Thursday November 4th
Afternoon

WOODY WEEDS WITH PARTICULAR REFERENCE TO THE COLONIES

Chairman: MR. F. S. COLLIER

SOME TRIALS WITH DEFOLIANTS AND ARBORICIDES IN EAST AFRICA

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Introduction

The use of chemicals for defoliating or killing trees in East Africa is of interest mainly in connection with tsetse fly control and the establishment or improvement of grassland.

Tsetse flies are dependent on the shade provided by the trees among which they live and breed and the possibility that some species of fly could be driven out of an area by defoliating the trees was first suggested by an experiment carried out in 1930. In this experiment a square mile of bush was defoliated by applying arsenic pentoxide solution to the base of the trees (Swynnerton, 1936). More recently, experiments have been conducted to test the defoliant action of the growth regulating herbicides when applied as sprays from the air. The preliminary experiments in 1950 and 1951 (Colonial Insecticides Committee 1950, Holly 1951) suggested that 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) merited more detailed investigation and in 1952 this chemical was applied on a larger scale by air to an isolated area of tsetse infested bush (Fryer, Johns and Yeo 1954). While spraying did not result in the eradication of the fly, a considerable degree of defoliation was brought about. Vegetation of the type sprayed is not normally subject to bush fires but, about 6 months after treatment much of the area was accidentally burnt and it is possible that this was due to the defoliation bringing about an increased growth of grasses and other herbaceous plants. One of the objects of the defoliant experiments described here was therefore to test the possibility of combining burning with defoliation as a tsetse control measure.

The problem of actually killing trees is involved both in tsetse control work and in pasture establishment. For the production of barriers to prevent the movement of tsetse into uninfested country, all the trees must be destroyed and to clear fly from infested country the normal procedure is to fell some or all of the trees. Similar problems are encountered where new grassland is being produced or where grazing has been invaded by woody species. When felled however, many of the common tree species regenerate rapidly from the stumps or underground stem systems and the regrowth has to be cut back every few years. Thus, if a chemical treatment will kill the trees and prevent their regrowth, it may be economic even though the initial cost of treatment is rather higher than that of cutting. Recent experiments in East and Central Africa in which regenerating bush has been sprayed several years after cutting have suggested that such regrowth is very difficult to kill with chemicals (Holly 1951, Fryer 1952, Nyasaland 1952). Applications to standing trees or to freshly cut stumps have shown much more promise (Fryer 1953) and for this reason most of the experiments now in progress are of this type.

Aerial spraying with defoliants

Defoliant experiments have been carried out on two different types of vegetation important as tsetse habitats. One on evergreen sub-riverine forest representative of a large area of tsetse country in the south-west of Kenya and the other on dense *Commiphora-Combretum* savannah typical of much of Tanganyika.

For the first experiment an Anson aircraft operated under a contract with Airworks Ltd., was used while for the second trial we were indebted to Desert Locust Control for the loan of an Auster.

(i) Evergreen sub-riverine forest. Kenya

In this area the dominant trees were Olea chrysophylla and Euclea divinorum growing to a height of 30 - 40 ft. Six strips, each 50 yds wide and 440 yds. long were sprayed with solutions of 2,4,5-T butyl ester in diesel oil. The W/V concentrations employed were 32.6, 16.4 and 5.4% (acid-equivalent). Each concentration was applied to two strips at the end of July 1953, about a month after the beginning of the dry season, and one of each pair of strips was resprayed with the same concentration 3 months later towards the end of the dry season.

The three concentrations were calculated to give rates of emission from the aircraft of approximately 3.0, 1.5 and 0.5 lbs/acre (acid-equivalent) of 2,4,5-T under the operating conditions employed and using about 1.5 galls/acre of solution. It was expected that 60% of these amounts would reach the ground in open spaces in the experimental area but assessments showed a ground recovery of only 40 - 50%. The actual mean amounts of 2,4,5-T reaching the ground in the areas observed were 1.54, 0.82 and 0.23 lbs/acre for the three concentrations at the first application and 1.75, 0.91 and 0.25 lbs/acre at the second application.

One of the disadvantages of aerial spraying is the difficulty of obtaining even deposits of spray. In this experiment, with the first application there was a four-to five-fold variation in the 2,4,5-T deposited at various places in the treated areas. Even with the second application where improved equipment was used the variation was threefold and this is about the best that can be expected under normal conditions of operating.

After spraying, a number of marked trees were observed at intervals over a period of 6 months and estimates were made of the degree of defoliation that took place and of the rate at which fresh leaves appeared. Because of the uneven distribution of the spray it is difficult to compare the effects of different dosages. In all the sprayed strips those trees which received an appreciable amount of spray were affected to much the same extent irrespective of the concentration applied and the main difference between the areas treated with different concentrations was in the number of trees affected. A summary of the observations made in this experiment is given in Table 1 where, for clarity, differences in concentration have been ignored and the figures given for each species are means from all the trees which were definitely hit by the spray.

TABLE 1

Mean percentage defoliation and degree of regeneration (figures in brackets) at various times after spraying with 2,4,5-T

Tree species	Sprayed once at 0 weeks					Sprayed twice at 0 and 12 weeks			
	Time after Spraying					Time after spraying			
	Approx. No./acre	2 weeks	8 weeks	18 weeks	25 weeks	2 weeks	8 weeks	18 weeks	25 weeks
Euclea divinorum	49	83	96 (0.3)	83 (2.4)	65 (3.3)	82	94 (0.4)	98 (0.2)	98 (1.5)
Olca chrysophylla	35	90	87 (0)	93 (0.4)	95 (0.8)	85	95 (0)	99 (0.1)	99 (0.8)
Maba abyssinica	18	5	25 (0)	41 (0)	48 (0.2)	2	26 (0)	40 (0)	75 (0)
Teclea simplicifolia	16	0	0 (0)	15 (0)	10 (0)	10	17 (0)	42 (0)	54 (0.2)
Apodytes dimidiata	12	100	100	100 (0.2)	100 (1.7)	90	90 (0.2)	100 (0)	100 (0.1)
Akocanthera friesiorum	11	0	0	0	0	0	10 (0)	18 (0)	28 (0.5)
Croton dichogamus	11	81	85 (0)	91 (0.2)	86 (1.9)	65	70 (0)	95 (0)	90 (2.0)
Grewia sp.	10	95	98 (1.0)	100 (2.0)	75 (3.5)	91	89 (0)	100 (0.5)	86 (1.7)
Canthium euryoides	10	0	37 (0)	71 (0)	65 (0)	0	5 (0)	33 (0)	52 (0)
Scolopia sp.	8	0	73 (0)	100 (0)	100 (0.7)	47	80 (1.0)	100 (0.8)	100 (2.5)
Elaeodendron sp.	6	0	90 (0)	90 (0)	90 (0.5)	17	100 (0)	100 (0.2)	100 (0.2)
Warburgia stuhlmannii	4	100	100 (0)	100 (0.5)	100 (0.5)	-	-	-	-
Acacia pennata		-	-	-	-	100	100 (2.0)	100(1.0)	80 (2.5)
Trichocladus ellipticus	2	-	-	-	-	0	0	0	0
Schrebera alata	1	0	70 (0)	100 (0)	100 (2.0)	-	-	-	-
Tarchonanthus camphoratus	1	0	95 (0)	100 (0)	100 (2.0)	-	-	-	-
Abutilon sp.		-	-	-	-	100	100	100	Dead

Regeneration has been estimated on an arbitrary scale from 0 = no regeneration to 5 = trees practically normal.

It is clear from the table that the two most frequent trees, Euclea and Olea lost most of their leaves shortly after spraying. With Euclea regeneration was also rapid; fresh shoots were appearing 2 months after spraying while, after 6 months, the trees were well on their way back to normal. Where a second spray was applied however, regeneration was much less advanced after 6 months and although numerous small shoots were present the trees still presented a bare appearence. With Olea, regeneration was much less rapid and even after 6 months was still in an early stage.

Of the other trees, Apodytes, Eleodendron, Warburgia, and Schrebera were more or less completely defoliated, Apodytes in particular being very susceptible. Akocanthera was the least susceptible tree while Maba, Teclea and Canthium were intermediate in susceptibility. These last three species responded much more slowly than Euclea and Olea and even after 6 months were not entirely defoliated; where they were defoliated however, regeneration appeared to be very slow. Of the shrubs, Croton, Grewia, Scolopia, Tarchonanthus and Acacia pennata were all severely affected for varying periods but after 6 months were regenerating rapidly. Trichocladus appeared to be particularly resistant.

On the basis of the relative numbers of each species, approximately 70% of the larger trees and a similar proportion of the smaller trees and shrubs were rapidly defoliated by the spray. With a single spray this effect persisted for about 4 months but after 6 months considerable regeneration was taking place. A second spray, 3 months after the first, considerably delayed regeneration so that after 6 months there was still a large degree of defoliation.

For the first few months after spraying the treated areas gave the impression that the degree of shade had been considerably reduced and, because of the defoliation of the smaller shrubs and the killing of many herbs, visibility within the woodland was greatly increased. The increased light reaching the ground presumably favoured grass growth but, although in this area the dry season is not generally very intense, there was very little rain in the latter half of 1953 with the result that not much grass was produced. In February 1954, just before the onset of the long rains, an attempt was made to burn the most severely affected strip but although conditions were favourable, the vegetation being dry and there being a strong wind, the fire did not penetrate into the woodland.

It is not possible to say whether a satisfactory burn would have been obtained if the weather conditions after spraying had been more favourable for the growth of grass. Euclea however appears to be a very fire - resistant tree and in nearby areas where similar bush is being cleared by cutting and burning, regeneration from underground parts of the tree occurs unless care is taken to pile brushwood over the stumps before burning.

Although the uneven distribution of spray made it difficult to determine the minimum dosage of 2,4,5-T required to bring about defoliation, it is estimated that, if about 0.5 lbs/acre is actually deposited on the vegetation this is sufficient to defoliate a large proportion of the trees in this type of bush. Under relatively dry conditions the defoliation persists for 3 - 4 months with one application but it is probable that under moister conditions new leaves would be produced more rapidly.

(ii) Commiphora - Combretum savannah. Tanganyika.

In this second defoliant experiment a more careful assessment of the dosage of 2,4,5-T reaching the ground was made in an attempt to obtain a closer correlation between the amounts of chemical deposited and the effects on the trees. Only one concentration was applied (18% acid-equivalent, expected to give a mean deposit of 1 lb/acre) but three lines of assessment papers were laid down instead of the single line used in the previous experiment. The papers were placed across the beginning, the middle and near the end of the two 440 x 50 yard strips and it was hoped that, with the results of the assessments, lines of trees could be marked which had received various known dosages.

In fact the correlation between the three lines of papers was not as close as had been hoped and, although each strip could be broadly divided into areas which received relatively high and relatively low doses, it was not possible to mark trees which had received accurately known doses of 2,4,5-T. Thus in this experiment also, although a considerable amount of information will be obtained on the susceptibility to defoliation by 2,4,5-T of a large number of tree species, there will be little information on the effect of varying dosage.

The strips sprayed in this experiment passed through several vegetation types varying from deciduous thornbush to mainly evergreen riverine thicket and observations are being made on 60 tree species. The main genera present are Acacia, Albizzia, Combretum, Commiphora, Grewia, Lannea and Markhamia. The spray was applied on Febuuary 25th, towards the end of the long rains and about 3 months before the majority of the deciduous trees normally lose their leaves.

As the observations have not yet been completed, detailed results will not be given. Observations to date, however, show that species of Acacia, Albizzia, Commiphora and Grewia are rapidly defoliated, species of Lannea and some Combretums are defoliated more slowly while other Combretums and Markhamia appear to be little affected. As in the previous experiment, those trees which were defoliated most rapidly were the first to produce fresh leaves and 3 months after spraying the Acacia and Commiphora species had regenerated extensively. By this time most of the Commiphora in the control area had undergone normal defoliation so that many of the trees in the sprayed strips had more leaves than the controls. The Combretums and Lanneas which were slow to lose their leaves were also slow to regenerate and, with the Lanneas in particular there has been very little regeneration.

