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POT EXPERIMENTS AT THE WEED RESEARCH ORGANIZATION WITH FOREST CROP AND WEED SPECIES

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WITH FOREST CROP AND WEED SPECIES

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SUMMARY

Results are presented of three post-emergence and two pre-emergence pot experiments, involving Sitka spruce (Picea sitchensis), Corsican pine (Pinus nigra var calabrica), Lodgepole pine (Pinus contorta), Lawson's cypress (Chamaecyparis lawsoniana), Japanese larch (Larix leptolepis), Western hemlock (Tsuga heterophylla), Douglas fir (Pseudotsuga taxifolia), Western red cedar (Thuja plicata), oak (Quercus petraea), beech (Fagus sylvatica), heather (Calluna vulgaris), Molinia caerulea, Deschampsia caespitosa and Calamagrostis epigejos. Some herbicides not now used in forestry may be useful for controlling weeds in nurseries, transplant lines or young plantations. In particular, trifop-methyl and terbuthylazine have potential for selectively controlling grass weeds. MCPA salt with added ammonium sulphate or various triazine herbicides, may also be useful against heather.

INTRODUCTION

The main weeding problem in forestry occurs during the establishment phase, when weed species can smother recently planted trees. In 1976 the total area planted in Britain was 33,000 ha. Weeds in forestry situations are often very expensive to control, particularly where this involves the use of hand labour: the bill for weeding by the Forestry Commission alone is around £1 million per year. Some of the weeds which occur in forests are not encountered elsewhere. Additionally it is very difficult to predict the response of woody species to herbicides because these are so different from other kinds of crop. Conifers in particular are a unique group, very different botanically and morphologically from all agricultural species. Before new herbicide treatments can be employed, special screening is needed. The selection of treatments which will kill forest weeds without injuring tree crops is largely trial and error; many crops are, however, very resistant to herbicides so that there are sometimes exciting possibilities for introducing new treatments. In the past, most screening work was carried out on relatively large field plots. Testing large numbers of treatments in this way is, however, costly and time consuming, so that at the Weed Research Organization (WRO) we have started working with pot grown material. Some difficulties have been encountered but in general we believe that pot experiments can provide useful indications of crop and weed resistance and susceptibility quickly and cheaply. This report summarises work carried out in three seasons, 1972/73, 1973/74 and 1976/77. Since 1976 the research has been financed by the Forestry Commission. Follow-on experiments, not now reported, are in progress. In general, the forestry studies can be regarded as an extension of other WRO research, on methods of controlling weeds of agricultural land. Some species of importance to farmers occur also in forest situations.

Herbicides which are tested include new compounds and various older products which do not appear to have been examined for forestry uses in the UK. Some mixtures of herbicides with non-herbicidal adjuvants are also screened, as are applications of some established or approved herbicides outside the normal season. In general, the policy has been to test at first one or two moderately high levels of a herbicide, choosing rates likely to control particular groups of weeds. This first stage of screening examines a relatively large range of compounds. Materials which show promise are then re-examined in more detail.

The programme at first examined crop species only but now also includes a number of important weeds. Heather (Calluna vulgaria) competes strongly with young conifers in many upland areas. The three grasses examined in the 1976/77 post-emergence experiment present problems because of their resistance to atrazine. Gorse (Ulex europaeus) was included in the 1976/77 pre-emergence programme because seedlings are sometimes a serious problem in newly planted areas which have been deep-ploughed and treated with phosphate fertilisers.

In reporting results, we have indicated some situations where selectivity between weed and crop may be worth following up. There is, of course, no intention of making recommendations for large scale practical uses. The results presented must be regarded with caution. Field trials, to explore some of our suggestions, are being undertaken by Forestry Commission research staff.

MATERIALS AND METHODS

Post-emergence treatments

Experiments examining treatments for use in transplant lines and young plantations were conducted in three seasons. In 1972/73 and 1973/74 only coniferous crops were tested, treatments being applied to the eight species listed in Tables 1 and 2. In 1976/77 crop species included hardwoods, oak (Quercus petraea) and beech (Fagus sylvatica) as well as Sitka spruce (Picea sitchensis), Lodgepole pine (Pinus contorta), Corsican pine (Pinus nigra var calabrica) and Douglas fir (Pseudotsuga taxifolia). Heather (Calluna vulgaris) was examined in 1973/74 and 1976/77. This last experiment included three grasses, Molinia caerulea, Calamagrostis epigejos and Deschampsia caespitosa. All the test species were established in large (150-300 mm) pots during the autumn and winter before spraying. Oak, beech and conifer plants were lifted from transplant lines and were 2-4 years old at treatment. Heather seedlings, mostly 1-2 years old, were collected from an abandoned nursery at Wareham, Dorset. Grass species were collected from sites in southern England and propagated by division of stools (Molinia, Deschampsia) or rhizomes (Calamagrostis). At treatment grass plants more or less completely filled 150mm or 200mm pots. Heather and Molinia were grown on acid sandy soil (pH 4.5) from Wareham, Dorset, while other species were planted in John Innes No. 2 soil-peat-sand compost. All test plants were kept out of doors on a paved pot-standing area, water and nutrient being supplied as necessary. Experiments comprised from three to six replicates, each "plot" consisting of a single plant established in a pot. Most experiments included from four to ten unsprayed control treatments.

Spray solutions were prepared from commercial herbicides or from formulated samples supplied by chemical firms. Conventional sprays were applied with a large cabinet sprayer fitted with multiple 730039 or 730077 Tee jets. Volume rates in 1972/73, 1973/74 and 1976/77 were 150 l/ha, 150 l/ha and 200 l/ha, respectively. As the spray boom was 1½m or more above the test plants the relatively small droplets were falling freely at terminal velocity when they impacted. In 1972 sprays were applied on three different dates, 23 May, 18 July and 12 September. The 1973/74 experiments tested mid-July and mid-September while in 1976/77 herbicides were applied on one date only, 25 August. In 1976/77 some glyphosate treatments were applied with a prototype Horstine Farmery controlled drop applicator, fixed to the spray trolley. This apparatus delivered 20 l/ha, as drops of 250-300 micron diameter. Additives tested included ammonium sulphate (Turner and Loader, 1972), "Actipron" emulsifiable spray oil (marketed by BP Ltd) and "Mixture B", an oil-surfactant blend which forms solubilized solution or micro-emulsions with water (Turner, 1976). Commercially formulated herbicides were used, extra wetting agent (0.5% Agral 90) being added to all spray solutions. No soil protection was given. Granular chlorthamid (Tables 1-2) was applied by hand, weighted amounts being distributed as evenly as possible over the surface of each pot. Plants were placed under a moveable shelter for 24 hours before and after spraying, to avoid effects of rainfall. After 24 hours, the plants were returned to the pot standing and watered thoroughly from above with irrigation equipment. Herbicide effects in the season of treatment, such as leaf injury and epinasty, were assessed by scoring. Longer term effects were measured by weighing living above-ground growth, new stem extension or leaf weights in the season after treatment.

