

CHEMICAL Weed Control Recommendations

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Cover photo—Selective spraying removed many broadleaf weeds from the left side of this barley field. Similar results can be expected with other grain and grass crops.

CHEMICAL Weed Control Recommendations

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THE WIDE-SCALE USE of new chemicals as weed killers often has resulted in some confusion because of lack of complete information. This bulletin is an attempt to bring together some generalized recommendations on weed control on the basis of present knowledge. The bulletin will be revised periodically to bring the recommendations up to date in light of new discoveries.

A note of caution on the use of these new chemicals should be interjected. Many of them are dangerous to other crop plants through drift or volatilization. Overdosage of the chemical even in the crops that are tolerant to it may result in injury and lower yield. A few of the chemicals may be poisonous to livestock and, therefore, proper precautions must be taken to protect the livestock from poisoning. In all cases it is recommended that the user learn as much as possible about the chemical, both as to its use and the precautions necessary, before wide-scale application.

Berries, Trees, and Ornamentals

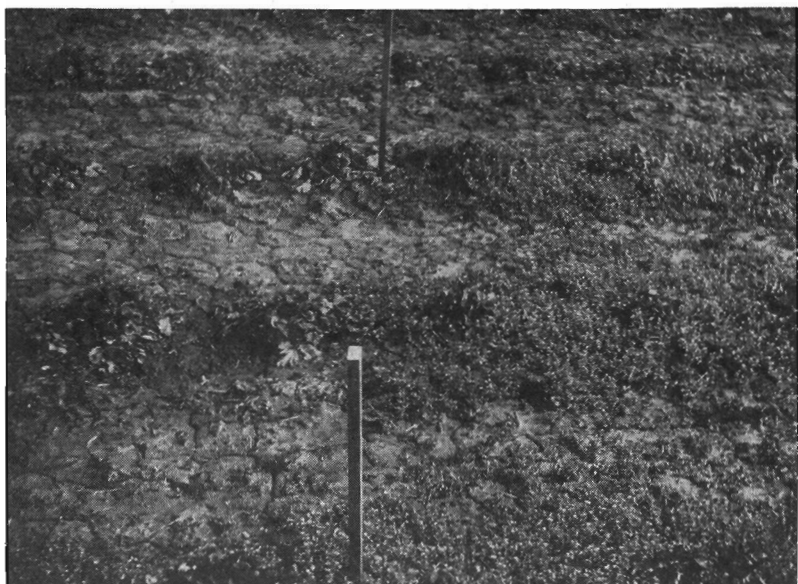
Strawberries

The weed problem in strawberries varies with the season and necessitates specific procedures for each situation.

► *Fall*: Many weeds which germinate in the fall become troublesome during the winter. Some of these, especially the grasses and chickweed, can be controlled with IPC applied in the late fall after complete dormancy of the strawberry. In late November or early December the application of 6 pounds of IPC in 40 gallons of water has been found effective. The addition of 4 pounds of 2,4-DS to this mixture will help control many broadleaf weeds if the field is clean when application is made.

► *Winter*: If it is not possible to make the fall application, 1½ quarts of dinitro general can be added to the IPC and sprayed before strawberry growth begins in January or early February. The dinitro will help to kill back weed growth already started. Dormancy

* The authors acknowledge the assistance of Dr. D. D. Hill, head of Department of Farm Crops at Oregon State College, for his help in preparing this publication.



Chickweed and annual grasses can be controlled without harming strawberries, as shown in left plot. Berries were sprayed in late fall and picture was taken in mid-March.

of the strawberry plants is necessary to avoid possible injury with this treatment.

► **Spring:** 2,4-DS applied immediately after cultivating and hoeing in the spring will do a good job of preventing further annual broadleafed weed growth for about a month or more depending on the amount of moisture received. The chemical will prevent germination but will not kill weeds already established, nor will it affect perennial weeds. Rates of 3 to 4 pounds in 40 gallons of water per acre will control most annual broadleafed weeds without damage to the strawberries. Repeat applications can be made at monthly intervals, but so far it has not been shown that the spray can be applied during blossoming. Best results are obtained when the surface soil is moist, as immediately after irrigation or just before a light irrigation.

► **Summer:** After the picking season, $1\frac{1}{2}$ quarts of dinitro general in 10 gallons of diesel oil and 50 to 70 gallons of water per acre, or 6 pounds of dinitro amine in 40 to 60 gallons of water per acre, will clean up most weeds which come up during the picking season. 2,4-D at 1 pound per acre can be used at this time to combat

Canada thistle or morning glory. The use of 2,4-D in strawberries should be restricted to this time, and then only, to combat the perennial weeds.

► **New planting:** When a new planting has become established—10 days to 2 weeks after planting—2,4-DS can be applied at a rate of 2 pounds in 40 to 60 gallons of water to control many weeds. After about 1 month another application of 3 pounds per acre can be made and then repeated treatments as needed. Moisture is needed to make this chemical active.

Caneberries

There are not yet available many results of chemical spraying in caneberries. It has been shown, however, that IPC or Chloro IPC can be used in the fall. During winter, dinitro general can be added to the spray solution.

Rates and times of application would be similar to the use of these chemicals in strawberries.

