ARS SPECIAL REPORT

SUGGESTED GUIDE

for

CHEMICAL CONTROL OF WEEDS

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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 the Weed Society of America and in four regional conferences to discuss research developments in 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.

This is a revision of, and supersedes, ARS 22-23, "Suggested Guide for Chemical Control of Weeds," April 1956

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SUGGESTED GUIDE FOR CHEMICAL CONTROL OF WEEDS[1]

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 is being made available, and the specific situations in which each is most effective are being determined. Wider use of selective herbicides in crop production will help bring about better harvesting methods, a greater degree of mechanization, better yields, and fewer losses.

Chemical weed control should be considered as a supplement to the use of improved cultural and management 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 are extremely important. There are no substitutes for proper fertilization and management of adapted crop plants.

Suggestions given in this publication on rates of herbicides to use are based upon the active ingredient or acid equivalent contained, and not upon the total weight of any commercial formulation.

SPECIAL NOTE

All chemicals included in this report either are registered for one or more specific uses or have received experimental permits under the Federal Insecticide, Fungicide, and Rodenticide Act. With certain exceptions (indicated in footnotes), the chemicals in this report may be used as specified since such use will result in the production of raw agricultural commodities meeting the requirements of Miller Pesticides Chemicals Amendment (Public Law 518). Each chemical should be applied in accordance with the directions on the manufacturer's label as to the crop specified, in the amounts specified, and at the times specified. The excepted chemicals have been found to be effective in controlling weeds, but (as of April 1, 1958) they cannot be recommended for use on the crops specified since evidence has not been developed to prove that they will leave no residues or/and tolerances have not been set under Public Law 518.

Since the status of many chemicals is changing rapidly, and new materials or new uses for older materials are being recommended, it is important to keep in touch with the U.S. Department of Agriculture, State agricultural experiment stations, or manufacturers of specific products for up-to-date information.

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

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.

Available information on the degree of toxicity of herbicides is listed in the descriptions of chemicals used for weed control. The symbol LD_{50} (lethal dosage that kills 50% of the experimental animals) precedes each number that indicates relative toxicity. For example, the single acute oral dose for calcium cyanamide, LD_{50} = 1,400 mg./kg., indicates a relatively low oral toxicity. The larger the LD_{50} number, the less poisonous the herbicide.

All LD values listed in this guide are based on a single dose of material orally administered to animals, followed by observation of the treated animals for a definite period of time. However, these findings do not indicate the possible hazards that may arise from skin contact or inhalation of the substance or substances indicated. Likewise, these data do not accurately predict the toxicity of a formulation which may differ according to the solvent or diluent employed.

PHENOXY COMPOUNDS

Several compounds in this group, including 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 2-methyl, 4-chlorophenoxyacetic acid (MCPA), and 2,4,5-trichlorophenoxypropionic acid (silvex) are used as post-emergence selective herbicides to control broadleaved weeds in corn, small grains, sorghum, rice, flax, lawns, and to control brush and weeds in pastures, along roadsides, rights-of-way, and drainage and irrigation ditches. Some of the phenoxy compounds also may 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 usually are formulated and marketed as two basic types. They are of low to intermediate oral toxicity (LD_{50} = 375 to 1,200 mg./kg.) for the various formulations.

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. 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.

Some of the phenoxy compounds also are commercially available as sodium and ammonium salt formulations. These compounds are available chiefly as water-soluble powders, but some of these herbicides also are 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.--This type includes 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 esters should be applied at the lower rates and the amine or other salts at the higher rates.

(b) Relatively low volatile esters.--This type includes the butoxyethanol, butoxyethoxypropanol, capryl, ethoxyethoxypropanol, isooctyl, propylene glycol butyl ether, and other esters known to be low volatile. The low volatile esters are less hazardous than high volatile esters in areas adjacent to susceptible crops when temperatures are 95° F. or less. When temperatures exceed 95° 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 hazardous to adjacent susceptible crops.

2,4-DICHLOROPHENOXYETHYL SULFATE (Sesone)

This herbicide is formulated as the sodium salt and is a white crystalline powder that is soluble in water. When applied to moist soils, sesone is converted into a herbicide with properties similar to 2,4-D. It is effective as a pre-emergency herbicide for weed control in a number of crops. Unlike 2,4-D, however, sesone possesses little or no phytotoxicity as a foliage spray on most plants. Sesone, 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. Sesone is not effective as a post-emergence foliage spray; therefore it must be applied to the soil before emergence of the weeds to give effective control. It has been effective as a post-planting spray for weed control in strawberries when applied before emergence of the weeds. The herbicide has been erratic in performance during periods of inadequate soil moisture.

Sesone is of relatively low toxicity (LD_{50} = 730 to 1,400 mg./kg.) for rats.

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 4,6-dinitro ortho secondary butylphenol (DNBP), 4,6-dinitro ortho secondary amylphenol (DNAP), and 3,5-dinitro ortho cresol (DNC). 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 used for selective pre-emergence and post-emergence weed control in some crops.

The dinitro compounds are yellow dyes that impart a yellow coloration to clothes and skin. These compounds 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. When these materials are used as pre-emergence sprays, severe injury to the crop often results if extremely high temperatures occur in the 2-week period following treatment.

The dinitro compounds are highly toxic (LD_{50} = 26 to 45 mg./kg.) for rats.

2. Chloro Substituted Phenols

These include pentachlorophenol (PCP), 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.

The pentachlorophenols are of relatively intermediate to high oral toxicity (LD_{50} = 50 to 500 mg./kg. for the various formulations) when fed to rats.

CARBAMATES

The carbamates at present include isopropyl N-phenylcarbamate (IPC), isopropyl N-(3-chlorophenyl)carbamate (CIPC), and 2-chloroallyl diethyldithiocarbamate (CDEC). 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-gallonage sprays. They are effective as selective dormant post-emergence sprays for the control of annual grasses, chickweed, and some other broadleaved weeds in alfalfa and clovers. CIPC is less volatile than IPC and possesses greater residual weed control properties. Both are now being used effectively in some areas for pre-emergence weed control in cotton, snapbeans, lima beans, spinach, and certain other field and horticultural crops. The carbamates also are used as pre-planting sprays for weed control in canning peas and sugar beets.

CDEC is formulated as an emulsifiable concentrate. Prolonged contact with the skin will cause irritation. CDEC has shown promise for the pre-

emergence control of certain weeds in several vegetable crops. It is more effective on weedy grasses than on broadleaved weeds; however, excellent control of henbit and moderate control of chickweed is obtained by pre-emergence treatments.

The carbamates are of relatively low oral toxicity (LD_{50} = 3,000 to 5,000 mg./kg.) for rats.

SUBSTITUTED UREA HERBICIDES

The substituted urea herbicides include 3-(p-chlorophenyl)-1,1-dimethylurea (monuron); 3-(3,4-dichlorophenyl)-1, 1-dimethylurea (diuron); 3-(phenyl)-1,1-dimethylurea (fenuron), and 1-n-butyl-3-(3,4-dichlorophenyl)-1-methylurea (neburon), previously known as CMU, DCMU, PDU, and DMBU, 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 noncultivated land. However, diuron and monuron also have shown considerable experimental promise and are being used as selective pre-emergence herbicides in cotton and certain other crops. Neburon has the least herbicidal activity and is least toxic of the substituted urea herbicides listed above to many crops, particularly perennial grasses.

The substituted urea herbicides are relatively low in oral toxicity (LD_{50} = 3,400 to 7,500 mg./kg.) for rats.

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, Bermudagrass, Johnsongrass, and other annual and perennial grasses. Best results are obtained when it is applied in combination with tillage and cultural practices. Sodium TCA also is being used as a pre-emergence spray for the control of annual grasses and several broadleaved weeds in flax, sugar beets, sugarcane, 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.

TCA has low oral toxicity (LD_{50} = 5,000 mg./kg.) for rats.

2,2-DICHLOROPROPIONIC ACID (Dalapon)

This herbicide possesses properties somewhat similar to TCA. In contrast with TCA, when dalapon is applied to the foliage of grasses in the vegetative stages of growth, it is translocated from the leaves to the roots of most species. Dalapon has proved less erratic and more effective than TCA when applied as a foliage spray for the control of most of the annual grasses. It is much more effective on quackgrass, Bermudagrass, Johnsongrass, and other perennial grasses. The sodium salt of dalapon,

which is highly soluble in water, is the most widely used formulation. Research indicates that it is most effective as a pre-emergence or post-emergence spray for 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[2] has shown promise in experiments for weed control in sugarcane, sugar beets, birdsfoot trefoil, alfalfa, and for spot treatment control of Johnsongrass and other grasses in cotton. It has given effective control of cattails and phragmites on irrigation and drainage canals.

Dalapon is low in oral toxicity (LD_{50} = 6,590 to 8,120 mg./kg.) for rats.

3-AMINO-1,2,4-TRIAZOLE (Amitrol)

This herbicide is generally available as a water soluble white, crystalline powder. It has shown promise for control of Canada thistle, leafy spurge, Russian knapweed, quackgrass, Bermudagrass, sedges, horsetail rush, cattails, and tules, and several woody plants such as poison ivy, poison oak, white ash, and prickly ash. Amitrol[3] is translocated throughout the plant and affects the growing points, producing chlorosis and inhibition. It is quickly inactivated in most soils and appears promising for control of certain perennial weeds in citrus orchards, grapes, and cranberries without injuring the crops.

Amitrol is low in oral toxicity (LD_{50} = 15,000 mg./kg.) for mice.

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. 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 also has shown some promise for weed control in irrigated cotton in the West.

NPA has low oral toxicity (LD_{50} = 8,200 mg./kg.).

3,6-ENDOXOHEXAHYDROPHTHALIC ACID (Endothal)

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

Endothal has high oral toxicity (LD_{50} = 35 to 120 mg./kg.) for rats.

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[2] Dalapon cannot be recommended (as of April 1, 1958) for use on birdsfoot trefoil and alfalfa since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[3] Amitrol cannot be recommended (as of April 1, 1958) for use in citrus orchards and on grapes since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

1,2-DIHYDRO-PYRIDAZINE-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 control of several annual and perennial grasses when applied in combination with tillage and cultural treatments. It is being used also 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.

MH has low oral toxicity (LD_{50} = 5,800 mg./kg.) for rats.

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 that 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 selective control of crabgrass in lawns.

The compound is highly toxic to humans and warm-blooded animals and must be handled with care. Its oral toxicity for rats: LD_{50} = 27 mg./kg. It is not used presently for weed control in cultivated crops.

POTASSIUM CYANATE (KOCN)

This herbicide is a white, water-soluble powder, effective in controlling 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 usually will disappear in 7 to 10 days.

KOCN has relatively low oral toxicity (LD_{50} = 780 mg./kg.) for rats.

CALCIUM CYANAMIDE

Calcium cyanamide is a water-soluble solid. It usually is formulated as a granulated solid or pulverized powder. The byproducts 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 in tobacco plant beds as an herbicide for weed control and as a fertilizer. In recent years, it has been used with erratic performance for pre-emergence weed control in corn and in several horticultural crops. The herbicide is also being used as a temporary pre-planting soil sterilant for turf seedbeds. The chemical should be applied and worked into the soil surface at least 3 weeks before seeding lawns and other turf.

In some areas, calcium cyanamide is being used in turf renovation programs.

Calcium cyanamide has relatively low oral toxicity (LD_{50} = 1,400 mg./kg.) for rabbits.