Pre-emergence treatments

Experiments examining pre-emergence treatments for use in seed-beds were conducted in 1976/77 only. One glasshouse and one outdoor trial were carried out, each comprising three replications, with extra unsprayed controls. Seeds of oak, beech, Corsican pine, Douglas fir, Lodgepole pine, Sitka spruce and *Ulex europaeus* (gorse) were sown in 100mm pots of acid sandy forest soil (pH 4.5). Beech and conifer seed was pretreated by soaking in water for 24-48 hours at 3° - 5°C. *Ulex* seed was treated with concentrated sulphuric acid for 15 minutes. Oak and beech seeds were sown five per pot, 18mm deep, conifers ten seeds per pot, 6mm deep and *Ulex* seeds 20 per pot, 6mm deep. Formulated herbicides supplied by chemical firms were applied to the surface of previously sown pots with a laboratory bench-type sprayer set to deliver 366 l/ha. Some soil incorporated treatments were also tested. With these treatments, herbicides were applied by sprayer to the surface of a soil layer 65mm deep, in a tinplate box. Immediately after spraying the soil was thoroughly mixed by repeated pouring through a large funnel and used to plant seed of each test species. The glasshouse experiment **sprayed** in December, was a partial failure because of severe damping-off which **killed many** conifer seedlings as they emerged. Useful results were however obtained with Corsican pine and oak. Seedlings of Corsican pine were counted 38 days after spraying. Oak seedlings were transferred outside and retained for 8 months, before counting survivors and weighing above-ground growth. The outdoor experiment was sown and sprayed on

5 April 1977 and the pots placed under wire mesh covers on a pot standing area. Water and nutrients were supplied as necessary and the pots were retained for about 5 months. At this stage, seedlings were counted and above-ground growth removed and weighed.

RESULTS

Post-emergence treatments

Some results of the 1972/73, 1973/74 and 1976/77 experiments are shown in Tables 1-3. As might be expected with experiments using single plant plots, experimental errors were often high.

1972/73 experiment (Table 1) Moderately high doses of the "established" woody plant herbicides 2,4-D and 2,4,5-T (as esters) were tolerated by Sitka spruce outside the normally recommended spraying season (August and September). With other conifers, application at unorthodox times often significantly reduced growth during the following season. As expected, Japanese larch and Western hemlock were severely checked by the herbicides even when applications were made in mid-September.

Other phenoxy herbicides, mecoprop, dichlorprop and MCPA, were tested at a higher rate, 8 kg/ha. The order of species susceptibility was similar to that observed with 2,4-D and 2,4,5-T, larch and Western hemlock being most injured, Sitka spruce almost unaffected. Salt formulations tended to be less active than esters.

Atrazine generally had little effect but early or mid-season applications severely damaged larch. Autumn treatments hardly affected any species. Added emulsified spray oil sometimes slightly increased phytotoxicity.

At 4kg/ha, metribuzin severely injured all species except Corsican pine. Spring or summer dalapon applications were also often damaging. As well as reducing growth in the following season, dalapon caused severe contact scorch, particularly on larch, Sitka spruce and Western hemlock.

Unexpectedly, 4kg/ha asulam seriously affected Western hemlock, even in autumn.

Spring or summer chlorthiamid treatments were often very phytotoxic. Autumn applications were, however, tolerated by many species. Sitka spruce was little affected even when chlorthiamid was applied in May.

Spring or summer glyphosate treatments were phytotoxic to most species: Sitka spruce and Corsican pine were, however, little affected by 1kg/ha, at any time. Autumn application had almost no effect on species other than Western hemlock and Japanese larch. With some conifers, notably Corsican pine, sublethal rates of glyphosate killed terminal buds and caused unnatural proliferation and growth of laterals.

Aminotriazole was very phytotoxic to all conifers except spruce. In this species the herbicide produced chlorosis in the season of treatment but had little long-term effect.

Metflurazone and its analogue norflurazone invariably caused marked chlorosis and pinkish needle colouration but in some species, notably Corsican pine, Cypress and Western red cedar, hardly affected weights of regrowth. Western hemlock, larch and spruce were, however, often severely checked or killed.

1973/74 experiment (Tables 2-3) At 1 kg/ha, glyphosate again hardly affected Sitka spruce, even during active growth. As in 1972/73, most species tolerated moderate autumn application. However, 2kg/ha of the herbicide severely reduced the growth of Corsican pine. The herbicide was moderately active against heather in July but less so when applied later (Table 3).

Norflurazon again produced dramatic chlorosis but often had little longer term effect on regrowth. As in 1972/73, Japanese larch and spruce were more severely damaged. Heather was almost unaffected.

At rates up to 10kg/ha, summer or autumn application of chlorthiamid had little effect on Corsican pine, Lawson's cypress, Sitka spruce, Western red cedar or heather. Autumn applications of 5kg/ha were tolerated even by Western hemlock and larch. Dalapon also was tolerated by some species when applied outside the normally recommended application season (March to early April).

High rates of atrazine applied in the growing season sometimes severely damaged conifers. Corsican pine and Lawson's cypress were, however, unaffected by July or September treatments. Sitka spruce and, surprisingly, Western hemlock, were unaffected by autumn treatments. July applications to heather were moderately damaging (Table 3).

Cyprazine had effects on conifers resembling those of atrazine. Resistant species like Corsican pine and Lawson's cypress were almost unaffected but susceptible conifers were often severely injured, particularly by July applications. Unexpectedly, the herbicide was very active against heather (Table 3) particularly when it was applied in July.

Metribuzin again severely injured or killed all conifers other than Corsican pine. It had virtually no activity against heather.

2,4-D as ester or amine salt had only moderate effects on heather but 8kg/ha of MCPA provided good control, particularly in July.

1976/77 experiment (Tables 4-5) Once again 1kg/ha glyphosate applied in autumn did not injure pines, Sitka spruce or Douglas fir. This treatment provided moderate control of the three grasses. Heather was little affected. At 2kg/ha, glyphosate slightly reduced conifer growth, but damaged oak and beech more severely. Added ammonium sulphate or the use of very low volume controlled drop applications sometimes significantly increased phytotoxicity to susceptible species such as beech.

Trifop-methyl had little effect on any crop species or heather but was very phytotoxic to grasses, even at 1kg/ha.

Cyprazine was again very active against heather but had less effect than expected on grasses; Calamagrostis being more susceptible than Molinia or Deschampsia. As in the previous experiment, all crop species tolerated 2kg/ha: oak was however injured by the 4kg/ha dose. Added emulsified or solubilised oil increased injury to some crop species, notably beech and Douglas fir.

As expected, most of the atrazine treatments had no appreciable effect on crop species; added Actipron or solubilized oil, however, increased crop injury a little. The herbicide was as expected relatively inactive against the three grasses but 4kg/ha was moderately phytotoxic to heather, particularly when Actipron was added.

Terbuthylazine also was relatively inactive against crop species but 8kg/ha was phytotoxic to heather and grasses, particularly Calamagrostis and Deschampsia.

At the rates tested, mefluidide (MBR 12325), metamitron, DPX 1108 (krenite) and oxadiazon had little effect on any test plants. By contrast tebuthiuron and bromacil were very active against all crop species.

Some rates of triclopyr were inactive against conifers but very damaging to oak and beech. This herbicide had almost no effect on heather. At the somewhat low doses tested, the related compound Dow 290 (Lontrel) was inactive.

Responses to phenoxy herbicides were more or less as in the previous experiments. Some 2,4-D or MCPA treatments significantly reduced conifer growth. As expected, both were more or less phytotoxic to oak, beech and heather, the effects of salts being considerably increased by ammonium sulphate. MCPA was again rather more effective against heather than 2,4-D.