Arboricide experiments

2,4,5-T and other arboricides are much more likely to find economical applications to East African bush control problems when they are sprayed from the ground than when applied from aircraft. A number of experiments with the chemicals applied from knapsack sprays have therefore been conducted but up to the present only a few of these experiments have been in progress long enough for any results to be available. The species on which arboricides have been tested include:-

(1) Tarchonanthus camphoratus

This bushy Composite tree known as 'leleshwa' is a serious pasture weed in many parts of Kenya. The base of the trunk is swollen below the ground and even when the stumps are dug out regeneration frequently occurs; it is also very resistant to fire.

In the first experiment on Tarchonanthus the effect of 2,4,5-T applied as a low volume spray in diesel oil to regenerating shoots was investigated. The regeneration consisted of dense clumps of shoots up to about 4' high and was the result of cutting and subsequently burning the bush in the previous year. The concentrations tested were 2,4, and 6% (acid-equivalent) roughly corresponding to 1, 2 and 3 lbs/acre. All treatments killed back the shoots to ground level in a few weeks but within two months fresh shoots had appeared from about 80% of the stumps and the regrowth showed no lack of vigour.

It is possible that an emulsion of 2,4,5-T applied at a higher volume rate would have given a more lasting effect but Fryer's (1953) results from spraying a mixed stand of regenerating tree stumps do not suggest that emulsions are any more effective than oil solutions.

The application of 2,4,5-T to the base of the trunks of unfelled trees or to freshly cut stumps is likely to be more effective than spraying regenerating shoots and a further experiment to test these treatments on leleshwa was carried out recently.

(ii) Commiphora spp. and Euphorbia matabelensis.

In an experiment on two species of Commiphora (C.schimperi and C.subsessilifolia both of which are common in many types of vegetation in Tanganyika) and Euphorbia matabelensis a comparison was made of the effects of 2,4,5-T applied in diesel oil to the base of the trunk with and without frilling. The frilling consisted simply of making a series of slashes into the bark around the trunk. The same treatments were also applied to freshly cut stumps. The W/V concentrations applied were 2.5, 5.0 and 10% (acid- equivalent) and approximately 100 ml. of solution were applied to each tree. The density of the bush was about 100 trees acre so that the treatments corresponded to 0.6, 1.1 and 2.2. lbs/acre of 2,4,5-T in 2.2 gals/acre of diesel oil.

The treatments were applied in October 1953 at the end of the long dry season and the results after 6 months are shown in Table 2 which records both the percentage of trees definitely dead (rotting and invaded by wood-boring insect larvae) and, in brackets, the percentage showing no signs of life but not obviously rotting.

TABLE 2

The percentage of trees dead 6 months after various treatments with 2,4,5-T in diesel oil

Treatment	Commiphora spp.	Euphorbia matabelensis
1. Frilled only	0	0
2. Frilled, dieseline	20 (40)	0
3. " 2.5% 2,4,5-T	10 (70)	100
4. " 5.0% "	100	70
5. " 10% "	70 (100)	75 (100)
6. No frill, dieseline	0	0
7. " " 2.5% 2,4,5-T	0	40 (80)
8. " " 5.0% "	40 (45)	-
9. " " 10% "	0 (50)	40 (80)
10. Stumps, untreated	0 (35)	0 (25)
11. " dieseline	0 (70)	40 (100)
12. " 2.5% 2,4,5-T	0 (90)	0 (100)
13. " 5.0% "	0 (85)	25 (100)
14. " 10% "	0 (90)	0 (100)

The figures suggest that preliminary frilling increases the effectiveness of 2,4,5-T or, if it is found that a larger proportion of the unfrilled trees eventually die, that death is more rapid with frilling. It is too early yet to determine whether spraying the base of the trunk is more effective than a stump treatment. None of the treated Euphorbia stumps has yet started to regenerate however, as compared with 75% of the controls, and few of the treated Commiphora stumps have yet sprouted. The experiment therefore demonstrates that some species of Commiphora and this Euphorbia can be killed by 2,4,5-T but lower concentrations would have to be effective for the treatment to be economical.

Lower concentrations are being tested in another experiment on cut stumps of Commiphora schimperi where 2,4,5-T at concentrations of 0.8, 1.7 and 3.3% in dieseline is being compared with the same concentrations applied in emulsion and also with ammonium sulphamate treatments at 10, 20 and 40%. This experiment was sprayed in March and the only observation so far was made 10 weeks later. By this time many of the sulphamate treated stumps were sprouting again but no regrowth was occurring from those treated with 2,4,5-T.

The doses of sulphamate were equivalent to approximately 10, 20 and 40 gr. per tree on stumps with a mean diameter of 3 in. These rates were rather lower than those normally recommended and better results with this material have been obtained in a small experiment on Isoberlinia.

(iii) Isoberlinia globiflora

This tree is one of the most important species in the very widespread type of woodland known as 'miombo' and is another species with very great powers of regeneration.

Ammonium sulphamate was applied in the solid form to the freshly cut surfaces of felled, 6 year old regeneration in April. The stumps treated were 1 - 1½ in. in diameter and 20 - 30 gr. of the crystals were piled on each stump. After 4 months the control stumps were growing vigorously and the regrowth was up to 2 ft. high while there was no sign of regrowth from the treated stumps.

Further experiments on this species using other arboricides have also been started.

(iv) Dichrostachys glomerata.

Dichrostachys is a small thorny tree similar in habit to some of the Acacias and with a very extensive and persistent underground stem system. It often appears to dominate heavily overgrazed or eroded areas and can form very dense thickets which exclude practically all other vegetation. Under such conditions it is quite impossible to spray until the trees have been cut down and a stump spraying experiment has therefore been carried out.

2,4,5-T has been tested at concentrations of 2.5, 5.0 and 10% applied in a relatively small volume (about 30 ml per stump) of diesel oil and at 0.8, 1.7 and 3.3% applied at three times the above rate. Ammonium sulphamate was also tested at three rates and, as in the Commiphora experiment, has been much less effective than 2,4,5-T. Again only interim results are available but after 3 months there has been scarcely any regeneration from the 2,4,5-T plots while the control is a mass of regenerating shoots up to a foot high.

(v) Solanum incanum (Sodom apple)

The work so far has been mainly concerned with tree species but experiments have also been conducted on the very widespread perennial pasture weed Solanum incanum.

In the first experiment the sodium salts of MCPA and 2,4-D and the butyl esters of 2,4-D and 2,4,5-T were compared when applied as high volume sprays at rates of 1, 2 and 3 lbs/acre (acid-equivalent). The treatments were applied to a stand of the weed in September when most of it was coming into flower and was up to 3 ft. high.

A summary of the observations made on this experiment 3 months after spraying is given in Table 3. The effects were assessed by visual estimates of the reduction in percentage cover and of the degree of regeneration (also expressed as a percentage). Each figure is a mean of the observations on three replicate plots.

TABLE 3

The effects of various herbicides on Solanum incanum 3 months after spraying

Treatment	Reduction in percentage cover	Degree of regeneration (percentage)
1. Control	12	96
2. Sodium MCPA 1 lb/ acre	33	70
3. " " 2 "	53	40
4. " " 3 "	78	15
5. Sodium 2,4-D 1 lb/acre	64	33
6. " " 2 "	71	30
7. " " 3 "	82	10
8. Butyl 2,4-D 1 lb/acre	83	8
9. " " 2 "	92	6
10. " " 3 "	95	4
11. Butyl 2,4,5-T 1 lb/acre	79	13
12. " " 2 "	85	10
13. " " 3 "	91	7

It appears from these results that the order of increasing effectiveness of the four compounds tested is:- sodium MCPA - Sodium 2,4-D - butyl 2,4,5-T - butyl 2,4-D. The difference between the esters of 2,4-D and 2,4,5-T is not great but there is a clear difference between esters and sodium salts. 2,4-D appears to be distinctly better than MCPA and brings about a very considerable reduction in the weed density.

Unfortunately the metal stakes used to mark out this experiment disappeared so that is has not been possible to make observations on the permanence of the weed suppression. It seems unlikely however that permanent control can be achieved by a single application and another experiment to determine the effects of repeated applications of 2,4-D ester at various times of year is in progress.

Summary

(1) Aerial spraying experiments with 2,4,5-T on two types of bush inhabited by tsetse flies are described. With both vegetation types there was a considerable degree of defoliation which persisted for several months before fresh leaves were produced.

(2) The tree species observed differ considerably in their reaction to 2,4,5-T, both in the speed and extent of defoliation and those which are the first to react appear to recover the most quickly.

(3) Under normal conditions aerial spraying appears to give a very uneven distribution of chemical so that estimation of the concentration which must be applied to produce a given effect is difficult.

(4) The successful use of aerial sprays of defoliants to encourage the growth of combustible vegetation within bush which it is desired to clear by burning is likely to depend to a large extent on favourable weather conditions after spraying.

(5) Experiments on the application of arboricides from the ground to trees including <u>Tarchonanthus camphoratus</u> (leleshwa), <u>Commiphora</u> spp, <u>Euphorbia matabelensis</u>, <u>Isoberlinia globiflora</u> and <u>Dichrostachys glomerata</u> are described and preliminary results discussed.

(6) Experiments on the perennial weed <u>Solanum incanum</u> (Sodom apple) show that the butyl ester of 2,4-D is the most promising of various growth regulator herbicides which have been tested.

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* These are unpublished reports to Colonial Office.

DISCUSSION OF DR. IVENS' PAPER INTRODUCED BY PROFESSOR G. E. BLACKMAN

Chairman: I would like to offer a few remarks on the forester's attitude to tree poisoning. The tropical moist forest very rarely contains less than 50% of useless timber, and these useless trees must be got rid of or they dominate the forest after the extraction of the merchantable timber and prevent regeneration of the latter. To get rid of the "weed" trees in the past sodium arsenite has been used in Malaya, West Africa, Trinidad and various other places. Its use entails the cutting of a 'frill girdle' completely round the tree and pouring the sodium arsenite in from locally made containers. Sodium arsenite is very dangerous material to have in the hands of labourers and frill girdling is an arduous occupation. Some weed species may be 200 ft. high and 20 ft. in circumference; a tree that size is quite difficult to kill. The Forest Department in Uganda has used hormone preparations sprayed on the bark two or three ft. from ground level, and is producing encouraging results. It may be that such treatment is the solution to the forester's problem.

Mr. C. G. Akhurst: I see in Dr. Ivens' paper that he refers to the need for spraying in dry weather and he refers to the difficulty of getting even deposition of the spray. I thought it might be of interest to refer to foliage spraying of rubber trees in Malaya from the air, in which country there is no dry season. The spraying has been quite successful. The compound used is 2,4,5-T butyl ester, a 10% solution in dieselene sprayed at 1 gallon per acre. This is not necessarily the optimum rate but it has defoliated rubber trees for at least a month.

Dr. Warren C. Shaw: The mesquite problem in the U.S.A. includes about 90 million acres. We have learned that after controlling mesquite there is very valuable grazing land underneath. We have recently found that 2,4,5-trichlorophenoxy-proprionic acid is at least as effective as 2,4,5-trichlorophenoxy acetic but it is less likely to injure cotton if drift occurs. As a result we can now increase the areas in which it is safe to spray.

THE EFFECTS OF CMU AND PDU ON LALANG-GRASS (IMPERATA CYLINDRICA) IN MALAYA

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Presented by Mr. T. C. BREESE (Plant Protection Ltd.)

Summary

In March, 1954 CMU and PDU (3-(phenyl)-1,1-dimethylurea) were tested against TCA (sodium) and a petroleum aromatic/diesel oil mixture on lalang (*Imperata cylindrica*) in Malaya. In some trials volumes of application were varied and in others various combinations were tested (e.g. CMU/PCP mixtures). In all trials chemicals were applied to (a) unslashed lalang, (b) slashed lalang and (c) lalang which had been slashed and 'changkolled' or 'chipped' (i.e. root-hoed).

Main indications were as follows:

(1) Only at 60-lb. per acre and above did CMU achieve effective control of lalang. After 6 months regeneration was in progress even at the highest (80-lb.) rate.

(2) PDU was inferior to CMU. After 6 months not even 80-lb. per acre had kept regeneration of the weed below 20%.

(3) TCA (sodium) at 150-lb. per acre gave excellent control of lalang, still very evident 6 months after application of chemical. Regeneration was in progress at the time of the '6 month' assessment. 200-lb. per acre gave slightly better results.