AMMONIUM SULFAMATE

This water-soluble, white, crystalline powder is most widely used for control of woody plants in areas adjacent to cotton, grapes, tomatoes, and other plants that 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.

Ammonium sulfamate has relatively low oral toxicity (LD_{50} = 3,900 mg./kg.) for rats.

HERBICIDAL OILS

Herbicidal oils usually are obtained in the distillation of petroleum and coal tar. Aromatic constituents usually have the greatest influence on their herbicidal properties. Recent research, however, 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 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 Johnsongrass on ditchbanks in the Southwest. Aromatic solvents also are being used to control aquatic weeds in irrigation canals and ditches in the Western States. Diesel oil, fuel oil, stove oils, and other oils are used as carriers for herbicides. Oil sprays usually are more effective than water sprays in wetting leaf surfaces and in penetrating waxy leaf surfaces. Oil-water emulsions fortified with dinitrophenols or chlorophenols are used rather extensively for control of annual weeds in orchards and alfalfa, as well as weeds on ditchbanks and other noncrop areas.

Herbicidal oils are relatively low in oral toxicity; for example, Stoddard solvent: LD_{50} = 2,000 mg./kg. for rats.

CHLORATES

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

Semipermanent soil sterilization in humid areas requires 500 to 2,400 pounds of sodium chlorate per acre (3 to 12 pounds per square rod). In semiarid areas, 500 to 1,000 pounds of the chemical per acre (3 to 6 pounds per square rod) are required for semipermanent soil sterilization. Sodium chlorate leaves the soil unproductive for 1 to 4 years, depending on the precipitation, prevailing temperatures, soil type, and other soil and climatic factors. For semipermanent sterilization, higher rates of application are required on the sandy soils of humid regions than on the heavy soils of lower rainfall areas. To kill all vegetation, higher initial rates of application are necessary on the heavy soils of arid regions than on soils of humid areas. Toxicity persists for longer periods in arid regions because there is less leaching and slower decomposition than in humid regions.

Sodium chlorate has low oral toxicity (LD_{50} = 7,000 mg./kg.) for rats.

Caution. The manufacturer's directions for use of sodium chlorate should be followed carefully. This chemical, 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 wet with a sodium chlorate solution become violently inflammable and even explosive. They can be ignited easily 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.

BORON COMPOUNDS

A number of boron compounds, including borax, sodium pentaborate, boron trioxide, anhydrous sodium biborate, and mixtures of these compounds with 2,4-D, sodium chlorate, and/or a substituted urea compound 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 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 soluble borate compounds are effective at lower rates of treatment. Addition of 2,4-D, sodium chlorate, or a substituted urea herbicide to boron compounds will greatly influence the rate of application required for killing all vegetation. Boron compounds normally are applied as dry granular formulations, but mixtures of boron and 2,4-D, and boron and sodium chlorate, also are formulated for spray application.

ARSENICALS

Arsenical herbicides include sodium arsenite, arsenic trioxide, arsenic pentoxide, disodium methyl arsonate, and other formulations of arsenic acid. 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 on soil type and climatic conditions.

Areas frequented by livestock should not be treated with sodium arsenite because of hazard of poisoning: Sodium arsenite is highly toxic for mammals (LD_{50} = 10 to 50 mg./kg.) when administered orally.

2-CHLORO-N,N-DIALLYLACETAMIDE (CDAA)

CDAA is formulated as an emulsifiable concentrate. It has shown promise for pre-emergence control of weed grasses in soybeans, corn, and in certain other crops. CDAA is less effective on broadleaved weeds than on grasses. It often causes some temporary stunting of broadleaved weeds which opens the way to more effective control by timely cultivation. CDAA may cause serious irritation to the eyes. This hazard can be reduced by wearing goggles and rubber gloves during application.

DICHLORAL UREA (DCU)

DCU is used for pre-emergence weed control in sugar beets. It is more effective for control of grasses than for broadleaved weeds. It is low in solubility and is formulated as a wettable powder.

DCU is claimed to have low oral toxicity.

METHYL BROMIDE

Methyl bromide applied at heavy rates as a volatile temporary soil sterilant will kill most weed seeds and plants. It has a boiling point of 38° F., and is sold in sealed cans as a liquid under pressure. When released at 68° F., it becomes a gas 3.2 times heavier than air. The gas must be released under an airtight cover for use as a soil sterilant. Confining the gas under an airtight cover for 24 hours is usually sufficient for weed control if soil in the treated area is moist and has been loosened to aid gas penetration. It is safe to plant crops 2 to 3 days after the airtight cover is removed. Methyl bromide gas is poisonous to man and animals. Effects of exposures within a 24-hour period are cumulative. Skin contact can produce severe burns. The gas is colorless with a slight, sweetish odor, and warning traces of other gases, such as chloropicrin, are sometimes added.

Methyl bromide is relatively toxic, having the power to be absorbed by the skin as well as by inhalation.

2,3-DICHLORO-1,4-NAPHTHOQUINONE (Dichlone)

Dichlone is available as a dry, wettable powder that wets and disperses readily in water. It is used for control of blue-green and green algae in lakes and ponds. It mixes well with oil, is chemically stable, and, as an algicide, remains active in water with a pH up to 9 or 10.

Dichlone is relatively low in oral toxicity (LD_{50} = 1,500 mg./kg.) for rats.

ROSIN AMINE D ACETATE (RADA)

RADA is a water-soluble material that effectively controls fresh-water algae in irrigation canals. It also prevents algae from forming on surfaces of such structures as humidification systems and irrigation installations.

NEW CHEMICALS AVAILABLE FOR EXPERIMENTAL AND TRIAL USE

The new herbicides described in the following section have shown promise in preliminary tests, but further evaluations are necessary before recommendations for their use can be made.

(1) 4-(2,4-dichlorophenoxy)butyric acid [4-(2,4-DB)] and 4-(2-methyl-4-chlorophenoxy)butyric acid [4-(MCPB)] have shown promise for post-emergence control of broadleaved weeds in (a) cereals underseeded with certain forage legumes; (b) establishment of pure stands of forage legumes; (c) forage legume seed-production fields; (d) flax; and (e) other weed-crop situations. Legumes that are relatively tolerant to 4-(2,4-DB) include white clover, alsike clover, red clover, alfalfa, and birdsfoot trefoil.

(2) 2-chloro-4,6-bis(ethylamino)-s-triazine (simazin) is a wettable powder with low solubility in water and in organic solvents. It is being tested for pre-emergence weed control in corn, transplanted tomatoes, and fruit crops. As a soil sterilant, simazin has been effective when applied at heavy rates. Test results show that it may remain active in the soil for long periods, but additional studies are needed to evaluate its residual activity in soils.

Simazin has low oral toxicity (LD_{50} = 5,000 mg./kg.) for mice.

(3) 2,3,6-trichlorobenzoic acid (2,3,6-TBA) and several other isomers of benzoic acid have shown promise as herbicides. The herbicide 2,3,6-TBA is translocated in plants and is effective against a number of weeds that other herbicides have failed to control. It has been used with some success as a pre-emergence spray for weed control in corn. It is effective as a post-emergence spray for the control of wild garlic, annual weed brome grasses, quackgrass, some species of brush, several perennial weeds, and certain other weeds that are serious pests in lawns and turf. It has residual herbicidal activity in the soil.

(4) Ethyl di-n-propylthiocarbamate (EPTC) has been used successfully in preliminary trials as a pre-emergence herbicide to control annual grasses and many broadleaved weeds in forage legume seedlings and in certain other field and horticultural crops. It remains active in the soil for short periods. EPTC is formulated as an emulsifiable concentrate, is stable, and apparently noncorrosive.

(5) 3,5-dimethyltetrahydro-1,3,5,2H thiadiazine-2-thione (DMTT) is a volatile soil sterilant that can be applied without the use of an airtight cover over the soil for control of weeds, soil fungi, and nematodes. It may be applied as a dry powder, or as a spray (wettable powder). After application in either form, the material is mixed into the soil to a depth of about 6 inches. Best weed control has resulted when this treatment has been followed by irrigation with at least 1 inch of water. A 21-day interval should elapse between time of treatment and planting crops.

(6) Sodium-N-methyl dithiocarbamate dihydrate (SMDC) is also a volatile soil sterilant that may be applied without the use of an airtight cover over the soil for control of weeds, soil fungi, and nematodes. This liquid may be applied in two ways: sprayed onto the soil surface, then soaked into the soil with water; or, mixed with the surface 6-inch layer of soil, followed by an application of water, thoroughly wetting the surface to provide a gas seal. A 7- to 14-day interval should elapse between treatment and the planting of crops.

II. GENERAL CONSIDERATIONS IN THE USE OF HERBICIDES

BASIS FOR PURCHASING HERBICIDES

The effectiveness of herbicides is largely dependent upon the active ingredients they contain. One of the best general guides to use in purchasing a commercial herbicide is the price per pound of active ingredient. The containers for all commercial herbicides have labels that state the amount of active ingredients contained in the material. The ingredients are expressed in percent by weight, or in pounds per gallon or package.

"Acid equivalent" is commonly used to express the active ingredient of 2,4-D and certain other herbicides. Usually the concentrated formulations are most economical to use. For example, a 2,4-D formulation that contains 4 pounds of acid equivalent per gallon usually will cost less per pound of 2,4-D than a formulation containing only 1 or 2 pounds of 2,4-D per gallon.

Another important consideration in purchasing 2,4-D or 2,4,5-T herbicides for certain weeds and special situations is the type of herbicide formulation--amine or ester (high-volatile or low-volatile ester). When vapors from the herbicide are likely to cause injury to adjacent crops or plants, either an amine salt formulation or a low-volatile ester should be used. Esters of 2,4-D and 2,4,5-T are classified as high or low-volatile according to the degree of vaporization that occurs. In general, the following are considered high-volatile esters: amyl, butyl, ethyl, isopropyl, and methyl. The low-volatile esters are: butoxyethanol, butoxyethoxypropanol, capryl, ethoxyethoxypropanol, isooctyl, propylene glycol butyl ether, and other long sidechain esters.

The carrier components contained in herbicides, such as emulsifiers, solvents, and adjuvents, often have a bearing on problems encountered in mixing and spraying and on weed control results. The large variety of these materials available for various purposes makes difficult the forming of general guides for purchasing.

SPRAYER CALIBRATION

The type and operating condition of sprayer equipment used to apply herbicides is of utmost importance to efficient chemical weed control. Uniform distribution of the spray solution is the most essential requirement of good spray equipment. For many weeds and situations, volumes of spray may vary widely (5 to 100 gallons per acre) without affecting results, if adequate coverage and spray distribution are obtained. Sprayer output should be determined for each particular spraying operation. A good 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 then should 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 wettable powders or other abrasive sprays 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

1. Power sprayers

(a) Fill the spray tank with water. Make sure it is completely full.
(b) Drive in a straight line for exactly 220 yards, operating the sprayer at exactly the same pressure and tractor speed planned for use in the field. It is a good practice to mark that notch on the throttle. (A tractor travels slower in a soft field than on hard ground.)
(c) Upon reaching the 220-yard mark, stop spraying. Then measure carefully the amount of water needed to refill the tank (a quart jar is satisfactory).
(d) 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.

Comments and Precautions.--In some row crops only a narrow band is sprayed, centered over the row, such as in pre-emergence treatments in cotton and soybeans. When treatments are made in this manner the rate of treatment is in terms of the area treated and not in terms of per-acre of actual crop. For example, in cotton with 36-inch row spacing, if a 12-inch band is treated at 1-1/2 pounds per acre (based on the area actually treated) the amount of chemical per acre of cotton would be 1/2 pound.

