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SUGGESTED GUIDE

for

CHEMICAL CONTROL OF WEEDS

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SPECIAL NOTE

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

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

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

Section I presents information on (1) the physical and chemical properties of all herbicides referred to in this report, (2) oral toxicity of the herbicides to warmblooded animals, (3) promising new experimental uses for existing herbicides and (4) promising experimental uses for new herbicides.

The new methods and new herbicide uses described in Section I are intended to show progress in the field of weed research. They should not be construed as recommendations for weed control in the crops specified, as evidence has not been developed to prove that they will leave no herbicide residues and/or tolerances have not been set under Public Law 518.

Section II provides information on (1) the manufacturer's method of indicating active ingredients in herbicide formulations, (2) a method of selecting appropriate herbicides for specific areas of use, (3) a method for calibrating herbicide spray equipment, and (4) the effect of climate on the performance of herbicides.

Sections III through IX contain information which can be used as a guide in the development of recommendations for use of herbicides to control weeds in crops and non-crop land areas. All of the suggested uses have been registered prior to Feb. 1, 1961, under the provisions of the Federal Insecticide, Fungicide and Rodenticide Act.

Since the status of chemical weed control is changing rapidly, and herbicide materials or new uses for older ones 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.
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SUGGESTED GUIDE FOR CHEMICAL CONTROL OF WEEDS

Safe and effective herbicides are available for the control of many weeds growing in varied environments including croplands; rangelands; noncrop areas; and potable, irrigation, drainage, and navigable waters. The successful and safe use of herbicides depends on strict adherence to the details of appropriate treatment methods. These details differ by localities because of differences in soils, climate, crop varieties, cultural methods, and weed species. Methods described herein are given as a broad general guide to current information on weed control. Specific information on application techniques required for the successful use of herbicides under local conditions can be obtained from local agricultural authorities.

New and improved methods of weed control are available to solve many weed problems on farms and to aid in the mechanization of crop production. Basic and applied weed control research is underway on a broad front and will continue to provide practical solutions to weed control problems.

Chemical weed control is an economical aid to mechanization of crop production. Maximum effective results with herbicides can be achieved only when their use is accompanied by the use of effective cultural techniques.

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

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 to warm-blooded animals is listed in the descriptions of chemicals used for weed control. The symbol LD₅₀ (lethal dosage that kills 50 percent of the experimental animals) precedes each number that indicates relative toxicity. For example, the single acute oral dose for sodium arsenite, LD₅₀ = 10 mg./kg., indicates a relatively high oral toxicity. The larger the LD₅₀ number, the less toxic the herbicide.

All LD₅₀ 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

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1 The technical information in this publication was compiled and reviewed by L. L. Danielson, D. L. Klingman, W. C. Shaw, F. L. Timmons, W. B. Ennis, Jr., and associated personnel of the Crops Research Division, Agricultural Research Service.
the possible hazards that may arise from skin contact or inhalation of the substances. 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-(2,4,5-trichlorophenoxy)pro-pionic 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.

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 weedy-crop situations. Legumes that are relatively tolerant to 4-(2,4-DB) include white clover, alsike clover, red clover, alfalfa, and birdsfoot trefoil.

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 are the diethanolamine, triethanolamine, dimethylamine, triethylamine, isopropylamine salts, and mixtures of these and others. These 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.

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, and amyl esters. 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, propyleenglycolbutylether, 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-emergence 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 (LD₅₀ = 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 also have 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 chlorophenols are of intermediate to high oral toxicity (LD_{50} = 50 to 500 mg./kg. for the various formulations) when fed to rats.

SUBSTITUTED BENZOIC ACIDS

2, 3, 6-trichlorobenzoic acid [2, 3, 6-TBA] and certain of its isomers are effective herbicides. 2, 3, 6-TBA is translocated in plants and is effective in controlling wild garlic, quackgrass, some species of brush, and a number of perennial broadleaved herbaceous weeds, including bindweed.

Sodium and amine salts of 2, 3, 6-TBA are sold commercially as a liquid concentrate containing a stated amount of 2, 3, 6-TBA plus a mixture of its isomers.

Amine salt formulations of polychlorobenzoic acids [PBA] are also available commercially as liquid concentrates.

CARBAMATES

The carbamates include isopropyl N-phenylcarbamate [IPC], isopropyl N-(3-chlorophenyl) carbamate [CIPC], 2-chloroallyl diethylthiocarbamate [CDEC], ethyl N,N-di-n-propylthiocarbamate [EPTC], and sodium-N-methyldithiocarbamate [SMDC]. 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 broad-leaved 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, snap-beans, lima beans, spinach, and certain other field and horticultural crops. Certain of 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.

EPTC has been used successfully in experiments 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.

SMDC is 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 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.

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

**SUBSTITUTED PHENYLUREAS**

The substituted phenylurea 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 being used for nonselective weed control on noncultivated land. Diuron and monuron also are being used widely as selective pre-emergence herbicides in cotton and certain other crops. Fenuron is effective for controlling many species of brush. Neburon has the least herbicidal activity and least toxicity of the substituted phenylurea herbicides listed above to many crops, particularly perennial grasses.

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

**TRICHLOROACETIC ACID [TCA]**

Several salts of trichloroacetic acid [TCA] are being used as weedkillers. The sodium salt of 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. The sodium salt of 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. The sodium salt of TCA is highly soluble in water, somewhat caustic, and may 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. Dalapon, commercially formulated as a sodium salt, is highly soluble in water. Research indicates that it is most effective 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 is effective in controlling weeds in sugarcane, sugar beets, birdsfoot trefoil, alfalfa, and for spot treatment control of Johnsongrass and other grasses in cotton. It effectively controls 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.

TRIAZINES

A large number of triazines have been evaluated as herbicides and a number of these chemicals have shown promise for control of weeds in corn, cotton, grain sorghum, and as soil sterilants. The triazines are of relatively low solubility in water, but are quite soluble in organic solvents. They are formulated as wettable powders or emulsifiable concentrates. Some of those for which practical uses have been developed include 2-chloro-4,6-bis (ethylamino)-s-triazine [simazine] and 2-chloro-4-ethylamino-6-isopropy lamino-s-triazine [atrazine].

Simazine is effective as a pre-emergence treatment for control of many annual broadleaved weeds and weed grasses in field corn. High rates of application have been effective in controlling all vegetation on noncrop areas. Because of the long residual action of this herbicide, further research is
needed to determine its most effective use on cropland without risk of injury to susceptible crops grown in rotation with corn.

Simazine has a low oral toxicity ($LD_{50} = 5000$ mg./kg.) for mice.

Atrazine is more water soluble and less persistent in soils than simazine. Atrazine has been effective as a pre-planting soil-incorporated treatment for control of quackgrass and many annual broadleaved weeds and weed grasses in field corn. Pre-emergence treatments have also been effective in controlling many annual weeds in corn.

3,5-DIMETHYL-TETRAHYDRO-1,3-5,2H-
THIADIAZINE-2-THIONE [DMTT]

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. This treatment is most effective when followed by at least 1 inch of irrigation. A 21-day interval should elapse between time of treatment and planting crops.

3-AMINO-1,2,4-TRIAZOLE [amitrole]

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. Amitrole is translocated throughout the plant and affects the growing points, producing chlorosis and inhibition. It is quickly inactivated in most soils.

A mixture of amitrole with ammonium thiocyanate in equal parts [amitrole-T] has proved more effective than amitrole alone on some species, particularly water hyacinth and water lettuce.

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

N-1-NAPHTHYLPHTHALAMIC ACID [NPA]

This chemical may be formulated as the sodium salt, imides, and acids. The sodium salt of NPA is available as a wettable powder and as a liquid concentrate. Presently, NPA sodium salt 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.) for rats.
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 (LD₅₀ = 35 to 120 mg./kg.) for rats.

1, 2-DIHYDROPYRIDAZINE-3, 6-DIONE [MH, maleic hydrazide]

MH 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. Additional research is needed to determine the place of this compound in the field of weed control.

MH has low oral toxicity (LD₅₀ = 5,800 mg./kg.) for rats.

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.

KOCN has relatively low oral toxicity (LD₅₀ = 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 by-products of calcium cyanamide decomposition in acid soils possess both phytotoxic and fertilizing properties. For this reason it is often used as a combination herbicide and crop fertilizer. This chemical has long been used in tobacco plant beds and as a herbicide for weed control and as a fertilizer.

Calcium cyanamide has relatively low oral toxicity (LD₅₀ = 1,400 mg./kg.) for rabbits.

AMMONIUM SULFAMATE [AMS]

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. It 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.

AMS has relatively low oral toxicity ($LD_{50} = 3,900 \text{ mg./kg.}$) 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$^\circ$ to 400$^\circ$ 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$^\circ$ 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. Non-selective herbicidal oils with high aromatic contents are being used effectively to control Johnsongrass on ditchbanks in the Southwest. Xylol-type 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 leafy 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: $LD_{50} = 2,000 \text{ mg./kg.}$ 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 phenylurea 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 phenylurea herbicide to boron compounds will greatly reduce 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 monomethylarsonate (DMA), 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-DIALYLACETAMIDE [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.

