INJURY TO SUGARCANE BY 2,4-D FORMULATIONS

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Abstract

Injury to sugarcane from phenoxyacetic acid formulations used for weed control is discussed. Two experiments were conducted to investigate the susceptibility of the varieties N:Co.376, N:Co.382 and N:Co.310 to normal and very high rates of application of a number of commercial formulations (ester, amine and M.C.P.A.) applied pre- and post-emergent to sugarcane. Visual ratings and growth measurements indicated that severe injury and reduction in growth rate occurred soon after post-emergent sprays were applied, but that the cane recovered and that final yield was unaffected. There was some evidence that ester formulations tended to cause slightly more injury than others, and N:Co.376 was the most susceptible of the varieties tested. No injury occurred with pre-emergent sprays.

Introduction

Phenoxyacetic acids have been used extensively for a number of years to control weeds in sugarcane fields. A total of almost 175,000 lb. acid equivalent of the phenoxyacetic acid group (2,4-D in the form of amine or ester, and MCPA) were used by the South African sugar industry during 1967[1]. Phenoxyacetic acid herbicides are the most important group of weedkillers currently recommended for general pre-emergent use with sugarcane. Alone or in combination with substituted ureas, they are also used for post-emergent weed control. Cane plants are therefore liable to receive 2,4-D type sprays at any period of growth between planting and canopy formation.

Nolla (1950)[4] described various forms of injury to sugarcane caused by 2,4-D applied post-emergent and he showed that the intercalary meristems of the stalks were among the tissues which reacted most to 2,4-D hormonal effects. Hypertrophy and necrosis of the root band, together with reduction in the rate of growth, were commonly associated with increasing rates of application of 2,4-D. One of his conclusions was that plants under three months old had greater resistance to 2,4-D damage than older plants and he suggested that the intercalary meristems of young plants were protected to some extent from spray contact due to the leaf sheath being closely attached to the stalk. He also showed that varieties differed in their susceptibility to damage caused by 2,4-D.

Havis (1953)[3], working in Costa Rica with the variety P.O.J. 2878, showed that 2,4-D amine sprayed at rates of up to one lb. acid equivalent per acre did not affect the growth of one-month-old cane, and that rates of up to 4 lb. a.e./acre were safe for plants two months old. Nolla[4], however, had already shown that P.O.J. 2878 was one of the varieties most susceptible to 2,4-D damage. Havis[3] also showed that applications of 2 and 4 lb. per acre of the isopropyl ester resulted in a marked reduction in the growth of one- and two-month-old cane. These rates were relatively safe when sprays were directed at the base of the plants, avoiding so far as it is possible, contact with the cane foliage. Application of a triethanolamine salt formulation also resulted in a reduction in growth of young plants when it was sprayed over the foliage at rates of 2 and 4 lb. per acre.

Ashton (1958)[2] using radioactive 2,4-D, showed that young sugarcane at the two to three leaf stage readily absorbed the herbicide when this was applied to the leaves. Rochecouste (1967)[5], however, in experiments carried out in Mauritius, has shown that plant cane is very susceptible to 2,4-D injury during the sett-root and root-transition stage. He suggests that this is due to the thinness of the cutin layer of the young leaves. Havis[3] showed that for cane in the three-leaf stage, no reduction in its growth rate occurred until a week after application. The maximum effect occurred in the third week, after which the growth rate became equal to that of untreated plants.

In South Africa, reports and observations of 2,4-D injury to cane have been made with increasing frequency in the past few years. An investigation was therefore carried out, designed to obtain information on the susceptibility of some cane varieties to 2,4-D, and to determine the effect of time of applying 2,4-D formulations on the development of 2,4-D injury.

Materials and methods

Experiment I

This experiment was conducted at Mount Edgecombe on a Rydalvale clay. Setts were planted in April 1967, the crop being harvested sixteen months later. Rainfall during this period amounted to 40 inches of which almost 30 inches fell over the six month period immediately after spraying. Three varieties, N:Co.376, N:Co.382 and N:Co.310, were sprayed post-emergent with six commercial phenoxyacetic acid formulations, at two rates, namely 3 and 18 lb. acid equivalent per acre. The formulations were:

Shellamine 7.2* : Dimethylamine salt of 2,4-D containing 7.2 lb. a.e./gal.