2. Hand-Type Boom Sprayers

Example: 3-gallon knapsack sprayer with a boom that sprays a 4-foot swath. 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.

3. Single-Nozzle Hand Sprayers

Example: 3-gallon hand sprayer with single nozzle. Mark off an area 5 by 20 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 standard kitchen measuring tablespoons) 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. One pint = 16 fluid ounces = 2 cups = 32 tablespoons.

EFFECT OF WEATHER CONDITIONS ON SPRAYING

Weather conditions have important effects on results obtained and hazards involved in spraying with herbicides.

1. Wind

Winds cause improper distribution of herbicides and greatly increase the hazard of damage from drift to sensitive crops in nearby fields or gardens. Ground applications of herbicides seldom should be made during winds of more than 10 to 15 miles per hour. Applications by airplane should stop when winds become stronger than 6 to 8 miles per hour.

The herbicide 2,4-D and other phenoxy herbicides never should be applied when wind of any velocity is blowing across the area to be sprayed toward nearby valuable sensitive plants.

2. Humidity

High or moderate humidity increases the effectiveness of most herbicide applications to foliage because it reduces losses of spray from evaporation and aids absorption of the chemicals by weed foliage. Low humidity, on the other hand, reduces the effectiveness of herbicide sprays by increasing the rate of evaporation. The disadvantages of low humidity can be overcome partially by using oil, or oil-water emulsions as spray solutions, instead of water.

3. Temperature

Moderate temperatures ranging from 70° to 85° F. are favorable for spray applications of most herbicides. Low temperatures during the week before spraying often slow plant growth and retard herbicidal activity. High temperatures increase losses of herbicides that are volatile and increase the possibility of injury to crops from selective herbicides. The carbamates, dinitro compounds, and high-volatile esters of 2,4-D, 2,4,5-T, and other phenoxy compounds volatilize rapidly at temperatures above 80° F. At temperatures above 95° F., even the low-volatile esters of 2,4-D and other phenoxy compounds become significantly volatile. Generally, all herbicidal spray treatments are avoided when the temperature is above 95° F.

4. Rainfall

Rainfall that occurs immediately after post-emergence foliage applications of herbicides may reduce the effectiveness of the amine salt formulations of 2,4-D, water-soluble dinitro compounds, and some other foliage toxicants. Usually, little harm is done if a moderate rain occurs several hours after post-emergence application. The effectiveness of pre-emergence herbicide treatments may be increased by moderate rain occurring shortly after application. In low-rainfall areas sprinkler irrigation is often used with good results when the water is applied immediately after pre-emergence herbicides applications. If heavy rains occur soon after pre-emergence treatments, however, weed kill may be reduced, or crop damage increased.

5. General Precautions on Use

Some herbicides may cause injury to susceptible plants growing nearby. Avoid spray drift of such herbicides as 2,4-D, 2,4,5-T, MCPA, silvex, and others to such susceptible plants as cotton, beans, peas, and ornamentals. Coarse sprays applied at moderate to low pressure are less likely to drift.

A sprayer used for herbicides should not be used for other purposes on plants that are very sensitive to injury because it is difficult to remove all traces of the herbicide from the sprayer. The following are examples of plants that are very sensitive to 2,4-D, 2,4,5-T, MCPA, silvex, and similar herbicides: cotton, tomatoes, and grapes. Such crops as alfalfa, soybeans, and clovers will tolerate trace amounts of these herbicides without serious injury. After thorough cleaning, the same sprayer used for herbicides also may be used for the application of fungicides and insecticides on these less sensitive crops.

Thorough cleaning of a sprayer with warm water and a detergent should remove most of the herbicide remaining in the sprayer. This cleaning should be followed by filling the spray tank with a solution of 1 part household ammonia in 100 parts of water. Run some of the solution through the sprayer boom and nozzles and allow the solution to remain in the equipment for 12 to 24 hours. Remove the solution and rinse the equipment with water before using.

Activated charcoal is also useful for cleaning herbicides from spray equipment. It is a much faster cleaning agent than household ammonia. Usually, 2,4-D and similar herbicides can be removed by rinsing the sprayer for about 2 minutes with a 0.25 percent suspension of activated charcoal (1 pound activated charcoal in 8 gallons of water containing a detergent) followed by a rinse of clean water.

Neither of the above methods is always completely effective. To check the sprayer for absence of herbicides, fill with water, then spray seedlings of a sensitive test plant, such as bean, tomato, or a sensitive weed. If the plant is not affected within 1 or 2 days, the equipment is safe for further use.

Do not store herbicides near seed, feed, fungicides, or insecticides.

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 before emergence. Pre-emergence treatment will not control perennial grasses, such as Johnsongrass 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. 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 generally is not advised on sandy soils when excess rainfall is likely to occur. Use lower rate of application on loam soils and higher rate on clay soils. On muck soils and on 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. Deep planting of corn provides additional safety. Lack of soil moisture may reduce effectiveness of treatment, but under such conditions weed populations usually are not serious. Pre-emergence treatments are especially valuable when excessive rainfall prevents cultivation for extended periods after corn emerges. Pre-emergence treatments applied to dry soil with subsequent extended drought may fail to control weeds. Only the low volatile esters 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 18 inches tall. Treatment does not control annual or perennial grasses, but may temporarily inhibit growth of such perennial broadleaved weeds as Canada thistle, milkweed, and horsenettle. For control of weeds in inbred lines in the Corn Belt, use the amine salt of DNBP at 3 to 4 pounds per acre between the emergence of corn and the 4-leaf stage of growth. 2,4-D usually is not recommended for inbred lines of corn.

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

If corn is more than 12 inches tall drop nozzles may be advantageous to direct the spray to the top of the weeds and to partially reduce the injury hazard of spraying in large 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 of rates suggested. Severe reductions in seed set may occur if applications are made during the 2-week period just before 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 the last cultivation until harvest: Ester or amine salt of 2,4-D applied at the 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.

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 12-inch stage of growth. Precautions regarding weed control in corn apply also to sorghum.

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

Small Grains Underseeded With Legumes

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, sweetclover, white clover, or other legumes: Amine salt of 2,4-D or MCPA 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. DNBP is less likely to injure legumes than 2,4-D. If DNBP is used, it should be applied only when the weeds are in the seedling stage. The 2,4-D or MCPA application should be made after cereals are well tillered (usually 4 to 8 inches tall), but before reaching boot stage. The legumes are less likely to be injured if a small grain canopy is allowed to develop before applying 2,4-D or MCPA. Apply the lowest gallonage possible at low pressure in order to reduce penetration of the canopy with the spray.

Comments and precautions.--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.

Small Grains Not Underseeded With Legumes

Post-emergence.--For control of mustard, wild radish, yellow-rocket, ragweed, wild vetch, lambsquarters, pigweed, cocklebur, smartweed,

sunflowers, shepherds-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 before the early boot stage. Growth of wild onion, wild garlic, Canada thistle, sowthistle, curled dock, buttercup, field bindweed, and whitetop 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. Here 1 to 2 pounds of 2,4-D may be required to control semitolerant weeds, and 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 at moderate rates of treatment 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. Greatest benefits to the grain crop result from early removal of the weeds. Fall treatments usually are severely injurious to winter small grains. Some varieties of oats are susceptible to injury from the seedling to the tillering stages of growth and are more tolerant to sprays of 2,4-D at the boot stage and thereafter.

Applications of 2,4-D or MCPA to cereal crops in the susceptible stages, such as the early seedling stages, before tillering or during the late jointing stages or the boot stage, and early heading stages, may result in reductions in yield and associated deleterious effects on the plants.

If cereal crops are underseeded to legumes, use minimum rate of amine salts of 2,4-D, MCPA, or DNBP necessary to control weeds (See Small Grains Underseeded with Legumes). Most legumes are susceptible to 2,4-D and 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 the early joint stage. The order of tolerance of these crops to 2,4-D is as follows, with the most tolerant listed first: wheat, barley, and oats. Oats should not be sprayed unless 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

Post-emergence.--For control of broadleaved weeds--mustard, lambsquarters, pigweed, pennycress, cocklebur, marsh-elder, and ragweed: Amine or sodium salts of MCPA or amine salt of 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 2 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 (pigeon grasses), giant foxtail, and barnyardgrass: TCA at 5 pounds per acre. 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 2 to 6 inches tall will control broadleaved weeds and the weed grasses listed above.

To prevent seed production by Canada thistle, and to control Russian-thistle: Esters of MCPA or 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.--MCPA is less likely than 2,4-D to injure flax. MCPA and 2,4-D 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

Humid Cotton Belt

(1) Pre-emergence.--For control of annual grasses and many broadleaved weeds for 4 to 6 weeks: CIPC at 5 to 10 pounds, diuron or monuron at 1-1/5 to 2 pounds in 20 to 40 gallons of water per acre applied during the planting operation. To reduce cost, apply CIPC or diuron immediately behind planter wheel or press wheel to a 12- to 14-inch band centered over row (1-1/2 to 3 pounds CIPC or 1/4 to 2/3 pound of diuron or monuron per acre of cotton). Lower rate suggested for sandy loam or lighter textured soils; higher rate suggested for loams and heavier textured soils.

Comments and precautions.--Some injury may be expected if heavy rains follow CIPC, diuron, or monuron applications on light textured sandy soils. Enlarged, injured hypocotyls, as a result of CIPC treatments, or stunting and chlorosis resulting from diuron or monuron treatments appear to increase the susceptibility of cotton seedlings to disease organisms. Sustained high temperatures of 90° F. or more reduce the period of effective weed control with CIPC. Band treatment over the row with diuron or monuron is less likely to result in residual chemical effects on succeeding crops than broadcast treatment.

(2) Directed post-emergence.--For control of most small annual grasses and broadleaved 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 at least 5 to 7 days apart, beginning when weeds first appear in the drill row 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 Johnsongrass, nutgrass, and vines.

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

Western Irrigated Cotton Belt

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 before, 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 only for use under the irrigated conditions of the Western cotton producing area. 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 the spring following cotton that has been treated with monuron or diuron for weed control.

SOYBEANS

Pre-emergence.--For control of annual weeds, such as crabgrass, foxtail, giant foxtail, pigweed, lambsquarters, morning-glory, cocklebur, and others: DNBP at 4 to 8 pounds or PCP at 18 to 24 pounds in 10 to 20 gallons of water per acre applied immediately after planting. Deep germinating annuals are usually less likely to be controlled than shallow germinating weeds. Perennial weeds, such as nutgrass, quackgrass, Johnsongrass, Canada thistle, and milkweed are not controlled. To reduce the cost of chemical weed control in soybeans, "band treatments" may be applied as described for cotton.

Comments and precautions.--If heavy rains follow application before 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 days following treatment. Temperatures of 90° F. or higher cause rapid evaporation of DNBP, and may greatly reduce the period of effective weed control.

PEANUTS

Pre-emergence.--For control of annual grasses and broadleaved weeds, such as crabgrass, pigweed, lambsquarters, morning-glory, cocklebur, and others: Sesone at 3 pounds in 20 gallons of water per acre or DNBP at 6 to 9 pounds in 10 to 20 gallons of water per acre applied during the planting operation or any time after planting and before emergence. Will not control such perennial weeds as nutgrass, Johnsongrass, and Bermudagrass. The treatment often is not effective in controlling deep germinating seedlings of cocklebur and other annuals.