CDAA has an intermediate oral toxicity (LD$_{50}$ = 700 mg./kg.) for rats.

METHYL BROMIDE

Methyl bromide applied at heavy rates as a volatile soil fumigant 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 fumigant. 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 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. Warning traces of other gases, such as chloropicrin, are usually added to increase safety in application.

Methyl bromide is relatively toxic, being 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 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 having a pH up to 10.

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

ACRYLALDEHYDE [acrolein]

Acrolein is a highly reactive water-soluble chemical solution that has proved very effective for controlling submerged aquatic weeds in irrigation and drainage channels. The chemical is toxic to mammals, and to fish and other aquatic animal life. It is highly volatile, flammable, and its vapor is a powerful irritant to the eyes and respiratory passages. Because of these properties, the chemical must be metered or pumped from the closed container into the water of the channel without contact with the air.
A formulation of acrolein is available for treatment of irrigation and drainage canals by licensed operators with especially adapted equipment. Acrolein is effective at low concentrations for control of submerged aquatic weeds and algae in ponds, lakes, and other bodies of static water without serious losses of fish.

By using special application techniques, fish can be herded without injury. Acrolein has high oral toxicity \( (LD_{50} = 46 \text{ mg./kg.}) \) for rats.

**NEW CHEMICALS AVAILABLE FOR EXPERIMENTAL TRIAL**

The new herbicides described in the following section have shown promise in preliminary investigations, but further evaluation studies are necessary before effective guides for their use can be developed.

1. 3-amino-2, 5-dichlorobenzoic acid \([\text{amiben}]\) has shown promise as a pre-emergence treatment for the control of many annual broadleaved weeds and weed grasses in soybeans, lima beans, and strawberries. Preliminary research with this herbicide has been successful on a number of other crops. Amiben is relatively low in oral toxicity \( (LD_{50} = \text{approximately } 3,500 \text{ mg./kg.}) \) for rats.

2. 2, 3, 6-trichlorophenylacetic acid \([\text{fenac}]\) has shown promise for control of quackgrass and annual broadleaved weeds and weed grasses when applied in the fall or spring and incorporated by tillage. Corn has been grown successfully following pre-planting treatments at low rates in the spring. It is also effective on bindweed and certain other perennials. Pre-planting soil-incorporated treatments with low rates of fenac have been effective in controlling witchweed. Oral toxicity \( (LD_{50} = 2,500 \text{ to } 3,000 \text{ mg./kg.}) \) is relatively low for rats.

3. 2, 3, 6-trichlorophenylacetamide has been compared to fenac in preliminary evaluation studies. Weeds respond more slowly to the acetamide and it remains active in the soil for longer periods than fenac.

4. tris(2, 4-dichlorophenoxyethyl)phosphite \([2, 4-\text{DEP}]\) has shown promise as a pre-emergence herbicide for control of a number of annual broadleaved weeds and weed grasses in certain field and horticultural crops. Oral toxicity \( (LD_{50} = 850 \pm 140 \text{ mg./kg.}) \) is relatively low for rats.

5. 4-chloro-2-butynyl N-(3-chlorophenyl)carbamate \([\text{barban}]\) is an effective herbicide for wild oats in wheat and barley when applied to wild oats in the 2-leaf stage. Studies on the control of wild oats in sugar beets, flax, and canning peas also appear promising. Oral toxicity \( (LD_{50} = 1,300 \text{ mg./kg.}) \) is relatively low for rats.

6. 2, 3-dichloroallyl diisopropylthio carbamate (cis and trans forms) is effective in controlling wild oats in barley, flax, and sugar beets when applied as a pre-planting soil-incorporated treatment. Experimental studies have indicated that certain horticultural crops are tolerant to this herbicide. Oral toxicity \( (LD_{50} = 250 \text{ to } 375 \text{ mg./kg.}) \) is intermediate for rats.

7. N-(3-chloro-4-methylphenyl)-2-methylpentanamide has shown promise as a post-emergence treatment for control of small (less than 2 inches) annual broadleaved weeds and weed grasses in tomatoes. Oral toxicity \( (LD_{50} = \text{more than } 10,000 \text{ mg./kg.}) \) is low for rats.
8) N-(3, 4-dichlorophenyl)-2-methylpentanamide is effective as a post-emergence treatment for the control of small annual broadleaved weeds and weed grasses in several vegetable, small-fruit, and ornamental crops. Oral toxicity (LD$_{50}$ = more than 10,000 mg./kg.) is low for rats.

9) N-(3, 4-dichlorophenyl)methacrylamide [DCMA] is effective as a directed post-emergence treatment for control of small annual broadleaved weeds and weed grasses in cotton. Other experiments have indicated that several vegetable, field, and ornamental crops have a tolerance to post-emergence treatments. Oral toxicity (LD$_{50}$ = 3,160 mg./kg.) is relatively low for rats.

10) O-(2,4-dichlorophenyl) O-methyl isopropylphosphoramidothioate is effective for the control of germinating crabgrass and other annual weed grasses in established turf. Nonviable seed are formed when crabgrass is sprayed during flowering. Oral toxicity (LD$_{50}$ = more than 1,000 mg./kg.) is relatively low for dogs and cats.

11) 2-chloro-4-diethylamino-6-isopropylamino-s-triazine [ipazine] is effective as a post-emergence spray for the control of small annual weeds in cotton. Oral toxicity (LD$_{50}$ = more than 5,000 mg./kg.) is low for mice.

12) 2, 3, 5, 6-tetrachloroterephthalic acid, the dimethyl ester, is effective in controlling many germinating annual broadleaved weeds and weed grasses in turf and in field and horticultural crops. Crop tolerance to post-emergence treatments suggests that it may prove useful for lay-by applications following clean cultivation. Oral toxicity (LD$_{50}$ = more than 3,160 mg./kg.) is relatively low for rats.
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 as pounds of active ingredients per gallon.

"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, 2,4-D formulations that contain 4 pounds of acid equivalent per gallon usually will cost less per pound of 2,4-D acid 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 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, methyl, ethyl, isopropyl, butyl, and amyl esters are considered highly volatile. The butoxyethanol, butoxyethoxypropanol, ethoxyethoxypropanol, propyleneglycolbutylether, and isoctyl esters and others with a long sidechain are low-volatile esters.

The carrier components contained in herbicides, such as emulsifiers, solvents, and other adjuvants, 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 it difficult to give 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 an essential requirement of good spray equipment. A sprayer must uniformly distribute any quantity from 5 to 100 gallons per acre, since various weeds and situations may call for a wide range of dilutions for proper plant coverage. 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 tabulations gives the ratio of weedkiller to water required to apply 1 pint of weedkiller per acre, based on discharge of the nozzle:

<table>
<thead>
<tr>
<th>Nozzle discharge per 100 sq. ft.</th>
<th>Equivalent discharge per acre</th>
<th>Ratio of weedkiller to water to apply 1 pt. weedkiller per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 pint</td>
<td>27 gal.</td>
<td>1 pt. in 27 gal. water</td>
</tr>
<tr>
<td>1 pint</td>
<td>55 gal.</td>
<td>1 pt. in 55 gal. water</td>
</tr>
<tr>
<td>1-1/2 pints</td>
<td>82 gal.</td>
<td>1 pt. in 82 gal. water</td>
</tr>
<tr>
<td>1 quart</td>
<td>110 gal.</td>
<td>1 pt. in 110 gal. water</td>
</tr>
</tbody>
</table>

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

1 A mixture of 1 ounce (or 2 standard kitchen measuring tablespoons) of weedkiller in 3 gallons of water is approximately equivalent to an application of 1 pint of weedkiller 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 instead of water as spray diluents.

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 herbicide 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 (1/4 pound activated charcoal in 10 gallons of water containing a household 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, or atrazine or simazine at 2 to 4 pounds in 20 to 40 gallons of water per acre, or on corn to be harvested for grain only, a mixture of 3-1/2 pounds of CDAA plus 8-1/2 pounds of trichlorobenzyl chloride [TCBC] in 5 to 20 gallons of water per acre. These may be applied any time after planting corn but before its emergence. Pre-emergence treatment will not control certain 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 or post-emergence herbicide treatments.

In most States the ester formulations of 2,4-D 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, especially on sandy soils.

Comments and precautions.--Deep planting of corn provides additional safety for pre-emergence treatments with all herbicides. 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. Use lower rates of all herbicides on loam or lighter soils and higher rates on clay soils. Treatment with 2,4-D is generally not advised on sandy soils when excessive rainfall is likely to occur. 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. 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 broad-leaved annual weeds: Esters or amine salts 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 the Corn Belt, use the amine salt of DNBP at 1 to 2 pounds per acre between the emergence of corn and the 2-leaf stage of growth. 2,4-D usually is not recommended for inbred lines of corn.

