Wild White Clover

Tentative — 2,4,5-T in amine and ester form with and without 2,4-D has given variable results on wild white clover. Dosage rates between 16 and 32 oz. per acre have been used. It would seem that at least some of the reports of failure of 2,4,5-T compounds to kill clover are due to confusion of *Trifolium dubium* with *T. repens*. The former appears to be more resistant to both 2,4-D and 2,4,5-T.

TABLE IV

THE SUSCEPTIBILITY OF COMMON TURF WEEDS TO MCPA AND 2,4-D

Susceptibility Categories

(Lower rates applying to 2,4-D ester and amine formulations)

V.S. Very Susceptible - Consistently killed by 16-32 oz. MCPA or 2,4-D per acre.

S. Susceptible - Often killed by 16-32 oz. MCPA or 2,4-D per acre, but a second application sometimes necessary.

M.S. Moderately Susceptible - Often killed by 32-48 oz. MCPA or 2,4-D per acre but a second application at this rate or several at 16-32 oz. sometimes necessary.

M.R. Moderately Resistant - Some useful effect by repeated applications under favourable conditions.

R. Resistant - No useful effect with up to maximum permitted dosages.

	Botanical Name	MCPA (Metal Salt, amine)	2,4-D (Amine)	2,4-D (Ester)
1.	*Achillea millefolium* (Yarrow)	MR	MR	MR
2.	*Alchemilla arvensis* *Aphanes arvensis* (Parsley-piert)	R	R	MR
3.	*Bellis perennis* (Daisy)	MS	S	S
4.	*Centaurea nigra* (Knapweed)	-	MS	-
5.	*Cerastium arvense* (Field mouse-ear chickweed)	-	-	-
6.	*Cerastium vulgatum* (Mouse-ear chickweed)	MS	MS	MS
7.	*Cirsium acaule* (Stemless thistle)	MS	MS	MS
8.	*Cirsium arvense* (Creeping thistle)	S	S	S
9.	*Crepis spp.* (Hawk's beard)	S	S	S
10.	*Erodium cicutarium* (Common storksbill)	-	-	-

	Botanical Name	MCPA (Metal Salt amine)	2,4-D (Amine)	2,4-D (Ester)
11.	*Erodium maritimum* (Sea storksbill)	-	-	-
12.	*Erodium moschatum* (Musk storksbill)	-	-	-
13.	*Galium hercynicum* (Heath bedstraw)	MS	MS	MS
14.	*Geranium molle* (Dove's-foot cranesbill)	MR	MR	-
15.	*Glaux maritima* (Sea milkwort)	MS	MS	-
16.	*Hieracium pilosella* (Mouse-ear hawkweed)	S	S	VS
17.	*Holcus lanatus* (Yorkshire fog)	R	R	R
18.	*Holcus mollis* (Creeping soft grass)	R	R	R
19.	*Hypochaeris radicata* (Cat's ear)	S	S	VS
20.	*Lotus corniculatus* (Birdsfoot-trefoil)	MR	MR	MS
21.	*Luzula campestris* (Field woodrush)	-	-	-
22.	*Montia verna* (Water chickweed (Blinks)	-	-	-
23.	*Plantago coronopus* (Starweed)	S	S	VS
24.	*Plantago lanceolata* (Ribwort)	VS	VS	VS
25.	*Plantago major* (Great plantain)	VS	VS	VS
26.	*Plantago maritima* (Sea plantain)	VS	VS	VS
27.	*Plantago media* (Hoary plantain)	VS	VS	VS
28.	*Polygonum aviculare* (Knotgrass)	*MS	*MS	S
29.	*Potentilla anserina* (Silverweed)	MS	MS	MS
30.	*Potentilla erecta* (Common tormentil)	-	-	-

* MS for seedlings, MR when established.

	MCPA (Metal Salt amine)	2,4-D (Amine)	2,4-D (Ester)
31. *Potentilla reptans* (Cinquefoil)	-	MR	MR
32. *Poterium sanguisorba* (Salad burnet)	-	MR	-
33. *Prunella vulgaris* (Self-heal)	MS	MS	MS
34. *Ranunculus acris* (Crowfoot)	S	MS	MS
35. *Ranunculus bulbosus* (Bulbous buttercup)	MR	MR	MR
36. *Ranunculus ficaria* (Celandine)	-	-	-
37. *Ranunculus repens* (Creeping buttercup)	VS	S	S
38. *Rumex acetosella* (Sheep's sorrel)	MS	MS	MS
39. *Sagina procumbens* (Pearlwort)	MS	MR	MR
40. *Senecio jacobaea* (Ragwort)	MR	MR	-
41. *Spergula arvensis* (Spurrey)	MS	MS	MS
42. *Statice maritima* *Armeria maritima* (Sea pink)	S	S	-
43. *Taraxacum officinale* (Dandelion)	MS	S	S
44. *Trifolium dubium* (Yellow trefoil)	MR	MR	-
45. *Trifolium repens* (White clover)	MS	MS	MS
46. *Tussilago farfara* (Coltsfoot)	MR	MR	-
47. *Veronica arvensis* (Wall speedwell)	MR	MR	MR
48. *Veronica chamaedrys* (Germander speedwell)	MR	MR	MR
49. *Veronica filiformis*	MR	MR	MR
50. *Veronica serpyllifolia* (Thyme-leaved speedwell)	MR	MR	-

Note (1) Weeds for which no categories are given are considered important but information concerning their susceptibility is inadequate.
(2) An index of common names is given in Table VIII at the end of the report.

Section III

Weed Control in Forestry Nurseries

Chemical treatments for the control of weeds in forest nurseries may be divided into four classes:

(I) Treatment of fallow land before making seed beds.

(II) Pre-sowing treatment of the seed bed.

(III) Pre-emergence treatment after sowing.

(IV) Post-emergence treatment.

(a) Early treatment

(b) Treatment of transplanted lines

Recommendations and general information concerning each method are given below.

Treatment of Fallow Land Before Making Seed Beds

Sodium chlorate applied at the rate of 2 cwt. per acre as a spray to fallow land will control many weeds. The relative susceptibility of 18 weeds to sodium chlorate is given in Table V Section IV.

Land which is to be used for seed beds should be fallowed in the previous year. Spray treatment of this fallow will reduce the amount of cultivation needed and ensure a good kill of perennial weeds in a wet season.

Six to nine months should be left between application of the chlorate and planting out of tree seeds. The exact period will depend upon soil type and rainfall, being shorter in sandy soils and under conditions of high rainfall.

Pre-sowing treatment of the Seed Bed

Tentative

Allyl alcohol has been used at the rate of 20 gallons allyl alcohol in 5,000 gallons of water per acre, applied seven days before sowing as a pre-treatment of nursery beds. This has proved satisfactory for all the common species of trees on which it has been tried, and has given a good control of weeds as well as some fungi.

The chemical has a very pungent and offensive smell making handling unpopular.

Injecting the concentrated material at 20 gallons per acre has been tried and this method will probably supersede the drench method, at it involves less handling of the material.

Pre-emergence treatment after sowing

Light mineral oils, selected white spirits and vaporizing oils, applied 3 - 4 days before the crop seedlings are expected to emerge will kill most annual weeds that have emerged except umbelliferous species and groundsel. Perennials are not controlled.

The amount of oil applied should NOT exceed 60 gallons per acre. Higher volumes will affect germination.

All species may be treated, but those most liable to damage are Larch, Norway Spruce, Sitka Spruces, Abies, Thuja and small seeded hard woods. The relative susceptibility of different species is approximately the same as given for post-emergence treatments (p.).

If germinating seeds of Sitka spruce are examined and found to have a ½" radicle they will probably emerge in 3 days. This test may be safely applied to most conifers.

The heavier the oil the more persistent it will be and the greater the chance of it causing a reduction in the germination of the tree seed.

White spirits are generally safer than vaporizing oils but should not have a higher aromatic content than that laid down in the following specifications for typical white spirits and vaporizing oils:-

White Spirits		Vaporizing Oils	
Specific gravity	0.78	Specific gravity	0.82
Boiling range	150 - 240°C	Boiling range	145 - 250°C
Aromatic hydro-carbons	18 - 20%	Aromatic hydro-carbons	12 - 35%

Post-emergence Treatment

(a) Early Treatment

Light mineral oils of the white spirit type containing about 18% aromatics, applied at a rate of 25 gallons per acre, can be used for the control of weeds in Pine (Scots, Corsican, Austrian and Mountain).

The application should be made either before the tree seedlings have shed their testas or 3-4 weeks afterwards. The frequency of application will be governed by the development of the weed population and sprays should be applied as required up to a maximum of six in one season. Weeds surviving two spray applications must be regarded as resistant and removed by hand.

For a satisfactory weed control at these doses the weeds must be sprayed at a very early stage preferably while they are still in the cotyledon or seed leaf stage.