Fernimine Selective 7** : Dimethylamine salt of 2,4-D containing 7.2 lb. a.e./gal.

Fernimine Selective 5** : Dimethylamine salt of 2,4-D containing 5.0 lb. a.e./gal.

Fernesta 7** : Isopropyl + Butyl esters of 2,4-D containing 7.0 lb. a.e./gal.

Shell Weedkiller 'D' concentrate* : Isopropyl + Butyl esters of 2,4-D containing 4.0 lb. a.e./gal.

Fernimine 4** : Potassium salt of M.C.P.A. containing 4.0 lb. a.e./gal.

* Registered product of Shell Chemical South Africa (Pty) Ltd.

** Registered product of African Explosives and Chemical Industries Ltd.

A split plot design, with two replicates of each treatment was used. Plots were 0.01 acres in size and contained four rows of cane. Sprays were applied over the row using a knapsack sprayer fitted with a pressure regulator, delivering approximately 60 gal./acre with a "Spraying Systems" 8003 E teejet. Growth stages of the cane were as follows:

Variety N:Co.376 ± 9 leaves unfurled
N:Co.382 ± 8 leaves unfurled
N:Co.310 ± 11 leaves unfurled.

Experiment II

This experiment was conducted at Pongola on a Makatini series soil. Setts were planted in November 1967 and the crop was harvested 12 months later. The cane was fully irrigated to estimated maximum requirements. Two varieties, N:Co.310 and N:Co.376, were sprayed with the commercial phenoxyacetic acid formulations used in Experiment I, except that Shell Weedkiller 'D' was omitted from the whole experiment and "Fernesta 7" from the post-emergent phase.

A split plot design with two replicates of each treatment was used, plot size being 1/64 acre and containing 5 cane rows. Sprays were applied in the same way as for Experiment I except that approximately 30 gal/acre were applied with a "Spraying Systems" T.K. 2.5 flood jet. Pre-emergent applications were made immediately after planting, and post-emergent sprays were applied 50 days after planting, when the cane was at the ± 4 leaf stage. Pre-emergence in this context refers to emergence of cane.

Both experiments were kept free from weeds by cultivation practices. Visual assessments of cane vigour were made at regular intervals, cognisance being taken of retarded growth, contact scorch, hypertrophy of node, and leaf die-back, according to a rating scale (0 = No damage, 9 = Severe damage). Height measurements to the first visible dewlap were made at intervals and, at harvest, yield of cane and percentage sucrose were recorded.

Results and discussion

Experiment I Varieties x Formulations x Rates

Varietal susceptibility: Soon after spraying it was observed that contact scorch and leaf die-back were more severe on N:Co.376 than on the two other varieties. This difference persisted for a considerable period. The syndrome of stunted development and foliar necrosis occurred to some extent on all varieties at all rates for all formulations. Visually this decreased with time and the production of new stalks, and after 4 months very few differences between treatments could be seen. In Table I, the visual ratings of damage for the different phenoxyacetic acid formulations are shown, the figures being the mean of ratings taken when damage due to the high rate of application was at its peak, and those obtained for the final rating.

TABLE I

Visual ratings of varieties sprayed post-emergent with 18 lb. a.e./acre of formulations of phenoxyacetic acid

Variety	Formulation	[0—No damage / 9—Severe damage] Mean rating after spraying 40 days	116 days
N:Co.376	Ester	8.7	4.5
	Amine	7.7	3.1
	M.C.P.A.	6.5	2.2
N:Co.382	Ester	6.0	2.3
	Amine	4.9	1.6
	M.C.P.A.	6.0	1.3
N:Co.310	Ester	4.8	1.3
	Amine	4.9	1.6
	M.C.P.A.	4.0	1.5

As may be seen from Table I, N:Co.376 has a consistently higher rating for damage than the other two varieties, while N:Co.310 shows the least damage. There is also an indication that greater damage is caused by the ester formulations. No matter which variety or formulation is involved however, visual damage is temporary and differences between treatments decrease rapidly with time.

