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Suggested Guide *for* **Chemical Control of Weeds**

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Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

FOREWORD

Research in the field of weed control with chemicals is conducted by the United States Department of Agriculture, State agricultural experiment stations, and industrial organizations. Representatives of these groups meet periodically in four regional conferences to discuss research developments in the field of chemical weed control and to formulate suggestions on control practices. Some of the suggested weed-control practices of the conferences are summarized in this report in order to make them generally available to agricultural workers in the various States who advise with farm people.

The effectiveness of herbicides is influenced by soil type, temperature, rainfall, and other soil and climatic factors. Because of this, the suggestions in this report should be evaluated in terms of local conditions and local experience. In a specific State, the recommendations of the agricultural experiment station and the agricultural extension service should be followed. Where such recommendations are not available, the suggestions in this report should be looked upon as a general guide.

All chemicals included in this report, especially when used on raw agricultural crops as defined under Public Law 518, should be applied in accordance with the directions on the manufacturer's label, as registered under the Federal Insecticide, Fungicide, and Rodenticide Act, as to the crop specified, in the amounts specified, and at the times specified.

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SUGGESTED GUIDE FOR CHEMICAL CONTROL OF WEEDS¹

Herbicides are efficient and economical weed-control tools for many weed-crop situations. However, they are precision tools which require the best and latest information available for successful use.

Chemicals still cannot be used for the control of all weeds in every crop. But through research an increasing number of herbicides are being made available, and the specific situations in which each is most effective are being determined. As selective herbicides come into wider use in crop production, better harvesting methods, a greater degree of mechanization, better yields, and fewer losses will prevail.

Chemical weed control should be considered as a supplement to the use of improved cultural practices. Good clean seed is a sound starting point for any weed-control program. Thorough tillage and seedbed preparation, followed by clean, efficient, shallow, timely cultivation is extremely important. Moreover, there are no substitutes for proper fertilization and management of adapted species, varieties, or hybrids of crop plants.

I. CHEMICALS USED FOR WEED CONTROL

Many herbicides are being used for weed control, and many others are being evaluated experimentally to determine their usefulness. Only those of current general interest and usefulness are described in this report.

PHENOXY COMPOUNDS

Several compounds in this group, including 2,4-D (2,4-dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), MCPA (2-methyl, 4-chlorophenoxyacetic acid), and 2-(2,4,5-TP) (2,4,5-trichlorophenoxypropionic acid) are variously used as post-emergence selective herbicides to control broadleaved weeds in corn, small grains, sorghum, rice, flax, lawns, and brush and weeds in pastures, along roadsides, rights-of-way, and drainage ditches. Some of the phenoxy compounds may also be applied to the surface of the soil as a pre-emergence treatment to control grasses and broadleaved weeds in corn and other crops.

Phenoxy compounds are usually formulated and marketed as two basic types.

1. Salts

The most widely used salts of 2,4-D, MCPA, 2,4,5-T, and other phenoxy acids include such organic amine salts as diethanolamine, triethanolamine, alkanolamine, dimethylamine, triethylamine, isopropylamine, and others. These organic amine salt formulations are available chiefly as water-soluble liquids, but water-soluble powder formulations of some of these phenoxy compounds are also available for commercial use. The amine salt formulations are more phytotoxic per pound of acid equivalent than the other salt forms, and are more effective in controlling a wider range of weeds.

¹The technical information in this publication was compiled and reviewed by W. C. Shaw, F. L. Timmons, W. B. Ennis, Jr., D. L. Klingman, R. J. Aldrich, and M. W. Parker of the Field Crops Research Branch, Agricultural Research Service.

Some of the phenoxy compounds are also commercially available as sodium and ammonium salt formulations. These compounds are available chiefly as water-soluble powders, but some of these herbicides are also available as water-soluble liquids. These salt formulations are satisfactory to use on easy-to-kill weeds, such as mustard, pigweed, and lambsquarters, but they are less phytotoxic per pound of acid equivalent than the amine salts and are not as effective in controlling as wide a range of weeds.

The salt formulations of 2,4-D, MCPA, 2,4,5-T, and other phenoxy compounds are practically nonvolatile, and are much safer to use near valuable susceptible plants than ester formulations if spray drift is avoided.

2. Esters

(a) Relatively high volatile esters.-- These types include the methyl, ethyl, isopropyl, butyl, amyl, and others known to possess relatively high vapor activity. These esters of 2,4-D, MCPA, 2,4,5-T, and other phenoxy compounds are liquids which, when properly formulated, form emulsions when mixed with water. Because they are highly volatile, they should not be used under high temperature conditions for weed control in areas adjacent to susceptible plants, such as cotton, tomatoes, grapes, flowers, and ornamentals. These volatile esters are more phytotoxic per pound of acid equivalent than the amine or other salts of 2,4-D, MCPA, and 2,4,5-T to most crops, annual weeds, and hard-to-kill weeds and brush, especially in the more arid regions and under conditions adverse to rapid plant growth. They penetrate leaves rapidly and their effectiveness is not reduced by rain unless it occurs immediately after application. If a range of rates of application is suggested, the relatively high volatile esters should be applied at the lower rates and the amine or other salts at the higher rates.

(b) Relatively low volatile esters.-- These types include the butoxyethanol, propylene glycol butyl ether, butoxyethoxypropanol, ethoxyethoxypropanol, capryl, iso-octyl, and other esters known to be low volatile. The low volatile esters of 2,4-D, MCPA, and 2,4,5-T are similar to the high volatile esters with respect to phytotoxicity and selectivity on annual weeds and crops in humid areas with moderate to low temperatures. Under high-temperature conditions, which are conducive to high rates of evaporation, the low volatile esters possess greater persistence and greater residual activity, and are somewhat more effective on some species where sustained residual activity on leaf or soil surfaces is necessary for maximum plant kill. Under most conditions, however, there have been no significant differences in the activity and selectivity of low volatile and high volatile esters of 2,4-D, MCPA, and 2,4,5-T for the control of annual weeds in crops. The low volatile esters are much less hazardous than high volatile esters in areas adjacent to susceptible crops when temperatures are 100° F. or less. When temperatures exceed 100° F., the vapors of both the high and low volatile esters will cause injury. Even under such high temperatures the low volatile esters are less injurious to susceptible crops.

2,4-DICHLOROPHENOXYETHYL SULFATE (2,4-DES)

This herbicide is a white crystalline powder which is soluble in water. When applied to moist soils, 2,4-DES is converted into a herbicide with properties similar to 2,4-D. It is effective as a pre-emergence herbicide for weed control in a number of crops. Unlike 2,4-D, however, 2,4-DES possesses little or no phytotoxicity as a foliage spray on most plants. 2,4-DES, therefore, is much safer than 2,4-D as a pre-emergence treatment in areas where 2,4-D spray drift, or vapors of esters of 2,4-D, are hazardous to susceptible crops, such as cotton, grapes, tomatoes, and sugar beets. 2,4-DES is not effective as a post-emergence foliage spray; therefore, it must be applied to the soil prior to emergence of the weeds to give effective control. It has been effective as a post-planting spray for weed control in strawberries when applied prior to emergence of the weeds. The herbicide has been erratic in performance in arid areas and also in humid areas during periods of inadequate soil moisture.

SUBSTITUTED PHENOLS

The dinitro alkyl phenols and chloro substituted phenols have been used widely as contact selective and nonselective post-emergence herbicides. They have also been used for selective pre-emergence weed control in a number of large-seeded crops, including peanuts, soybeans, lima beans, snapbeans, and cotton. The substituted phenols consist mainly of two types.

(1) Dinitro compounds.-- These include the parent compounds DNBP (dinitro ortho secondary butylphenol), DNAP (dinitro ortho secondary amylphenol), and DNC (dinitro ortho cresol). They are not soluble in water but are soluble in oil and may be applied in an oil carrier, or emulsified with water and applied as an emulsion. The parent compounds are used for pre-emergence and nonselective post-emergence weed control. The salts of these compounds, including sodium, ammonium, various amines, and others, are water soluble, and are generally used for selective pre-emergence and post-emergence weed control in some crops.

The dinitro compounds are yellow dyes which impart a yellow color to clothes and skin. They are poisonous to livestock and humans when taken internally or under conditions of sustained contact with the skin. However, they can be used for weed control without danger if precautions are taken to avoid inhaling the vapors or coming in contact with the spray drift or spray solution.

(2) Chloro substituted phenols.-- These include PCP (pentachlorophenol), which is soluble in oil but not in water, and its sodium salt (sodium pentachlorophenate), which is soluble in water. PCP is used as a fortifying agent in oil sprays for nonselective weed control. PCP in oil and sodium PCP in water are also used for selective pre-emergence weed control in several crops.

CARBAMATES

The carbamates at present include IPC (isopropyl N-phenylcarbamate) and CIPC [isopropyl N-(3-chlorophenyl)carbamate]. They are relatively insoluble in water but are formulated with organic solvents as emulsifiable concentrates. The carbamates form emulsions with water and may be applied as either low- or high-gallage sprays. Considerable improvement has been made in formulating these products in recent years. They are effective as selective dormant post-emergence sprays for the control of annual grasses, chickweed, and other broadleaved weeds in alfalfa, clovers, and strawberries. CIPC is less volatile than IPC and possesses greater residual weed-control properties. It is now being used effectively in some areas for pre-emergence weed control in cotton, soybeans, snapbeans, lima beans, spinach, and certain other field and horticultural crops. The carbamates are also used as pre-planting sprays for weed control in canning peas, strawberries, and sugar beets.

SUBSTITUTED UREA HERBICIDES

This new group of herbicides includes monuron [3-(p-chlorophenyl)-1,1-dimethylurea], diuron [3-(3,4-dichlorophenyl)-1,1-dimethylurea], and fenuron [3-(phenyl)-1,1-dimethylurea], previously known as CMU, DCMU, and PDU, respectively. These compounds are only slightly soluble in water. They are formulated as wettable powders or as liquids and must be applied as suspensions in high volumes of water. They are the first group of organic chemicals to possess sufficient residual properties to be used as soil sterilants. At present they are being used for nonselective weed control on non-cultivated land. However, diuron and monuron have also shown considerable experimental promise and are being used as selective pre-emergence herbicides in cotton, asparagus, and certain other crops.

TRICHLOROACETIC ACID (TCA)

There are several salts of trichloroacetic acid (TCA) being used as weed killers, including the ammonium and sodium salts. Sodium TCA is used most widely. It has shown varying degrees of effectiveness in controlling quackgrass, Bermuda grass, Johnson grass, and other annual and perennial grasses. Best results are obtained when it is applied in combination with tillage and cultural practices. Sodium TCA is also being used as a pre-emergence spray for the control of annual grasses and several broadleaved weeds in flax, sugar beets, sugar cane, and certain other crops. The residual toxicity from high rates of TCA for the control of perennial grasses may disappear within a few weeks or may persist for a year or longer depending on the rate of application, soil type, temperature, and soil-moisture relations. Sodium TCA is highly soluble in water, somewhat caustic, and will corrode spray equipment.

2,2-DICHLOROPROPIONIC ACID (DALAPON)

This relatively new herbicide possesses properties somewhat similar to TCA. However, when applied to the foliage of grasses in the vegetative stages of growth, it has proved less erratic and more effective than TCA for the control of most of the annual grasses and is much more effective on quackgrass, Bermuda grass, Johnson grass, and other perennial grasses. Dalapon possesses higher herbicidal phytotoxicity than TCA, and is often used at lower rates of application than those suggested for TCA. The sodium salt of dalapon, which is highly soluble in water, is the most widely used formulation at present. Research indicates that it is more effective as a pre-emergence or post-emergence spray in controlling perennial grasses when applied in combination with tillage and cultural practices. Dalapon apparently possesses less residual toxicity than TCA, but further research is needed to determine the rate of disappearance of the herbicide from the soil. Dalapon has shown experimental promise for weed control in sugar cane, sugar beets, birdsfoot trefoil, alfalfa, and for spot treatment control of Johnson grass and other grasses in cotton.

N-1-NAPHTHYL PHTHALAMIC ACID (NPA)

This chemical is formulated for experimental herbicidal use as the sodium salt, imide, and acid. The sodium salt of NPA is available as a wettable powder and as a liquid concentrate. Its greatest potential use is a pre-emergence herbicide. Presently NPA is being used for pre-emergence control of grasses and broadleaved weeds in cucumbers, squash, cantaloupes, and other crops in the cucurbit group. It has also shown some promise for weed control in irrigated cotton in the West.