In spring and summer a spray of 2,4-DS at 3 to 4 pounds per acre should prevent considerable weed growth.

Nursery stock

These plants may be treated in a manner similar to caneberries.

Orchards

For the perennial weeds which are not controlled adequately by limited cultivation—Canada thistle, morning glory, or wild garlic—2,4-D sprays can be used at rates and times determined for these weeds.

2,4-D is dangerous to use in the orchard since most trees are quite susceptible to it. However, if caution is used in application—keeping the spray off the trees and using only the amine form—damage to trees may be prevented. Large volumes of water should be used at low pressure.

After spraying with 2,4-D the ground should not be worked for at least 1 month. Soil that has 2,4-D on it can be blown by the wind and cause damage similar to spraying 2,4-D on the tree.

IPC and 3 Chloro IPC at the rate of $\frac{1}{2}$ pound per 1,500 square feet in $3\frac{1}{2}$ gallons of diesel oil can be used to control quackgrass or other grasses without danger of injury to the trees. This is useful especially near the tree trunk where it is not possible to cultivate.

To knock down cover crops or to control annual weeds, one of the weed oils could be used to reduce the needs of cultivation if desired.

Lilies and daffodils

Both pre-emergence and post-emergence treatments may be used in the control of weeds in these bulb crops.

In the late fall, about 2 to 3 weeks before the lilies emerge, the rows may be sprayed with a mixture of 6 pounds of IPC plus $1\frac{1}{2}$ quarts of dinitro general in 15 gallons of diesel oil and 50 to 70 gallons of water per acre. This will knock down any weed growth already started and will leave a residual effect, especially against grassy weeds. If grasses are not a problem, one of the lighter oils (such as carrot oil) may be used at a rate of 40 to 60 gallons per acre, after the weeds come up but before the lilies emerge.

The effectiveness of postemergence treatments in the spring has not been demonstrated fully as yet, but small areas might be tried. After the crop has been sidedressed with fertilizers and existing weeds controlled completely, the postemergence application can be made. From 2 years experimental work the mixture of 5 pounds of 3 Chloro IPC and 3 pounds of 2,4-DS in 40 to 60 gallons of water per acre has given promising results. In some cases this one treatment has kept the rows virtually weed-free until mid-July and into August. Second applications, when new weed growth appeared, did not hurt the lilies.

Legumes

Broadleafed annuals

The control of broadleafed annual weeds in perennial legume crops, such as alfalfa, red clover, alsike clover, Ladino clover, and lotus can be accomplished most readily by the use of $1\frac{1}{2}$ quarts of dinitro general in 10 to 15 gallons of diesel oil applied during dormancy. This mixture should be applied in 30 to 40 gallons of water. For control of spring-germinating annual weeds, this mixture can be applied immediately after the first cutting of the legume.

Broadleafed annuals and easy-to-kill perennials, such as buckhorn and dandelion, have been selectively controlled in Ladino and subterranean clover by the use of 2,4-D or MCP. Both of these

materials injure the clovers, but under proper conditions the clovers recover and make normal seed production. 2,4-D should be tried at rates of $\frac{1}{2}$ to $\frac{3}{4}$ pound during May or June. Higher rates may severely injure the clover. MCP is safer to use in these legume crops with rates of not greater than 1 pound suggested. Application should be made in May or June.

Weedy annual grasses

Weedy annual grasses may be controlled selectively in perennial legume crops by the use of IPC at rates of 4 to 6 pounds per acre. Applications should be made during the rainy season from October to March. Unless annual spring germinating grasses are a problem, the fall application is preferable. The higher rate should be used in spring applications.

Chloro IPC is suggested for trial to control annual weedy grasses. Rates of 3 to 4 pounds per acre should be used. Applications should be made during the dormant season with a fall application preferred. Applications made in the spring may retard the legume crop.

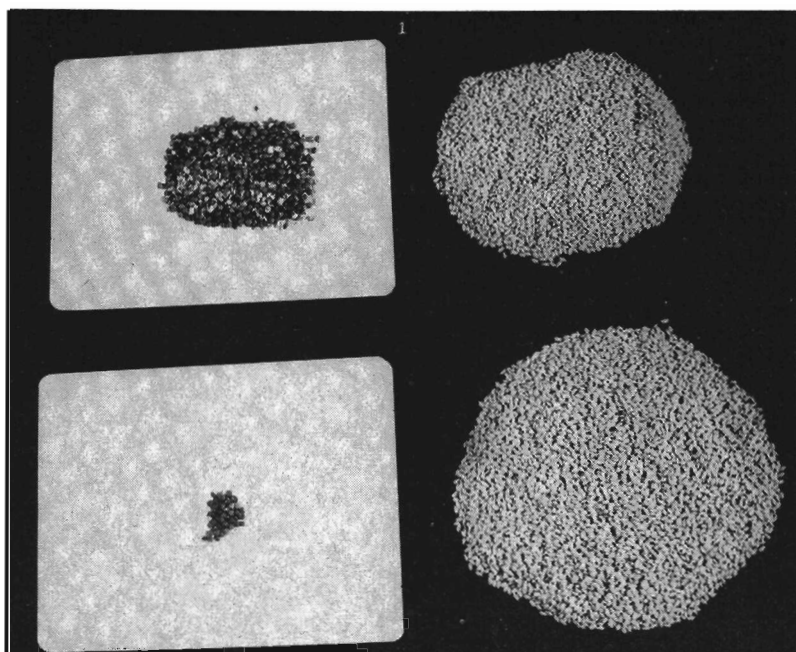
Where both broadleaved annuals and weedy grasses occur in legumes the IPC and dinitro general in oil may be combined in a single dormant application.