(4) The optimum rate of TCA (sodium) necessary for 'economic' control of lalang would seem to lie between 100-lb. and 150-lb. per acre.

(5) Single applications of the petroleum aromatic/diesel oil mixture, even at 400 gals. per acre, gave very poor results.

(6) There were indications that slashing the grass before application of chemical reduced the effectiveness of TCA (sodium), whereas with CMU and PDU, slashing and slashing plus 'chipping' have tended to increase slightly the effect of the herbicides.

(7) There were no well-marked differences ascribable to volume of application of CMU, PDU or TCA (sodium).

(8) In one trial, a TCA/diesel emulsion spray was considerably more effective than equivalent rates of TCA (sodium) in a straight aqueous spray.

(9) The addition of PCP to CMU and PDU merely increased speed of kill of aerial growth of lalang. Only very slight long-term effects were noted.

Introduction

Imperata cylindrica, known as 'lalang' in Malaya and 'illuk' in Ceylon, is a perennial grass with very strong and extensive rhizomes. In Malaya, particularly, it is capable of amazingly rapid and vigorous growth and will invade, in an incredibly short time, land which has been cleared but not cultivated, or cultivated land which has been abandoned. The weed infests these areas as a 'sheet' and when the land is required for planting rubber, the 'sheet' lalang must first be removed. Lalang also competes with young growing rubber and constant vigilance is required to keep it in check until the rubber trees are sufficiently well grown to shade out the grass.

At the present time sodium arsenite is used on a very large scale on sheet lalang, also on lalang in growing rubber. The principle employed is one of constant defoliation and the most up-to-date technique in Malaya is to make about five applications each of 15-lb. As_2O_3 per acre in 60 gallons of water at fortnightly intervals, followed by four rounds of "oil-wiping". This latter operation consists of wiping each individual leaf of the remaining lalang with a rag soaked in aromatic oil.

TCA (sodium) is used to a limited extent at high rates as a single application and aromatic oils are sometimes applied on the multiple-treatment principle. Neither of these methods is practiced on the scale of the arsenite technique.

The object of the work described in this report was to evaluate CMU and PDU against TCA (sodium) and a recognised 'lalang' oil on lalang, also to investigate the effects of applying combined sprays (e.g. TCA/diesel; CMU/PCP).

Experimental Results

The experimental programme was divided into three main and three subsidiary investigations as follows:

Main

(a) Straight comparisons of CMU, PDU, TCA (sodium) and an aromatic/diesel oil mixture. There were five trials in this series and rates of application were as follows:

(1) CMU and PDB: 20, 40, 60 and 80-lb. of an 80% dispersible powder per acre in 100 gallons of water.

(2) TCA (sodium): 50, 100, 150 and 200-lb. per acre in 100 gallons of water.

(3) 50:50 Petroleum aromatic/diesel oil mixture: 100, 250 and 400 gallons per acre.

(b) Investigation of influence of (a) slashing and (b) slashing and 'chipping' on effectiveness of chemical treatments. In all trials on lalang the grass was subjected to each of these preparatory treatments.

(c) Phytotoxicity tests with above chemicals at the same rates on rubber basket seedlings, 2 year old budded rubber, oil palm and coconuts.

Subsidiary

(a) Comparison of medium-low and high volume applications of CMU, PDU and TCA (sodium). Here 20-lb. of CMU and PDU in 20 gallons of water per acre and 40-lb. of these chemicals in 40 gallons of water per acre were compared with the same rates of chemicals in 100 gallons of water per acre. With TCA (sodium) 75 and 150-lb. of the chemical were applied in (a) 50 and (b) 100 gallons of water per acre.

(b) Comparison of TCA (sodium) with TCA (sodium)/diesel oil/water mixtures at equivalent rates of TCA. TCA(sodium) at 50, 100 and 150-lb.

in 100 gallons of water per acre was tested against the same rates of TCA (sodium) with 50 gallons of water and 50 gallons of diesel.

(c) Addition of PCP to CMU and PDU. 3.2-lb. of PCP was added to (a) 40 and (b) 80-lb. of CMU and PDU. These treatments were compared with the same rates of chemicals alone.

Application throughout was made with ordinary hand-operated knapsack sprayers except that in one trial, on some plots, CMU and PDU were applied as granules. Frequent agitation was necessary with CMU and PDU to secure a good dispersion of the chemicals.

Trials were laid down at three main centres, Sungei Rinching Estate in Selangor, Sagil Estate in North Johore, and United Patani Estate in Kedah. Phytotoxicity tests were also made near Kuala Lumpur (oil palm) and near Sepang (coconut). The whole of the experimental programme was laid down in March, 1954.

Description of Results

Straight comparison of chemicals on Lalang (5 trials) - Histograms 1, 2, 3 and 4.

CMU did not achieve worthwhile control, even after four months, except at 60 and 80-lb. per acre. Six months after application only at the highest rate was lalang regeneration kept below 20%. PDU was inferior to CMU. Four months after application only 80-lb. per acre plus preparatory slashing was really successful and after six months no rate had kept regeneration of the weed below 20%.

Persistance of CMU in particular is showing signs of being of shorter duration than was anticipated.

TCA (sodium), though ineffective at 50-lb. per acre and only fair at the 100-lb. rate, gave excellent control at rates of 150-lb. and 200-lb. per acre. These effects were still very striking after six months. Siam weed (Eupatorium odoratum) Lantana camara and sedges (Cyperaceae) had invaded all TCA treatments by September, 1954.

Single applications of a 50:50 mixture of a treated petroleum aromatic oil and diesel oil gave poor results even at the very high rate of 400 gallons per acre. Though all rates produced good initial effects on aerial growth, these were only fleeting.

The granulated form of CMU used in one trial appeared to be inferior to the dispersible powder formulation.

Influence of slashing and 'chipping' on effectiveness of chemicals - all histograms

Though there was some variation between trials there were indications that slashing the lalang prior to treatment with TCA (sodium) reduced the effect of the chemical at rates of 100-lb. per acre and above. With CMU and PDU on the other hand, preparatory slashing and slashing plus 'chipping' increased slightly the effect of the chemicals. Slashing or slashing and 'chipping' alone had a negligible effect on the growth of lalang except during a very short period immediately after such treatment.

Phytotoxic aspects (6 trials)

At the time of the second general assessment of these trials, no severe phytotoxic symptoms were showing in rubber basket seedlings planted on the higher rate CMU, PDU and TCA (sodium) plots at Sungei Rinching and Sagil.

On 2 year old budded rubber, an inspection made in late July 1954 (4 months after application of chemicals) yielded results as follows:

(1) Trees treated with 40-lb. per acre CMU: Slight leaf necrosis in lower whorls, some new 'flushes' appearing.

(2) Treas treated with 60-lb. per acre CMU: One tree defoliated with slight 'die-back'. One tree showing slight leaf necrosis. One tree unaffected.

(3) Trees treated with 80-lb. per acre CMU: All trees defoliated, terminal 'die-back'; some buds shooting on lower portion of stem.

(4) Trees treated with 40-lb. per acre PDU: One tree slight terminal 'die-back', other 2 trees 'flushing'.

(5) Trees treated with 60-lb. per acre PDU: One tree slight defoliation other 2 trees 'flushing'.

(6) Trees treated with 80-lb. per acre PDU; Two trees defoliated; some terminal 'die-back'. Remaining tree slight defoliation.

(7) Trees treated with 100-lb. per acre TCA (sodium): Very slight leaf necrosis.

(8) Trees treated with 150-lb. per acre TCA (sodium): Very slight leaf necrosis.

(9) Trees treated with 200-lb. per acre TCA (sodium): Leaf necrosis on lower whorls new 'flushes' appearing. One tree slight terminal 'die-back'.

In late September there were no symptoms of damage showing on coconut palms. Oil palms were not inspected, but July observation indicated no obvious toxic effects at that time.

Comparison of high and low application volumes (2 trials) - Histograms 5, 6, 7 and 8

With CMU there were few marked differences which could be ascribed to volume of application. In one trial 40-lb. per acre of CMU in 40 gallons of water per acre following slashing and chipping was decidedly more effective than the same rate of chemical in 100 gallons of water per acre. In the second trial this difference was not at all marked. In any case, neither rate of CMU or PDU was of much practical effect.

TCA (sodium) showed no clear-cut differences at 50 and 100 gallons per acre. Differences due to rate however, were considerable in one trial.

There are no clear trends arising out of this comparison of volumes, but from personal experience of the difficulties of application the writers have little confidence in volumes lower than 100 gallons per acre with the formulations and rates of CMU and PDU employed in these trials.

Effect of spplying TCA (sodium)/diesel oil/water mixture (2 trials) - Histograms 9 and 10

Though there was some variation between results from the two trials, both at Sungei Rinching and at Sagil, the inferiority of the mixture was obvious. Generally, 100-lb. per acre of TCA (sodium) plus 50 gallons of diesel oil per acre with 50 gallons of water per acre appeared to give very slightly better results than 150-lb. of TCA (sodium) in 100 gallons of water per acre. Regeneration between July and September was also slightly less with the mixture than with straight TCA (sodium).

Effect of adding PCP - Histograms 11 and 12

The addition of PCP to CMU and PDU at 40 and 80-lb. per acre resulted in little more than a fleeting effect, an increase in the rapidity of the kill of aerial growth of lalang. The treatments containing PCP tend to be very slightly more effective than those without.

Discussion of Results

Though these trials were extensively replicated, and though in the straight comparisons of chemicals each main treatment was replicated in effect some twenty times, the only possible assessment consisted of a system of estimates of percentage area covered; in other words, a grading. Conditions of growth obtaining on the trial sites made a physical count of shoots a task beyond contemplation. This means that the results described above must be accepted as trends, some of them nevertheless very clear trends, as the histograms show. Another point is that due mainly to a fire the lalang at Sagil was rather less vigorous than at Sungei Rinching and United Patani Estates. This may explain some of the variations in the results.

The most interesting points arising from the results are:

(1) The high rates of methyl urea derivatives required to suppress lalang.

(2) The apparent short-term persistence of CMU in particular.

(3) The 'neutral' and sometimes negative influence of slashing and slashing plus chipping on the effectiveness of TCA (sodium).

Concerning (3) above, one suggestion worth consideration is that the aerial growth of the lalang acted as a 'catchment' for the TCA (sodium) and guided it down the shoot via the crown to the rhizome bud. Continuing the argument, it could be said that application of TCA to slashed lalang may check growth quite efficiently, but regrowth, when it begins, has little competition whereas the standing unslashed lalang does delay re-growth.

Short term persistence of CMU may be due to heavy rainfall and rapid leaching. This would seem logical at Sagil, where the soil is light in texture, and at United Patani Estate where the soil is lateritic in origin. At Sungei Rinching, however, the soil of the trial area is medium in texture and not likely to permit of quick leaching. A later assessment may indicate speed of regeneration but the indications are that the trials have 'turned the corner'.

The high rates of CMU and PDU necessary to suppress lalang must be due to the inherent resistance of the weed itself to these chemicals. A previous report by Akhurst (1) and (2) indicated that rates as high as 80-lb of CMU per acre were necessary. These trials appear to confirm that point. There is no doubt that with improved formulations of CMU the results could be better - but not startingly so.

The effects of lower volumes of application indicate that perhaps there might be something in the American idea that CMU can be applied at concentrations of 1-lb. per gallon of water quite successfully. Nevertheless, the authors' impressions are that for consistent results with CMU and PDU, volumes approaching the 100 gallon mark are more likely to give satisfaction.

The good results from TCA (sodium)/diesel oil/water mixtures are very interesting technically, but at the chosen rate of 50 gallons diesel, there is no economic benefit in that, in Malaya, a mixture of 100-lb. TCA (sodium) and 50 gallons diesel oil would cost approximately the same as 150-lb. per acre of TCA (sodium).

The inferiority of PDU to CMU on lalang is interesting in view of the fact that opinion in America is that PDU is better than CMU on deep-rooted perennials - this opinion may refer to tap-rooted dicotyledonous perennials. If grasses are included in the group then the work described in this report does not support that opinion.

TCA (sodium) at 150-lb. per acre seems a good practical treatment from the technical view point. Further work might indicate that a rate of between 100 and 150-lb. per acre will be adequate.