At the rates tested, asulam, with or without additives, had no effect on woods species.

Pre-emergence treatments

The results of glasshouse and outdoor experiments are summarised in Table 6. Herbicides with little effect on some or all conifers included diphenamid, hexazinone (Velpar), chloroxuron, chlornitrofen, RH 2915, WL 29226, USB 3153, propham, chlorpropham, penoxalin, butam, trifop-methyl, K 1441, dalapon, prometryne, chlorthal dimethyl, trifluralin, nitrofen, terbuthylazine and cyanazine. Most of these compounds were also inactive against oak and beech. Very phytotoxic treatments included 0.5kg/ha tebuthiuron, 4kg/ha oxadiazon, 4kg/ha RP 20630, 0.5kg/ha bromacil, 2kg/ha lenacil, 0.5kg/ha terbacil, 3kg/ha norflurazone, 3kg/ha chlorthiamid, 4kg/ha perfluidone, 0.5kg/ha metribuzin, 3kg/ha dimefuron (RP 23465), 0.5kg/ha buthaidazole, 4kg/ha desmetryne, 3kg/ha triclopyr. Other herbicides had intermediate effects. Dowco 290 applied in error at the relatively high rate of 5kg/ha was very damaging to oak, beech and some conifers but almost inactive against Lodgepole pine. A very large dose of glyphosate had no pre-emergence effects on the very sandy soil used for this experiment.

Gorse (Ulex europaeus) often responded differently, being unaffected by some otherwise very phytotoxic herbicides, such as lenacil. Lethal or near lethal treatments included atrazine, hexazinone (Velpar), Dowco 290, triclopyr, nitrofen and terbuthylazine.

DISCUSSION

Several herbicides appear to be worth further trial pre- or post-emergence, either in new pot experiments or in the field. These are discussed very briefly, in relation to specific crop and weed situations.

1. Post-emergence treatments

(a) For grass control in conifers

Glyphosate with or without additives has already been tested in the field by Forestry Commission research staff. Results so far available suggest that 1kg/ha in late summer or autumn is tolerated by most conifers including Sitka spruce, Lodgepole pine, Corsican pine and Douglas fir. This confirms manufacturer's recommendations (Monsanto, 1977). The use of ammonium sulphate or low volume CDA methods may allow dose reductions. Glyphosate with ammonium sulphate was particularly effective against Deschampsia.

Hexazinone (Velpar) is perhaps worth testing further at 2-4kg/ha, as a treatment for controlling Molinia and other grasses in pines and spruce. Further work with additives is contemplated. Hexazinone will also control other broad-leaved woody and herbaceous weeds, but probably not heather.

Summer or autumn applications of atrazine were tolerated by most crop species. It is thought that grasses in active growth may be more susceptible to this compound, particularly when oil or surfactant additives improve foliage activity. Further study in this area may well be justified: extension of the present recommended application period may in any case have logistic advantages.

Terbuthylazine does not appear to have been tested previously for forestry uses in Britain but has been used in New Zealand (Bowers and Patterson, 1974). It was unusually active against Calamagrostis and thus may be useful on clayland areas where this grass is a problem. It is probably also worth testing in other situations, particularly as higher doses may control heather (see below). Pot trials with oil and surfactant additives are in progress.

Trifop-methyl (HOE 29152) had outstandingly good effects on weed grasses: field experiments have already been suggested. Of all the herbicides ao far tested this is probably the most interesting. Further pot work with lower doses and with a range of oil and surfactant additives is in progress.

Aminotriazole may be worth further trial in spruce but is too phytotoxic to be used in the presence of other crops.

(b) For grass control in broad-leaved crop species

Glyphosate and hexazinone are probably too phytotoxic to be used in summer as overall sprays, although it may be worth experimenting with directed applications. At present, terbuthylazine and trifop-methyl are of much greater interest. Both are more active than atrazine against problem grasses but may have less effect on susceptible hardwoods. Both compounds are being tested in mixtures with oil and surfactant additivies.

(c) For broad-leaved woody weed control in conifers

The choice of treatments will obviously depend on the particular weed species present. Many woody weeds are already adequately controlled by the established 2,4-D and 2,4,5-T treatments. Aspens (Populus tremula) are more susceptible to MCPA (Barring, 1977). For species resistant to phenoxy herbicides, relatively high rates of glyphosate and hexazinone might be used; the former is more phytotoxic to beech, the latter more active against oak (Table 4). Triclopyr also may be of use: it is being tested again in pot experiments and may also be worth trying in the field. While there is some margin of selectivity between conifers and hardwood weeds, it is not known whether this will be sufficient for safety. Other WRO work shows that triclopyr can give useful suppression of many broad-leaved herbaceous weeds. It also will control blackberry (Byrd et al, 1975). In America, pines are said to be more susceptible than spruces or Douglas fir (Byrd et al, 1975).

(d) For heather control in conifers

In both 1973/74 and 1976/77, Cyprazine was by far the most promising herbicide for selectively controlling heather in young conifers. Most unfortunately, this compound has now been withdrawn by its manufacturers and is, therefore, unavailable for forestry uses.

4 kg/ha or 8 kg/ha MCPA as salt or ester, appears to be more effective than currently recommended 2,4-D ester treatments. Salt formulations are also appreciably cheaper. The activity of both 2,4-D and MCPA salts is enhanced by ammonium sulphate (Table 5). Further pot and field studies with MCPA salt ammonium sulphate sprays are suggested.

Relatively high doses of atrazine and terbuthlylazine were unexpectely active against heather (Table 5). Further work with these and other triazine herbicides is proposed. It may be possible to increase phytotoxicity by the use of oil or surfactant additives: however, at dose levels which will control heather, crop damage may be expected.

2. Pre-emergence treatments, for controlling seedling grass and dicotyledonous weeds in seedbeds

There were often large differences in the response of the test species to particular herbicides. While it is obviously possible to specify different treatments for each crop species this could well lead to difficulties, particularly with certain very persistent compounds. In general, it is much more convenient to have herbicide treatments which can be used generally in the nursery, if possible with broad-leaved species as well as conifers. In choosing compounds for further evaluation we have kept this point in mind. Some materials retained in the programme have injured individual crop species but on the other hand, most herbicides were tested only at a single, moderately high level of dose. Additionally, responses in pot experiments do not always reflect performance under field conditions.

Herbicides likely to be of special interest are discussed below:

K1441 and trifop-methyl had virtually no effect on the germination or growth of any crop species. At the doses tested, the compounds will probably provide up to six months control of grass seedlings (Richardson and Parker, 1977, (a) and (b)). Both are somewhat lacking in activity against Poa annua but this weed is well controlled by relatively low doses of other compounds, including some listed below. Studies with mixtures are called for.

Propham, chlorpropham, pendimethalin, butam, WL 29226, prodiamine, dalapon and trifluralin, also inactive against most crop species, are primarily grass killers. Some of these compounds are less active or less persistent than trifop-methyl or K 1441, but have special advantages including greater activity towards Poa annua. The low effects on conifers of 8kg/ha dalapon was surprising.