3,6-ENDOXOHEXAHYDROPTHALLIC ACID (ENDOTHAL)

In research studies the disodium salt of this acid has shown promise for the control of certain weeds in turf. It is being used as a pre-harvest aid, a general contact herbicide, and chemical defoliant.

1,2-DIHYDRO-PRYDAZINE-3,6-DIONE (MALEIC HYDRAZIDE, MH)

This chemical is formulated as a water-soluble sodium or diethanolamine salt for use as a herbicide. It has shown promise for the control of several annual and perennial grasses when applied in combination with tillage and cultural treatments. It is also being used as a grass inhibitor to reduce mowing on areas such as roadsides. The chemical, however, has performed erratically both as a herbicide and as a grass inhibitor. Additional research is needed to determine the place of this compound in the field of weed control.

PHENYL MERCURIC ACETATE (PMA)

This herbicide is available in a number of formulations. It is sometimes impregnated on various carriers such as vermiculite, but PMA is also available as a liquid

concentrate which must be diluted with water and applied as a spray. Most of the formulations presently available contain 10 percent PMA by weight or approximately 1 pound of active ingredient per gallon of concentrate. PMA is an effective herbicide for the selective control of crabgrass in lawns. The compound is poisonous to humans and other warm-blooded animals and must be handled with care. It is not presently used for weed control in cultivated crops.

POTASSIUM CYANATE (KOCN)

This herbicide is a white water-soluble powder which is effective on seedling weeds. It is used as a selective spray for weed control in onions, and to control crabgrass and chickweed in lawns. For best results against crabgrass, it should be applied when the crabgrass is small. The herbicide will often discolor lawn grasses at rates required to kill crabgrass, but the discoloration will usually disappear in 7 to 10 days.

CALCIUM CYANAMIDE

Calcium cyanamide is a water-soluble solid. It is usually formulated as a granulated solid or pulverized powder. The by-products of calcium cyanamide decomposition in acid soils possess both phytotoxic and fertilizing properties. For this reason it is often used as a combination herbicide and crop fertilizer.

This chemical has long been used as a herbicide for weed control and as a fertilizer in tobacco plant beds. In recent years it has been used for pre-emergence weed control in corn and several horticultural crops. The herbicide is also being used as a pre-planting temporary soil sterilant for turf seedbeds. The chemical should be applied and worked into the soil surface at least 3 weeks prior to seeding lawns and other turf. Calcium cyanamide is also being used in turf renovation programs in some areas.

AMMONIUM SULFAMATE

This water-soluble white crystalline powder is most widely used for the control of woody plants in areas adjacent to cotton, grapes, tomatoes, and other plants which are susceptible to the phenoxy compounds. It will prevent stumps from sprouting when applied to the cut surface, and will kill large trees and sprouting stumps when the crystals or concentrated solutions are used in cups (ax chips) made around the base of a tree or stump.

HERBICIDAL OILS

Herbicidal oils are usually obtained in the distillation of petroleum and coal tar. Aromatic constituents usually have the greatest influence on their herbicidal properties. However, recent research has shown that a number of constituents of oils affect both total herbicidal activity and selectivity. Several herbicidal oils are known under a variety of names such as aromatic solvent, solvent naphtha, and petroleum naphtha. These oils vary widely in their herbicidal toxicity and selectivity depending on their origin and composition. One specific example is a petroleum naphtha with A. P. I. gravity 49 to 50, boiling range 300° to 400°F., unsaturated compounds 0.5 to 1.0 percent, aromatic content 22 to 24 percent, sulfur compounds 0.25 to 0.30 percent, and a maximum aniline point to 128°F. which is being used extensively as a directed post-emergence spray for the control of seedling annual grasses and broadleaved weeds in cotton.

Stoddard solvent and light aromatic oils have been used extensively as selective herbicidal oils for weed control in crops of the carrot family. Nonselective herbicidal oils with high aromatic contents are being used effectively to control Johnson grass on ditchbanks in the Southwest. Aromatic solvents are also being used to control aquatic weeds in irrigation canals and ditches in the Western States. Diesel oil, fuel oil, stove

oils, and others are also used as carriers for other herbicides. Oil sprays are usually more effective than water sprays in wetting leaf surfaces and in penetrating waxy leaf surfaces.

CHLORATES

A number of chlorates, including calcium and sodium, are used to control deep-rooted perennial weeds, and for temporary and semipermanent soil sterilization to prevent the growth of all types of vegetation. Sodium chlorate, a white crystalline water-soluble powder, is used most extensively. It can be applied in dry form by hand or with various types of spreaders, or as a spray using high-volume spray equipment.

For semipermanent soil sterilization in humid areas, 800 to 1,900 pounds of sodium chlorate per acre (5 to 12 pounds per square rod) are required; in semiarid areas, 500 to 1,000 pounds per acre (3 to 6 pounds per square rod) are required for semipermanent soil sterilization. However, higher rates may be required to kill certain perennial weeds under some conditions. Sodium chlorate leaves the soil unproductive for a period varying from 1 to 4 years depending on the precipitation, prevailing temperatures, soil type, and other soil and climatic factors. On sandy soils of humid regions higher rates are required for residual sterilization than on the heavy soils under lower rainfall conditions. In the arid regions on heavy soils, higher initial rates of application are required to kill all vegetation, but the residual toxicity persists for longer periods due to less leaching and slower decomposition than normally occur under humid conditions.

Caution. Sodium chlorate, particularly in spray solutions, must be handled with extreme caution. Any inflammable materials, such as clothing, shoes, hay, wood, or weeds, that have dried after having been wetted with a sodium chlorate solution become violently inflammable and even explosive. They can be easily ignited by friction, sparks, or even by the heat from the sun. Serious injury or property damage may result from carelessness or failure to observe this precaution. The manufacturer's instructions for the use of this chemical should be followed carefully.

BORON COMPOUNDS

A number of boron compounds, including borax, sodium pentaborate, boron trioxide, anhydrous sodium baborate, and mixtures of these compounds with 2,4-D and/or sodium chlorate are used to control deep-rooted perennial weeds, and for temporary and semipermanent soil sterilization to prevent growth of all vegetation. Boron compounds should be applied at rates of 2,400 to 4,800 pounds of borax equivalent per acre (15 to 30 pounds per square rod) for the control of all vegetation and semipermanent soil sterilization in humid areas; in arid regions the rates required are usually higher--4,800 to 6,400 pounds per acre (30 to 40 pounds per square rod). The addition of 2,4-D or sodium chlorate to boron compounds will greatly influence the rate of application required for killing all vegetation. Boron compounds are normally applied as dry granular formulations, but mixtures of boron and 2,4-D, and boron and sodium chlorate, are also formulated for spray application.

ARSENICALS

Arsenical herbicides include sodium arsenite, arsenic trioxide, arsenic pentoxide, and other formulations of arsenic acid. They are highly poisonous to animals, and for this reason have not been used widely as herbicides on agricultural lands. Sodium arsenite (the most commonly used arsenical) is used extensively to kill submerged aquatic weeds, and as a semipermanent soil sterilant to control all vegetation on driveways, tennis courts, railroad rights-of-way, industrial storage sites, and on other nonagricultural areas inaccessible to animals. It leaves the soil unproductive for 1 to 4 years, depending upon the soil type and climatic conditions.

II. SPRAYER CALIBRATION

The mechanical equipment used in the application of herbicides is of utmost importance to efficient chemical weed control. Even distribution of the spray solution is the most important characteristic of good spray equipment. Volumes of spray may vary widely (5 to 100 gallons per acre) without affecting the results if adequate coverage and spray distribution are obtained. The sprayer output should be determined for each particular spraying operation. The best method of calibration is to make initial adjustments to suit the machine and job requirements, and then make a trial run to determine the actual output of the machine. The herbicide spray mixture should then be prepared accordingly. The calibration should be repeated frequently to check for nozzle orifice wear and other factors affecting performance. This is especially important when abrasive solutions are used.

Individual nozzles should be checked for accuracy of delivery. This may be done by measuring the volume of spray delivered by each nozzle in 1 minute. There are many methods of calibrating a sprayer. One method is given below for calibrating each of three different types.

HOW TO DETERMINE PER-ACRE OUTPUT OF SPRAYERS

(a) Power sprayers

1. Fill the spray tank with water. Make sure it is completely full.
2. Drive in a straight line for exactly 220 yards, operating the sprayer at exactly the same pressure and tractor speed you plan to use in the field. It is a good practice to mark that notch on the throttle.
3. When you reach the 220-yard mark, cease spraying. Then measure carefully the water used in refilling the tank (a quart jar works well).
4. Convert the number of quarts of water used into gallons by dividing by 4, and then multiply this figure by 66. Divide the result by the width in feet of the strip sprayed. The answer obtained is the number of gallons the sprayer will put on 1 acre when it is operated at the same settings. Example: Suppose the sprayer boom sprays a strip 20 feet wide. After traveling 220 yards it takes 6 quarts to refill the tank. Six quarts divided by 4 equals 1 1/2 gallons. Multiply 66 by 1 1/2, which equals 99. Then divide 99 by 20 feet (the width in feet of the sprayed strip). The answer is just under 5, which is the rate of application in gallons per acre.

(b) Hand-Type Boom Sprayers

Example: 3-gallon knapsack sprayer with a 4-foot boom. Fill sprayer and walk at a steady pace, maintaining a constant tank pressure, for 110 yards. Refill tank, change number of quarts required to refill sprayer into gallons, and multiply by 132. Divide this figure by the width of the spray swath (4 feet). The answer is the number of gallons the hand sprayer is delivering per acre at the pace walked and the tank pressure maintained.

If too much spray is being applied, walk faster or use less tank pressure. For marked changes in rate of application, it may be necessary to obtain different nozzle tips.

(c) Single-Nozzle Hand Sprayers

Example: 3-gallon hand sprayer with single nozzle. Mark off an area 10 by 10 feet (100 square feet). Fill sprayer with water to 3-gallon level and spray 100-square-foot area using same speed and pressure that will be used for spraying weeds. Refill

sprayer, measuring accurately the amount of water to refill to original level. The following tabulation gives the ratio of weed killer to water required to apply 1 pint of weed killer per acre, based on discharge of the nozzle:

Nozzle discharge per 100 sq. ft.	Equivalent discharge per acre	Ratio of weed killer to water to apply 1 pt. weed killer per acre
1/2 pint	27 gal.	1 pt. in 27 gal. water
1 pint	55 gal.	1 pt. in 55 gal. water*
1 1/2 pints	82 gal.	1 pt. in 82 gal. water
1 quart	110 gal.	1 pt. in 110 gal. water

NOTE.-- The volume of water is given to the nearest gallon.

*A mixture of 1 ounce (or 2 tablespoonfuls) of weed killer in 3 gallons of water is approximately equivalent to an application of 1 pint of weed killer per acre at a nozzle discharge rate of 1 pint per 100 square feet.

III. WEED CONTROL IN FIELD CROPS

CORN

(1) Pre-emergence.--For control of annual grasses and broadleaved weeds, such as crabgrass, foxtail, ragweed, pigweed, lambsquarters, and others: An ester or amine salt of 2,4-D at 1 to 2 pounds in 5 to 20 gallons of water per acre applied any time after planting but prior to emergence will often give good control. Pre-emergence treatment will not control perennial grasses, such as Johnson grass and quackgrass, or other perennial weeds such as Canada thistle or field bindweed, but treatment may temporarily inhibit their growth and make them easier to control by cultivation. NOTE: In most States the ester formulations are preferred for pre-emergence treatment, and some States specifically suggest that the amine salt formulations not be used for pre-emergence weed control in corn.

Comments and precautions.--Treatment is not advised on sandy soils. Use lower rate of application on loam soils and higher rate on clay soils. On muck soils and heavy clay soils high in organic matter 2 to 4 pounds of 2,4-D per acre may be required to control weeds. Although the amine salts may be used on heavy soils, the esters of 2,4-D are not as likely to leach through the soil as amine salts, and are less likely to cause injury if heavy rains follow application. Lack of soil moisture may reduce effectiveness of treatment, but under such conditions weed populations are usually not serious. Pre-emergence treatments are especially valuable when excessive rainfall prevents cultivation for extended periods after corn emerges. Pre-emergence treatments may fail to control weeds if extended droughts follow the application. The low volatile ester or amine salts of 2,4-D should be used for pre-emergence weed control in fields adjacent to susceptible crops such as cotton, tobacco, grapes, and certain vegetables.