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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 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 these 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 lay-by.--For control of annual grasses and broadleaved weeds from after the last cultivation until harvest: Esters or amine salts 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

Post-emergence.--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 a post-emergence spray, it should be applied at the 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

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 foliage 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.

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, plainain, docks, field bindweed, and others: Esters or amine salts 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 perennial weeds, such as horehound, 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 wintersmall grains.

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, including reduced quality.

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 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. Wheat is the most tolerant of these grains to 2,4-D, barley less so, and oats least
tolerant. 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 the 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. A 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: Diuron or monuron at 1/2 to 2 pounds, CIPC at 4 to 12 pounds, in 20 to 40 gallons of water applied immediately after planting. To reduce cost, apply diuron or CIPC immediately behind the planter press wheel to a 12-inch band centered over the row (1 to 3-1/2 pound CIPC or 1/6 to 2/3 pound of diuron or monuron per acre of cotton). Lower rate suggested for low-organic sandy loams; higher rate suggested for high-organic clay loams.

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 other weeds, but will not kill established perennials such as Johnsongrass, nutgrass, and vines.

N-(3,4-Dichlorophenyl) methacrylamide [DCMA] is suggested for trial use on a small scale as a vertically directed post-emergence spray for the control of small annual weeds in cotton when the crop is over 3 inches high. DCMA should be diluted with water to a concentration of 1/12 pound per gallon. This herbicide will require good agitation in the spray tank. The listed final concentration of the chemical should be applied as a vertically directed spray at the broadcast rate of 40 gallons per acre. Thus, if one-fourth the row width is treated, the rate of application should be 10 gallons per acre of cotton. This treatment, properly applied, will control the same weeds as herbicidal oils.

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

Directed post-emergence in established cotton.—For control of annual grasses and broadleaved weeds from lay-by until harvest: Monuron or diuron at 1 to 2 pounds or CIPC at 6 to 9 pounds in 24 to 40 gallons of water per acre applied on soil surface between rows and on bases of cotton plants in the row just after the last cultivation. Special care in water management is necessary to insure thorough wetting of the cotton beds in the first irrigation following herbicide application.

Comments and precautions.—These treatments are suggested only for use under the irrigated conditions of the Western cotton-producing area. Residual activity of phenyl-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 phenyl-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 amine salt at 4 to 8 pounds, PCP at 18 to 24 pounds, amiben at 2 to 6 pounds (for soybeans grown for seed only) 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 and cause serious crop injury.

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 amine salt 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. These will not control such perennial weeds as nutgrass, Johnsongrass, and Bermuda-grass. 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

(1) Late pre-emergence (suggested for Arkansas only).--For control of barnyardgrass and other annual grass weeds: Apply CIPC at 6 to 8 pounds per acre as a broadcast spray using 10 gallons per acre of total solution. Apply as grass weeds emerge and before they get beyond the first leaf stage of growth, usually 4 to 8 days after seeding. Drill seed rice 1 to 2 inches deep. If the soil becomes dry to the point of crusting within 2 to 4 days after spraying, irrigate the rice. Flood rice 10 to 14 days after spraying.

(2) Late post-emergence.--For control of coffeeweed, curly indigo, mud-plantain, red stem and other broadleaved weeds and certain sedges: 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 boot stage. These will not control annual or perennial grasses. The rice plant is
sensitive to 2,4,5-T, MCPA, 2,4-D, and silvex 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 weeds. If application is necessary during early stages, use 2,4,5-T, MCPA, or silvex instead of 2,4-D since these herbicides are less injurious to rice than 2,4-D.

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 20 gallons of water per acre applied to surface of soil and thoroughly disked into soil surface 2 to 4 weeks before planting. IPC usually is not satisfactory for control of foxtails or pigeon grass. In some irrigated regions, endothal at 2-1/2 to 5-1/2 pounds in 10 to 20 gallons of water per acre may be used to control some annual grasses (not wild oats or volunteer cereals) and some broadleaved weeds. Endothal is applied in bands and worked into the surface 1-1/2 inches of soil ahead of the planter units.

(2) Pre-emergence.—For control of most annual grasses (except wild oats and volunteer cereals) and some broadleaved weeds: TCA at 5 to 7 pounds in 10 to 20 gallons of water per acre applied before emergence of beets. In some high-rainfall areas, endothal at 5-1/2 pounds in 10 to 20 gallons of water per acre will control some annual grasses (not wild oats or volunteer cereals) and some broadleaved weeds.

(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 have 2 to 4 true leaves. It will not control lambsquarters or purslane. Dalapon at 3 to 6 pounds in 10 to 20 gallons of water per acre will control seedling grasses including wild oats. Dalapon should be applied when the beets have 1 to 4 leaves.

Comments and precautions.—Chemical weed control practices in sugar beets vary widely depending on weeds present and soil and climate factors. Rates given are based on broadcast application. When band application is made, appropriate rate adjustments must be made. Endothal may cause injury to sugar beets on sandy soils or under extreme drought conditions.
TOBacco (Plant Beds)

Preplanting.--For control of most broadleaved weeds and annual grasses in tobacco plant beds: 1 pound of commercial urea and 1/2 pound of calcium cyanamide or 1 to 1-1/2 pounds of calcium cyanamide per square yard, or 1 pound of methyl bromide per 100 square feet of plant bed area. Applications of 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 disk ing and raking. Methyl bromide is a volatile soil fumigant, 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 weed 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, or NPA sodium salt at 4 to 8 pounds in 10 to 40 gallons of water per acre applied after diskling and before spear emergence. Beds are commonly disked to loosen the soil, destroy weeds, and to remove old ferns.

(3) Established beds, after cutting season.--For control of many annual broadleaved weeds and weed grasses: Monuron at 1 to 1-1/2 pounds per acre. For control of perennial weed grasses: Dalapon at 5 to 10 pounds per acre as spot spray.

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. 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

(1) Pre-emergence.--For control of most broadleaved weeds and annual grasses with little or no crop injury: DNBP amine salt at 4 to 8 pounds, EPTC at 3 to 5 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 EPTC, CIPC or CDEC at 3 to 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.

(2) At emergence.--For control of most broadleaved weeds and annual grasses: DNBP amine salt at 3 to 4 pounds applied in 20 to 40 gallons of water per acre during early emergence when beans are not beyond the crook stage.

Beets

Use same control measures suggested for sugar beets.

Cantaloups

(1) Pre-emergence.--For control of most annual weeds: NPA sodium salt 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. NPA will control weeds for 4 to 6 weeks with little or no crop injury. CDEC at 3 to 6 pounds per acre is effective as pre-emergence applications.

(2) Post-emergence.--NPA sodium salt 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.--Use lower rates on sandy soils and reduce rate of CDEC when daily temperatures average less than 60°F.

Carrots, Celery, Dill, Parsnips, Parsley

(1) Pre-emergence.--Stoddard solvent at 40 to 100 gallons per acre is effective in controlling many annual broadleaved weeds and weed grasses in the early stages of growth before the crops emerge. Stoddard solvent does not control ragweed or galinsoga.

(2) 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 not later than 6 weeks before harvest. Aromatic oils are most effective if applied when air movement is downward and relative humidity is high. Light aromatic oils should be applied to celery only when in seedbeds. Later applications than those suggested on the other crops may result in off flavor.

Cole Crops (cabbage, cauliflower, broccoli, brussels sprouts)

Pre-emergence.--For control of annual grasses and many broadleaved weeds in direct-seeded crops: CDEC at 3 to 6 pounds applied in 40 gallons of water per acre. Lower rates are used when daily temperatures average less than 60°F.

Cucumbers

Pre-emergence and post-emergence.--Follow suggestions for use of NPA sodium salt given for cantaloups.

Greens (collards, Hanover salad greens, kale, mustard greens, spinach, and turnip greens)

Same control measures suggested for Cole crops.

Comments and precautions.--These crops, and in some instances varieties within a crop, show differing levels of tolerance to these chemicals. Small trial use must therefore precede commercial use in each locality to determine varietal and soil relationships.

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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

(1) 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: 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, monuron at 1 to 2 pounds, or sesone 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 so as to miss the plant except at the base. 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 monuron or sesone are effective in seed onions in Western low-summer-rainfall areas.

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. These 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 application if temperature is 85°F., or higher.

Potatoes

(1) Preplanting.—For control of nutgrass and annual broadleaved weeds and weed grasses: EPTC at 4 to 8 pounds in 20 to 40 gallons of water per acre. Incorporate immediately after application by disk ing or suitable cultivation. Granular formulations are also effective.

For control of quackgrass: Dalapon at 10 pounds applied in 20 to 40 gallons of water per acre.

(2) Pre-emergence.—For control of germinating annual broadleaved weeds and weed grasses: DNBP amine salt at 3 to 4-1/2 pounds or sesone at 3 to 4 pounds in 20 to 40 gallons of water per acre applied just before emergence of potatoes.

For control of annual grasses: Apply dalapon at 3 pounds in 20 to 40 gallons of water per acre just before potatoes emerge.

For control of quackgrass: Apply dalapon at 7-1/2 pounds per acre after grass emerges but before potatoes emerge.