Trade product differences: Means of esters and amines were used in Table I because no statistically significant differences in activity were found between trade products of a particular formulation at any given rate. Figure I compares the three commercial products of 2,4-D amine applied at the high rate. The decrease in visual damage with time, with no difference between products, applies equally to the esters.

Formulation differences: At the 3 lb. a.e./acre rate of phenoxyacetic acid, no differences were observed between the three formulations, but at the higher rate there was a distinct indication that M.C.P.A. causes the least damage. Amine and ester formulations caused a similar degree of damage for some time, but it was found subsequently that cane sprayed with ester formulations had a slightly lower rate of recovery. (Figure 2, Table I.)

Rates differences: As expected, the high rate of herbicide application caused significantly more damage than the lower rate. The mean amine ratings for all varieties shown in Figure 3 illustrates the degree of damage.

It is of considerable practical importance that after four months, the difference in degree of visual damage caused by the applications — one of which was six times greater than the accepted commercial rate of application — was so small. Recovery remained incomplete, however, and yield tended to be lower although there was no statistically significant evidence of yield depression.

Experiment II Varieties x Formulations x Rates x Time of application

Results follow closely those obtained in Experiment I. However, it was found in addition, that pre-emergence sprays caused no detectable cane damage. No differences were recorded from visual observations and from stalk height measurements, for any treatment at any rate on either variety when sprays were applied pre-emergence.

As in the first experiment, marked visual effects were recorded for post-emergent sprays (Table II). It was again found that the highest application rate caused the greatest damage, that N:Co.376 was more

Figure 1: Visual damage ratings of commercial 2,4—D amine formulations applied post-emergent at 18 lb. a.e./acre.