Comments and precautions.--Both sesone and DNBP may cause some injury to peanuts on light sandy soils if heavy rains following application leach herbicides into zone of germination. Effectiveness of sesone is reduced if prolonged drought follows application. Where sesone or other herbicides are used, peanuts should be planted as deep as feasible to minimize herbicidal injury. 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.

RICE

Post-emergence.--For control of coffeeweed and other broadleaved weeds: Amine salt formulations of 2,4-D, 2,4,5-T, MCPA, or silvex at 1/2 to 1-1/4 pounds, applied any time after rice is well tillered but before 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-D, 2,4,5-T, MCPA, and silvex may be seriously injured by vapors or spray drift from these herbicides. These four herbicides rank as follows according to their toxicity to cotton, with the least toxic listed first: 2,4,5-T, silvex, MCPA, and 2,4-D. In cotton-producing areas, use only amine salt 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 some other annual grasses and volunteer cereals: 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. Usually not satisfactory for control of foxtails or pigeon grass.

(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 before emergence of beets. In Western States where TCA is not effective: DCU[4] at 15 pounds on the surface or 7-1/2 pounds disked into the soil has been relatively effective 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. Dalapon at 4 to 6 pounds per acre will control seedling grasses and some broadleaved weeds. Treatments with dalapon should be applied when the beets are in the 4- to 6-leaf stage of growth.

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)

Pre-planting.--For control of most broadleaved weeds and annual grasses in tobacco plant beds: 1 pound of commercial urea and 1/2 pound of calcium

[4] DCU cannot be recommended (as of April 1, 1958) for use on table beets since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

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 commercial urea-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 gastight 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 monuron at 1 to 2 pounds, 2,4-D at 1-1/2 to 2 pounds, sesone at 3 to 6 pounds, TCA[5] at 6 to 8 pounds, NPA at 4 to 8 pounds, or DNBP[6] at 4 to 8 pounds in 10 to 40 gallons of water per acre applied after disking and before 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 both grasses and broadleaved weeds.

Beans

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 15 to 24 pounds, or CDEC or CIPC at 4 to 8 pounds in 20 to 40 gallons of water per acre. A mixture of DNBP at 4 pounds and CIPC or CDEC at 4 pounds in 20 gallons of water per acre will control smartweed and annual grasses not controlled by DNBP alone; also will control lambsquarters and ragweed which are not normally controlled by CIPC alone.

Beets

Same control measures suggested for sugar beets (except DCU).

Cole Crops: Cabbage, Cauliflower, Broccoli, Brussels Sprouts

Pre-emergence.--For control of annual grasses and many broadleaved weeds in direct-seeded crops as an emergency measure: TCA[7] at 6 to 8 pounds in 10 to 20 gallons of water per acre. In many of the mid-Atlantic States experimental results have shown that CIPC[8] 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. Pre-emergence applications

[5] TCA cannot be recommended (as of April 1, 1958) for use on asparagus since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[6] DNBP cannot be recommended (as of April 1, 1958) for use on asparagus since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[7] TCA cannot be recommended (as of April 1, 1958) for use on broccoli and Brussels sprouts since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[8] CIPC cannot be recommended (as of April 1, 1958) for use on cabbage, cauliflower, broccoli, and Brussels sprouts since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

of 2 to 4 pounds of CDEC in 25 to 50 gallons of water per acre have been used successfully for control of annual weeds in many of these crops in the mid-Atlantic States with less injury to the crop than is experienced when CIPC is used. Lower rates are used when daily temperatures average less than 60° F.

Cantaloupes

(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.--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 pre-emergence application. Post-emergence treatments have not been as effective as pre-emergence treatments and often fail to control established weeds. Post-emergence treatments should be used only as emergency measures.

Comments and precautions.--Less likely to cause injury if applied when soil temperatures are low.

Carrots, Celery, Dill, Parsnips, Parsley

Post-emergence.--For control of small annual weeds on muck and upland soils: Application of undiluted special light aromatic oils such as Stoddard solvent 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

Pre-emergence and post-emergence.--Same as for cantaloupes.

Greens

(1) Kale, Collards, Turnip Greens, Mustard Greens, Hanover Salad Greens.--Same control measures suggested for Cole Crops.

(2) Spinach (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.

CDEC at rates of 2 to 4 pounds in 25 to 50 gallons of water per acre has given control of several annual weeds with less retardation of crop growth than is experienced with CIPC. Use lower rate on very sandy soil. Granular applications appear to be equally effective.

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.

Lettuce

Pre-emergence.--Experiments in Arizona have shown CDEC at 5 to 7-1/2 pounds per acre to be effective for control of purslane in head lettuce without injury to the crop. CIPC at 1 to 3 pounds in 10 to 40 gallons of water will control annual weeds.

Onions

Pre-emergence.--For control of a wide variety of annual grasses and broadleaved weeds: A light aromatic oil emulsion at 40 to 80 gallons per acre, 3- to 5-percent solution of sulfuric 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 before the emergence of onions. Combinations of CIPC and light aromatic oils will effectively control smartweed and purslane.

For control of annual weeds in onion seed crops: Diuron[9] or monuron at 1 to 2 pounds per acre or CIPC at 6 to 12 pounds per acre applied immediately after the mother bulbs are planted in early spring or before new growth begins from overwintered bulbs.

(2) Post-emergence.--For control of most annual weeds in onions in the loop stage: 2- to 3-percent solution of sulfuric 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 or early bolting stage, and after last cultivation when onions are being, or have been, laid by and are bulbing or bolting: CIPC at 2 to 8 pounds, KOCN at 16 to 20 pounds, diuron or monuron at 1 to 2 pounds, or sesone[10] at 2 to 4 pounds, in 20 to 40 gallons of water per acre, or a 3- to 4-percent solution of sulfuric acid in water at 100 gallons per acre applied as a basal directed spray. Avoid hitting tops of onion plants. The KOCN and sulfuric acid sprays should be delayed until seedling weeds emerge following the last cultivation of onions.

Comments and precautions.--Chemical and rate of application to use will be determined by weeds present, rainfall pattern (summer or winter), soil type, and stage of growth of onions and weeds; for example, only diuron, monuron, or sesone are effective in seed onions in Western low-summer-rainfall areas.

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[9] Diuron cannot be recommended (as of April 1, 1958) for use on onions since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[10] Sesone cannot be recommended (as of April 1, 1958) for use on onions since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

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 States: 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 States: 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.

Irish Potatoes

Post-emergence.--For control of annual grasses, lambsquarters, and pigweed: Sesone at 3 to 4 pounds in 40 gallons of water per acre after the last cultivation. Granular applications appear to be as effective as sprays.

Sweetpotatoes

(1) Transplanting-time.--For control of annual grasses and important broadleaved weeds: NPA, imid formulation, at 2 to 4 pounds in 40 gallons of water per acre after setting the plants. Use lower rate on sandy soil. Granular forms appear to be as effective as spray forms.

(2) After Last Cultivation.--For control of annual grasses and important broadleaved weeds: NPA, imid formulation, or CIPC at 2 to 4 pounds in 40 gallons of water per acre after last cultivation. Use lower rate on sandy soils.

Comments and precautions.--Apply treatments only when soil is moist enough for rapid weed seed germination.

Sweet Corn

(1) Pre-emergence.--For control of annual broadleaved weeds and grasses: Low-volatile ester of 2,4-D at 3/4 to 1 pound, 2,4-D amine salt at 1 to 1-1/2 pounds, DNBP at 4 to 8 pounds, or PCP at 12 to 20 pounds in 20 to 40 gallons of water per acre. Effective 4 to 6 weeks after treatment.

(2) Post-emergence.--For control of sensitive broadleaved weeds: Amine salt of 2,4-D at 1/4 to 1/2 pound or the 2,4-D ester at 1/8 to 1/4 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).

Certain sweet corn varieties are not tolerant of 2,4-D. Small-scale trials on local varieties should precede any large-area applications.

Watermelons

Pre-emergence and post-emergence.--Same as for cantaloupes.

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--(a) DNBP at 2 to 4 pounds, (b) an amine salt of 2,4-D at 1/2 to 1 pound, or (c) sesone[11] at 3 to 6 pounds in 20 to 40 gallons of water per acre applied before emergence of weeds or new canes. Second application--Delay 2,4-D treatment until new canes are tall enough to permit directed basal application without getting spray on cane tips. Apply all basal-directed contact sprays when weeds are small.

(2) For control of winter annual grasses and broadleaved weeds in fall or early winter: CIPC[12] 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 weed-free cultivated soil in the dormant season has controlled 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 usually are 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 to 10 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 usually is adequate.

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[11] Sesone cannot be recommended (as of April 1, 1958) for use on blackberries and blueberries since evide ice has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law)18.

[12] CIPC cannot be recommended (as of April 1, 1958) for use on blueberries since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

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, silvex, 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

Varietal responses to herbicides vary and must be determined locally in each case.

(1) For weed control on full-year basis: (a) 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 sesone at 3 to 6 pounds in 10 to 40 gallons of water per acre on soils prepared in advance where soil types permit. (b) Post-planting treatments of sesone 14 to 21 days after transplanting and at intervals thereafter as needed. Cultivation should be avoided during the period between preplanting treatment and transplanting. Cultivation should precede each sesone 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 chickweed and winter annual 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, sesone 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 sesone at 3 pounds or 2,4-D at 2 pounds per acre; or combinations of TCA at 6 pounds with sesone 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.--Sesone 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. Sesone 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: Sesone 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 airtight cover. Cover may be removed after 24 hours. Methyl bromide does not persist in soil, and plantings may be made safely within 72 hours after removing plastic cover. Soil fumigants are now available for application as drenches at a stated period prior to planting. Plastic or other covers are not required. Examples of materials of this type are 3,5-dimethyltetrahydro-1,3,5,2-H-thiadiazine-2-thione and sodium-N-methyl dithiocarbamate dihydrate. Other soil fumigants and steam sterilization also may 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 ESTABLISHMENT

Perennial Grass Seedlings

For control of broadleaved weeds (if land is not heavily infested with seeds of annual weed grasses): Amine or ester formulation of 2,4-D up to 3/4 pound per acre applied after perennial grass seedlings have reached the 2- to 4-leaf stage.

Legume Seedlings

(1) For control of susceptible weeds such as bitterweed, tarweed, ragweed, lambsquarters, pigweed, mustard, sneezeweed, and others: Sodium or amine salts of 2,4-D or MCPA at 1/8 to 1/4 pound in 5 to 20 gallons of water per acre. Treatments may seriously injure alfalfa, crimson clover, sweetclover, bur-clover, hop clover, vetch, red clover, white clover, and birdsfoot trefoil. 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 most grasses. When high temperatures and humid conditions prevail, use lowest rate suggested. For control of chickweed spray with DNBP[13] at 1/2 to 3/4 pound per acre when it first appears in the fall and repeat the treatment as necessary.

(3) For control of annual weed grasses, such as crabgrass and foxtails, in seedling stands of birdsfoot trefoil and alfalfa: 3 to 4 pounds of dalapon per acre applied as a post-emergence treatment when weed grasses are 2 to 3 inches tall. Dalapon[14] will reduce the growth and vigor of broadleaved weeds, but will not kill most of them. They should be mowed when they are 10 to 14 inches tall. Repeat treatments with dalapon may be made for control of weed grasses that germinate later in the summer. White clover, red clover, hop clover, lespedeza, and vetch may be seriously injured by dalapon.

Comments and precautions.--Use of MCPA, 2,4-D, or DNBP on seedling legumes should be avoided unless crop is seriously threatened by heavy weed infestations.