Small Grain and Grass Seed Crops

The cereal crops are only slightly susceptible to the hormone herbicides which means that the broadleaf weeds can be controlled selectively in these crops. Wheat is usually the most resistant of the cereals to injury by 2,4-D and other hormone herbicides followed closely by barley and oats. Oats tend to be the most susceptible to injury of the small grain crops.

Broadleaved weeds also can be controlled selectively in grass seed crops. Herbicides should be applied on seedling grasses only after the seedlings are well established and starting to tiller. Rates of not more than $\frac{1}{4}$ pound acid per acre should be applied on seedling grasses. Grasses which are going to be harvested for seed should be sprayed before the boot stage. Spraying when the heads have started to emerge will often cause considerable reduction in seed set.

The hormone-type herbicides have been found effective for the control of many broadleaved annual weeds occurring in grain and grass crops. They have assisted also in the control of many broadleaved perennial weeds. Their use to control heavy infestations of perennial weeds such as morning glory and Canada thistle often has made it possible to produce a crop on land previously abandoned.



Comparative amounts of wheat and weed seed in equal samples from unsprayed and sprayed parts of field treated with selective herbicide. Seed at top from unsprayed plot.

The three hormone herbicides used for selective weed control in cereals and grass seed crops are 2,4-D, 2,4,5-T, and MCP. Mixtures of 2,4-D and 2,4,5-T are used more commonly than 2,4,5-T alone. 2,4-D is the most widely used of the hormone herbicides, both because it was the first one introduced and because it has been less expensive. As a whole, more weed species are susceptible to 2,4-D than to the other hormone herbicides. Certain weeds are, however, more susceptible to 2,4,5-T or MCP than to 2,4-D. These two compounds, therefore, have some special uses.

The most common forms of all three of the hormone herbicides used are amine salts, standard alkyl esters, and low volatile or L.V. esters. The amine salt formulation has been the most popular in western Oregon because of the volatilization danger encountered with esters during warm weather. The ester forms have been used more widely in eastern Oregon where the danger of injury to susceptible crops such as clover and garden crops often is not as great as it is in western Oregon. The ester forms in some cases are slightly

more effective than the amine salt. The standard alkyl esters present some danger of volatilization and the drifting of the resultant fumes during warm weather. This danger has been partially eliminated with the new low volatile esters. Preliminary information indicates that the low volatile esters also may be slightly more effective than the standard alkyl esters in some cases.

Regardless of the form used, the hormones should be applied only at the recommended time to avoid danger of injury to the grain or grass crop. Application on fall cereals should be made after the grain starts to tiller (stool), and before the boot stage. The proper time of application in spring-sown cereals is when the grain is about 6 inches tall. Application should also be made before the spring cereals are in the boot stage. Spraying seedlings too young will usually cause injury which may substantially reduce the yield. This is also true of late spraying. Spraying after the grain is in the boot stage often results in blank or distorted heads.

Rates of $\frac{1}{2}$ to $\frac{3}{4}$ pound acid per acre are recommended for both eastern and western Oregon for the control of annual weeds. Rates of 1 pound per acre are recommended where infestations of perennials such as garlic, morning glory, and Canada thistle occur. Rates above 1 pound are not recommended because of danger of injuring the cereal.

The hormone types of herbicides usually are applied with water as the carrier. It is important to use enough volume of application to insure complete coverage of the field. Extremely low volumes of application may result in many plants being missed.

Extreme caution should always be used when applying any hormone type of herbicide. Many crop plants are injured by minute quantities of these materials, especially tomatoes and grapes. Many other crops such as vetch and clovers may be injured by drift of the materials. The actual drifting of spray in the wind is the most common cause of injury to nearby crops. This danger is not eliminated by the use of the amine salt or the low volatile esters. The best precaution against injury is to avoid spraying on days when there is a wind if susceptible crops are in the neighborhood. Low pressures not greater than 40 to 60 pounds per square inch should be used. The use of low volumes of application which cause a mist-type spray should be avoided where susceptible crops are grown in the neighborhood.

It is extremely difficult to eradicate perennial weeds infesting grain or grass fields by the use of the growth regulator chemicals. Where there is a small or a new infestation it would appear economical to use a soil sterilant such as a borate-chlorate mixture or

sodium chlorate to eliminate the weed even though no crop could be harvested from that area.

On areas having extensive infestations of perennial weeds such as morning glory and Canada thistle it may be possible to "live with" the weeds while gradually diminishing the stand with the growth regulator chemicals. To do this the material should be applied as a selective treatment and again at or just after harvest. Due precautions should be taken in spraying a summer fallow area, however, since the wind blown soil that has 2,4-D on it may cause damage similar to that found in drifting spray.

For control measures of these perennial weeds, refer to pages 22 and 23.