(2) Post-emergence.--For control of pigweed, ragweed, lambsquarters, field bindweed, annual morning-glory, cocklebur, smartweed, and other broadleaved annual weeds: Ester or amine salt of 2,4-D at 1/4 to 1/2 pound in 5 to 20 gallons of water per acre applied when weeds are small and corn is 4 to 24 inches tall. Treatment does not control annual or perennial grasses, but may temporarily inhibit the growth of such perennial broadleaved weeds as Canada thistle, milkweed, and horsenettle.

Comments and precautions.--In the western Great Plains and Intermountain region, 2,4-D at 1/2 to 1 pound per acre is usually suggested for control of most weeds in corn.

Some injury to corn from 2,4-D applications made at any time from emergence to tasseling may occur if the treatment is applied during conditions favoring rapid growth. Avoid applications when temperatures are high and corn is growing at a maximum rate. Use the esters of 2,4-D at the lower rate and the amine salts at the higher rate in the range. Severe reductions in seed set may occur if applications are made during the 2-week period just prior to silking and until the silks are dry. Hybrids vary in their susceptibility to 2,4-D but differences are of little importance at rates below 1/2 pound per acre. Avoid cultivation for several days after treatment in order to reduce stalk breakage if brittleness develops.

(3) Directed post-emergence treatment at layby.--For control of annual grasses and broadleaved weeds from after last cultivation until harvest: Ester or amine salt of 2,4-D applied at rate of 1/2 pound per acre to base of cornstalks and in such a manner as to spray weeds in the row (post-emergence), and at rate of 1-1/2 pounds per acre to soil between rows to prevent new weed growth (pre-emergence). Spray is applied with drop nozzles having different volume capacities. Example: Prepare a solution in proportion of 1/2 pound of 2,4-D to 5 gallons of water. Direct a nozzle delivering

solution at rate of 5 gallons per acre (equal to 1/2 pound of 2,4-D) on top of weeds in the row; direct a second nozzle delivering at rate of 15 gallons per acre (equal to 1-1/2 pounds of 2,4-D) on soil between rows.

Comments and precautions.--Treatment is especially valuable in fields where weeds become serious between layby and harvest. Nozzles should be adjusted to apply herbicide on top of weeds. There is less chance of injuring corn from this treatment than from either pre-emergence or earlier post-emergence treatments.

SORGHUM

The use of 2,4-D for weed control in sorghum is suggested only as an emergency treatment when weeds cannot be controlled by cultivation. When 2,4-D is used as post-emergence spray, it should be applied at lowest rate necessary for weed control and not to exceed rates suggested for weed control in corn. Sorghums are most tolerant to 2,4-D in the 4- to 8-inch stage of growth. Precautions regarding weed control in corn apply also to sorghum.

WHEAT, BARLEY, AND OATS--FALL OR SPRING SEEDED

A. Small Grains Underseeded With Legumes

(1) Post-emergence.--For emergency control of serious infestations of mustard, yellow rocket, and other broadleaved weeds if cereal crops are underseeded with a mixture of legumes such as alfalfa, birdsfoot trefoil, lespedeza, red clover, sweet-clover, white clover, or other legumes: Amine salt of MCPA or 2,4-D at 1/8 to 1/4 pound in 5 to 20 gallons of water per acre, or amine salt of DNBP at 3/4 to 1 pound in 30 to 50 gallons of water per acre. MCPA and DNBP are less likely to injure legumes than 2,4-D. The MCPA application should be made after cereals are well tillered, usually 4 to 8 inches tall, but prior to jointing or reaching boot stage. If DNBP is used, it should be applied only when the weeds are in the seedling stage. The legumes are less likely to be injured if a small grain canopy is allowed to develop prior to application of MCPA. NOTE: Avoid use of post-emergence applications of 2,4-D and MCPA unless the weed infestation is serious enough to result in reduction or loss of legume stands and reduced small grain yields.

B. Small Grains Not Underseeded with Legumes

(1) Post-emergence.--For control of mustard, wild radish, yellow rocket, ragweed, wild vetch, lambsquarters, pigweed, cocklebur, smartweed, sunflowers, shepherd's purse, prickly lettuce, plaintain, docks, field bindweed, and others: Ester or amine salt of 2,4-D or MCPA at 1/4 to 1/2 pound in 5 to 20 gallons of water per acre applied after cereals are well tillered, usually 4 to 8 inches tall, but prior to jointing or reaching boot stage. Growth of wild onion, wild garlic, Canada thistle, sow thistle, curled dock, buttercup, field bindweed, and white top in arid areas, and several other weeds may be effectively inhibited but not necessarily killed. Grasses and several perennial weeds, such as horsenettle, white cockle, milkweed, and others, will not be controlled by the treatment.

Comments and precautions.--In the western Great Plains and Intermountain region, 2,4-D should be applied at 1/2 to 1 pound per acre to control most weeds infesting small grains. One to 2 pounds of 2,4-D may be required to control semitolerant weeds, but these rates may be used without serious injury to the small grains. In other agricultural areas, rates of more than 1 pound per acre should be used only when necessary to kill weeds causing serious damage to small grains.

Both 2,4-D and MCPA can be used to control weeds in wheat, barley, and oats without injuring crops if treatments are restricted to the most tolerant stages of growth of the cereals.

Applications of 2,4-D or MCPA to cereal crops in the early seedling stages prior to tillering or during the late jointing stages or the boot stage, and early heading stages may result in serious reductions in yield, lowered germination of grain, changes in protein content of grain, and lowered quality of products made from the treated crops. If cereal crops are underseeded to legumes, use minimum rate of amine salts of 2,4-D, MCPA, or DNBP necessary to control weeds. All legumes are susceptible to 2,4-D and most are susceptible to MCPA, and serious injury may result if these herbicides are applied at rates greater than 1/4 pound per acre. If cereals are underseeded with legumes, application of MCPA or 2,4-D should be delayed until the maximum small grain canopy has developed, but not later than early joint stage. The order of tolerance of these crops to 2,4-D is as follows with the most tolerant first: wheat, barley, and oats. If oats are not heavily infested with weeds, yields may be reduced by applications of 2,4-D made at any time from emergence to heading. Oats, however, are more tolerant to MCPA than to 2,4-D.

FLAX

(1) Post-emergence.--For control of broadleaved weeds--mustard, lambsquarters, pigweed, pennycress, cocklebur, marsh elder, and ragweed: Amine salt of MCPA or 2,4-D at 1/8 to 1/4 pound in 5 to 20 gallons of water applied when weeds are small and flax is 3 to 6 inches tall. For southwestern flax growing area: 2,4-D or MCPA at 1/2 to 3/4 pound per acre.

For annual grasses--green foxtail, yellow foxtail, giant foxtail, and barnyard grass: Mixture of 1/4 pound MCPA and 5 pounds TCA in 10 to 20 gallons of water per acre applied when weeds are small and flax is 3 to 6 inches tall. Will also control broad-leaved weeds listed above.

To prevent seed production by Canada thistle and to control Russian thistle: Esters of MCPA and 2,4-D at 1/4 to 1/2 pound in 5 to 20 gallons of water per acre applied on a spot-treatment basis.

Comments and precautions.--Will not control wild oats, quackgrass, milkweed, white cockle, and Russian knapweed. Applications to flax should be avoided from early bud through bloom stages.

COTTON

A. Humid Cotton Belt

(1) Pre-emergence.--For control of annual grasses and many broad-leaved weeds for 4 to 6 weeks: CIPC at 5 to 10 pounds in 20 to 40 gallons of water per acre applied during the planting operation. To reduce cost, apply CIPC at 1-1/2 to 3 pounds per acre immediately behind planter wheel or press wheel to 12- to 14-inch band centered over row (rows 40 inches apart). Lower rate (1-1/2 pounds on a 12-inch band basis, or about 5 pounds per acre on a complete coverage basis) suggested for sandy loam or lighter textured soils; heavier rates suggested for loams and heavier textured soils. Complete coverage applications are more desirable than band treatments but they have not been used because of the higher cost.

The substituted urea herbicides, monuron and diuron, are being extensively investigated for pre-emergence weed control in cotton, but are not suggested for general use. Research information is also needed on the residual effect of these herbicides on crops following cotton in the rotation. They are available commercially for trial under the technical assistance and supervisory program of the manufacturer.

Performance of DNBP compounds as pre-emergence herbicides has been erratic, and, therefore they are not presently being used for weed control in cotton.

Comments and precautions.--Some injury may be expected if heavy rains follow CIPC applications on light textured sandy soils. Enlarged, injured hypocotyls, as a result of CIPC treatments, appear to increase the susceptibility of cotton seedlings to seedling disease organisms. Sustained high temperatures of 90° F. or more reduce the period of effective weed control.

(2) Directed post-emergence.--For control of most small annual grasses and broad-leaved weeds: Special nonfortified herbicidal oils at the rate of 5 gallons per acre (based on 40-inch rows) directed to the 8- or 10-inch drill area centered over the row. Oil should be directed laterally to drill area at a height of less than 1 inch above the soil. Apply no more than 3 treatments; they should be applied at least 5 to 7 days apart, beginning when weeds first appear in the drill and the cotton is at least 3 inches tall. Applications should not be made after bark cracks appear in the cotton stalk. These treatments properly applied will kill crabgrass, foxtail, pigweed, lambsquarters, morning glory, cocklebur, and others, but do not kill established perennials such as Johnson grass, nutgrass, and vines.

Comments and precautions.--Sprayer nozzles must be set properly to avoid serious injury to the cotton foliage and to insure control of the weeds.

B. Western Irrigated Cotton Belt

(1) Directional post-emergence in established cotton.--For control of annual grasses and broadleaved weeds from layby until harvest: Monuron or diuron at 3/4 to 1-1/2 pounds or NPA at 4 to 6 pounds in 40 gallons of water per acre applied on soil surface between rows and on bases of cotton stalks in the row just prior to or after the last cultivation. NPA has not been as consistent in controlling annual morning glory as monuron and diuron.

Comments and precautions.--These treatments are suggested for use under the irrigated conditions of the western cotton producing area only, and only on a trial basis. Residual activity of urea herbicides (including monuron and diuron) on crops following cotton in a rotation is being investigated. Available information indicates small grains planted after cotton that has been treated with monuron or diuron may be seriously injured by residual activity of these herbicides. Crops that are more tolerant to urea herbicides, such as grain sorghum or cotton, should be planted following cotton that has been treated with monuron or diuron for weed control.

SOYBEANS

(1) Pre-emergence.--For control of annual weeds, such as crabgrass, foxtail, giant foxtail, pigweed, lambsquarters, morning glory, cocklebur, and others: CIPC or DNBP at 4 to 8 pounds in 10 to 20 gallons of water per acre applied immediately after planting. The control of deep germinating annuals is usually less effective than shallow germinating weeds. Will not control perennial weeds, such as nutgrass, quackgrass, Johnson grass, Canada thistle, and milkweed. To reduce the cost of chemical weed control in soybeans, band treatments may be made as described for cotton.

Comments and precautions.--If heavy rains follow application and prior to crop emergence, treatment may injure soybeans; if prolonged drought follows application, weed control may be erratic. DNBP compounds produce vapors toxic to soybean seedlings if temperatures of 88° F. or higher prevail for 5 to 10 continuous days when soybeans are emerging. Temperatures of 90° F. or higher cause rapid evaporation both of CIPC and DNBP, and may greatly reduce their period of effective weed control.

PEANUTS

(1) Pre-emergence.--For control of annual grasses and broadleaved weeds, such as crabgrass, pigweed, lambsquarters, morning glory, cocklebur, and others: DNBP at 6 to 8 pounds in 10 to 20 gallons of water per acre applied during the planting operation or any time after planting and prior to emergence. Will not control such perennial weeds as nutgrass, Johnson grass, and Bermuda grass. The treatment is often not effective in controlling deep germinating seedlings of cocklebur and other annuals.

2,4-DES at 3 pounds in 20 gallons of water per acre has proved effective in controlling annual grasses and broadleaved weeds in peanuts.

