours of labor are the additional hours required in the switch from soybeans to rice. Rice requires 9.2 man-hours of family labor per acre and soybeans need 3.3 man-hours for a net addition of 5.9 man-hours per acre.

Table 11.--Other crops: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre			Total costs
		Materials	Application	Total	
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	3,590	0.50	1.00	1.50	5.4
Substitute practice 2/					
Additional acres 3/	538	----	----	39.67	21.3
Additional costs					
Substitute practice 4/	----	----	----	----	15.9
				Hours per acre	Million hours
Additional family labor	538	----	----	6.78	3.6

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.
2/ Allocation of acres based on ARS estimates.
3/ Acres needed to offset loss in production on the 3,590 thousand acres of other crops. Fifteen percent more acres are needed to replace losses due to lower yields and quality, and the lower productivity of the additional acres. The cost per acre for the additional acres is an average variable cost for the other crops weighted by the acres treated with phenoxy herbicides. Variable costs are per planted acre, not per treated acre; thus, no adjustment is made in the additional acres to allow for those that would not be treated.
4/ Cost of substitute practice less cost of using phenoxy herbicides.

Table 12.--Pasture: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre			Total costs
		Materials	Application	Total	
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	5,178	1.00	1.00	2.00	10.4
Substitute practice 2/					
Renovation	2,500	----	----	15.66	39.1
Mowing	2,678	----	----	1.55	4.2
Total	----	----	----	----	43.3
Additional costs					
Substitute practice	----	----	----	----	32.9
				Hours per acre	Million hours
Additional family labor	5,178	----	----	3/0.91	4.7

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.
2/ Allocation of acres based on ARS estimates. Assumes that on the average 5,178 thousand acres need to be treated each year. The same acreage would not generally be treated in successive years. Productivity would be maintained by renovation and mowing.
3/ Weighted average of additional hours used for renovation and mowing obtained by dividing total hours by acres where used.

Table 13.--Rangeland: Costs of restricting the use of phenoxy herbicides, United States, 1969 1/

Weed control practice	Acres	Costs per acre			Total costs
		Materials	Application	Total	
	1,000 acres	Dollars	Dollars	Dollars	Million dollars
1966 use of:					
Phenoxy herbicides	2,589	1.80	1.00	2.80	7.2
Substitute practice 2/					
Renovation 3/	800	----	----	15.66	12.5
Bulldozing 4/	1,288	----	----	23.16	29.8
Mowing	501	----	----	1.55	.8
Total	----	----	----	----	43.1
Additional costs					
Substitute practice	----	----	----	----	35.9
				Hours per acre	Million hours
Additional family labor	2,589	----	----	5/1.27	3.3

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966 and on substitute practices available in 1969.
2/ Allocation of acres based on ARS estimates. Assumes that on the average 2,589 thousand acres need to be treated each year. The same acreages would not generally be treated in successive years.
3/ Includes disc plowing, cultivating, seeding, and reseeding on land not presently infested with brush.
4/ Also includes root plowing, cultivating, seeding, and reseeding where needed on enough of the remaining acreage to maintain production at levels attained with phenoxy herbicides. All of this remaining land is brush infested. It was estimated that 72 percent of the acres not renovatable could be bulldozed and reseeded to maintain carrying capacity. Such treatments are generally effective for more than 10 years.
5/ Weighted average of additional hours used for renovation, bulldozing, and mowing obtained by dividing total hours by acres where used.

Table 14.--Effects of restricting the use of phenoxy herbicides in farm production, United States, 1969 1/

Crop	Acres on which phenoxys used 1966	Additional inputs needed		Lower phenoxy and application costs	Additional costs			Net additional costs 4/
		Land 2/	Family labor		Substitute herbicides and application	Additional cultural practices 3/	Production on additional acres 3/	
	1,000 acres	1,000 acres	1,000 hours	Million dollars				
Corn	23,136	---	---	37.0	122.5	21.2	----	106.7
Wheat	14,577	3,335	5,003	21.9	15.3	12.1	45.0	50.5
Other small grain	9,692	1,838	2,757	14.6	10.9	9.1	23.1	28.5
Sorghum	3,558	---	---	5.6	14.5	2.4	----	11.3
Rice	145	---	142	.4	----	5/6.4	1.6	7.6
Other crops	3,590	538	3,648	5.4	----	----	21.3	15.9
Pasture	5,178	---	4,736	10.4	----	43.3	----	32.9
Rangeland	2,589	---	3,292	7.2	----	43.1	----	35.9
Total	62,465	5,711	19,578	102.5	163.2	137.6	91.0	289.3

1/ Estimates based on use shown by the ERS Pesticide and General Farm Survey, 1966, and on substitute practices available in 1969. Does not include Alaska and Hawaii. Does not include fence rows, ditches, building sites, other noncropland, Government-sponsored control programs, nor any nonfarm use.

2/ Calculated based on ARS estimates of yield reductions.

3/ Includes costs for hired labor assuming the national average ratio of hired labor to total labor used for each crop.

4/ Additional costs for alternative materials, for growing new acreages, and for lower payments less the lower expenditures for phenoxy herbicides.

5/ Additional costs for cultural practices and loss in quality related to maintaining rice production minus returns for rice above those for soybeans on the additional acres where rice was grown in place of soybeans. Includes $2.2 million for lower income from loss in quality.

