WEED CONTROL IN SUGAR BEET IN SOUTH OTAGO

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Summary

Field trials carried out for two seasons studied the efficiency of herbicides for weed control in sugar beet established and maintained without hand labour. Initial and final beet populations were sometimes reduced by cycluron/BiPC and propham/TCA although yield increases through good weed control were still maintained. Cycluron/BiPC and particularly pyrazon (applied post-emergence) were less efficient than propham/endothal and propham/TCA where spurrey (*Spergula arvensis*) and seedling grasses were the main weeds.

INTRODUCTION

IN AN EFFORT to establish a sugar beet industry, the South Otago Sugar Beet Investigation Company was formed to study the problems of beet production in the field. From 1963 to 1965, the Department of Agriculture, Invermay Research Station, undertook the weed control investigations involved during these field studies.

It is clear that control of weeds is of paramount importance in sugar beet crops established and maintained with low labour input. Early control of weeds is essential to enable close inter-row hoeing and thinning. Beet seedlings cannot tolerate competition and so early removal of weeds is essential.

One of the objectives of these investigations was to study the effect of herbicides on beet populations, established without hand labour. It is important to distinguish between establishment methods in this case, because it is feasible that, if a herbicide severely checks some seedlings and not others (through differences in depth, time of emergence, etc), an individual who is thinning by hand may make the decision to remove weak seedlings where a choice is possible, while a machine, of course, cannot (yet) make the decision between weak or strong seedling removal.

REVIEW OF CHEMICALS

Work reported from Europe on specific herbicides has been mainly concerned with a propham/endothal mixture, cycluron/BiPC, and pyrazon. The main points so far defined on the use of each material have been as follows:

PROPHAM/ENDOTHAL

Dosage is initially dependent on clay content of soils, thus the cost may be prohibitive on a clay loam. At least 0.125 in. rain is required within the first two weeks after drilling, earlier if drilling late in the season. The most resistant weeds are orache (*Atriplex* spp.), fathen (*Chenopodium album*), cleavers (*Galium* spp.), and probably crucifers such as wild turnip (*Brassica camprestis*).

TABLE 1: MECHANICAL ANALYSIS OF SOIL (BOUYOUCOS)

	1963–4				1964–5		
	Stirling	*Wangaloa*	*Hillend*	*Kaihiku*	*Wangaloa*	*Hillend*	*Clydevale*
Coarse sand ...	4	1	1	1	3	1	4
Fine sand	63	51	44	40	46	42	44
Silt	26	29	31	36	31	34	31
Clay	8	19	24	23	20	23	22

TABLE 2: SITE DETAILS AT TIME OF LAYING DOWN TRIALS

	1963–4			1964–5			
	Stirling	*Wangaloa*	*Hillend*	*Kaihiku*	*Wangaloa*	*Hillend*	*Clydevale*
Date of last cultivation	27.9.63	1.10.63	3.10.63	4.10.63	18.9.64	16.9.64	15.9.64 54°
Date beet sown	28.9.63	1.10.63 (p.m.)	3.10.63	5.10.63	19.9.64	17.9.64	16.9.64
Date sprayed:							
Pre-em.	1.10.63	2.10.63	3.10.63	5.10.63	21.9.64	17.9.64	16.9.64
Post-em.					30.10.64	30.10.64	30.10.64
Rainfall — 1 day later	Nil	Nil	0.02	Nil	0.07	0.13	Nil
Rainfall — 1 week later ...	0.07	0.02	0.05	0.18	0.17	0.44	0.44
Rainfall — 2 weeks later	0.11	1.46	1.51	1.49	0.41	0.66	0.51
3 in. soil temp. at spraying	43°	51	51	47	49	52	54
Post-em.	—	—	—	—	53	58	58

CYCLURON/BIPC

Dry conditions give unsatisfactory results, but rain-storms after application may cause yield reductions. A growth check occurs during the 2- to 4-leaf stage but yields are usually normal at harvest. Population density may be reduced before singling, but counts at harvest show no difference from controls. It should be applied only to friable soils of low organic matter, well prepared and moist to stimulate weed germination.

Resistant weeds are bindweed, orache, nettle, black nightshade, and dead nettle.

Residual activity is generally 40 days.