Comments and precautions.--Both DNBP and 2,4-DES may cause some injury to peanuts on light sandy soils if heavy rains following application leach herbicides into zone of germination. If average daily temperatures are 88° F. or higher from time of application to emergence of crop, DNBP compounds will volatilize. This will reduce the effective period of weed control, and the vapors may injure germinating peanut plants. Effectiveness of 2,4-DES is reduced if prolonged drought follows application. Where 2,4-DES or other herbicides are used, peanuts should be planted as deeply as feasible to minimize herbicide injury.

RICE

(1) Post-emergence.--For control of coffeeweed and other broadleaved weeds: Amine salt formulations of 2,4,5-T, MCPA, or 2,4-D at 1/2 to 1 pound in 5 to 20 gallons of water applied any time after rice is well tillered but prior to jointing or reaching boot stage. Will not control annual or perennial grasses. The rice plant is sensitive to 2,4,5-T, MCPA, and 2,4-D in the early seedling, boot, and early heading stages. Applications at these stages should be avoided unless heavy weed infestations seriously threaten the crop. If applications are necessary during sensitive stages of growth, use minimum rate required to control the weeds.

Comments and precautions.--Cotton, soybeans, and other crops sensitive to 2,4,5-T, MCPA, and 2,4-D may be seriously injured by vapors or spray drift from these herbicides. These three herbicides rank as follows according to their toxicity to cotton, with the least toxic first: 2,4,5-T, MCPA, and 2,4-D. Several esters of these three herbicides are highly volatile while others are much less volatile. In cotton producing areas, use only amine salt or low volatile ester formulations to control weeds in rice. Avoid application when wind direction is toward cotton or other susceptible crops. In certain States it is not permissible to use esters of the phenoxy compounds. State regulations should be complied with in all cases.

SUGAR BEETS

(1) Preplanting.--For control of wild oats and other annual grasses and some broadleaved annual weeds: IPC at 3 to 6 pounds in 10 to 40 gallons of water per acre applied to surface of soil and thoroughly disked into soil surface 2 to 4 weeks before planting.

(2) Pre-emergence.--For control of most annual grasses (except wild oats) and some broadleaved weeds: TCA at 5 to 7 pounds in 10 to 20 gallons of water per acre just prior to emergence of beets.

Several herbicides have been studied in localized areas as pre-emergence sprays to control weeds not controlled by TCA. These treatments have involved an evaluation of the use of dalapon at 4 to 8 pounds, PCP at 6 to 10 pounds, IPC at 3 to 6 pounds, and DCU at 6 to 24 pounds per acre. Rates of applications have varied considerably,

depending on the weed species, soil type and available soil moisture, and several other soil and climatic factors.

(3) Post-emergence.--For control of many broadleaved weeds on acid or neutral soils in the humid regions: Sodium chloride at 200 to 300 pounds in 100 to 200 gallons of water per acre applied when beets are in 2- to 4-true-leaf stage. Will not control lambsquarters or purslane. In preliminary studies, dalapon at 4 to 6 pounds per acre has looked promising as a post-emergence spray for the control of seedling weedy grasses and certain broadleaved weeds in sugar beets.

Comments and precautions.--Chemical weed-control practices in sugar beets vary widely depending on weeds present and several soil and climatic factors.

TOBACCO (PLANT BEDS)

(1) Pre-emergence.--For control of most broadleaved weeds and annual grasses in tobacco plant beds: 1 pound of uramon and 1/2 pound of calcium cyanamide or 1 to 1-1/2 pounds of calcium cyanamide per square yard, or 1 pound of methyl bromide per 100 square feet of plant bed area. Applications of uramon-cyanamide or cyanamide alone should be made in October in the mid-Atlantic States and thoroughly mixed in the upper 3 inches of soil by disking and raking. Methyl bromide is a volatile soil sterilant, and the plant bed must be covered with a gas-tight cover for the chemical to be effective. Methyl bromide may be used in the spring without residual toxicity to tobacco plants.

IV. WEED CONTROL IN HORTICULTURAL CROPS

VEGETABLE CROPS

Asparagus

(1) Seedbeds, pre-emergence.--For control of most annual broadleaved weeds and grasses with little or no crop injury: Monuron at 1 to 1-1/2 pounds or a light aromatic oil at 80 gallons per acre applied just prior to emergence of asparagus. Higher rates of application may result in injury.

(2) Established beds, pre-emergence.--For control of many annual weeds with little or no crop injury: Either 2,4-D at 1-1/2 to 2 pounds, 2,4-DES at 3 to 6 pounds, TCA at 6 to 8 pounds, NPA at 4 to 8 pounds, DNBP at 4 to 8 pounds, or monuron at 1 to 2 pounds in 10 to 40 gallons of water per acre applied after disking and prior to spear emergence. Beds are commonly disked to loosen the soil, destroy weeds, and to remove old ferns.

Comments and precautions.--Use highest rate on muck soils and heavy clay soils under arid conditions; use lowest rate on light sandy soils under humid conditions. TCA, 2,4-D, and monuron should not be applied more than once each season. Herbicide mixtures are often required for satisfactory weed control if the weed population contains grasses and broadleaved weeds.

Beans

(1) Pre-emergence.--For control of most broadleaved weeds and annual grasses with little or no crop injury: DNBP at 4 to 8 pounds, PCP at 12 to 24 pounds, or CIPC at 4 to 8 pounds in 10 to 40 gallons of water per acre. A mixture of DNBP at 4 pounds and CIPC at 4 pounds in 20 gallons of water per acre will give control of smartweed and annual grasses not controlled by DNBP alone; will also control lambsquarters and ragweed which are not normally controlled by CIPC alone.

Beets

(1) Same as suggested for sugar beets.

Cabbage, Cauliflower, Collards, Kale, Rape, Broccoli, Turnips, Mustard (as leafy vegetables)

(1) Pre-emergence.--For control of annual grasses and many broadleaved weeds on direct seeded crops as an emergency measure: TCA at 6 to 8 pounds in 10 to 20 gallons of water per acre. In several of the mid-Atlantic States experimental results have shown that CIPC is effective as a pre-emergence spray at 1 to 3 pounds in 10 to 40 gallons of water per acre to control annual weeds in many of these crops. Injury to some of these crops has been reported following the use of CIPC.

Cantaloupes, Muskmelons

(1) Pre-emergence.--For control of most annual weeds: NPA at 2 to 3 pounds in 10 to 40 gallons of water per acre on light sandy soils, 3 to 4 pounds on loam soils, and 4 to 6 pounds on clay and muck soils. Will control weeds for 4 to 6 weeks with little or no crop injury.

(2) Post-emergence.--A post-emergence application of NPA at 2 to 4 pounds in 20 to 40 gallons of water per acre may be applied 4 to 6 weeks after emergence to extend the effective period of weed control. Post-emergence treatments have not been as

effective as pre-emergence treatments and often fail to control established weeds. Such treatments should be used only as emergency measures.

Comments and precautions.--Less likely to cause injury if applied when soil temperatures are low. Certain varieties of pumpkins and squash are not tolerant to this treatment, and varietal responses should be known prior to large-scale use.

Carrots, Celery, Dill, Parsnips, Parsley

(1) Post-emergence.--For control of small annual weeds on muck and upland soils: Application of undiluted special light aromatic oils at 80 to 100 gallons per acre applied when weeds are 1 to 3 inches tall, and, in case of carrots and parsnips, before taproots are more than 1/4 inch in diameter. Most effective if applied when air movement is downward and relative humidity is high. Light aromatic oils should only be applied to celery when in seedbeds. Later applications on the other crops may result in off flavor.

Cucumbers

(1) Pre-emergence and post-emergence.--Same as for cantaloupes and muskmelons.

Lettuce

(1) Pre-emergence.--Same as for cabbage.

Onions

(1) Pre-emergence.--For control of a wide variety of annual grasses and broad-leaved weeds: A light aromatic oil at 40 to 80 gallons per acre, 3- to 5-percent solution of sulphuric acid in water at 100 gallons per acre, or CIPC at 2 to 8 pounds per acre applied when weeds are in seedling stage but prior to emergence of onions. Combinations of CIPC and light aromatic oils will effectively control smartweed and purslane.

(2) Post-emergence.--For control of most annual weeds in onions in the loop stage: 2 to 3 percent solution of sulphuric acid in water at 100 gallons per acre, or KOCN at 10 to 16 pounds in 50 to 100 gallons of water per acre, applied when first true leaf of onions is at least 2 to 3 inches long (loop stage).

For control of most annual weeds in onions in the 5-leaf stage and after last cultivation when onions are being or have been laid by and are bulbing: CIPC at 2 to 8 pounds, KOCN at 16 to 20 pounds, and monuron at 2 pounds in 20 to 40 gallons of water per acre, or a 3- to 4-percent solution of sulphuric acid in water at 100 gallons per acre applied as a basal directed spray. Avoid hitting tops of onion plants.

Comments and precautions.--Chemical and rate of application to use will be determined by weeds present, soil type, and stage of growth of onions and weeds.

Peas

(1) Preplanting.--For control of wild oats and other grasses in Intermountain region: IPC at 3 to 6 pounds in 10 to 40 gallons of water per acre applied to the soil, and thoroughly disked into soil surface 2 to 4 weeks before planting.

(2) Pre-emergence.--For control of annual weeds in Northeastern region: Any one of several amine salts of DNBP at 4 to 6 pounds in 10 to 20 gallons of water per acre.

(3) Post-emergence.--For control of most broadleaved annual weeds in all pea-producing areas: Amine salt of DNBP at 3/4 to 1-1/4 pounds in 20 to 40 gallons of water per acre applied when weeds are small and peas are 3 to 8 inches tall.

For control of annual broadleaved weeds in North-Central region: Amine or sodium salt of MCPA at 1/8 to 1/3 pound in 5 to 20 gallons of water applied when weeds are small and peas are 3 to 8 inches tall. Will inhibit growth of Canada thistle and other perennial weeds, and control them under some conditions.

Comments and precautions.--When using DNBP compounds, apply lower rates in the range if temperature is over 70° F.; use higher rates if temperature is lower than 70° F. Avoid applications if temperature is 85° F. or higher.

Potatoes

(1) Pre-emergence.--For control of broadleaved annual weeds and annual grasses: DNBP at 3 to 6 pounds, PCP at 10 to 20 pounds, or TCA at 8 to 10 pounds in 20 to 40 gallons of water per acre applied following blind cultivation and prior to emergence of potatoes.

Spinach

(1) Pre-emergence, early spring planting.--For control of annual grasses and many broadleaved weeds: CIPC at 1 to 2 pounds on sandy soils, 4 to 6 pounds on heavier mineral soils, and 6 to 8 pounds on muck soils, in 10 to 20 gallons of water per acre. When temperatures are higher and the loss of CIPC through volatilization is greater, CIPC as a pre-emergence spray should be applied at 4 pounds per acre on sandy soils and 6 pounds per acre on heavier mineral soils. The lowest rates in the suggested range should be used when temperatures are 60° F. or less, and the higher rates when temperatures are above 60° F. Results have varied widely with soil and climatic conditions.

Comments and precautions.--In the Mississippi River delta and some other agricultural areas, fall-planted spinach may be seriously injured by CIPC at rates required to control weeds.

Sweet Corn

(1) Pre-emergence.--For control of annual broadleaved weeds and grasses: Low volatile ester of 2,4-D at 1-1/2 to 2 pounds, DNBP at 4 to 8 pounds, or PCP at 12 to 20 pounds per acre. Effective for 4 to 6 weeks after treatment.

(2) Post-emergence.--For control of sensitive broadleaved weeds: Amine salt or ester of 2,4-D at 1/4 to 1/2 pound in 5 to 20 gallons of water per acre applied when weeds are small and while corn is 4 to 12 inches tall. Does not control grasses.

Comments and precautions.--Follow those given for weed control in field corn. Pre-emergence applications of 2,4-D, however, may result in some injury if applied to shallow-planted stands (1/4 to 1/2 inch).

Watermelons

(1) Pre-emergence and post-emergence.--Same as for cantaloupes and muskmelons.

SMALL FRUITS

Brambles (Raspberries, Blackberries) and Blueberries

(1) For control of weeds in early Spring in brambles grown in the hedge or linear system: First application--2,4-DES at 3 to 6 pounds or an amine salt of 2,4-D at 1/2 to 1 pound in 20 to 40 gallons of water per acre. DNBP at 2 to 4 pounds in 20 to 40 gallons of water per acre should be applied prior to emergence of weeds or new canes.

