BULBS

EXPERIMENTS WITH PRE-EMERGENCE WEEDKILLERS

ON BEDS OF NARCISSUS AND TULIP 1953 - 56

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Summary

The results of field experiments conducted over a period of three successive years are given. The value and limitations of the pre-emergence herbicides compared for use on narcissus and tulip crops are assessed. Suggestions for further trials are made.

Introduction

In a previous account of the weed problem in bulb crops (1) attention was drawn to the specific crop requirements which have always to be kept in mind when choosing herbicides for use on bulb beds. As yet, the bulb grower's choice is limited to types suitable for use in the pre-emergence period of bulb growth. Commercially, on beds of daffodils and tulips in this country, the few substances widely used are those generally employed for potato haulm destruction. Despite their usefulness on bulbs they are likely to be superseded as soon as other herbicides become available that are equally effective, but easier to handle.

Of the herbicides used in trials at Kirton prior to 1953, PCP emulsion gave most promise and seemed worthy of further trial. New herbicides likely to be useful were becoming available for experimental purposes, and Ormrod (2) and Woodford (3) had already conducted preliminary trials with C.I.P.C. and CMU. In collaboration therefore with the A.R.C. Unit of Experimental Agronomy, Oxford it was decided that further trials should be carried out with these herbicides as pre-emergence sprays on bulbs.

Accordingly these trials were carried out at the two N.A.A.S. Experimental Centres directly concerned with bulb crops; Kirton E.H.F., Lincs. and Rosewarne E.H.S. Cornwall.

Aim and Method

In the experiments at Kirton here recorded the aim was to observe the residual effect of pre-emergence sprays applied in winter; usually under adverse conditions when temperatures are generally low.

The bulb plots, or beds, each consisted of 50 bulbs spaced 6" apart in the row and 10" between rows. The planting operations were done by Dutch bedding methods when the land had first been ploughed and harrowed after lifting an early potato crop. Following customary practice no manures were applied for bulbs.

The sprays were applied by hand sprayer at the most favourable opportunity shortly before the emergence of the bulb shoots, irrespective of the stages of weed growth. Assessment of the effectiveness of the treatments was by visual judgement, noting the type, and comparative amount of weed growth, freedom of the crop from the visual signs of injury, and comparison of yields at harvest after the bulbs were cleaned. The details relating to the trial conducted in 1953-54 are given in Table I.

Vicarage Field 1953-54 — Trial of Pre-emergence Weedkillers on Narcissus and Tulip Beds

Cultivars: Narcissus Baths Flame: weight planted 84 oz
Tulip Rose Copland: " " 42 oz

Layout: 14 treatments in 5 randomised blocks.
All sprays applied mid-December 1953 at 100 gallons per acre

Table I

Mean Yields in oz

Treatments	lb per acre	Narcissus Mean Yield	% of Control Yield	Tulip Mean Yield	% of Control Yield
Unweeded		178.0	100.0	103.4	100.0
Handweeded once		220.0	123.7	125.4	121.2
TCA	10	174.0	97.7	100.0	96.7
TCA	20	177.0	99.4	93.2	90.1
CIPC	4	220.0	123.5	120.4	116.4
CIPC	8	228.0	128.1	113.0	109.2
CMU	4	204.4	114.8	100.2	96.9
DNC	12	224.2	125.9	117.4	113.5
Dinoseb	8	221.4	124.8	121.2	117.2
H_2SO_4 12.5%	-	211.8	119.0	123.6	119.5
" " plus cult.	-	220.8	124.1	130.4	126.1
PCP	16	216.6	121.6	129.6	125.3
" plus cult.	16	225.6	126.7	128.2	123.9
Cultivation only	-	218.5	122.7	124.4	120.3

In addition to the above, sodium arsenite was used on 'look see' plots. Within a few days of application differences were noticed, though the amount of weed present was small; H_2SO_4, sodium arsenite, DNC, dinoseb and PCP had scorched the weed seedlings. A fortnight later the pattern had changed. TCA was giving good control of Poa annua, and CMU and CIPC were killing all weeds. Subsequently apart from the control of grass the TCA plots were no better than the un-weeded plots but could be picked out easily, in the case of tulip, by the paler foliage of the crop. By the beginning of February tulips were also showing signs of injury by CMU; the leaves were dying at their tips. By April when Stellaria media, Senecio vulgaris and Veronica spp were establishing themselves the CMU and CIPC plots remained remarkably clean, and of the others all except TCA were cleaner than the control plots. Ultimately the injury to tulips by CMU was visible from a distance and on closer inspection, with narcissus plants also, there was reason to suspect that both CIPC at 8 lb/ac and CMU at 4 lb/ac were causing slight injury to the outer leaves.

1954 - 55 Trials

In setting up the trial for 1954-55 only one series of TCA plots was retained. Sodium arsenite was included along with White Oil which had favourably impressed growers who had used it. Different cultivars of narcissus and tulip were used, but otherwise the trial was similar to that of the previous year. The yields are given in Table II.

Asplands Nine 1954-55 — Trial of Pre-emergence Weedkillers on Narcissus and Tulip Beds

Cultivars: Narcissus King Alfred: Weight planted 75.5 oz
Tulip Princess Elisabeth " " 31 oz

Layout: 15 treatments in 5 randomised blocks.
All sprays were applied on 26th January, 1955; the rate of application being 100 gallons per acre excepting White Oil: 80 gallons per acre.

Table II

Mean Yields in oz

Treatment	lb per acre	Narcissus Mean Yield	% of Control Yield	Tulip Mean Yield	% of Control Yield
Unweeded		103.4	100.0	60.6	100.0
Handweeded		166.0	108.2	60.4	99.6
TCA	20	153.2	99.8	54.0	89.1
CIPC	4	155.2	101.1	57.2	94.3
CIPC	8	162.0	105.6	51.4	84.8
CMU	4	156.4	101.3	59.0	97.3
DNC	12	158.0	102.9	57.4	94.7
Dinoseb	8	153.0	99.7	57.2	94.3
Sodium arsenite (AS_2O_3 98%) 1 gal		159.0	104.3	63.2	104.3
White Oil 80 gal		150.8	98.3	56.2	92.7
H_2SO_4 12.5%		155.2	101.1	56.2	92.7
H_2SO_4 " + cultivation		159.8	104.1	64.0	105.6
PCP	16	159.2	103.7	65.2	107.5
PCP plus cultivation	16	158.8	103.5	64.8	106.9
Later cultivation		161.0	104.9	62.2	102.6

Owing to adverse weather conditions in autumn 1954 the bulbs were not planted until November. Scarcely any weed growth had taken place when the sprays were applied, nor was subsequent weed growth at any time prolific. Differences in the effects of the treatments were again obvious though to a lesser degree. Injury to tulip by CMU was again evident, but narcissus did not exhibit any ill effects from either CMU or the heavier dressing of CIPC. Cool showery weather continued over a long period and by the end of May only the plots treated with CIPC remained clean. Differences between the others were irregular but injury to tulips by CMU again became conspicuous.

On plots of bulbs retained and replanted from the previous year's trial, flower injury was observed in narcissus previously grown on plots treated with TCA in December 1953. Reports of this occurrence at Rosewarne, where even lower amounts had been used, had already been received. In consequence of this injury TCA was omitted from the subsequent trial.

1955-56 Trials

In laying down the third trial in autumn 1955, TVO was included for comparison with White Oil. Harvesting data was obtained in July 1956 only for the tulip crop - actually the progeny bulbs from those planted. It was decided in the case of narcissus to continue the experiment for a period of two years, repeating the treatments on the same beds and lifting the bulbs at the end of the second year; thus adopting the commercial practice more usually followed in this country. Bulbs from the 1954-55 trial were again planted to observe any subsequent injurious effects of treatments previously received.

When examining yield figures for tulips it was felt that since grading of the bulbs for size is important when assessing values, these should be given. The details are presented in Table III.

Jessop's Field 1955-56 — Trial of Pre-emergence Weedkillers on Narcissus and Tulip Beds

Cultivars: Narcissus King Alfred: weight planted 65 oz
Tulip Rose Copland: " " 28 oz

Layout: 15 treatments in randomised blocks.
All sprays applied at the rate of 100 gallons per acre on 8th December, 1955.

Table III

(Treatment Yields and Grades of Progeny from 200 Tulip Bulbs 9/10 cm Planted)

Treatment lb per acre	Yield in oz	% Increase	Salable Sizes 12 cm+	12 cm	11 cm	Total	Planting Sizes 10 cm	9 cm	8 cm	Total Graded Bulbs	Wt. oz "seed"
Unweeded	216	93	1	6	35	42	59	70	32	203	81
Handweeded	308	175	19	39	80	136	51	24	64	277	89
CIPC 4 lb	410	266	75	83	30	188	22	53	87	350	94
CIPC 8 lb	389	247	55	87	43	185	10	57	84	336	94
CMU 4 lb	169	51	16	23	24	63	21	25	31	140	55
DNC 12 lb	293	162	14	48	56	118	62	30	40	250	86
DNBP 8 lb	324	189	24	63	71	158	32	39	62	291	84
As_2O_3 9.8 lb	276	146	3	19	86	108	72	29	37	246	90
White Oil	372	232	35	88	50	173	31	42	72	318	92
TVO	402	259	56	78	45	179	22	45	95	341	103
H_2SO_4 12.5%	342	205	27	53	74	154	41	42	63	300	86
" " plus cult.	380	240	34	85	54	173	26	55	84	338	91
PCP 16 lb	402	259	70	77	38	185	19	50	81	335	98
PCP 16 lb plus cult.	403	259	62	88	27	177	22	56	72	327	96
Cultivation only	342	205	23	55	77	155	33	35	59	282	97

The 1955-56 period will be remembered for the prolific growth of weeds. In early December the plots had a moderate covering of seedlings comprising chickweed, annual meadow grass, speedwell, and groundsel. After the sprays were applied rain occurred intermittently for several days, with occasional frost at night and moderate snow on 19th December. Intermittent rain followed till heavy snowfall occurred on 8th January. Despite weather conditions, sulphuric acid, and PCP, were most effective. Dinoseb, DNC and TVO were having some effect, but sodium arsenite was disappointing. CMU and CIPC had had no obvious effect. A week later the pattern was changing and sulphuric acid was not maintaining its early promise. Ultimately CIPC, PCP, and TVO had the best effect. CMU controlled most weeds, except speedwell, but injury to the crop was severe not only on tulips but also on narcissus. The effects of cultivation in March, following previous treatment with sulphuric acid and PCP, had little influence upon the subsequent amount of weed growth. Though weed control with DNC, and dinoseb remained fairly good the crop never looked well, though it was not possible to detect definite signs of injury. By early June the weeds on the control plots were taller than the crop; one of the most prolific being Papaver rhoeas.

Narcissus bulbs from plots treated with TCA in 1953 still produced malformed flowers in April 1956. Others from the 1954-55 trials had malformed buds which did not open.

Discussion of Results

In endeavouring to assess the merits and demerits of herbicides, it is at once obvious that the more difficult task is that of judging crop tolerance to the substances used. The latter aspect of the trials on bulb crops is all the more important because many bulb "forcers" purchase bulbs solely for that specific purpose. The bulb producer's responsibility is to provide a reliable commodity. It is therefore essential in trials, to grow on samples of bulbs that have been used, to detect delayed effects.