Conclusions

1. CMU is only effective on lalang at uneconomically high rates (60 - 80-lb. per acre). Preparatory slashing and chipping of the lalang improves results to a certain extent. A better formulation of CMU might enhance further the results.

2. Under the conditions of these experiments, persistence of CMU appears to be surprisingly short, possibly due to heavy rainfall and rapid leaching.

3. PDU in these trials was quite unsuitable for use on lalang.

4. TCA (sodium) gave an excellent control of lalang at 150-lb. per acre and above. Slashing and chipping, if anything, reduced the effect of the chemical at rates above 150-lb. per acre. Further work with rates between 100 and 150-lb. per acre should prove worthwhile.

5. The petroleum aromatic/diesel oil mixture used in these experiments had very little long term effect when applied as a single treatment, even at the high rate of 400 gallons per acre.

6. Mixtures of TCA (sodium)/ diesel oil and water are worth further investigation, using reduced quantities of diesel.

7. There is little value in adding PCP to CMU or PDU when treating lalang.

8. No comments can be made, as yet, on the phytotoxicity tests in progress.

9. Considering the expense of slashing and chipping indications are that neither preparatory treatments is worthwhile.

Acknowledgements

Thanks are due to Mr. John Voin, Manager of Sungei Rinching Estate; to Mr. William Wall, Manager of the Dunlop Sagil Estate, and to Mr. J. Thornton, Research Officer, Dunlop Estates (Malaya) Ltd; to Mr. W. E. N. Northcote Green (Manager) and Mr. Howard Keedwell (Assistant) of the United Patani Estates, Sungei Patani, and to Mr. Brink of Tulik Merbau Estate for their willing co-operation in finding sites and helping with labour problems; to Mr. E. F. Allen and Mr. Henderson of the Department of Agriculture for making available an experimental site at the Federal Experimental Station at Serdang.

References

1. AKHURST, C. G.,
Rep. Conf. Rubber Research Inst., Bogor 1952 p. 155.

2. AKHURST, C. G.,
Planters' Bulletin, R.R.I., Malaya. New Series No. 4. Jan. 1953 pp. 2 - 3.

DISCUSSION

Mr. C. G. Akhurst: I would like to make two comments on Dr. Allen's paper. The first concerns the size of plot that he used. There are many difficulties in carrying out spraying trials in Malaya on lalang, amongst these is the one of finding a sufficiently uniform area of the grass. Often the age and previous history of the grass is unknown. It is important for instance to know whether it is regenerating from burnt over land, and if so, how many times the land may have been burned over. I raise the question of plot size because if he used very large plots it may account for some of the variations in results which he suggests have occurred. The other point is to do with his reference to phytotoxicity effects of TCA (sodium) on rubber trees. He says nothing can be mentioned as yet. I would like to refer to my own experience. If sodium TCA is used as a weedkiller in rubber growing areas then the rubber trees are very likely to defoliate. The point of interest to me is that where this defoliation does occur there is invariably a two month lag period after the weeds have been killed and before the rubber trees defoliate. Sodium TCA is highly soluble. Malayan rainfall is on an average about 100" a year. It does not seem likely that the sodium TCA remains in the soil for two months and I am wondering whether Mr. Breese can offer any comments. In previous papers reference has been made to sodium TCA holding over in the soil in cold weather conditions in Sweden and Canada. Such an explanation can hardly apply in Malaya!

Mr. T. C. Breese: I cannot give you the exact plot size but to the best of my knowledge these were all relatively small trials so that the area under consideration would have been fairly uniform. With regard to the phytotoxicity of TCA I think Dr. Allen is referring to the control of sheet lalang prior to planting. I would like to ask Mr. Akhurst in turn if he was speaking of the toxicity of TCA to rubber planted after the control of sheet lalang, or was he referring to phytotoxicity to established rubber?

With regard to the delay of toxicity of TCA I offer no explanation but we do know from other work on both tea and coffee that this type of toxicity may occur after a considerable interval of time; I think about six months in the case of coffee.

Mr. C. G. Akhurst: I was referring to spraying in areas where rubber is actually growing. I think Dr. Allen also refers to such areas in his paper.

Mr. L. W. L. Cole: I should like to make some comments on the use of oil as a herbicide for the control of lalang. Dr. Allen's results are not very promising on sheet lalang and I think he would have been more successful if he had applied the oil in split applications rather than in one dose. His histogram No. 1 shows clearly that increasing the rate from 100 to 400 gallons of oil did not prevent regeneration to any greater extent, and I suspect that a large part of that oil was wasted. However, it is necessary to draw a distinction between the control of this pure stand of the weed with the control of the sporadic lalang which occurs on estates under normal conditions. Sheet lalang is largely a heritage left by the Japanese occupation, whereas before the war, and today, one of the major problems is the control of the small infestations that occur all over an estate and which are brought there by seed coming from patches of lalang on roadside verges, on small holdings or on waste land. Here a herbicidal oil is being used by a "wiping" technique which has developed over the last few years and which is quite successful. Labour, and particularly male labour, is becoming more expensive and hoeing charges are, therefore, increasing. Instead of digging out the weed, therefore, women, and in some cases children, can go around with a small can of oil and a rag and can carry out this rather remarkable practice of "wiping" the small shoots of lalang that occur. They dip the rag into the oil and squeeze the rag so that some of the oil runs down the leaves to the base of the plant. The result is the death of that small plant. This practice is, today, used quite widely. It is quite successful, carries no toxicity hazard and is cheap.

Mr. E. H. Probyn: Is there any possibility of this work on lalang in rubber being applied to the treatment of grasses of the Hyporenia growing in seedlings of Eucalyptus or Pine?

Mr. T. C. Breese: I have no information regarding the susceptibility of Hyporenia to TCA but I imagine that there would be considerable danger of the chemical affecting the Eucalyptus or Pine.

Mr. P. de Sedouy: Has a mixture of sodium chlorate and hormone weedkillers been used in trials? We get very good results from this combination in French West and Equatorial Africa.

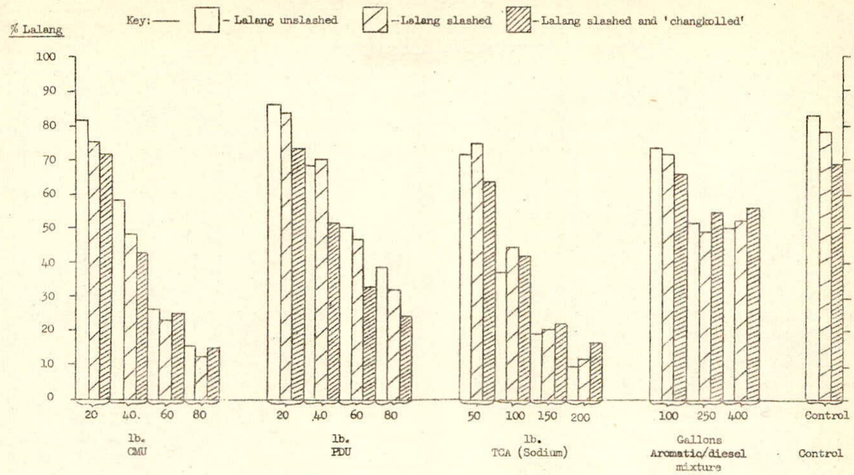
Chairman: I understand they have been used separately in Uganda but I have no exact information of their use in mixture.

Summary of Results of Trials L1, L2, L5 and L6, Malaya, 1954

HISTOGRAM I

COMPARISON OF CMU, PDU, TCA (SODIUM) AND AN AROMATIC/DIESEL OIL MIXTURE

Recovery of lalang about 190 days after application of chemicals

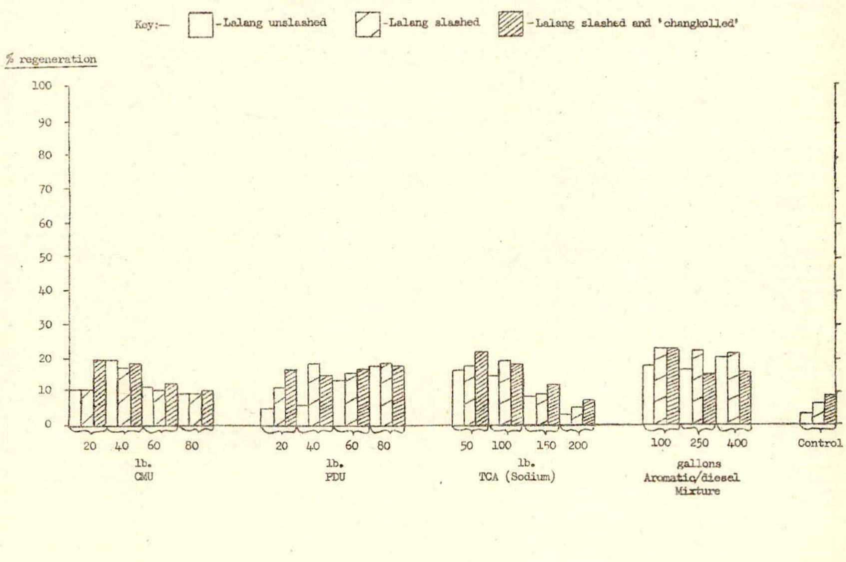


Summary of results of Trials L1, L2, L5 and L6, Malaya 1954

HISTOGRAM 2

COMPARISON OF CMU, PDU, TCA (SODIUM) AND AN AROMATIC/DIESEL OIL MIXTURE

Regeneration of Lalang between July and September 1954



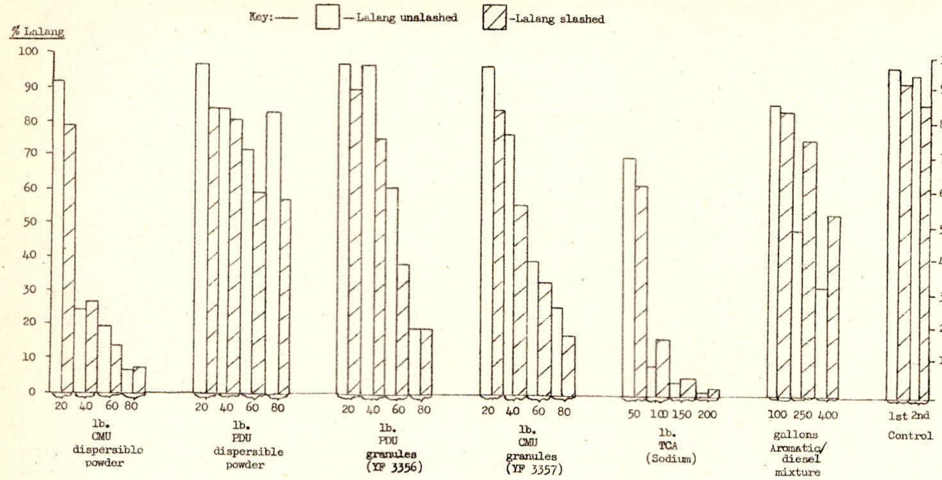
Trial L10, Sungei Patani (United Patani Estates)

HISTROGRAM 3

2nd Assessment:
7th October 1954

COMPARISON OF CMU, PDU, TCA (SODIUM) AND AN AROMATIC/DIESEL OIL MIXTURE

Recovery of Lalang 188 days after application of chemicals

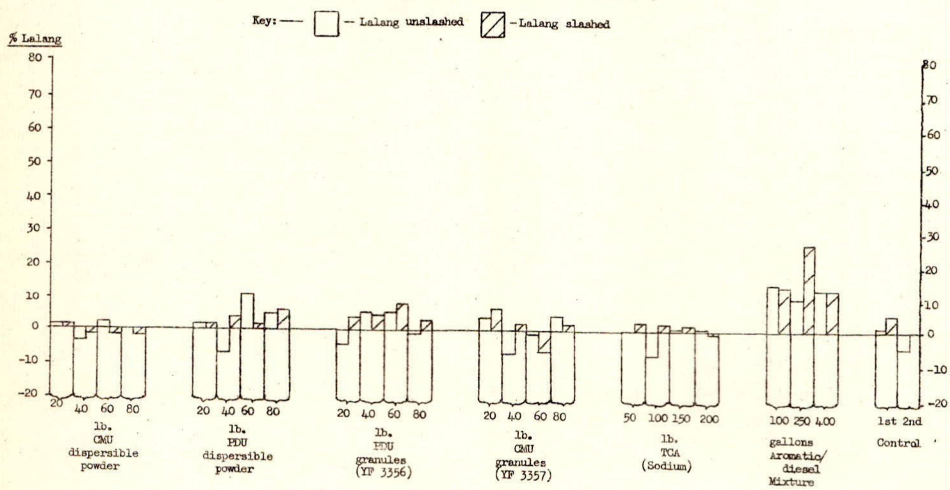


Trial L10, Sungei Patani (United Patani Estates)