Second application--2,4-D treatment should be delayed until new canes are tall enough to permit directed basal application without getting spray on cane tips. All basal directed contact sprays should be applied when weeds are small.

(2) For control of winter annual grasses and broadleaved weeds in fall or early winter: CIPC at 4 to 8 pounds in 20 gallons of water per acre prior to weed emergence. Particularly effective also in controlling chickweed after emergence.

(3) In recent preliminary research investigations, monuron at 1 to 3 pounds in 50 gallons of water per acre applied to clean cultivated soil in the dormant season has given control of annual grasses and broadleaved weeds without significant injury to the crop.

Comments and precautions.--Do not use 2,4-D in brambles during blooming stage. Suitable mulches will aid in reducing weed problems, but mulching costs are usually high. Bramble crops are tolerant to a number of herbicides.

Grapes

(1) For control of annual grasses and broadleaved weeds beneath trellis: Oil-water emulsion of CIPC and DNBP. A mixture of 6 pounds CIPC plus 1 pound of oil-soluble DNBP in an oil-water emulsion (10 gallons of oil plus 40 gallons of water) applied to an 18- to 24-inch band on each side of the trellis at the rate of 50 gallons per acre will give excellent control of emerged grasses and broadleaved weeds. The contact action of DNBP kills the emerged annuals and the CIPC provides residual pre-emergence weed control.

(2) In recent research studies, monuron applied prior to weed emergence at 2 pounds in 40 gallons of water per acre as a soil treatment in the dormant season gave effective control of annual grasses and broadleaved weeds in mature vineyards. One application per year is usually adequate.

Comments and precautions.--Avoid application of herbicides to grape foliage and to young vines that have not developed a coating of loose bark. Grapes are extremely sensitive to phenoxy herbicides, such as 2,4-D, 2,4,5-T, 2-(2,4,5-TP), MCPA, and others. Do not use spray equipment that has been used to apply phenoxy-type herbicides to other crops unless equipment has been thoroughly cleaned and is known to be free of these herbicides.

Strawberries

(1) For weed control on full-year basis: Preplanting treatments (10 to 15 days before transplanting)--DNBP at 8 to 10 pounds, CIPC at 4 to 8 pounds, 2,4-D at 2 to 4 pounds, or 2,4-DES at 3 to 6 pounds in 10 to 40 gallons of water per acre, followed by post-planting treatments of 2,4-DES 14 to 21 days after transplanting and at intervals thereafter as needed. Do not cultivate during the period between preplanting treatment and transplanting. Cultivation should precede each 2,4-DES treatment until runner production limits cultivation.

(2) For control of broadleaved weeds and seedling annual grasses from 2 to 4 weeks after setting until fruit-bud differentiation begins: 2,4-D at 1/2 to 1 pound per acre applied as a selective foliage treatment.

(3) For fall and winter weed control when strawberries are dormant: DNBP at 1 to 2 pounds will control broadleaved weeds, and CIPC at 2 to 4 pounds in 40 gallons of water will control winter annual broadleaved weeds and grasses.

FLOWERS AND ORNAMENTALS

Gladiolus, Dutch Iris, Narcissus

(1) Pre-emergence.--For control of annual grasses and broadleaved weeds: 2,4-D at 2 to 4 pounds, 2,4-DES at 3 to 6 pounds, CIPC at 4 to 8 pounds, DNBP at 4 to 8 pounds, TCA at 6 to 10 pounds, combinations of CIPC at 4 pounds with 2,4-DES at 3 pounds or 2,4-D at 2 pounds per acre, or combinations of TCA at 6 pounds with 2,4-DES at 3 pounds or 2,4-D at 2 pounds in 20 to 40 gallons of water per acre applied just prior to emergence. Effective for 30 to 60 days or more.

(2) Post-emergence.--2,4-DES at 3 to 4 pounds in 20 to 40 gallons of water per acre applied 30 to 60 days after pre-emergence treatment but before weeds begin to emerge will usually extend period of weed control until harvest. Amine salts of 2,4-D at rates up to 1 pound per acre may be used as a post-emergence spray if applied before leaf blades open. 2,4-DES is less likely to cause injury than 2,4-D as a post-emergence spray.

Established Evergreen and Deciduous Plants

(1) For control of annual grasses and broadleaved weeds in rows of coniferous transplants and deciduous stocks: 2,4-DES at 3 to 6 pounds or CIPC at 4 to 8 pounds in 20 to 40 gallons of water per acre applied as a basal directed spray. For maximum effectiveness, both herbicides should be applied prior to weed emergence or to clean cultivated soil. Also herbicides should be applied so only a minimum of spray comes in contact with bases of plants.

(2) For control of annual weeds between rows: DNBP at 2 pounds or PCP at 4 pounds in 50 gallons of aromatic oil per acre. A low-pressure sprayer with a hooded boom should be used to prevent spray drift from coming in contact with nursery crops.

Comments and precautions.--Perennial weeds are not controlled by these treatments.

Seedbeds and Transplant Beds

(1) For control of most annual and perennial weeds: Methyl bromide at 1 pound per 100 square feet applied under a plastic gas-proof cover. Methyl bromide does not persist in soil, and plantings may be made safely within 72 hours after removing plastic cover. Other soil fumigants and steam sterilization may also be used effectively to control weeds in seedbeds and transplant beds.

(2) For control of most weeds germinating in upper 4 inches of soil: Calcium cyanamide at 50 to 75 pounds per 1,000 square feet applied to surface of soil and worked into the upper 2 to 3 inches of soil. Seeding or transplanting after using calcium cyanamide should be delayed for 3 to 6 weeks to avoid residual toxic effects of the treatment.

V. WEED CONTROL IN FORAGE CROPS, PASTURES, AND RANGELANDS

SEEDLING GRASS-LEGUME MIXTURES

(Including alfalfa, red clover, Ladino clover, alsike clover, birdsfoot trefoil, and lespedeza)

(1) For control of susceptible weeds such as bitterweed, tarweed, ragweed, lambs-quarters, pigweed, mustard, yellow rocket, sneezeweed, and others: Sodium or amine salts of MCPA or 2,4-D at 1/8 to 1/4 pound in 5 to 20 gallons of water per acre. Treatments will have little or no effect on grasses, but alfalfa, crimson clover, sweet-clover, bur clover, hop clover, and vetch may be injured. Herbicides should be applied when weeds are small and growing rapidly.

(2) For control of seedling broadleaved weeds: Amine salts of DNBP at 3/4 to 1-1/2 pounds in 20 to 40 gallons of water per acre may be applied without serious injury to legumes or grasses. When high temperatures and humid conditions prevail, use lowest rate in suggested range of application. DNBP may injure birdsfoot trefoil.

Comments and precautions.--Use of herbicides on seedling legumes should be avoided unless crop is seriously threatened by heavy weed infestations.

ESTABLISHED GRASS-LEGUME MIXTURES

(Including alfalfa, red clover, Ladino clover, alsike clover, birdsfoot trefoil, and lespedeza)

(1) For control of sensitive broadleaved weeds: MCPA or 2,4-D at 1/8 to 1/4 pound in 5 to 20 gallons of water per acre may be applied when legumes are in the early dormant stage or immediately after hay harvest without serious reduction of legume stand. The herbicides will have little if any effect on grass stand in the mixture. NOTE: Use of MCPA or 2,4-D on established grass-legume mixtures should be considered only as an emergency measure to control serious weed infestations that threaten loss of the crop. CIPC should not be applied on grass-legume mixtures since this herbicide will kill many cultivated grasses as well as the weedy grasses.

(2) For control of winter annual weeds, such as chickweed, henbit, and yellow rocket: Amine salts of DNBP at 1 to 2 pounds in 20 to 40 gallons of water per acre when legumes are dormant may be applied without injury to legume stand. DNBP should be applied in the fall as soon as legumes are dormant and while weeds are small. In grass-legume mixtures that are heavily infested with chickweed and other winter annual weeds to the extent the stand becomes lodged and matted, a second application of DNBP should be made in late winter or early spring while legumes are still dormant.

ESTABLISHED LEGUME MIXTURES

(Including alfalfa, red clover, Ladino clover, alsike clover, birdsfoot trefoil, and lespedeza)

(1) For control of winter annual broadleaved weeds and grasses, such as chickweed, yellow rocket, ryegrass, weedy brome grasses, and certain perennial grasses in humid regions: CIPC at 2 to 6 pounds in 5 to 20 gallons of water per acre applied in early fall or winter when legumes are dormant. NOTE: CIPC should not be applied on grass-legume mixtures since this herbicide will kill many cultivated grasses as well as the weedy grasses.

(2) For control of many weedy annual grasses: TCA at 6 to 8 pounds or dalapon at 3 to 6 pounds in 10 to 40 gallons of water per acre may be applied prior to grass emergence or when grasses are in the seedling stage without significant injury to

many legumes. Red clover, alsike clover, and annual lespedezas, however, are sensitive to TCA, and mixtures containing these species should not be sprayed for weed control with this herbicide. NOTE: Use of MCPA and 2,4-D on established legume mixtures, especially those containing alfalfa, should be considered as an emergency weed control measure. These herbicides should not be used unless serious weed infestations threaten the loss of the crop. If used, MCPA and 2,4-D, along with DNBP, should be applied following suggestions outlined for weed control in established grass-legume mixtures.

(3) For preharvest control of many grasses and most broadleaved annual weeds in legume seed fields: DNBP at 1 to 2 pounds or PCP at 4 to 6 pounds in 5 to 10 gallons of diesel oil per acre. Treatment will also facilitate harvest by desiccating and defoliating legumes. For serious grass infestations, endothal at 1 to 2 pounds plus ammonium sulphate at 4 to 6 pounds in 20 to 40 gallons of water per acre will often give better results than the DNBP treatment.

Higher rates of application are usually required under the arid conditions of the West.

ESTABLISHED FORAGE GRASSES FOR SEED PRODUCTION

(1) For control of most annual and many broadleaved perennial weeds: Post-emergence application of an amine salt or ester of 2,4-D or MCPA at 1/2 to 1 pound in 5 to 20 gallons of water per acre after grasses are well tillered but prior to reaching the boot stage may be applied without significant injury to the grasses. Applications of 2,4-D or MCPA should not be made in the early seedling stage, the boot stage, or in the early heading stage. The brome grasses, bluegrass, orchard grass, the fescues, the ryegrasses, dallis grass, and many others are tolerant to the treatment. However, the bent grasses and some others are known to be sensitive and treatment should not be attempted unless the tolerance of the grass species is known.

ESTABLISHED PERMANENT GRASS-LEGUME PASTURES

(Including white, Ladino, and alsike clovers)

(1) For control of most broadleaved weeds, such as bitterweed, tarweed, ragweed, boneset, sneezeweed, pigweed, chicory, dandelion, curled dock, burdock, Canada thistle, and others: Post-emergence application of an amine salt or ester of 2,4-D at 1/2 to 1 pound in 5 to 20 gallons of water per acre applied in late spring after the period of initial rapid growth of legumes but while weeds are still small.

(2) For control of wild garlic, wild onion, Canada thistle, and other semitolerant pasture weeds in many areas, 2 applications each year for 2 or more years may be required. Two applications--one during the period, October to December, and the second during the period, February to May--have proved effective in some areas for controlling wild onion, wild garlic, and curled dock in pastures. Foliage applications of 2,4,5-T may be used for spot treatment control of woody plants in pastures.

Comments and precautions.--Good cultural practices, including proper fertilization and efficient grazing management, must be emphasized as necessary for successful control of weeds in pastures. When these practices have been followed within the limits of practicality and weed infestations still occur, 2,4-D and 2,4,5-T or mixtures of these herbicides may be used effectively and safely for weed and woody plant control.

WEEDS AND WOODY PLANTS ON RANGELANDS

Aerial Applications

(1) For control of sand sagebrush: Ester of 2,4-D at 1 pound in oil or in an emulsion of 1 gallon of diesel oil to 2 to 4 gallons of water per acre applied in May or early

June to the foliage when plants are growing rapidly and have made 6 to 8 inches of new growth.

(2) For control of big sagebrush: Ester of 2,4-D at 1 to 2 pounds in 50 gallons, per acre, of oil, water, or oil-water emulsions when bunch grasses are heading.