(3) Post-emergence.—For control of germinating annual grasses, lambs-quarters, and pigweed: Sesone at 3 to 4 pounds in 20 to 40 gallons of water per acre applied immediately after clean cultivation at lay-by.

For control of growing quackgrass: Apply dalapon at 10 pounds in 20 to 40 gallons of water per acre.

Sweetpotatoes

(1) Transplanting-time.—For control of annual grasses and important broad-leaved weeds: NPA imide at 2 to 3 pounds in granular form per acre after setting the plants. Use lower rate on sandy soil.

(2) After Last Cultivation.—For control of annual grasses and important broadleaved weeds: NPA imide or CIPC at 2 to 3 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 weed grasses: Low-volatile esters of 2,4-D at 1/2 to 1 pound, an amine salt of 2,4-D at 1 to 1-1/2 pounds, or DNBP amine salt at 4 to 8 pounds, in 20 to 40 gallons of water per acre. These are effective for 4 to 6 weeks after treatment.

(2) Post-emergence.--For control of sensitive broadleaved weeds: Amine salts of 2,4-D at 1/4 to 1/2 pound or a 2,4-D low-volatile 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. DNBP amine salt may be used at 1 to 2 pounds per acre when corn is in the spike stage to 2-leaf stage. These do not control grasses.

Comments and precautions.--Pre-emergence applications of 2,4-D, may result in some injury if applied to shallow-planted stands (1/4 to 1/2 inch). Post-emergence applications of 2,4-D should not be made after corn is 12 inches tall, and drop nozzles should be used wherever practicable.

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.--Follow suggestions for use of NPA sodium salt given for cantaloups.

SMALL FRUITS

Brambles (raspberries and blackberries)

Pre-emergence and dormant sprays.--For control of weeds in early spring in brambles grown in the hedge or linear system: First application--(a) DNBP amine salt at 2 to 4 pounds, (b) an amine salt of 2,4-D at 1/2 to 1 pound, or (c) sesone at 3 to 6 pounds in 20 to 40 gallons of water per acre applied before emergence of weeds or growth. Second application--Use the 2,4-D treatment when weeds are still small but the new berry-plant growth tall enough for spraying around the plant base without getting any chemical on the new growth.

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

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) Pre-emergence and post-emergence.--For control of annual grasses and broadleaved weed 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) Soil treatment.--For control of Johnsongrass and Bermudagrass under trellises in western grapes grown under irrigation: Spot spray with dalapon using 1 pound to 10 gallons of spray solution.

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, and MCPA. Do not use spray equipment that has been used to apply phenoxy-type herbicides unless it 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) Post-planting.--For weed control on a full-year basis: Post-planting treatments of sesone at 3 to 6 pounds, or a combination of sesone at 2 pounds plus CIPC at 1 pound applied in 20 to 40 gallons of water per acre 14 to 21 days after planting and thereafter as needed at intervals of 4 to 8 weeks. Clean cultivation should precede each application until runner production limits cultivation.

(2) After harvest.--For control of established broadleaved weeds after harvest is completed: 2,4-D at 1/2 to 1 pound applied in 10 to 40 gallons of water. Limit to a single application per summer.

(3) During dormancy.--For fall and winter weed control when strawberries are dormant: Sesone at 2 pounds plus CIPC at 1 pound will control germinating chickweed, henbit, wild vetch, and annual bluegrass; DNBP amine salt at 1 to 2 pounds will control chickweed and germinating winter annual grasses.

TREE FRUITS

Apples, Cherries, Peaches, Pears, Plums

(1) For control of annual broadleaved weeds and weed grasses: One pound of oil-soluble DNBP plus 6 to 8 pounds of CIPC dissolved in 10 gallons of fuel oil and 40 gallons of water (a total of 50 gallons of spray per acre) to be applied in early spring so as to just miss the base of the tree.
(2) For control of annual and perennial grasses in apples, peaches, pears, and plums: Dalapon at 2 to 6 pounds applied in 50 to 100 gallons of water per acre as directed spray on grass foliage in a radius of 3 to 4 feet from trunk of trees and repeat in 2 to 3 weeks.

Comments and precautions. -- Avoid spraying trees less than 4 years old. Do not graze meat or dairy animals in treated areas. Do not spray more than twice in one season.

FLOWERS AND ORNAMENTALS

Gladiolus, Dutch Iris, Narcissus, Lilies

(1) Pre-emergence. -- For control of annual broadleaved weeds and weed grasses: Sesone at 3 to 6 pounds, CIPC at 2 to 8 pounds, DNBP amine salt at 4 to 8 pounds in 20 to 40 gallons of water. Follow this treatment sequence: (a) plant, (b) irrigate, and (c) apply herbicide as soon as soil will support spraying equipment.

(2) Post-emergence. -- For control of germinating annual broadleaved weeds and weed grasses: Sesone at 3 to 6 pounds applied in 20 to 40 gallons of water per acre. Spray at the pre-flowering stage and repeat at post-flowering stage by the following procedure: (a) Remove all weeds by clean cultivation and/or handweeding, (b) irrigate, and (c) spray up to the base of the plants as soon as soil will support a sprayer.

Roses

For control of germinating annual broadleaved weeds and weed grasses in liners and established plantings: CIPC at 4 to 8 pounds or DNBP amine salt at 4 to 8 pounds in granular form as a soil-directed application. Brush granules off foliage.

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 amine salt 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.
Control of Most Annual and Perennial Weeds

1. Use methyl bromide at 1 pound per 100 square feet, applied under an airtight plastic cover as described on the chemical label. The cover may be removed after 24 hours. Methyl bromide does not persist in the soil, and plantings may be made safely within 72 hours after removing the plastic cover.

2. Soil fumigants are now available for preplanting use as drenches without plastic covers. DMTT and SMDC are examples of these materials. Other soil fumigants and steam sterilization also may be used effectively to control weeds in seedbeds and transplant beds.

Control of Most Weeds Germinating in Upper 4 Inches of Soil

Use calcium cyanamide at 50 to 75 pounds per 1,000 square feet, applying it to the surface and working it 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

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

(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 at 1/2 to 3/4 pound per acre when it first appears in the fall and repeat the treatment as necessary.

Legume Seedlings

(1) For control of susceptible weeds such as ragweed, lambsquarters, pigweed, mustard, sneezeweed, bitterweed, tarweed, and others in all seedling legumes grown for seed except sweet clover: Amine salts and esters of 4-(2,4-DB) at 1/2 to 1-1/2 pounds in 5 to 20 gallons of water per acre. These treatments give less injury to legumes than 2,4-D and permit application at a later stage of weed growth than does DNBP. Treatment is most effective if applied when weeds are still small.

(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 clovers and alfalfa. When high temperatures and humid conditions prevail, use lowest rate suggested. For control of chickweed spray with DNBP at 1/2 to 3/4 pound per acre when it first appears in the fall and repeat the treatment as necessary; when forage grasses are not present, spray with CIPC at 1 to 2 pounds per acre during the winter months.

(3) For control of annual weed grasses, such as crabgrass and foxtails in seedling stands of birdsfoot trefoil and alfalfa: 2 to 4 pounds of dalapon per acre applied as a post-emergence treatment only in crops to be used for seed when weed grasses are 2 to 3 inches tall. Dalapon will reduce the growth and vigor of broadleaved weeds, but will not kill most of them. When birdsfoot trefoil or alfalfa is grown for seed production, the broadleaved weeds may be sprayed with 4-(2,4-DB) while small or 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 summer. White clover, red clover, hop clover, lespedeza, and vetch are seriously injured by dalapon.

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 or seriously injure the seeded grasses.

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

(1) For control of sensitive broadleaved weeds: Spray with 2,4-D at 1/8 to 1/4 pound in 5 to 20 gallons of water per acre when legumes are in the early dormant stage or immediately after hay harvest. NOTE: Use of this herbicide 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 by 2,4-D. Conversely, Ladino clover and lespedeza, after the initial rapid growth period, will tolerate this treatment 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 3 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. These chemicals temporarily stunt the growth of alfalfa. To control most annual weeds in alfalfa and birdsfoot trefoil seed fields in Western States, apply 2 pounds of diuron per acre in the fall or in early spring before 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 or CDEC at 6 to 10 pounds per acre applied as a spray in the spring when alfalfa is starting to grow or in granular form after alfalfa is 6 to 10 inches tall but before dodder has germinated. 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 seed 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

For control of most annual and many perennial broadleaved weeds in grass-seed fields: Amine salts or esters of 2,4-D, 2,4,5-T, silvex, or MCPA at 1/2 to 1-1/2 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. In recent investigations, monuron and diuron have proved promising for the control of annual weed grasses and broadleaved weeds in established perennial grasses grown for seed production.