HISTOGRAM 4

COMPARISON OF CMU, PDU, TCA (SODIUM) AND AN AROMATIC/DIESEL OIL MIXTURE

Regeneration of Lalang between July and October, 1954



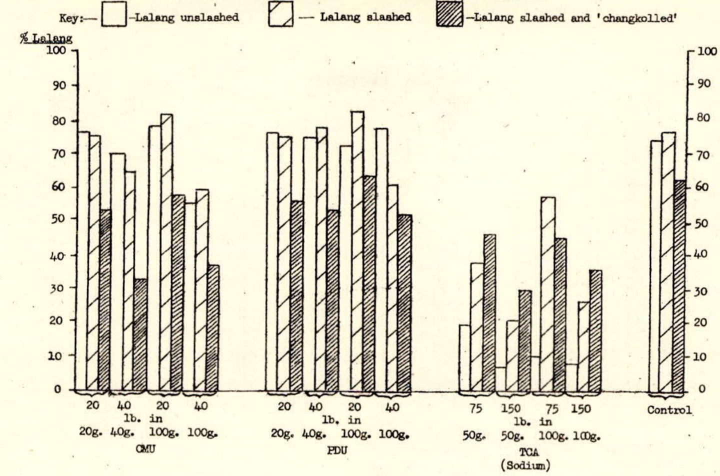
Trial L4, Sungei Rinching

2nd Assessment 21st September 1954

HISTOGRAM 5

COMPARISON OF CMU, PDU AND TCA (SODIUM) AT DIFFERENT VOLUMES OF APPLICATION

Recovery of Lalang 190 days after application of chemicals

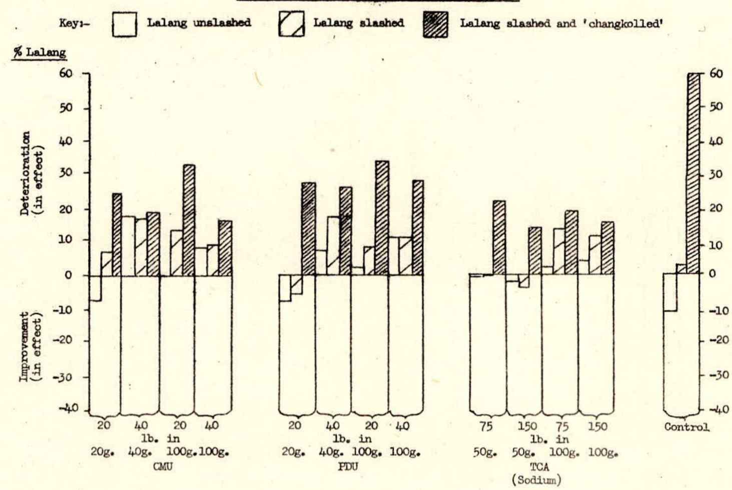


Trial L4, Sungei Rinching

HISTOGRAM 6

COMPARISON OF CMU, PDU AND TCA (SODIUM) AT DIFFERENT VOLUMES OF APPLICATION

Regeneration of Lalang since July assessment



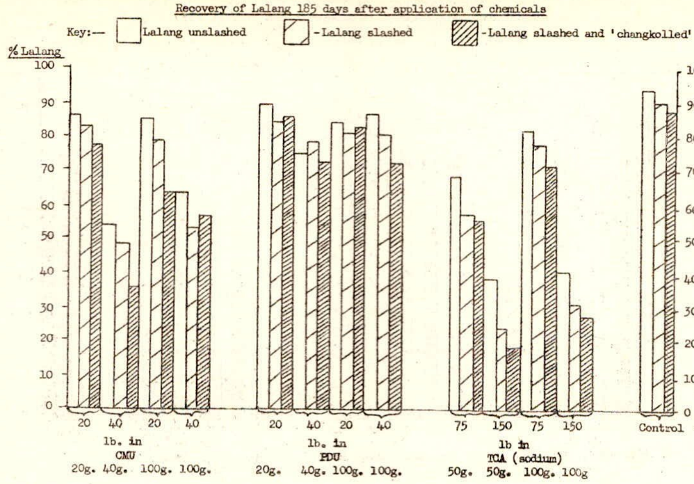
Trial L9, Sagil

2nd Assessment 24th September 1954

HISTOGRAM 7

COMPARISON OF CMU, PDU AND TCA (SODIUM) AT DIFFERENT VOLUMES OF APPLICATION

Recovery of Lalang 185 days after application of chemicals

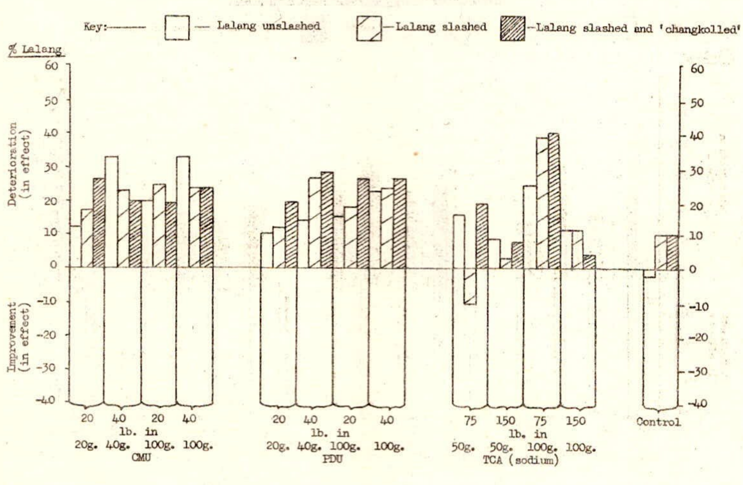


Trial L9, Sagil

HISTOGRAM 8

COMPARISON OF CMU, PDU AND TCA (SODIUM) AT DIFFERENT VOLUMES OF APPLICATION

Regeneration of Lalang since July assessment



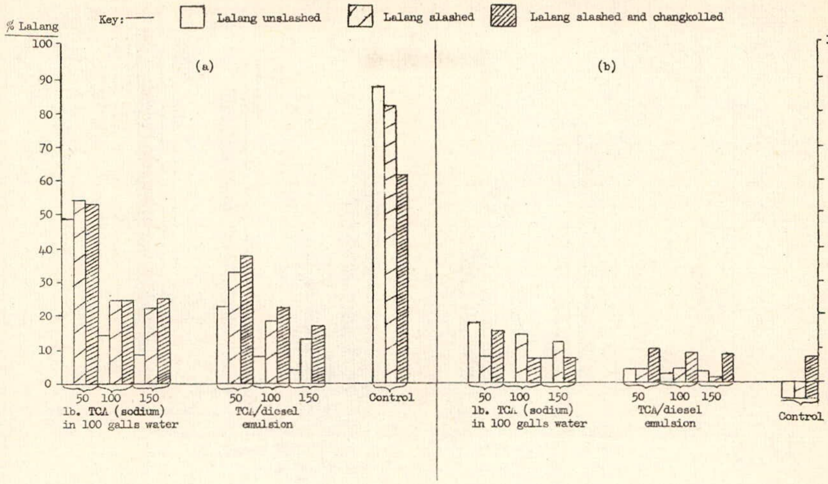
Trial L3, Sungei Rinching

2nd Assessment, 20th September 1954

COMPARISON OF TCA (SODIUM) WITH TCA/DIESEL OIL COMBINED SPRAY

(a) Recovery of Lalang 188 days after application of chemicals

(b) Regeneration of Lalang between July and September 1954



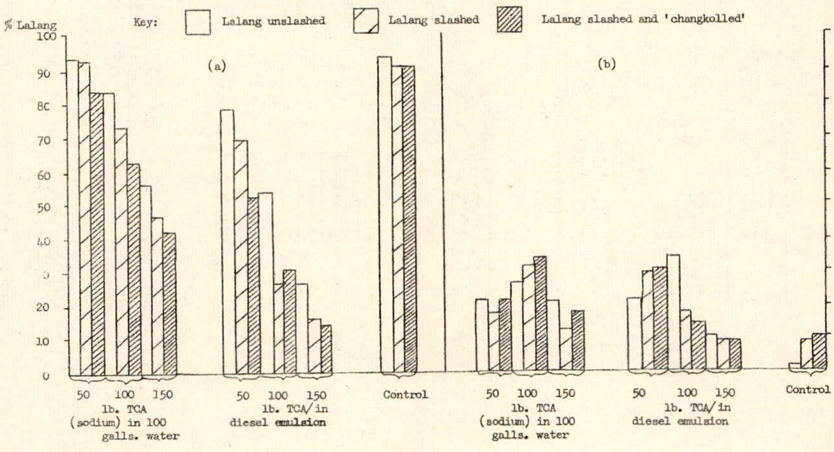
Trial L8, Sagil

2nd Assessment 24th October 1954

COMPARISON OF TCA (SODIUM) WITH TCA/DIESEL OIL COMBINED SPRAY

Histograms showing (a) Recovery of Lalang 184 days after application of chemicals

(b) Regeneration of Lalang between July and September, 1954



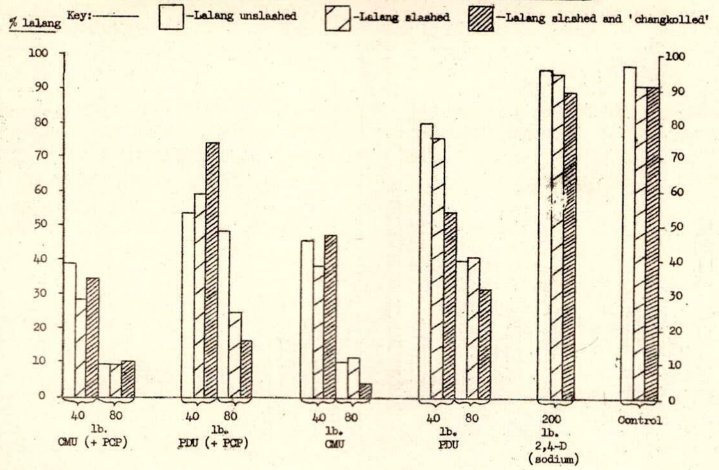
Trial L7, Sagil

2nd Assessment 24th September 1954

HISTOGRAM 11

ADDITION OF PCP TO METHYL UREA DERIVATIVES

Histogram showing recovery of Lalang 186 days after application of chemicals



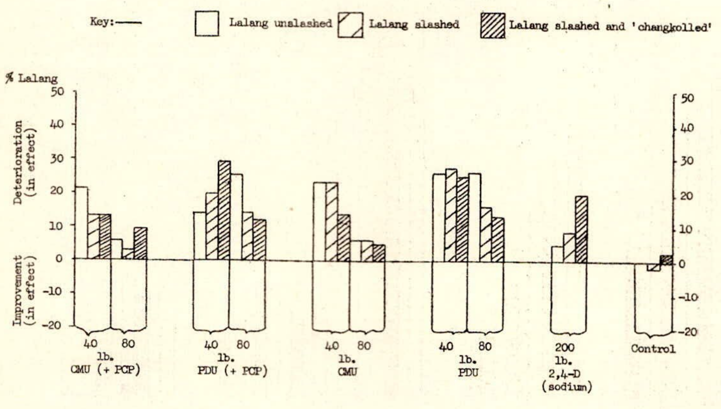
Trial L7, Sagil

2nd Assessment 24th September, 1954

HISTOGRAM 12

ADDITION OF PCP TO METHYL UREA DERIVATIVES

Histogram showing regeneration of Lalang between July and September 1954



(22394)

THE USE OF 2,4-D. and 2,4,5-T. BRUSHKILLERS ON RAILWAY EMBANKMENTS

by

K. CARPENTER and C. WILSON, (May & Baker Ltd)

Summary

Experiments starting in 1952 are described, in which a 2,4-D., 2,4,5-T. formulation has been used to check regrowth of brush on railway sites. Many of these sites have been kept free of effective rabbit cover for up to three winters after spraying at 2 lbs. of mixed acid equivalent per acre at both high and low volume. Species most successfully controlled so far include bramble, briar, birch, hazel, poplar and willow. By suitable variations in spraying technique effective treatment of many of the hard wood species has been possible over a long season, February to July, inclusive.