TCA is so far the only herbicide used in these trials that has had such a delayed effect. With CMU on tulips injury was severe; but injury was not always evident in narcissus. Also, with DNC and dinoseb it was difficult to discern definite signs of injury. The smallness of the plots is a factor influencing the significance of yields, so that in this instance only marked differences are reliable. Consistency in performance indicated that both CIPC and PCP have some promise for use on narcissus and tulip as pre-emergence sprays.

Conclusion

While CIPC and PCP are worthy of further attention they need to be suitably formulated. There is, however, still urgent need for herbicides suitable for post-emergence application on bulb crops. There are also many points such as the quantity of spray necessary, the value of combined herbicides, which call for trial and investigation.

Acknowledgements

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References

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2. ORMROD, J. F. (1953) The use of DNBP and CIPC for weed control in lucerne ibid 1953. 265-275.

3. WOODFORD. E. K. (1953) CMU, exploratory experiments under British conditions ibid (1953). 319-327.

DISCUSSION ON THE PREVIOUS PAPER

Mr. W. Ochiltree

A few years ago I did some work on daffodils with sodium chlorate. In the first year the King Alfred daffodils were normal in size but next year they were 1/3 of their normal size.

Mr. R. J. Chancellor

What were the number and species of weeds that Mr. Wood was trying to control?

Mr. J. Wood

In the case of the weeds of our bulb crops, we tried to get a control of all weeds present, e.g. chickweed and speedwell and so on. On the monuron plots we obtained a very good example of a pure clone of the speedwell although most of the other things were controlled.

Mr. G. G. Fisher

I was very interested in Mr. Wood's remarks about the delayed effects of TCA on bulb crops. Similar delayed effects have been observed in sisal. It is believed that concentrations of TCA are built up in the leaves of the plant, this delaying the effect on the flowering parts and indicating persistency of TCA in the plant rather than in the soil. Is there any information on the safety period required between treatment with TCA and using the same land for planting bulbs?

Mr. J. Wood

I have no actual experience of this but there is a certain amount of circumstantial evidence to say that we shall have to go rather more carefully than we had thought. The flowers were quite good in the first year and could have been marketed, but it is our custom to retain samples from all bulbs that have been treated in experiments, and we keep them for observations until we are satisfied that no damage has been done. It was by this system that we discovered the trouble in the second year. We did not consider that it was our work to start finding out how long TCA should be applied before planting - we just said that this was of very little value from our point of view; but we may have eventually to work this problem out because our bulb growers are farmers and bulbs are part of the crop rotation. If a farmer is going to use TCA against twitch, he may want to plant bulbs immediately afterwards.

Mr. D. W. Robinson

Will 6 lb/ac CIPC control common groundsel?

Mr. J. Wood

Not entirely. With monuron we could get a very nice spread of speedwell and with CIPC we got a nice few plants of groundsel.

Mr. J. L. Hunt

Has Mr. Wood had any experience of the use of PCP on gladioli or anemones? If so, at what rate?

Mr. J. Wood

No. We have confined our experiments to tulips and narcissi because they are grown in much larger numbers. We will turn to these crops as soon as facilities are available.

Dr. F. H. Feekes

Is the 6-8 lb/ac of CIPC the active ingredient and how was it formulated and applied to the soil? PCP will give good results for some time, however, the after-effect of propham and CIPC is longer.

Mr. J. Wood

We normally take it that when we receive herbicides from the Agricultural Research Council's Unit of Experimental Agronomy, Oxford that they have gone into these things.

Dr. E. K. Woodford

Any formulations we have are with non-phytotoxic materials and if we formulate CIPC, it is in a non-toxic oil which is emulsified. The rate applied refers to the active ingredient.

Research Report No. E.12

EXPERIMENTS IN FOREST NURSERIES WITH SOME RECENTLY DEVELOPED WEEDKILLERS

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Summary

This paper describes results of experiments testing the suitability of MCPB, 2,4-DB, CDAA, CDEC and PCP as seedbed weedkillers in forest nurseries.

2,4-DB and MCPB applied as post-emergence sprays were found to be unsuitable because conifer seedlings were seriously damaged.

CDAA and CDEC were applied as pre-sowing, pre-emergence and post emergence sprays. Applications on the last two dates damaged conifer seedlings and gave only moderate control of weeds. Pre-sowing sprays showed promise and at rates of 4 lb/ac CDAA (active ingredient) did little damage to the crop and gave good control of weeds. CDAA was more phytotoxic than CDEC.

PCP was found to be unsuitable for use in forest nurseries whether applied pre- or post-sowing or pre-emergence because rates of PCP necessary to give adequate control of weeds substantially reduced the yield of conifer seedlings.

Introduction

This paper summarises the results of experiments carried out in 1955 in Forestry Commission research nurseries in England with recently developed weedkillers. Visual impressions (Sept. '56) of similar experiments still in progress are also given.

The following materials were included in these experiments:-

Name	Abbreviation	Remarks
2-methyl-4-chloro-phenoxybutyric acid	MCPB	Sodium salt
2,4-dichlorophenoxybutyric acid	2,4-DB	" "
2-chloro-N,N-diallylacetamide	CDAA	
2-chloroallyl-diethyl-dithiocarbamate	CDEC	
Pentachlorophenol	PCP	Two formulations tested

Present position and objects

Before discussing in detail the results of experiments using these materials, the present weed-control practice and the objects of experimentation should be stated.

In forest nurseries, seed is sown in beds and plants growing there may remain in the seedbed for one or two years. Seedbeds may be treated with weedkillers (a) just before sowing (pre-sowing) (b) just after sowing (post-sowing), (c) 3-4 days before seedlings emerge above the soil surface (pre-emergence) or (d) after emergence of seedlings (post-emergence). After plants have been lifted from the seedbeds, they are transplanted in rows (lined out). Weed-killers can be applied to transplant lines either completely over plants and weeds (overall application) or directed between the rows (inter-row applications).

Details of current recommendations are given in the B.W.C.C. Handbook (1). It will be seen that mineral oils are the only materials so far recommended: the alternative is removal of weeds by hand. In practice, pre-emergence applications of vaporising oil are almost always given to all seed-beds; post-emergence applications of white spirit are used only on a very limited scale, the difficulty being that during the 6 to 8 weeks after crop germination when it is unsafe to spray, weeds frequently get out of control and are too big to be killed by the time it becomes safe to apply white spirit. Mineral oils give satisfactory control of weeds in transplant lines. In Scotland, a certain amount of damage to small transplants has resulted from the use of vaporising oil and white spirit is preferred. In England, this trouble has not been serious and vaporising oil is used on a limited scale.

The objects of weed-control experimentation in forest nurseries are to find and develop in order of importance:

1. Materials which are selective in favour of conifer seedlings against a wide range of nursery weeds and which can be used to control weeds immediately after the seedling crop has emerged above the ground.

2. Pre-emergence weed-killers which are more economic or more persistent but at the same time more selective than vaporising oil.

3. Pre-sowing killers capable of killing weeds and weed seed but which are fairly quickly dispersed.

4. Transplant sprays selective against weeds in favour of conifers.

When testing a material, more importance is attached to its effect on the crop than its effect on any particular species of weed. The weed-controlling effect of the material is assessed by observing and recording the time required to remove by hand all weeds from a plot. Results obtained in this way have been very satisfactory, the only slight disadvantage being that weeding times from one nursery cannot strictly be compared with those from another because of differences in weed population. Information on weeds resistant to a given material is obtained by recording species remaining after treatment at the time of hand weeding.

Experimental results

1. Hormone weedkillers MCPB and 2,4-DB.

Previous work in forest nurseries has shown that MCPA and 2,4-D are of little value as weed-killers in forest nurseries primarily because they caused death or distortion of the seedling crop. They were also unable to control grasses, in particular *Poa annua.* Wain's work demonstrating the greater selectivity of the butyric homologues of hormone weed-killers (2) revived our interest for, if conifers could be shown to tolerate the butyric homologues, they would find a place in nurseries where broad-leaved weed species were present in quantity.

An experiment was carried out at Yateley nursery, Bramshill in which MCPB and 2,4-DB were each applied at 0.5, 1, 2, and 4 lb/ac (a) at intervals of 3 weeks commencing 3 weeks after germination had begun or (b) as a single application 3 weeks after germination had begun. The effect of each material on numbers and heights of seedlings of Corsican pine and Douglas fir measured at the end of the growing season is given in Table 1 below. In addition to the reductions in numbers, the stems of surviving Corsican pine seedlings were appreciably thickened even on plots receiving a single application of hormone at the lighter rates. Seedlings of Douglas fir were more tolerant but nevertheless showed signs of distortion and swelling on plots given repeated applications of hormone at the heavier rates.

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Table 1

	Corsican pine						Douglas fir			
	single application			repeated application			single application		repeated application	
	No./sq.yd.		Height in.	No./sq.yd.		Height in.	No./sq. yd.	Height in.	No./sq. yd.	Height in.
		Trans-formed			Trans-formed					
MCPB 0.5 lb	403	2.05	0.86	332	1.97	0.86	104	3.64	112	3.31
1 "	269	1.88	0.88	79	1.35	0.78	89	2.72	96	2.84
2 "	204	1.76	0.80	8	0.50	-	97	3.07	86	2.95
4 "	73	1.33	0.80	0	0.00	-	85	2.72	80	2.25
2,4-DB 0.5 lb	413	2.06	0.87	213	1.78	0.79	82	2.71	84	3.07
1 "	332	1.97	0.87	6	0.43	-	89	2.79	68	2.68
2 "	185	1.72	0.79	2	0.16	-	71	2.72	53	1.97
4 "	87	1.40	0.78	0	0.00	-	76	2.60	55	1.90
White spirits A	x	x	x	493	2.14	0.88	x	x	82	2.39
B	x	x	x	450	2.10	0.91	x	x	97	2.86
Difference for	5%	0.31	0.11		0.31	0.11	43.6	0.68	43.6	0.68
Significance	1%	0.42	0.14		0.42	0.14	58.5	0.91	58.5	0.91

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2. CDAA and CDEC.

An experiment was carried out at Yateley nursery, Bramshill in which each material was applied as a spray at rates of 4, 8 and 12 lb/ac active ingredient in 60 gal/ac water to seedbeds sown with seed of Sitka spruce, Corsican pine, Japanese larch, *Tsuga heterophylla* and *Thuja plicata*. Seed of the last two species germinated badly and little can be said about their reaction to either material. Treatments were applied (i) three days before sowing.

(ii) three - four days before the estimated date of emergence of the earliest germinating species.

(iii) Pre-emergence application as in (ii) plus a post-emergence application ten weeks later.

Assessments at the end of the growing season showed that both seedling numbers and heights of Japanese larch and Sitka spruce were significantly reduced by almost all applications of CDAA, the only treatment which had no significant or appreciable effect being the lightest rate applied before sowing. Corsican pine tolerated CDAA better and seedling heights were not affected. Seedling numbers were, however, significantly lower on treated plots than on those which received vaporising oil.

CDEC had a less damaging effect on seedlings of all three species - only the pre- and post-emergence application (iii above) significantly reduced numbers and heights of Japanese larch and Sitka spruce seedlings; however, the reduction both in numbers and heights of seedlings in the other treatments was appreciable. Corsican pine seedlings were not significantly affected by any treatment with CDEC.