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 pastures. Amitrole alone, or in combination with dalapon, has been useful in the northeastern United States. The herbicide treatments may be made in the fall to kill grasses and to reduce the number of diskings necessary for seedbed preparation. The area should not be grazed until the following growing season. If perennial broadleaved weeds are present the pasture should be sprayed with 2,4-D, 2,4,5-T, or MCPA at 1 to 2 pounds per acre in the spring or early summer before renovation is attempted. The dalapon residues decrease in warm, moist soils in 3 to 4 weeks and seedings can then be made. Amitrole disappears more rapidly from the soil.

Comments and precautions.—Good pasture agronomic practices, including proper fertilization and efficient grazing practices, 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, 2,4,5-T, or mixtures of these herbicides, are effective and safe for weed and woody plant control. Some injury may occur to legumes, especially from the repeated treatments of 2,4-D, MCPA, and 2,4,5-T. The legumes may recover or may be reestablished after satisfactory control of the weeds.
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: Esters 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: Esters of 2,4-D at 1-1/2 to 2 pounds in 5 gallons of oil, water, or oil-water emulsions per acre applied after spring growth begins and before soil moisture depletion in the upper 8 to 10 inches of soil.

(3) For control of rabbitbrush: Esters of 2,4-D at 3 pounds in 5 gallons of oil, water, or oil-water emulsion per acre when new twig growth is 3 inches or longer and before soil moisture depletion in the upper 8 to 10 inches of soil.

(4) For control of mesquite: Esters of 2,4,5-T at 1/3 to 1/2 pound in oil or in an emulsion of 1 gallon of diesel oil to 3 gallons of water per acre applied to foliage in the spring. 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.

(5) For control of shinnery oak: Three repeated annual applications of an ester of 2,4,5-T or silvex at 1 2 to 1 pound in oil or in an emulsion of 1 gallon of diesel oil to 2 to 4 gallons of water per acre when the plants have attained the full-leaf stage and only if they are actively growing.

(6) For control of post oak, blackjack oak, and other associated woody plants: Esters of 2,4,5-T or silvex at 2 pounds per acre in sufficient diesel oil to make 1 gallon and combined with 4 gallons of water to form an emulsion. Applications should be repeated for 2 or 3 consecutive years although applications in alternate years may be acceptable. A mixture of esters 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, where use of 2,4-D would not be hazardous. These mixtures should be applied at 3 pounds per acre. Mixing instructions are the same as for 2,4,5-T and silvex.

(7) 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 must be made soon after full foliage has been reached.

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

(9) Tansy-ragwort: Esters of 2,4-D at 2 pounds per acre at the early-bolting stage.
(10) Halogeton: Low-volatile esters of 2,4-D at 2 pounds per acre at the early-branching prebloom stage.

(11) Deathcamas: Esters of 2,4-D at 1-1/2 to 3 pounds per acre when plants have 3 to 5 leaves. Effectiveness drops very rapidly as spraying is delayed.

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

(13) For control of low larkspur: Ester of 2,4-D at 1-1/2 to 2 pounds per acre when plants are fully emerged, but before the appearance of flower stems.

(14) For control of tall larkspur: Esters of 2,4,5-T or silvex at 4 pounds per acre when plants are in very early-bud stage of growth. Treatments should be repeated annually until desired control is obtained.

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. Where native grasses are present, deferred grazing during the growing season for 1 or 2 years is often desirable.

High-Volume Farm-sprayer Applications

(1) Drenching 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 and at the time of application. All foliage should be wetted completely with this spray.

(2) AMS 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. AMS corrodes equipment.

Individual Tree Treatments

Individual plants of woody species can be killed at any season of the year by esters of 2,4-D, 2,4,5-T, or silvex in a light fuel 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 near or in the same pasture with legumes or other susceptible pasture or crop plants. (Treatments are fully described in Sec. VII, page 43.)

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 ON CROPLAND

Herbaceous perennial weeds often have deep and extensive root systems and are difficult to kill with herbicides 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 herbicides 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 herbicides are effective on both types.

Comments and precautions.--Spot sprays and preplanting application of all herbicides on herbaceous perennial weeds in row crops must be used in accordance with the restrictions on crop use stated on the manufacturer's label.

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: Repeated treatments of 2,4-D at 1 to 4 pounds per acre.

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

(4) For control of white bedstraw: Apply silvex at 3 pounds per acre in late fall or early spring.

Comments and precautions.--2,4-D, silvex, and 2,4,5-T are effective on many broadleaved species and usually provide an 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.
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.

**Chloro Substituted Benzoic Acids**

2,3,6-TBA at 15 to 20 pounds or PBA at 35 to 40 pounds per acre will control bindweed. Higher rates may be required for control of additional species of herbaceous perennial weeds. These rates of application sterilize the soil temporarily and investigations are continuing to determine the cultural and rotational practices that must accompany their use.

**Soil Sterilants**

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), and erbon. Sodium chlorate should be applied at 3 to 10 pounds per square rod (480 to 1600 pounds per acre), borax at 15 to 40 pounds (2400 to 6400 pounds per acre), and mixtures at 6 to 20 pounds. Erbon should be applied at 80 to 160 pounds per acre. Surviving plants should be treated again in subsequent years.

**PERENNIAL GRASSES, RUSHES, AND NUTSEDSSES**

**Perennial Grasses**

Cultivation and combination of herbicides.—Johnsongrass, Bermudagrass, and quackgrass can be controlled by repeated intensive cultivation which prevents top growth and destroys food reserves in the roots. Intensive cultivation is most effective under dry weather conditions, but with ample soil moisture to promote active growth from roots and rhizomes.

The amount of cultivation needed for control can be reduced by applying TCA at 25 to 50 pounds or dalapon at 10 to 20 pounds per acre as a foliage and soil surface treatment 1 week before plowing or disk ing in late fall or early spring. Cultivated row crops should be grown the first year following these treatments to insure continued control by frequent general cultivation, spot cultivation, or herbicide application. A strongly competitive crop limits weed growth by shading and competition for moisture and nutrients.

Pre-planting treatments.—(1) For control of quackgrass: A fall or spring application of 2 to 4 pounds of simazine or atrazine in 20 to 40 gallons of water per acre has proved effective when followed by plowing or cultivation before planting corn.

Spring application of dalapon at 4 to 5 pounds in 20 to 40 gallons of water per acre when quackgrass is 4 to 10 inches tall followed by plowing in 1 week reduces the stand and vigor of this grass. Planting of corn should be delayed for 4 weeks 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.
(2) For control of Johnsongrass: Dalapon at 10 to 20 pounds applied in 20 to 40 gallons of water per acre when the grass averages 15 inches in height, and followed by disk ing in 2 weeks has proved effective.

Spot spraying in cultivated row crops.—Spot spraying with dalapon at 1/4 pound per gallon of water, or TCA at 1/4 to 1/2 pound, about once a month during the growing season will effectively control small patches of Johnsongrass or Bermudagrass in row crops. Aromatic oils and dinitrofortified 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.

Rushes

For control of horsetail rush, apply amitrole at 3 to 6 pounds when the weed is 12 to 18 inches tall.

Nutsedges

Preplanting.—For control of yellow and purple nutsedges: EPTC has shown promise for suppression of nutsedge when applied at 6 to 10 pounds in 20 to 40 gallons of water per acre as a pre-planting soil-incorporated treatment.
VII. CONTROL OF WEEDS ALONG FENCEROWS, DITCHBANKS, ROADSIDES, UTILITY LINES, AND OTHER NONCULTIVATED AREAS

WOODY PLANTS

Foliage Sprays

Woody plants and weeds, including mixed brush species: Esters of 2,4-D, 2,4,5-T, silvex, or MCPA at 2 to 4 pounds per 100 gallons of water, applied as a drenching 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 drenching foliage spray of AMS at 3/4 pound in 1 gallon of water also will effectively control mixed brush species.

Basal Sprays During Growth or Dormant Periods

Trees and brush less than 6 inches in diameter: Esters 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. 2,4,5-T is much more effective than 2,4-D on many species. A gallon of solution is enough to spray about 100 diameter inches, that is, fifty 2-inch trees or twenty-five 4-inch trees. 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: Esters 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. The 2,4,5-T is much more effective than 2,4-D on many species. 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 AMS 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: Esters 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 freshly cut stumps are completely wet to ground level. All exposed roots should be sprayed.
(2) AMS may be applied as crystals to surface of freshly cut 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

In many situations careful livestock grazing management affords inexpensive and effective control of ditchbank weeds. Factors that influence the kind of management needed to maintain desirable vegetation and prevent erosion on ditchbanks are (a) size and kind of ditchbank, (b) slope length and steepness of the ditchbank, (c) whether it is a "dry-run" or "continuous-flow" type of ditch, (d) size of drainage area, and (e) kind of vegetation used to stabilize the banks. In other situations, herbicides may be used to better advantage.

(1) For annual and perennial broadleaved weeds where few or no weed grasses are present: Amine or low-volatile esters of 2,4-D at 1 to 2 pounds per acre applied during early growth stage. Repeat as necessary to maintain control. Some species that do not respond to 2,4-D may respond to 2,4,5-T and silvex at the same rate of treatment.