(3) For control of mesquite: Ester of 2,4,5-T at 1/3 to 3/4 pound in oil or in an emulsion of 1 gallon of diesel oil to 3 gallons of water per acre applied to foliage. 2-(2,4,5-TP) has also shown promise for the control of mesquite.

(4) For control of shinnery oak: Repeated applications of an ester of 2,4-D at 1 pound in oil or in an emulsion of 1 gallon of diesel oil to 2 to 4 gallons of water per acre applied to foliage.

(5) For control of post oak, blackjack oak, and other associated woody plants: Ester of 2,4,5-T or 2-(2,4,5-TP) at 2 pounds in an emulsion of 1 gallon of diesel oil to 4 gallons of water or in 5 gallons of diesel oil per acre. Application should be repeated for 2 to 3 consecutive years using 1 to 2 pounds of either chemical. If a mixture of 2,4-D and 2,4,5-T is used, the first application should be made with 3 pounds and succeeding treatments with 2 pounds in an emulsion of 1 gallon of diesel oil to 4 gallons of water or in 5 gallons of diesel oil per acre.

(6) For control of buckbrush: Repeated applications of an ester of 2,4-D at 1 to 2 pounds in an emulsion of 1 gallon of diesel oil to 3 gallons of water or in 4 gallons of diesel oil per acre.

Single applications of foliage sprays with aerial equipment will often control mesquite, sand sage, and big sagebrush. Repeated treatments, however, are frequently needed. For satisfactory control of mixed stands of oak species and buckbrush, repeated applications for 2 or more consecutive years are normally required.

Ground Equipment Applications

(1) Foliage sprays applied with ground equipment may also be used to control the above species. Depending upon the tolerance of the particular species 2,4-D, 2,4,5-T, or 2-(2,4,5-TP) should be applied at 3 pounds per 100 gallons of water per acre. The best time to apply foliage sprays on most woody plants is at the full leaf stage and during the 3- to 4-week period thereafter, providing conditions are favorable for active growth prior to time of application.

(2) For effective control of mixed brush: Ammonium sulfamate at 3/4 pound to 1 gallon of water applied to foliage as a wetting spray.

(3) For control of large brush and trees: 2,4-D, 2,4,5-T, or 2-(2,4,5-TP) applied to basal bark, stump, or cut surface. (Treatments more fully described in Sec. VII, page 26.)

Comments and precautions.--In attempting to control weeds and woody plants growing in association with desirable forage grasses and legumes, it should be remembered that the margin of selectivity is often quite narrow. The difference between weed and brush control and no injury to forage species or severe injury to forage crops may often depend on a number of conditions that are subject to the fluctuations of environment in localized areas.

An attempt should always be made to apply the herbicide when the weeds are most susceptible and when the desirable species are least likely to be injured. These times of application are not always compatible. Frequently, desirable species are susceptible at the same time weeds are most susceptible. In these instances, the

seriousness of weed infestation will influence the decision to use herbicides or not.

Whenever possible, allow the weed canopy or companion-crop canopy to develop so it will mask spray from the forage species.

The herbicides 2,4-D, 2,4,5-T, 2-(2,4,5-TP), and MCPA are not poisonous to livestock at the rates of application normally used to control weeds in forage crops, pastures, and rangelands. If no poisonous weeds or woody plants or weeds containing poisonous constituents are present in the treated area, livestock need not be removed while or after the applications are made.

If poisonous weeds or poisonous woody plants are known to occur in pastures or on rangelands, remove the livestock from the area while spraying and for at least 30 days after treatment. Several herbicides, including 2,4-D, 2,4,5-T, and MCPA, are known to produce marked changes in the chemical composition of treated plants. There is also some evidence that some herbicides affect the palatability of certain plants and that livestock will eat certain species after they are treated that they normally would not eat.

VI. CONTROL OF HERBACEOUS PERENNIAL WEEDS

Herbaceous perennial weeds which die back to the ground each fall and develop new growth from crowns or roots the following spring usually have deep and extensive root systems and are difficult to kill with chemicals or other methods. On cultivated land control of such weeds may be most effectively and economically achieved by intensive cultivation in combination with suitable competitive crops and selective herbicides or temporary soil sterilant chemicals. On noncultivated land herbicides alone or in combination with tolerant grass crops must be used. Usually, different chemicals must be used for killing perennial grass weeds such as Johnson grass and quackgrass than for killing broadleaved perennial weeds like bindweed, Canada thistle, and leafy spurge. However, a few chemicals are effective on both types.

BROADLEAVED PERENNIALS

The phenoxy compounds 2,4-D, MCPA, and 2,4,5-T, are effective on many broadleaved species and usually provide the most economical means of control. Some of these weeds require repeated chemical treatments for 2 or more years for satisfactory control.

The broadleaved species which usually can be controlled by repeated treatments at 1/2 to 2 pounds of 2,4-D per acre are field bindweed, whitetop (hoary cress), sow-thistle, and Canada thistle. More resistant species that require 1 to 4 pounds per acre of 2,4-D are bur ragweed, dogbane, leafy spurge, and Russian knapweed. Weeds of the horsenettle group should be treated with 2,4,5-T at 1 to 4 pounds per acre.

Where possible, the phenoxy compounds should be used in combination with competitive crops of cereals, corn, or perennial grasses. Sometimes cereals and corn are damaged by the relatively high rates of chemical required for these weeds so, when possible, the treatment should be made before the crop is planted or after it is harvested. In dryland areas it is often advantageous to precede chemical treatment with 1 to 3 months of intensive cultivation to provide optimum growing conditions for the weed.

Canada thistle, Russian knapweed, leafy spurge, and some other broadleaved perennial weeds can sometimes be controlled with a single heavy application of amine or ester formulations of 2,4-D at 25 to 80 pounds per acre. The application should be made in the fall or early spring. The effects of the chemical remain in the soil for only a few weeks after the treatment.

Soil sterilants such as sodium chlorate, borax, or combinations of the two are effective and suitable for controlling deep-rooted broadleaved species on noncultivated land or small patches in cultivated fields. Chlorate should be used at 3 to 10 pounds per square rod, borax at 20 to 40 pounds, and mixtures at 6 to 20 pounds. Surviving plants should be re-treated as necessary in subsequent years. The arsenicals generally are much less effective on deep-rooted broadleaved species than on the shallower rooted grasses and sedges.

PERENNIAL GRASSES AND SEDGES

Johnson grass, Bermuda grass, and quackgrass in cultivated fields can be most easily and economically controlled by frequent cultivation--every 2 or 3 weeks during one growing season. Frequently the amount of cultivation necessary can be greatly reduced by applying TCA at 25 to 50 pounds or dalapon at 10 to 20 pounds per acre as a foliage and soil surface treatment before plowing or disking in late fall or early spring. Intertilled row crops should be grown the first year following such treatments to provide frequent tillage, competition for light, and permit spot cultivation or

chemical treatment to control surviving plants or patches of grass. Spot spraying with dalapon at 1/4 pound per gallon of water or TCA at 1/4 to 1/2 pound about once a month during the growing season will effectively control small patches of Johnson grass or Bermuda grass in cotton, corn, sorghum, or other row crops. Aromatic oils and dinitro-fortified fuel oils can also be effectively used in the same manner. Damage to crops in the treated areas usually will not exceed that caused by hand hoeing heavy weed infestations.

On ditchbanks and roadsides, in fence rows, and on other noncultivated areas, soil sterilant chemicals provide effective means of controlling Bermuda grass, Johnson grass, quackgrass, canary grass, reed grasses, Para grass, nutgrasses, and other grasses or sedges. The urea compounds, such as monuron, diuron, and fenuron, at 20 to 80 pounds per acre usually give excellent control of these species when adequate precipitation comes following application. These weeds usually are not controlled at or below the waterline along drainage and irrigation canals. Sodium chlorate at 4 to 10 pounds per square rod and borax at 20 to 40 pounds are also effective in many situations.

Single or repeated applications of TCA at 80 to 160 pounds per acre as a soil treatment and dalapon at 10 to 40 pounds per acre as a foliage treatment are effective on most perennial grasses in southern, eastern, and north-central regions. These chemicals are effective on Johnson grass in the Southwest but are less effective on quackgrass in the Western Intermountain States, perhaps because of highly alkaline soils.

VII. CONTROL OF WOODY PLANTS AND WEEDS ALONG FENCEROWS, DITCHBANKS, ROADSIDES, UTILITY LINES, AND ON NON-CULTIVATED AREAS

FOLIAGE SPRAYS

(1) Woody plants and weeds, including mixed brush species.--Woody plants and weeds sensitive to esters of 2,4-D, 2,4,5-T, 2-(2,4,5-TP), and MCPA may be controlled by the application of a wetting foliage spray containing 3 pounds of the herbicide per 100 gallons of water. A mixture of 2,4-D and 2,4,5-T is suggested for the control of mixed brush species, some of which are tolerant to 2,4-D but not to 2,4,5-T and vice versa. A wetting foliage spray of ammonium sulfamate at 3/4 pound in 1 gallon of water will effectively control mixed brush species.

BASAL SPRAYS DURING GROWTH OR DORMANT PERIODS

(1) Trees and brush less than 6 inches in diameter.--Basal sprays containing esters of 2,4-D or 2,4,5-T or mixtures of these herbicides at 8 to 16 pounds in 100 gallons of diesel oil may be applied during dormancy or active growth periods to kill trees and brush that are less than 6 inches in diameter. The spray should be applied to the entire basal area of all stems to a height of 12 to 18 inches and to the point of run-off. Basal treatment is usually more effective on the tolerant species than foliage applications.

CUT SURFACE TREATMENTS

(1) Trees 6 inches in diameter or larger.--An ester of 2,4,5-T at 16 pounds in 100 gallons of diesel oil applied in frills or cups cut into the trunks of trees will give good control of trees 6 inches in diameter or larger. This treatment is also suggested for the control of woody species with thick bark.

STUMP TREATMENT

(1) Stumps and stump sprouts.--In recently cut-over areas, and on rights-of-way of roadsides and utility lines where standing trees are objectionable, it is often desirable to prevent sprouting of stumps after the trees have been cut and removed by mechanical means. The stumps of cut trees may be effectively killed and sprouting prevented by using 2,4,5-T or mixtures of 2,4-D and 2,4,5-T at 8 to 16 pounds of acid equivalent per 100 gallons of diesel oil applied to the stump so as to wet completely the top and sides to ground level. High volume should be used and all exposed roots should be sprayed.

Ammonium sulfamate may be applied as crystals to the surface of the stump or the entire stump may be sprayed with the herbicide at 4 to 6 pounds per gallon of water. This treatment is also effective in preventing sprouting of stumps.

SOIL STERILIZATION

The term "soil sterilization" refers to nonselective weed control in which the soil is rendered unproductive for varying durations but not permanently.

Soil sterilants are used to control all the vegetation on an area. Few if any chemicals alone will kill all species of plants at rates of application that would be economically feasible. For this reason, herbicide mixtures are finding wider use for soil sterilization.

Sodium chlorate at 500 to 1,800 pounds per acre, borax at 1,800 to 4,800 pounds, sodium arsenite at 300 to 1,200 pounds, the urea herbicides at 20 to 100 pounds, and mixtures

of these herbicides with 2,4,5-T, 2,4-D, dalapon, or TCA and fortifying agents such as the herbicidal oils, the dinitro compounds, and pentachlorophenol may be used for the control of vegetation on railroad rights-of-way, industrial sites, and in other noncultivated areas. Use the higher rates of application if semipermanent soil sterilization is required and the lower rates if contact kill or temporary soil sterilization is the objective. The treatments suggested above will render most soils unproductive for periods of 30 days to 4 years or more depending on the chemical used, the soil type, and a number of soil properties and climatic factors.

VIII. WEED CONTROL IN LAWNS AND OTHER TURF AREAS

WEED CONTROL IN LAWN AND TURF SEEDBEDS PRIOR TO ESTABLISHMENT

When establishing a lawn or seeding turf areas, annual grasses and broadleaved weeds may be controlled by a preplanting treatment of calcium cyanamide. The chemical should be applied and disked or raked to mix it into the upper 1/2- to 1-inch layer of soil at the rate of 50 to 80 pounds per 1,000 square feet. Most effective results are usually obtained by making a split application. Apply 25 to 40 pounds per 1,000 square feet and rake it into the upper 1/2 to 1 inch of soil. Then apply 25 to 40 pounds per 1,000 square feet on the soil surface. Seeding of the turf grasses must be delayed for 2 to 4 weeks until the toxic effects of the calcium cyanamide have disappeared. Once the toxic effects have disappeared, the decomposition products of calcium cyanamide serve as an excellent source of nitrogen and calcium.