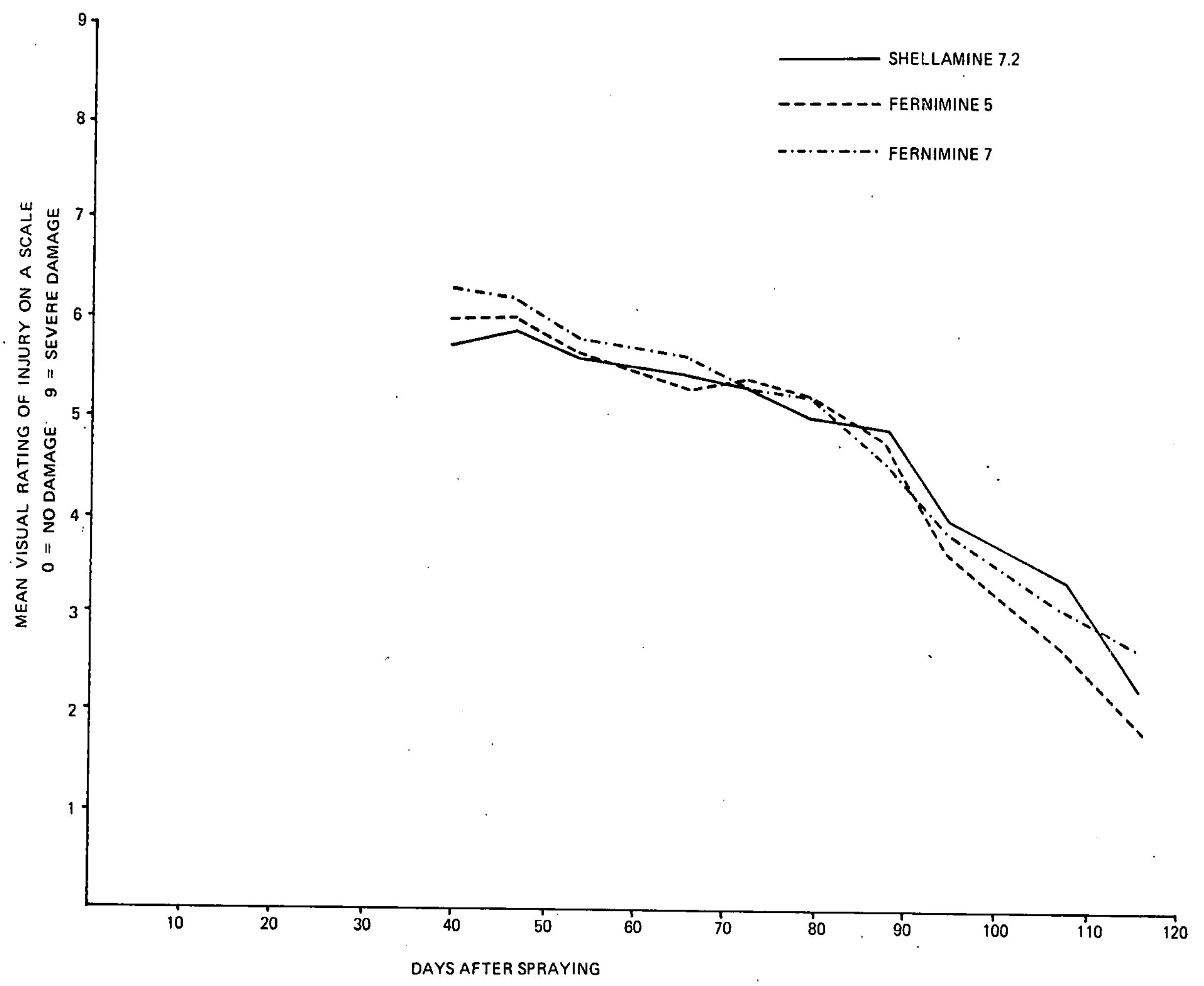


Figure 2: Visual damage ratings of amine, ester and M.C.P.A. formulations of phenoxy acetic acid applied post-emergent at 18 lb. a.e./acre.