(2) For annual weed grasses where no broadleaved weeds are present: Dalapon at 6 to 10 pounds per acre, amitrole 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, amitrole 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 amitrole 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, monuron, diuron, and simazine at 10 to 80 pounds, erbon at 80 to 160 pounds, and mixtures of these herbicides with 2,4,5-T, 2,4-D, silvex, 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

For control of water-hyacinth and waterlettuce: Amine salts or low-volatile esters of 2,4-D at 1 to 4 pounds in 2 to 150 gallons of water per acre. The higher volumes of spray often give better results. 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. A mixture of amitrole and ammonium thiocyanate (known as amitrole-T) at 2 to 4 pounds per acre has proved more effective than 2,4-D on both water-hyacinth and waterlettuce in Florida experiments.

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): (a) 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." This circular is not now stocked for distribution but should be available in many libraries. (b) Acrolein at 1 to 3 gallons per c.f.s. has proved even more effective than aromatic solvents in numerous experiments and limited commercial use. Due to severe irritation of respiratory passages and eyes, it must be applied by licensed skilled operators with specialized equipment. Each application gives control for 4 to 8 weeks. Follow instructions of manufacturers relative to use of water by livestock.

(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 drainage canals in Florida. Water temperature and movement influence 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): For green algae, apply copper sulfate at 1/5 to 2 pounds per c.f.s. every 2 to 4 weeks during the growing season. For red algae, apply copper sulfate at 10 to 12 p.p.m. during a continuous treatment period of 30 minutes. The treatments 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

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 to 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 usually for 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): 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.
EMERGENT AND MARGINAL WEEDS

(1) For control of cattails and bulrushes: (a) Low-volatile esters of 2,4-D at 4 to 6 pounds in a 1:20 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 15 to 25 pounds per acre or amitrole at 8 to 10 pounds, applied at late heading or post-heading stages and in late summer 2 to 4 weeks before first frost. Addition of 5 to 10 gallons of oil per acre to the dalapon 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 agronomic practices supplemented by improved methods of weed control. Proper agronomic 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 important in obtaining a weed-free lawn.

The following table is a guide for 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 a 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>
<thead>
<tr>
<th>Concentration shown on label</th>
<th>Amount of herbicide in 1 gal. of water required for treating 1,000 sq. ft. at the rate of 1 pound per acre1</th>
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<tbody>
<tr>
<td>Percent acid equivalent</td>
<td>Pounds acid equivalent per gallon</td>
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<td>6.0</td>
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</table>

1To apply a 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

For control of seeds, seedling plants, or plant parts, disease organisms, nematodes, insects, and other organisms in the soil: Methyl bromide as a soil fumigant 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 below 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 salts 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, follow the directions given in the table.

(2) For control of wild onions, wild garlic, red sorrel, knotweed, and other hard-to-kill broadleaved weeds: Repeated sprayings of low-volatile esters of 2,4-D or amine salts 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 strayed with silvex soon after emergence.

(3) For control of chickweed, henbit, knotweed, burclover, pennywort, white clover and many other weeds: Silvex at 1 to 1-1/2 pounds per acre. Follow directions for mixing on label of container. Endothal at 2 pounds per acre in 50 to 100 gallons of water per acre will control burclover, knotweed, pennywort, and henbit while still small. Endothal may give temporary discoloration of foliage of ryegrass and bluegrass.

Crabgrass and Other Weed Grasses

(1) For pre-emergence control of crabgrass: Applications in late March or early April of calcium arsenate at 10 to 16 pounds per thousand square feet, O-(2,4-dichlorophenyl)Q-methyl isopropylphosphoramidothioate at 20 pounds per acre, and 2,3,5,6-tetrachloroterephthalic acid, dimethyl ester, at 10 pounds per acre are effective for selective control of crabgrasses in turf.

(2) Post-emergence control of crabgrass and other grasses: For control of crabgrass, Dallisgrass, goosegrass and sandbur in turf: DMA and similar arsonates, applied according to instructions on the label. DMA may cause a slight discoloration of the turf which disappears in 7 to 14 days.

(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) DNBP and calcium arsenate are poisonous to warmblooded 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 the first rain (or sprinkling) following treatment.
(b) 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, 2,4,5-T, or silvex. All herbicides available for weed control in lawns should be used according to manufacturer's directions.

(c) 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.

(d) 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 (DNBP), 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.

(e) 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. They are not always available from local garden supply stores, but usually are available from agricultural chemical dealers, or at least obtainable through them from the manufacturers.

Read the labels carefully. The label on every tradename 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, atrazine, simazine, mixture of CDAA and TCBC (p. 18)
- Post-emergence--2,4-D; inbred-line fields--DNBP (p. 18)
- Directed post-emergence treatment at lay-by--2,4-D (p. 19)

Sorghum:
- Post-emergence--2,4-D (p. 19)

Wheat, barley, and oats--Fall- or Spring-Seeded:
- Underseeded with legumes:
  - Post-emergence--MCPA, 2,4-D, DNBP (p. 19)
- Not underseeded with legumes:
  - Post-emergence--2,4-D, MCPA (p. 20)

Flax:
- Post-emergence--MCPA, 2,4-D, mixture of MCPA and TCA (p. 21)

Cotton:
- Humid Cotton Belt:
  - Pre-emergence--CIPC, diuron, monuron (p. 21)
  - Directed post-emergence--nonfortified herbicidal oils and DCMA (p. 22)
- Western irrigated Cotton Belt:
  - Directed post-emergence in established cotton--monuron, diuron, and CIPC (p. 22)

Soybeans:
- Pre-emergence--DNBP, PCP, amiben (p. 22)

Peanuts:
- Pre-emergence--DNBP, sesone (p. 23)

Rice:
- Late pre-emergence--CIPC (p. 23)
- Late post-emergence--2,4-D, MCPA, 2,4,5-T, silvex (p. 23)

Sugar beets:
- Preplanting--IPC, endothal (p. 24)
- Pre-emergence--TCA. (In localized areas, endothal) (p. 24)
- Post-emergence--sodium chloride, dalapon (p. 24)

Tobacco (plant beds):
- Preplanting--commercial urea and calcium cyanamide, calcium cyanamide, methyl bromide (p. 25)

VEGETABLES

Asparagus:
- Seedbeds, pre-emergence--monuron, light aromatic oil (p. 26)
- Established beds, pre-emergence--2,4-D, monuron, sesone, NPA (p. 26)
- Established beds, after cutting season--monuron, dalapon (p. 26)
Beans:
  Pre-emergence--DNBP, CDEC, CIPC, EPTC, (p. 26)
  At emergence--DNBP (p. 26)

Beets:
  Same as suggested for sugar beets (p. 26)

Cantaloupes:
  Pre-emergence--NPA, CDEC (p. 26)
  Post-emergence--NPA (p. 27)

Carrots, celery, dill, parsnips, parsley:
  Pre-emergence--Stoddard solvent, (p. 27)
  Post-emergence--Stoddard solvent (p. 27)

Cole Crops:
  Pre-emergence--CDEC (p. 27)

Cucumbers:
  Pre-emergence and post-emergence--NPA (p. 27)

Greens:
  Same as for cole crops (p. 27)

Lettuce:
  Pre-emergence--CDEC in Arizona, CIPC (p. 28)

Onions:
  Pre-emergence--light aromatic oil, sulfuric acid, CIPC, and combination of CIPC and light aromatic oils (p. 28)
  Seed Crops--monuron, CIPC (p. 28)
  Post-emergence--for onions in the loop stage, sulfuric acid, KOCN; for onions in 5-leaf stage and after last cultivation, CIPC, KOCN, monuron, sulfuric acid, sesone (p. 28)

Peas:
  Preplanting--IPC (p. 28)
  Pre-emergence--DNBP (p. 28)
  Post-emergence--DNBP; in North-Central States, MCPA (p. 29)

Potatoes:
  Preplanting--EPTC (p. 29)
  Pre-emergence--DNBP, sesone, dalapon (p. 29)
  Post-emergence--sesone, dalapon, (p. 29)

Sweetpotatoes:
  Transplanting-time--NPA (p. 29)
  After last cultivation--NPA, CIPC (p. 29)

Sweet corn:
  Pre-emergence--2,4-D, DNBP (p. 30)
  Pre-emergence--2,4-D, DNBP (p. 30)

Watermelons:
  Pre-emergence and post-emergence.--NPA (p. 30)
SMALL FRUITS

Brambles (raspberries and blackberries):
Pre-emergence and dormant treatments—sesone, 2,4-D, DNBP, CIPC (p. 30)

Grapes:
Pre-emergence and post-emergence—DNBP, CIPC (p. 31)
Soil treatment—dalapon (p. 31)

Strawberries:
Post-planting—sesone, sesone plus CIPC (p. 31)
After harvest—2,4-D (p. 31)
During dormancy—sesone, sesone plus CIPC, DNBP (p. 31)

TREE FRUITS

Apples, cherries, peaches, pears, plums: CIPC, DNBP, and dalapon (p. 31)