Seedlings should not be sprayed in drought or bright sun. Soil moisture should be high (natural or by watering) though the foliage should be dry. Best results are achieved by spraying early or late in the day to avoid intensely hot and drying conditions.

Tree species can be grouped according to their resistance to mineral oil as follows:-

Group I Resistant

Pinus sylvestris	Scots pine
Pinus nigra	Corsican pine
Pinus mugo	Mountain pine
Pinus contorta	
Picea sitchensis	Sitka spruce
Picea abies	Norway spruce
Thuja spp.	Thuja
Chamaecyparis lawsoniana	Lawson Cypress

Group II Less resistant or sensitive
(Should not ordinarily be sprayed)

Pseudotsuga taxifolia	Douglas fir
Larix spp.	Larches
Tsuga spp.	
Abies spp.	

Group III Most sensitive - hardwood species (when in leaf) Should be sprayed only when trees are dormant and leafless.

Quercus spp.	Oak
Fagus spp.	Beech
Betula spp.	Birch
Acer pseudoplatanus	Sycamore
Alnus spp.	Alder
Tilia spp.	Lime
Fraxinus spp.	Ash

Tentative Douglas fir and Larch may be sprayed under northern conditions if not more than 10 gallons per acre are used.

The weeds controlled are -

Poa annua	Annual meadow grass
Brassica sinapis	Charlock, yellow
Stellaria media	Chickweed
Chenopodium album	Fat hen
Urtica urens	Nettle, annual
Lamium purpureum	Nettle, dead
Atriplex patula	Orache (Goosefoot)
Papaver rhoeas	Poppy (Redweed)
Capsella bursa-pastoris	Shepherd's purse
Veronica spp.	Speedwell (Birds-eye)
Fumaria officinalis	Fumitory
Matricaria spp.	Mayweed
Sonchus oleraceus	Thistle, sow-annual

Generally, resistance increases with age, though the more resistant trees can be safely sprayed while the cotyledons are enclosed in their testas. While the testas are being shed and immediately afterwards there is a period of extreme susceptibility but this will pass as the tree develops in 3-4 weeks, depending on growing conditions, but freshly acquired resistance is usually accompanied by a slight darkening in colour. If damage occurs it usually consists of scorched leaves or may be merely stunting of growth without scorching. This must be considered before applications are repeated.

(b) Treatment of Transplanted Lines

Pines (Scots, Corsican, Austrian and mountain) when 2 years old can be treated with an overall spray under conditions similar to those recommended for the early stage applications. Hardwoods and other species may be treated by using a hooded sprayer so that only the weeds and some of the base of the stem of the tree is wetted. If an inter-row sprayer without a hood is used hardwoods should not be sprayed.

Light oils of low aromatic content (16-20%) should be used at rates not exceeding 60 gallons per acre.

All trees are more sensitive from 6-8 weeks after bud burst.

The weeds controlled by this treatment will be the same as for the post-emergence, early treatment (see above).

The volumes of oil that can be applied are critical and the rates of application given above must be adhered to strictly. It is particularly important to avoid overlapping and consequent double dosage. A constant application rate can be assured only by a set speed and an application pressure maintained at a steady level. These can be obtained by means of a light, wheeled frame carrying a speedometer, and a knapsack sprayer fitted with an automatic reduction valve to ensure constant output pressure though the pressure in

the reservoir is falling. It may be of assistance in calculating the rate applied to note that 1 gallon of spray applied to 75 square yards of seed bed is at the rate of 60 gallons per acre equivalent to:

	75	linear yards	3 ft. wide
or	64	" "	3 ft. 6 in. wide
	56	" "	4 ft. wide.

PART II

RECOMMENDATIONS FOR THE NON-SELECTIVE USE OF HERBICIDES

Section IV

Non-Selective Weed Control

Non-selective herbicides may be used (i) during a bare fallow in a crop rotation to kill perennial weeds not controlled by normal cultivations, or (ii) on uncropped and waste areas (such as military and industrial lands round buildings etc., woodyards, firebreaks, rubbish tips and railway tracks). The control of weeds in the latter case may also be achieved by mechanical means.

Soil factors influence the efficiency of chemicals used as soil sterilants and little accurate information is available on the susceptibility of various species of plants to the chemicals. This makes it difficult to recommend precise application rates. The figures given, which have been collected from several sources are, therefore, very tentative and may have to be modified as more information becomes available.

In treating dense foliage better results are likely to be achieved with the use of soil sterilants when the foliage is first cut off.

Weeds seeds in the soil are not killed by soil sterilants.

Sodium Chlorate

As a general soil sterilant 1 to 4 cwts. per acre should be applied, depending upon the weed infestation and the soil type. This will kill the majority of plants and maintain the land relatively free from weeds for up to twelve months. The effectiveness of sodium chlorate is reduced in alkaline soils, and heavier application may be required on sandy soils than on heavy soils. Sodium chlorate may be applied as a solid, or as a solution using the volume of water that is practicable.

Table V

Minimum Effective Application Rates of Sodium Chlorate when Applied as an Aqueous Solution to Growing Plants in Undisturbed Soil

(Lighter applications may give equal control when combined with cultivations).

	Weed	Dose (lb. per acre)
Tentative	*Stellaria Media* (Chickweed)	20
	Veronica spp. (Speedwell)	20
	Lamium purpureum (Red deadnettle)	20
	Senecio vulgaris (Groundsel)	40
	Epilobium spp. (Willowherb)	50
	Ranunculus repens (Creeping buttercup)	50
	Senocio jacobaea (Ragwort)	50
	Polygonum aviculare (Knotgrass)	100
	Symphytum officinale (Comfrey)	120
	Calluna vulgaris (Heather)	150
	Tussilago farfara (Coltsfoot)	150
	Urtica dioica (Nettle)	150
	Pteridium aquilinum (Bracken)	170
	Agropyron repens (Couch)	225
	Ranunculus ficaria (Lesser celandine)	270
	Cirsium arvense (Creeping thistle)	350
	Rumex sp. (Docks)	400
	Aegopodium podagraria (Ground elder)	500

Where sodium chlorate is applied on arable land at a rate of 1-2 cwt. per acre for the control of *Agropyron repens* the land should be kept free from crops for several months; an early autumn application can be made and a crop sown the following spring. Some crops, however, are more sensitive to chlorate than others: oats, vetches, peas, potatoes and cabbage are relatively tolerant and may be sown in the spring following an autumn application; but barley, mangolds, beet and turnips are more sensitive and should not be sown until about twelve months after treatment.

Sodium chlorate should not be used near valuable plants or crops as their roots may reach out into the area treated with the chemical and take up a lethal dose.

Sodium chlorate applied in two doses may achieve a better kill, one third of the quantity being applied to destroy most of the foliage and two thirds being applied later.

Organic matter wetted with sodium chlorate and subsequently dried becomes highly inflammable: clothing wetted by the solution should be washed as soon as possible. Commercial formulations of sodium chlorate often include calcium chloride, borax or some other compound to reduce this fire hazard.

Sodium arsenite

This chemical is poisonous to man and animals and its use is therefore restricted. It is used in a manner similar to sodium chlorate and at similar or slightly higher rates, but its effectiveness as a soil sterilant may persist rather longer. Most annual weeds are readily controlled, but perennial weeds may show resistance as for example *Convolvulus arvensis*. Quite often this chemical does little more than defoliate heavy infestations of some creeping perennial grasses.

Trichloroacetic acid

This is toxic principally to grasses and used alone is, therefore, of little use as a non-selective herbicide. To control *Agropyron repens* in fallow land, cultivations should be combined with an application of 40 lb. of TCA per acre. Best results are obtained by splitting the application of TCA (with an interval of 3-6 weeks between applications) and cultivating prior to each treatment. Treatment may be during the time that the couch is actively growing; and summer or autumn treatment can be followed by normal cropping in the following spring, except on some fen soils and soils high in humus content.

For the destruction of grass swards and where treatment is not combined with cultivations at least 120 lb. of TCA per acre appears to be required.

Borax

Because of its low solubility borax is usually applied to the soil in powder or granular form. It is slow to affect plants, but its effects persist for some years when applied at high rates (15 to 40 cwt. per acre). Grasses are tolerant to quite high amounts of borax and up to 30 and 40 cwt. of borax per acre may be required for the control of all vegetation. Deep rooted perennial weeds also are not easily killed since borax, being relatively insoluble in water, tends to stay in the upper soil layer.

Minimum effective Application Rates in cwts per acre

Tentative	*Poa annua* (Annual meadow grass)	1
	Anagallis arvensis (Scarlet pimpernel)	1
	Veronica spp. (Speedwells)	1
	Papaver rhoeas (Poppy)	1
	Stellaria media (Chickweed)	2
	Polygonum convolvulus (Black bindweed)	2
	Hypericum perforatum (St. John's Wort)	10
	Cirsium arvense (Creeping thistle)	14

A mixture of sodium chlorate and borax in the proportion of 1 to 4 (by weight) produces a quicker initial kill and better control of grasses; for general use the application rate may be 8 to 10 cwt. per acre.