Hexazinone, chloroxuron, chlornitrofen, oxyfluorfen (RH 2915), prometryne, chlorthal-dimethyl, terbuthylazine, cyanazine and nitrofen, also tolerated by most crop species, are active against dicotyledons as well as grasses. Chlornitrofen and oxyfluorfen (RH 2915) are ethers related to nitrofen. Both are at least as active as the latter compound, (Richardson et al, 1976, (a) and (b)).

Terbuthylazine has been used pre-emergence in Sweden (Barring, 1976). This herbicide may also be tolerated when applied post-emergence (Table 4). The relatively low pre-emergence effects of hexazinone on crop species was unexpected. This result is probably well worth following up; oak and beech as well as conifers were little affected. The expected half life in soil of this herbicide is one to six months (Du Pont, 1977). Prometryne also is a relatively persistent herbicide, perhaps providing several months weed control (Fryer and Evans, 1968). Both this compound and chlorthal-dimethyl are relatively old established herbicides which have been available since the early 1960's. Cyanazine, a Shell product developed primarily for use in maize has a relatively short residual life in soil, (Shell International Chemical Co. Ltd. 1970). Both it and chloroxuron may be suitable for early post-emergence as well as pre-emergence use.

Results with gorse (Ulex europaeus) are best discussed separately. Herbicides which may provide pre-emergence control of seedlings include atrazine, tebuthiruon, hexazinone, Dowco 290, trichlopyr, oxadiazon, RP 20630, bromacil, norflurazone, chlorthamid, ethodfumesate, dimefuron (RI 23465), buthidazole, desmetryne, nitrofen and terbuthylazine. Of these compounds hexazinone, Dowco 290, nitrofen and terbuthylazine may be useful for selective use in conifer seedbeds. In transplant lines, atrazine, oxadiazon, triclopyr and chlorthiamid could also be tried. In grassland, Dowco 290 or trichlopyr have obvious advantages: these herbicides may be worth testing post- as well as pre-emergence. Gorse appears to be resistant to several other active pre-emergence herbicides including terbutryne, linuron, chloroxuron, lenacil, metamitron, alachlor and cyanazine.

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Table 1. 1972/73 Post-emergence experiment. Above ground weights as % of control

TREATMENT	CORSICAN PINE			DOUGLAS FIR			LAWSON CYPRESS			WESTERN HEMLOCK			JAPANESE LARCH			SITKA SPRUCE			WESTERN RED CEDAR		
	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L
Control		100			100			100			100			100			100			100	
2,4-D (iso-octyl ester) 4 kg/ha	66	52	89	84	104	86	74	66	81	83	68*	123	102	44*	57*	157	119	112	56*	73	103
2,4,5-T (iso-octyl ester) 4 kg/ha	50	58	109	65*	78	85	70	88	94	70*	65*	86	59*	60	78	92	102	140	49*	75	92
Mecoprop (K^+ salt) 8 kg/ha	114	94	72	64*	38*	36*	57*	68	76	61*	40*	57*	50*	57*	57*	87	77	130	56*	76	75
Mecoprop (iso-octyl ester) 8 kg/ha	82	89	150	52*	62*	75	76	70	81	44*	41*	83	70	32*	52*	103	106	95	37*	60*	83
Dichlorprop (K^+ salt) 8 kg/ha	92	62	77	83	39*	86	95	61*	93	57*	46*	85	77	49*	78	84	121	143	59*	47*	69
Dichlorprop (iso-octyl ester) 8 kg/ha	87	82	104	86	66*	63*	62*	50*	74	40*	20*	89	72	17*	50*	98	120	123	33*	40*	61*
MCPA (K^+ salt) 8 kg/ha	115	40*	149	92	28*	55*	107	104	81	78	45*	82	85	27*	41*	105	102	108	95	89	120
MCPA (iso-octyl ester) 8 kg/ha	79	46*	81	76	66*	79	69	43*	80	37*	45*	65*	32*	19*	82	100	93	138	65*	86	100
Atrazine 4 kg/ha	73	77	121	74	57*	99	118	117	94	80	93	102	45*	48*	85	130	73	106	89	88	105
Atrazine 4 kg/ha + 10% v/v Sunoco Spray Oil	71	79	138	81	94	68	70	114	126	67*	66*	162	57*	29*	69	125	107	109	75	101	99
Metribuzin 4 kg/ha	71	58	84	15*	37*	35*	0*	0*	76	0*	0*	0*	0*	0*	0*	0*	0*	22*	31*	0*	42*
Dalapon 10 kg/ha	61	41*	101	62*	68*	67*	68	74	82	30*	13*	26*	43*	70	60	55*	82	89	58*	78	77
Asulam 4 kg/ha	70	102	89	73	45*	93	101	76	82	43*	59*	57*	70	102	81	93	85	93	92	117	132
Chlorthiamid 10 kg/ha (as granules)	29*	24*	96	9*	98	66*	74	80	98	0*	0*	8*	67	37*	42*	112	86	132	45*	106	101
Glyphosate 1 kg/ha	59	72	96	44*	79	117	40*	51*	113	0*	0*	39*	0*	6*	42*	95	120	72	55*	111	107
Glyphosate 4 kg/ha	22*	22*	74	5*	24*	32*	32*	62*	89	0*	0*	0*	0*	0*	13*	60*	103	89	11*	48*	85
Aminotriazole 4 kg/ha	46*	76	87	31*	40*	47*	78	55*	66	11*	20*	33*	46*	7*	0*	131	121	128	10*	42*	66*
Metflurazon 8 kg/ha	133	105	103	100	107	121	100	93	110	100	73*	40*	21*	16*	19*	76	40*	55*	130	126	107
Norflurazon (SAN 9789) 8 kg/ha	104	97	97	123	110	56*	111	114	129	16*	24*	89	0*	0*	31*	57*	30*	77	109	129	116
L.S.D. (5%) Treatment means vs control mean		51.0			40.5			35.4			26.9			40.3			39.2			32.6	

E Treatments applied 23.5.72 - assessment at 14 months from application (July 1973)
M Treatments applied 18.7.72 - assessment at 12 months from application
L Treatments applied 12.9.72 - assessment at 10 months from application

* Treatment mean significantly less than control mean (P = 0.05)

Table 2. 1973/74 Post-emergence experiment. (Conifer species) Above ground weights as % of control

