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Studies on rubber vine (*Cryptostegia grandiflora*): IV The effects of herbicide formulations, carrier, and placement on control of rubber vine

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Summary

Free acid, ethyl or butyl ester and dimethylamine salt formulations of 2,4-D and 2,4,5-T and free acid and dimethylamine salt formulations of dicamba were applied as oil solutions, aqueous solutions, or oil-in-water emulsions as appropriate to the basal stem section or upper stem or leaves of rubber vine (*Cryptostegia grandiflora*).

Dicamba treatments were more effective than 2,4,5-T or 2,4-D treatments. Dicamba amine was superior to 2,4,5-T amine ($P<0.01$) which was, in turn, superior to 2,4-D amine ($P<0.01$), as foliar applications in water. Dicamba acid and 2,4-D acid were more effective than 2,4,5-T acid ($P<0.01$) as basal bark treatments, while dicamba acid was more effective than 2,4,5-T acid ($P<0.01$) which was more effective than 2,4-D acid ($P<0.05$) when applied to the tops of stems.

2,4-D and 2,4,5-T ester formulations were more effective than the respective acid formulations ($P<0.01$) as basal bark treatments, but the acid formulations were more effective (2,4,5-T, $P<0.01$; 2,4-D, $P<0.05$) than the esters when applied as high stem treatments.

Basal bark treatment was superior to high stem treatment ($P<0.01$) which was, in turn, superior to leaf placement ($P<0.01$) of acid and ester formulations in oils. Water was a more effective carrier than diesel distillate or power kerosene in terms of plant response, for applying these herbicides to the leaves of rubber vine plants ($P<0.01$).

Introduction

In a previous paper (Harvey, 1981b) the author reported good results with the herbicides 2,4-D, 2,4,5-T, dicamba, picloram and triclopyr as acid and ester formulations when applied as basal bark treatments to seedlings of rubber vine (*Cryptostegia grandiflora* R.Br.).

Differential uptake and translocation of herbicides by plant species are important factors in control of unwanted plants with herbicides. Depending on the formulation and the species to which they are applied, 2,4-D, 2,4,5-T and the other phenoxyalkanoic acid herbicides may be absorbed almost completely or not at all, may be mobile in the symplast and apoplast or almost immobile and, consequently, either effective or ineffective (Ashton and Crafts, 1973; Crafts and Crisp, 1971; Hay, 1976; Hull, 1970; Richardson, 1977; Robertson and Kirkwood, 1969, 1970). Compared with 2,4-D and 2,4,5-T, dicamba is more mobile in the plant (Eliasson, 1972; Chang and Vanden Born, 1971), and is particularly effective against deep-rooted perennials.

A simple way of determining herbicide mobility, but not uptake, is by selective placement of the herbicide on the plant. This paper reports the results of such a trial using 2,4-D, 2,4,5-T and dicamba on rubber vine.

Materials and Methods

Rubber vine seedlings were grown as reported earlier (Harvey, 1981b).

2,4-D and 2,4,5-T are available commercially as water-soluble dimethylamine salts (as Farmco D-50 and Farmco TA-20) and oil-soluble, water-emulsifiable ethyl ester (as Farmco D-80) or butyl ester (as Farmco T-80) concentrates. Oil-soluble, water-emulsifiable 2,4-D and 2,4,5-T acid formulations were prepared in the laboratory. Dicamba formulations used were the commercially available dimethylamine salt (as Banex) and an experimental oil-soluble free acid formulation.

All herbicide concentrates were diluted to 5% a.e. solutions in oil (diesel distillate or power kerosene) or water or oil-in-water emulsions. Ten-microlitre droplets of the acid and ester formulations in oil were applied to the basal 2.5 cm of stem (B), to the top few centimetres of stem (H), or to the leaves (L). Similarly, 10-microlitre droplets of the herbicide amines in water, or the 2,4-D and 2,4,5-T acid or ester emulsions were applied to the leaves. These treatments are summarized in Table 1.

Table 1 List of herbicide treatments

1	2,4-D ester, B, diesel[1]
2	2,4-D ester, H, diesel
3	2,4-D ester, L, diesel
4	2,4-D ester, L, emulsion
5	2,4-D acid, B, power kero
6	2,4-D acid, H, power kero
7	2,4-D acid, L, power kero
8	2,4-D acid, L, emulsion
9	2,4-D amine, L, water
10	2,4,5-T ester, B, diesel
11	2,4,5-T ester, H, diesel
12	2,4,5-T ester, L, diesel
13	2,4,5-T ester, L, emulsion
14	2,4,5-T acid, B, diesel
15	2,4,5-T acid, H, diesel
16	2,4,5-T acid, L, diesel
17	2,4,5-T acid, L, emulsion
18	2,4,5-T amine, L, water
19	dicamba acid, B, diesel
20	dicamba acid, H, diesel
21	dicamba acid, L, diesel
22	dicamba amine, L, water

[1]Solvents: diesel = diesel distillate
power kero = power kerosene (30% aromatic content)
emulsion = oil-in-water emulsion
water = solution in water

The experimental design was a randomized block design with nine replicates and ten plants per plot. Treatments were assessed about three months after application when some plants first showed signs of recovering. Percentage mortality was calculated for each plot and the data analysed by factorial analysis of variance using arcsine transformed data.