Table 15.--Variable costs per planted acre and related data for growing additional acres of wheat, other small grains, and rice in areas where phenoxy herbicides were used, United States, 1969

Input	Unit	Wheat			Other small grains			Rice		
		Quantity per acre	Costs		Quantity per acre	Costs		Quantity per acre	Costs	
			Per unit	Total per acre		Per unit	Total per acre		Per unit	Total per acre
			Dollars	Dollars		Dollars	Dollars		Dollars	Dollars
Seed	Bushels	1.1	2.00	2.20	1.6	.95	1.52	3.0	4.26	12.78
Labor										
Family	Hours	1.5	----	----	1.5	---	----	9.2	----	----
Hired	Hours	.5	1.60	.80	.5	1.60	.80	3.1	1.50	4.65
Fertilizer										
N	Pounds	16.7	.10	1.67	10.3	.10	1.03	72.5	.10	7.25
P_2O_5	Pounds	13.0	.10	1.30	10.3	.09	.93	24.0	.09	2.16
K_2O	Pounds	6.3	.04	.25	5.5	.05	.28	15.3	.05	.77
Variable application costs	Dollars	----	----	.12	----	---	.07	----	----	2.12
Pesticides										
Material	Dollars	----	----	----	----	---	----	----	----	4.61
Variable application costs	Dollars	----	----	----	----	---	----	----	----	1.80
Variable machine costs										
Preharvest	Dollars	----	----	2.81	----	---	3.17	----	----	4.74
Harvest	Dollars	----	----	2.84	----	---	3.33	----	----	23.75
Irrigation	Dollars	----	----	----	----	---	----	----	----	10.27
Machine depreciation and investment costs 1/	Dollars	----	----	1.51	----	---	1.41	----	----	4.55
Total	Dollars	----	----	13.50	----	---	12.54	----	----	79.45

1/ Twenty percent of the usual per acre interest on investment and depreciation costs. It is assumed that 80 percent of the machinery and equipment necessary to farm the added acres is currently available on farms.

Table 16.--Acres treated with phenoxy herbicides and variable costs per additional acre, selected crops, United States, 1969 1/

Crop 2/	Acres treated with phenoxy herbicides 3/	Variable costs per acre 4/
	1,000 acres	Dollars
Cotton	182	56.69
Soybeans	373	17.61
Peanuts	62	71.45
Sugarbeets	16	5/79.22
Other field crops	1,497	6/50.10
Hay	461	24.40
Vegetables other than potatoes	138	5/146.28
Citrus	18	5/154.67
Apples	21	5/187.05
Other fruits	33	5/139.25
Summer fallow	789	2.65
All crops	3,590	7/39.67

1/ Does not include Alaska and Hawaii.
2/ Includes all crops where phenoxy herbicides were reported used in an ERS Pesticide and General Farm Survey, 1966, other than corn, wheat, other small grain, sorghum, rice, pasture, and rangeland.
3/ Data from ERS Pesticide and General Farm Survey, 1966.
4/ Includes seed, hired labor, fertilizer, pesticides, fuel, oil, machinery repairs, custom services, 20 percent of machinery depreciation and interest, and all production interest charges.
5/ Preharvest costs only.
6/ Weighted average of crops other than summer fallow.
7/ Weighted average of crops including summer fallow.

Table 17.--Identification of pesticides mentioned in this report

Common name or other designation	Chemical Name
amiben	3-amino-2,5-dichlorobenzoic acid
atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine
(B-Nine(R), ALAR(R))	2,2-dimethyl hydrazide
bromoxynil	3,5-dibromo-4-hydroxybenzonitrile
butylate	S-ethyl diisobutylthiocarbamate
carbaryl	1-naphthyl methylcarbamate
CDAA	N,N-diallyl-2-chloroacetamide
chloroxuron	3-[p-(p-chlorophenoxy)phenyl]-1,1-dimethylurea
chlorpropham	isopropyl m-chlorocarbanilate
2,4-D	(2,4-dichlorophenoxy)acetic acid
2,4-DB	4-(2,4-dichlorophenoxy)butyric acid
DEF(R)	S,S,S-tributylphosphorotrithioate
2,4-DEP	tris[2-(2,4-dichlorophenoxy)ethyl]phosphite
dicamba	3,6-dichloro-o-anisic acid
dichlorprop	2-(2,4-dichlorophenoxy)propionic acid
diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
erbon	2-(2,4,5-trichlorophenoxy)ethyl 2,2-dichloropropionate
fenac	(2,3,6-trichlorophenyl)acetic acid
fluometuron	1,1-dimethyl-3-alpha,alpha,alpha-trifluoro-m-tolyl)urea
Folex(R)	tributyl phosphorotrithioite
linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
MCPA	[(4-chloro-o-tolyl)oxy]acetic acid
MCPB	4-[4-chloro-o-tolyl)oxy]butyric acid
mecoprop	2-[4-chloro-o-tolyl)oxy]propionic acid
naptalam	N-1-napthylphthalamic acid
nitralin	4-(methylsulfonyl)2,6-dinitro-N,N-dipropylaniline
propachlor	2-chloro-N-isopropylacetanilide
propanil	3',4'-dichloropropionanilide
propham	isopropyl carbanilate
sesone	2-(2,4-dichlorophenoxy)ethyl sodium sulfate
silvex	2-(2,4,5-trichlorophenoxy)propionic acid
simazine	2-chloro-4,6-bis(ethylamino)-s-triazine
2,4,5-T	(2,4,5-trichlorophenoxy)acetic acid
2,3,6-TBA	2,3,6-trichlorobenzoic acid
trifluralin	alpha,alpha,alpha-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine

PROTECT

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife -- if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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