Treatment			CORSICAN PINE M	CORSICAN PINE L	DOUGLAS FIR M	DOUGLAS FIR L	LAWSON'S CYPRESS M	LAWSON'S CYPRESS L	WESTERN HEMLOCK M	WESTERN HEMLOCK L	JAPANESE LARCH M	JAPANESE LARCH L	SITKA SPRUCE M	SITKA SPRUCE L	WESTERN RED CEDAR M	WESTERN RED CEDAR L
Control			100		100		100		100		100		100		100	
Glyphosate	0.25	kg/ha	-	-	81	81	-	-	45*	93	48*	80	88	93	-	-
"	0.5	kg/ha	87	116	42*	93	99	110	38*	106	17*	62*	76	92	100	138
"	1	kg/ha	39*	123	9*	66*	94	97	2*	28*	0*	63*	76	83	88	108
"	2	kg/ha	35*	16*	-	-	75	83	-	-	-	-	-	-	40*	85
Norflurazon	2	kg/ha	-	-	-	-	-	-	98	79	80	97	97	83	-	-
(SAN 9789)	4	kg/ha	126	135	84	76*	115	97	93	105	55*	70*	49*	87	150	135
"	8	kg/ha	129	94	79	84	124	92	-	-	-	-	-	-	136	123
Chlorthiamid	2.5	kg/ha	-	-	-	-	-	-	32*	126	69*	85	-	-	-	-
(as granules)	5	kg/ha	97	119	61*	79	114	88	75	128	19*	97	91	106	96	112
"	10	kg/ha	84	129	30*	70*	106	97	-	-	-	-	67*	103	121	125
Dalapon	2.5	kg/ha	94	113	72*	57*	122	88	53*	75	73*	85	75*	82	102	100
"	5	kg/ha	74	90	53*	67*	92	67*	31*	57	50*	74*	84	69*	108	77
Atrazine	8	kg/ha	106	116	75*	61*	138	139	52*	170	0*	36*	47*	96	52*	63*
Cyprazine	1	kg/ha	145	100	81	66*	124	101	120	124	83	72*	114	92	127	146
"	4	kg/ha	123	106	29	60*	107	121	64	77	0*	20*	41*	72*	35*	25*
Metribuzin	0.5	kg/ha	-	-	80	66*	114	136	54*	31*	20*	77	87	100	119	115
"	1	kg/ha	119	119	-	-	-	-	-	-	-	-	-	-	-	-
"	2	kg/ha	-	-	36*	31*	32*	15*	0*	8*	0*	24*	16*	0*	4*	2*
"	4	kg/ha	25*	55*	-	-	-	-	-	-	-	-	-	-	-	-
LSD (5%) Treatment vs. control means			31		23		27		45		26		25		32	

M Treatments applied 18/7/73, assessed at 12 months from application
L Treatments applied 19/9/73, assessed at 10 months from application

* Treatment mean significantly less than control mean (P = 0.05)

Table 3. 1973/74 Post-emergence experiment. (Heather)

Treatment	% leaf injury at 14/11/1973		Above ground weight at 18/7/74	
	M	L	M	L
Control	12		100	
Glyphosate, 0.5 kg/ha	25	18	91	85
" 1 kg/ha	83	31	25	91
" 2 kg/ha	90	27	7	71
Norflurazon, 2 kg/ha	3	25	110	89
(SAN 9789) 8 kg/ha	20	17	108	98
Chlorthiamid, 5 kg/ha	17	12	111	107
" 10 kg/ha	3	8	104	102
Dalapon, 2.5 kg/ha	3	10	121	103
" 5 kg/ha	4	2	126	101
Atrazine, 8 kg/ha	73	10	34	54
Cyprazine, 1 kg/ha	72	3	44	91
" 4 kg/ha	100	12	0	3
Metribuzin, 1 kg/ha	20	19	89	119
" 4 kg/ha	10	27	109	132
2,4-D (as salt), 4 kg/ha	75	38	30	98
" (as ester) 4 kg/ha	61	47	85	71
Mecoprop (as salt), 8 kg/ha	40	42	73	76
" (as ester), 8 kg/ha	42	25	95	98
Dichlorprop (as salt), 8 kg/ha	32	28	73	108
" (as ester), 8 kg/ha	40	31	70	90
MCPA (as salt), 8 kg/ha	83	47	19	69
" (as ester), 8 kg/ha	87	51	19	48
LSD (5%) Treatment vs. control means	18	14	29	29

M Treatments applied 18/7/73
L Treatments applied 19/9/73

Table 4. 1976/77 Post-emergence experiment (Crop species). Fresh weights, as % of control.

(Sprayed 25/8/76: Assessed Summer 1977)

TREATMENT	OAK	BEECH	CORSICAN PINE	DOUGLAS FIR	SITKA SPRUCE	LODGEPOLE PINE
	Fresh weight, leaves		Fresh weight, 1977 growth			
Control	100	100	100	100	100	100
Glyphosate 0.5 kg/ha	77	77	111	123	126	78
" " + 5% $(NH_4)_2SO_4$	94	99	140	97	106	96
" " applied CDA	105	36*	103	108	94	78
" " + 5% $(NH_4)_2SO_4$, CDA	87	17*	105	92	96	109
Glyphosate 1 kg/ha	116	86	93	79	129	87
" " + 5% $(NH_4)_2SO_4$	88	36*	89	153	102	97
" " applied CDA	98	21*	91	82	76	95
" " + 5% $(NH_4)_2SO_4$, CDA	86	3*	55*	110	122	63*
Glyphosate 2 kg/ha	21*	24*	63*	68	93	110
" " + 5% $(NH_4)_2SO_4$	62*	3*	55*	106	61*	101
" " applied CDA	66*	0*	65	74	113	140
" " + 5% $(NH_4)_2SO_4$, CDA	35*	1*	119	43*	110	110
Mefluidide (MBR 12325) 0.25 kg/ha	82	103	114	81	63*	85
1 kg/ha	92	93	115	99	117	100
Trifop-methyl (HOE 29152) 1 kg/ha	96	94	149	58*	100	95
4 kg/ha	91	90	90	106	128	90
Cyprazine 1 kg/ha	106	111	99	113	108	94
" " + 10% Actipron	101	56*	101	102	120	79
" " + 10% Oil "B"	69*	51*	106	114	104	107
Cyprazine 2 kg/ha	110	96	126	111	114	109
" " + 10% Actipron	85	38*	113	94	126	100
" " + 10% Oil "B"	76	68*	126	65	109	118
Cyprazine 4 kg/ha	58*	77	142	83	80	109
" " + 10% Actipron	90	68*	81	71	113	102
" " + 10% Oil "B"	75	71	83	32*	111	108
Atrazine 1 kg/ha	97	90	145	112	106	107
" " + 10% Actipron	94	72	118	114	100	100
" " + Oil "B"	106	89	119	113	111	89
Atrazine 2 kg/ha	121	85	132	69	130	112
" " + 10% Actipron	74	82	139	98	127	118
" " + Oil "B"	94	109	84	111	125	101
Atrazine 4 kg/ha	99	102	166	98	132	94
" " + 10% Actipron	74	90	164	72	154	123
" " + 10% Oil "B"	99	63*	128	111	147	82
Metamitron 4 kg/ha	71*	91	107	116	89	97
" 8 kg/ha	111	99	144	107	122	86
Hexazinone (Velpar) 1 kg/ha	26*	91	83	111	101	107
" 2 kg/ha	13*	41*	143	79	154	128
" 4 kg/ha	0*	74	111	100	137	117
Oxadiazon 2 kg/ha	107	105	147	72	135	94
" 8 kg/ha	103	93	121	59*	127	77
Terbuthylazine 2 kg/ha	112	86	118	94	120	102
4 kg/ha	113	94	127	58*	128	101
8 kg/ha	102	94	113	147	89	94
Tebuthiuron 1 kg/ha	6*	66*	0*	1*	26*	33*
" 2 kg/ha	0*	25*	0*	3*	17*	0*
4 kg/ha	0*	1*	0*	0*	0*	3*
Bromacil 1 kg/ha	13*	90	43*	59*	112	32*
" 4 kg/ha	21*	53*	0*	0*	0*	0*
Triclopyr (Dow 233) 0.5 kg/ha	6*	7*	104	90	114	94
2 kg/ha	0*	0*	59*	55*	85	79
Dow 290 (Lontrel) 0.25 kg/ha	103	83	144	82	113	99
" 1 kg/ha	92	91	104	114	87	101
DPX 1108 (Krenite) 2 kg/ha	117	58*	107	134	98	85
" 4 kg/ha	83	75	92	98	72	88
2,4-D as amine 2 kg/ha	40*	111	97	98	109	82
" " +5% $(NH_4)_2SO_4$	55*	74	81	70	129	96
" 4 kg/ha	34*	85	101	68	111	81
" " +5% $(NH_4)_2SO_4$	34*	78	78	80	103	63
2,4-D as ester 2 kg/ha	50*	99	112	60*	107	97
4 kg/ha	53*	49*	83	63	97	74
MCPA as K-salt 2 kg/ha	35*	130	105	79	105	98
" " +5% $(NH_4)_2SO_4$	55*	85	94	59*	84	62*
" 4 kg/ha	32*	85	65	91	101	89
" +5% $(NH_4)_2SO_4$	68*	80	99	40*	99	57*
MCPA as ester 2 kg/ha	23*	86	105	74	122	114
" 4 kg/ha	55*	72	84	61	100	78
Asulam 3 kg/ha	98	90	112	91	91	81
" 1.5 kg/ha + 2 kg/ha urea + 0.1% Ethylan BCP	114	121	108	94	96	91
" 3 kg/ha + 2 kg/ha urea + 0.1% Ethylan BCP	108	97	122	89	102	103
L.S.D. (5%) Treatment vs control mean	26	31	36	39	35	29