PYRAZON

Unlike the above two products, which can only be applied pre-emergence, pyrazon is best applied immediately before beet emergence or after the early cotyledon stage of beet but before the 4-true-leaf stage of weeds. Damage to beet may occur if sprayed in direct sunshine, with temperature above 77°F and R.H. 80 to 90%.

There is good control of most common weeds including fathen, but wild turnip, fumitory (*Fumaria officinalis*) and cleavers are only moderately susceptible.

Established perennial weeds are resistant to all the above materials.

The present study is reported in two parts — (a) 1963–4 and (b) 1964–5. The 1963–4 trials concentrated principally on an evaluation of propham-endothal and cycluron/BiPC with only a preliminary examination of pyrazon; while in 1964–5 propham/endothal and cycluron/BiPC were compared with pyrazon and a mixture of propham and TCA (trichloracetic acid).

MATERIALS AND METHOD

Four field trials were carried out in 1963–4 and three in 1964–5, and a pilot trial was also carried out in 1963–4. All were laid down in South Otago.

Mechanical analyses of soil from each site are shown in Table 1.

Each season's trials were of standard design and were taken through to harvest. The treatments (in lb active ingredient per acre) were as follows:

1963–4: Pre-emergence:

1.	Cycluron/BiPC	1.5
2.	Cycluron/BiPC	2.0
3.	Propham/Endothal	6.8
4.	Propham/Endothal	9.1
5.	Control (untreated)	

1964–5 Pre-emergence:

1.	Endothal/Propham	9.1
2.	Cycluron/BiPC	2.0
3.	Propham 3/TCA 6	
4.	Propham 4.5/TCA 9	

Post-emergence:

5.	Pyrazon	2.5
6.	Pyrazon	3.5
7.	Control (untreated)	

Table 2 shows the relevant details for each site at the time of laying down the trials.

All treatments were applied in 30 gal water per acre through a modified Oxford precision sprayer. Sharpes Klein E seed of constant grade, rubbed and graded, was sown in 20 in. rows using a Stanhay precision seeder throughout all trial areas, spacing 1½ in.

Inter-row hoeing was carried out using a "Stanhay" hoe while a "Hudson" rotary thinner was used for mechanical thinning.

Germination counts were made by recording the number of beet-containing inches on a 50 in. rod placed at random 10 times in each plot.

Visual assessments of weed control values were made by three observers, using the following scale 1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = very good weed control.

Beet vigour was assessed using a similar numerical scale.

The trials were harvested in June of each year by a Catchpole Cadet harvester. Washed and cleaned root yields were recorded together with the number of roots per plot. Samples from each treatment in 1963–4 were sent to the British Sugar Corporation, England, for the determination of any herbicide effect on purity.

1963–4 RESULTS

The number of beet-containing inches per hundred inches of row for each site are shown in Table 3.

TABLE 3: BEET-CONTAINING INCHES PER 100 in. OF ROW

Treatment (lb) *Date counted*	*Stirling* *25.10.63*	*Wangaloa* *25.10.63*	*Hillend* *5.11.63*	*Kaihiku* *5.11.63*
Cycluron/BiPC 1.5	36.3 aAB	36.2 aA	35.8 a	39.6 aA
Cycluron/BiPC 2.0	33.1 bB	33.1 bA	35.9 a	34.8 bA
Propham/Endothal 6.84	36.9 aAB	35.8 aA	35.8 a	39.5 aA
Propham/Endothal 9.12	36.3 aAB	35.3 abA	35.6 a	37.7 abA
Control	38.6 aA	35.9 aA	36.9 a	37.4 abA
CV	4.8%	5.1%	6.3%	6.2%
Main Effects:				
Cycluron/BiPC	34.7 bA	34.7 a	35.9 a	37.2 a
Propham/Endothal	36.6 aA	35.5 a	35.2 a	38.6 a

Only at Hillend was the growth of beet poor, the population here consisting mainly of prostrate rosettes of beet with a harsh or hard appearance to the foliage.

Cycluron/BiPC at 2.0 lb significantly reduced the plant population in three trials when compared with propham/endothal and in two when compared with control. In one trial (Stirling) the reduction by the cycluron/BiPC group was significant when compared with the propham/endothal group.