Grass-Legume Mixture Seedlings

The information given for legume seedlings above applies to grass-legume mixtures except that dalapon and CIPC cannot be used because they also would kill the seeded grasses.

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[13] DNBP cannot be recommended (as of April 1, 1958) for use on legume seedlings on pasture and rangeland since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[14] Dalapon cannot be recommended (as of April 1, 1958) for use on legume seedlings on pasture and rangeland since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

Established Legumes for Hay (including alfalfa, red clover, Ladino clover, alsike clover, birdsfoot trefoil, and lespedeza)

(1) For control of sensitive broadleaved weeds: Either 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. NOTE: Use of MCPA or 2,4-D on established legumes should be considered only as an emergency measure to control serious weed infestations that threaten loss of crop. Alfalfa, red clover, sweetclover, and birdsfoot trefoil may be seriously injured. Conversely, Ladino clover and lespedeza, after the initial rapid growth period, will tolerate these treatments with little injury.

(2) For control of winter annual weeds, such as chickweed, henbit, and seedlings of yellow-rocket: Amine salts of DNBP at 1 to 2 pounds in 20 to 40 gallons of water per acre may be applied when legumes are dormant without injury to legume stand. DNBP should be applied in the fall as soon as legumes are dormant and while weeds are small. In legumes that are heavily infested with chickweed and other winter annual weeds to the extent the stand becomes lodged and matted, and with yellow-rocket, a second application of DNBP should be made in late winter or early spring while legumes are still dormant. CIPC at 1 to 3 pounds per acre gives good control of chickweed. In northern regions, MCPA applied at the rate of 1/2 to 1 pound per acre after alfalfa becomes dormant results in good control of susceptible winter annual and other broadleaved weeds without significant injury to the alfalfa.

Established Legumes for Seed Production (including alfalfa, red clover, Ladino clover, alsike clover, birdsfoot trefoil, and lespedeza)

(1) For control of most annual grasses in alfalfa and in birdsfoot trefoil seed-production fields: Dalapon at 4 pounds per acre applied when grasses are 1 to 3 inches tall. TCA at 6 pounds applied as a pre-emergence treatment has given good grass control in certain areas. To control most annual weeds in alfalfa and birdsfoot trefoil seed fields in Western States, apply 2 pounds of diuron per acre just as the crop starts growth. To control cheatgrass in alfalfa in the Pacific Northwest, apply endothal at 6 to 8 pounds per acre in November or early December while cheatgrass is in the seedling stage.

(2) To control dodder in alfalfa seed fields: CIPC at 6 to 10 pounds per acre applied as a spray in the spring when alfalfa is starting to grow. Treatment is effective only in areas with cool, moist, early spring weather and with little rainfall during late spring and early summer. Spot treatment with aromatic oils or dinitro-fortified oils before dodder blooms is effective on small, scattered patches in alfalfa or in other leguminous seed crops.

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

Established Grasses for Seed Production

(1) For control of most annual and many perennial broadleaved weeds in grass-seed fields: Amine salt or ester of 2,4-D, 2,4,5-T, or MCPA at 1/2 to 1 pound per acre applied as a spray after grasses are well tillered, but before reaching the boot stage will control weeds without significant injury to the grasses. Avoid spraying when grasses are in the boot or early heading stages. Most grasses are tolerant to treatment; however, bentgrasses and a few others have been reported as being more sensitive.

Established Pastures (including pastures with white, Ladino, and alsike clovers in mixtures)

(1) For control of most broadleaved weeds, such as ragweed, bitterweed, tarweed, 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 per acre in late spring after the period of initial rapid growth of legumes, but while weeds are still small. Foliage applications of 2,4,5-T may be used for control of some woody plants that are resistant to 2,4-D, but more injury to the clovers and killing of lespedeza may be expected than with 2,4-D.

(2) For control of wild garlic, wild onion, curled dock, and other semi-tolerant pasture weeds in many areas: 2 applications of 2,4-D each year for 2 or more years, are usually required. One application should be made during the period, October to December, and the other during the period, February to May.

(3) For renovation of sod: Dalapon at 4 to 8 pounds per acre is effective in killing many grasses in preparation for renovating pasture sod. Amitrol[15] alone, or in combination with dalapon, has been useful in the northeastern United States. The herbicide treatments may be made in the fall or spring to kill grasses and reduce the number of diskings necessary for seedbed preparation. The dalapon residues decrease in warm, moist soils in 3 to 4 weeks and seedings can then be made. Amitrol disappears more rapidly from the soil.

Comments and precautions.--Good pasture management practices, including proper fertilization and efficient grazing management, are necessary for successful control of weeds. 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. Some injury may occur to legumes, especially from the repeated treatments; however, the legumes may recover or may be re-established after satisfactory control of the weeds.

[15] Amitrol cannot be recommended (as of April 1, 1958) for renovation of sod since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

Aerial or farm-sprayer applications (volumes of spray refer to aerial applications; treatments with farm sprayers may be made at higher volumes).

(1) For control of sand sagebrush: Ester of 2,4-D at 1 pound in diesel oil, or in an emulsion of 1 gallon of oil to 2 to 4 gallons of water per acre, applied to the foliage in May or early June 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 5 gallons of oil, water, or oil-water emulsions per acre applied 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. Silvex also has shown promise for the control of mesquite. In the arid Southwest, repeated annual treatments are necessary at the highest rates for 2 or more years.

(4) For control of shinnery oak: Repeated annual applications of an ester of 2,4,5-T or 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 silvex 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. A mixture of 2,4-D and 2,4,5-T also may be used with 2,4,5-T making up at least 1/3 of the mixture. The first application should be made with 3 pounds of the mixture and succeeding treatments with 2 pounds per acre in an emulsion of 1 gallon of diesel oil to 4 gallons of water or in 5 gallons of diesel oil.

(6) For control of buckbrush: Repeated applications of an ester of 2,4-D at 1 to 2 pounds per acre in an emulsion of 1 gallon of diesel oil to 3 gallons of water or in 4 gallons of diesel oil. Treatment should be made soon after full foliage has been reached.

(7) Loco, silvery lupine, two-grooved milk vetch, princes plume, woody aster, and waterhemlock: Ester of 2,4-D at 2 pounds per acre at the bud-to-early bloom stage. Repeated annual applications may be necessary.

(8) Tansy-ragwort: Ester of 2,4-D at 2 pounds per acre at the early bolting stage.

(9) Halogeton: Low-volatile ester of 2,4-D at 2 pounds per acre at the early branching prebloom stage.

(10) Deathcamas: Ester of 2,4-D at 3 pounds per acre at the early bud stage.

(11) Orange sneezeweed: Ester of 2,4-D at 3 to 5 pounds per acre at the prebloom stage.

(12) Larkspurs: For low larkspur--ester of 2,4-D at 3 pounds; for tall larkspur--ester of 2,4-D at 6 pounds. Repeated annual applications at the prebud stage of growth may be necessary.

Comments and precautions: Single applications of foliage sprays 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 annual applications for 2 or more consecutive years are normally required.

High-Volume Equipment Applications

(1) Foliage sprays applied with high-volume ground equipment also may be used to control the above species. Depending on the tolerance of the particular species, 2,4-D, 2,4,5-T, or silvex should be applied at 2 to 3 pounds in 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 before the time of application. All foliage should be wet completely with this spray.

(2) Ammonium sulfamate at 3/4 pound in 1 gallon of water applied to foliage as a wetting spray is effective for control of mixed brush. It is less hazardous in areas growing crops sensitive to 2,4-D and 2,4,5-T, but is corrosive to equipment.

Individual Tree Treatments

Individual plants of woody species can be killed at any season of the year by the ester of 2,4-D, 2,4,5-T, or silvex in a light oil, such as diesel or kerosene, applied to the basal bark or cut surface of trees. These treatments are particularly appropriate for scattered stands growing either nearby or in the same pasture with legumes or other susceptible pasture or crop plants. (Treatments are fully described in Sec. VII, page 39.)

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 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.

General Considerations

An attempt always should be made to apply the herbicide when weeds are most susceptible and when 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 the spray from the forage species.

The herbicides 2,4-D, 2,4,5-T, silvex, and MCPA are not poisonous to livestock at the rates of application used to control weeds in forage crops, pastures, and rangelands. If no poisonous plants are present in the treated area, livestock need not be removed during or after application.

If poisonous weeds or poisonous woody plants are known to occur in pastures or on rangelands, remove the livestock from the area 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 also is evidence that some herbicides affect the palatability of certain plants and that livestock will eat some treated species that they normally would not eat.

VI. CONTROL OF HERBACEOUS PERENNIAL WEEDS IN CROPLAND

Herbaceous perennial weeds often 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. Usually, different chemicals must be used for killing perennial weed grasses, such as Johnsongrass 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

(1) For control of field bindweed, whitetop (hoary cress), sowthistle, and Canada thistle: Repeated treatments of 2,4-D at 1/2 to 2 pounds per acre.

(2) For control of bur ragweed, dogbane, leafy spurge, and Russian knapweed: 2,4-D at 1 to 4 pounds per acre.

(3) For control of weeds in the horsenettle group: 2,4,5-T at 1 to 4 pounds per acre.

Comments and precautions.--2,4-D, MCPA, and 2,4,5-T are effective on many broadleaved species and usually provide the most economical means of control, although eradication is not often attained. Some of these weeds require repeated annual chemical treatments for 2 or more years for satisfactory control.

Where possible, the use of phenoxy compounds on weeds should be combined with the growing of competitive crops of cereals, corn, or perennial grasses for effective weed control. Sometimes cereals and corn are damaged by the relatively high rates of chemical required for these weeds. Under these circumstances, 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 reduce the root reserves and to provide optimum growing conditions for weeds.

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

Chlorinated Benzoic Acids[16]

(1) Recent experimental trials with these acids have produced excellent results.

[16] Chlorinated benzoic acids cannot be recommended (as of April 1, 1958) for use on broadleaved perennials on cropland since evidence has not been developed to prove they will leave no residue or/and tolerances have not been set under Public Law 518.

Amitrol[17]

(1) For control of Canada thistle and leafy spurge: Amitrol at 4 to 8 pounds per acre. Repeated applications usually are necessary.

Soil Sterilants

(1) For control of deep-rooted broadleaved species in small patches in cultivated fields: Soil sterilants, such as sodium chlorate, borax, or mixtures of these two. Chlorate should be applied at 3 to 10 pounds per square rod, borax at 15 to 40 pounds, and mixtures at 6 to 20 pounds. Surviving plants should be treated again in subsequent years.

PERENNIAL GRASSES, RUSHES, AND SEDGES

(1) Cultivation and combinations with herbicides: Johnsongrass, Bermudagrass, 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, or amitrol at 3 to 5 pounds per acre as a foliage and soil surface treatment 1 week 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.

(2) Preplanting: The application of 4 to 5 pounds per acre of dalapon in the spring when quackgrass is 4 to 10 inches tall, followed by plowing in about 1 week, gives good reductions in stand. Planting of corn or other crops should be delayed until at least 4 weeks have elapsed after treatment. In humid regions, early spring foliage applications of 4 pounds of MH, followed in 4 to 8 days by plowing, has given effective control. MH does not leave a toxic residue in the soil and crops may be planted as soon as soil preparation is completed.

(3) Spot spraying in cultivated row crops: Spot spraying with dalapon at 1/4 pound per gallon of water, or TCA[18] at 1/4 to 1/2 pound, about once a month during the growing season will effectively control small patches of Johnsongrass or Bermudagrass in cotton, corn, sorghum, or other row crops. Aromatic oils and dinitro-fortified fuel oils also can 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.