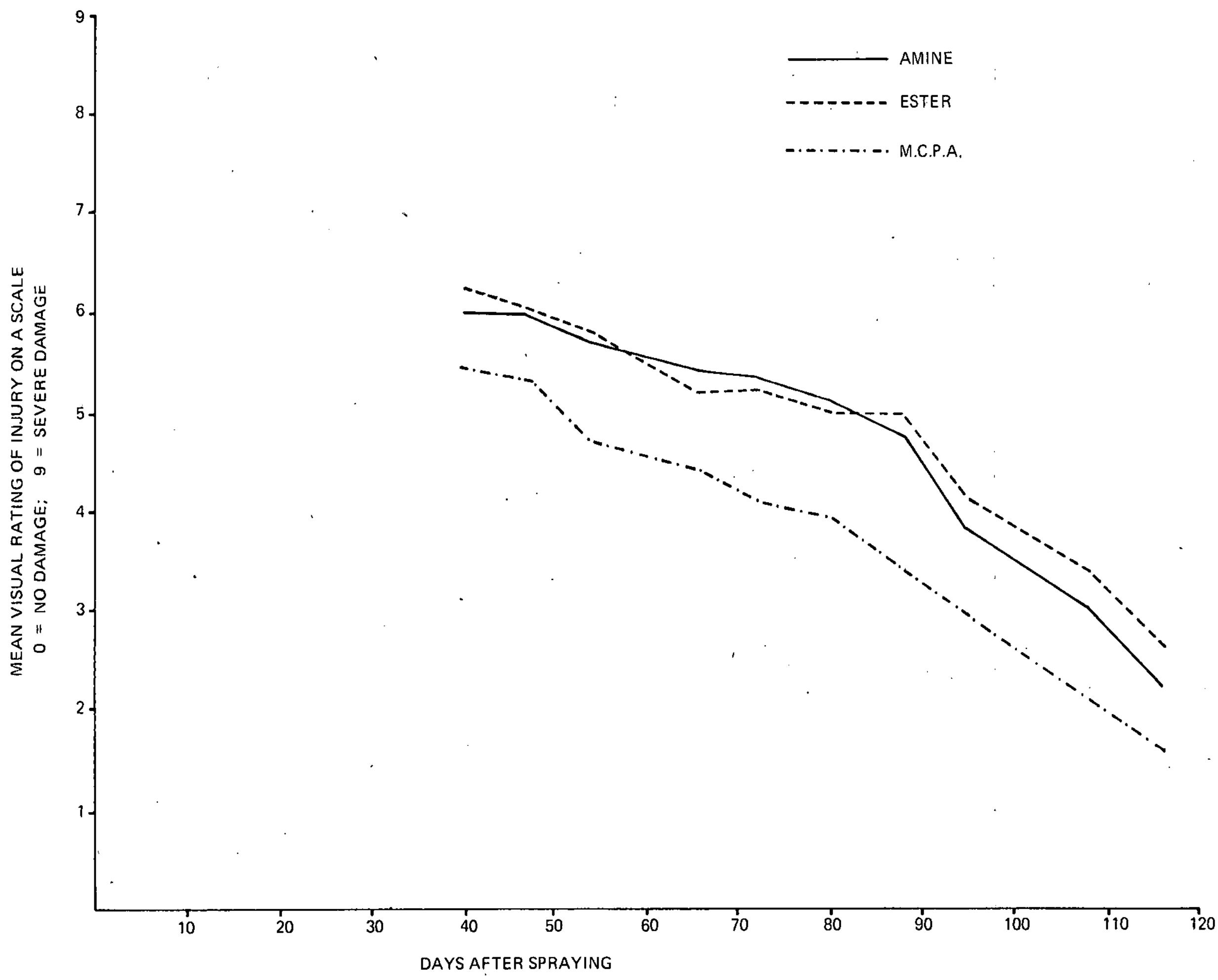


Figure 3: Visual damage rating of 2,4–D amine formulations applied post-emergent at two rates.