Fortified Oils

The toxicity of oils to plant tissues varies with the proportion of aromatic compounds present and with the boiling point. The toxicity of oils can be increased by fortifying them with dinoseb, DNC, pentachlorphenol (PCP) or a growth regulating substance. Fortified oils do not induce soil sterility in the manner of the other chemicals mentioned and deeply growing rootstocks may not be killed.

Rates of application vary, depending on the toxicity of the oil and the presence of a fortifier; as little as 10 gallons of fortified oil applied as an emulsion at 100 gallons per acre can control young herbaceous growth, but greater rates are needed in dense weed growth. Unfortified oil can be applied direct at 100 to 300 gallons per acre depending upon the density and type of weed.

Used as fortifying agents dinoseb can be included at 1 to 1½ lb., or PCP or DNC at 4 lbs. per 100 gallons of oil, or, where the oil is applied as an emulsion, per 100 gallons of emulsion.

Section V

Woody Weed Control

Woody weeds present a very definite problem in agricultural land due for reclamation, sometimes in forest plantations and occasionally along roadsides, railway embankments and large installations which are difficult to keep tidy. Mechanical methods of control are well known and include repeated cutting or repeated defoliation, digging or grubbing, cabling and girdling. Burning is also a well-tried method of control. The discovery that the growth-regulating chemicals, 2,4-D and, more particularly, 2,4,5-T are of considerable value in the control of woody species has stimulated interest in the techniques of their application and also that of older chemicals such as ammonium sulphamate. These techniques will vary according to the type, size and mode of growth of the woody species concerned as well as to their situation.

CHEMICALS

Many different chemicals including MCPA, sodium chlorate and sodium arsenite are known to be suitable for controlling woody growths, but the chemicals proving most useful for woody weed problems which exist in the British Isles are 2,4,5-T and 2,4-D and mixtures of these, and to a lesser extent ammonium sulphamate. Accordingly, the remarks in this section are confined to the last-mentioned materials.

Ammonium sulphamate

This is non-poisonous, and presents neither an explosion nor a fire hazard. It is very soluble in water and absorbs moisture when exposed to the air. In solution it is corrosive to some metals, particularly brass. It is both a contact and a translocated herbicide and may act as a temporary soil sterilant. It can be applied either in a spray or as dry crystals.

Rhododendron, hazel and oak can be controlled by spraying individual cut stumps in early summer with a concentrated solution of 3-lb. ammonium sulphamate in 1 gallon of water plus wetting agent. Application should be made within three days of cutting.

This recommendation may possibly be extended to other species but no information other than that quoted above is at present available from the British Isles.

2,4-D and 2,4,5-T

Ester formulations are preferred for woody weed control. The majority of woody weeds are more susceptible to 2,4,5-T than to 2,4-D. It is not generally held that certain species are more susceptible to mixtures than to the individual chemicals. Mixtures are most useful for mixed stands of woody weeds, some of which may be more susceptible to 2,4,5-T than to 2,4-D and vice versa.

Products based on 2,4-D, 2,4,5-T and 2,4-D/2,4,5-T mixtures can be formulated for dilution with water only, oil only and either water or oil and all the remarks in this section refer to suitably formulated products. Diesel oil, vapourising oil, gas oil, kerosene and diesel oil/vapourising oil mixtures are suitable diluents for oil miscible products.

METHODS OF APPLICATION

These must be adapted to the type of vegetation, its mode of growth and the terrain. Four methods are commonly employed and may be classified as on the next page.

Methods (2), (3) and (4) may be used in the dormant season as well as during the normal growing season. Overall dormant sprays are not very commonly

employed and require high concentrations of 2,4,5-T or 2,4-D/2,4,5-T mixtures in oil as water is not a suitable carrier for this purpose.

(1) Foliage Treatment

Best results are obtained some time after maximum leaf development until the end of the period of shoot growth (July and August). It is essential that all parts of the plant should be thoroughly wetted with the spray. Water is a very satisfactory carrier but for more resistant species superior results may be obtained by using oil as the carrier. Some regrowth is to be expected in the year following spraying.

(2) Basal bark treatment

The entire basal area from ground level up to 1½ - 2 ft. should be thoroughly wetted to run-off with oil-carried sprays. This technique applies mainly to trees but it is also applicable to small shrubs. Where regrowth is likely to occur from underground parts of the plant, the area immediately surrounding the plant should be thoroughly soaked with the spray.

(3) Cut-surface treatment

This involves application of the chemical to the cut stump of felled shrubs and trees. 2,4,5-T ester in oil is the best formulation for the purpose. With some species such as gorse, sweet chestnut and rhododendron, best results follow application immediately after cutting, before the surface of the cut stump has dried.

(4) Ring barking or frill-girdling

This method which applies mainly to large trees consists of removing completely a band of bark together with the phloem all the way around the woody stem. If the girdle is made wide enough to prevent healing and deep enough to prevent the cambium from developing a new phloem it may be effective on its own in killing trees. The application of 2,4-D or (preferably) 2,4,5-T in oil to the girdle will aid in killing the active cambium. Painting on the chemical is a good method of application. Regrowth which develops subsequent to treatment, either from laterals below the girdled area or from suckers, should be removed.

SUSCEPTIBILITY OF SPECIES

This matter, and those of preferred chemicals, suitable doses and application techniques are best summarised in tabular form as in the attached table.

PRECAUTIONS

It must be borne in mind that 2,4-D and 2,4,5-T present hazards concerning danger of drift on to susceptible species. In addition, some of the ester formulations of both 2,4,5-T and 2,4-D are volatile.

Table VI

THE SUSCEPTIBILITY OF COMMON WOODY WEEDS TO 2,4-D AND 2,4,5-Y

All the recommendations in this section should be regarded as tentative

SUSCEPTIBILITY CATEGORIES

S. Consistently good control of aerial growth by suggested technique.

MS. Good control of aerial growth by suggested technique but generally requiring a higher dose than for 'S' category.

MR. Some useful effect by foliage applications of up to 64 oz. in water and in dormant applications of up to 480 oz. in oil.*

R. No useful effect by rates up to those quoted in the 'MR' category above.

The doses given above and in the table refer to ounces of 2,4-D and 2,4,5-T acid equivalent per 100 gallons of diluent.

* It should be remembered that much smaller quantities of oil diluted spray are usually required for dormant applications than for full foliage applications of water diluted sprays.

Tentative

Botanical name	2,4-D ester	2,4,5-T ester	Diluent	Application	Remarks
1. *Alnus glutinosa* (Alder)	MS 32-64	S 16-32	Water	Full foliage	
2. *Betula verrucosa* (Silver birch)	MS 32-64	MS 32-48 MS 32-64	Water oil	Full foliage Basal bark	
3. *Corylus avellana* (Hazel)	S R	S 16-32 S 160-480	Water Oil	Full foliage Basal bark (2,4-D) Cut stump or re-growth (2,4,5-T)	
4. *Crataegus monogyna* (Hawthorn)	R	MR 48-64 MR 160-480	Water Oil	Full foliage Cut stump	
5. *Castanea sativa* (Sweet chestnut)		MS 32-48 MS 160-480	Water Oil	Full foliage Cut stump	
6. *Hedera helix* (Ivy)		R			
8. *Ilex aquifolium* (Holly)		R			
8. *Juniperus communis* (Juniper)	R	R			
9. *Prunus spinosa* (Blackthorn, Sloe)		MR 48-64	Water	Full foliage	
10. *Quercus robur* (Oak)	R	MR 48-64 MS 320	Water oil	Full foliage Basal bark	

Botanical name	2,4-D ester	2,4,5-T ester	Diluent	Application	Remarks
11. *Rubus spp.* (Blackberry, Bramble)		S 16-32	Water	Full foliage	Some re-growth to be expected in year following treatment.
12. *Rhododendron ponticum*	R	MR			
13. *Sambucus nigra* (Elder)	S 16-32 S 80-160	S 16-32 S 80-160	Water Oil	Full foliage Cut stump	
14. *Sarothamnus scoparius* (Broom)	S 16-32	 MS 160-480	Water Oil	Full foliage Cut stump	
15. *Sorbus aucuparia* (Rowan, Mountain ash)	MS 32-64	MS 32-48 MS 160-480	Water Oil	Full foliage Basal bark or cut stump	
16. *Salix spp.* (Willow)	S 16-32	S 16-32	Water	Full foliage	
17. *Ulex europaeus* (Gorse)		MS 32-48 MS 160-480	Water Oil	Full foliage Fresh cut stumps	Regrows from roots

AFTER TREATMENT

None of the methods discussed in this section can be expected to give complete control with a single treatment. Repeat treatments should be made as required. Frequently chemical treatment alone is inadequate and must be supplemented by burning and mechanical measures such as cutting, digging or grubbing and cabling. Consideration must also be given to the resowing and management of reclaimed land if rapid reinvasion by undesirable species is to be prevented.