(4) Control of Rushes: For control of horsetail rush, apply amitrol at 3 to 6 pounds when the weed is 12 to 18 inches tall.

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[17] Amitrol cannot be recommended (as of April 1, 1958) for use on Canada thistle and leafy spurge on cropland since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[18] TCA cannot be recommended (as of April 1, 1958) for use on corn since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

VII. CONTROL OF WEEDS ALONG FENCEROWS, DITCHBANKS, ROADSIDES, UTILITY LINES, AND OTHER NONCULTIVATED AREAS

WOODY PLANTS

Foliage Sprays

(1) Woody plants and weeds, including mixed brush species: Ester of 2,4-D, 2,4,5-T, silvex, or MCPA at 2 to 3 pounds per 100 gallons of water, applied as a wetting foliage spray. A mixture of 2,4-D and 2,4,5-T is suggested for control of mixed brush species, some of which are tolerant to one of the herbicides but not the other. A wetting foliage spray of ammonium sulfamate at 3/4 pound in 1 gallon of water also will effectively control mixed brush species.

Basal Sprays During Growth or Dormant Periods

(1) Trees and brush less than 6 inches in diameter: Ester of 2,4-D, 2,4,5-T, or mixtures of these herbicides, at 8 to 16 pounds in 100 gallons of diesel oil applied as a basal spray during either dormant or active growth periods. Apply the spray to the entire basal area of all stems, completely wetting the bark to a height of 6 to 12 inches. Basal treatment usually is more effective than foliage applications on tolerant species.

Cut Surface Treatments

(1) Frill application: Ester of 2,4,5-T or 2,4-D at 8 to 16 pounds in 100 gallons of diesel oil applied in the frills made by overlapping ax cuts through the bark near the base of the tree. Apply the solution until frills are wet. This treatment, which gives good control of trees 6 inches in diameter or larger, also is suggested for killing trees with thick bark.

(2) Cup or notch treatment: 1/2 ounce (about 1 tablespoon) or more of ammonium sulfamate crystals per notch in notches made not more than 6 inches apart around the base of stems and, when possible, on root collars. This treatment will kill trees up to 10 inches in diameter when used any time throughout the year.

(3) Tree injections: Ester of 2,4,5-T at 24 to 48 pounds in 100 gallons of diesel oil will control trees under 6 inches in diameter when injected into outer sapwood with a tree injector. Injections should be made not more than 2 inches apart around the base of stems, and not less than 1/6 fluid ounce (about 1 teaspoon) of the solution should be applied in each injection.

Stumps and Stump Sprouts

(1) 2,4,5-T, or mixtures of 2,4-D and 2,4,5-T, at 8 to 16 pounds per 100 gallons of diesel oil applied so that tops and sides of stumps are completely wet to ground level. All exposed roots should be sprayed.

(2) Ammonium sulfamate may be applied as crystals to surface of stumps at the rate of 1 tablespoon for each 2 inches of stump diameter, or the entire stump may be sprayed with a solution containing 4 to 6 pounds of the herbicide per gallon of water.

HERBACEOUS WEEDS

Ditchbank Weeds

Where practical, livestock grazing affords the least expensive and most effective way of controlling most ditchbank weeds. In many instances, however, herbicides can be used to advantage.

(1) For annual and perennial broadleaved weeds where few or no weed grasses are present: Amine or low-volatile ester of 2,4-D at 1 to 2 pounds per acre applied during early growth stage. Repeat as necessary to maintain control.

(2) For annual weed grasses where no broadleaved weeds are present: Dalapon at 6 to 10 pounds per acre, amitrol at 4 to 6 pounds per acre, or dinitro-fortified fuel oil at 60 to 80 gallons per acre, when grasses are small.

(3) For perennial grasses such as Johnsongrass, Bermudagrass, quackgrass, canarygrass, Paragrass, and reed grasses: Repeated applications of dalapon at 20 to 30 pounds, amitrol at 8 to 12 pounds, or aromatic oil or dinitro fuel oil at 120 to 160 gallons per acre. Oil treatments often must be repeated every 3 or 4 weeks to eliminate the weeds in 1 or 2 growing seasons. Usually, 1 or 2 applications of amitrol or 2 to 3 applications of dalapon per year will maintain adequate control.

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 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--monuron and diuron--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 control of vegetation on ditchbanks, railroad rights-of-way, industrial sites, and on 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. CONTROL OF AQUATIC WEEDS

FLOATING WEEDS

(1) For control of water-hyacinth and waterlettuce: Amine or low-volatile ester of 2,4-D at 1 to 4 pounds in 2 to 150 gallons of water per acre. Spray at low pressure with large nozzles to reduce spray drift. Use oil, or an oil-water emulsion in spraying waterlettuce to insure proper wetting of the leaves.

SUBMERSED WEEDS

In Irrigation and Drainage Canals

(1) For control of rooted submersed species (such as pondweeds and waterweed in Western and Great Plains irrigated areas): Emulsifiable aromatic solvents (methylated benzenes such as Xylene) applied in canal at 400 to 740 p.p.m., which is 5.4 to 10 gallons per c.f.s. (cubic feet per second) of water flow, during a 30-minute period. More than one treatment may be necessary in regions with long growing seasons. For detailed recommendations on use of this method, see USDA Circular No. 971, "The Use of Aromatic Solvents for Control of Submersed Aquatic Weeds in Irrigation Channels."

(2) For control of rooted submersed species (such as southern naiad, coontail, and bladderwort in Southeastern States): Use emulsifiable aromatic solvents at 20 to 200 p.p.m. during a continuous treatment period of 24 to 48 hours. Gasoline mixtures with polychlorobenzenes at similar concentrations and exposure times have given good control in Florida tests. Water temperature and movement influences the rate of treatment and exposure time. The warmer water and quasi-static water conditions prevalent in water control canals of Southeastern States permit much longer treatment exposure times and make possible control of waterweeds with much lower concentrations of herbicides than are necessary in colder and rapidly flowing water conditions in canals of Western and Great Plains States.

(3) For control of filamentous green and red algae (in water flowing at a velocity of 0.5 foot or more per second): Apply copper sulfate at 10 to 12 p.p.m. during a continuous treatment period of 30 minutes. Rosin amine D acetate (RADA) at 10 to 12 p.p.m. applied in canal for 30 minutes has satisfactorily controlled red algae and, in some situations, green algae. Treatments of either copper sulfate or RADA usually must be repeated at intervals of 2 to 6 weeks to maintain adequate control of algae. Aromatic solvents at 100 to 150 p.p.m. applied during a 15-minute period have satisfactorily controlled filamentous green algae in Western irrigation canals.

In Reservoirs and Large Canals Carrying Water for Potable or Industrial Uses or for Irrigation

(1) For control of algae or rooted submersed aquatic species in slowly moving water: Copper sulfate applied continuously in sufficient quantity to maintain 0.6 to 1.0 p.p.m. concentration in the water throughout the growing season for aquatic weeds. The concentration should be maintained at 1.0 p.p.m. early in the season. It may be reduced gradually after midsummer

as low as 0.6 p.p.m. late in the growing season. These treatment rates give adequate control and are well below the maximum concentration of 3.0 p.p.m. of copper ion or 7.5 p.p.m. of copper sulfate in potable water supplies, as established by the U.S. Public Health Service.

In Ponds and Lakes

(1) For control of rooted submersed species in still water: Sodium arsenite at 3 to 4 p.p.m. will give adequate control for usually all, or most, of one growing season. For treating localized areas along the shoreline of a lake, concentrations of 6 to 10 p.p.m. may be necessary for adequate control because of diffusion into untreated areas.

Comments and precautions.--Arsenical compounds are recognized poisons and must be handled with extreme care to avoid injury or death to human beings, livestock, or game animals. Wash application equipment and empty containers thoroughly with water after each use. Wear goggles during spray application and wash hands thoroughly afterward. Delay use of treated water for bathing, swimming, lawns, gardens, or animals for 3 days. Do not use the arsenical treatment in any waters intended for use in rice culture. Carefully observe all State laws on applications of arsenicals.

Fish are not killed by concentrations of sodium arsenite below 11 to 12 p.p.m., which are in excess of the concentrations recommended for aquatic weed control.

(2) For control of rooted species (such as parrotfeather, waterweed, coontail, pondweeds, and naiad): 2,3-dichloro-1,4-naphthoquinone (dichlone) at 10 to 20 pounds per surface acre. At these rates, concentrations of the chemical in treated water range from 2.7 p.p.m. to 10.8 p.p.m. in water 5 to 10 feet deep. Toxicity of dichlone to fish has been variable and safe concentrations have not been definitely determined.

(3) For control of blue-green algae: Dichlone at 1 pound per surface acre of water has given effective control without injury to higher aquatic life, fish, or zooplankton. Repeated applications usually are necessary to maintain control.

(4) For control of filamentous green algae: Copper sulfate at 0.5 to 1.0 p.p.m., or RADA at 0.3 to 1.0 p.p.m.

EMERGENT AND MARGINAL WEEDS

(1) For control of cattails and bulrushes: (a) Low-volatile ester of 2,4-D at 4 to 6 pounds in a 1-to-20 oil-water emulsion for a total volume of 150 to 300 gallons per acre applied as a foliage spray. The first spray treatment should be made just before heading stage of the weeds and repeated as necessary on regrowth. About 3 applications over a 2-year period are necessary for complete control of these weeds. (b) Dalapon at 10 to 20 pounds per acre or amitrol at 6 to 10 pounds, applied at the preheading or early heading stages. Addition of 5 to 10 gallons of oil per acre to the spray solution greatly improves results in most situations. Repeated applications may be necessary. These treatments are more expensive than the 2,4-D treatment, but are safer to use near crops extremely sensitive to 2,4-D, such as cotton, grapes, and tomatoes. Reasonable care should be used, however, to prevent herbicide treatments from drifting to crop plants.

(2) For control of water lilies, lotus, spatterdock, arrowhead, pickerelweed, spikerush, and smartweed: 2,4-D at 1/2 to 2 pounds per 100 gallons of diesel oil in sufficient volume to thoroughly cover foliage.

IX. WEED CONTROL IN LAWNS AND OTHER TURF AREAS

The most effective method of weed control in lawns results from good management techniques supplemented by improved methods of weed control. Proper management and maintenance techniques include: (1) Adequate fertilization based on fertility needs as established by a soil analysis; (2) planting turf grasses best adapted to the soil and location; (3) mowing most turf grasses to a height of 1-1/2 to 2-1/2 inches; (4) use of proper watering practices (infrequent but thorough wetting of the soil); and (5) controlling insects and diseases. A healthy vigorous lawn is the first step in obtaining a weed-free lawn.

Chemicals may be used to control weeds as part of any good lawn management program. The practices outlined herein are suggested as supplemental weed-control treatments.

Table 1 may be used as a guide in mixing herbicides for use on home lawns. The concentration of the herbicide as shown on the label of the container of a liquid herbicide will usually fall within the range of concentrations shown in the first two columns of the table. The amount of an herbicide required to mix a spray solution to treat at the rate of 1 pound per acre is indicated in the last two columns of the table.

