LINURON

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Summary

Trials were carried out with linuron on maize, sweet corn, french beans, peas, carrots and parsnips during 1962-63 season, in various parts of New Zealand. Particular attention was paid to finding crop tolerance and acceptable weed control with this new herbicide. Trials were laid down with both pre- and post-emergence treatments, demonstrating a "two-way" weed control. Soil samples were tested to determine residues in the soil remaining after crop harvesting. *Maize*: 2 to 3 lb active ingredient per acre as a directed spray gave good weed control, particularly of barnyard grass (*Echinochloa crusgalli*). *Peas*: a post-emergence treatment at ¼ lb active ingredient per acre gave excellent weed control with no apparent crop damage. *French Beans*: pre-emergence treatment at 1 to 1½ lb active ingredient per acre appears to give good crop tolerance and satisfactory weed control. *Carrots*: post-emergence treatments at ½ lb active ingredient per acre gave excellent weed control and no apparent stunting. Pre-emergence treatments on carrots and parsnips at 1 to 2 lb active ingredient per acre gave very good weed control and again no apparent damage.

INTRODUCTION

LINURON IS THE newest member in the range of urea herbicides. Chemically it is 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea. It is the methoxy analogue of diuron. Linuron has the following structural formula

and an empirical formula $C_9 H_{10} Cl_2 N_2 O_2$. The molecular weight is 249.1.

The chemical and physical properties of the pure compound are as follows: physical form — white crystalline solid; odour — none; melting point — 93/94° C; solubility — 75 parts per million in water at 25° C. Toxicity figures indicate that it has an acute oral LD_{50} for rats of 1,500 mg per kg. The commercial product is available as a 50% wettable powder.

Trials commenced in New Zealand in 1962, to determine the effectiveness of linuron in the control of weeds in crops which were evaluated and proved successful overseas. Careful note was taken of visible crop tolerances in relation to soil type and rainfall. Since the trials were purely introductory and of a screening nature no yield data are available. All rates of linuron used are expressed in lb active ingredient per acre.

EXPERIMENTAL TRIALS

MAIZE AND SWEET CORN

Thompson (1962) has stated that in principal maize growing areas, grassy weeds were becoming a problem as a result of the control of

broad-leafed weeds. In view of the promising results obtained in the United States by Du Pont de Nemours & Co (1962) with linuron on grasses as a directed post-emergence spray, trials were conducted in Gisborne to determine crop tolerance and rates necessary to kill grass species, particularly barnyard grass (*Echinochloa crusgalli*).

Four trials were carried out in the Gisborne area and three in Hawke's Bay on sweet corn. Trials were conducted on growers' farms in the Gisborne district on clay loam soil types. All treatments were applied in 80 gal of water per ac. The Wisconsin Hybrid 643 maize seed was used. All plots had received at least two or three cultivations, which is the normal practice prior to the treatment being applied. In two trials the area had previously been sprayed with the amine salt of 2,4-D and the only problem was barnyard grass 6 to 15 in. high. The remaining two trials had not been treated with any hormone preparation. All plots, except where mentioned, were directionally sprayed. Table 1 gives a summary of the results obtained in the Gisborne area.

TABLE 1: TRIALS WITH MAIZE AND SWEET CORN, GISBORNE AREA

	Rate (lb)	Weed Control	Comments
Trial 1*	1	Poor	Barnyard grass not affected
	2	Good	Barnyard grass 50% reduction in height
(2 reps.)	3	Very good	90 to 95% kill of barnyard grass
	4	Very good	90 to 95% kill of barnyard grass
Control		Nil	
Trial 2*	1.5	Poor	Barnyard grass not affected
	2.5	Variable	50% reduction in height
(1 rep.)	3.5	Good	75% incomplete kill of barnyard grass estimated 75% control
Control		Nil	
Trials 3, 4†	1.5	Very good	No broadleaves; 75% reduction barnyard grass
	2.5	Excellent	No broadleaves; virtually complete kill of barnyard grass
(2 reps.)	3.5	Excellent	No broadleaves; virtually complete kill of barnyard grass
Control		Nil	

* Areas previously treated with amine salt of 2,4-D.

† Area treated with linuron only.