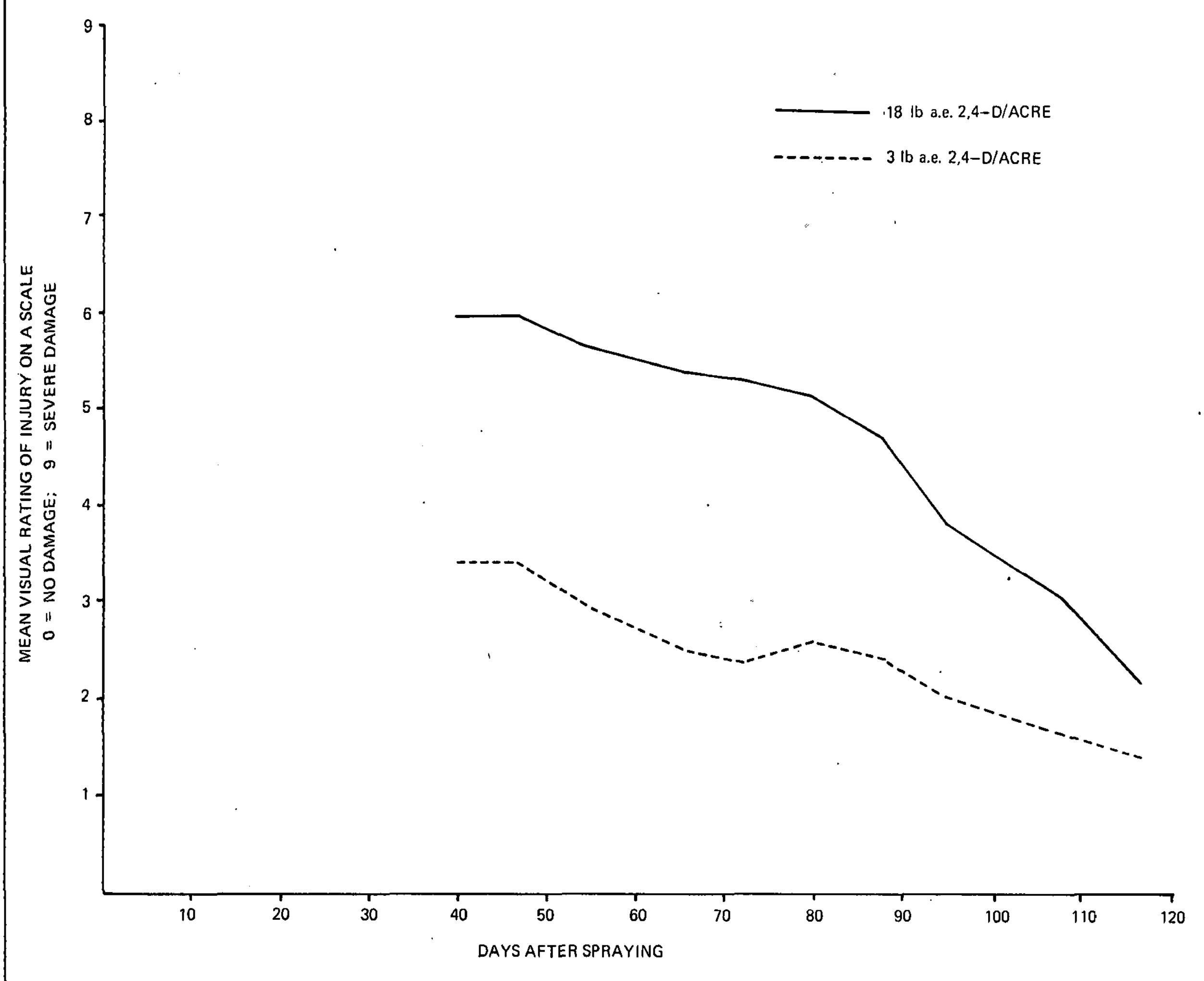


Figure 4: The effects on growth of variety N: Co. 376 when sprayed post-emergent with 2,4–D amine.

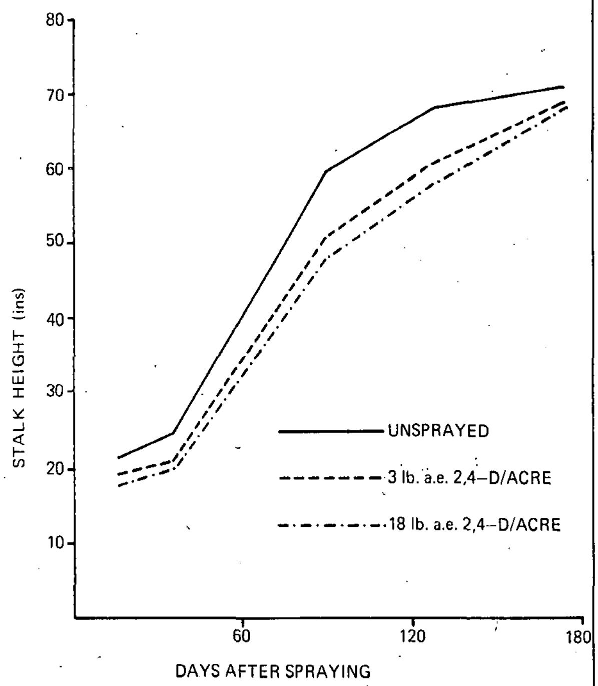
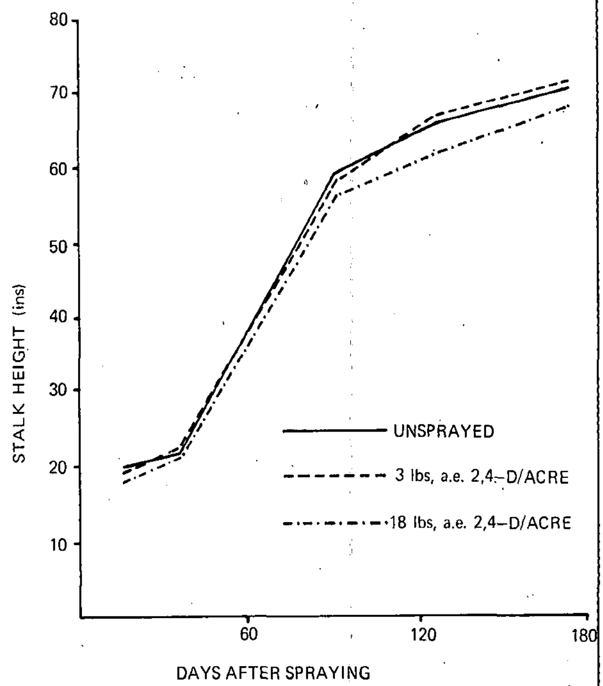


Figure 5: The effects on growth of variety N: Co. 310 when sprayed post-emergent with 2,4–D amine.



susceptible than N:Co.310, and that there were no real differences between commercial products of the same formulation. The indication that M.C.P.A. caused least damage was again evident in the case of N:Co.376.