Weedy Grasses in Perennial Grass Seed Crops

Weedy annual grasses such as common ryegrass and rattail fescue may be controlled selectively in certain perennial grass seed crops in western Oregon. Two chemicals have been used successfully for this purpose, IPC and Chloro IPC.

Both of these chemicals are effective primarily on germinating seed and very young seedling grasses. Since these materials act through the soil, in order to be effective they must be in the soil and come in contact with the germinating seed or the root of the seedling plant. The success of treatment, with either IPC or Chloro IPC, depends on how long the chemical will last in the soil. The longer the materials last the more effective the treatment.

A number of conditions influence the length of time IPC and Chloro IPC will be effective in the soil. The first and the one most easily controlled is the rate of application or the number of pounds applied per acre. It is not profitable to increase the dosage of these chemicals above that recommended where you are attempting to control a weed in a crop. If too high a dosage is applied, the crop may be injured almost as badly as the weed. In this case it is necessary to apply chemicals in such a manner and under such conditions that they will give the greatest possible effectiveness with the smallest effective dose per acre.

For the control of weedy grasses in grass seed crops, Chloro IPC or IPC must be applied during the month of October under western Oregon conditions. Applications made after the first of November may result in serious reductions in seed yield and, in some cases, injury to the crop plant. In the spraying of fine fescues it is desirable to make the treatment before the 20th of October and for Alta fescue the treatment should be made by the first of November.

Neither Chloro IPC nor IPC should be applied at rates in excess of 4 pounds per acre on grass seed crops. From 3 to 4 pounds of either material per acre are recommended for alta fescue and not over 3 pounds of IPC for either Chewings or creeping red fescue. Where the soil is light and well drained a maximum of 4 pounds per acre may be used on alta fescue, but as the soil becomes heavier and more poorly drained 3 pounds will be satisfactory. Chloro IPC should not be used on either Chewings or creeping red fescue.

The experimental work on the control of weedy annual grasses has been conducted on alta fescue, creeping red fescue, and Chewings fescue. This treatment is recommended only for these three crops.

The age of the stand of the crop is important when considering application of the chemicals. The grass must be well established before treatment is made. Alta fescue may be treated when about 6 months old if well established. No more than 3 pounds of chemical per acre should be used. In the case of Chewings fescue or creeping red fescue, the stand must be at least 1 year old or older before treating.

Vegetable Crops

Asparagus

With proper timing of application calcium cyanamid can give satisfactory weed control in asparagus beds. The granular form may be used at a rate of 300 pounds per acre in a band over the bed before emergence of the crop. For effective weed control it is important that the soil surface be moist at the time of application. Treatment immediately after disking down the bed appears to be most effective.

As new weeds begin to emerge 3 to 4 weeks later, the powdered type of calcium cyanamid can be used at a rate of 75 to 100 pounds per acre in a band over the row. This is safe during the cutting season, but to be effective must be applied while the weeds are in the two- or four-leaf stage; it is more effective if the foliage is wet with dew or rain.

2,4-D may be used for the control of perennial weeds such as morning glory or Canada thistle in asparagus beds. This chemical is safe *only after* the cutting season and *before* the asparagus "ferns" out.

Green beans

Recent research indicates that the amine salt of dinitro compounds (such as Premerge or Sinox P. E.) can be used as a pre-

emergence spray for beans with no apparent injury to the crop. The best time of application appears to be just before the beans emerge from the soil. Small weeds which have emerged at this time will be killed by contact with spray, and if the soil surface is moist the chemical will prevent germination of weed seeds. If the soil surface is not moist at the time of application, a light irrigation following treatment would be safe and make the chemical effective. A smooth, firm seedbed also improves the weed kill.

For covering the entire field with spray, a rate of 3 to 6 pounds active ingredient in about 40 gallons of water per acre is recommended. Treatment often may be limited to a band of 18 inches over the row with regular cultivation used between the rows. This reduces the amount of chemical needed by about two-thirds. If this type treatment is used, it is important that soil should not be thrown into the row during cultivation so that weed seeds are not moved into the treated area.

Table beets

Beets apparently are very sensitive to most of the weed chemicals. Considerable benefit often can be derived from pre-emergence treatment with a light contact oil. The area should be worked up about 10 days previous to planting, and when the weeds have germinated and begun to grow the beets should be planted with as little disturbance of the soil as possible. Then spray the field with one of the light oils (such as is used for carrots) at a rate of 40 to 80 gallons per acre depending on the amount of vegetation. The spray should be applied within a day or two after planting. The emerged weeds are killed by contact action, but there is no residual effect in the soil.

After the beets are up some weed control can be had by spraying beets with concentrated salt solution. Solutions containing 2 pounds of salt per gallon of water applied at 150 to 200 gallons per acre control many *young* weeds, but not lambsquarter, purslane, or mustard. This should not be applied before the beets have two or three true leaves. Best results seem to be obtained when the temperature and humidity are high, but when the soil surface is dry.

Carrots

Successful weed control can be accomplished in carrots by the use of several well-known "carrot" oils. These light oils can be sprayed in a band over the carrot row at a rate of 60 to 80 gallons per acre. This application should be made after the carrots have one or two true leaves, but before the root attains the size of a lead pencil. If the oil is applied after this stage there is danger of the carrots containing an oily flavor after harvest.