An assessment of beet vigour on all sites was also made on November 5, 1963. There were no differences in vigour at Hillend, but cycluron/BiPC reduced vigour particularly on the high rate at all other sites as shown in Table 4.

Gradings for weed control are shown in Table 5. The site at Hillend was exceptionally clean and no grading was carried out.

A further inspection on January 14, 1964, indicated that the weed control picture was essentially the same as that shown by assessments on November 5, 1963.

TABLE 4: BEET VIGOUR, NOVEMBER 5, 1963

Treatment (lb)	*Stirling*	*Wangaloa*	*Kaihiku*
Cycluron/BiPC 1.5	2.7 bB	3.6 bB	3.1 cBC
Cycluron/BiPC 2.0	2.6 bB	2.7 cB	2.4 dC
Propham/Endothal 6.84	4.4 aA	3.5 bB	3.8 bB
Propham/Endothal 9.12	4.0 aA	3.4 bB	3.9 bB
Control	4.8 aA	4.9 aA	5.0 aA
CV	15.2%	13.4%	11.7%
Main effects:			
Cycluron/BiPC	2.6 bB	3.1 a	2.7 bB
Propham/Endothal	4.2 aA	3.4 a	3.8 aA

TABLE 5: WEED CONTROL ASSESSMENTS, NOVEMBER 5, 1963

Treatment (lb)	*Stirling*	*Wangaloa*	*Kaihiku*
Cycluron/BiPC 1.5	4.3 abAB	4.0 bB	2.8 cC
Cycluron/BiPC 2.0	4.8 aA	4.5 bAB	3.9 bB
Propham/Endothal 6.8	3.3 bBC	4.1 bB	4.2 abAB
Propham/Endothal 9.1	3.8 bAB	5.0 aA	4.7 aA
Control	2.1 cC	1.1 cC	1.0 dD
CV	18.2%	10.1%	9.3%
Main effects:			
Cycluron/BiPC	4.6 aA	4.2 a	3.6 bB
Propham/Endothal	3.5 bB	4.6 a	4.5 aA

The weed population at Stirling consisted of variable quantities of fathen, docks (*Rumex* spp.) (mainly seedlings), annual grasses (*Poa annua*), shepherd's purse (*Capsella bursa-pastoris*) and chickweed (*Stellaria media*) with a total weed cover of 10%. All treatments reduced the fathen population, the high rate of cycluron/BiPC being most efficient — while the high rate of propham/endothal was the most efficient in controlling seedling docks.

Poa annua was the main weed at Wangaloa, with some spurrey and shepherd's purse. Ground cover by weeds in the 5 replicates of control was 75, 60, 90, 80 and 90%, respectively: all treatments gave good control, there being no tendency for any particular weed species to survive certain treatments.

At Kaihiku the principal weed was spurrey with only small quantities of shepherd's purse, fathen, *Poa annua* and chickweed. Ground cover by weeds in the 4 replicates of control was 30, 35, 50 and 30%, respectively. Mean percentage weed cover with cycluron/BiPC 1.5 and 2.0 lb, propham/endothal 6.8 and 9.1 lb was 18, 9, 6 and 0%, respectively.

Table 6 shows the yield of beet in tons/acre. Apart from Hillend where there were no yield differences, all treatments resulted in significantly greater yields (often at the 1% level) than control. There were no significant differences between sprayed treatments except at Wangaloa where the high rate of cycluron/BiPC yielded less than the high rate of propham/endothal.

Ultimate or final plant populations as affected by herbicidal treatment and/or variation in weed control efficiency are shown in Table 7 which gives the number of beet/acre at the time of harvest.

TABLE 6: YIELD OF CLEAN BEET IN TONS/ACRE

Treatment (lb) *Date harvested*		*Stirling* *18.6.64*	*Wangaloa* *13.5.64*	*Hillend* *27.5.64*	*Kaihiku* *24.4.46*
Cycluron/BiPC	1.5	24.8 aAB	18.3 abA	11.9 a	14.6 aA
Cycluron/BiPC	2.0	26.8 aA	16.3 bA	10.8 a	16.3 aA
Propham/Endothal	6.8	26.3 aA	18.1 abA	11.7 a	15.4 aA
Propham/Endothal	9.1	24.9 aAB	19.7 aA	11.8 a	16.8 aA
Control		21.6 bB	12.0 cB	11.1 a	9.8 bB
CV		5.8%	12.3%	7.0%	10.7%
Main effects:					
Cycluron/BiPC		25.8 a	17.3 a	11.4 a	15.4 a
Propham/Endothal		25.6 a	18.9 a	11.7 a	16.1 a