It is considered that a combined spraying and cutting programme will enable sites to be kept open more economically than by current practice.

Introduction

For some years considerable use has been made in the U.S.A. of 2,4,5-T. and 2,4-D. ester brushkillers for the suppression of woody growth under power lines, along roadsides and railways and similar sites. The scale of these problems in Britain does not appear to have been sufficient to rouse quite the same enthusiasm and emphasis has tended to be placed on eradication of woody growth in land reclamation. Complete eradication of a mixed stand is rarely possible at an economic level and mechanical methods have often proved cheaper and more permanently effective. As May & Baker have been interested in ester formulations of this type for some years, we have kept possible uses under careful review and early in 1952 became aware of a special but extensive problem that might be solved by something less than complete eradication.

In brief there are many thousands of acres associated with railway tracks in this country, including embankments, cuttings and land between flyovers, which are covered by brushwood of various densities. This brushwood is in itself not harmful and performs a useful service - practically by the binding action of the roots, and aesthetically by blending the railway system so well into the countryside. If not kept in reasonable control, however, it presents two serious problems:-

(a) Interference with visibility.

(b) Safe harbourage for rabbits.

It is the latter problem which causes the most concern and even the establishment of myxomatosis has not significantly lessened its importance.

To keep this brushwood within bounds at present requires a very large amount of expensive hand cutting, the effect of which is very short-lived. Two to three seasons is probably the maximum period in many cases for which the ground remains open enough to make gassing and trapping rapid and effective. Bramble and thick sapling brush are probably the worst offenders and where the two are in association adequate clearance becomes nearly impossible.

It seemed to us that 2,4,5-T. brushkillers might be used in conjunction with hand cutting to reduce both the quantity and rate of regrowth of the woody scrub and bramble and thus allow a more effective use of the existing labour force.

At that time (1952) no relevant experimental results of the activity of 2,4,5-T. under British conditions had been published. The very numerous American and Australian references, too many to enumerate here, did give some guidance on susceptible species, rates and methods of application and suitable types of formulation.

It was obvious that even if the material were effective, certain special application difficulties would have to be faced. Direct spraying from trains was not feasible, as in the case of weed control on the track itself. Spraying by lance from train-mounted spraying machines was also not practicable since the consequent amount of interruption to ordinary traffic could only be tolerated for limited periods. This was particularly undesirable for, in order to obtain the maximum economic efficiency, the spray section of the maintenance gang would have to be kept working continuously and over as much of the year as possible. Trackside application appeared to be imperative. Unfortunately, many of the sites would be inaccessible by road and transport of water would be difficult, particularly in winter. Low volume methods were obviously attractive and might be preferred even if accompanied by a slight reduction in killing power.

Bearing these special problems in mind, a series of experiments were laid down in Essex and Herts. by our Horticultural Research Division with the co-operation of British Railways. Work began in the summer of 1952 and continued throughout the following seasons up to the present time.

Experimental results

(a) Spraying Material

A self-emulsifying concentrate containing 47 per cent w/v of 2,4-D. acid equivalent and 23 per cent w/v of 2,4,5-T. acid equivalent, both present as the butoxy ethyl esters, was used throughout. The remainder of the formulation consisted of emulsifiers and stabilizers. This formulation had been chosen as being suitable for general commercial use, partly on the basis of American experience, and it was known to have high comparative efficiency under a variety of conditions. As we were concerned chiefly with the details of the usefulness of this product of known general efficiency in solving a special problem, no comparison with other formulations was included.

(b) Spraying Machinery

Applications were made by pneumatic knapsack sprayers adapted to suit the different methods. In all cases a constant pressure apparatus and standard nozzles were used and results could readily be translated to power machine application. Where the application rate was on an area basis the machines were calibrated for each site, as slope, denseness of brush and evenness of the ground, all affected the speed of movement and the quantity of spray needed to give adequate cover.

(c) Methods, Time and Rates of Application

As time and rate of application depended on the method used they will be considered under each of the methods employed.

(i) Foliar spray

High volume applications were made at 50-60 p.s.i. giving approximately

100 gallons of water per acre. For tall or particularly dense brush a double nozzle fruit spray lance was used with hollow cone jets. For shorter and more even vegetation, i.e. up to about 4' in height, a three nozzle boom fitted with hollow cone jets and giving a swath width of 5'6" was employed instead as this allowed much more rapid and economical treatment. Spraying with either of these methods was to complete cover but not to run off.

Low volume application was tried wherever possible. The usual volume was 20-30 gallons per acre. A lightweight boom fitted with three 'fanjet' nozzles, operating at 30 p.s.i., gave a swath width of 4'6". With this lance used horizontally adequate cover of vegetation up to 5' high was obtained. Used vertically 9' bushes could be covered if not too dense. The best coverage was obtained by holding the lance so that the spray could drift within the individual bushes.

Water was used as the carrier in all foliar sprays. The dose rates were 1 lb. and 2 lb. of total acids per acre in all sites and for both volumes, but with the addition of 3 lb. and 4 lb. in sites 47/6 and 56/2.

Nearly all the foliar sprays were applied in the summer months but one series (56/2) has covered the effect of early spring treatments on bramble. Dates of treatment on individual sites are given in Table 1.

(ii) Basal bark spray

This method consisted of spraying the lower 3' of the trunks with a concentrated solution containing 1-2 lb. of total acids in formulation in 10 galls. of kerosene. For larger trees or saplings, where individual treatment was necessary, a fruit spray lance was used, but for dense stands of young growth a jet pistol was employed. This was made quite easily from an ordinary trigger operated single nozzle lance by shortening the stem to about 3" and removing the swirl plate so that a long narrow jet was produced. At 50-60 p.s.i. this penetrated adequately to 10-12'. Providing that it could be directed from two positions, complete encirclement of saplings up to 2" diameter was obtained at this range, aided by the considerable spreading powers of the kerosene-emulsifier combination.

This type of treatment was tried at various times from January to July. Dates of application on individual sites are given in Table 1.

(iii) Stump treatment

This was a spot treatment applied with a high volume spray lance at the same concentration as the basal bark spray. Both water and kerosene were used as carriers and care was taken to saturate all the crevices of the stump and any exposed root growth adjacent to it. Applications were made at monthly intervals from February to July on two sites.

(d) Plot Layouts

Size of plots was to some extent conditioned by the nature of the site, but in general they were 10'-15' wide and 10'-20' long. There were three replicates of each treatment arranged in simple randomised blocks. The number of treatments was also governed by the size of the site but was generally between seven and fifteen. The sites were therefore chosen, as far as possible, to give a 300' length of even population. Where this was impossible the blocks were separated to cover the major variations.

TABLE 1

GENERAL DESCRIPTION OF SITES

Ref. No.	State at Treatment	Dates of Treatment	Method of Application
(a) Bramble			
25/1	Old dense bramble, 4-5' high.	8.7.52.	Foliar spray high volume.
25/2	Bramble in coppiced wood cut winter 1951-52. Dense regrowth 6' long.	9.7.52.	Foliar spray low volume.
47/3	Dense growth old bramble and rose-bay willow herb.	7.6.53. 19.8.53.	Foliar spray high and low volume.
47/6A	Dense low regrowths of bramble and briar after cutting back winter 1952/53.	8.6.53.	Foliar spray high and low volume.
47/6B	Adjacent site but uncut for many years. Very old bushes 6' high.	8.6.53.	Foliar spray high and low volume.
56/2	Immediately adjacent & similar to 47/6A. Cut in winter 1952/53. Now dense mass of regrowth.	26.2.54.x -28.5.54.	Foliar spray low volume.
56/9	Same site as 47/6. Retreated regrowth.	8.8.54.	Foliar spray low volume.
(b) Hardwood Brush Sites			
25/2	Coppiced hazel, poplar & bramble cut in winter 1951/52. Regrowth 3-4' high.	9.7.52.	Foliar spray low volume.
25/3	Silver birch saplings and seedlings.	8.7.52.	Foliar spray high volume.
47/1	Ash, birch, hazel, oak and willow. Uncut for 10-12 years.	4.6.53. 18.8.53.	Foliar spray high and low volume.
47/2	Adjacent and similar to above but cut in winter 1952/53. Regrowth 2-3' high (June).	4.6.53. 18.8.53.	Foliar spray high and low volume.
56/1	Coppiced hazel, birch, poplar, thorn and hornbeam at all stages up to 15'. Uncut for 10-12 years.	22.1.54.x -28.5.54.	Basal bark spray
56/3	Ash, oak, elm, hazel, cut back autumn 1953. Regrowth 6" in May.	10.2.54.x - 7.5.54.	Stump treatment in oil and water.
56/4	Dense sallow brush up to 15' high.	8.2.54.x -21.6.54.	Basal bark spray.
56/5	Populus generosa avenue, felled winter 1952/1953.	9.3.54.x -18.6.54.	Stump spray in oil and water,
56/7	Adjacent and similar to 47/2. Cut back in winter 1952/1953. Regrowth now 6-8' high.	29.7.54.	Foliar spray low volume.

x sprayed at monthly intervals.

TABLE 11

EFFECT OF SUMMER FOLIAR SPRAYS ON MOST NUMEROUS SPECIES

Species	Site Ref.	Treatment Date	Degree of control at successive autumn observations			Notes
			1952	1953	1954	
Ash	47/1	4/6/53	-	xxx	xxx	Recutting not needed.
		18/8/53	-	x-xx	o-x	No effect now.
Birch	25/3	8/7/52	xxxx	xxxx	xxxx	Dead
	47/1	4/6/53	-	xxxx	xxxx	
		18/8/53	-	x	xx-xxx	Effect not apparent at first.
	47/2	4/6/53	-	xx	xxx-xxxx	
		18/8/53	-	x	o-xx	
Bramble	25/1	8/7/52	xxxx	xxxx	xxx-xxxx	
	25/2	9/7/52	xxxx	xxxx	xxx-xxxx	
	47/3	7/6/53	-	xxxx	xxx-xxxx	
		19/8/53	-	x-xx	x-xx	
	47/6A	8/6/53	-	xx	xx-xxxx	Low volume inferior.
	47/6B	8/6/53	-	xxx	xxx	Coverage difficulty.
Briar	47/6A	8/6/53	-	xxx	xxx	
Hawthorn	Various sites and dates.		-	o-xx	o-xx	Effect on small bushes only.
Hazel	25/2	9/7/52	xx	xxx	xxx	
	47/1	4/6/53	-	xx-xxx	xx-xxx	
		18/8/53	-	x	xx	
	47/2	4/6/53	-	xxx	xx-xxx	
		18/8/53	-	x	o-xx	
Poplar (Black)	25/2	8/7/52	xx	xxx	xxxx	
Oak	Several sites		-	o-xx	o-xx	Small trees only are affected.

(e) Sites

Sites were chosen as being represenatives of plant population and regeneration after cutting. In the following Table they are divided into two Groups, those mainly bramble and those mainly hardwood brush.

(f) Method of Assessment

A quantitative assessment of experiments of this kind would be difficult and misleading. As in this case we are mainly interested in the rate of regrowth, a scoring system has been based on a combination of top kill and regrowth and is used in the tables of results thus:-

xxxx	Complete kill of tops, no regrowth.
xxx	Complete kill of tops, slight regrowth.
xx	Incomplete kill of tops, moderate regrowth.
x	Some temporary check, or strong regrowth.
o	No effect.

The results are expressed as the mean of the three replicates but where there is considerable variation between them a range is given. Assessment has been made in each September of all the surviving sites of earlier years as well as those of the current year in order to check duration of effect. So far the maximum duration has been two and a half years on three sites. The qualitative estimate is checked by more than one observer and is usually backed by a photographic record. (Slides of some of these, particularly those showing duration of effect, were shown at the Conference.)