Best results are obtained when temperatures are high, but not over 90° F. High humidity or heavy dews increase the chances of injury to the carrots. A pressure of not over 100 pounds per square inch is desirable.

Onions

Under certain conditions weed control can be attained in onions. As a pre-emergence treatment the dust form of calcium cyanamid can be used at a rate of about 75 pounds per acre applied at least 3 days before crop emergence. It is essential that there be moisture in the surface soil to make the chemical active on germinating weeds previous to emergence of the onions. If the soil surface is dry at the time of treatment there is danger of injury to germinating onions.

As a pre-emergence treatment, 3 Chloro IPC might be tried in limited areas. This chemical is normally considered to be a grass killer, but it will prevent germination of many broadleaf weeds too. About 3 to 4 pounds actual ingredient in sufficient water for good coverage—30 gallons per acre—is suggested on the trial basis.

As a selective or postemergence treatment potassium cyanate at 8 to 10 pounds in 100 gallons of water per acre, sprayed when the onions are at the flag stage, is often very successful on small weeds which are in a tender, succulent stage of growth. To prevent injury to the onion crop *do not* spray when the onions are wet with dew or rain.

Wettable IPC can be used to control grasses in onions if applied while the grasses are very small. The recommended rate is 4 pounds actual ingredient in 50 gallons of water per acre. It might be worthwhile to apply potassium cyanate and wettable IPC at the same time.

Peas

Wild oats in peas can be controlled with IPC, and many broadleaf weeds can be controlled with the amine or ammonium salts of dinitro phenols.

For wild oats a preplanting treatment is used. Four pounds of actual IPC per acre is applied and worked 3 to 4 inches into the soil previous to planting the peas. The oil concentrate form of IPC can be used in about 3 gallons of diesel oil per acre when applied by airplane. In ground sprayers a sufficient volume of water should be used with the emulsifiable type of IPC to achieve adequate coverage. IPC will control only the weedy grasses and not the broadleaf plants. 3 Chloro IPC should *not* be used in place of regular IPC.

The amine or ammonium salts of dinitro phenols can be sprayed on peas at a rate of from $\frac{1}{2}$ to $\frac{3}{4}$ pound parent material in enough

water (40 to 60 gallons) to give adequate coverage. This application should be made when the weeds are small and the peas 3 to 4 inches tall. Best weed control is obtained if the spray is applied when the temperature is above 60° F. Damage to peas can occur if the plants are wet with rain or dew. Only succulent, fast growing weeds will be killed.

Sweet corn

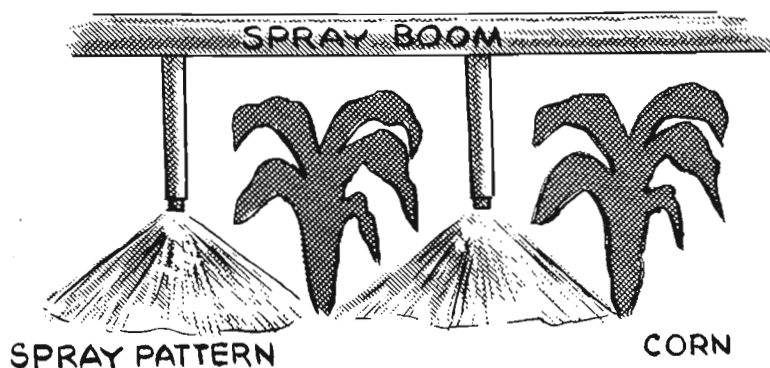
Although sweet corn is more sensitive to 2,4-D than field corn, this compound or the amine salt of dinitro phenol gives very good control of weeds when used as pre-emergence treatments. The sodium salt formulation of 2,4-D can be used at 1 pound in 20 to 40 gallons of water per acre. The dinitro salt should be sprayed at the rate of 3 to 6 pounds of active ingredient in 20 to 40 gallons of water per acre. The dinitro compound may be sprayed as late as the day that the corn emerges, but the 2,4-D should be applied previous to corn emergence. The presence of some soil surface moisture will increase the effectiveness of either spray.

2,4-D will control only broadleaf plants, whereas the dinitro spray will have some effect on certain annual grasses.

Sweet corn also can be treated with 2,4-D (sodium salt formulation) when it is about 18 inches tall for the control of most broad-leaf weeds. The rate of 1 pound in at least 20 gallons of water per acre is suggested.

An added safety measure in the selective spraying of sweet corn is to use drop pipes from the spray boom arranged so that only the lowest portions of the corn plant are hit by the spray.

As in any case where 2,4-D is used, adequate care should be taken to prevent damage to susceptible crops by drifting 2,4-D.



Weed Control in Pasture

Very often, pastures can be improved by chemical weed control. For most pasture problems such as plantains, dandelions, and buttercup, spring or fall application of 1 to 1½ pounds of 2,4-D in the amine form will give satisfactory results. This treatment will reduce or kill the legumes in the pasture depending on their tolerance to the chemicals. The more tolerant legumes such as white clover may recover without the necessity of reseeding.