TABLE 7: NO. OF BEET/ACRE AT TIME OF HARVEST

Treatment (lb)	*Stirling*	*Wangaloa*	*Hillend*	*Kaihiku*
Cycluron/BiPC 1.5	36,600 a	45,000 abAB	34,700 bcAB	51,300 aBA
Cycluron/BiPC 2.0	39,700 a	44,200 bcBC	32,200 cB	47,000 bA
Propham/Endothal 6.8	42,000 a	54,000 aA	39,000 aA	55,300 aA
Propham/Endothal 9.1	40,100 a	51,100 aAB	36,900 abAB	55,000 aA
Control	42,300 a	39,800 cC	40,600 aA	54,100 aA
CV	8.9%	8.1%	7.1%	7.6%
Main effects:				
Cycluron/BiPC	38,100 a	46,600 bB	33,400 bB	49,200 bA
Propham/Endothal	41,100 a	52,600 aA	38,000 aA	55,100 aA

In three trials, the high rate of cycluron/BiPC significantly reduced final plant populations and in one trial (Hillend) the low rate also gave a reduction. Populations were reduced at Stirling, but this was not significant and, apart from this trial, the overall comparison of the two herbicides shows that cycluron/BiPC is significantly lower than propham-endothal at all times.

No sugar determinations were made on treated beet (there is little published evidence of any herbicide effect on sugar content).

1964–5 RESULTS

Propham/endothal had no significant effect on initial plant population at any site (see Table 8). Cycluron/BiPC caused a reduction at Hillend and Clydevale, the reduction at Clydevale being significant. Propham/TCA also tended to reduce populations, but only when compared with propham/endothal at Clydevale: however, the high rate gave a significant reduction at Hillend. At Wangaloa there were no effects on population: at this site pyrazon (post-emergence) treatments were also counted and populations were normal. Pyrazon treatments were not counted at other sites as it was thought that they had not had sufficient time for treatment to take full effect.

TABLE 8: BEET-CONTAINING INCHES PER 100 in. OF ROW (as at October 28, 1964)

Treatment (lb)	*Wangaloa*	*Hillend*	*Clydevale*
Propham/Endothal	31.8 a	33.3 aA	32.1 aA
Cycluron/BiPC	32.0 a	29.7 abA	27.6 bA
Propham/TCA 3:6	31.3 a	29.4 abA	29.4 abA
Propham/TCA 4½:9	31.1 a	28.2 bA	29.3 abA
Pyrazon 2.5	31.6 a	Not counted	Not counted
Pyrazon 3.5	30.3 a	Not counted	Not counted
Control	32.1 a	32.6 aA	29.9 abA
CV	5.5%	8.6%	6.9%

Differences in beet vigour at Wangaloa were small, although they were significant, while at Clydevale only cycluron/BiPC caused a marked and significant drop in beet vigour (Table 9). However, at Hillend where growing conditions and fertility are generally poorer, the crop was more sensitive to weedkiller effect, and both cycluron/BiPC and the high rate of propham/TCA caused highly significant reductions in beet vigour. Pyrazon 3.5 lb was significantly poorer than endothal/propham.

TABLE 9: BEET VIGOUR, NOVEMBER 4, 1964

Treatment (lb)	*Wangaloa*	*Hillend*	*Clydevale*
Propham/Endothal	4.2 abA	4.7 aA	4.2 aA
Cycluron/BiPC	4.5 abA	2.9 cdB	2.7 bB
Propham/TCA 3:6	4.5 abA	3.8 abcAB	3.9 aAB
Propham/TCA 4½:9	4.2 bA	2.5 dB	3.8 aAB
Pyrazon 2.5	4.5 abA	3.8 abcAB	4.1 aA
Pyrazon 3.5	4.2 bA	3.7 bcAB	4.6 aA
Control	4.8 aA	4.5 abA	4.4 aA
CV	7.7%	16.3%	14.7%