In the plots that were not treated with amine salt of 2,4-D, *Amaranthus* spp., fathen (*Chenopodium album*) and nightshade (*Solanum nigrum*) were present with equal proportions of barnyard grass.

One pre-emergence and two post-emergence trials in sweet corn in Hawke's Bay were sprayed on November 16 at 1, 2 and 4 lb, the main weeds present being as indicated in Table 1, with the addition of marshmallow (*Althaea officinalis*). No barnyard grass was present. All three rates gave excellent weed control and there was no apparent reduction in crop vigour.

Discussion

There was no apparent injury to the maize plants except where the plants had been sprayed unintentionally. Measurements of maize plants were taken at regular intervals, and there was no appreciable difference between the treated areas and control plots. Where linuron was applied to occasional maize plants, they showed early stunting but later recovered. No difference could be detected after three months between those in the control plot and those that had been stunted. It was very obvious from the trials that better control of barnyard grass was obtained when the grass was less than 8 in.

tall. In Trial 2 where the barnyard grass was up to 15 in. high, results were less satisfactory. This trial also showed that it was highly important to obtain an accurate directed spray below the maize plant so as to avoid contact damage.

It is evident from the results obtained, particularly in Gisborne, that there is very little difference between the tolerance to linuron of barnyard grass and the maize plant. It is interesting to note that the problem was overcome in U.S.A. by the introduction of specialized machinery. The results obtained in 1962 in U.S.A. by Du Pont de Nemours & Co. (1963) which have now become available, suggest that the addition of a surfactant (wetting agent) at $\frac{1}{2}$ to 1% v/v increases the effectiveness of linuron, allowing a reduction in rates. Results, also from U.S.A., suggest that diuron at 1.6 lb plus a surfactant at the above rate will also give foliage absorption, and trials will be carried out in 1963 to compare the two products. As a result of the control of weeds with 2,4-D over the past few years, barnyard grass has become a worse problem. It is probable that if the broadleaf weeds were left, these could be adequately controlled by a later application of linuron when spraying for barnyard grass could also be carried out. Trials 3 and 4 indicate that this is indeed a fact. No pre-emergence treatments were tried in the Gisborne area because past experience indicated that weather conditions were not suitable for this type of treatment.

CARROTS AND PARSNIPS

In carrots and parsnips pre-emergence trials were carried out in three areas. Excellent weed control was obtained and no crop damage was apparent. As a result of information received from Du Pont Co. (U.K.) Ltd (1963) regarding post-emergence treatments of carrots, trials were laid down at the two-leaf stage and results were outstanding.

Early experimental trials in the U.S.A. indicated that carrots show a high degree of tolerance to linuron both pre- and post-emergence. Pre-emergence trials were conducted at Ohakune and Pukekohe and the results are shown in Table 2. No post-emergence work was done until the report prepared by Du Pont Co. (U.K.) Ltd. (1963) was received. This report shows that $\frac{1}{2}$ lb gave satisfactory control of most weeds and it also indicated a high crop tolerance. Trials were carried out in the beginning of April 1963 and have not yet been concluded, but trials appeared so promising that the results from progress reports have been incorporated into the paper. The trials at Ohakune were carried out on a silt loam soil of volcanic ash origin. The carrots were sown on November 13, 1962, and sprayed the same day at a rate of 1 to 2 lb. The variety of carrot was Manchester Table and parsnip was Hollow Crown. Weeds controlled were *Amaranthus* spp., fathen, cornbind (*Polygonum convolvulus*) and redshank (*Polygonum persicaria*). Table 2 shows the measure of control obtained after 9 to 16 weeks.

TABLE 2: TRIALS WITH CARROTS AND PARSNIPS

Rate (lb)	Degree of Control	
	9 Weeks	16 Weeks
1	60% control willow weed present	40% control willow weed present
2	99% ; sorrel appearing	95% sorrel present

Sorrel (*Rumex acetosella*) mentioned in Table 2 was from regrowth. A replicated plot trial on carrots and parsnips was also carried out at Karioi, near Ohakune, on an extremely light volcanic ash soil at 1 to 2 lb. The trial was sprayed on November 13 and when inspected after nine weeks the weed control was excellent, and there

was only a trace of weed growth present, mainly Californian thistle (*Cirsium arvense*). However, this trial was terminated when the experimental area was sprayed over with carrot oil by mistake. After 16 weeks soil samples were taken from the plot trials carried out in the Ohakune district from a depth of 0 to 2 in. and 2 to 4 in. to determine residues of linuron remaining in the soil. Oats were sown into the samples of soil taken and indicated no residues in the soil.