In coastal regions and in wet areas where Tussock or Rush becomes a problem, the 2,4-D ester applied at the rate of 3 to 5 pounds of acid equivalent per acre with 5 gallons of diesel oil and 95 gallons of water will give satisfactory control. Where the Tussock does not present a solid stand, treatment of individual clumps may be made with this mixture. The application should be made in the spring of the year for best results.

Preharvest Spraying Suggestions

In recent years a great deal of interest has been shown by seed growers in the use of various chemicals to hasten the maturity of certain seed crops. Considerable acreages have been sprayed during the last 2 years with varying degrees of success. Results so far indicate that chemical maturation of crops can be best accomplished when the seed crop has already started to mature, and the herbicide is used chiefly as a means of hastening the reduction in moisture content and to provide uniform moisture content of the herbage at harvest time. This treatment also may be used to cause drying of green weeds in an already mature crop. Best results have been obtained when the chemicals are applied during warm, dry weather. Since the materials being used are of the contact type, they kill only that vegetation with which they come in contact. Penetration and coverage have been the greatest limiting factors in the success of preharvest sprays. Wetting and sticking agents should be employed in all applications. The materials used so far have not shown indications of reducing the germination of harvested seed. Complete information is not yet available on whether there is danger in feeding sprayed crop residue to livestock. The recommendations which follow are suggested for trial:

The use of high volumes of application to insure maximum coverage is suggested especially where foliage is dense. Volumes of 40 to 100 gallons per acre for ground application and 10 gallons per acre by airplane are suggested. Spreader stickers should be used in all cases.

Table 1. SUGGESTED PREHARVEST SPRAYS

Crop	Material	Rate used
Red clover	Dinitro general	1 to 2 quarts in 10 to 15 gallons of diesel or aromatic oil
	Pentachlorophenol (penta)	5 to 10 pounds in 5 to 15 gallons of diesel oil per acre
Alfalfa	Dinitro general	1 to 2 quarts in 10 to 15 gallons of diesel oil or aromatic oil
	Pentachlorophenol	5 to 10 pounds in 5 to 15 gallons of diesel oil
	Endothal	2 pounds active ingredient in water
Alsike clover	Same as alfalfa	Same as alfalfa
Ladino clover	Same as red clover	Same as red clover
Lotus	Same as for red and alsike clover	Same as for red and alsike clover
Vetch	Same as alfalfa with Endothal preferred	Same as alfalfa
Crimson clover	Same as for vetch	Same as for vetch
Alta fescue	Sodium monochlor acetate	15 to 30 pounds per acre in water
Flax	Same as for red clover	Same as for red clover

Special attention is called to the fact that Endothal has not been recommended for trial on Ladino clover since it may injure the stand.

Attention also is called to the fact that all recommendations are for a trial basis since no assurance can be given that they will give satisfactory results.

In most cases it will take from 3 to 7 days following application before the crop is sufficiently dry for combining.

Preharvest sprays are of interest chiefly from the standpoint of bringing about uniform ripening in crops where all areas of a field do not ripen simultaneously, or as a means of maturing crops which normally do not ripen sufficiently to permit direct combining, and as a means of eliminating the shattering that occurs in windrows. Preharvest sprays also may be used as an aid in the mowing of such crops as Ladino clover when they fail to ripen sufficiently for easy mowing.

Aquatic Weeds

Occasionally, weedy plants present a problem in irrigation drainage ditches. For the submersed type of aquatic, the aromatic oils are highly effective when applied to the stream.

Tests in Idaho and other western states show that aromatic oils are effective in the control of most submerged water weeds. These oils can be applied with regular spray equipment. The aromatic oils are discharged under the surface of the water. Spray nozzles with .02- to .04-inch orifices are recommended.

Oil-resistant hoses should be used. Pressures of 40 to 150 pounds per square inch are recommended. The higher pressures are better.

Tests show that 6 gallons of aromatic oil in each cubic foot of water per second (1 gallon aromatic oil to each 2,250 gallons of water) are needed to control water weeds for $\frac{3}{4}$ to $1\frac{1}{4}$ miles. The solvent should be discharged into the water over a 20- to 30-minute period.

The treatment should be made when the weeds are making a vigorous growth. Spraying should be done *before* the weed growth reaches the surface of the water.

The recommended spray rate in the tests did not injure garden crops which were irrigated with treated water. Livestock will not drink treated water if untreated drinking water is available. Fish are killed by the treatment.

For emergent aquatics other treatments may be needed.

For cattail and similar plants the 2,4-D ester plus TCA in the proportion of 3 pounds acid equivalent of 2,4-D and 10 pounds of TCA per 100 gallons of water, applied to wet the plant thoroughly before the catkin emerges, gives excellent control.

Table 2. SPRAY RECOMMENDATIONS FOR AQUATIC WEEDS

Weeds	Suggested treatment	Remarks
Cattail	3 pounds 2,4-D ester, 10 pounds TCA plus wetting agent per 100 gallons of water	Thoroughly wet plants before emergence of catkins
Annual broadleaf weeds	2,4-D or 2,4,5-T combinations at $\frac{1}{2}$ -1 pound per acre	Usually most effective when plant is in rosette stage
Annual grasses	1. IPC or 3 Chloro IPC at 3 to 6 pounds per acre 2. CMU at 4 to 10 pounds per acre 3. Aromatic weed oils at 60 to 100 gallons per acre	1. Most effective before emergence or immediately after 2. Most effective on young grasses. 3. Contact action primarily

Brush Control

There are two distinct methods of chemical brush control in common use. Each method has its advantages and its disadvantages.