Table 1.--Amount of herbicide per gallon of water required to spray 1,000 square feet at the rate of 1 pound of herbicide per acre.[1]

Concentration shown on label		Amount of herbicide in 1 gal. of water required for treating 1,000 sq. ft. at the rate of 1 pound per acre	
Percent acid equivalent	Pounds acid equivalent per gallon	Ounces of herbicide	Tablespoons of herbicide
5	0.5	6.2	12.5
10	1.0	3.1	6.2
20	2.0	1.5	3.1
30	3.0	1.0	2.1
40	4.0	0.7	1.5
50	5.0	0.6	1.2
60	6.0	0.5	1.0

[1]To apply an herbicide at the rate of 1/2 pound per acre, use 1/2 the amounts indicated; to apply 2 pounds per acre, double the amounts of herbicide shown in the table.

LAWN AND TURF SEEDBEDS PRIOR TO ESTABLISHMENT

(1) For control of annual grasses and broadleaved weeds: A preplanting treatment of calcium cyanamide. The chemical should be applied and disked or raked and mixed 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 usually are obtained by making a split application of the chemical. 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 turf grasses must be delayed for 2 to 4 weeks until

toxic effects of the calcium cyanamide have disappeared. After toxic effects have disappeared, decomposition products of calcium cyanamide serve as an excellent source of nitrogen and calcium.

(2) For control of seeds, seedling plants, or plant parts, disease organisms, nematodes, insects, and other organisms in the soil: Methyl bromide as a soil sterilant at 1 pound per 100 square feet of seedbed, which should be well prepared and moist. The fumigant is applied under a gastight cover, such as large plastic sheets available for this purpose. The additional cost of this treatment, in comparison with other chemical weed control measures, is offset at least in part by improved chances for successful lawn establishment and in subsequent savings in time and effort on maintenance. When soil temperature is above 65° F., at time of treatment, seeding may follow after 24 hours. When temperatures are 50° to 65° F., the rate of treatment and time between treatment and seeding should be approximately doubled. Follow manufacturer's instructions.

ESTABLISHED LAWNS AND TURF

Broadleaved Weeds

(1) For control of dandelion, buckhorn, other plantains, curled dock, and many other relatively easy-to-kill broadleaved weeds: Amine salt of 2,4-D at 1 pound per acre. Apply any time weeds are actively growing. Fall treatments are preferred because during this season desirable grasses invade more readily the space left by dead weeds. Lawn grasses grow most rapidly during the fall and spring. NOTE: For treating home lawns or small areas with hand equipment, use 1 ounce (2 tablespoons) of 2,4-D amine (having 4 pounds per gallon of herbicide) in a gallon of water, completely wetting the foliage; or follow directions on label of container.

(2) For control of wild onions, wild garlic, red sorrel, knotweed, and other hard-to-kill broadleaved weeds: Repeated sprayings of a low-volatile ester of 2,4-D or an amine salt of 2,4-D at 1 pound per acre, plus a detergent to improve wetting of the plants with the spray; or follow directions on label of container, using highest recommended rate. To control wild garlic and wild onion, spray in late fall and again in late winter or early spring each year; to control such weeds as red sorrel and knotweed, spray annually in the spring. Knotweed should be sprayed soon after emergence.

(3) For control of white clover and many other weeds: Silvex or 2,4,5-T at 1 to 1-1/2 pounds per acre. Follow directions for mixing on label of container.

(4) For control of chickweed and henbit and other hard-to-kill winter annual weeds: DNBP at 3/4 to 1-1/2 pounds per acre or 2 ounces (4 tablespoons) in 1 gallon of water per 1,000 square feet. Apply in fall when plants are young and when air temperature is 65° F., or above. Injury to grass foliage is only temporary. Other herbicides used for control of chickweed are: (a) Silvex, which gives satisfactory control; (b) 2,4-D, which usually will give good control when applied in repeated sprayings, although complete elimination is not always accomplished; (c) KOCN; and (d) sodium arsenite. Sodium arsenite is extremely poisonous, and should be applied only by experienced spray applicators.

Crabgrass and Other Weed Grasses

(1) For pre-emergence control of annual weed grasses and many broadleaved weeds in areas of plentiful moisture: 2,4-D as a spray at 1 to 2 pounds per acre (for small lawns use highest rate recommended on container label) applied just before germination of weed grasses. This treatment is successful only when soils are moist. If some of the crabgrass has emerged, use a mixture of 1-1/2 pounds of 2,4-D and 3/4 pound of PMA.

(2) For pre-emergence control of crabgrass: PMA at 3/4 pound per acre (or 6 pints of a PMA formulation containing 10 percent PMA by weight) in 40 gallons of water. For small lawns, 2 ounces or 4 tablespoons of PMA in 2 gallons of water per 1,000 square feet of area to be treated. Treatments may be applied any time between emergence of crabgrass and the two-leaf stage of growth. Apply 2 additional treatments at 7- to 10-day intervals. PMA is poisonous, but need not be hazardous if reasonable care is used (see Comments and Precautions at the end of this section). NOTE: Sodium arsenite is used widely for crabgrass control on extensive turf areas. It should be applied only by experienced applicators. KOCN and disodium monomethyl arsonate also have been used as crabgrass herbicides with varying degrees of success. They should be applied according to manufacturer's instructions.

(3) For control of perennial grasses such as orchardgrass, timothy, quackgrass, nimblewill, and others: Dalapon at 1/4 pound dissolved in 1 gallon of water, applied to individual plants or infested areas. Since lawn grasses are also killed by this treatment, use care in treating weeds and limit the areas sprayed. Dalapon usually will disappear from warm, moist soil within 3 to 6 weeks, but persists longer in cool or dry soils.

Comments and precautions.--(a) PMA, DNBP, and sodium arsenite are poisonous to warm-blooded animals. They usually are not hazardous to man or animals after they are applied to lawns for weed grass control. As a precautionary measure, however, keep children and animals off sprayed areas until after the first rain (or sprinkling) following treatment.

(b) KOCN should be used with care on lawns containing bentgrasses and fescue grasses. Avoid use of 2,4-D on bentgrass lawns at rates of more than 1/4 pound per acre.

(c) Flowers, shrubs, and trees may be damaged by spray drift or vapors, which may be avoided by spraying when wind velocities are low. Use only salts or low-volatile esters of 2,4-D or MCPA. All herbicides available for weed control in lawns should be used according to manufacturer's directions.

(d) 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 control of spot infestations of wild onion or wild garlic, use 5 ounces or 10 tablespoons of an amine salt of 2,4-D in 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 wild onions or wild garlic by dipping a gloved hand into the mixture then firming the hand around the tops of the weed. Press hard enough to break through the waxy coating on the leaves. This will permit the chemical to penetrate into the plant

and move downward, killing both above-ground and below ground parts.

(e) For spot treatment control of dandelions, plantain, and curled dock, apply the same solution used to kill wild onion and wild garlic. Fasten a piece of kitchen sponge to the end of a stick or broom handle. Dip the sponge into the solution and spot treat broadleaved weeds by pressing the moist sponge against the crown of each plant. Grasses are not injured, and desirable plants nearby will not be injured if care is used to avoid touching their foliage. This spot-treatment method eliminates danger of spray drift and allows the operator to kill weeds growing close to desirable flowers and shrubs.

(f) After applying spray materials that are absorbed through foliage and translocated to other parts of the plant, delay mowing for 24 to 48 hours. Included in this group are 2,4-D, 2,4,5-T, and silvex. For materials that kill upon contact with foliage or are taken up from the soil (PMA, DNBP, KOCN, and sodium arsenite), mowing and removal of clippings before spraying may increase the efficiency of the treatment. Rain or sprinkling shortly after treatment with some herbicides will not decrease their effectiveness, but, as a general rule, avoid sprinkling for 24 to 48 hours.

(g) Avoid spraying very young seedlings of lawn grass with herbicides. After they have begun to tiller or spread by rhizomes they may be given moderate herbicide treatments.

SOURCE OF HERBICIDES

Herbicides are sold under a number of trade names and some are not always available from local garden supply dealers, but usually are available from agricultural chemical dealers. Local agricultural chemical dealers also can help obtain these herbicides from the manufacturers if they are not available locally. Calcium cyanamide may be obtained from local fertilizer dealers.

Carefully read the information on labels. The label on every trade-name product indicates the name of the active herbicidal ingredient, the amount of active ingredient in the product, and directions for mixing and use. Follow directions of the manufacturer carefully in using herbicides on lawns and turf.

X. SUMMARY OF CHEMICALS BY CROPS

FIELD CROPS

Corn:
- Pre-emergence--2,4-D (p. 17)
- Post-emergence--2,4-D; inbred-line fields--DNBP (p. 17)
- Directed post-emergence treatment at layby--2,4-D (p. 18)

Sorghum:
- Post-emergence--2,4-D (p.18)

Wheat, Barley, and Oats--Fall or Spring Seeded:
- Underseeded with legumes:
  - Post-emergence--MCPA, 2,4-D, DNBP (p. 18)
- Not underseeded with legumes:
  - Post-emergence--2,4-D, MCPA (p. 18)

Flax:
- Post-emergence--MCPA, 2,4-D, mixture of MCPA and TCA (pp. 19,20)

Cotton:
- Humid Belt:
  - Pre-emergence--CIPC, diuron, monuron (p. 20)
  - Directed post-emergence--Nonfortified herbicidal oils (p. 20)
- Western Irrigated Cotton Belt:
  - Directed post-emergence in established cotton--monuron, diuron, NPA (pp. 20,21)

Soybeans:
- Pre-emergence--DNBP, PCP (p. 21)

Peanuts:
- Pre-emergence--DNBP, sesone (p. 21)

Rice:
- Post-emergence--2,4-D, MCPA, 2,4,5-T, (silvex) (p. 22)

Sugar beets:
- Pre-planting--IPC (p. 22)
- Pre-emergence--TCA. (In localized areas, TCA, DCU) (p. 22)
- Post-emergence--Sodium chloride, dalapon (p. 22)

Tobacco (plant beds):
- Pre-emergence--Commercial urea and calcium cyanamide, calcium cyanamide, methyl bromide (pp. 22,23)

VEGETABLES

Asparagus:
- Seedbeds, pre-emergence--Monuron, light aromatic oil (p. 24)
- Established beds, pre-emergence--2,4-D, sesone, TCA[1], NPA, DNBP[2] (p. 24)

Beans:
- Pre-emergence--DNBP, PCP, CDEC, CIPC (p. 24)

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[1] TCA cannot be recommended (as of April 1, 1958) for use on asparagus since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[2] DNBP cannot be recommended (as of April 1, 1958) for use on asparagus since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

Beets:
Same as suggested for sugar beets, except DCU[3] (p. 22)

Cole Crops:
Pre-emergence--TCA[4] : cabbage, cauliflower, broccoli, and Brussels sprouts (p. 24)
CIPC[5] : cabbage, cauliflower, broccoli, and Brussels sprouts (p. 24)
CDEC: cabbage, cauliflower, broccoli, Brussels sprouts (p. 25)

Cantaloupes:
Pre-emergence--NPA (p. 25)
Post-emergence--NPA (p. 25)

Carrots, Celery, Dill, Parsnips, Parsley:
Post-emergence--Light aromatic oils (p. 25)

Cucumbers:
Same as for cantaloupes (p. 25)

Greens:
Pre-emergence--CIPC : collards, kale, Hanover salad greens, spinach, and turnips (p. 24)
CDEC: collards, kale, Hanover salad greens, spinach, mustard greens, and turnip greens (p. 25)

Lettuce:
CDEC in Arizona, CIPC (p. 26)