Section VI

Crop Desiccation

PRE-HARVEST SPRAYING OF LUCERNE, WHITE AND RED CLOVER FOR SEED PRODUCTION

Over the past three years experiments in the pre-harvest spraying of lucerne, white and red clover for seed production have indicated that certain sprays satisfactorily reduce the moisture content of these crops and greatly facilitate their harvesting, in many cases making it possible to combine them direct. It is probable that many contact herbicides may be used successfully for the purpose but experience in this country is mainly limited to dinitro compounds. While results have been favourable, the following recommendations must be regarded as tentative.

Tentative

Dinitro compounds in oil may be used at the following rates:- Dinoseb 1-2 lb. or DNC 2-4 lb. per acre. For crop desiccation these compounds are formulated as emulsion concentrates and prepared for spraying by dilution with water to a volume of 20 gallons or more per acre. The addition of 1-2 gallons per acre of diesel oil to the concentrate before dilution may improve the result.

Tentative

Sodium monochloracetate at 8-16 lb. per acre, applied in high volume with added wetting agent, has been very effective on red clover seed crops, but results with lucerne or white clover have not been as good. In some areas sulphuric acid has been used for this purpose. Satisfactory results have been obtained with an 8-9% v/v solution with wetting agent applied at the rate of 100 gal. per acre or 20 gall. of 77% v/v sulphuric acid (undiluted BOV) without wetting agent per acre.

The timing of the application to the crop is important and is best determined by examining the crop at frequent intervals and applying the spray when random sampling indicates from 60% to 70% of mature seed heads in each sample; this is usually about 7-10 days in advance of the normal harvesting date. Germination tests have indicated that the viability is in no way impaired but, as the proportion of hard seed is increased, it is necessary to 'scarify' to achieve maximum germination.

Where dinitro materials have been used, on no account should any part of the crop be fed to stock after threshing.

Section VII

Potato Haulm Destruction

The destruction of potato haulm may be carried out to stop the growth of tubers, to ease the lifting of potatoes or to prevent the spread of blight from foliage to tubers. All recommended methods of haulm destruction, including mechanical means, are equally effective for stopping growth and/or making harvesting more easy, providing the treatments are carried out 10 - 14 days prior to lifting. With mechanical haulm destruction a full 14 days should be allowed. For the prevention of the spread of blight to the tubers it is necessary to spray before the blight has spread to any extent through the crop (such early treatment may reduce yield), and the spray used should produce a quick kill. For the prevention of tuber infection in the soil, good soil cover, blight preventative spraying of the foliage and the use of the more blight resistent varieties is as important, if not more so, than haulm destruction. Late destruction of the haulm may do little to prevent tubers becoming blighted and in such cases the use of chemicals may be unnecessary as a rapid kill of the haulm can be achieved by the spread of the blight itself.

Sulphuric Acid

Sulphuric Acid is the most effective material and should be applied at 100 gallons per acre as a 12 per cent solution, i.e. 12 gallons of acid in 88 gallons of water, or 15 gallons of B.O.V. in 85 gallons of water. (B.O.V. is a commercial form of sulphuric acid commonly available and contains 77 per cent of sulphuric acid). B.O.V. may be used undiluted at the rate of 20 gallons per acre. In diluting sulphuric acid the acid must always be added to the water and NOT vice versa.

Sodium Arsenite

Sodium arsenite should be applied at the rate of 10 lb. As_2O_3 equivalent per acre at a medium or high volume rate (i.e. in 25-100 gallons of water per acre,) It is slow in its action. The material is poisonous and care must be taken both in using it and in disposing of surplus material. Sodium arsenite is non-corrosive to metals.

Tar Oil Fraction

Fluid coal tar oils containing not less than 20 per cent of phenols of which not less than 80 per cent distil within the range of 220 - 330°C., can be applied without dilution at 25-30 gallons per acre for normal conditions and 30-35 gallons per acre on vigorous haulm in the early season (e.g. in seed production). Tar oil fractions may leave on the machinery a tarry material that is difficult to remove. They are non-corrosive to metals but can cause smarting and reddening of the skin.

Sodium chlorate

Sodium chlorate should be applied at 15 lb. per acre at a high or medium volume rate. Increasing the dose above 15 lb. does not generally increase its efficiency. It is only moderately effective as a potato haulm destroyer as it does not readily kill the stems. Warning of the fire hazard connected with the use of sodium chlorate has already been given (Section IV Page 46).

DNC

DNC formulated as an oil/water emulsion should be used at the rate of 3 lb. of DNC per acre, at a volume rate of not less than 25 gallons per acre.

Copper Sulphate and Salt

Copper sulphate and salt at the rate of 30 lb. of copper sulphate and 10 lb. of salt in 100 gallons of water per acre can be used, although results

may not be as satisfactory as by using some of the other materials. As with sodium chlorate, there is a relatively poor kill of stems. The mixture is corrosive to metals, particularly brass.

Sulphuric acid acts more quickly than sodium arsenite or tar oil fractions and is therefore preferable where blight control is the primary aim of spraying. DNC oil emulsions have some direct effect in killing blight spores and persist as a protective layer on the soil for some days after application. Sodium chlorate acts quickly on leaves, but very slowly on the stems on which blight may continue to sporulate for some time after spraying. With mechanical means of destruction, foliage on which blight can flourish for some days may be left in the bottom of the potato rows; mechanical destruction is not so effective as spraying for the destruction of low growing weeds in the furrows.

It is important, with all sprays, that the foliage should be thoroughly covered; and the weather should generally be fine for some time after spraying. Tar oil fractions and DNC in particular require good weather following application, although sulphuric acid may give better results during damp or misty weather. Chickweed and other low growing weeds in the potato rows can be effectively killed providing the spray can penetrate their foliage: chickweed which is spongy and wet may not be killed.

PART III

GENERAL CONSIDERATIONS

Section VIII

Application of Herbicides

Types of Application

Weedkilling by means of chemicals involves the distribution of the so-called 'active ingredients' over the area to be treated and the method of application can be one of three types:-

Overall: Application is made uniformly over the whole area and is the most usual method.

'Directed': The area treated is confined to a band extending a few inches on each side of the crop row. This method is employed to kill weeds in the rows where mechanical methods are satisfactory for removing those between the rows.

'Spot' treatment is of great use where the distribution of the weed is not sufficiently great to justify 'overall' treatment. In this type application is to the weeds only.

In any of the above three types the spray may be applied at low volume, medium volume or high volume.

Low volume is when the diluted chemical is applied below 20 gallons per acre of ground treated.

Medium volume usually refers to application rates from 20 to 60 gallons per acre of ground treated.

High volume is above 60 gallons per acre of ground treated.

Formulation

The majority of herbicides used at present are effective in such relatively small quantities that they require to be diluted with some chemically inert material to enable even distribution to be made. (Exceptions to this are the vaporising oils and concentrated sulphuric acid). These herbicides may be distributed in the form of:-

Dusts: In a dust the active ingredient may be either a solid or a liquid but the diluent is always a solid, usually of high density.

Sprays: The concentrated chemical is usually diluted with water to form either:-

Water solution: The chemical concentrate may be solid or liquid but on dilution with water it forms a true solution, e.g. Sodium, potassium and amine salts of MCPA.

Emulsion: Here the active ingredient is insoluble in water or is not sufficiently soluble to allow quick dilution. It is therefore formulated so that the concentrate on dilution with water forms an emulsion which resembles a solution for the purposes of spraying, e.g. esters of 2,4-D

Suspension: In a suspension the chemical remains as solid particles distributed throughout the water diluent. A suspension can be used where the active ingredient is insoluble in water and where it is not possible to use an emulsion. The concentrate may be a solid or a concentrated suspension.

Machinery

There are many methods by which even distribution of the chemical can be attained and these depend mainly on the physical characteristics of the active ingredient and to a lesser extent on its biological properties. The machinery for application can be broadly divided into:-

Dusting machines: There are many types available from hand dusters to tractor mounted or even trailer machines. In the absence of a specially made dusting machine a fertiliser distributor is sometimes used for applying herbicidal dusts, e.g. dusts of MCPA or 2,4-D.

Spraying machines can be divided into 3 main categories, depending on their application rates at the normal spraying speed of 4 m.p.h.:- low volume, medium volume, high volume. The rates of application, as previously defined, determine the categories into which a machine will fall. Some machines fall into more than one category by varying the spraying speed or by changing the nozzles.

Low volume sprayers: These are machines with a tank capacity of 20 or more gallons and a small pump. Mechanical agitation is seldom included and the liquid is kept mixed by circulation. These machines may be trailer or tractor mounted types though the latter is the more usual.