CDAA applied before sowing controlled weeds (chiefly *Poa annua* and *Spergula arvensis*) as well as or better than a pre-emergence application of vaporising oil. However, pre- or post-emergence applications failed to control weeds as well as pre-emergence vaporising oil. No treatment with CDEC controlled weeds as well as vaporising oil, the nearest being those applied before sowing. The only explanation which can be put forward to account for the better control of weeds with pre-sowing sprays is that such sprays were applied to the soil surface whereas the pre- and post-emergence applications were applied to the surface of the grit chippings used to cover the seed after sowing. This grit, a 0.25 in. washed gravel, is applied to form a layer 0.18 - 0.25 in. thick; it is possible that the grit would form a layer protecting germinating weed and weed seed and would be a better surface from which the materials could evaporate. Weather conditions and soil temperature and moisture were similar at the time of application of all treatments.

Current experiments with both materials have been restricted to pre-sowing applications either 10 or 3 days before sowing at rates similar to those used in 1955. Cultivation following application was introduced as an additional factor. Visual assessment (Sept. 1956) supports the view that CDAA is the more toxic material both to weeds and plants. The seedling crop does not appear damaged by lower rates of CDAA nor by low and medium rates of CDEC. Both materials have damaged seedlings more in a nursery with a sandy loam soil, pH about 6.5 than in an acid, sandy nursery, damage being very slightly less where applications were made 10 days before sowing than those made 3 days before sowing. Cultivation following application has substantially increased the damage caused by both materials to the seedling crop.

3. PCP

Pentachlorophenol has been in use as a weed-killer for a far longer period than the materials just mentioned. It has been included in a number of experiments all of which have given similar results, namely, that rates of PCP necessary to give adequate control of weeds reduce the yield of conifer seedlings too much to permit the material to be used in forest nurseries. Damage occurs at the time of germination and height growth of seedlings surviving treatment is seldom significantly lower than that of seedlings in control treatments. Table 2 gives the results of an experiment carried out at Ampthill nursery in 1955. PCP was applied in two proprietary formulations, one 'Sprex' (S) manufactured by Shell Chemicals Ltd., and one R.D.4194 (M) manufactured by Monsanto Chemicals Ltd. In each case, the amount of active ingredient is given. The material was applied by spray in water to seedbeds. Sitka spruce seed was sown.

It will be seen from Table 2 that the experiment strongly supported the general conclusion reached concerning the effect of PCP in forest nurseries. It will also be seen that vaporising oil (2) (a new oil then under test) at 80 gal/ac, i.e., 20 gal/ac more than the rate currently recommended, gave the best weed control of all treatments and left the crop undamaged. It will also be noted that formulation substantially influences the effectiveness of PCP, the Shell formulation being less phytotoxic than that of Monsanto.

References

(1) BRITISH WEED CONTROL COUNCIL (1957). Weed control handbook, 55-57.

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Table 2

Treatment	Rate per Acre	Date Applied	Seedling Numbers		Seedling Heights in.	Weeding Times Mins. per sq. yd	
				Trans-formed			Trans-formed
Control V.O. (1)	60 gal	3	1103	17.5	0.85	3.5	0.54
V.O. (2)	40 gal	3	984	16.5	0.74	9.9	1.00
"	60 "	3	945	16.2	0.85	4.2	0.62
"	80 "	3	1166	18.0	0.84	1.7	0.23
PCP (S)	2 lb	1	977	16.5	0.82	18.7	1.27
"	" "	2	930	16.1	0.90	23.4	1.37
"	" "	3	895	15.8	0.74	10.9	1.04
PCP (S)	4 lb	1	1049	17.1	0.85	10.3	1.01
"	" "	2	518	12.0	0.73	17.5	1.24
"	" "	3	470	11.4	0.82	8.5	0.93
PCP (S)	6 lb	1	965	16.4	0.80	10.5	1.02
"	" "	2	501	11.8	0.69	14.1	1.15
"	" "	3	325	9.5	0.77	5.9	0.77
PCP (M)	1 lb	1	596	12.9	0.74	8.9	0.95
"	" "	2	679	13.7	0.83	8.9	0.95
"	" "	3	327	9.5	0.83	4.2	0.62
PCP (M)	2 lb	1	606	13.0	0.81	8.5	0.93
"	" "	2	462	11.3	0.75	4.7	0.67
"	" "	3	96	5.2	0.71	2.8	0.45
PCP (M)	3 lb	1	380	10.3	0.83	2.8	0.45
"	" "	2	165	6.8	0.67	2.2	0.35
"	" "	3	71	4.4	0.63	2.2	0.35
Differences for significance	5%			2.8	0.21		0.23
	1%			3.7	0.28		0.31

Date of Application 1 = 4 days before sowing (12.5.55.)
2 = 4 days after sowing (20.5.55.)
3 = 3-4 days before estimated date of seedling emergence (1.6.55.)

WEED CONTROL BY WHITE SPIRIT AND WHITE SPIRIT + TURPENTINE IN NORWEGIAN FOREST NURSERIES

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The Norwegian forest nurseries and contract growers delivered in 1956 95 million plants, 96% of which consist of Norway spruce and Scots pine. Under the existing shortage of manpower it would be inconceivable to raise the number of plants presupposed by the afforestation programme, without the use of chemical herbicides.

The trials in 1949 showed that oils with boiling range: 150-200°C, and a content of from 15 to 20% aromatic hydrocarbons, could be used as selective weed-killers. In addition to the special vaporising oils manufactured by British Petroleum, Esso, and Shell, white spirit, too, is obtainable on the Norwegian market. The last-mentioned oil is somewhat cheaper. In these trials the effect of white spirit equalled that of the approved vaporising oils.

The correct application of the sprays is of major importance if the best possible results are to be obtained. During the years 1950-1953 a total of 85 trials were carried out in 2/0, and older plants, in order to throw some light on a few of the factors that may affect the results. The aim of the trials was to find an answer to the following questions:

(1) Does white spirit become more effective against oil-resistant weeds, in particular Matricaria matricarioides, Senecio vulgaris, and Erysimum cheiranthoides, when fortified with sulphate turpentine.

(2) Do different times of spraying during the day influence the effectiveness of the treatment?

(3) Is there any connection between weather conditions and the effects of the oil sprays?

(4) Of what consequence is the stage of development on the results of spraying?

(5) To what extent is hand-weeding reduced by the use of vaporising oils?

During the years 1950-1951 47 trials were carried out with a number of preparations. During the next period (1952-1953) two sprays, white spirit and white spirit fortified with 10% sulphate turpentine, were selected. These sprays were applied at different times of the day, namely at 7 and 12 a.m. (1 p.m. in 1953), and at 7 p.m. During 1952-1953 38 trials were carried out. Not all of these trials, however, were sufficiently complete during this period, or the first, to be included in all the summaries.

The trials were carried out on plots arranged in rows, with 2 replications for each treatment. Plot size was 2 sq.m. The sprays were applied with a syringe. Rate of application was 1000 litres per hectare. The stage of development of the dominant weed species was recorded. In addition the weather conditions on the day of application and on the following two days were noted.

The effects on weeds and conifer plants were investigated about one week after treatment, by counting the number of plants, or by weighing, within ½ sq.m.

on each plot. The time required for hand-weeding the rest of the plots was recorded. The burning of the conifer plants was graded roughly.

Although the trials were laid out according to a simple design, and the spraying was effected by simple equipment, the analyses of variance shows that the experimental data permit some conclusions to be drawn.

1. Addition of turpentine increases the effects.

The numerical results are shown in Table 1.

TABLE 1

Average for all trials 1950-1953 sprayed with white spirit and white spirit + 10% turpentine, at 1000 litres per hectare

	No. of trials	Control Pl/m² (g/m²)	Percent. Survival	
			White spirit	White spirit + 10% turpentine
			Untreated control = 100	
Poa annua	43	114	11	16
Capsella bursa-pastoris	24	65	19	17
Spergula arvensis	20	242	11	7
Stellaria media	19	(53)	3	1
Chenopodium album	19	75	13	12
Matricaria matricarioides	13	364	115	47
Sagina procumbens	13	50	20	9
Juncus bufonius	12	88	7	7
Erysimum cheiranthoides	12	61	56	34
Rumex acetosella	12	51	10	8
Polygonum spp.	9	77	4	3
Gnaphalium uliginosum	8	122	27	24
Galeopsis spp.	8	37	1	2
Viola spp.	6	20	24	14
Veronica officinalis	5	53	48	9
Equisetum spp.	4	39	17	9
Gramineae spp.	3	842	55	52
Senecio vulgaris	3	108	139	30
Stachys palustris	3	104	90	67
Rorippa silvestris	3	16	5	0
Arenaria serpyllifolia	2	462	1	1
Puccinella maritima	2	200	61	18
Puccinella distans	2	65	25	26
Cardamine flexuosa	1	112	15	25
Veronica serpyllifolia	1	46	10	19
Trifolium repens	1	30	16	11
Fumaria spp.	1	26	0	0
Hepaticae spp.	1	20	27	10
Hand weeding, man-hours per hectare	75	1867	752	654
Hand weeding, relative figures		100	40	35

A number of weed species are quite easily killed by applications of white spirit alone. For these species, nothing is gained by adding 10% turpentine to the spray. With the species fairly resistant to white spirit, however, the addition of turpentine improved the results considerably. This was particularly true of the species Senecio vulgaris, Màtricaria matricarioides, Stachys palustris, Erysimum cheiranthoides, and Veronica officinalis. For Matricaria matricarioides and Erysimum cheiranthoides the results were significant. The other species occurred in too few experiments to enable an analysis of this sort.

It will be seen, however, from the time required for hand-weeding, that white spirit fortified with turpentine generally was of more effect than white spirit alone. The time saved in addition was 100 man-hours per hectare.

The control of weeds is not the only factor of importance in this case, however. It is to be expected that the use of turpentine will increase the risk of injury to the plants. This is indicated by the experimental data. The damage caused by both sprays to seedlings of Norway spruce was catastrophic. The 2 to 4 year old spruce plants, however, were not severely injured by spraying, except when they had young, succulent sprouts. The percentage of spruce plants killed, however, increased in only 3 out of the 35 trials after which 10% sulphate turpentine had been added to white spirit. In a trial with 2 year plants of Scots pine the injury caused by white spirit alone was hardly noticeable, whereas a comparatively severe burning resulted from the application of white spirit fortified with turpentine.

2. Time of application during the day may influence the results

Spraying at different times of the day gave relatively small and varying differences in weed kill. The results varied also widely from trial to trial. The weighted mean for all species showed the lowest weed kill after applications at noon, and the highest after sprayings in the evening, the difference, however, was slight. Spraying at noon gave particularly low effect against Erysimum cheiranthoides. The influence of the time of spraying was significant for this weed. ($P < 0.05$).

The time required for hand-weeding of untreated and treated plots affords a good measure of the total effects of different treatments. Table 3 shows the figures obtained for hand-weeding, and for the effects on the weed after applications at different times of the day. We were unable to show any significant difference in the time required for hand-weeding after sprayings at different times of the day, when all sites were included, irrespective of the weather.

In three of the trials the damage from burning was most severe when the spraying had been performed in the middle of the day; for the rest, however, wide and accidental variations occurred from one time of application to another, within the different fields. It was then natural to compare the results with the notes on the weather conditions, and the condition of the plants, wet or dry, during spraying.

3. Weather conditions may prove more important than time of application during the day.

There seems to be reason for supposing that the conditions influencing the evaporation may affect the degree of burning. The present material is too small to yield any clear experimental evidence of this. Since the most severe damage, however, arose in fields where the sprays had been applied to plants wet with rain, and at especially high temperatures (about 25°C), we have to advise against the application of sprays under such conditions.