FLOWERS AND ORNAMENTALS

Gladiolus, dutch iris, narcissus, lilies:
Pre-emergence—sesone, CIPC, DNBP (p. 32)
Post-emergence—sesone (p. 32)

Roses:
CIPC, DNBP (p. 32)

Established evergreen and deciduous plants:
Sesone, CIPC, DNBP, PCP (p. 32)

Seedbeds and transplant beds:
Control of most annual and perennial weeds—methyl bromide, DMTT, SMDC (p. 33)
Control of most weeds germinating in upper 4 inches of soil—calcium cyanamide (p. 33)

FORAGE CROPS, PASTURES, RANGELANDS

Perennial grass seedlings:
2,4-D for broadleaved weeds where annual weed grasses are not present (p. 34)
Silvex for chickweed, henbit, and knotweed (p. 34)
DNBP for seedling broadleaved weeds (p. 34)

Legume seedlings:
4-(2,4-DB) for susceptible weeds in legumes grown for seed (p. 34)
DNBP for seedling broadleaved weeds (p. 34)
Dalapon for annual weed grasses (p. 34)
CIPC for chickweed control (p. 34)
Grass-legume mixture seedlings:
Same as for legume seedlings, except dalapon and CIPC, which cannot be used (p. 34)

Established legumes for hay:
2,4-D for sensitive broadleaved weeds (p. 35)
DNBP, CIPC, MCPA for winter annual weeds (p. 35)

Established legumes for seed production:
Dalapon, TCA in certain areas, diuron in Western States, endothal in Pacific Northwest, for most annual grasses; CIPC or CDEC, aromatic oils, dinitro-fortified oils for dodder; DNBP, PCP for pre-harvest control of grasses and broadleaved annual weeds and as a desiccant (p. 35)

Established grasses for seed production:
2,4-D, 2,4,5-T, silvex, MCPA for most annual and many perennial broadleaved weeds (p. 36)

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; 2,4-D, 2,4,5-T, MCPA, or dalapon; or in Northeastern States, amitrole alone or in combination with dalapon, for renovation of sod (p. 36)

Weeds and woody plants on rangelands and permanent pastures:
Aerial or farm-sprayer applications--
For most woody plants--2,4-D (p. 37)
Mesquite--2,4,5-T, silvex (p. 37)
Shinnery oak--2,4-D, 2,4,5-T, silvex, or mixture of 2,4-D and 2,4,5-T (p. 37)
Post oak--silvex, mixture of 2,4-D and 2,4,5-T (p. 37)
Tall larkspur--2,4,5-T, silvex (p. 37)
High-volume farm-sprayer applications--
2,4-D, 2,4,5-T, silvex (p. 38)
AMS for mixed brush (p. 38)
Individual tree treatments--
2,4-D, 2,4,5-T, silvex (p. 38)

HERBACEOUS PERENNIAL WEEDS ON CROPLAND

Broadleaved perennials:
2,4-D, 2,4,5-T, 2,3,6-TBA, PBA, erbon, silvex, sodium chlorate, borax (p. 40)

Perennial grasses, rushes, and sedge:
Perennial grasses--
Cultivation and combinations of herbicides--Dalapon, TCA (p. 41)
Preplanting--Dalapon, atrazine, simazine, or EPTC, and in humid regions, MH (p. 41)
Spot spraying cultivated areas--Dalapon, TCA, aromatic oils, or dinitro-fortified oils (p. 42)
Rushes--amitrole (p. 42)
Nutsedges--preplanting--EPTC (p. 42)
WEEDS ALONG FENCEROWS, DITCHBANKS, ROADSIDES, UTILITY LINES, AND ON OTHER NONCULTIVATED AREAS

Woody plants:
2,4-D, 2,4,5-T, silvex, MCPA, AMS (p. 43)

Stumps and stump sprouts:
2,4,5-T, or mixtures of 2,4,5-T and 2,4-D, AMS (p. 43)

Ditchbank weeds:
2,4-D, 2,4,5-T, amitrole, silvex, dalapon, dinitro-fortified fuel oil, aromatic oil (p. 44)

Soil sterilization:
Sodium chlorate, borax, sodium arsenite, monuron, diuron, simazine, erbon, or mixtures of these herbicides with 2,4,5-T, 2,4-D, silvex, dalapon, or TCA and fortifying agents, such as herbicidal oils, dinitro compounds, and pentachlorophenol (p. 44)

AQUATIC WEEDS

Floating weeds:
2,4-D, amitrole-T (p. 46)

Submersed weeds:
Irrigation and drainage canals—Emulsifiable aromatic solvents, or acrolein for rooted species in Western and Great Plains areas and Southeastern States; emulsifiable aromatic oils, gasoline mixtures with polychlorobenzine in Florida; copper sulfate for control of filamentous green and red algae; aromatic solvents for control of filamentous green algae in the West only (p. 46).
Reservoirs and large canals carrying water for potable or industrial uses or for irrigation—copper sulfate (p. 47).
Ponds and lakes—sodium arsenite, dichione, copper sulfate (p. 46)

Emergent and marginal weeds:
2,4-D, dalapon (p. 48)

LAWNS AND OTHER TURF AREAS

Lawn and turf seedbeds prior to establishment:
Methyl bromide (p. 49)

Established lawns and turf:
For many broadleaved weeds, 2,4-D; for white clover, silvex; for chickweed, henbit and many other hard-to-kill weeds, silvex, 2,4-D, and endothal. (p. 50)

Crabgrass and other weed grasses:
DMA, dalapon, O-(2,4-dichlorophenyl) O-methyl isopropylphosphoramidothioate, 2,3,5,6-tetrachloroterephthalic acid (the dimethyl ester), calcium arsenate (p. 50)
XI. CHEMICALS REFERRED TO IN THIS REPORT