TABLE 10: WEED CONTROL ASSESSMENTS AS AT NOVEMBER 4, 1964

Treatment (lb)	*Wangaloa*	*Hillend*	*Clydevale*
Propham/Endothal	4.5 aA		4.7 aA
Cycluron/BiPC	3.0 bB		4.9 aA
Propham/TCA 3:6	4.6 aA	WEED	4.7 aA
Propham/TCA 4½:9	4.8 aA		5.0 aA
Pyrazon 2.5	2.0 cC	FREE	1.9 cB
Pyrazon 3.5	1.9 cC		2.7 bB
Control	1.0 dD		2.0 bcB
CV	10.7%		12.1%

At Wangaloa, the main weed, spurrey, provided 60 to 90% ground cover, together with a very small percentage of seedling thistles (*Cirsium* spp.), hawkbit (*Leontodon hispidus*), seedling dock and white clover (*Trifolium repens*). Both endothal/propham and propham/TCA mixtures gave very good weed control while cycluron/BiPC was significantly poorer (Table 10). Both rates of pyrazon checked spurrey in vigour and caused some leaf tip scorch, but it did not eliminate spurrey sufficiently for the row of beet to be easily defined for precision hoeing.

At Hillend the trial area was virtually weed-free. Spurrey was the main weed at Clydevale, although its cover, estimated at 20%, was not as dense as at Wangaloa. Probably because of this, cycluron/BiPC gave as efficient weed control as did propham/endothal and propham/TCA. Pyrazon at both rates only checked the spurrey and scorched the leaf tips. At Wangaloa all treatments gave highly significant increases in yield (Table 11); propham/endothal was the most efficient, but there were no significant differences between the remaining treatments. In addition, all treatments significantly increased ultimate plant population (Table 12), the propham/endothal and propham/TCA mixtures showing marked effect in this case (Table 12).

TABLE 11: YIELD OF CLEAN BEET IN TONS/ACRE

Treatment (lb)	*Wangaloa*	*Hillend*	*Clydevale*
Propham/Endothal	17.2 aA	15.3 aA	23.5 abA
Cycluron/BiPC	15.4 abAB	12.9 bA	20.2 abA
Propham/TCA 3:6	15.7 abAB	15.6 aA	23.7 abA
Propham/TCA 4½:9	14.6 bAB	15.2 aA	22.8 abA
Pyrazon 2.5	14.1 bAB	15.4 aA	19.5 abA
Pyrazon 3.5	13.8 bB	15.4 aA	24.4 aA
Control	9.5 cC	14.9 aA	18.8 bA
CV	10.2%	8.6%	13.7%

TABLE 12: NUMBER OF BEET/ACRE AT TIME OF HARVEST

Treatment (lb)	*Wangaloa*	*Hillend*	*Clydevale*
Propham/Endothal	47,800 a	46,000 aA	49,500 aA
Cycluron/BiPC	43,100 b	31,000 cB	37,800 cB
Propham/TCA 3:6	47,100 ab	43,000 abA	45,100 abAB
Propham/TCA 4½:9	47,600 ab	37,800 bAB	41,800 bcAB
Pyrazon 2.5	43,400 b	44,600 aA	46,400 abAB
Pyrazon 3.5	44,200 b	42,700 abA	47,000 abAB
Control	37,300 c	46,000 aA	47,000 abAB
CV	7.7%	9.2%	9.5%

Beet yields at Hillend, which can be regarded as a tolerance trial, were reduced only by cycluron/BiPC. Ultimate plant populations closely indicate beet tolerance to the herbicides: propham/endothal, the low rate of propham/TCA and pyrazon all had no significant effect on beet numbers, while the high rate of propham/TCA gave a significant reduction and the reduction from cycluron/BiPC was highly significant.

Probably because of the lower weed intensity at Clydevale than at Wangaloa, there was less response to treatment and only pyrazon 3.5 lb gave a significant increase in yield. However, both propham/endothal and propham/TCA gave high though non-significant yield increases. Beet numbers fluctuated less than yields in this trial, thus only cycluron/BiPC failed to maintain plant population.