Medium volume sprayers usually have a larger tank capacity and pump. Agitation may be by mechanical means or by circulation. Again they may be tractor mounted or trailer types.

High volume sprayers have a still larger tank and pump and agitation may be either mechanical or by circulation. The large types are trailer machines while the smaller types are either trailer or tractor mounted.

Volume rates

The particular weed or mixture of weeds together with the particular crop determine the type of herbicide to be used, and this in turn determines the volume of application per acre. With the growth regulating herbicides it is possible to achieve satisfactory weed control at 5 gallons per acre although better results are usually obtained with a minimum of 10 gallons per acre, particularly with the higher doses of herbicide in common use. With contact herbicides, e.g. DNC and dinoseb, high volume application gives the best results because to achieve satisfactory control the maximum amount of coverage should be obtained. With these chemicals there is loss in selectivity when applied at medium or low volume rates. Suspensions like DNC require efficient agitation to maintain an even composition of the active ingredient in the spray tank and consequently on the weeds and crop.

Nozzles

The main types of nozzles used for herbicidal work are:-

Fan type nozzles, generally used for low or medium volume sprays because the spray which they produce at low pressure has good penetrating properties. They have the disadvantage that, for even coverage, the spray fans should meet just above the target, and hence particular care should be taken to see that the spraybar height is correct.

Hollow cone nozzles, generally used for medium or high volume sprays. Some types can be operated at low pressures of 30-60 lb. while others can only act efficiently at pressures above 100 lb. Compared with fan type nozzles they give a more even distribution irrespective of spraybar height - provided the spraybar is high enough to allow the cones to meet.

Pressure

An increase in pressure reduces the droplet size. Too high a pressure may produce too many fine droplets which may be undesirable, e.g. spray drift is increased, or with dinoseb on peas there is a loss in selectivity when a very fine spray is applied. The right nozzle should therefore be chosen for the job in hand, and where different volumes per acre are required, different sets of nozzles or nozzle parts will usually be required.

Spraying procedures

The manufacturer's instruction for both the chemical and machinery should be studied and followed. Check the output with water and adjust if necessary to give the desired volume per acre.

(a) Filling: Use a clean water supply, preferably soft because with some herbicides more chemical is needed to obtain the same results from hard water. It is better partly to fill the sprayer with water before adding the chemical. The filters should always be used even if it takes longer to get the chemical washed through.

(b) Timing: Spray when the crop and weed are at the correct stage. Spray during good growing conditions and only during suitable weather, not in strong winds, or when rain or frost is imminent. Due regard must be made for the climatic conditions when applying temperature-dependent weed-killers such as dinoseb.

(c) Spray technique: A well proven method for cereals is to spray the headlands first - once in the case of tractor mounted or small trailer sprayers - and a second bout inside the first in the case of large trailer machines. The remainder of the field should be sprayed along the drill rows starting on the leeward side.

(d) Matching up work: Slight overlap is usually desirable. An inexperienced operator should at first use a marker or marking device to prevent misses or too much overlap. When mixing is done in the sprayer, spraying should be continued until it is empty (or nearly so) before refilling, as otherwise the concentration of chemical may increase above that recommended. When the sprayer becomes empty during a bout, the machine should immediately turn into the previous bout and proceed to the filling station. After filling it should proceed down the partly sprayed last bout and commence spraying near where the wheel marks turn into the previous bout.

(e) Nozzle blockage: If the chemical or water being used is liable to block the nozzles, the filters should be cleaned frequently and repaired or replaced if damaged. A quick spraying test should be done on the headland (off the crop) or on waste ground near the filling station. Blocked or partially blocked nozzles should be replaced by clean nozzles or parts. The blocked nozzles can then be cleaned near the water supply. This applies especially when poisonous chemicals are used.

If a single nozzle gets blocked during spraying, it is sometimes preferable to wait until the headland is reached before replacing. This applies particularly to dangerous chemicals and to contact weedkillers being used on a machine without an anti-drip device.

(f) Statutory requirements: For scheduled weedkillers the Agriculture (Poisonous Substances) Regulations 1954 must be followed. (See Section IX, Weedkillers and the Law).

(g) Spray drift: Do not allow drift from herbicides on to nearby susceptible crops, people or buildings, especially if the chemical is poisonous. Drift can be reduced by (i) spraying in relatively still conditions or (ii) by using as coarse a spray as is consistent with

satisfactory weed control or (iii) using a boom shield to trap the fine droplets that would otherwise be blown away.

Spraying downwind produces less drift than into wind or crosswind though it may be undesirable to do this from the point of view of the operator's safety or comfort.

(h) Spillage of unsightly or poisonous chemicals should be covered with earth.

Contamination of water supply should be avoided during filling or spraying. If unwanted spray mixture is left over from an operation, it should be disposed of so that it cannot contaminate water, or is not dangerous to humans or animals. Empty or partly emptied chemical tins should be similarly disposed of.

(i) Decontamination: At the end of each day's work the sprayer should be emptied, refilled with water and sprayed out on an uncultivated area. Again refilled and left overnight. This will prevent chemical drying and caking inside, and eventually flaking off to block nozzles. Where spraying with herbicide is to continue the following day, the water left overnight in the tank may be used. If a change is being made from herbicide to insecticide, it should be sprayed out again and the sprayer should be further decontaminated by washing 3 or more times with 10 lb. Soda ash + ½ pint wetting agent per 100 gallons. At the end of the spraying season the same procedure should be followed. Then refill with Soda ash as above and leave this until the machine is repaired or required next season.

N.B. The machine should be stored under cover so that frost does not damage the pump or pipework. If damage is likely, the Soda ash mixture should be drained from the pump and pipework.

Section IX

Weedkillers and the Law

The Committee are indebted to Mr. G. F. Aronson, Solicitor of the Legal Department of the Ministry of Agriculture and Fisheries for the preparation of this Section.

The increasing use of weedkillers both poisonous and non-poisonous in agriculture makes it desirable to consider the obligations imposed by law on contractors and farmers who use them, and the legal consequences which are involved when persons are injured or killed, or property is damaged. It is convenient to divide the subject into two parts, and to consider in the first place criminal responsibility, and secondly, civil claims for damages which might possibly arise.

CRIMINAL LIABILITY. While it is true to say that a person who misuses toxic chemicals in such a way that a person is killed may render himself liable to a charge of manslaughter, in practice such a charge is unlikely to be preferred except where negligence of a most serious nature can be established by the prosecution. Assuming that personal injury, or damage occurs accidentally and not deliberately, the person responsible is not guilty of any offence, except insofar as it falls within the scope of the Agriculture (Poisonous Substances) Act, 1952.

The object of this Act is indicated by its long title, "an Act to provide for the protection of employees against risks of poisoning by certain substances used in agriculture", and it is to be noted, therefore, that the provisions of the Act do not extend to the self-employed man or to members of the public, but only to the employees of contractors and farmers. The Act does not itself lay down the precautions to be observed when poisonous substances are used, since obviously these will vary from time to time as conditions change, and scientific knowledge grows: it authorises the Minister of Agriculture and Fisheries and the Secretary of State for Scotland to make regulations, which may be amended or revoked at any time. Before making regulations the two Ministers are required to consult with the representative organisation of the industries concerned, although they are not legally bound by the advice which they are given. The Act provides for the appointment of inspectors who are charged with the duty of enforcing the Act and the regulations and confers on them rights of entry on to land, and other miscellaneous powers, such as the right to require the production of documents and to take statements. An inspector is also empowered to take samples of substances to which the Act applies and it contains provision for such samples to be analysed by an approved analyst, whose certificate in any legal proceedings as to the result of any analysis is admissible in evidence without the need of calling the analyst in person as a witness.

The Act does not apply to all weedkillers or even to all poisonous substances but only to substances which fall within the following classifications:- (a) dinitro-phenols and their salts; (b) dinitro-substituted phenols and their salts; (c) organo-phosphorus compounds; and (d) preparations or mixtures containing any of these substances.

The Minister and the Secretary of State can, however, make an Order extending the application of the Act to other substances if they are satisfied that their use in agriculture would be likely to involve substantial risk of poisoning to workers who use them. At present no such order has been made.

Not all substances which fall within these classifications are necessarily controlled. The Regulations which are at present in force (which replaced the earlier Regulations originally made) are the Agriculture (Poisonous Substances) Regulations, 1954 (S.I. 1954 No. 828), and they extend only to the substances which are described in the Second Schedule to those Regulations. Since the Regulations draw a distinction between those substances which are considered to be more dangerous than the rest and therefore require greater precautions to be

observed when they are used, the Schedule is divided into two parts. Part I contains the more dangerous substances, namely dimefox, demeton - P, demeton - S, and bis (dimethylamino) azidophosphine oxide (for which no common name has yet been allotted by the British Standards Institute): Part II contains the less dangerous substances, namely DNC, dinoseb, parathion, schradan, mipafox, TEPP (HETP), and sulfotepp.