* Treatment mean significantly less than control mean (P = 0.05)

Atrazine 1 kg/ha		87	110	91	79
" "	+ 10% Actipron	98	85	107	90
" "	+ 10% Oil "B"	98	84	139	102
Atrazine 2 kg/ha		133	89	167	104
" "	+ 10% Actipron	101	75*	94	89
" "	+ 10% Oil "B"	74	83	126	103
Atrazine 4 kg/ha		25*	75*	109	72
" "	+ 10% Actipron	2*	91	107	50*
" "	+ 10% Oil "B"	16*	86	68	76
Metamitron	4 kg/ha	155	95	128	89
	8 kg/ha	99	108	50*	93
Hexazinone (Velpar)	1 kg/ha	106	52*	87	84
" "	2 kg/ha	77	34*	68	67*
" "	4 kg/ha	63*	7*	56	21*
Oxadiazon	2 kg/ha	107	-	-	-
"	8 kg/ha	102	-	-	-
Terbuthylazine	2 kg/ha	102	101	102	10*
"	4 kg/ha	100	85	37*	0*
"	8 kg/ha	6*	27*	0*	0*
Tebuthiuron	1 kg/ha	71	68*	109	47*
"	2 kg/ha	142	15*	95	11*
"	4 kg/ha	83	6*	63	10*
Bromacil	1 kg/ha	36*	80*	95	72
"	4 kg/ha	0*	39*	30*	82
Triclopyr (Dow 233)	0.5 kg/ha	111	-	-	-
" "	2 kg/ha	83	-	-	-
Dow 290 (Lontrel)	0.25 kg/ha	97	-	-	-
" "	1 kg/ha	96	-	-	-
DPX 1108 (Krenite)	2 kg/ha	105	-	-	-
" "	4 kg/ha	110	-	-	-
2,4-D as amine	2 kg/ha	93	-	-	-
"	" + 5%$(NH_4)_2SO_4$	28*	-	-	-
"	4 kg/ha	38*	-	-	-
"	" + 5%$(NH_4)_2SO_4$	30*	-	-	-
2,4-D as ester	2 kg/ha	56*	-	-	-
"	4 kg/ha	47*	-	-	-
MCPA as K-salt	2 kg/ha	104	-	-	-
"	" + 5%$(NH_4)_2SO_4$	31*	-	-	-
"	4 kg/ha	23*	-	-	-
"	" + 5%$(NH_4)_2SO_4$	10*	-	-	-
MCPA as ester	2 kg/ha	89	-	-	-
"	4 kg/ha	30*	-	-	-
Asulam 3 kg/ha		-	-	-	-
" 1.5 kg/ha + 2 kg/ha urea + 0.1% Ethylon BCP		-	-	-	-
" 3 kg/ha + 2 kg/ha urea + 0.1% Ethylon BCP		-	-	-	-
L.S.D. (5%) Treatment vs control mean		37	20	46	30

* Treatment mean significantly different from control mean (P = 0.05)

Table 5. 1976/77 Post-emergence experiment (Heather and Grasses). Fresh weights of living above-ground growth as % of control. (Sprayed 25/8/76: assessed Summer 1977)

TREATMENT	HEATHER (Calluna vulgaris)	MOLINIA CAERULEA	DESCHAMPSIA CAESPITOSA	CALAMAGROSTIS EPIGEJOS
Control	100	100	100	100
Glyphosate 0.5 kg/ha	95	45*	60	73
" " $+5\% (NH_4)_2SO_4$	100	44*	31*	64*
" " applied CDA	99	24*	39*	51*
" " $+5\% (NH_4)_2SO_4$, CDA	95	50*	9*	56*
Glyphosate 1 kg/ha	101	11*	13*	18*
" " $+5\% (NH_4)_2SO_4$	110	9*	0*	14*
" " + applied CDA	89	10*	53*	30*
" " $+5\% (NH_4)_2SO_4$, CDA	79	15*	8*	64*
Glyphosate 2 kg/ha	118	-	-	-
" " $+5\% (NH_4)_2SO_4$	100	-	-	-
" " applied CDA	46*	-	-	-
" " $+5\% (NH_4)_2SO_4$, CDA	73	-	-	-
Mefluidide (MBR 12325) 0.25 kg/ha	88	102	47*	101
" " 1 kg/ha	99	96	127	95
Trifop-methyl (HOE 29152) 1 kg/ha	114	32*	21*	8*
" " 4 kg/ha	89	3*	0*	0*
Cyprazine 1 kg/ha	0*	105	106	88
" " +10% Actipron	17*	82	126	86
" " +10% Oil"B"	32*	81	112	105
Cyprazine 2 kg/ha	0*	89	97	82
" " +10% Actipron	0*	93	104	59*
" " +10% Oil"B"	0*	80*	130	52*
Cyprazine 4 kg/ha	0*	87	111	29*
" " +10% Actipron	0*	74*	113	21*
" " +10% Oil "B"	0*	73*	99	29*

Table 6. Pre-emergence applications. Number and (in brackets) fresh weight of emerged seedlings