A pre-emergence trial at Pukekohe was commenced on January 24, carrots having been planted two days earlier. After ten days no rain had fallen but 2 in. of spray irrigation water was applied. Rates used were ½, 1 and 2 lb. After two months there was no apparent damage at all rates. However, some speedwell (*Veronica arvensis*) had appeared at the ½ lb rate.

Post-emergence trials were commenced at the beginning of April 1963 and large-scale trials had been laid down at ½ lb and 1 lb. Varieties tried were Manchester Table, Touchen, and Spring Market. After two weeks control of the following species had been noted: twin cress (*Coronopus didymus*), fathen (up to 1 in. in height), speedwell, *Amaranthus* spp., *Poa annua*, spurrey (*Spergula arvensis*), marshmallow, groundsel (*Senecio vulgaris*). The only weed showing resistance is fumitory (*Fumaria officinalis*). There appeared to be no damage at either rate and the carrots were bigger than an adjacent carrot-oil-sprayed crop.

Discussion

The results above show linuron is undoubtedly a useful chemical tool for weed control in carrots and parsnips. The results obtained with post-emergence treatments on carrots are very promising. The deficiencies of other materials show that a broad spectrum post-emergence weedkiller such as linuron will indeed be very useful. It is intended to carry out extensive trials at one-true-leaf stage and to determine whether further sprays of linuron are needed during the later stages of the carrot growth. Indications from the United Kingdom are as follows: (a) if the weeds exceed 3 in. in height when carrots are past the two-true-leaf stage a higher rate, ¾ lb, will be required; (b) carrots may be sprayed at the one-true-leaf stage when the weeds do not exceed 3 in. in height at ½ lb.

FIELD BEANS

Soyabeans have been found to have good crop tolerance. Because of the relationship to french beans it was decided to carry out small plot trials to determine the crop tolerance and weed control with linuron as a pre-emergence treatment in Hawke's Bay.

Trials were laid down during the last season on a processor variety of beans in the Hawke's Bay district. The soil type in each case was a clay loam. The first trial of three replicates was sprayed on November 14 after the beans had been sown on November 7. The beans had begun germinating, but were still 1 in. deep. Results are summarized in Table 3.

It became evident during the second visit to the trials that the 2 and 3 lb rates were rather high. A second trial of three replications was laid down. The beans were sown on December 8 and sprayed on December 13 and evaluated four weeks later. The results are given in Table 4.

Discussion

It is apparent from the trials outlined in Tables 3 and 4 that the rate of 0.75 to 1.5 lb is all that is required to give acceptable weed control. However, crop tolerance varied in both trials, and yield trials will be necessary to establish crop tolerance.

TABLE 3: FIRST TRIAL WITH BEANS

Rate (lb)	Four Weeks		Eight Weeks	
	Weed Control	Crop Tolerance	Weed Control	Crop Tolerance
1	Excellent	Healthy, 5 in. high	Excellent	No apparent damage
2	Excellent	3 to 5 in. high, chlorosis evident on 1st leaves	Excellent	Healthy, no sign of chlorosis
4	Excellent	2 to 5 in., badly scorched, dead leaves	Excellent	Beans practically eliminated
Control	<i>Amaranthus</i> vigorous 5 in. high	2 to 5 in., healthy, not vigorous	Plots covered in weeds <i>Amaranthus</i> , fathen, marshmallow	Healthy

TABLE 4: SECOND TRIAL WITH BEANS

Rate (lb)	Weed Control	Crop Tolerance
0.75	Excellent	Normal
1.5	Excellent	Normal, some yellowing evident
2.25	Excellent	1st leaves affected, 2nd leaves apparently normal
Control	Weeds 4 in. high, nightshade, <i>Amaranthus</i>	Beans normal

PEAS

Initial pre-emergence trials were conducted and indicated crop safety and good weed control. However, because peas have a thicker cuticle than most annual weeds, it was decided to treat with linuron at low rates as a post-emergence spray at the four to six true-leaf stage. Initially the rates were too high but later trials indicated that very low rates of material gave satisfactory weed control without any apparent crop injury.