The Regulations specify ten separate operations (of which spraying a ground-crop is perhaps the most typical and the most important), and according to whether the substance used falls within Part I or Part II of the Second Schedule, lays down the protective clothing which a worker is required to wear when carrying them out. The Regulations impose an obligation not only on the employer to ensure that the worker wears the required protective clothing, but on the worker himself also. Therefore not only the employer but the worker too may be charged with infringing the Regulations. Other matters which are dealt with in the Regulations include the number of hours during which workers may be engaged on the specified operations; the age at which they may be employed; working in greenhouses; the provision and maintenance of protective clothing; the provision of washing facilities for workers; the notification of sickness; the training and supervision of workers; and the keeping of a register containing certain prescribed particulars.

In order to provide for special circumstances, inspectors are empowered to grant certificates of exemption, if they are satisfied that any of the Regulations could reasonably be dispensed with if alternative conditions were observed, or by reason of exceptional circumstances, or the small extent of the operations carried out, any of the provisions of the Regulations are unnecessary for the protection of the worker.

A person guilty of an offence against the Act or the Regulations is liable to a fine not exceeding fifty pounds, and in respect of an offence continued after conviction, to an additional fine not exceeding ten pounds for each day on which the contravention is continued.

CIVIL LIABILITY. In dealing with civil liability it is important to appreciate that the law requires of persons who deal with things which are dangerous in themselves, such as poisons, a very high standard of care indeed, so that in many cases it is unnecessary for the person injured to prove that the other party has been guilty of negligence. Although it is not possible to deal exhaustively with every type of case which could arise, the following are examples of relationships which might give rise to claims for damages:-

Employer and employee. Quite irrespective of the obligations laid down in the Agriculture (Poisonous Substances) Regulations, 1954, an employer owes to his workmen a duty to ensure that a safe system of work is adopted, and if the employer fails in this duty, he is liable in damages if a worker sustains injury in consequence. What constitutes a safe system of work is in every case a question of fact depending on the circumstances. Moreover, a worker who suffers damage through failure of the employer to comply with the Regulations such as e.g. to provide the proper protective clothing, need not prove negligence on the part of his employer at all, but is entitled to bring an action for breach of statutory duty. It may be that in some cases the employer will have a defence to either of the above types of claim that the worker was himself guilty of contributory negligence, but if the alleged contributory negligence consists of failure to take steps which it was the employer's duty under the Regulations to ensure that the worker should take, such a defence is likely to fail.

Duty to neighbours. If an occupier of land uses chemicals to spray his crops, and the chemicals escape and damage his neighbour's crops or livestock, in general it is true to say that he is absolutely liable and no question of negligence arises. The only defence which the occupier might have would be that the damage had occurred through the intervention of a third party or was due to an Act of God, but in practice neither of these defences is likely to be of much avail. If the spraying is

undertaken by a contractor, the occupier will still be liable, but in such a case he will be able to recover indemnity from the contractor if he can show that the damage occurred through the contractor's negligence.

An occupier of land is under a duty to fence in his cattle, but he is under no obligation to fence out his neighbours cattle. Consequently, in general, no legal redress exists if the cause of poisoning was that the cattle were trespassing on land which was being sprayed; but the position might be different if a fence was known to be weak, and the chemical used was known to be poisonous to cattle, and the occupier failed to issue a warning.

Duty to the Public. Both an occupier of land and a contractor owe a duty to members of the public, e.g. persons lawfully passing along the highway (including any recognised footpath which crosses land which is being sprayed), to ensure that they are not injured by chemicals which are used. This responsibility also extends to persons visiting the land for the purpose of trade or business, and probably also to purely social visitors. There is, however, no duty or care owed to a mere trespasser, who therefore has no ground for complaint if he is injured while trespassing on land on which spraying operations are being carried out. An exception to this rule, however, may arise in the case of young children, of whom the law does not expect the same standard of behaviour as of adults. If the operations being carried out are such as to constitute an "irresistible lure" to children, e.g. spraying operations carried out by a helicopter, then it is the duty of the person responsible for carrying out the operations to see that effective measures are taken to exclude children; otherwise if they are injured the occupier or contractor is likely to be held liable.

Contractor's duty to occupier. In the absence of any special stipulation in the spraying contract, the contractor owes to the occupier of land for whom he has engaged to carry out spraying operations a duty to exercise proper care, and if through negligence the employer's livestock or crops are injured, the contractor will be held liable. It is however important to realise that there is nothing to prevent a contractor from limiting his liability to the occupier by making it a term of the contract that his liability extends only to certain acts or omissions or is not to exceed a certain figure, or even excluding liability altogether so that he is not held responsible for any claims however caused. This however, would not absolve the contractor from claims for negligence brought by the occupier's employees.

This statement of the law is by no means exhaustive, nor does it attempt to set out more than the basic principles which are involved, but as will be seen from even this brief summary, a heavy responsibility rests on both occupiers and contractors who make use of weedkillers, more especially those which are poisonous, to ensure that every possible care is taken. It is of course normally possible for such persons to protect themselves against the possibility of civil claims by insurance. This, no doubt, is a prudent course and one which will be adopted in many cases.

For further information see papers in the proceedings by Mr. J. A. McMillan - "The Present Position Concerning the Law on Injurious Weed Seeds and Noxious Weeds" and Mr. J. Henniker Smith - "Legal Aspects of Spray Damage".

Section X

New Herbicides

This section contains a few brief notes on a number of new herbicides currently being developed. The notes are intended to provide guidance on weed problems for which these chemicals appear promising, but they are not in any sense recommendations. In almost all cases these new herbicides have been discovered in the U.S.A. and all the initial experiments have been conducted under North American conditions. Caution is therefore required in extrapolating the results to British conditions. Compounds in the very early stages of developments as herbicides are not included. Mention in this section does not necessarily imply that the herbicide concerned is available in Great Britain as yet.

It should be noted that many of these compounds have not been fully evaluated for possible adverse effects on human health and due caution should be used when handling and applying them.

Information on the physical properties of these compounds is given in the table at the end of this section.

3-(p-chlorophenyl)-1, 1-dimethyl urea
3-phenyl-1, 1-dimethyl urea
3-(3, 4-dichlorophenyl)-1, 1-dimethyl urea

These substituted ureas are highly phytotoxic and persistent herbicides. North American and British work shows that they can be used at doses of 40-80 lb. per acre for soil sterilisation, to eliminate vegetation on railway tracks, around buildings and industrial sites, etc. Good control may continue with the higher doses for at least 2 years. The dichloro substituted compound appears to be the most persistent in soil and the compound without chlorine substitution the least persistent. There is some indication that the latter compound may be the more effective against deeper rooted perennial weeds. When using these compounds it must be remembered that nearby plants, such as large woody plants, whose roots pass into or near the treated area, may also be damaged.

At low doses these compounds appear promising for the pre-emergence control of a range of weeds in several crops. Rates of use vary from 0.1 to 2 lb. per acre. Crops found to possess some degree of resistance to these doses under British conditions include beans (broad and French), peas, carrots, vetch and beet. North American work indicates that these compounds are particularly effective for weed control in asparagus, and they are under trial in a number of other crops.

Some differences in level of dose required and in selectivity appear to exist between the three compounds. Effectiveness also varies according to soil type and rainfall.

Trichloroacetic acid

This compound is primarily effective on grasses and is not readily absorbed by the foliage, entry being mainly through the root system. In this country attention has been directed to its possibilities for controlling *Agropyron repens* and considerable but not complete control has been obtained with two applications of 20 lb. per acre three weeks apart and combined with cultivation. British and North American evidence indicates 60-100 lb. per acre to be necessary for anything approaching complete kill under most conditions. Such doses can only be applied to uncropped land.

Lower doses are recommended for the selective control of annual grasses in a variety of crops in North American, both pre-and post-emergence. Examples include doses of 5-8 lb. per acre on asparagus beds before 'spear' emergence, 5-10 lb. per acre pre-emergence on beet and cabbage, and 5-10 lb. per acre post-emergence on linseed.

Soil persistance seems to be dependent on soil type and rainfall after application. This compound is generally used in the form of its sodium and ammonium salts.

2,2-dichloropropionic acid

This compound resembles trichloracetic acid in its effects but differs from the latter compound in that it can be absorbed and translocated by the foliage of grasses. Promising uses suggested in North America are for the control of grasses in uncultivated land, such as railway lines, ditches and along fences, using doses of 10-50 lb. per acre, and for the selective control of annual grasses in lucerne, beet and linseed at 3-6 lb. per acre. It is applied as the sodium salt and the addition of a wetting agent to the spray solution is most important. Effects are slow in developing, but at the higher doses on perennial grasses it can induce dormancy or actual death of crown and rhizome buds.