TREATMENT		Glasshouse experiment: OAK	Glasshouse experiment: CORSICAN PINE	Outdoor Experiment: LODGEPOLE PINE	Outdoor Experiment: SITKA SPRUCE	Outdoor Experiment: DOUGLAS FIR	Outdoor Experiment: CORSICAN PINE	Outdoor Experiment: BEECH	Outdoor Experiment: GORSE
Surface applied except as shown									
Control		4.1 (6.6)	4.0	1.5 (0.4)	2.9 (1.0)	4.1 (0.8)	8.3 (3.2)	0.8 (0.5)	9.0 (4.8)
Diphenamid	4 kg/ha	4.3 (6.5)	6.0	1.0 (1.4)	1.7 (0.5)*	7.7 (1.4)	8.7 (4.0)	1.0 (0.9)	11.0 (3.4)
Atrazine	1 kg/ha	3.7 (6.5)	0.0*	0.7 (0.3)	0.3 (Tr)*	0.7 (0.1)*	5.0 (2.3)	1.0 (1.0)	0.3 (Tr)*
Simazine	1 kg/ha	3.7 (7.2)	0.0*	0 (0)	0.3 (Tr)*	3.0 (0.6)	7.7 (2.3)	1.0 (0.9)	1.0 (0.9)*
Hexazinone	0.5 kg/ha	4.0 (9.5)	2.7	1.0 (0.4)	0.7 (0.2)*	3.7 (0.7)	5.3 (2.8)	0.7 (0.3)	0.0 (0.0)*
Terbutryne	2 kg/ha	4.0 (6.6)	0.0*	1.0 (0.8)	0 (0)*	2.7 (0.7)	7.0 (3.0)	0.7 (0.6)	5.0 (3.6)*
Tebuthiuron	0.5 kg/ha	4.3 (4.7)	0.0*	0 (0)	0 (0)*	0 (0)*	0 (0)*	1.3 (0.5)	0.0 (0.0)*
Linuron	1 kg/ha	3.7 (5.6)	0.0*	1.3 (0.4)	0 (0)*	2.0 (0.5)	5.0 (2.3)	0.7 (0.7)	3.7 (3.9)*
Chloroxuron	3 kg/ha	3.7 (8.3)	2.7	4.0 (1.6)	1.3 (0.1)*	2.0 (0.6)	8.3 (3.3)	1.0 (0.7)	7.0 (4.7)
Dowco 290	5 kg/ha	1.0 (0.6)*	0.0*	2.0 (0.6)	1.7 (0.1)*	1.0 (0.1)*	0.7 (0.1)*	0.0 (0.0)	0.0 (0.0)*
Chlornitrofen	4 kg/ha	3.3 (7.0)	4.3	2.3 (1.2)	0.7 (0.2)*	4.3 (1.0)	9.7 (3.8)	2.7 (1.8)	5.0 (5.2)*
Oxyfluorfen (RH 2915)	0.5 kg/ha	3.0 (6.3)	3.3	3.3 (1.3)	1.3 (0.2)*	5.7 (1.0)	7.7 (3.1)	1.0 (1.3)	3.0 (2.5)*
Oxadiazon	4 kg/ha	3.3 (6.7)	0.7*	0 (0)	0 (0)*	0 (0)*	0.7 (0.4)*	0.3 (0.2)	0.0 (0.0)*
RP 20630	4 kg/ha	3.7 (8.4)	0.3*	0 (0)	0 (0)*	0 (0)*	0 (0)*	0.0 (0.0)	0.0 (0.0)*
WL 29226	4 kg/ha	4.3 (9.1)	3.3	1.3 (0.5)	2.3 (0.4)*	1.7 (0.4)	9.0 (3.6)	1.0 (0.5)	8.0 (3.6)
Bromacil	0.5 kg/ha	3.7 (7.2)	0.3*	0 (0)	0 (0)*	1.0 (0.2)*	0 (0)*	2.0 (0.7)	0.0 (0.0)*
Lenacil	2 kg/ha	3.7 (7.7)	0.7*	0 (0)	0 (0)*	1.3 (0.4)*	0 (0)*	0.7 (0.5)	5.7 (4.9)
Terbacil	0.5 kg/ha	4.0 (8.2)	0.3*	0.3 (Tr)	0 (0)*	3.0 (0.5)	0 (0)*	2.0 (1.5)	0.3 (0.6)*
Norflurazone	3 kg/ha	4.3 (8.2)	0.0*	0 (0)	0 (0)*	0 (0)*	1.0 (0.4)*	0.3 (0.2)	0.0 (0.0)*
Dinitramine (incorporated)	1 kg/ha	4.0 (6.3)	0.3*	3.0 (0.3)	0.7 (Tr)*	4.0 (0.4)	7.0 (1.4)	1.0 (1.2)	--
Prodiamine (Incorporated)	1 kg/ha	4.7 (9.4)	2.0	2.3 (0.4)	2.3 (0.1)*	6.3 (0.6)	9.3 (3.0)	0.3 (0.2)	--
Eptam (incorporated)	4 kg/ha	3.3 (6.7)	1.3*	1.3 (0.5)	0 (0)*	1.3 (0.1)*	8.0 (2.3)	0.7 (0.3)	--
Propyzamide	2 kg/ha	3.3 (5.8)	0.7*	0.3 (Tr)	0 (0)*	4.3 (0.3)	3.7 (0.7)	0.7 (0.4)	1.7 (1.8)*
Napropamide	4 kg/ha	3.7 (6.2)	4.3	4.0 (1.1)	0.3 (Tr)*	5.3 (1.0)	9.7 (3.2)	0.7 (0.4)	2.7 (1.3)*
Propham	3 kg/ha	3.0 (5.7)	1.3*	2.7 (1.3)	2.0 (0.6)	5.0 (1.0)	8.3 (3.1)	0.3 (0.3)	7.3 (5.0)
Chlorpropham	3 kg/ha	4.0 (8.3)	1.3*	1.0 (0.3)	0 (0)*	4.7 (1.1)	0.7 (0.2)*	2.0 (1.1)	3.0 (1.7)*
Chlorthiamid	3 kg/ha	0.3 (0.3)*	0.0*	0 (0)	0 (0)*	0 (0)*	0 (0)*	1.0 (1.0)	0.3 (0.1)*
Perfluidone (MBR 8251)	4 kg/ha	3.3 (6.0)	0.0*	0 (0)	0 (0)*	0 (0)*	0 (0)*	0.0 (0.0)	3.0 (3.8)*
Ethofumesate	2 kg/ha	3.3 (2.0)*	0.0*	0.3 (Tr)	0.7 (0.1)*	0.3 (Tr)*	3.3 (0.8)	0.7 (0.2)	0 (0.0)*
Alachlor	1 kg/ha	3.3 (6.8)	1.3*	0 (0)	0.3 (Tr)*	2.3 (0.5)	7.0 (3.3)	1.0 (0.8)	9.3 (4.7)
Pendimethalin	4 kg/ha	3.3 (5.3)	1.3*	2.0 (0.8)	0.3 (0.1)*	6.0 (0.9)	7.3 (2.9)	1.0 (0.6)	6.0 (2.2)
Methabenzthiazuron	3 kg/ha	4.3 (9.4)	0.0*	4.0 (2.0)	0.3 (Tr)*	4.7 (1.0)	6.3 (2.9)	0.3 (0.6)	3.3 (2.5)*
Metamitron	3 kg/ha	3.7 (7.4)	0.3*	0.3 (Tr)	1.3 (0.1)*	3.0 (0.5)	7.0 (2.2)	0.3 (0.1)	10.0 (8.1)
Metribuzin	0.5 kg/ha	4.7 (8.2)	0.3*	0.3 (Tr)	0 (0)*	0.7 (Tr)*	0 (0)*	0.7 (0.4)	6.3 (3.2)
Dimefuron (RP 23465)	3 kg/ha	4.0 (3.9)	0.3*	0 (0)	0 (0)*	0 (0)*	0 (0)*	0.7 (0.3)	0 (0.0)*
Butam	2 kg/ha	4.0 (7.5)	4.7	1.3 (0.5)	3.0 (0.5)*	5.0 (1.2)	8.7 (3.8)	1.0 (0.7)	10.0 (6.3)
Buthidazole (VEL 5026)	0.5 kg/ha	4.0 (5.6)	0.0*	0 (0)	0 (0)*	0.3 (Tr)*	0 (0)*	0.7 (0.5)	0.3 (Tr)*
Trifop-methyl (HOE 29152)	3 kg/ha	3.3 (6.7)	5.0	2.3 (1.3)	3.3 (0.9)	5.7 (1.2)	8.3 (3.3)	1.3 (1.4)	7.3 (4.6)
K 1441	4 kg/ha	3.7 (8.8)	4.3	2.0 (1.0)	2.3 (0.4)*	4.3 (1.0)	9.0 (3.8)	0.7 (0.3)	9.0 (6.2)
Dalapon	8 kg/ha	2.7 (5.7)	0.7*	0.7 (0.4)	2.3 (0.6)	1.7 (0.2)	4.7 (2.3)	0.0 (0.0)	5.7 (4.8)
Orga 3045 (Tetrapion-Na)	4 kg/ha	1.7 (0.5)*	3.0	0 (0)	0.7 (0.2)*	3.3 (0.4)	2.0 (0.4)	1.3 (1.1)	3.0 (2.8)*
Prometryne	2 kg/ha	2.7 (5.5)	1.0*	2.0 (1.1)	1.3 (0.4)*	2.3 (0.6)	8.7 (3.4)	1.3 (0.9)	1.3 (1.7)*
Desmetryne	4 kg/ha	4.0 (7.0)	0.0*	0 (0)	0 (0)*	0 (0)*	1.0 (0.3)*	0.3 (0.1)	0.6 (Tr)*
Chlorthal-dimethyl	8 kg/ha	4.7 (10.1)	3.3	2.0 (1.1)	1.3 (0.5)*	2.7 (0.5)	9.7 (3.3)	0.7 (0.3)	11.3 (6.6)
Trifluralin (incorporated)	1 kg/ha	4.7 (8.3)	4.0	3.0 (1.5)	3.3 (0.2)*	3.3 (0.5)	8.7 (3.3)	0.7 (0.7)	--
Glyphosate	10 kg/ha	4.0 (8.2)	-	1.7 (0.8)	2.3 (1.3)	4.0 (0.7)	8.3 (3.5)	1.0 (0.6)	11.3 (5.7)
Triclopyr	3 kg/ha	-	-	0 (0)	0 (0)*	0 (0)*	0 (0)*	0.0 (0.0)	0.6 (Tr)*
Nitrofen	0.8 kg/ha	-	-	1.3 (0.3)	0.7 (0.1)*	2.7 (0.4)	2.3 (0.3)*	0.7 (0.5)	0.3 (Tr)*
Terbuthylazine	1 kg/ha	-	-	1.0 (0.5)	0.7 (Tr)*	1.0 (0.2)*	8.7 (3.4)	2.7 (2.0)	0.3 (0.9)*
Cyanazine	1 kg/ha	-	-	1.0 (0.5)	1.7 (0.6)	3.0 (0.7)	7.0 (3.6)	0.0 (0.0)	11.0 (8.4)
L.S.D. (5%)	Treatment vs control mean	1.9 (3.6)	2.2	N.S.	1.5 (0.4)	2.7 (0.6)	2.3 (0.7)	N.S.	3.9 (3.2)