One post-emergence trial is reported on in Gisborne and two in Hawke's Bay, whilst another two pre-emergence trials were carried out, one in Canterbury and the other in Hawke's Bay. In the pre-emergence treatments, trials were carried out at 1, 1.25, 2, and 4 lb. The soil types were a clay loam and a heavy loam for the Hawke's Bay and Christchurch areas respectively. Weed control in the Canterbury area was good — especially fathen and spurrey; however, poor weed control was obtained of redshank, Californian thistle, and nightshade. In Hawke's Bay, 1 lb gave good control, 2 lb very good control, and 4 lb excellent control, and the crop was normal. In the control plot, fathen, nightshade, *Amaranthus* spp. and Californian thistle were present. The post-emergence trials carried out in Gisborne and Hawke's Bay are summarized in Tables 5 and 6. The variety was victory Freezer and the crops were all at the four-to six-true-leaf stage. Weeds varied between 1 and 3 in. in height, the major weed species being *Amaranthus* spp., nightshade and fathen. In the Gisborne trial there was also a good proportion of barnyard grass. There was no marked difference in maturity at all rates.

Discussion

It is evident from the trials carried out that there is not a great deal of crop tolerance. It is considered that the 0.25 lb rate gives results at least as good as the current weed control practice. Whilst

TABLE 5: TREATMENTS AND RESULTS WITH PEAS
IN HAWKE'S BAY

<i>Treatment (lb)</i>	<i>Weed Control</i>	<i>Crop</i>
1	Excellent	20% healthy, balance 1st leaf distorted
2	Excellent	Eliminated
4	Excellent	Eliminated
Control	90% <i>Amaranthus</i> , balance nightshade	Healthy
0.25 lb	Excellent, occasional <i>Amaranthus</i> spp.	Healthy
0.5 lb	Excellent, occasional <i>Amaranthus</i> spp.	Smaller than 0.25 lb rate, few distorted leaves
0.75 lb	Excellent, occasional <i>Amaranthus</i> spp.	25% population remained
Control	Weeds 15 in. high, sup- pression pea growth	Same as for 0.5 lb rate; no distortion

TABLE 6: TREATMENTS AND RESULTS WITH PEAS
AT GISBORNE

<i>Treatment (lb)</i>	<i>Grasses</i>	<i>Broadleaved Weeds</i>	<i>Crop</i>
(3 WEEKS)			
0.5	30% reduction	Dead	Bottom leaves show chloro- sis, minor reduction in number.
0.75	50% reduction	Dead	Increased damage.
1.0	60% reduction	Dead	50% reduction compared with control.
Control	Barnyard grass thriving	40% of population	Healthy but not vigorous due to weed competition.
(7 WEEKS)			
0.5	Barnyard grass 1 in. high	Dead	Peas appear normal, chlorosis still showing.
0.75	Barnyard grass 1 in. high	Dead	Some bottom leaves dead, otherwise normal.
1.0	Some control of barnyard grass	Dead	Definite 60% reduction in numbers
Control	Barnyard grass 12 to 18 in. high	40% of population	Healthy, but not vigorous.

no trials were compared with the current programme, the area alongside the trial was treated with dinoseb/MCPB mixture. It appeared as though linuron-treated peas were at least as healthy as an adjacent area treated with the mixture. It was apparent that weed control was better with linuron.

ACKNOWLEDGEMENTS

The following growers co-operated in the field trials: Messrs Gumbley, Cooper, Burland, Pardoe (Gisborne), Russell, McDougall (Pukekohe), Webb (Hawke's Bay), Foster and O'Neill (Ohakune). The writer is indebted to Gerald Krynen, Neill, Cropper and Co. Ltd., Wellington, for trial work in the Hawke's Bay area; Peter McKitterick, Neill, Cropper and Co. Ltd., Christchurch; to R. June and J. Renolf of J. Watties Canneries Ltd.; to New Zealand Foods Ltd., Hastings; R. B. Hudson and A. G. Rogers of E. I. Du Pont de Nemours and Co. Inc.

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