4-chlorophenoxyacetic acid
3,4-dichlorophenoxyacetic acid

These two substituted phenoxyacetic acids appear to be only slightly inferior to MCPA and 2,4-D in their phytotoxicity to certain weed species, but differ somewhat in their selectivity, according to American evidence. In particular 3,4-dichlorophenoxyacetic acid is reported to be less damaging than MCPA and 2,4-D to lucerne, red clover, and certain other legumes.

Sodium 2,4-dichlorophenoxyethyl sulphate
2,4-dichlorophenoxyethyl benzoate
Sodium 2,4,5-trichlorophenoxyethyl sulphate

These compounds are inactive or only partially active when applied to foliage but are converted to an active form when applied to soil. They are used therefore to kill germinating and emerging weeds but not older seedlings. They are active in the soil for 3-4 weeks under moderate rainfall conditions, with the benzoate appearing to have the greatest residual effects. Moist soil is needed for conversion to the active form but subsequent dry weather prolongs activity.

North American work has shown these compounds to be promising for the control of annual weeds in strawberries, raspberries and asparagus at doses of 2-4 lb. per acre. The first named compound has been used extensively on strawberries in North America.

Isopropyl N-phenylcarbamate
Isopropyl N-(3-chlorophenyl)-carbamate
and other substituted carbamates

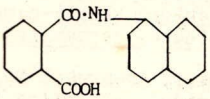
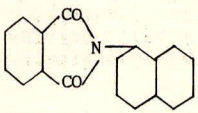
For many years isopropyl N-phenylcarbamate has been known to possess selective herbicidal properties when applied to soil in which crops and weeds are germinating. In practical applications it has been largely superseded by the more soluble isopropyl N-(3-chlorophenyl)-carbamate which is now used on a field scale in North America. Certain other substituted carbamates are currently under investigation and appear to differ slightly in their herbicidal properties.

These compounds are not absorbed by foliage and are dependent on absorption through the root system. They are therefore primarily pre-emergence herbicides and are effective mainly in controlling germinating grasses and also some other species. Post-emergence application to certain weeds such as *Stellaria media* have also been successful. Effectiveness of the chloro compound persists in soil for 4-6 weeks but is dependent on temperature and other soil factors. Successful uses in North America have been in lucerne and clovers, peas, established perennial grass crops and nursery stock. Doses of the chloro compound are generally within the range of 2-8 lb. per acre.

TABLE

PHYSICAL PROPERTIES

The information in this table has been collected from a variety by manufacturers of the chemicals concerned.

Compound	Common or abbreviated name	Formula	Physical state
3-phenyl-1,1-dimethyl urea	PDU	$C_6H_5 \cdot NH \cdot CO \cdot N \cdot (CH_3)_2$	Solid
3-(p-chlorophenyl)-1,1-dimethyl urea	CMU	$(C_6H_4Cl) \cdot NH \cdot CO \cdot N(CH_3)_2$	solid
3-(3,4-dichlorophenyl)-1,1-dimethyl urea		$(C_6H_3Cl_2) \cdot NH \cdot CO \cdot N \cdot (CH_3)_2$	solid
sodium trichloroacetate	TCA (sodium)	$CCl_3 \cdot COONa$	solid
sodium 2,2-dichloropropionate		$CH_3 \cdot CCl_2 \cdot COO\ Na$	solid
4-chlorophenoxyacetic acid		$(C_6H_4Cl) \cdot O \cdot CH_2 \cdot COOH$	solid
3,4-dichlorophenoxyacetic acid		$(C_6H_3Cl_2) \cdot O \cdot CH_2 \cdot COOH$	-
sodium 2,4-dichlorophenoxyethyl sulphate	SES	$(C_6H_3Cl_2) \cdot O \cdot CH_2 \cdot CH_2 \cdot O \cdot SO_2 \cdot ONa$	solid
2,4-dichlorophenoxyethyl benzoate		$(C_6H_3Cl_2) \cdot O \cdot CH_2 \cdot CH_2 \cdot O \cdot CO \cdot C_6H_5$	solid
sodium 2,4,5-trichlorophenoxyethyl sulphate		$(C_6H_2Cl_3) \cdot O \cdot CH_2 \cdot CH_2 \cdot O \cdot SO_2 \cdot ONa$	solid
isopropyl N-phenylcarbamate	IPC, propham	$(C_6H_5 \cdot NH \cdot COO \cdot CH \cdot (CH_3)_2$	solid
isopropyl-N-(3-chlorophenyl) carbamate	CIPC	$(C_6H_4Cl) \cdot NH \cdot COO \cdot CH \cdot (CH_3)_2$	liquid at room temp.
N-1 naphthyl phthalamic acid	NP		solid
N-1 naphthyl phthalimide			solid

VII

OF NEW HERBICIDES

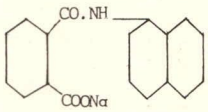
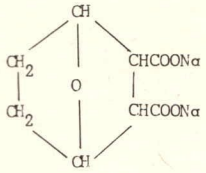
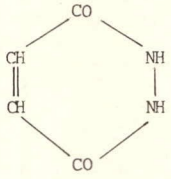
of published sources, primarily from information sheets provided
A dash (-) indicates no information available.

Solubility in Water	Solubility in organic solvents: Methanol	Ethanol	Acetone	Ether	Xylene	Benzene	High aromatic oils	Medium aromatic oils	Low aromatic oils	Carbon tetrachloride	Stability	Corrosion	Types of Formulation
2900 ppm at 24°C	-	-	-	-	-	c	c	c	c	-	-	-	wettable powder
230 ppm at 25°C	-	-	c	-	-	c	c	c	c	-	stable to O_2 moisture	non-corrosive	wettable powder
42 ppm at 24°C	-	-	-	-	-	-	-	-	-	-	-	-	wettable powder or aqueous dispersion
high	-	-	-	-	-	-	-	-	-	-	hygroscopic	slightly corrosive to Fe, Zn, Al	aqueous solution
90 g./100 ml. at 25°C.	a	b	c	c	c	c	-	c	-	c	hygroscopic and undergoes hydrolysis, though to small extent at 25°C and below	-	aqueous solution
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
25% at room temp.	-	-	-	-	-	-	-	-	-	-	stable	-	-
48 ppm.	-	-	-	-	-	-	-	-	-	-	-	-	wettable powder
c. 6g./100 ml.	-	-	-	-	-	-	-	-	-	-	-	-	-
32 ppm	-	-	-	-	b	b	-	b	-	b	stable	little or none	emulsifiable solution, wettable powder or dust
insoluble	a	a	-	a	a	-	-	b	-	-	stable	-	emulsifiable solution
0.02%	-	c	c	-	-	c	-	-	-	-	unstable above pH 9.5 or 180°C	non-corrosive	wettable powder
insoluble	-	c	c	-	-	c	-	-	-	-	hydrolysed to acid by alkali	non-corrosive	wettable powder

a = high solubility, of the order of 50% or higher
b = moderate solubility
c = low solubility, less than 1%, or insoluble

In most instances the data refer to temperatures of 20 - 25°C

TABLE VII

Compound	Common or abbreviated name	Formula	Physical state
sodium N-1 naphthyl phthalamate	NP (sodium)		solid
disodium 3,6-endoxohexahydrophthalate	endothal (sodium)		solid
maleic hydrazide	MH		solid
pentachlorophenol	PCP	C_6Cl_5OH	solid
sodium pentachlorophenate	PCP (sodium)	C_6Cl_5ONa	solid

(Contd.)

Solubility in Water	Solubility in organic solvents										Stability	Corrosion	Types of Formulation
	Methanol	Ethanol	Acetone	Ether	Xylene	Benzene	High aromatic oils	Medium aromatic oils	Low aromatic oils	Carbon tetra-chloride			
30%	-	-	-	-	-	-	-	-	-	-	stable in absence of excess base	non-corrosive	aqueous solution
c. 21%	-	-	-	-	-	-	-	-	-	-	stable to light and temps. up to 150°C	non-corrosive	aqueous solution
0.4% at 20°C	c	c	-	-	-	-	-	-	-	-	-	-	aqueous solution of salts
20-25 ppm at 20°C	a	a	b	a	b	b	-	b	-	-	stable under ordinary conditions	non-corrosive	In organic solvents and high aromatic oils
33% at 25°C	-	b	b	-	-	c	-	c	-	-	may precipitate 20% at room temp.	non-corrosive	aqueous solution

a = high solubility, of the order of 50% or higher
b = moderate solubility
c = low solubility, less than 1%, or insoluble

In most instances the data refer to temperatures of 20 - 25°C

N-1 naphthyl phthalamic acid

This compound has been used in North America in a variety of formulations, primarily to control weeds pre-emergence. It does not control most weeds which have already emerged. Doses used range from 2-8 lb. per acre and are effective over a 3-8 week period. The dose used is dependent to some extent on soil moisture and type. The more widely adopted uses are for selective weed control in established beds of asparagus, and in cucurbitaceaeous crops such as melon. and cucumber.