TABLE 2

Effect on Norway spruce and Scots pine of oil sprays applied at different times of the day, at 1000 litres per hectare

Tree species and age classes	No. of trials	Needles showing damage, %					
		White spirit			White spirit + 10% turpentine		
		Morning	Noon	Evening	Morning	Noon	Evening
1st application							
1 year Norway spruce	1	100	100	100	100	100	100
2 year Norway spruce	1	2,5	4,0	2,5	6,5	8,0	7,5
"	1	0,2	0,3	0,2	0,2	0,1	0,2
"	1	+	+	+	+	+	+
"	5	0	0	0	0	0	0
3 year Norway spruce	1	10	18	0	14	20	7,5
"	1	2	1,5	0	2,5	0,5	0
"	1	0	0	3,5	0	0	65
"	1	+	+	0,8	4	3	7
"	1	0	0	5	5	5	28
"	1	0	0	0	5	10	5
"	1	0	+	0	5	5	+
"	1	0	0	0	+	0	0
"	3	0	0	0	0	0	0
4 year Norway spruce	1	10	0	0	10	50	5
"	1	+	+	0	0	+	+
"	2	0	0	0	0	0	0
2 year Scots pine	1	+	+	+	12	7,5	8
2nd application							
3 year Norway spruce	1	0	0	+	11	15	15
"	2	0	0	0	0	0	0
4 year Norway spruce	1	0	0	0	0	0	0
		Trees killed by treatment, %					
1st application							
1 year Norway spruce	1	29	50	30	33	40	41
2 year Norway spruce	8	0	0	0	0	0	0
3 year Norway spruce	1	0	0	3,1	3,2	3,1	11,4
"	1	0	0	1,0	0	0	5,2
"	1	0	0	0,9	0	0	2,5
"	9	0	0	0	0	0	0
4 year Norway spruce	1	1,8	0	0	0	0	0
"	4	0	0	0	0	0	0
2 year Scots pine	1	0	0	0	0	0	0
2nd application							
3 year Norway spruce	4	0	0	0	0	0	0
"	3	0	0	0	0	0	0
2 year Scots pine	1	0	0	0	0	0	0

TABLE 3

Effect on weeds of oil sprays applied at different times of the day

	No. of trials	Untreated control	Percent. Survival					
			White spirit			White spirit + 10% turpentine		
			Morning	Noon	Evening	Morning	Noon	Evening
Hand-weeding, min. per sq.m.	34	14,9	6,7	6,6	6,3	5,6	5,7	5,5
	34	100	45	44	42	38	38	37
Weed species		pl/m² (g/m²)	Untreated control = 100					
Poa annua	15	142	25	25	21	16	21	15
Spergula arvensis	9	(353)	15	8	12	8	5	15
Matricaria matricarioides	6	627	63	65	60	38	41	39
Erysimum cheiranthoides	6	69	49	83	53	37	44	24
Sagina procumbens	6	60	38	20	17	19	15	9
Juncus bufonius	5	154	5	5	2	6	2	0
Capsella bursa-pastoris	4	73	8	13	17	8	7	13
Chenopodium album	4	104	1	2	1	0	1	2
Stellaria media	4	(82)	0	0	0	0	0	0
Viola spp.	4	23	41	38	27	13	31	18
Gnaphalium uliginosum	3	246	6	3	9	1	10	5
Galeopsis spp.	3	55	3	4	1	1	+	0
Stachys palustris	3	105	65	104	101	74	59	69
Rumex acetosella	2	62	3	6	8	13	7	2
Polygonum spp.	2	46	0	1	0	0	0	0
Senecio vulgaris	1	230	30	31	68	36	7	91
Veronica serpyllifolia	1	46	11	18	2	10	19	12
Trifolium repens	1	30	21	5	9	16	11	0
Unweighted mean	-	-	21,3	23,8	22,1	16,4	15,6	17,4
Weighted mean	79	-	24,4	26,3	22,5	16,5	17,5	15,9

The figures for hand-weeding varied widely from field to field. The reason of this is likely to be found in the variation in weed population, the density of the weeds, and their stage of development. In addition, the growth conditions particularly the weather conditions before, during, and immediately after the spraying, are of great consequence in determining the susceptibility of the weed species to herbicides.

In order to obtain some orientation on these questions, the trials were classified into the following groups:

I. Bright throughout the day of spraying.

II. More or less cloudy but no rain on the day of application.

III. More or less rain during the day of application.

The relative figures for hand-weeding are given below:

Untreated control = 100

	No. of trials	White spirit	White spirit + turpentine
I. Bright and warm	21	39	33
II. Cloudy	32	37	31
III. Rain	22	45	44

There is thus a distinct tendency towards the effect of spraying being lower in rainy weather than in fine weather. The greatest reduction in toxicity occurred in the white spirit + turpentine treatment, but the total effect was not inferior to that of white spirit alone.

In bright weather, time of application during the day is very important

By grouping the sites according to weather at the time of application, we found significantly lower effects of sprays applied in the middle of the day in bright weather. In cloudy, dry weather, or rain, the differences were doubtful.

In Table 4 are presented the results of the analyses of variance.

4. The stage of development is the most important factor.

The importance of controlling the weeds before they have developed too far, has always been insisted upon. A grouping of the data on the hand-weeding time according to the stage of development of the weeds on the day of spraying, however, was difficult, owing to the fact that generally several weed species, that had germinated at different times of the year, occurred within the same field. In this respect there is a distinct difference between annual and biennial weeds. The latter may germinate in autumn, and continue their growth in spring. In beds of two to four year old conifer plants, we, therefore, generally find a mixture of weeds germinating in spring and autumn.

In grouping the trials according to the stage of development of the weeds, most weight was put on species germinating in the spring. The trials were classified into the following groups:

A. Cotyledon stage - 4 true leaves.
B. 6 true leaves - flowering

TABLE 4

Analysis of variance of experimental data. F - values
* = P < 0,05, ** = P < 0,01, *** = P < 0,001

	No. of trials	Direct effects: Different fields	Different sprays	Different times of spr.	Interaction: Fields x sprays	Fields x times of spr.	Sprays x times of spr.
Hand-weeding time							
All trials	34	245***	41,28***	1,83	2,64***	4,06***	< 1
I. Bright	11	60,45***	24,55***	5,45*	2,18	4,73***	< 1
II. Cloudy	12	190,0***	20,33***	1,63	4,28**	2,66*	< 1
III. Rain	11	599***	2,22	3,33	< 1	5,44***	2,22
Weed species							
Poa annua	15	20,25***	6,36*	1,03	1,20	2,82**	< 1
Spergula arvensis	9	10,52***	1,73	3,78*	2,27	4,74**	1,83
Matricaria matricaroides	6	10,34**	35,45***	< 1	< 1	1,50	< 1
Erysimum cheiranthoides	6	9,41**	13,61**	4,25*	1,45	1,60	1,12
Sagina procumbens	6	4,45*	4,10	3,02	< 1	1,19	< 1
Capsella b-pastoris	4	64,30***	2,62	5,15*	7,61*	11,79**	1,54
Viola spp.	4	26,13***	7,37*	1,65	2,86	1,84	1,55

TABLE 5

Effect of oil sprays at different stages of development

Stage of development	No. of trials	Hand-weeding, man-hours per hectare: Untreated	White spirit	White spirit + turpentine
A. Cotyledon - 4 true leaves	24	127 7	38 3	30 7
B. 6 true leaves - flowering	51	215 0	92 7	81 8
$F \frac{1}{75}\left(\frac{\text{Variance between classes}}{\text{Inter class variance}}\right)$	-	4,99*	9,32**	8,51**

In these trials the weeding of the untreated plots required an additional 875 man-hours per hectare, if the weed had been allowed to develop more than 4 true leaves.

The amount of hand-weeding required for treated plots was also considerably greater when the spraying had been applied to large weeds than to small ones. The differences were 545 and 511, man-hours per hectare, respectively. The analysis of variance showed that the differences were significant ($P < 0.01$).

The results confirm wholly the old experience, that it pays to control the weeds by mechanical or chemical methods while they are small and weak.

Concerning the stage of development, it should also be remembered that conifer plants have a sensitive period with regard to vaporising oils, while their annual shoots are new and tender. In the fields where the plants had been injured, the records showed that the plants had been in the sensitive stage.

5. Chemical weed control saves a great amount of weeding.

The time required for hand-weeding the small plots can not be directly applied as an economic measure of the time saved by spraying as compared to weeding alone. Useful data can, nevertheless be obtained from the experimental data. The average for 75 trials, distributed all over the country during the years 1950-1953, for a single weeding of the untreated plots was 1867 man-hours per hectare (cf. Table 1). An application of 1000 litres of white spirit reduced the time of weeding by 60%, i.e. 1120 man-hours less than for untreated plots. A mixture of 900 litres of white spirit fortified with 100 litres of sulphate turpentine per hectare, reduced the amount of weeding by 65%, or about 1220 man-hours per hectare.

When the sprays are applied during the periods in which the plants are not injured, it is obviously good business to spray with vaporising oils against weeds in nursery beds of Norway spruce and Scots pine. If the weed population comprises oil-resistant species, 10% sulphate turpentine should be added. It should be kept in mind, however, that hand-weeding after treatment is required to keep the beds free from weeds, and to prevent the weed population from changing to resistant species.

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EXPERIMENTS ON THE CHEMICAL CONTROL OF RHODODENDRON PONTICUM

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Summary

The problem of *Rhododendron ponticum* as an obstacle to forestry operations is described, with a note on normal methods of clearance and control. An account is given of the results of experiments on chemical methods of control carried out by the Forestry Commission during the period 1949-55. A wide range of chemicals was applied at various stages of growth but no really efficient cheap treatment has been found. Chemical treatments have been tested on several growth stages, viz., seedlings, cut stumps of large bushes, coppice regrowth present 1-2 years after cutting large bushes, and basal bark treatment and over-all foliage spray of standing bushes. Chemicals applied include sodium chlorate, sodium arsenite, ammonium sulphamate, TCA (sodium), monuron, 2,4-D and 2.4,5-T, and recently 3 amino-triazole and 2,3,6-trichloro-benzoic acid (2,3,6-TBA).

Ammonium sulphamate to cut stumps or young regrowth was the only compound giving complete control. 2,4,5-T ester in oil considerably reduced vigour of regeneration applied at these stages, and proved effective for control of seedlings. Basal bark spraying and over-all foliage treatment of standing bushes proved unsatisfactory.

The rhododendron problem in forestry

Considerable areas of woodland and potential forest land are occupied by dense shrubberies of rhododendron which present most difficult clearance and land reclamation problems. *Rhododendron ponticum* was introduced in the mid 18th century, and since then has been extensively planted in gardens and on estates for roadside and amenity planting and in establishment of shrubberies for game covert. It has spread from these centres to cover large tracts of land particularly in the south and west of the country.

The plant is capable of vigorous growth on a wide range of soil conditions, but it is a calcifuge and thrives particularly on the more acid sites. It can grow on open ground but grows especially well under a light canopy of trees in open woodland where there is some degree of shade and shelter. Even under the most favourable conditions rhododendron is not a fast growing shrub, and rarely exceeds a height of 15 ft and is commonly much less. Abundant quantities of fertile seeds are produced but its most important method of reproduction and spread is by means of layering of lateral branches where they touch the ground. Established bushes can spread by this means so that individual shrubs merge with each other to form thickets. Its strong, bushy and evergreen habit of growth results in thickets which may be so dense as to be quite impenetrable in many areas. Root development is usually very extensive, but quite shallow, most of the feeding roots being located in the acid litter and humus layers accumulated beneath the plant. A well-established rhododendron thicket completely suppresses all other ground vegetation and effectively prevents any natural regeneration of tree species.