Results

Table 2 Results of herbicide treatments, in ranked order

	Treatments	Mortality[1] (%)	Arcsine transformed data
1	2,4-D ester, B, diesel	100	1.5708
10	2,4,5-T ester, B, diesel	100	1.5708
19	dicamba acid, B, diesel	100	1.5708
20	dicamba acid, H, diesel	97	1.3875
5	2,4-D acid, B, power kero	87	1.1977
22	dicamba amine, L, water	81	1.1175
21	dicamba acid, L, diesel	71	0.9986
14	2,4,5-T acid, B, diesel	31	0.7483
15	2,4,5-T acid, H, diesel	31	0.5963
18	2,4,5-T amine, L, water	29	0.5702
6	2,4-D acid, H, power kero	11	0.3437
4	2,4-D ester, L, emulsion	10	0.3267
13	2,4,5-T ester, L, emulsion	7	0.2718
11	2,4,5-T ester, H, diesel	4	0.2032
2	2,4-D ester, H, diesel	1	0.1159
16	2,4,5-T acid, L, diesel	1	0.1073
9	2,4-D amine, L, water	1	0.0715
8	2,4-D acid, L, emulsion	0	0.0515
3	2,4-D ester, L, diesel	0	0.0
7	2,4-D acid, L, power kero	0	0.0
12	2,4,5-T ester, L, diesel	0	0.0
17	2,4,5-T acid, L, emulsion	0	0.0
L.S.D.	1%		0.2900
	5%		0.2197

[1]Mean of nine replicates

Factorial analyses yielded the following results: (i) basal bark treatment (B) was superior to high stem treatment (H) ($P<0.01$) which was, in turn, superior to leaf placement (L) ($P<0.01$), and (ii) water was a more effective carrier than diesel distillate or power kerosene, in terms of plant response, for applying these herbicides to the leaves of rubber vine plants ($P<0.01$).

Dicamba treatments were more effective than 2,4,5-T or 2,4-D treatments. Dicamba amine was superior to 2,4,5-T amine ($P<0.01$) which was, in turn superior to 2,4-D amine ($P<0.01$), all as foliar (L) applications in water. Dicamba acid and 2,4-D acid were more effective than 2,4,5-T acid ($P<0.01$) as basal bark treatments (B), while dicamba acid was more effective than 2,4,5-T acid ($P<0.01$) which was more effective than 2,4-D acid ($P<0.05$) when applied to the tops of stems (H).

An interesting result was that 2,4-D and 2,4,5-T ester formulations were more effective than the respective acid formulations ($P<0.01$) as basal bark treatments (B), but the acid formulations were more effective (2,4,5-T, $P<0.01$; 2,4-D, $P<0.05$) than the esters when applied as high stem treatments (H).

Discussion

Susceptibility of plant species to the herbicides 2,4-D, 2,4,5-T and dicamba depends on four factors — absorption, translocation, toxicity *per se* and rates of detoxification (Norris and Freed, 1966a, 1966b, 1966c; Eliasson, 1972; Eliasson and Hallmen, 1973; Hallmen and Eliasson, 1972; Chang and Vanden Born, 1971). Eliasson (1972) found that 2,4-D, 2,4,5-T and dicamba were equally toxic to aspen (*Populus tremula*), but dicamba was more phloem mobile than 2,4-D and 2,4,5-T in this species. Chang and Vanden Born (1971) also found dicamba to be very mobile in susceptible species.

Norris and Freed (1966a) studied the effects of formulation on uptake and translocation of 2,4-D and 2,4,5-T in the resistant *Acer macrophyllum*. They found the ester formulations to have the highest absorption values, but to be less effectively translocated to the roots than the acid and amine formulations. The series of papers by these authors (Norris and Freed, 1966a, 1966b, 1966c) illustrates quite well the species–herbicide interaction in terms of differential uptake, translocation, and metabolism of different herbicides of the phenoxyalkanoic acid group in a plant and the relative immobility of these herbicides in a resistant species. These findings have been confirmed and extended to dicamba and picloram by Chang and Vanden Born (1971) and Eliasson and Hallmen (Eliasson, 1972; Hallmen and Eliasson, 1972; Eliasson and Hallmen, 1973).

Differences between the 2,4-D and 2,4,5-T acid and ester formulations, in oil, as basal bark (B) and high stem (H) treatments (Table 2), indicate that the ester may be more completely absorbed, but the acid is more mobile. Differences between these same formulations as foliar applications in water also indicate greater absorption of the ester, as found by Norris and Freed (1966a).

Assuming lower uptake of the amine salts than of the ester and acid formulations (Richardson, 1977), the data for dicamba and 2,4,5-T indicate greater translocation of the amine formulations, consistent with the data of Norris and Freed (1966a). The 2,4-D leaf treatments are nearly all ineffective and do not allow any explanation of the results.

The greater effectiveness of all dicamba treatments illustrates the mobility of this herbicide (Chang and Vanden Born, 1971; Eliasson, 1972), and possibly, a greater phytotoxicity *per se* than 2,4-D or 2,4,5-T against rubber vine. No firm conclusions can be drawn about the relative mobility and toxicity of 2,4-D and 2,4,5-T.

The fact that the data in this experiment using 2,4-D, 2,4,5-T and dicamba on the susceptible species *Cryptostegia grandiflora* are consistent with the data of Norris and Freed (1966a, 1966c) using 2,4-D, 2,4,5-T and related herbicides on the resistant *Acer macrophyllum* indicates that the differences found for formulations and carriers are consistent irrespective of species. The absolute amounts of herbicide absorbed and translocated will vary with the species, and together with factors such as the rate of detoxification of herbicide will determine susceptibility of the species. However, the pattern of differences in absorption and translocation among different formulations of the one herbicide will remain consistent in both susceptible and resistant species.

The results obtained with the carriers used in this experiment (water and diesel distillate or power kerosene, water being the better carrier ($P<0.01$) for applying these herbicides to the leaves of rubber vine) are consistent with field data using a non-phytotoxic emulsifiable oil (Harvey, 1981a). This reinforces the previous conclusion that addition of oils to aqueous, foliar-applied herbicide sprays is undersirable for effective control of rubber vine.

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