WEED CONTROL IN ESTABLISHED LAWNS AND TURF

Spring Treatments for Control of Crabgrass and Broadleaved Weeds

(1) Home Lawns.--For the control of crabgrass and broadleaved weeds such as dandelions, plantain, curled dock, wild onion, chickweed, and henbit in home lawns, use a mixture consisting of 2 ounces or 4 tablespoons of PMA (based on any product containing 10 percent PMA by weight) and 1 ounce or 2 tablespoons of an amine salt of 2,4-D (any product containing 4 pounds of 2,4-D per gallon of concentrate) in 2 gallons of water per 1,000 square feet. The PMA-2,4-D mixture should be applied just at crabgrass emergence and any time after emergence up to the two-leaf stage of crabgrass growth. Omit the 2,4-D from the mixture and repeat the PMA treatment at 7- to 10-day intervals until three applications have been made.

Potassium cyanate (KOCN) at 3 1/2 ounces or 7 tablespoons in 2 gallons of water per 1,000 square feet may be used to replace PMA in the treatments described above. MCPA at the same rate of application suggested for 2,4-D may be used instead of 2,4-D in mixtures with PMA or KOCN.

Chickweed not treated in the fall should be sprayed as soon as it appears in early spring. Use 4 ounces or 8 tablespoons of ammonium DNBP (4,6-dinitro ortho secondary butyl phenol) or 2 ounces or 4 tablespoons of amine DNBP in 1 gallon of water per 1,000 square feet of lawn.

(2) Extensive Turf Areas.--For the control of crabgrass and broadleaved weeds on extensive turf areas a mixture consisting of 1 pound of an amine salt of 2,4-D (or 1 quart of an amine salt of 2,4-D from any commercial product containing 4 pounds of 2,4-D per gallon of concentrate) and 3/4 pound of PMA (or 6 pints of any PMA formulation containing 10 percent PMA by weight) in 40 gallons of water per acre should be applied immediately after crabgrass emergence and any time up to the two-leaf stage of crabgrass growth. Omit the 2,4-D from the mixture and apply two additional treatments of PMA alone at 3/4 pound in 40 gallons of water per acre at 7- to 10-day intervals in order to obtain satisfactory control of crabgrass.

The first treatment with the PMA-2,4-D mixture will effectively control such broadleaved weeds as dandelions, plantain, curled dock, wild onion, chickweed, and others. The two additional treatments of PMA alone are required to control crabgrass and other annual grasses. The PMA-2,4-D mixture should be applied immediately following mixing.

Potassium cyanate (KOCN) at 8 to 16 pounds in 40 gallons of water used in the same manner as described for PMA above may be used instead of PMA depending on cost

and availability of chemicals. KOCN should not be used on lawns or turf containing a high percentage of the bent or fescue grasses.

For the control of chickweed on extensive turf areas when fall treatments are not possible, use 1 pound of ammonium DNBP or 1 1/2 pounds of amine DNBP in 40 gallons of water per acre. The treatment should be made in late winter or in early spring as soon as chickweed appears. Re-treatment may be necessary to control regrowth and late germinating chickweed.

Fall Treatments for Control of Broadleaved Weeds

(1) Home Lawns.--For the control of broadleaved weeds in home lawns in the fall a mixture containing 1 ounce or 2 tablespoons of an amine salt of 2,4-D and 4 ounces or 8 tablespoons of an ammonium salt of DNBP (4,6-dinitro ortho secondary butyl phenol) (or 2 ounces or 4 tablespoons of an amine salt of DNBP) in 1 gallon of water per 1,000 square feet applied in the fall after chickweed has germinated will give good control of chickweed and other weeds such as dandelions, plantain, curled dock, wild onion, wild garlic, and henbit.

KOCN may be used to replace DNBP in the mixture if DNBP compounds are not available. KOCN should be applied at 3 1/2 ounces per gallon of water per 1,000 square feet.

Fall applications of 2,4-D are more effective than spring applications in controlling dandelions, plantain, curled dock, and other perennial weeds in lawns in many areas. In areas where crabgrass is a serious lawn weed, broadleaved weeds that are killed by spring applications of 2,4-D will be replaced by germinating crabgrass before the turf grasses fill in the sod. The turf grasses will fill in the sod prior to crabgrass emergence if 2,4-D is used to kill broadleaved weeds in the fall rather than in the spring.

(2) Extensive Turf Areas.--For the control of broadleaved weeds in the fall on extensive turf areas, a mixture consisting of an amine salt of 2,4-D at 1 pound (1 quart of any product containing 4 pounds of 2,4-D per gallon) and 1 to 1 1/2 pounds of DNBP (1 gallon of ammonium DNBP or 1/2 gallon of an amine salt of DNBP) in 40 gallons of water per acre applied in the fall after chickweed has germinated will give good control of chickweed and other weeds such as dandelions, plantain, curled dock, ground ivy, wild onion, wild garlic, and henbit. The treatment should be applied in the late summer or early fall during periods favoring active plant growth. KOCN at 10 pounds in 40 gallons of water per acre may be used to replace DNBP in the above mixture.

Control of Spot Infestations of Weeds (Fall or Spring Treatments)

(1) Home Lawns.--Weedy lawn grasses such as orchard grass, timothy, quackgrass, goose grass, dallis grass, nimble will, and others may be killed with an application of dalapon or TCA when they occur in spot infestations in lawns. Prepare the solution by dissolving 1/4 pound dalapon or 1/2 pound of TCA in 1 gallon of water. Using a syringe or other application devices wet the crowns of the weedy grass plants. This treatment will also kill desirable turf grasses if the chemical is applied directly to the lawn grasses. The localized spot treatment of weedy grasses is possible without injury to lawn grasses only if the chemical application is restricted to the crowns of the weedy grasses.

Broadleaved weeds such as wild onion, wild garlic, dandelions, and plantain may be killed with localized treatments of 2,4-D without spraying the entire lawn. For the control of spot infestations of wild onion or wild garlic use a 5 percent solution of 2,4-D in water. This solution may be prepared by mixing 5 ounces of an amine salt of 2,4-D to approximately 1 gallon of water. Place a rubber glove over your hand to protect it from

the chemical and pull an absorbent cotton glove over the rubber glove. Apply the solution to the wild onions by dipping your gloved hand into the mixture and then firming your hand around the tops of the weed. Press hard enough to break through the waxy coating on the onion or garlic leaves. This will permit the chemical to penetrate into the plant and move downward killing both the above ground and below ground parts.

For the spot treatment control of dandelions, plantain, and curled dock, the same solution used to kill wild onion and wild garlic may be applied. Fasten a piece of kitchen sponge to the end of a stick or broom handle. Then dip the sponge into the solution and spot treat broadleaved weeds by pressing the moist sponge against the crown of each plant. Desirable plants nearby will not be injured if you are careful not to touch their foliage. This spot treatment method eliminates the danger of spray drift and allows the operator to kill weeds growing close to desirable flowers and shrubs.

Comments and precautions.--The PMA or KOCN-2,4-D mixtures will give control of crabgrass, plantain, dandelion, curled dock, wild onion, chickweed, henbit, and other woody annual grasses and broadleaved weeds. KOCN may be used instead of PMA and MCPA may be used instead of 2,4-D with approximately the same degree of effectiveness.

KOCN should be used only with care on lawns containing the bentgrasses and fescue grasses. The use of 2,4-D at rates more than 1/4 pound per acre on bentgrass lawns should be avoided.

PMA and DNBP are poisonous to humans and animals in concentrated form, and should be stored where they are not accessible to children. Contact with spray solutions or vapors should always be avoided. These chemicals do not present a hazard to humans or animals after they are applied to lawns for crabgrass control. However, children and animals should be kept off the sprayed areas until the first rain after application. Contaminated gloves and spray equipment should not be stored near sensitive plants.

Flowers, shrubs, and trees may be damaged by spray drift or vapors. Avoid spray drift by spraying on days when wind velocities are low, and use low pressures to produce a coarse spray. Use only the salts or low volatile esters of 2,4-D or MCPA. Other herbicides, however, are available for weed control in lawns, and should be used according to the directions of the manufacturer.

IX. PLANTS REFERRED TO THIS IN THIS REPORT

FIELD CROPS

1. Alfalfa	<u>Medicago sativa</u>
2. Alsike clover	<u>Trifolium hybridum</u>
3. Barley	<u>Hordeum vulgare</u>
4. Birdsfoot trefoil	<u>Lotus corniculatus</u>
5. Burclover	<u>Medicago hispida</u>
6. Bromegrasses	<u>Bromus spp.</u>
7. Corn	<u>Zea mays</u>
8. Cotton	<u>Gossypium hirsutum</u>
9. Crimson clover	<u>Trifolium incarnatum</u>
10. Dallis grass	<u>Paspalum dilatatum</u>
11. Flax	<u>Linum usitatissimum</u>
12. Hop clover	<u>Trifolium agrarium</u>
13. Kentucky bluegrass	<u>Poa pratensis</u>
14. Ladino or white clover	<u>Trifolium repens</u>
15. Lespedeza	<u>Lespedeza spp.</u>
16. Oats	<u>Avena sativa</u>
17. Orchard grass	<u>Dactylis glomerata</u>
18. Peanuts	<u>Arachis hypogaea</u>
19. Peas	<u>Pisum sativa</u>
20. Red clover	<u>Trifolium pratense</u>
21. Rice	<u>Oryza sativa</u>
22. Ryegrasses	<u>Lolium spp.</u>
23. Sorghum	<u>Sorghum vulgare</u>
24. Soybeans	<u>Soja max</u>
25. Sugar beets	<u>Beta vulgaris</u>
26. Sweetclover	<u>Melilotus spp.</u>
27. Tall fescue	<u>Festuca spp.</u>
28. Tobacco	<u>Nicotiana tabacum</u>
29. Wheat	<u>Triticum vulgare</u>

HORTICULTURAL CROPS

1. Asparagus	<u>Asparagus officinalis</u>
2. Blackberries	<u>Rubus spp.</u>
3. Blueberries	<u>Vaccinium spp.</u>
4. Broccoli	<u>Brassica oleracea</u>
5. Cabbage	<u>Brassica oleracea</u>
6. Cantaloupes	<u>Cucumis melo</u>
7. Carrots	<u>Daucus carota</u>
8. Cauliflower	<u>Brassica oleracea</u>
9. Celery	<u>Apium graveolens</u>
10. Collards	<u>Brassica oleracea</u>
11. Cucumbers	<u>Cucumis sativus</u>
12. Dill	<u>Anethum graveolens</u>
13. Dutch iris	<u>Iris spp.</u>
14. Gladiolus	<u>Gladiolus spp.</u>
15. Grapes	<u>Vitis spp.</u>
16. Kale	<u>Brassica oleracea</u>
17. Lettuce	<u>Lactuca sativa</u>
18. Lima beans	<u>Phaseolus lunatus</u>
19. Muskmelons	<u>Cucumis melo</u>
20. Mustard	<u>Brassica juncea</u>
21. Narcissus	<u>Narcissus spp.</u>

22. Onions	<u>Allium cepa</u>
23. Parsley.....	<u>Petroselinum hortense</u>
24. Parsnips	<u>Pastinaca sativa</u>
25. Potatoes.....	<u>Solanum tuberosum</u>
26. Rape.....	<u>Brassica napus</u>
27. Raspberries.....	<u>Rubus spp.</u>
28. Red beets	<u>Beta vulgaris</u>
29. Snapbeans.....	<u>Phaseolus vulgaris</u>
30. Spinach	<u>Spinacia oleracea</u>
31. Strawberries.....	<u>Fragaria spp.</u>
32. Sweet corn.....	<u>Zea mays</u>
33. Turnips.....	<u>Brassica rapa</u>
34. Watermelons.....	<u>Citrullus vulgaris</u>