The large numbers of springy woody stems produced on each root system, the close inter-twining of stems and its dense habit of growth makes clearance difficult and costly. Several methods of initial clearance prior to planting a tree crop have been used and it is useful to consider these briefly before discussing chemical treatments. Clearance by hand cutting tools has been applied most commonly, but this is most laborious, and costs of cutting and burning of tops vary from £20 - £80/ac according to the nature of the growth and terrain. These costs can be reduced by partial clearance in the form of cleared spots or lanes in preparation for planting.

Mechanical methods of clearance can be employed on ground which is not too boggy or steep for tractors to operate, and costs can be reduced by this means. Winching out of whole bushes is effective but very costly, and generally a complete or partial clearance by means of tractor mounted cutting, bulldozing, or grubbing blades is most satisfactory and can reduce costs to one quarter to one half that of hand clearance. Humus and surface soil is thoroughly mixed by the blade and the tractor tread during these operations, and many stems and surface roots are bruised, severed, or pulled out completely, retarding the vigour of re-sprouting. Rhododendron cut to the ground soon produces many fresh sprouts from the cut stool and sucker shoots may also be produced from roots below ground. Coppice shoots on well rooted stools can be very vigorous, growing 1 to 2 ft/year for several years following cutting, also fragments of roots broken and buried in the course of mechanical clearance also seem capable of producing fresh shoots.

Tree planting would normally be done shortly after site clearance, but in the first few years of the plantation it will be necessary to cut back the rhododendron regrowth to prevent interference with the planted crop until the trees can suppress the regrowth. Whenever possible, present practice is to plant a heavy shade-casting species such as Tsuga, Abies, or Douglas fir, which, once canopy has been closed, may shade out and suppress rhododendron growth. However, these species establish themselves relatively slowly and regrowth of rhododendron requires cutting back by hand for several years after planting. Planting of species such as European larch or Scots pine can result in great difficulties later owing to dense rhododendron beneath the light canopy impeding access and tending operations.

This then is the problem from the forester's angle. In practice it is being overcome by hand or mechanical clearance methods, careful choice of planting species, and regular weeding of regrowth until the new crop can suppress the shrubs. However, costs are still high and it seems necessary to assess the possible use of chemical control methods to supplement hand and mechanical methods.

Experiments on the chemical control of rhododendron

In 1949, it was decided to carry out preliminary screening trials of a variety of possible chemical compounds and methods of application for control of rhododendron. The account which follows describes the results of these, and other experiments, carried out by the Forestry Commission between 1949 and 1955. The investigations have included trial applications at the following stages:

(a) Seedlings (2-4 years old).

(b) Foliage treatment of regrowth appearing on cut stumps within 1 - 2 years of cutting.

(c) Freshly cut stumps after clearance of large bushes.

(d) Basal bark treatment of large bushes.

(e) Over-all foliage spraying of large bushes.

Applications at stages (a) (b) and (c) are relatively easy. However, stages (d) and (e) are troublesome owing to difficulty of access with the spraying equipment, and considerable preparation in clearing tracks and access routes through standing thickets is necessary before applications can be made at these stages. Because of these difficulties it was appreciated from the start that chemical treatments are most likely to be of use to supplement other methods by:

(a) Prevention of regrowth from stumps and roots remaining after complete or partial clearance.

(b) Control of standing bushes by basal bark or foliage treatment after partial clearance.

Foliage spraying of large blocks of uncut thicket is not considered a practical proposition as it would involve aerial spraying or drift spraying from the ground. The limited acreages of solid blocks of rhododendron, and the danger of spray drift on to valuable crops mitigate against such methods for this species.

<u>Preliminary Experiments.</u> The first trials were carried out at Bramshill Forest, Hants., in 1949 to test a range of compounds applied to cut stumps and to young coppice regrowth following hand clearance of dense 10 ft high rhododendron. Cut stumps were treated in August, within 2 days of cutting, and regrowth was treated when 18 in. high on stumps cut one year beforehand. Treatments included MCPA (sodium), 2,4-D (sodium and amine), and 2,4,5-T (amine), at 3 lb/ac a.e. in water, 2,4-D (ethyl ester) at 3 lb and 18 lb/ac in water and kerosene, and 2,4,5-T (butyl) at 3 lb/ac in kerosene. All were applied as over-all sprays at 100 gal/ac. Inorganic salts tested were ammonium sulphamate at 250 lb/ac, sodium arsenite at 50 lb, and sodium chlorate at 200 lb, all applied in aqueous solution as over-all sprays at 200 gal/ac.

Assessment of cut stumps one year after treatment showed that none of the growth regulators had any persistent effect, with the exception of 2,4-D (ethyl) at 18 lb a.e. in water and 2,4,5-T (butyl) at 3 lb/ac a.e. in kerosene. In these treatments, regrowth was rather weak and deformed, but recovered rapidly in the second year. MCPA (sodium) and 2,4-D (sodium) had little effect, while 2,4-D (amine) and 2,4,5-T (amine) caused only a slight initial loss of vigour. Sodium arsenite had a negligible effect at the single rate tested, while sodium chlorate caused only a temporary check in the rate of re-sprouting. Ammonium sulphamate was the only fully successful treatment, and 250 lb/ac killed all stumps treated.

Foliage spraying one year old coppice shoots gave similar results. Ammonium sulphamate was the most effective compound, and only sporadic regrowth occurred from treated stools. Sodium chlorate and sodium arsenite killed back aerial shoots to ground level, but fresh sprouts were produced within a few months. 2,4-D and 2,4,5-T (esters) caused considerable malformation and death of sprayed shoots, but the effects did not extend into the stump as further regrowth was unaffected. The results of these first trials pointed to the necessity of further tests with ammonium sulphamate, and with a wider range of rates of the growth regulating compounds, particularly ester forms of 2,4,5-T.

Treatment of seedlings. In 1950, a series of small trials were made to assess the susceptibility of 2 - 4 year old seedling rhododendron to foliage spraying, as this could be quite a valuable technique for arresting the spread of the weed from established thickets. These tests showed 2,4-D (sodium) or 2,4,5-T (potassium) at rates of 3 - 12 lb a.e. in 100 gal/ac of water to be ineffective apart from initial shoot deformation. 2,4-D (ethyl) at 3 lb/a.e. in diesel oil at 100 gal/ac was much more effective, killing 50% of sprayed seedlings. Unfortunately, no higher rates of ester in oil formulations were tested in the 1950 trial, but further trials in 1951-2 indicated that ethyl 2,4-D at 5 lb (acid), or 2,4,5-T (ethyl butyl or butyl iso-butyl) at 5 lb a.e. in 100 gal of oil can give nearly 100% control of seedlings up to three years old. Ammonium sulphamate at rates exceeding 100 lb/ac also gave a high degree of control.

Foliage treatment of coppice regrowth. Following on the preliminary experiments in 1949-50 further trials were carried out on this stage at Wareham, and Ringwood Forests. All treatments were applied in August as foliage sprays to regrowth present on stumps cut in the previous autumn and winter. The results of visual scores of the vigour and health of coppice shoots and the percentage of stools killed, are summarized in Table 1.

Table 1

Rhododendron ponticum. The effects of summer foliage spraying of coppice shoots on stumps cut 6 to 8 months before treatment

(All treatments were applied in August when coppice shoots were 1.5 - 2 ft high).

Treatments (Sprays were applied to thoroughly wet the foliage. Rates 50 to 100 gal/ac fluid according to foliage density.)	average score (1 to 10)* of condition of shoots: 6 months after spray	average score (1 to 10)* of condition of shoots: 12 months after spray	% stools dead
Ammonium at 50 lb per 100 gal water	6	6	0
Sulphamate at 300 lb per 100 gal water	8	8	10
" " 550 " " " " "	10	10	95
" " 800 " " " " "	10	10	100
Sodium " 50 " " " " "	7	1	0
Arsenite " 100 " " " " "	8	2	0
" " 150 " " " " "	9	3	0
TCA " 25 " " " " "	5	1	0
(Sodium) " 50 " " " " "	8	1	0
" " 100 " " " " "	7	1	0
Sodium " 50 " " " " "	3	4	0
Chlorate " 300 " " " " "	6	6	0
" " 550 " " " " "	7	6	0
" " 800 " " " " "	7	6	0
Monuron " 2 " " " " "	2	2	0
(applied on " 10 " " " " "	4	4	0
and around 30 " " " " "	5	5	0
stumps at 100 gal/ac			
2,4-D 5 " (acid)" " (diesel oil)	4	3	0
(ethyl-butyl) 10 " " " " " "	6	4	0
40 " " " " " "	7	4	0
5 " " " " water	2	2	0
10 " " " " "	2	3	0
40 " " " " "	4	4	0
2,4,5-T 5 " " " " (diesel oil)	6	7	0
(ethyl-butyl) 10 " " " " " "	6	7	5
40 " " " " " "	8	8	5
5 " " " " water	2	4	0
10 " " " " "	4	5	0
40 " " " " "	6	7	5
Control - untreated	1	1	0

* Visual scores were taken independently on each replicate of each treatment. A scale of 1 to 10 was used to assess the general health and vigour of shoots. 1 = normal healthy; 10 = no shoots, stump apparently dead.

Ammonium sulphamate at rates exceeding 300 lb/100 gal of water was the only compound giving anywhere near a complete kill of stumps. Sodium arsenite and TCA (sodium) at the rates tested gave a high initial kill of shoots, but by the following summer further regrowth was almost back to normal. Similarly, with sodium chlorate, but regrowth was considerably reduced and weakened one year after treatment. Monuron applied as an over-all spray, on and around the coppicing stools was only slightly effective at rates up to 30 lb/ac. Trials of ethyl butyl esters of 2,4-D and 2,4,5-T at rates of up to 40 lb a.e./100 gal diesel oil and water gave disappointing results. Dilution in oil resulted in high initial kill of foliage and shoots compared with water dilutions, but no treatment gave a complete kill of stools. 2,4-D in water or oil gave poor results and caused only slight weakening of fresh regrowth following treatment. 2,4,5-T was more effective, and at the highest rates in oil or water caused considerable weakening of the stumps so that new shoots were reduced in vigour and number, about 5% of stumps being killed. No stumps were re-treated but this is considered worth testing, particularly in the case of 2,4,5-T.

The effects of the season of application of foliage sprays on coppice regrowth was not examined in these trials, but an experiment was laid down in late 1955 to examine this point for 2,4-D and 2,4,5-T treatments in oil and water. To date, there appears to be little difference between summer and winter spraying, judging by the rate and extent of death of foliage and shoots present at the time of spraying. As in the main trials, translocation into the roots appears to be limited and fresh coppice shoots are appearing on all treatments, including 2,4,5-T.

Surface treatment of freshly cut stumps. Following the first experiments in 1949 further trials have been carried out recently at Wareham forest to provide more extensive tests of rates of 2,4-D and 2,4,5-T in oil, ammonium sulphamate, and sodium chlorate. The area selected carried dense rhododendron thicket up to a height of 10-15 ft which was cut to within 6 in. of ground level in July, a few days prior to spraying. All treatments were applied using a knapsack sprayer to wet the surface of each stump to the point of run off. No other method of treatment appears practicable owing to the large number of stems on each stump. Results of assessments made one year after treatment are presented in Table 2.