Results

A. Foliar Spray

Since the 2 lb. treatment was generally superior to the 1 lb., for the sake of brevity only the results for the former are included in the following table. High and low volume treatments were generally similar. Where there was a marked difference it is indicated. Figs. I and II show a selection of plots from site 47/1 and illustrate the effect of dose, time of spray application and spray volume.

B. Basal Bark and Stump Treatment

Only one set of observations has been possible on these treatments so far. These are summarised in Table 111 p.529. Owing to the nature of site 56/1 some of the species were distributed rather unevenly. The results of some of the treatments were thus unreliable and have been omitted. Where results are given for 1 per cent concentration only, it is due to this factor. All results are given for solutions in kerosene unless otherwise stated.

The results are assessed as the period over which control was definitely obtained. The degree of control is indicated by a method which is related to the previous scoring method, thus:-

≡	represents	xxxx
=	represents	xxx
—	represents	xx or less.

Table 111.

PERIOD OVER WHICH EFFECT OF BASAL APPLICATION ON CHIEF SPECIES IS KNOWN

Species	Site		Conc.	Method	Period of known effect (February, March, April, May, June)
Ash	56/3		2%	Stumps	
Birch	56/1	small	1%	Basal Bark	
		large	2%	"	
Elm	56/3		2%	Stumps	
Hazel	56/1		2%	Basal Bark	
	56/3		2%	Stumps	
Hawthorn	56/1	small	1%	Basal Bark	
		large	2%	"	
Hornbeam	56/1	small	2%	Basal Bark	
		large	2%	"	
Oak	56/1		2%	Basal Bark	
Populus nigra	56/1		1%	Basal Bark	
Populus generosa	56/5		2%	Stumps	
Sallow	56/4		2%	Basal Bark	

DISCUSSION

General Activity

The susceptibilities of the various species as shown in Tables 11 and 111 are in general agreement with other published data.

Rates of Application

The published rates of application for brush eradication are generally in the region of 3 - 4 lb. per acre. In fact, we found that these rarely gave complete eradication. The difference between the effects of these higher rates and those at 2 lb. per acre would probably not alter the frequency of clearance of susceptible species, with the possible exception of hazel. The difference between the effect of 2 lb. per acre and 1 lb. per acre was sometimes quite marked, particularly with low volume application. With high volumes the results from a 1 lb. treatment against bramble and birch were frequently as good as the 2 lb. rate.

Method and Time of Application

(a) Foliar Spray. Although we have not yet had sufficient experience of other methods to give a final judgement, foliar spray has so far given the most certain and economical control of the largest number of species. Its chief drawbacks are the quantity of water needed, even at low volume, and the comparatively short season of maximum effectiveness.

(i) Effective timing. The difference between June and August treatments on sites 47/1, 47/2, 47/3 were most striking. It seems probable that, once rapid shoot elongation has slowed down towards the beginning of August, translocation of 2,4,5-T becomes less effective. This effect of timing was most noticeable in the field on established bramble and on rosebay willow herb. On the hardwood species the August treatment caused an immediate defoliation but death of the shoots did not occur until the following spring, and was then only partial. Subsequent regrowth was very rapid.

Published results and a series of experiments not yet completed (56/9) suggest that spring treatment of bramble can begin too early and that growth must be well advanced to get the best effect. This puts the optimum period between mid-May and mid-July.

(ii) Effect of volume. The lowest convenient volume for foliar spray was 20-25 galls. per acre. The actual volume applied with any particular setting varied according to the type of brush. In very dense vegetation low volume nozzles might give in effect a high to medium volume of spray. In general, where the vegetation was not too dense or too high (3-4' maximum) there was not a great difference between the effect of high and low volume applications. In very dense brush high volume is definitely preferable, if feasible.

(b) Basal Bark and Stump Treatment. The results so far (Table 111) show that this method can be very effective for some species. Time was often important but no general rule can be formulated, some species showing opposite trends from others (c.f. ash and hazel with hornbeam and sallow). With several species a very extended effective period of treatment was shown.

The basal bark treatment with the jet pistol was fairly rapid and effective in young dense brush but the volume of material used was sometimes quite high - up to 25 galls. per acre if the brush were particularly dense or awkward to cover from more than one angle. When using an oil carrier this represents a substantial extra cost. Further experiments are indicated with finer jets and possibly with water as a carrier (in spite of some unfavourable reports).

Relation between Cutting and Treatment

Under the special conditions of this type of site the treatment of young regrowths of cut-back brush gave the most successful results, with the exception of bramble. Regrowth in the first summer after cutting up to about 4' high could easily be sprayed by foliar application and later growth up to 1½" in diameter, by the basal bark method. Larger saplings required much more individual treatment. Although this often gave more complete kill it would not fit so readily into the economic and labour framework of this particular problem.

Young vigorous regrowth from bramble was generally much more resistant than the older growth and it was not until at least the second summer after cutting, that adequate suppression was obtained on all plots.

Development of Vegetation after Treatment

The experiments have not been in progress long enough to give information on the type of brushwood succession likely to take place after the type of treatment envisaged. There is a possibility that the resistant species might become more numerous, hawthorn being the most likely, but the only useful indication so far is that young seedlings of most of the resistant species are severely checked or killed.

The most striking immediate change is the very rapid colonisation by grasses after foliar application. In three sites a complete cover of grass growth was established within three months of spraying. After two seasons this is so thick and vigorous as to have seriously competed with bramble regrowth. Hence the apparent increase in control of bramble on site 47/6A (Table 11). On site 47/1 colonisation took a year longer, as the established brush took longer to die and disintegrate, but on the younger bramble sites the dead runners had completely disappeared in six months. The dominant grasses in all these cases were Holcus lanatus and Brachypodium sylvaticum. This rapid establishment of grasses is of particular importance on cuttings and embankments. It was probably facilitated by the low rates of application used and by reduction of herbaceous weeds by its 2,4-D component.

Duration of Effect

So far, data on the duration of effect are only available for foliar sprays and then only for a maximum of three years. They are, however, quite promising. None of the successfully treated plots requires cutting-back yet, nor seems likely to do so for at least another year or two. Most of the control plots had grown 4-6' in the first season after cutting and on the bramble sites effective rabbit cover was completely restored by the second summer. On the other hand spray treatment had kept plots free of effective cover for three years. Eradication, even of the susceptible species, has not been achieved in all cases but as the proportion of less susceptible species is usually sufficient to make complete independence from hand cutting unlikely, this is not serious.

Practical Methods and Economics

The results so far have been sufficient to suggest some practical methods combining cutting and spraying. Well established brushwood should be coppiced and sprayed subsequently either by immediate stump treatment or by foliar or basal bark spray in the following seasons. Survivors and regrowths of susceptible species could then be kept in check by spot treatments at suitable intervals, perhaps three to four years.

Resistant species would have to be hand cut and if too numerous grubbed out where feasible. Particular attention would have to be paid to possible infiltration into cleared areas by resistant species.

Very dense established bramble might require preliminary treatment which, owing to the physical difficulties, might only be partially effective. If possible the dead material should be then burnt in situ. This treatment would greatly improve ease of movement within the site and after two years a more thorough spraying of the regrowths will be possible and effective.

Where access allows, power spraying machinery with lances attached is preferable but in many cases where it does not, considerable clearance can be made by small teams using pneumatic knapsack sprayers at low volume. A conservative estimate based on our own experience suggests that a three man team - two spraying and one preparing solutions - could spray at least two acres of fairly dense brush a day, allowing for the sites being small and separated. Sufficient water for low volume treatment of such areas could easily be dumped on the track-side in 40 gallon drums by the normal maintenance trains. Comparative figures for hand-cutting are not available but the areas covered would obviously be much less.

Acknowledgements

The authors would like to acknowledge the valuable preliminary work on finding a suitable formulation carried out by Miss M. Soundy, of this Division.

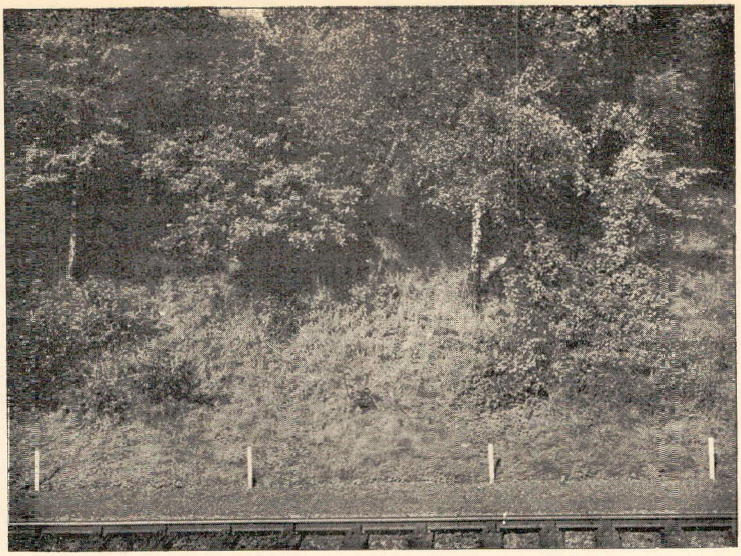


FIG. I

2lb/20 gall.
applied June

1lb/100 gall.
applied June

2lb./20 gall.
applied August

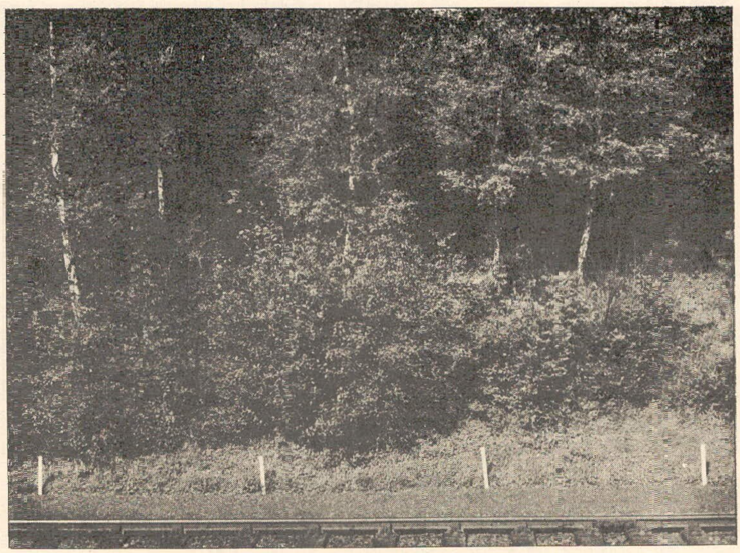


FIG. II

1lb/20 gall.
applied August

Control

1lb/100 gall.
applied August

Figs. I and II. A selection of plots from site 47/1 showing effect of dose rate, timing and spray volume.

(22394)

SOME PRACTICAL ASPECTS OF THE CONTROL OF WOODY GROWTH

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Summary

An account is given of a series of trials in which ester formulations of 2,4-D and 2,4,5-T were tested on common species of woody plant. It is shown that a mixture of 2,4-D and 2,4,5-T esters, suitably formulated, is generally effective as a summer foliage spray, though certain species of plant are resistant. In most instances, plants which are resistant to summer spraying, may be killed by winter spraying with an oil solution of the esters. Information is given about the relative resistance of a number of woody plants to a 2,4-D/2,4,5-T formulation. Other sections of the report deal with various practical aspects of spraying.

Introduction

Although it has been recognised for a number of years that esters of 2,4-D, and particularly of 2,4,5-T, may be used to control many species of woody plant, very little information has been published about the relative susceptibilities of British plants to these chemicals. In the absence of such data, sprayers have tended to rely on information from American and Commonwealth sources. This information has been useful as a general guide, but has needed confirmation under British conditions.

During the past three years, a large number of trials have been carried out with 2,4-D/2,4,5-T ester formulations on the more common British woody weeds. The objects of the trials were to find the minimum doses which would kill various species of woody growth, and the most effective methods of application.

Experimental Results

The trials reported in this paper were done with two types of ester formulation. The first type was a miscible oil formulation, containing 5 lb. per gallon of 2,4-D and 2½ lb. per gallon of 2,4,5-T (on acid equivalent basis), both being in the form of 2-ethyl butyl esters. The rest of the formulation consisted of a mixture of non-ionic emulsifiers. The second formulation was of the preformed emulsion type. 2,4,5-T (2-ethyl butyl) was dissolved in the oil phase in such amount that one gallon of the emulsion contained 1¼ lb. of 2,4,5-T (acid equivalent). The remainder of the oil phase consisted of aromatic solvents.