WEEDS

1. Barnyard grass	<u>Echinochloa crusgalli</u>
2. Big sagebrush.....	<u>Artemesia tridentata</u>
3. Bittersweet.....	<u>Helenium tenuifolium</u>
4. Boneset.....	<u>Eupatorium spp.</u>
5. Buck brush	<u>Symphoricarpos vulgaris</u>
6. Burdock	<u>Arctium minus</u>
7. Buttercup	<u>Ranunculus spp.</u>
8. Canada thistle	<u>Cirsium arvense</u>
9. Chickweed	<u>Stellaria media</u>
	<u>Cerastium spp.</u>
10. Chicory.....	<u>Cichorium intybus</u>
11. Cocklebur.....	<u>Xanthium spp.</u>
12. Coffeeweed	<u>Sesbania macrocarpa</u>
13. Crabgrass	<u>Digitaria sanguinalis</u>
14. Curled dock.....	<u>Rumex crispus</u>
15. Dandelion	<u>Taraxacum officinale</u>
16. Field bindweed	<u>Convolvulus arvensis</u>
17. Foxtail.....	<u>Setaria spp.</u>
18. Henbit.....	<u>Lamium amplexicaule</u>
19. Horsenettle.....	<u>Solanum carolinense</u>
20. Ironweed	<u>Vernonia spp.</u>
21. Johnson grass	<u>Sorghum halepense</u>
22. Lambsquarters.....	<u>Chenopodium album</u>
23. Marsh elder.....	<u>Iva xanthifolia</u>
24. Mesquite	<u>Prosopis juliflora</u>
25. Milkweed.....	<u>Asclepias spp.</u>
26. Annual morning glory	<u>Ipomoea purpurea</u>
27. Mustard	<u>Brassica kaber</u>
28. Nutgrass	<u>Cyperus rotundus</u>
	<u>C. esculentus</u>
29. Oaks.....	<u>Quercus spp.</u>
30. Pigweed	<u>Amaranthus retroflexus</u>
31. Plantain	<u>Plantago spp.</u>
32. Prickly lettuce	<u>Lactuca scariola</u>
33. Quackgrass.....	<u>Agropyron repens</u>
34. Ragged robin.....	<u>Centaurea cyanis</u>
35. Ragweed.....	<u>Ambrosia artemisiifolia</u>
36. Russian knapweed	<u>Centaurea repens</u>
37. Sand sagebrush.....	<u>Artemisia filifolia</u>
38. Shepherds purse	<u>Capsella bursa-pastoris</u>
39. Smartweed.....	<u>Polygonum pennsylvanicum</u>
40. Sneezeweed.....	<u>Helenium nudiflorum</u>

41. Sow thistle.....	<u>Sonchus arvensis</u>
42. Pennycress.....	<u>Thlaspi arvense</u>
43. Sunflower.....	<u>Helianthus annuus</u>
44. Tarweed.....	<u>Iva ciliata</u>
45. Vetch.....	<u>Vicia spp.</u>
46. White cockle.....	<u>Lychnis alba</u>
47. Whitetop.....	<u>Cardaria draba</u>
48. Wild garlic.....	<u>Allium vineale</u>
49. Wild oats.....	<u>Avena fatua</u>
50. Wild onion.....	<u>Allium canadense</u>
51. Wild radish.....	<u>Raphanus raphanistrum</u>
52. Yellow rocket.....	<u>Barbarea vulgaris</u>

X. CHEMICALS REFERRED TO IN THIS REPORT

<u>Abbreviation</u>	<u>Chemical name*</u>	<u>Rates of application expressed in terms of:</u>
1. 2,4-D	2,4-dichlorophenoxyacetic acid.....	Acid equivalent
2. 2,4,5-T	2,4,5-trichlorophenoxyacetic acid.....	Acid equivalent
3. MCPA	2-methyl-4-chlorophenoxyacetic acid.....	Acid equivalent
4. 2-(2,4,5-TP)	2,4,5-trichlorophenoxypropionic acid.....	Acid equivalent
5. IPC	Isopropyl N-phenylcarbamate.....	100% IPC
6. CIPC	Isopropyl N-(3-chlorophenyl)carbamate.....	100% CIPC
7. Monuron	3-(p-chlorophenyl)-1,1-dimethylurea.....	100% monuron
8. Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea.....	100% diuron
9. Fenuron	3-(phenyl)-1,1-dimethylurea.....	100% fenuron
10. TCA	Trichloroacetic acid.....	Acid equivalent
11. Dalapon	2,2-dichloropropionic acid.....	Acid equivalent
12. DNBP	4,6-dinitro ortho secondary butylphenol.....	DNBP equivalent
13. DNAP	4,6-dinitro ortho secondary amylphenol.....	DNAP equivalent
14. DNC	4,6-dinitro ortho cresol.....	DNC equivalent
15. PCP	Pentachlorophenol.....	PCP equivalent
16. 2,4-DES	2,4-dichlorophenoxyethyl sulfate.....	100% 2,4-DES
17. Endothal	3,6-endoxohexahydrophthallic acid.....	100% endothal
18. NPA	N-1-naphthyl phthalamic acid.....	Acid equivalent
19. MH	1,2-dihydro-pyridazine-3,6-dione (maleic hydra- zide).....	100% MH
20. PMA	Phenyl mercuric acetate.....	100% PMA
21. KOCN	Potassium cyanate.....	100% KOCN

*All other herbicides are referred to by their chemical names.

XI. SUMMARY OF CHEMICALS BY CROPS

FIELD CROPS

- Corn:
Pre-emergence--2,4-D
Post-emergence--2,4-D
Directed post-emergence treatment at layby--2,4-D
- Sorghum:
Post-emergence--2,4-D
- Wheat, Barley, and Oats--Fall or Spring Seeded:
Underseeded with legumes:
Post-emergence--MCPA, 2,4-D, DNBP
Not underseeded with legumes:
Post-emergence--2,4-D, MCPA
- Flax:
Post-emergence--MCPA, 2,4-D, mixture of MCPA and TCA
- Cotton:
Humid Belt:
Pre-emergence--CIPC
Directed post-emergence--Nonfortified herbicidal oils
Western Irrigated Cotton Belt:
Directed post-emergence in established cotton--monuron, diuron, NPA
- Soybeans:
Pre-emergence--CIPC, DNBP
- Peanuts:
Pre-emergence--DNBP, 2,4-DES
- Rice:
Post-emergence--2,4-D, MCPA, 2,4,5-T
- Sugar beets:
Pre-planting--IPC
Pre-emergence--TCA. (In localized areas, TCA, dalapon, DCU, PCP, IPC are used.)
Post-emergence--Sodium chloride, dalapon
- Tobacco (plant beds):
Pre-emergence--Uramon and calcium cyanamide, calcium cyanamide, methyl bromide

VEGETABLES

- Asparagus:
Seedbeds, pre-emergence--Monuron, light aromatic oil
Established beds, pre-emergence--2,4-D, 2,4-DES, TCA, NPA, monuron
- Beans:
Pre-emergence--DNBP, PCP, CIPC
- Beets:
Same as suggested for sugar beets

Cabbage, Cauliflower, Collards, Kale, Rape, Broccoli, Turnips, Mustard (as leafy vegetables):

Pre-emergence--TCA; CIPC in several Mid-Atlantic States

Cantaloupes, Muskmelons:

Pre-emergence--NPA

Post-emergence--NPA

Carrots, Celery, Dill, Parsnips, Parsley:

Post-emergence--Light aromatic oils

Cucumbers:

Same as for cantaloupes and muskmelons

Lettuce:

Same as for cabbage

Onions:

Pre-emergence--Light aromatic oil, sulphuric acid, CIPC, and combinations of CIPC and light aromatic oils

Post-emergence--Sulphuric acid, KOCN; for onions in 5-leaf stage and after last cultivation, CIPC, KOCN, monuron, sulphuric acid

Peas:

Preplanting--IPC

Pre-emergence--DNBP

Post-emergence--DNBP; in North-Central Region, MCPA

Potatoes:

Pre-emergence--DNBP, PCP, TCA

Spinach:

Pre-emergence, early spring planting--CIPC

Sweet Corn:

Pre-emergence--2,4-D, DNBP, PCP

Post-emergence--2,4-D

Watermelons:

Same as for cantaloupes and muskmelons

SMALL FRUITS

Brambles (Raspberries, Blackberries) and Blueberries:

Pre-emergence and dormant treatments--2,4-DES, 2,4-D, DNBP, CIPC, monuron

Grapes:

Pre-emergence and post-emergence--DNBP, CIPC

Soil treatment--Monuron

Strawberries:

Pre-planting, post-planting, and dormant treatments--DNBP, CIPC, 2,4-D, 2,4-DES

FLOWERS AND ORNAMENTALS

Gladiolus, Dutch Iris, Narcissus:

Pre-emergence--2,4-D, 2,4-DES, CIPC, DNBP, TCA, combinations of CIPC with 2,4-DES or 2,4-D, combinations of TCA with 2,4-DES or 2,4-D

Post-emergence--2,4-DES, 2,4-D

Established Evergreen and Deciduous Plants:

2,4-DES, CIPC, DNBP, PCP

Seedbeds and Transplant Beds:

Methyl bromide, calcium cyanamide

FORAGE CROPS, PASTURES, RANGELANDS

Seedling Grass-Legume Mixtures:

MCPA or 2,4-D for susceptible weeds; DNBP for seedling broadleaved weeds

Established Grass-Legume Mixtures:

MCPA or 2,4-D for sensitive broadleaved weeds; DNBP for winter annual weeds

Established Legume Mixtures:

CIPC for winter annual broadleaved weeds and grasses; TCA or dalapon for many weedy annual grasses; DNBP or PCP in diesel oil. (MCPA or 2,4-D only as emergency measures.)

Established Forage Grasses for Seed Production:

2,4-D, MCPA

Established Permanent Grass-Legume Pastures:

2,4-D; 2,4,5-T for spot treatment control of woody plants

Weeds and Woody Plants on Rangelands:

Sand sagebrush--2,4-D

Big sagebrush--2,4-D

Mesquite--2,4,5-T, 2-(2,4,5-TP)

Shinnery oak--2,4-D

Post oak, blackjack oak, and associated woody plants--2,4,5-T, 2-(2,4,5-TP), mixture of 2,4-D and 2,4,5-T

Buckbrush--2,4-D

Mixed brush--Ammonium sulfamate

Large brush and trees--2,4-D, 2,4,5-T, 2-(2,4,5-TP)

HERBACEOUS PERENNIAL WEEDS

Broadleaved Perennials:

2,4-D, MCPA, 2,4,5-T

Perennial Grasses and Sedges:

Cultivated areas--TCA, dalapon, aromatic oils, dinitro-fortified fuel oils; non-cultivated areas--urea compounds such as monuron, diuron, and fenuron, sodium chlorate, borax

WOODY PLANTS AND WEEDS ALONG FENCEROWS, DITCHBANKS, ROADSIDES, UTILITY LINES, AND ON NONCULTIVATED AREAS

Woody Plants and Weeds:

2,4-D, 2,4,5-T, 2-(2,4,5-TP), MCPA, ammonium sulfamate

Trees and Brush Less Than 6 Inches in Diameter:

2,4-D, 2,4,5-T, mixtures of the two

Trees 6 Inches in Diameter or Larger:

2,4,5-T

Stumps and Stump Sprouts:

2,4,5-T, mixture of 2,4-D and 2,4,5-T, ammonium sulfamate

Soil Sterilization:

Sodium chlorate, borax, sodium arsenite, urea herbicides, and mixtures of these herbicides with dalapon, TCA, 2,4,5-T, 2,4-D, herbicidal oils, dinitro compounds, pentachlorophenol, or other fortifying agents

LAWNS AND OTHER TURF AREAS

Weed Control in Lawn and Turf Seedbeds Prior to Establishment:

Calcium cyanamide

Spring Treatments for Control of Crabgrass and Broadleaved Weeds:

Home Lawns--Mixture of PMA and 2,4-D, mixture of KOCN and 2,4-D, mixture of PMA and MCPA, mixture of KOCN and MCPA, DNBP

Extensive turf areas--Mixture of PMA and 2,4-D, KOCN, DNBP

Fall Treatments for Control of Broadleaved Weeds:

Home Lawns--Mixture of 2,4-D and DNBP, mixture of 2,4-D and KOCN

Extensive turf areas--Mixture of 2,4-D and DNBP, mixture of 2,4-D and KOCN

Control of Spot Infestations of Weeds:

Home Lawns--For weedy lawn grasses, TCA; for broadleaved weeds, 2,4-D