Table 2

Rhododendron ponticum. The effects of summer spraying of freshly cut stumps

Treatments (Sprays applied to stump surfaces to point of runoff. Rates 25 to 50 gal/ac)	assessments 1 year following treatment	
	average score 1-10	% stools dead
Ammonium at 50 lb/100 gal water	5	0
Sulphamate at 300 lb/100 gal water	8	35
" " 550 " " "	10	95
" " 800 " " "	10	100
Sodium " 50 " " "	4	0
Chlorate " 300 " " "	6	0
" " 550 " " "	5	10
" " 800 " " "	8	30
2,4-D at 5 lb (acid) per 100 gal	2	0
(Ethyl-butyl) " 10 " " " diesel oil	2	0
" 20 " " " " "	2	0
" 40 " " " " "	2	0
2,4,5-T at 5 " " " " "	4	0
(Ethyl-butyl) " 10 " " " " "	5	0
" 20 " " " " "	8	5
" 40 " " " " "	8	10
Diesel oil	1	0
Control - untreated	1	0

These results are closely similar to those recorded for foliage spraying of coppice shoots. Ammonium sulphamate was the only compound to give a complete kill. Sodium chlorate was rather more effective to stumps than to coppice shoots, but even so only killed 30% of stools at the highest rate. 2,4,-D (ethyl butyl) at rates up to 40 lb a.e./100 gal of oil was almost completely ineffective. 2,4,5-T was more effective and although regrowth was considerably retarded, killed a maximum of only 10% of stools. Diesel oil alone had no appreciable effect on regeneration of the stools. A subsidiary trial of illuminating kerosene as a diluent for 2,4-D and 2,4,5-T showed it to be no more effective than diesel oil for this purpose. In 1955, two untried compounds, 3-amino triazole and 2,3,6-trichlorobenzoic acid at rates up to 20 lb/100 gal of diluent were tested as cut stump treatments. Neither compound was fatal to stumps, but the highest rate of 2,3,6-TBA in diesel oil caused a slight reduction in the vigour of regenerating shoots.

Basal bark treatments of standing growth. As mentioned in the introduction a successful kill at this stage could provide a useful technique for controlling the rate at which cleared spots or lanes close over. The first experiments were done in 1955 on well established rhododendron thickets and included trials of ethyl-butyl, 2,4-D and 2,4,5-T and 2,3,6-TBA. Applications were made in diesel oil, using a knapsack sprayer to wet the bark at the base of the standing growth to the point of run off from a height of 18 in. to ground level. The results of treatments applied in July or October 1955 have been disappointing. 3-amino triazole in water and 2,3,6-TBA in oil at rates of 5, 10, and 20 lb/100 gal of diluent were completely ineffective apart from slight discolouration of foliage. 2,4-D (ethyl butyl) in diesel oil at rates of 40 lb a.e./100 gal showed nil effects other than a mottling and slight deformation of foliage. 2,4,5-T (ethyl) gave very variable results but was more effective than any other treatment. However, one year after treatment it is clear that no compound has killed shoots or buds. Many of the stems sprayed with 2,4-D and 2,4,5-T showing profuse growth of epicormic shoots along the whole length of the stems.

Foliage spraying of standing bushes. This has never been considered practical for large bushes owing to the difficulty in application, consequently no proper experiments have been carried out. Simple tests of over-all spraying of individual relatively small bushes, accessible with a long spray lance from the ground, indicate that 2,4,5-T is more effective than 2,4-D, but whether applied in oil or water, translocation appears to be limited. A large proportion of foliage and new shoots can be killed but woody shoots are unaffected and recover rapidly by production of new buds.

Miscellaneous. Knowledge of the calcifuge habit of rhododendron prompted trial of heavy liming following thicket clearance. Lime was applied to a cut over area in summer 1954 as ground limestone at rates up to 30 tons/ac. Observations on these plots 2 years following treatment show no significant effect from any rate.

Conclusions

Well established rhododendron is clearly a most difficult subject to kill by external application of chemicals. Basal bark spraying and over-all foliage spraying of standing growth has given poor results, and generally treatment of seedlings, or freshly cut or coppicing stumps appears more practical. For obvious practical reasons the forester is most interested in a treatment to kill and prevent all further regeneration from treated plants. So far ammonium sulphamate applied to cut stumps or coppice shoots at rates exceeding 5 lb/gal, is the only compound to fulfill this requirement. For cut stump treatments as described, 25-50 gal/ac fluid are needed, requiring 125-250 lb/ac of the salt for full control. Unfortunately at present, ammonium sulphamate is relatively expensive, which limits the extent of practical application of this treatment.

Sodium chlorate, sodium arsenite, TCA, and monuron have proved disappointing for treatment of coppicing or freshly cut stumps. 2,4-D has also given poor results at these stages but 2,4,5-T although killing few stumps, has seriously weakened subsequent regrowth at rates of 20 lb/100 gal and over. It seems likely that a repeat spraying at a lower rate, about one year after the initial treatment, will be effective but this has not yet been tested. 2,3,6-TBA and 3-amino triazole have proved almost completely ineffective applied as stump or basal bark treatments. Similarly heavy liming has been ineffective in preventing vigorous weed growth.

Unfortunately none of the methods tested indicate any way in which chemicals may be utilized to assist in the initial clearance of rhododendron thickets. However, compounds such as ammonium sulphamate and 2,4,5-T could be valuable in reducing regeneration following clearance thereby reducing labour and costs of subsequent weeding operations.

Chemical Weed Control in Norwegian Ornamental Nurseries

by

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Introduction

Weed control in nurseries usually constitutes the largest individual cost item. If the weeds are to be controlled by mechanical methods, the result will very often be a highly disadvantageous distribution of the work. In spring the demand for labour is very high, as the delivery of plants and weed control start simultaneously. Moreover manpower is expensive and difficult to obtain in Norway at the present time.

The possibility of controlling weeds by chemical methods has, therefore, aroused considerable interest.

Trials have been carried out in the nurseries at the Agricultural College of Norway since 1941. However chemicals that seem to afford possibilities of an effective control of germinating weed seeds, have only appeared in recent years. Trials have been conducted in first-year seedbeds, as well as in older nursery stocks. The trials in the first-year seedbeds, however, are still in a preliminary stage and therefore are not included in this report.

Trials in 1954

In 1954 ten trials were carried out in ten older nursery stocks. The aim of the trials was partly to compare the effects of different chemicals, and partly to determine the importance of the rate of application.

In the trials with different chemicals the sprays were applied on June 6, and the trial comprised the following species, and age classes: *Syringa reflexa* 2/0, *Buxus sempervirens* 2/2, *Sorbus intermedia* 2/0, *Acer ginnala* 2/0, *Rosa rugosa* 2/0, and *Berberis thunbergii* 2/0. The height of the plants varied from 15 to 40 cm. The nursery is situated on a terminal moraine, so that the soil consists of clayey sand with an intermixture of humus in the topsoil. Two to three days prior to spraying, the fields were cleared of established weeds.

Type of chemical and rate of application will be seen from Table 1.

The plot size ranged from 0.75 to 1.30 sq.m, because of the variations in the spacing of the rows. Number of replications was 3. Spray volume was 1,000 litres per hectare for all herbicides.

The nursery stocks were in full leaf at time of spraying, and no precautions were taken to prevent the sprays from falling on the plants. During spraying and the days immediately following, the weather was fine and warm. The first rainfall occurred on June 8, 3½ days after spraying.

The effect of the herbicides were assessed by counts of number of weeds, and by weighing the individual weeds within a 1/16 sq.m quadrat on each plot, on July 9. The results are presented in Tab. 1. The effects of the

Table 1. Preliminary experiments in established stocks. Effect on weeds.

Species	No. of trials	Untreated	NPA 7 kg/ha	2,4-DES 7 kg/ha	MCPES 7 kg/ha	CMU 4 kg/ha
			Weeds as % of control 5 weeks after spraying			
		No/sq.m				
Poa annua	6	272	39	92	53	4xx
Taraxacum sp.	3	336	41	31	22	-
Senécio vulgaris	3	85	2	+	3	0x
Matricaria matricarioides	2	224	28	26	1	0x
Viola tricolor + V. arvensis	1	77	65	0	0	-
Gnaphalium uliginosum	1	69	47	41	16	0x
Other species	4	208	18	22	7	0xx
All species	4	-	30	41	22	1xx
		g/sq.m				
Stellaria media	3	142	8	39	6	0xx
Gnaphalium uliginosum	1	96	71	23	6	0x
Matricaria matricarioides	2	98	+	+	+	0
Senécio vulgaris	3	26	+	0	8	0
Taraxacum sp.	3	18	+	+	+	-
Poa annua	6	16	17	22	27	+
Viola tricolor + V. arvensis	1	2	+	0	0	-
Other species	4	61	32	28	28	0xx
All species	4	-	14	17	16	0xx

x1 trial. xx 2 trials.

herbicides on the nursery stocks were checked on September 16. CMU caused considerable injury. The other chemicals had no visible influence on the growth and vigour of the nursery stocks.

Trials with increasing volumes of preparations.

On June 19 trials were laid out in the following nursery stocks: *Spiraea arguta*, *S. vanhouttei*, *Cotoneaster lucida*, *Mahonia aquifolium*. The first 3 nursery stocks were transplanted in the spring of 1954. All the plants were from 15 to 20 cm in height.

Type of chemical and rate of application will be seen from Table 2.

Table 2. Experiments with different rates of weedkillers in established stocks.

	No. of trials	Untreated	2,4-DES 5 kg/ha	2,4-DES 10 kg/ha	MCPES 5 kg/ha	MCPES 10 kg/ha
			Weeds as % of control 5 weeks after spraying			
		Plants/sq.m				
Poa annua	3	144	96	59	111	72
Matricaria matricarioides	2	176	36	23	35	47
Other species	3	86	41	30	24	31
All species	3	-	60	39	59	50
		g/sq.m				
Stellaria media	3	256	159	62	85	37
Poa annua	3	76	140	50	140	106
Matricaria matricarioides	2	928	15	0,2	10	2
Other species	3	352	37	12	35	30
All species	3	-	94	34	73	48

Three replications were used, and the plot size was 1.5 sq.m. The spray volume was 1000 litres per hectare. During the spraying the weather was cloudy with light rain.

The effects of the herbicides were assessed on August 21, by counting and weighing the different weeds within a 1/16 sq.m quadrat per plot. The results are presented in Table 2.

No results were obtained for the weeds in *Mahonia aquifolium*, as this trial was weeded by mistake. No injuries to the nursery stocks were observable on September 16.

Trials 1955/56

On September 3, 1955, trials were laid out in the following 13 nursery stocks. (Age classes are given in brackets): Rosa rugosa (1/0), Spiraea japonica (0/1/1), Cornus alba (0/1/1), Spiraea margaritae (0/1/1), Forsythia intermedia (0/1/1), Berberis ottawensis "superba" (0/1/1), Kolkwitzia amabilis (0/1/1), Viburnum roseum (0/1/1), Philadelphus (0/1/1), Cotoneaster lucida (2/2), Picea abies (2/2), Spiraea vanhouttei (0/1/1).

There had been a long drought earlier in the summer, and the soil had been prepared, so that the fields contained no established weeds. The night prior to spraying the precipitation was 27 mm. It was, therefore, thought likely that weeds would emerge anew.