Experimental results are set out in Tables I, II and III.

Table I shows the relative susceptibilities of a number of plants to summer and winter sprays. The table is based upon the results of 44 series of summer trials in 11 areas and 25 series of winter trials in 5 areas.

For all summer spraying, water was used as diluent, and for all winter treatments, the diluent was oil. Only the miscible oil formulation was used in obtaining this table of susceptibilities. Spraying was thorough and covered the entire plant. The summer sprays contained 20 - 40 oz/100 gallons of 2,4-D (2-ethyl butyl) and 10 - 20 oz./100 gallons of 2,4,5-T (2-ethyl butyl) in terms of acid equivalent. For the winter sprays, the figures were 32 - 64 oz./100 gallons of 2,4-D (2-ethyl butyl) and 16 - 32 oz./100 gallons of 2,4,5-T (2-ethyl butyl). Several types of oil diluent were used. These were gas oils, vaporising oils and sump oils.

The plants were classified as follows:-

S = Susceptible.
MS = Moderately susceptible.
MR = Moderately resistant.
R = Resistant.

Tables II and III show details of trials with bramble, elder and hawthorn. The brambles were tough and well-seasoned bushes. The elders and hawthorns were from 5 - 10 years old. Damage was assessed on a numerical scale of 0 - 10, representing "no effect" to "complete kill".

TABLE 1

SPECIES	SUMMER SPRAY (Water diluent)	WINTER SPRAY (Oil diluent)
Alder (Alnus glutinosa)	S	S
Ash (Fraxinus excelsior)	MR	S
Beech (Fagus sylvatica)	MS	S
Birch (Betula pendula)	MS	S
Bramble (Rubus spp.)	S	S
Briar (Rosa spp)	S	S
Buckthorn (Rhamnus frangula)	S	S
Crab Apple (Malus pumila)	MS	-
Currant (Ribes spp)	S	S
Dogwood or Cornel (Cornus sanguinea)	S	-
Elder (Sambucus nigra)	S	S
Elm (Ulmus spp)	MS	S
Gorse (Ulex europaeus)	R	S
Hawthorn (Crataegus monogyna)	R	S
Hazel (Corylus avellana)	S	-
Horse Chestnut (Aesculus hippocastanum)	MS	-
Ivy (Hedera helix)	R	S
Oak (Quercus spp)	MR	S
Old Man's Beard (Clematis vitalba)	MS	S
Pine (Pinus spp)	S	-
Poplar (Populus spp)	S	-
Raspberry (Rubus idaeus)	S	-
Rowan (Sorbus aucuparia)	MS	-
Sloe (Prunus spinosa)	MR	S
Sweet Chestnut (Castanea sativa)	MS	-
Willow (Salix spp)	S	S

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TABLE II - Summer Treatment

Species of Plant	Toxicant Name	Toxicant Ozs. per 100 Gals.	Formulation	Diluent	Month Sprayed	Damage Assessed after 1 Month	3 Months	12 Months	24 Months
Elder	2,4-D 2,4,5-T	80 40	Misc.Oil	Water	June	9	10	10	10
"	2,4-D 2,4,5-T	40 20	" "	"	"	8	9	10	10
"	2,4-D 2,4,5-T	20 10	" "	"	"	7	9	10	10
"	2,4,5-T	20	Ester/oil emulsion	"	"	8	10	10	-
"	2,4,5-T	10	"	"	"	7	9	10	-
"	2,4,5-T	5	"	"	"	6	9	10	-
Bramble	2,4-D 2,4,5-T	80 40	Misc.Oil	"	"	9	10	10	10
"	2,4-D 2,4,5-T	40 20	" "	"	"	8	9	10	10
"	2,4-D 2,4,5-T	20 10	" "	"	"	8	9	10	10
"	2,4,5-T	20	Ester/oil emulsion	"	"	8	10	10	-
"	2,4,5-T	10	"	"	"	8	10	10	-
"	2,4,5-T	5	""	"	"	7	9	10	-
Hawthorn	2,4-D 2,4,5-T	80 40	Misc.Oil	"	"	6	8	8	8
"	2,4-D 2,4,5-T	40 20	" "	"	"	5	8	8	6
"	2,4-D 2,4,5-T	20 10	" "	"	"	4	5	2	0
"	2,4,5-T	20	Ester/oil emulsion	"	"	4	8	6	-
"	2,4,5-T	10	"	"	"	3	5	3	-
"	2,4,5-T	5	""	"	"	2	2	1	-

TABLE III - Winter Treatment

Species of Plant	Toxicant		Formulation	Diluent	Month Sprayed	Damage Assessed after		
	Name	Ozs. per 100 gals.				5 Months	7 Months	9 Months
Elder	2,4-D 2,4,5-T	64 32	Misc.oil	Gas Oil	January	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" "	"	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	Vap. oil	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" "	"	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	50% Sump oil 50% Vap. oil	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" " "	"	10	10	10
Bramble	2,4-D 2,4,5-T	64 32	Misc. oil	Gas Oil	January	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" "	"	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	Vap. Oil	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" "	"	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	50% Sump oil 50% Vap. oil	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" " "	"	10	10	10
Hawthorn	2,4-D 2,4,5-T	128 64	Misc.oil	Gas Oil	January	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	" "	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" "	"	8	9	9
"	2,4-D 2,4,5-T	128 64	" "	Vap. Oil	"	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	" "	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" "	"	8	9	8
"	2,4-D 2,4,5-T	128 64	" "	50% Sump oil 50% Vap. oil	"	10	10	10
"	2,4-D 2,4,5-T	64 32	" "	" " "	"	10	10	10
"	2,4-D 2,4,5-T	32 16	" "	" " "	"	9	8	8

Discussion

From examination of Table I, it will be seen that a wide variety of plants was readily controlled by means of a foliage spray applied in Spring or Summer. Plants of intermediate resistance could also be controlled, but required higher rates of toxicant. The unsatisfactory effect of the summer spray on resistant plants is demonstrated in Table II. Control of hawthorn, for instance, could be obtained when the plants were young, but older plants sustained no lasting damage, and recovered from moderate doses of 2,4-D and 2,4,5-T after two years. Incidentally, this resistance on the part of hawthorn made it possible to spray well-established hedges, and remove briars, brambles and other unwanted growth, without causing more than slight temporary damage to the hawthorn itself.

Table III gives results of the winter sprays using various oils as diluents. These trials were very successful. Table I shows that none of the plants tested proved resistant to the winter treatment. Plants susceptible to summer sprays, and also those of intermediate resistance were readily killed by the winter spray, even at the lowest rate. Resistant plants such as hawthorn (Table III) seemed to be killed completely at the higher rates of application. There was no sign of regrowth during the following Summer.

The 2,4,5-T emulsion formulation was effective against susceptible species at exceptionally low rates of application. It was not outstandingly effective when used on resistant species. There was evidence, however, that the carrier oils assisted penetration without causing immediate scorch or defoliation. The results were sufficiently encouraging for further trials with this formulation to be planned.

From observation of these trials, a number of conclusions were reached about the most favourable conditions for the application of the sprays.

Summer Treatment

The use of oil as a carrier for foliage sprays led to rapid defoliation, and adequate absorption of the hormone did not take place. Consequently, results were erratic, and in many instances a complete kill was not obtained.

It was found that for summer spraying, the plants should be in full leaf and growing vigorously, and spraying should preferably be done as soon as these conditions have been attained. Adequate coverage was essential, but heavy "run-off" was wasteful and did not give better results. It was not necessary to wet both sides of the foliage. It was advantageous to spray the trunks, especially those of younger trees, but very little penetration seemed to take place through heavy bark.

Winter Treatment

When spraying plants during the dormant season, it was essential to use oil as the diluent. Dormant sprays with aqueous emulsions were most unsatisfactory. During the winter, good adhesion of the spray was essential to ensure adequate time for penetration and this was provided by the oil carrier. The type of oil did not greatly influence the effectiveness of the spray, and gas oils, vaporising or illuminating oils and sump oils were all used successfully. Gas oils were extremely unpleasant in use, and could not be recommended. Sump oil was difficult to use because of its high viscosity. It had good sticking properties, but the rate of absorption of the active material into the plant was lower than for the light oils. The most suitable diluent for ease of spraying and low cost was a mixture of sump oil with either vaporising or illuminating oil. The best proportions to use varied according to the viscosity of the sump oil. A mixture of 40 parts of tractor sump oil and 20 parts vaporising oil was generally satisfactory. In using sump oil, it was noted that the "detergent" oils imparted good spreading properties to the spray.

It was found best, when treating small trees, to spray the whole surface down to the ground. For larger trees, with trunks about 8 inches in diameter, this method was too expensive, and it was generally sufficient to spray only the basal area up to about 3 feet from the ground. It was necessary to cover the whole of this surface from all sides. A sufficient area around the tree was also sprayed thoroughly, in order to prevent any sucker growth.

Spraying Equipment

Most of the spraying was done with a hose and lance. A three pronged lance, using discs with apertures from 4/64 to 6/64 was very satisfactory. For treatment of hedges, a spray-bar used vertically was effective and rapid, though penetration was not adequate for very dense growth. For tall trees or high growth, long-range swirl-plates were used. High pressures were found to be undesirable because of drift, and in general, pressures of 60 - 75 p.s.i. proved adequate.

Weather Conditions

The most rapid results were obtained, from summer treatments, when spraying was done during warm, dry weather. Spraying in dull, cool weather gave satisfactory results, but the plants died more slowly. Generally speaking, spraying during hot, dry weather was not satisfactory. There was too much initial scorching of the foliage, and absorption of the spray was probably incomplete. The best final kill was generally obtained by spraying during warm, humid weather, though in some trials, rain falling shortly after spraying led to an unsatisfactory kill.

Winter spraying was carried out successfully from early December to the end of March. The temperature at the time of spraying did not seem to affect the results. Successful treatments were carried out on comparatively warm days, and also in conditions of 5^{o} of ground frost, and even when snow was falling.

Conclusions

It was found that an emulsifiable oil formulation of 2,4-D (2-ethyl butyl) and 2,4,5-T (2-ethyl butyl) was effective in killing a wide range of woody plants. There were marked differences in the resistance of various species to aqueous sprays applied in Summer. This type of treatment was useful for mixed growth. Susceptible species were often satisfactorily controlled by 20 ozs. 2,4-D and 10 ozs. 2,4,5-T (acid equivalent) per 100 gallons of spray. It was necessary to double these quantities for plants of intermediate resistance. The really resistant varieties, such as hawthorn, were not killed by aqueous sprays, but were readily controlled by dormant season spraying with 64 ozs. 2,4-D and 32 ozs. 2,4,5-T (acid equivalent) in 100 gallons of oil.

Discussion on Two Previous Research Reports

Mr. J. G. Elliott: One of the difficulties of this type of experimental work is the estimation of the amount of chemical applied by means of a hand lance. The dose depends so much on the operator; different sizes and densities of bushes receive different doses with consequent variability in the results. Would Mr. Carpenter like to comment on this point?

Mr. K. Carpenter: A point in favour in these experiments was that the growth on the embankments was fairly even. It was only this even and level woody growth that we were working with. Admittedly, such plots are more difficult to spray evenly than crops but a fair degree of evenness on the ground was achieved. We used plots that were 10 - 15 ft. wide and applied chemicals with various adapted knapsack sprayers. These sprayers were calibrated for average ground cover on each site and then filled with the calculated quantity for each plot as a check on tha actual dose.

Mr. F. R. Stovell: Mr. Carpenter using an oil spray mentioned walking along a path and using a jet that was directed as a basal spray into a coppice. Dr. Harding describes winter bark treatment with oil and says that he needed a complete all round treatment to get control. I wonder if these two speakers could make some comment on this aspect of their results.

Mr. K. Carpenter: I would emphasise that our method of application would only work on the kind of sapling growth shown in this picture and would only be necessary on dense growth of this type. Bigger trees would need individual treatment.

Mr. G. O. P. Eaton: As regards our treatments in winter, unless an all round basal treatment for an area of 2 or 3 ft. around the plant is applied then sucker growth is not controlled. We tried applications on one side of cut stumps only and found that this did not control sucker growth on the unsprayed side.