3,6-endoxohexahydrophthalic acid

This compound has been used, primarily as the sodium salt, in North America as a pre- and post-emergence herbicide at doses of the order of 4 lb. per acre but it has only limited selectivity in most crops. Beet appears to be one of the more tolerant crops.

This compound has defoliant and desiccant properties which are now being utilised on a field scale as a pre-harvest treatment in North America. At 2 lb. per acre or less it is valuable for drying out the vegetative portions of legume crops to permit direct combining. The addition of ammonium sulphate and a surface-active agent increases the effectiveness of this compound when applied to foliage.

Maleic hydrazide

This compound possesses certain growth inhibitory as well as herbicidal properties. At rates of 4-8 lb. per acre it inhibits the growth of perennial grasses for up to 10 weeks. In North America it is used in this way to reduce the need for mowing grass areas, such as roadsides, but it should not be used on fine turf where scorching effects might be considered unsightly. Application at any time when the grass is growing can be effective but winter treatment should be avoided. Spraying just prior to dormancy in autumn inhibits growth when this restarts in the following spring. Mowing may precede spraying, or, if the grass was long when treated, it may be mown after 10 days have elapsed. This chemical is sensitive to rainfall and 18 hours dry weather after application is necessary for the full effect to develop.

In America maleic hydrazide has given appreciable control of *Agropyron repens* at 4-16 lb. per acre applied to the foliage and followed by ploughing 2 days - 2 weeks later.

Maleic hydrazide has effectively prevented sprouting of a variety of root crops in storage as shown by both North American and European research. The chemical is applied as a spray at 3-7 lb. per acre to the vegetative growth 2-6 weeks before harvest.

In all uses of maleic hydrazide the addition of a wetting agent improves the effect.

Pentachlorophenol

This compound has been known for many years to have herbicidal properties similar in numerous respects to those of the dinitro alkyl phenols, but with a lower mammalian toxicity. However, only recently have its potentialities been seriously investigated.

Pentachlorophenol is not translocated and thus acts only as a contact herbicide and as a germinating seed toxicant through the soil. Pentachlorophenol itself may be used as a fortifying agent in oils for general contact weed control. Both pentachlorophenol and its sodium salt may be used as contact and residual pre-emergence treatments on a variety of crops. The sodium salt is applied for this purpose at 4 - 20 lb. per acre in aqueous solution and the phenol itself dissolved in oil or in an oil-water emulsion at 1 - 4 lb. per acre. British crops on which such pre-emergence treatments have been effective include onions, lettuce and sugar beet.

Index to Common Names of Weeds Listed in the Weed Susceptibility Tables III, IV and VI

T = Turf Weeds. Table IV (p.37)
W = Woody Weeds. Table VI (p.50)
A = Agricultural Weeds. Table III (p.21)

The numbers in this table refer to the weed numbers in the weed susceptibility tables.

	Weed No.		
	T	W	A
Carrot, wild			53
Cat's ear	19		
Celandine	36		
Chamomile, corn			12
Chamomile, wild			95
Chamomile, yellow			14
Charlock, white			133
Charlock, yellow			146
Chervil, rough			37
Chickweed			155
Chickweed, field mouse-ear	5		
Chickweed, mouse-ear	6		36
Chickweed, water	22		
Cinquefoil	31		124
Cleavers			67
Clover, white	45		160
Coltsfoot	46		161
Comfrey			156
Corncockle			5
Cornflower			33
Couch grass			4
Cow parsley			15
Cow parsnip			74
Cranesbill, cut-leaved			71
Cranesbill, dove's-foot	14		72
Cranesbill, meadow			73
Crocus, autumn			46
Crowfoot	34		129
Crow garlic			9
Daisy	3		23
Daisy, ox-eye			40
Dandelion	43		157
Dead-nettle, red			89
Dead-nettle, white			87
Dock, broad-leaved			138
Dock, curled			137
Dodder, common			51
Dove's-foot cranesbill	14		72
Dungweed			39
Elder		13	
Elder, ground			2
Earthnut			48
False oat			18
Fat hen			39
Feverfew			96
Field mouse-ear chickweed	5		
Fiorin			6
Flags			80
Fleabane			128
Fleabane, Canadian			59
Fumitory			64
Gallant soldier			66
Garlic, crow			9
Germander speedwell			167
Goat's-beard			159
Goosefoot			39
Goosegrass			67
Gorse		17	

	Weed No.		
	T	W	A
Gromwell, corn			92
Ground elder			2
Groundsel			143
Hardheads			34
Hawbit, autumnal			91
Hawk's beard	9		50
Hawkweed, mouse-ear	16		
Hawthorn		5	
Hazel		4	
Heart's ease			174
Heather, bell			58
Hemlock			47
Hemlock water dropwort			103
Hemp-nettle			65
Henbane			78
Henbit			88
Herriff			67
Hoary pepperwort			30
Hogweed			74
Holly		7	
Horsetail			56
Horsetail, marsh			57
Iris			80
Ivy		6	
Jointed charlock			133
Juniper		8	
Keck			15
Kelk			146
Kew-weed			66
Knapweed	4		34
Knapweed, greater			35
Knotgrass	28		117
Marestail			56
Marigold, corn			41
Mayweed, scentless			96
Mayweed, stinking			13
Meadow-grass, annual			116
Meadow-sweet			63
Medick, black			98
Milfoil			1
Mint, corn			101
Mountain ash		15	
Mouse-ear chickweed	6		36
Mouse-ear hawkweed	16		75
Mugwort			19
Musk storksbill	12		
Mustard, black			24
Mustard, hedge			147
Mustard, treacle			61
Mustard, white			145
Nettle, annual			163
Nettle, perennial			162
Nightshade, black			148
Nightshade, woody			149
Nipplewort			90

	Weed No.		
	T	W	A
Oak		10	
Oat, false			18
Oat-grass			18
Oat, wild			21, 22
Onion, wild			9
Orache, common			20
Oxalis, creeping			107
Ox-eye daisy			40
Ox-tongue, bristly			111
Pansy, corn			174
Pansy, field			173
Parsley, cow			15
Parsley, piert	2		8
Parsnip, cow			74
Pearlwort	39		139
Penny-cress, field			158
Pepperwort, hoary			30
Persicaria			121
Persicaria, pale			120
Pignut			48
Pimpernel, scarlet			11
Pineapple weed			97
Plantain, broad-leaved			114
Plantain, buck's-horn			112
Plantain, great	25		114
Plantain, hoary	27		115
Plantain, sea	26		
Poppy, corn			109
Radish, wild			133
Ragwort	40		142
Ragwort, marsh			141
Redshank			121
Rhododendron		12	
Ribgrass			113
Ribwort	24		113
Rosebay willow-herb			38
Rough chervil			37
Rowan		15	
Runch			133
Rush, common			82, 83
Rush, jointed			81
Rush, hard			84
Rush, heath			85
Saffron, meadow			46
Salad burnet			125
Sandweed			154
Scabious, field			86
Scarlet pimpernel			11
Sea storksbill	11		
Sedges			32
Sea milkwort	15		
Self-heal	33		126
Sea pink	42		
Sheep's sorrel	39		136
Shepherd's needle			140
Shepherd's purse			29
Silver birch		2	
Silverweed	29		122
Sloe		9	

	Weed No.		
	T	W	A
Snakepipe			57
Snake-root			118
Soft-grass, creeping	18		76
Sorrel, procumbent yellow			107
Sorrel, sheep's	38		136
Sorrel, upright yellow			108
Sorrel, wood			105
Sowthistle, annual			152
Sowthistle, corn			150
Sowthistle, spiny			151
Speedwell	49		
Speedwell, germander	48		167
Speedwell, ivy-leaved			168
Speedwell, thyme-leaved	50		170
Speedwell, wall	47		
Speedwell, water			165
Spurge, sun			62
Spurrey, corn	41		154
Starveacre			130
Starweed	23		112
Storksbill, common	10		60
Storksbill, musk	12		
Storksbill, sea	11		
Sun spurge			62
Sweet chestnut		3	
Tares			171
Thorn-apple			52
Thistle, creeping	8		43
Thistle, marsh			44
Thistle, musk			31
Thistle, spear			45
Thistle, stemless	7		42
Tormentil, common	30		123
Treacle, mustard			61
Trefoil, birdsfoot	20		93
Trefoil, yellow	44		
Twitch			4
Twitch, black			10
Venus's looking-glass			153
Vetch, common			172
Vetch, tufted			171
Viper's bugloss			54
Water dropwort, hemlock			103
White mustard			145
Wild oat			21, 22
Wild radish			133
Willow		16	
Willow-herb			55
Willow-herb, rosebay			38
Willow-weed			121
Wireweed			117
Woodrush, field	21		94
Wood sorrel			105
Yarr			154
Yarrow	1		1
Yellow rattle			134
Yorkshire fog	17		77