The sprays were applied by means of a knapsack sprayer equipped with a spraying boom, covering 1.5 m. The spray volume was 500 litres per hectare. No precautionary measures were taken to prevent the spray from falling on the leaves of the nursery stocks.

The size of the treated plots varied somewhat from field to field, according to the space available. The smallest plots were 3.5 sq.m, and the largest 11.2 sq.m (see tables).

The number of replications in the fields varied from four to nine. Two fields, comprised several nursery stocks, which resulted in the number of replications being reduced to two and three.

The chemicals and the rate of application employed are given in Tables 3-9. The aim of the trials was partly to compare different chemicals, and partly to compare different rates of application.

The first precipitation worth mentioning (4.1 mm) came six days after the spraying. After that there was moderate precipitation, enabling the soil to keep its moisture, without the herbicides being washed out. The temperature a 1 p.m. varied from 12 to 23°C during the first month following the application. Winter frosts were normal and there was snow up to the last days of April, 1956. There was no precipitation worth mentioning in spring, leaching can, therefore, be discounted.

The effects on the weeds was assessed on October 22, by counts of all plants growing in an area of 1/16 sq.m, in two places within each treated plot. In spring, on May 25-26, the effects were remeasured by a rough grading of the degree in which the weeds covered the treated plots. In addition, possible injuries to the nursery stocks were graded on the same day. These results have been tabulated (Tables 3-10).

The effects on the nursery stocks.

The injuries that CMU caused to the nursery stocks were of such a severe nature, that we found no reason for continuing the trials with this herbicide. The other preparations tested (NPA, 2,4-DES, MCPES, propham and CIPC) never caused any permanent, severe injuries. The application of CIPC resulted in some burning, however. The data obtained at the time of assessment in May, 1956, will be seen from Tables 3-9. In the summer following the treatment, on the plots treated with NPA and 2,4-DES, we observed concrescences of the leaves in Philadelphus, so that they formed funnels. During the autumn, however, the plants grew normally. The field laid out in 1955 was assessed for the last time on August 7, 1956. CIPC seemed to have injured Kolkwitzia; otherwise, there was no sign of any injuries caused by spraying.

Effects on weeds

CMU had decidedly the best effect on the weeds. At equal rates of application, the effects of MCPES were somewhat superior to those of 2,4-DES, specially on Stellaria media. We had, unfortunately, no MCPES at our disposal when laying out the trials in 1955, and were, therefore, unable to throw more light on this question. 2,4-DES proved especially effective against Capsella bursa-pastoris, Draba verna, Senécio vulgaris, Matricaria sp., and Myosurus minimus. However, they had little effect on Poa annua and Stellaria media.

NPA has proved particularly effective against Capsella bursa-pastoris, Myosurus minimus, Draba verna, and Senécio vulgaris. At the highest rates of application it was also very effective against Stellaria media. The effect on Poa annua was not very good at the first assessment following application, but in the course of the spring of the next year it too, was killed, and the NPA plots were for some time quite free from weeds.

CIPC and propham had practically the same selectivity, but CIPC gave the best eradication of the weeds. The good effect of these herbicides against Poa annua and Stellaria media should be emphasized. Their effect on Matricaria sp. and Senécio vulgaris, on the other hand, was slight.

Discussion

CMU seems to involve too great a risk to be used in nurseries. It may cause severe injuries to the nursery stocks.

The spray of CIPC may burn the nursery stocks. There are also indications that it may influence the subsequent growth of the nursery stocks. The rate of application is certainly a factor that should be investigated more closely for this herbicide.

NPA, 2,4-DES, MCPES, and propham seem to be of considerable importance as selective herbicides in older nursery stocks. The selectivity differs somewhat, as will be seen from the tables, but in these trials there have been no annual or biennial weeds that have not been killed by at least one of the herbicides. No herbicide, however, has killed all the weed species. It seems, therefore, logical to test mixtures of, e.g. 2,4-DES and CIPC, NPA + propham, and so forth. In trials, still running, I have tested such mixtures, with excellent results. Thus, applications of 2.5 kg of 2,4-DES + 2.5 kg of CIPC per hectare have been most effective.

In employing these herbicides it is very important that the spraying is performed directly after all the established weeds have been removed. These herbicides are only effective against germinating weed seeds. If the weeds have developed too far, little effect can be expected. Nor can a good effect be expected against weeds that regenerate from underground vegetative organs.

It is also very likely that the type of soil, and the moisture conditions are factors of great consequence. To attain the desired effect there should be suitable moisture conditions for germination. . Also, there should be no leaching.

These trials, carried out in one nursery only, cannot be said to have resolved the problems involved in the use of selective herbicides against weeds in older nursery stocks. They have, however, given results, which are sufficiently promising to justify the hope of a rational and labour-saving weed control method for nurseries. Practical weed control in the future will never depend solely on the use of chemicals. Cultivation will always be needed to maintain the soil structure, to control perennial weeds, and to remove the weeds that have survived the herbicidal spray. Mechanical and chemical weed control combined, will perhaps prove the most economic solution in the future.

Table 3. Trial in Rosa rugosa, Sprayed 3rd September 1955.
Plot size: 9,0 sq.m. No. of replication: 5.

	Untreated No./sq.m	2,4-DES 10 kg per ha	NPA 10 kg per ha	propham 10 kg per ha	CIPC 10 kg per ha
		Relative fig. Control = 100			
The weeds counted October 22, 1955:					
Draba verna	707	+	1	91	0
Poa annua	518	37	57	3	0
Myosurus minimus	461	0	0	0	0
Stellaria media	1118	6	2	1	0
Senécio vulgaris	24	7	0	220	47
Capsella bursa-pastoris	21	0	0	162	0
Matricaria matricarioides + M. inodora	11	0	0	271	57
All species	1860	11	16	41	1
Weed cover	% cover				
Estimated May 26, 1956					
Poa annua	22	41	0	3	0
Myosurus minimus	16	2	0	4	0
Draba verna	13	2	+	48	+
Other species	7	53	33	78	44
All species	59	23	2	22	5
Injury ratings (Rosa rugosa)	10 = no injury, 0 = no commercial value				
May 26, 1956	10	10	10	10	5

Table 4. Trial in *Spiraea japonica*. Sprayed 3rd September 1955.
Plot size 3,5 sq.m. No. of replications: 4.

	Untreated No/sq.m	2,4-DES 10 kg per ha	NPA 10 kg per ha	propham		CIPC 10 kg per ha
				5 kg per ha	10 kg per ha	
Weed counts October 22, 1955		Relative figures. Control = 100				
Draba verna	2080	0	5	52	38	0
Poa annua	228	42	60	0	1	0
Myosurus minimus	94	0	0	34	0	0
Other species	52	4	12	27	65	15
All species	2454	4	10	46	34	0,3
Weed cover						
Estimated May 25, 1956.						
	% cover					
Poa annua	19	22	3	0	0	0
Draba verna	14	0	0	11	0	11
Matricaria matricarioides + *M. inodora*	5	78	6	56	100	61
Other species	3	17	17	75	25	108
All species	40	20	3	16	13	19
Injury ratings:	10 = no injury, 0 = no commercial value					
May 26, 1956 *Spiraea japonica*	10	10	10	10	7,3	10

Table 5. Trials in Cornus alba, Spiraea margaritae, Forsythia intermedia and Berberis ottawemsis "superba". Sprayed 3rd September 1955. Plot size: 3,5 sq.m. No. of replications: 8 (2 per stock).

	Untreated No. per sq.m	2,4-Des 10 kg per ha	NPA 10 kg per ha	CIPC 10 kg per ha
Weed counts October 22, 1955		Relative fig. Control = 100		
Matricaria matricarioides + M. inodora	358	0	23	31
Senécio vulgaris	155	2	22	112
Capsella bursa-pastoris	93	0	8	0
Poa annua	89	51	94	5
Stellaria media	18	44	6	0
Other species	60	62	23	40
All species	773	12	29	41
Weed cover	% cover			
Estimated May 25, 1956.				
Matricaria matricarioides + M. inodora	49	52	25	52
Poa annua	7	17	+	2
Capsella bursa-pastoris	5	23	15	+
Chenopodium album	3	92	46	29
Other species	5	50	50	100
All species	69	47	24	45
Injury ratings	10 = no injury, 0 = no commercial value			
26/5 1956				
Cornus alba	10	10	10	8,5
Spiraea margaritae	10	10	10	10
Forsythia intermedia	10	10	10	10
Berberis ottaweusis "superba"	10	10	10	10

Table 6. Trials in Kalkwitzia, amabilis, Philadelphus and Viburnum roseum. Sprayed 3rd September 1955. Plot size: 3,5 sq.m. No. of replications: 9 (3 per stock).

	Untreated No. per sq.m	2,4-DES 10 kg per ha	NPA 10 kg per ha	Propham 10 kg per ha	CIPC 5 kg per ha	CIPC 10 kg per ha
		Relative figures. Control = 100				
Weed counts						
October 22, 1955.						
Matricaria matricarioides + M. inodora	388	0	12	46	15	14
Senécio vulgaris	282	1	22	37	57	17
Poa annua	118	37	46	29	2	0
Stellaria media	14	6	6	0	0	0
Other species	64	33	32	206	78	26
All species	867	8	21	52	31	14
Weed cover	% cover					
Estimated May 25, 1956						
Matricaria matricarioides + M inodora	29	29	22	107	34	40
Other species	12	63	31	78	35	39
All species	42	39	25	99	34	40
Injury ratings	10 = no injury, 0 = no commercial value					
25/5 1956						
Kolkwitzia amabilis	10	10	10	10	4	5,3
Philadelphus	10	10	8,3	10	8,7	9
Viburnum roseum	10	10	10	10	7	8

Table 7. Trial in Cotoneaster lucida. Sprayed 3rd September 1955.
Plot size: 11,2 sq.m. No. of replications: 4.

	Untreated No. per sq.m	2,4-DES kg per ha		NPA kg per ha		Propham kg per ha		CIPC kg per ha	
		5	10	5	10	10	20	10	20
		Relative figures. Control = 100							
Weed counts									
October 22, 1955									
Poa annua	602	85	78	149	137	1	0	1	1
Capsella bursa-pastoris	554	1	0	1	0	61	0	0	0
Matricaria matricarioides + M. inodora	380	2	1	13	22	75	69	27	33
Draba verna	330	6	0	6	4	157	28	0	0
Myosurus minimus	288	8	22	0	0	9	0	0	0
Stellaria media	168	71	26	23	13	0	0	0	0
Senécio vulgaris	82	+	+	27	7	12	17	10	83
All species	2404	29	25	44	43	50	17	5	10
Weed cover	% cover								
Estimated May 26, 1956									
Capsèlla bursa-pastoris	40	6	+	0	0	14	6	0	0
Poa annua	18	79	37	1	+	0	0	0	0
Matricaria matricarioides + M. inodora	18	53	49	10	9	164	93	44	67
Viola tricolor + V. arvensis	5	11	5	26	58	16	0	0	0
Draba verna	3	0	+	0	0	58	8	0	0
Other species	9	18	26	3	6	65	44	35	32
All species	91	30	19	4	5	47	25	12	16
Injury ratings		10 = no injury, 0 = no commercial value							
Cotoneaster lucida									
May 26, 1956	10	10	10	10	10	10	9,5	9	9,3

(47011)

Table 8. Trial in Picea abies. Sprayed 3rd September 1955.
Plot size: 7 sq.m. No. of replications: 4.