Visual ratings are supported by stalk height measurements. These are shown in Figure 4 and 5 and illustrate the tendency for the temporary reduction in growth rate to be followed by recovery.

Yield

No statistically significant yield differences were recorded for any treatments applied pre-emergent at either rate on either of the two varieties tested. (Table III.)

Under the conditions prevailing for Experiment II no differences were recorded for any of the post-emergent applications. (Table III.) However, in Experiment I, which had a high coefficient of variation, there is evidence, although it falls short of statistical significance, that the yield of cane sprayed with ester formulations was slightly lower than yields obtained when amine and M.C.P.A. formulations were used. (Table IV.)

There is also an indication that yields from the cane which received heavier dosages of herbicide (18 lb. a.e./acre) were less than those where lower rates were employed (3 lb. a.e./acre).

Varieties did not differ significantly in their response to the herbicides, although the difference between high and low rates of application was greater for N:Co.376 than for other varieties. The smallest difference was obtained with N:Co.310. The results obtained from yield data follow closely the trends observed from visual ratings carried out during the early growth of the experiments.

Conclusions

The two experiments, in which different rates and formulations of phenoxyacetic acid herbicides were applied pre- and post-emergent to a number of cane varieties, indicate that at normal rates of application, the yields at harvest are unlikely to be affected. Severe symptoms of damage may become apparent soon after spraying, but these tend to disappear with time as the crop recovers and new tillers are formed.

On the evidence available from one of the experiments, supported by observations made from time to time within the cane belt, there is every reason to believe that injury ensues only when post-emergent sprays are applied. There appears to be no danger from pre-emergent sprays at normal rates of application.

Differences in the susceptibility of varieties to damage were observed and of the varieties tested N:Co.376 was more susceptible than N:Co.382 and N:Co.310. The last named variety showed the highest tolerance to phenoxyacetic acid herbicides.

The experiments show that there is no apparent difference between trade products of a particular formulation of phenoxyacetic acid, when these are used at similar rates of a.e. per acre. There is, however, an indication that ester formulations can cause slightly more damage than formulations based on amine or M.C.P.A., and that with all formulations injury increases with increasing rates of application.

The fact that symptoms of damage do occur, even though only temporarily, suggests that as far as possible, post-emergent sprays should be directed so as to avoid wetting the foliage.

TABLE II

Visual ratings of varieties sprayed post-emergent with commercial products of phenoxyacetic acid-type

		[0—No damage 9—Severe damage]	
Variety	Formulation	Mean rating 22 days after spraying Low rate	High rate
N:Co.376	Amine A	4.0	5.5
	Amine B	4.0	5.5
	Amine C	3.5	6.5
	M.C.P.A.	2.5	5.0
N:Co.310	Amine A	0.0	2.0
	Amine B	1.0	3.5
	Amine C	2.5	2.5
	M.C.P.A.	1.0	3.0

TABLE IV

Experiment I: Yield of cane (tons/acre) after spraying with different formulations of phenoxyacetic acid

Formulation	[Mean of varieties] Herbicide application rate (a.e./acre) 3 lb.	18 lb.
Amine A	49.4	40.2
Amine D	45.4	44.0
Amine C	47.7	40.3
Ester A	41.4	39.9
Ester B	42.4	36.5
MCPA	46.1	44.8
Unsprayed	43.5	

S.E. of treatment mean (6 plots)=3.08
Coefficient of variation =17.5%

TABLE III

Experiment II: Yield of cane (tons/acre) after spraying with different formulations of phenoxyacetic acid