Table 6 p. 3

* No. of emerged seedlings or fresh weight significantly less than control (P = 0.05)

ABBREVIATIONS

ångström	Å	freezing point	f.p.
Abstract	Abs.	from summary	F.s.
acid equivalent*	a.e.	gallon	gal
acre	ac	gallons per hour	gal/h
active ingredient*	a.i.	gallons per acre	gal/ac
approximately equal to*	$\simeq$	gas liquid chromatography	GLC
aqueous concentrate	a.c.	gramme	g
bibliography	bibl.	hectare	ha
boiling point	b.p.	hectokilogram	hkg
bushel	bu	high volume	HV
centigrade	C	horse power	hp
centimetre*	cm	hour	h
concentrated	concd	hundredweight*	cwt
concentration	concn	hydrogen ion concentration*	pH
concentration x time product	ct	inch	in.
concentration required to kill 50% test animals	LC50	infra red	i.r.
		kilogramme	kg
cubic centimetre*	cm^3	kilo ($x10^3$)	k
cubic foot*	ft^3	less than	<
cubic inch*	in^3	litre	l.
cubic metre*	m^3	low volume	LV
cubic yard*	yd^3	maximum	max.
cultivar(s)	cv.	median lethal dose	LD50
curie*	Ci	medium volume	MV
degree Celsius*	^oC	melting point	m.p.
degree centigrade	^oC	metre	m
degree Fahrenheit*	^oF	micro ($x10^{-6}$)	μ
diameter	diam.	microgramme*	μg
diameter at breast height	d.b.h.	micromicro (pico: $x10^{-12}$)*	μμ
divided by*	÷ or /	micrometre (micron)*	μm (or μ)
dry matter	d.m.	micron (micrometre)*†	μm (or μ)
emulsifiable concentrate	e.c.	miles per hour*	mile/h
		milli ($x10^{-3}$)	m
equal to*	=	milliequivalent*	m.equiv.
fluid	fl.	milligramme	mg
foot	ft	millilitre	ml

† The name micrometre is preferred to micron and μm is preferred to μ.

millimetre*	mm
millimicro* (nano: x10^{-9})	n or mμ
minimum	min.
minus	-
minute	min
molar concentration*	M (small cap)
molecule, molecular	mol.
more than	$>$
multiplied by*	x
normal concentration*	N (small cap)
not dated	n.d.
oil miscible concentrate	o.m.c. (tables only)
organic matter	o.m.
ounce	oz
ounces per gallon	oz/gal
page	p.
pages	pp.
parts per million	ppm
parts per million by volume	ppmv
parts per million by weight	ppmw
percent(age)	%
pico (micromicro: x10^{-12})	p or μμ
pint	pint
pints per acre	pints/ac
plus or minus*	$\pm$
post-emergence	post-em
pound	lb
pound per acre*	lb/ac
pounds per minute	lb/min
pound per square inch*	lb/in^2
powder for dry application	p. (tables only)
power take off	p.t.o.
precipitate (noun)	ppt.
pre-emergence	pre-em.
quart	quart
relative humidity	r.h.
revolution per minute*	rev/min
second	s
soluble concentrate	s.c.
soluble powder	s.p.
solution	soln
species (singular)	sp.
species (plural)	spp.
specific gravity	sp. gr.
square foot*	ft^2
square inch	in^2
square metre*	m^2
square root of*	$\sqrt{\ }$
sub-species*	ssp.
summary	s.
temperature	temp.
ton	ton
tonne	t
ultra-low volume	ULV
ultra violet	u.v.
vapour density	v.d.
vapour pressure	v.p.
varietas	var.
volt	V
volume	vol.
volume per volume	v/v
water soluble powder	w.s.p. (tables only)
watt	W
weight	wt
weight per volume*	w/v
weight per weight*	w/w
wettable powder	w.p.
yard	yd
yards per minute	yd/min

* Those marked * should normally be used in the text as well as in tables etc.

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