	Untreated No. per sq.m	2,4-DES 10 kg per ha	NPA 10 kg per ha	Propham 10 kg per ha
		Relative figures. Control = 100		
Weed counts				
October 22, 1955.				
Draba verna	1810	1	5	100
Matricaria matricarioides + M. inodora	504	4	23	188
Poa annua	426	73	68	1
Stellaria media	210	50	10	0
Senécio vulgaris	124	0	5	55
Other species	12	250	133	300
All species	3086	15	17	93
Weed covering	% cover			
Estimated May 25, 1956				
Matricaria matricarioides + M. inodora	26	27	14	114
Draba verna	20	5	3	53
Poa annua	16	106	8	8
Other species	3	54	46	138
All species	65	40	11	71
Injury ratings (Picea asies)	10 = No injury, 0 = no commercial value			
May 25, 1956	10	10	10	10

Table 9. Trial in Spiraea vanhouttei. Sprayed 3rd September 1955.
Plot size: 3,5 sq.m No. of replications: 4.

	Untreated No. per sq.m	2,4-DES 5 kg per ha	2,4-DES 10 kg per ha	NPA 5 kg per ha	NPA 10 kg per ha	CIPC 10 kg per ha
		Relative figures.	Control = 100			
Weed counts						
October 22, 1955						
Matricaria matricarioides + M. inodora	960	3	1	27	52	43
Senécio vulgaris	50	0	0	24	52	124
Poa annua	36	72	94	78	44	0
Other species	24	100	58	8	0	25
All species	1070	7	5	28	50	45
Weed cover	% cover					
Estimated May 25, 1956						
Matricaria matricarioides + M. inodora	40	64	59	47	40	73
Other species	7	24	17	17	17	24
All species	48	58	53	42	37	66
Injury ratings (Spiraea sp.)	10 = no injury, 0 = no commercial value					
May 25, 1956	10	10	10	10	10	10

Table 10. Results of 4 experiments with different chemicals sprayed 3rd September 1955.

	No. of trials	Untreated No. per sq.m	2,4-DES 10 kg per ha	NPA 10 kg per ha	Propham 10 kg per ha	CIPC 10 kg per ha
			Relative figures.		Control = 100	
Weed counts						
October 22, 1955.						
Poa annua	4	367	49	75	8	0,3
Draba verna	3	1039	0	3	95	0
Myosurus minimus	3	281	7	0	0	0
Matricaria matricarioides + M. inodora	3	260	0,3	11	131	33
Senécio vulgaris	3	129	3	10	90	25
Stellaria media	33	100	13	7	0,3	0
Capsella bursa-pastoris	2	288	0	0	112	0
Other species	2	58	19	22	136	21
All species	4	1896	12	23	44	5
Weed cover		% cover				
Estimated May 25, 1956						
Poa annua	3	20	33	1	1	0
Matricaria matricarioides + M. inodora	3	17	52	12	124	48
Draba verna	3	10	0,7	0	35	4
Capsella bursa-pastoris	1	40	+	0	14	0
Myosurus minimus	1	16	2	0	4	0
Viola tricolor + V. arvensis	1	5	5	58	16	0
Other species	4	8	40	22	62	57
All species	4	58	25	9	45	19

DISCUSSION ON THE PREVIOUS FOUR PAPERS

Mr. J. R. Aldhous (Introduction to discussion)

Before discussing the two papers on weed control in forest nurseries, I would like to make one or two general points. Forest nurseries in Britain are generally to be found on the lighter less fertile soils. The older ones frequently are found on light loams but the present trend is for new nurseries to be formed on infertile sandy soils. Such soils have the advantages of being acid and therefore most suited to the raising of conifer crops, and of being workable at any time of the year.

Prof. Sanders said that the token of a good farmer was a clean farm. Likewise, the token of a good forest nurseryman is a clean nursery especially on infertile soils where the loss of nutrients to weeds must be minimised.

In contrast to horticultural and agricultural crops, the growth of a number of conifer species is slow and the risk of seedlings being smothered by unchecked weeds is high. Also, merely checking the weeds so that the crop can get ahead and smother further the weed crop does not work as few forest species grow fast enough in their first few years.

I would like to deal with Vidme and Bylterud's paper first and mention English experience in relation to each of the conclusions reached in their paper.

1. The rate of application of white spirit is higher than we would consider safe for two year old plants but I note that only slight damage is reported. (1000 litres per hectare equals approximately 90 gal/ac).

2. The list of weed species and their frequency corresponds closely to lists of the common weeds in English forest nurseries. Poa annua is one of our most serious weeds and more work on its control would be very welcome.

3. The conclusion that turpentine increases the killing effect of mineral oil corresponds with our own findings. The addition of turpentine would increase the aromatic content of the white spirit by about 50% and so increase its toxicity. In passing, it should be noted that while in England, white spirit is two or three times as expensive as vaporising oil; in Norway, Mr. Bylterud tells me, the white spirit is, if anything, slightly cheaper.

4. The conclusion that time of day when application is made has little influence on the occurrence of damage agrees with our own experience. The conclusion that weather conditions may prove most important agrees with British experience in general but not in detail. He found that damage from sprays is worse when applied in rain, on the contrary, our experience suggests that the phytotoxicity of oil is decreased in wet conditions. Our worst damage seems to be associated with hot dry conditions.

5. The stage of development is the most important factor. We could not agree more with this conclusion. It is essential to apply oils when weeds are small. Similarly, we would agree wholeheartedly with the last conclusion that chemical (i.e. mineral oil) weed control saves a great amount of weeding.

6. Turning to my own paper, this describes the results of screening trials on herbicides of potential value in forest nurseries. Such trials are an important but unspectacular part of our work, and results, more often than not are negative. Our prime aim is to find an efficient cheap weedkiller capable of killing the common weeds in tender recently germinated conifer seedlings.

Of the three groups of material reported, the butyric homologues of MCPA and 2,4-D have proved damaging to the crop, and little different in effect from their acetic forms.

There is some promise that CDAA may be an effective herbicide if applied at least ten days before sowing but as a pre- or post-emergence spray, it causes too much crop damage.

Lastly PCP seemed to show promise, but from a number of trials it appeared that rates which controlled weeds also damaged the crop, and so this material too has been rejected.

Mr. G. D. Holmes (Introduction to discussion)

In my paper the problem of *Rhododendron ponticum* as an obstacle to forestry operations is described together with notes on the use of mechanical and chemical methods of clearance and control. Well established thickets of this species present a most difficult afforestation problem, which in practice is being overcome by hand or machine clearance, careful choice of planting species, and regular weeding of regrowth until the new crop can suppress the shrubs. Costs, however, are very high, (£20-80/ac for hand clearance and 0.25 to 0.5 these figures for clearance by heavy machinery), and it has been necessary to assess the value of chemical control methods. The trials described included applications to several types of growth namely:-

(a) 2-4 year old seedlings
(b) Regrowth on stumps several months after cutting
(c) Freshly cut stumps
(d) Basal bark spraying of standing growth
(e) Overall foliage spraying of large bushes.

Compounds tested included sodium chlorate, sodium arsenite, ammonium sulphamate, 2,4-D, 2,4,5-T, amino triazole, TCA and trichlorobenzoic acid.

Results show that small established rhododendron is one of the most difficult plants to kill by external application of chemicals. Basal bark spraying and overall foliage spraying of standing growth has given poor results and generally treatment of seedlings, or freshly cut or coppicing stumps appears more practical.

Ammonium sulphamate applied at rates exceeding 300 lb/100 gal of water to cut stumps or coppice shoots was the only treatment to give a complete kill at these stages. Unfortunately, the present cost of ammonium sulphamate limits the extent of practical application of this treatment.

2,4,5-T (ester) in oil proved effective for control of seedlings, and considerably reduced the vigour of regeneration when applied at high rates to cut stumps of coppice shoots.

Sodium chlorate, sodium arsenite, TCA, monuron, 2,4-D, amino triazole and trichlorobenzoic acid have had little lasting effect at the rates tested.

Unfortunately, none of the methods examined indicate any way in which chemicals may be utilised to assist in the initial opening up of rhododendron thickets, prior to tree planting. However, compounds such as ammonium sulphamate or 2,4,5-T could be valuable in reducing regeneration following mechanical or hand clearance, thereby reducing labour and costs of subsequent weeding operations.

Weed control in nurseries concerned with raising ornamental trees and shrubs usually comprises the largest item of production cost and trials of chemical control methods have been carried out at the Agricultural College of Norway since 1941. The present report described trials carried out in 1954 and 1955 to compare different chemicals and rates of application for selective control of germinating seeds of annual and biennial weed species. A range of compounds were tested applied as overall sprays to growing shrubs and young trees to land bearing few established weeds at a time when conditions were favourable for weed seed germination.

The 1954 trials were concerned with tests of NPA (N-1-naphthylphthalamic acid) 2,4-DES and MCPES at 7 kg/hectare and monuron at 4 kg/hectare applied as overall sprays in June to 2 to 4 year old stocks of *Syringa*, *Buxus*, *Sorbus*, *Acer*, *Rosa*, *Berberis*, *Spiraea* and *Mahonia*. A high degree of weed control was reported, and there was little damage to the ornamentals except from monuron which caused serious crop damage.

Trials were continued in 1955 by sprayings in early autumn shortly after rain following a long drought, at a time when abundant weed germination could be expected. In these second trials monuron was dropped in favour of CIPC, which was tested along with NPA, 2,4-DES, MCPES and propham.

Assessments in spring following treatment indicated no appreciable damage to 13 species of ornamentals from NPA, 2,4-DES, MCPES and propham at rates of 5 to 10 kg/hectare. CIPC, however, can cause some foliage scorch, and may depress subsequent height growth of the nursery stocks, particularly in *Rosa* and *Kolkwitzia*. Weed control was generally good but no compound killed all annual and biennial weeds present.

2,4-DES was effective against most species except *Poa annua* and *Stellaria media*. CIPC and propham were similar in effect controlling many species including *Stellaria* and *Poa annua*. They were, however, only slightly effective against *Matricaria* and *Senecio*, which were controlled by 2,4-DES.

NPA was very effective against a wide range of species and its effect on *Poa* is of some interest as initial toxicity was poor but treatment residues greatly reduced germination in the following spring.

It seems logical from this evidence to consider mixtures of these compounds to secure more complete weed control. Mixtures such as 2,4-DES + CIPC, and NPA + propham are proving effective for this purpose, and certainly warrant further research. In conclusion, it is important to stress that these herbicides are effective only against germinating weed seeds and little effect can be expected from treatment of established weeds. Because of this, timing of applications is most critical, nevertheless these compounds show great promise for weed control in ornamental and forest nurseries, and could well be combined with present methods of inter-row spraying with mineral oils and cultivation.

Mr. P. Bracey

I would suggest that an alteration in formulation may be a way of tackling rhododendrons - formulation is much more important than has been considered so far. Emulsions are generally more active than wettable powders, and emulsions of phenyldimethylurea and monuron incorporated with compounds, such as stickers like synthetic resins would give a greater lasting effect on saplings and young trees.

Mr. G. D. Holmes

In observational trials on rhododendron ethyl, ethyl-butyl, and isopropyl esters of 2,4-D and 2,4,5-T have failed to bring out any appreciable differences between the effects of ester formulations. With regard to monuron, this has been tested only as a wettable powder. Monuron emulsions have not been tried, and may well be worth testing.