Foliage applications

Brush control by application of the chemical to the leaves of the plant is best done in the late spring and summer months after the plant has fully leafed out. With some plants such as blackberry, the summer months will yield more effective control.

On species such as bigleaf maple and oak that tend to sprout back vigorously, repeated applications are needed.

For control of such brush species as willow and alder, 2,4-D will give satisfactory results. This material, used preferably as the low volatile ester, is mixed at the rate of 2 to 3 pounds of 2,4-D acid equivalent per 100 gallons of spray solution and applied to wet the plants thoroughly and uniformly. Usually 100 to 150 gallons of spray per acre will be required to obtain coverage of plants 10 feet high.

For more difficult species and those which are resistant to 2,4-D, a mixture of 2,4-D and 2,4,5-T known as the brush killer combination is recommended. Again for ground application 2 to 3 pounds per 100 gallons of water is the recommended strength. On particularly difficult species such as maple, the addition of 10 pounds of TCA per 100 gallons of solution often will increase the effectiveness of the treatment.

Ammonium sulfamate (Ammate) is a very effective agent for the control of certain brush species. This material is a yellow, crystalline salt readily soluble in water. It is dissolved in water at the rate of $\frac{3}{4}$ to 1 pound per gallon of water and sprayed on the foliage to wet the plant thoroughly and uniformly. This material is especially effective for the control of poison oak.

Sodium chlorate and mixtures of sodium chlorate and sodium borate are sometimes used for brush control. These materials if used at the rate of 1 pound to the gallon of water and sprayed to wet the plant thoroughly will yield satisfactory results. Sodium chlorate, however, when mixed with organic matter such as litter constitutes a fire hazard and often a stock poisoning hazard. It is not recommended, therefore, for general use in pasture areas or other areas accessible to livestock.

Dormant treatments

A recent discovery in brush control has been that brushy plants having stems 2 to 4 inches in diameter can be controlled by a mix-

ture of brush killer in oil applied to the basal 18 inches of the stem. This application is frequently made in the winter using a low volume sprayer. The mixture used for this purpose is a $2\frac{1}{2}$ to $3\frac{1}{2}$ per cent mixture of the brush killer in diesel oil or an aromatic weed oil. A $2\frac{1}{2}$ per cent mixture consists of 4 pounds acid equivalent of 2,4-D and 2,4,5-T or 1 gallon of the 4-pound brush killer combination in about 12 gallons of solution. This same mixture is highly effective for treating the cut stumps of trees that tend to resprout such as maple, alder, willow, and oak.

Injection and frilling treatments

In the case of large trees, it is often desired to kill the plant without cutting it down. This can be accomplished through the use of certain chemicals in either a frill or an injection treatment. The

Table 3. SPRAY RECOMMENDATIONS FOR BRUSH

Brush species	Suggested treatment	Remarks
Alder, Cottonwood, and Willow	<ol style="list-style-type: none"> 1. 2,4-D as solution containing 3 pounds 2,4-D per 100 gallons of water 2. 2,4-D or 2,4-D-2,4,5-T brush killer at 3 pounds in 10 gallons of oil 	<ol style="list-style-type: none"> 1. Foliage application after full leaf of the plant 2. Apply to lower 12 to 18 inches of trunks not greater than 4-inch diameter
Blackberry	<ol style="list-style-type: none"> 1. 2,4-D-2,4,5-T brush killer at 3 pounds per 100 gallons of water 	<ol style="list-style-type: none"> 1. Apply after full leaf of plant, usually late spring or early summer
Poison oak	<ol style="list-style-type: none"> 1. 2,4-D-2,4,5-T brush killer at 3 pounds per 100 gallons of water 2. Ammate at $\frac{1}{2}$ pound per gallon of water 3. 2,4-D-2,4,5-T brush killer at 3 pounds per 10 gallons oil 	<ol style="list-style-type: none"> 1. Foliage treatment after full leaf of plant 2. After full leaf of plant, apply to thoroughly wet foliage 3. Apply to lower 12 to 18 inches of stems not greater than 4-inch diameter
Maple and Oak	<ol style="list-style-type: none"> 1. 2,4-D-2,4,5-T brush killer at 2 pounds plus 10 pounds TCA per 100 gallons water 2. Ammate at $\frac{1}{2}$ pound per 1 gallon 3. 2,4-D-2,4,5-T brush killer at 4 pounds per 10 gallons oil 	<ol style="list-style-type: none"> 1. After full leaf of plant, thoroughly wet the foliage 2. After full leaf of plant, thoroughly wet foliage 3. Spray lower 12 to 18 inches of stems less than 3-inch diameter

injection treatment for large trees, particularly for those having a thick bark such as oak, consists of cutting vertical gashes in the tree at 4-inch intervals in a band around the stem. This can be done with a shingling hatchet or a similar type of tool. Into such incisions is injected the straight formulation of either the amine salt of 2,4-D or mixtures of 2,4-D and 2,4,5-T. In no case should the material be diluted by more than 1 to 1 with either oil or water. The pure formulation is more effective. In this type of treatment, only the growth regulator type of material can be considered effective.