NOTE: In this section, * means that the common name is also the chemical name. Chemicals marked ** have no common name.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Chemical name</th>
<th>Rates of application expressed in terms of</th>
</tr>
</thead>
<tbody>
<tr>
<td>acrolein</td>
<td>acrylaldehyde</td>
<td>100% acrolein</td>
</tr>
<tr>
<td>amiben</td>
<td>3-amino-2,5-dichlorobenzoic acid</td>
<td>acid equivalent</td>
</tr>
<tr>
<td>amitrole</td>
<td>3-amino-1,2,4-triazole</td>
<td>100% amitrole</td>
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<tr>
<td>amitrole-T</td>
<td>3-amino-1,2,4-triazole-ammonium thiocyanate</td>
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<td>AMS</td>
<td>ammonium sulfamate</td>
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<td>arsenicals</td>
<td>sodium arsenite, arsenic trioxide, arsenic pentoxide, disodium monomethylarsenate [DMA], calcium arsenate</td>
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<td>atrazine</td>
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<td>barban</td>
<td>4-chloro-2-butynyl N-(3-chlorophenyl) carbamate</td>
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</tr>
<tr>
<td>boron com-</td>
<td>borax, sodium pentaborate, boron trioxide, anhydrous sodium bborate</td>
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<tr>
<td>pounds</td>
<td>calcium cyanamide</td>
<td>100% calcium cyanamide</td>
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<td>calcium</td>
<td>* 2-chloro-N,N-diallylacacetamide</td>
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<tr>
<td>cyanamidde</td>
<td>2-chloroallyl diethylthiocarbamate</td>
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<td>chlorates</td>
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<tr>
<td>CIPC</td>
<td>isopropyl N-(3-chlorophenyl) carbamate</td>
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<td>copper</td>
<td>* 2,2-dichloropropionic acid</td>
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<td>DCMA</td>
<td>disodium monomethylarsenate</td>
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</tr>
<tr>
<td>dichlone</td>
<td>3,5-dimethyltetrahydro-1,3,5,2H-thiadiazine-2-thione</td>
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<tr>
<td>DMA</td>
<td>4,6-dinitro-o-sec-amylphenol</td>
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<tr>
<td>DMTT</td>
<td>4,6-dinitro-o-sec-butylphenol</td>
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<td>3,5-dinitro-o-cresol</td>
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<td>3,6-endoxohexahydrophthalic acid</td>
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<td>ethyl N,N-di-n-propylthiolcarbamate</td>
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<td>2-(2,4,5-trichlorophenoxy)ethyl</td>
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<td>erbon</td>
<td>2,2-dichloropropionate</td>
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<tr>
<td>fenac</td>
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</tr>
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<td>4-(MCPB)</td>
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</tr>
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<td>4-(2,4-dichlorophenoxy)butyric acid</td>
<td>acid equivalent</td>
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<tr>
<td>Herbicidal Oils</td>
<td>Chemical Name</td>
<td>Rates of Application Expressed in Terms of Volume</td>
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<td>-------------------------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
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<tr>
<td>Ipazine</td>
<td>2-chloro-4-diethylamino-6-isopropylamino-s-triazine</td>
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<tr>
<td>IPC</td>
<td>isopropyl N-phenylcarbamate</td>
<td>100% IPC</td>
</tr>
<tr>
<td>KOCN</td>
<td>potassium cyanate</td>
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<tr>
<td>MCPA</td>
<td>2-methyl-4-chlorophenoxyacetic acid</td>
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<td>Methyl Bromide</td>
<td>1,2-dihydropyridazine-3,6-dione</td>
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<tr>
<td>MH</td>
<td>[maleic hydrazide]</td>
<td>100% MH</td>
</tr>
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<td>Monuron</td>
<td>3-(p-chlorophenyl)-1,1-dimethylurea</td>
<td>100% monuron</td>
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<tr>
<td>Neburon</td>
<td>1-n-butyl-3-(3,4-dichlorophenyl)-1-methylurea</td>
<td>100% neburon</td>
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<td>NPA</td>
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<td>PBA</td>
<td>Polychlorobenzoic acid</td>
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<td>PCP</td>
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<td>Sesone</td>
<td>Sodium 2,4-dichlorophenoxyethyl sulfate</td>
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<td>Silvex</td>
<td>2-(2,4,5-trichlorophenoxy) propionic acid</td>
<td>Acid equivalent</td>
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<td>Simazine</td>
<td>2-chloro-4,6-bis(ethylamino)-6-triazine</td>
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<td>SMDC</td>
<td>Sodium-N-methyldithiocarbamate</td>
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<td>TCA</td>
<td>Trichloroacetic acid</td>
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<td>TCBC</td>
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<td>2,4,5-T</td>
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<td>2,3,6-TBA</td>
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<tr>
<td>**</td>
<td>N-(3-chloro-4-methylphenyl)-2-methylpentanamide</td>
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<td>N-(3,4-dichlorophenyl)-2-methyl-pentanamide</td>
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<td>**</td>
<td>O-2,4-dichlorophenyl O-methyl isopropylphosporamidothioate</td>
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<td>2,3-dichloroallyl diisopropyl-thiolcarbamate</td>
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<td>2,3,5,6-tetrachloroterephthalic acid, dimethyl ester</td>
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<td>**</td>
<td>2,3,6-trichlorophenylacetamide</td>
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</table>
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Chickweed, Stellaria media or Cerastium spp. - Brambles (30), legume
    seedlings (34), legumes (35), lawns and turf (50)
Chicory, Cichorium intybus - Pastures (36)
Cocklebur, Xanthium spp. - Corn (18), small grains (20), flax (21), cotton
    (21, 22), soybeans (22), peanuts (23)
Coffee weed, Daubentonias texana - Rice (23)
Coontail, Ceratophylum demersum - Submersed weeds (46, 47)
Crab grass, Digitaria spp. - Corn (18, 19), cotton (21, 22), soybeans (22),
    peanuts (23), rice (23), legume seedlings (34), lawns and turf (50)
Curly dock, Rumex crispus - Pastures (36), lawns and turf (50, 51)
Curly indigo, Aescynomene virginica - Rice (23)
Dallis grass - Paspalum dilatatum - Lawns (50)
Dandelion, Taraxacum officinale - Pastures (36), lawns and turf (50, 51)
Death camus, Zigadenus venenosus - Pasture and range (37)
Dodder, Cuscuta spp. - Alfalfa (35)
Dog bane, Apocynum cannabinum - See broadleaved perennials (40)
Field bindweed, Convolvulus arvensis - Corn (18), small grains (20), see
    also, broadleaved perennials (40)
Foxtail, Setaria spp. - Corn (18, 19), flax (21), cotton (21, 22), soybeans (22),
    rice (23), legume seedlings (34)
Goose grass - Eleusine indica - Lawns (50)
Halogeton, Halogeton glomeratus - Pasture and range (38)
Henbit, Lamium amplexicaule - Legumes (35), lawns and turf (50)
Horsenettle, Solanum carolinense - See broadleaved perennials (40)
Horsetail, Equisetum arvense - See perennial grasses, rushes, and sedges (41, 42)
Johnson grass, Sorghum halepense - Grapes (31), perennial grasses, rushes,
    and sedges (41, 42), ditchbank weeds (43)
Knot weed, Polygonum aviculare - Lawns and turf (50)
Lamb quarters, Chenopodium album - Corn (18, 19), small grain (20), flax
    (21), cotton (21, 22), soybeans (22), peanuts (23), beans (26), Irish
    potatoes (29), legume seedlings (34)
Larkspur, Delphinium spp. - Pasture and range (38)
Leafy spurge, Euphorbia esula - See broadleaved perennials (40)
Loco, Oxytropis spp. - Pasture and range (37)
Lotus, Nelumbo lutea - Emergent and marginal weeds (48)
Marsh elder, Iva xanthifolia - Flax (21)
Mesquite, Prosopis juliflora - Pasture and range (37)
Morning glory, annual, Ipomoea purpurea - Corn (18), cotton (21, 22), soy-
    beans (22), peanuts (23)
Mudplantains, Heteranthera spp. - Rice (23)
Mustard, Brassica kaber - Small grains (19, 20), flax (21), legume seedlings (34)
Nimblewill, Muhlenbergia schreberi - Lawns and turf (50)
Oaks, Quercus spp. - Pastures and range (37)
Orchardgrass, Dactylis glomeratus - Lawns and turf (50)
Paragrass, Panicum purpureascens - Ditchbank weeds (43)
Parrotfeather, Myriophyllum proserpinacoides - Submersed weeds (47)
Pennycress, Thlaspi arvense - Flax (21)
Pennywort, Hydrocotyl sibthorpioides - Lawns and turf (50)
Pickerelweed, Pontederia spp. - Emergent and marginal weeds (48)
Pigweed, Amaranthus spp. - Corn (18, 19), small grains (20), flax (21), cotton (21, 22), soybeans (22), peanuts (23), Irish potatoes (29), legume seedlings (34), pastures (36)
Plantain, Plantago spp. - Small grains (20), lawns and turf (51)
Pondweeds, Potamogeton spp. - Submersed weeds (46, 47)
Prickly lettuce, Lactuca scariola - Small grains (20)
Princes plume, Polygonum orientale - Pasture and range (37)
Purple nutsedge, Cyperus rotundus - Irish Potatoes (29), Cropland (42)
Purslane, Portulaca oleracea - Lettuce (28), onions (28)
Quackgrass, Agropyron repens - Irish potatoes (29), perennial grasses, rushes and sedges (41), ditchbank weeds (43), lawns and turf (50)
Rabbitbrush, Chrysothamnus spp. - Pasture and range (37)
Ragweed, Ambrosia spp. - Corn (18, 19), small grains (20), flax (21), beans (26), legume seedlings (34), pastures (36), see also broadleaved perennials (41)
Red sorrel, Rumex acetosella - Lawns and turf (50)
Red stem, Ammophila coccinea - Rice (23)
Reed, Phragmites communis - Ditchbank weeds (44)
Russian knapweed, Centaurea repens - See broadleaved perennials (40)
Russian thistle, Salsola kali - Flax (21)
Sandbur - Cenchrus pauciflorus - Lawns (50)
Sand sagebrush, Artemisia filifolia - Pasture and range (37)
Sedges, Cyperus spp. - Rice (23)
Shepherdspurse, Capsella bursa-pastoris - Small grains (20)
Silvery lupine, Lupinus spp. - Pasture and range (37)
Smartweed, Polygonum pensylvanicum - Corn (18), small grains (20), beans (26), onions (28), emergent and marginal weeds (48)
Sneezeweed, Helianthus nudiflorum - Legume seedlings (34), pastures (36), pasture and range (38)
Southern naiad, Najas flexilis - Submersed weeds (46, 47)
Sowthistle, Sonchus arvensis - See broadleaved perennials (40)
Spatterdock, Nuphar spp. - Emergent and marginal weeds (48)
Spikerush, Eleocharis spp. - Emergent and marginal weeds (48)
Sunflower, Helianthus annuus - Small grains (20)
Tansy-ragwort, Senecio jacobaea - Pasture and range (37)
Tarweed, Iva ciliata - Legume seedlings (34), pastures (36)
Timothy, Phleum pratense - Lawns and turf (50)
Vetch, Vicia spp. - Small grains (20), pasture and range (37)
Waterhemlock, Cicutia maculata - Pasture and range (37)
Water-hyacinth, Eichhornia crassipes - Floating weeds (46)
Waterlettuce, Pistia stratiotes - Floating weeds (46)
Water lilies, Nuphar advena - Emergent and marginal weeds (48)
Waterweed, Elodea canadensis - Submersed weeds (46, 47)
White clover, Trifolium repens - Lawns and turf (50)
Whitetop, Cardaria draba - See broadleaved perennials (40)
Wild garlic, Allium vineale - Pastures (36), lawns and turf (50)
Wild oats, Avena fatua - Sugar beets (24), peas (28)
Wild onion, Allium canadense - Pastures (36), lawns and turf (50)
Wild radish, Raphanus raphanistrum - Small grains (20)
Woody aster, Aster parryi - Pasture and range (37)
Yellow nutsedge, Cyperus esculentus - Irish potatoes (29), cropland (42)
Yellow rocket, Barbarea vulgaris - Small grains (19, 20), established legumes (35)

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