Variety	Time of Application	Formulation	Herbicide application rate (a.e./acre) 3 lb.	18 lb.
N:Co.376	Pre-emergent	Amine A	49.1	58.6
		Amine B	55.9	51.1
		Amine C	47.1	55.3
		Ester A	58.7	55.6
		MCPA	56.8	54.3
	Post-emergent	Amine A	51.8	50.7
		Amine B	56.3	51.3
		Amine C	60.9	52.4
		MCPA	52.0	53.5
		Untreated	54.8	
N:Co.310	Pre-emergent	Amine A	46.7	49.9
		Amine B	50.2	45.7
		Amine C	49.8	43.1
		Ester A	43.8	53.7
		MCPA	49.3	50.9
	Post-emergent	Amine A	51.1	46.7
		Amine B	47.3	52.4
		Amine C	53.5	48.3
		MCPA	46.6	44.2
		Untreated	51.9	

S.E. of treatment mean (2 plots)=3.19
Coefficient of variation =8.7%

Amine A : "Shellamine" 7.2 *obtained locally
B : "Fernimine" 7.0 **manufactured in France
C : "Fernimine" 7.0 **manufactured in Germany
D : "Fernimine" 5.0 **obtained locally
Ester A : "Fernesta" 7.0 **
B : "Shell Weedkiller D" *
M.C.P.A. : "Fernimine" 4.0 **

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Discussion

Mr. Gilfillan: The formulations used were supplied by different trade sources but might have come from a common manufacturer.

The Experiment Station reported some time ago a herbicide screening trial at Pongola where apparently there was severe retardation to yield from 2, 4-D.

Mr. Richardson: Where possible the formulations were obtained from different manufacturers. The sources are listed as an appendix to Table III. The yield reduction recorded for 2, 4-D sprayed plots in the post-emergent screening trial at Pongola was complicated by the failure of the 2, 4-D to control the grasses. The reduction was probably due more to the effect of the heavy grass infestation than to 2, 4-D damage.

Mr. Wise: Would an aerial application of 2, 4-D at four gallons mixture per acre produce the same effect? You have used sixty gallons.

Mr. Richardson: I do not think that the amount of water matters as long as there is uniform distribution.

Mr. Stewart: Would not oil be more satisfactory than water? Water may evaporote before reaching the ground and cause a high concentration of chemical.

In Table IV the unsprayed yield of 43.5 tons cane per acre as opposed to a reasonably high yield from the 3 lb. a.e. application of the amine of 49 tons per acre is rather interesting.

The recommended rates of application of 2, 4-D are increasing. We used to apply only 2 lb. a.e. Possibly reports of damage by growers are due to these higher rates, combined with knapsack application which is inherently dangerous.

Although the current application here is 3 lb. a.e. per acre, in the highveld it is per morgen, that is, only half the rate of application.

Mr. Richardson: The unsprayed control did have a slightly lower yield—which was not significant—than might have been expected, and a delayed weeding might account for this.

In some areas a rate of 2 lb. a.e./acre will probably be sufficient providing this is accurately and uniformly applied, but the use of 3 lb. allows a safety margin for good weed control.

Dr. Thompson: We have found from our own trials that an application of three pounds per acre is to be recommended.

Dr. Gosnell: Was there any visible distortion on the mature stalks? Some years ago reports of distorted stalks came from a number of areas and these were attributed to 2, 4-D damage.

Also, has any work been done on spraying at different times of the day or under different radiation conditions?

There is some suspicion that if you spray on a very hot day damage from 2, 4-D might be greater due to high insolation.

Mr. Richardson: In connection with distortion, there was no bending of stalk, but there was hypertrophy of the node and the production of abnormal roots from the root band.

Spraying was usually carried out in the early morning but I agree that the climatic conditions prevailing could have a considerable effect on the extent of damage.

Mr. Gilfillan: Regarding resistant weeds and application rates, we have found that the addition of a surfactant materially aids in the control of Carmolina, or 'wandering jew'. Does Mr. Richardson think that the addition of a surfactant would influence the damage to sugarcane?

Mr. Richardson: In the trials reported no surfactant was used but in a new series it has been added and the general effects remain the same. Surfactant increases foliar absorption and greater damage might well occur.