In frilling a tree, gashes are made in a band around the trunk spreading the bark out from the trunk. This forms a frill something like a cut. Into this frill may be placed either crystals of ammonium sulphamate or Ammate or very strong solutions of this material. Sodium arsenite may also be used for this purpose.

Soil Sterilization

Not infrequently it is desired to kill all vegetation in an area such as around buildings, along roadsides, and occasionally to sterilize small patches of perennial weeds in the field. Several chemicals are available for soil sterilization work, each having a special place of use.

Generally, in western Oregon under high rainfall conditions the application should be made in the spring months before the rain ceases. In low rainfall areas such as eastern Oregon, these materials should be applied in the fall before the rainy season starts.

Boron compounds

The boron compounds are not classed as highly effective soil sterilants in view of the substantial quantities needed to achieve control of a given plant species. There are a few plants that are fairly susceptible to control by the boron compounds such as bracken fern and the various knapweeds. The advantages of the boron compounds, however, are their very low toxicity to livestock and the absence of fire hazard. Between 8 to 15 pounds of boric oxide is required per square rod for soil sterilization. This corresponds roughly to about 20 pounds of borax per square rod.

Chlorate-borate mixtures

Mixtures of sodium chlorate and boron compounds are frequently used as soil sterilants. This mixture combines the quick action of sodium chlorate with the long residual action of the boron compounds. It has proved highly effective for the control of many



A soil sterilant has killed practically all the vegetation growing in the sprayed area. The small amount of quackgrass still showing in the picture died within a very short time.

plant species when used at rates of not less than 3 pounds of sodium chlorate per square rod combined with 4 to 6 pounds of boric oxide per square rod.

Sodium chlorate

Sodium chlorate is one of our oldest soil sterilants and is still a highly effective material. This is a water soluble salt with a rapid action on most plants. It may be applied either dry or as a spray. This material should be used cautiously since it forms a very combustible mixture when mixed with organic matter such as vegetation or clothing. The operator, in applying this material, should use protective clothing which is washed thoroughly in clean water every day. Rubber boots are recommended also when applying sodium chlorate. Sodium chlorate is commonly used at the rate of 4 pounds per square rod and up for the control of perennial weeds. This material is highly effective on such perennial weeds as Canada thistle and white top, but it is less effective than some others on the grasses.

CMU

CMU is a new organic soil sterilant. This material is a white, wettable powder that is applied as a spray. It is highly effective for the control of grasses, but is less effective for the control of certain of the broadleaf perennials and brushy plants. Where these plants are encountered in soil sterilization, the addition of 2,4-D or brush killer mixture may enhance the activity of CMU. CMU should be applied at not less than 25 pounds per acre for the control of perennial grasses in a light soil up to 60 to 80 pounds per acre for control of mixed weed growth on heavy soils. Such treatment will give sterilization for about a year and one-half under most conditions with the shortest period of sterilization resulting in heavy rainfall areas.

Perennial Weeds

It is very difficult to eliminate perennial weeds by selective treatment. This program requires continued effort over many years due to the extensive underground root systems of most of these plants. Soil sterilants on small patches may eradicate the weeds much more economically.

Recommendations for timing of application to specific crops should be consulted when spraying perennial weeds in these crops.

Table 4. RECOMMENDED CONTROL OF PERENNIAL WEEDS

Weeds	Suggested treatment		
	Selective on cropland	Nonselective on noncropland	Timing for noncropland
Canada thistle and White Top	2,4-D or MCP at 1 to 1½ pounds per acre	2,4-D or MCP at 1½ to 3 pounds per acre	Apply just before bud stage of Canada thistle
Dandelion	2,4-D at 1 to 1½ pounds per acre	Same	Apply when in good active growth
Garlic	2,4-D ester at 1 to 1½ pounds per acre	2,4-D ester at 1½ to 3 pounds per acre	Apply as soon as garlic is 6 inches tall
Morning glory	2,4-D at ¾ to 1½ pounds per acre	2,4-D at 1 to 2 pounds per acre	Apply in early blossom stage
Plantain	2,4-D at 1 to 1½ pounds per acre	Same	Apply when in good active growth
Quackgrass		1. For extensive areas — summer fallow 2. CMU at 40 pounds per acre	2. See soil sterilants.
Russian knapweed		1. 2,4-D-2,4,5-T at 3 to 6 pounds per acre 2. Borax at 20 to 25 pounds per square rod 3. Sodium chlorate at 4 to 6 pounds per square rod	1. Apply when in good active growth 2. See soil sterilants 3. See soil sterilants
Tansy ragwort		1. 2,4-D ester at 3 pounds per acre 2. Chlorate at 1 pound per gallon of water	1. Apply in spring before bolting 2. Thoroughly wet the foliage. See soil sterilants
Tussock		1. 2,4-D ester at 3 to 5 pounds per acre. Add 5 gallons oil and water to make 100 gallons of solution per acre	1. Apply in spring when in good active growth