Onions:
Pre-emergence--Light aromatic oil, sulfuric acid, CIPC, and combinations of CIPC and light aromatic oils (p. 26)
Seed crops--Diuron,[6] monuron, CIPC (p. 26)
Post-emergence--Sulfuric acid, KOCN; for onions in 5-leaf stage and after last cultivation, CIPC, KOCN, diuron, monuron, sulfuric acid, sesone[7] (p. 26)

Peas:
Preplanting--IPC (p. 27)
Pre-emergence--DNBP (p. 27)
Post-emergence--DNBP; in North-Central Region, MCPA (p. 27)

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[3] DCU cannot be recommended (as of April 1, 1958) for use on table beets since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[4] TCA cannot be recommended (as of April 1, 1958) for use on broccoli and Brussels sprouts since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[5] CIPC cannot be recommended (as of April 1, 1958) for use on cabbage, cauliflower, broccoli, and Brussels sprouts since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[6] Diuron cannot be recommended (as of April 1, 1958) for use on onions since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[7] Sesone cannot be recommended (as of April 1, 1958) for use on onions since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

Irish Potatoes:
Post-emergence--Sesone (p. 27)

Sweetpotatoes:
Transplanting-time--NPA, imid formulations (p. 27)
After last cultivation--NPA, imid formulations (p. 27)

Sweet Corn:
Pre-emergence--2,4-D, DNBP, PCP (p. 27)
Post-emergence--2,4-D (p. 27)

Watermelons:
Same as for cantaloupes (p. 25)

SMALL FRUITS

Brambles (Raspberries, Blackberries) and Blueberries:
Pre-emergence and dormant treatments--Sesone[8], 2,4-D[9], DNBP, CIPC[10] (p. 28)

Grapes:
Pre-emergence and post-emergence--DNBP, CIPC (p. 28)
Soil treatment--Monuron (p. 28)

Strawberries:
Pre-planting, and dormant treatments--DNBP, CIPC, 2,4-D; post-planting, sesone (p. 29)

FLOWERS AND ORNAMENTALS

Gladiolus, Dutch Iris, Narcissus:
Pre-emergence--2,4-D, sesone, CIPC, DNBP, TCA, combinations of CIPC with sesone or 2,4-D, combinations of TCA with sesone or 2,4-D (p. 29)
Post-emergence--Sesone, 2,4-D (p. 29)

Established Evergreen and Deciduous Plants:
Sesone, CIPC, DNBP, PCP (pp. 29, 30)

Seedbeds and Transplant Beds:
Methyl bromide, calcium cyanamide, 3,5-dimethyltetrahydro-1,3,5, 2-H-thiadiazine-2-thione (DMTT), sodium-N-methyldithiocarbamate (SMDC) (p. 30)

FORAGE, CROPS, PASTURES, RANGELANDS

Perennial Grass Seedlings:
2,4-D for broadleaved weeds where annual weeds are not present (p. 31)

Legume Seedlings:
2,4-D or MCPA for susceptible weeds (p. 31)
DNBP[11] for seedling broadleaved weeds (p. 31)
Dalapon[12] for annual weed grasses (p. 31)

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[8] Sesone cannot be recommended (as of April 1, 1958) for use on blackberries and blueberries since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[9] 2,4-D cannot be recommended (as of April 1, 1958) for use on blueberries since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[10] CIPC cannot be recommended (as of April 1, 1958) for use on blueberries since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[11] DNBP cannot be recommended (as of April 1, 1958) for use on forage crops, pastures, and rangelands since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[12] Dalapon cannot be recommended (as of April 1, 1958) for use on forage crops, pastures, and rangelands since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

Grass-legume Mixture Seedlings:
Same as for grass seedlings, except dalapon and CIPC cannot be used (p. 31)

Established Legumes for Hay:
MCPA, 2,4-D for sensitive broadleaved weeds (p. 32)
DNBP, CIPC for winter annual weeds (p. 32)

Established Legumes for Seed Production:
Dalapon, TCA in certain areas, diuron in Western States, endothal in Pacific Northwest, for most annual grasses; CIPC, aromatic oils, dinitro-fortified oils for dodder; DNBP, PCP for preharvest control of grasses and broadleaved annual weeds and a desiccant (p. 32)

Established Grasses for Seed Production:
2,4-D, 2,4,5-T, MCPA for most annual and many perennial broadleaved weeds (p. 33)

Established Pastures:
2,4-D for most broadleaved weeds; 2,4,5-T for resistant woody plants; 2,4-D (2 applications) for semitolerant pasture weeds in many areas; dalapon, or in Northeastern States, amitrol[13] alone or in combination with dalapon for renovation of sod (p. 33)

Weeds and Woody Plants on Rangelands and Permanent Pastures:
Aerial Treatment--
2,4-D (pp. 34, 35)
Mesquite--2,4,5-T, silvex (p. 34)
Shinnery oak--2,4-D, 2,4,5-T, or mixture of 2,4-D and 2,4,5-T (p. 34)
Ground Treatment--
2,4-D, 2,4,5-T, silvex (p. 35)
Ammonium sulfamate for mixed brush (p. 35)
Individual Tree Treatments--
2,4-D, 2,4,5-T, silvex (p. 35)

HERBACEOUS PERENNIAL WEEDS

Broadleaved Perennials:
2,4-D, 2,4,5-T, chlorinated benzoic acid[14], amitrol[15], sodium chlorate, borax (p. 37)

Perennial Grasses, Rushes, and Sedges:
Cultivated areas--Dalapon, TCA (p. 38)
Preplanting--Dalapon; in humid regions, MH (p. 38)
Spot spraying cultivated areas--Dalapon, TCA[16], aromatic oils or dinitro-fortified oils (p. 38)
Rushes--Amitrol (p. 38)

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[13] Amitrol cannot be recommended (as of April 1, 1958) for use on established pastures since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[14] Chlorinated benzoic acid cannot be recommended (as of April 1, 1958) for use on broadleaved perennials since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[15] Amitrol cannot be recommended (as of April 1, 1958) for use on broadleaved perennials since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[16] TCA cannot be recommended (as of April 1, 1958) for use in spot spraying cultivated areas since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

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

Woody Plants:
2,4-D, 2,4,5-T, silvex, MCPA, ammonium sulfamate (p. 39)

Stumps and Stump Sprouts:
2,4,5-T, mixture of 2,4,5-T and 2,4-D, ammonium sulfamate (p. 39)

Ditchbank Weeds:
2,4-D, amitrol, dinitro-fortified fuel oil, aromatic oil (p. 40)

Soil Sterilization:
Sodium chlorate, borax, sodium arsenite, monuron, diuron, or mixtures of these herbicides with 2,4,5-T, 2,4-D, dalapon, or TCA and fortifying agents, such as herbicidal oils, dinitro compounds, and pentachlorophenol (p. 40)

AQUATIC WEEDS

Floating Weeds:
2,4-D (p. 41)

Submersed Weeds:
Irrigation and Drainage Canals--Emulsifiable aromatic solvents for rooted species in Western and Great Plains areas and Southeastern States; emulsifiable aromatic oils, gasoline mixtures with polychlorobenzenes in Florida; copper sulfate, RADA, aromatic solvents (in the West only), for control of filamentous green and red algae (p. 41)
Reservoirs and Large Canals Carrying Water for Potable or Industrial Uses or Irrigation--Copper sulfate (pp. 41, 42)
Ponds and Lakes--sodium arsenite, dichlone, copper sulfate (p. 42)

Emergent and Marginal Weeds:
2,4-D, dalapon (p. 42)

LAWNS AND OTHER TURF AREAS

Lawn and Turf Seedbeds Prior to Establishment:
Calcium cyanamide, methyl bromide (pp. 42, 43)

Established Lawns and Turf:
2,4-D; for white clover, 2,4,5-T; for chickweed and other hard-to-kill winter annuals, DNBP, silvex, 2,4-D, KOCN, sodium arsenite (p. 44)

Crabgrass and Other Weed Grasses:
PMA, sodium arsenite, KOCN, disodium monomethyl arsonate, dalapon (pp. 45, 46)

XI. CHEMICALS REFERRED TO IN THIS REPORT

Designation	Chemical name	Rates of application expressed in terms of:
2,4-D	2,4-dichlorophenoxyacetic acid	Acid equivalent
2,4,5-T	2,4,5-trichlorophenoxyacetic acid	Acid equivalent
MCPA	2-methyl-4-chlorophenoxyacetic acid	Acid equivalent
Silvex	2-(2,4,5-trichlorophenoxy) propionic acid	Acid equivalent
IPC	Isopropyl N-phenylcarbamate	100% IPC
CIPC	Isopropyl N-(3-chlorophenyl) carbamate	100% CIPC
Monuron	3-(p-chlorophenyl)-1, 1-dimethylurea	100% monuron
Diuron	3-(3,4-dichlorophenyl)-1, 1-dimethylurea	100% diuron
Fenuron	3-(phenyl)-1, 1-dimethylurea	100% fenuron
Neburon	1-n-butyl-3-(3,4-dichlorophenyl)-1-methylurea	100% neburon
TCA	Trichloroacetic acid	Acid equivalent
Dalapon	2,2-dichloropropionic acid	Acid equivalent
DNBP	4,6-dinitro ortho secondary butylphenol	DNBP equivalent
DNAP	4,6-dinitro ortho secondary amylphenol	DNAP equivalent
DNC	3,5-dinitro ortho cresol	DNC equivalent
PCP	Pentachlorophenol	PCP equivalent
Sesone	Sodium 2,4-dichlorophenoxyethyl sulfate	100% sesone
Endothal	3,6-endoxohexahydrophthalic acid	100% endothal
NPA	N-1-naphthyl phthalamic acid	Acid equivalent
MH	1,2-dihydro-pyridazine-3,6-dione (maleic hydrazide)	100% MH
PMA	Phenyl mercuric acetate	100% PMA
KOCN	Potassium cyanate	100% KOCN
CDAA	2-chloro-N, N-diallylacetamide	100% CDAA
CDEC	2-chloroallyl diethyldithiocarbamate.	100% CDEC
Amitrol	3-amino-1,2,4-triazole	100% Amitrol
DCU	Dichloral urea	100% DCU
Dichlone	2,3-dichloro-1,4-naphthoquinone	100% dichlone
Arsenicals	Sodium arsenite, arsenic trioxide, arsenic pentoxide, disodium monomethyl arsenate	Arsenic trioxide equivalent
Copper sulfate		100% copper sulfate
RADA	Dihydroabietylamine acetate (Rosin amine D acetate).	100% RADA
4-(2,4-DB)	4-(2,4-dichlorophenoxy) butyric acid.	Acid equivalent
Simazin	2-chloro-4,6-bis(ethylamino)-s-triazine	100% simazin
EPTC	Ethyl N, N-di-n-propylthiolcarbamate	100% EPTC
DMTT	3,5-dimethyltetrahydro-1,3,5, 2H thiodiazine-2-thione	100% DMTT
SMDC	Sodium-N-methyldithiocarbamate dihydrate	100% SMDC

Designation	Chemical name	Rates of application expressed in terms of:
Calcium cyanamide	.....	100% basic chemical
Ammonium sulfamate	.....	100% basic chemical
Herbicidal oils	.....	Volume
Chlorates	Sodium chlorate, calcium chlorate..	100% basic chemical
Boron compounds	Borax, sodium pentaborate, boron trioxide, anhydrous sodium biborate	100% basic chemical
Methyl bromide	.....	100% basic chemical
4-(MCPB)	4-(2-methyl-4-chlorophenoxy) butyric acid	Acid equivalent
2,3,6-TBA	2,3,6-trichlorobenzoic acid	Acid equivalent

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