DISCUSSION

As may be expected with a crop such as sugar beet, which is rather sensitive to minor differences in season and variabilities in soil or seedbed, it is difficult to detect any correlations between the two seasons' results except where major effects are present. Comparison between the two seasons is also rendered more complicated by the fact that mechanical inter-row hoeing of the trials was delayed in 1964–5 to allow post-emergent pyrazon applications to take full effect on beet and weeds: whereas in 1963–4 mechanical hoeing was early and up-to-date with work in the associated paddock-scale trials.

It is evident that cycluron/BiPC may on occasions reduce both initial and final beet populations. When considered in conjunction with the significant reduction in beet yield at Hillend in 1964–5 (which being a weed-free site is therefore a tolerance trial), it is clear that sugar beet is not fully tolerant to cycluron/BiPC. On the other hand, reductions in plant populations are not necessarily reflected in lower root yields as is evident in the other trials reported here where good husbandry has prevailed and yields are significantly better than controls or similar to other less phytotoxic treatments.

Apart from some reduction in beet seedling vigour 4 to 5 weeks after spraying at two sites in 1963–4, there is little indication that beet is other than highly tolerant to propham/endothal, provided the dose range is adjusted to compensate for varying levels in the silt plus clay fraction of the site, as indicated by Caldicott (1962). Physical analysis of the soils involved in this study showed that there was little difference in the silt plus clay fraction for all sites except Stirling (1963–4).

Similarly, both initial and ultimate plant populations plus beet vigour indicate that beet is highly tolerant to pyrazon applied post-emergence. However, this tolerance is not always reflected as clearly in higher beet yields as is propham/endothal, because pyrazon is less efficient in controlling certain weeds.

As with cycluron/BiPC, beet is not fully tolerant to propham/TCA, there being significant reductions in plant population and beet vigour at the high rate under test at Hillend. Examination of this mixture was prompted by the predominance in 1963–4 trials of weeds such as spurrey and *Poa annua*. It is known that both propham and TCA are reasonably efficient in controlling such weeds, and this mixture holds economic attractions because TCA is considerably cheaper than the endothal component contained in the commercial mixture of propham/endothal. Previous work at Invermay Research Station (I.R.S. Annual Reports 1962, 1963, 1964) had shown that mangolds were tolerant to a propham/TCA mixture at the ratio tested in these trials.

Weed control values by the three combinations, cycluron/BiPC, propham/endothal and propham/TCA were, in general, good. In 1963–4 cycluron/BiPC gave better results where fathen, seedling docks, shepherd's purse, chickweed and wireweed (Stirling) were present, but was at a disadvantage on the medium fertility sites

(Wangaloa and Kaihiku) where spurrey and seedling grasses were the main problem. Both weedy sites (Wangaloa and Clydevale) in 1964–5 were of medium fertility dominated by spurrey and annual grasses; here again propham/endothal was the most efficient, the substitute mixture propham/TCA was similar in efficiency, while pyrazon was rather poor.

However, propham/endothal, propham/TCA and cycluron/BiPC are not a reliable or satisfactory answer where dense populations of fathen occur and resort must be made to pyrazon which is selective for fathen control in beet crops (Fischer, 1962; Lhoste *et al.*, 1963). A pilot trial carried out in 1963–4, but not reported in this paper, indicated that acceptable control of dense fathen could be achieved by post-emergence application of pyrazon. However, there were indications that wireweed control might not be satisfactory, while seedling grasses and spurrey were partially resistant.

These latter indications were confirmed in 1964–5 trials (Clydevale and Wangaloa), where pyrazon did not eliminate spurrey and seedling grasses sufficiently well in the early stages to clearly define the row for precision hoeing which is the prerequisite for successful mechanical thinning.

From this work and others reported overseas, it seems that pyrazon will not be a panacea for all weed problems, and so it is evident that good and economic weed control over a range of weed/crop situations in sugar beet establishment will depend on the successful prediction (*i.e.*, at the time the crop is sown) as to which weed species are likely to occur in that particular paddock.

Field data indicate that highly significant, worthwhile and presumably profitable increases in yield result from successful control of weeds in this crop. In addition, there are other advantages stemming from good weed control — *i.e.*, improved efficiency of steerage hoes, and mechanical thinners, together with improvements in harvesting speed and efficiency when using complete mechanical harvesting techniques.

These investigations were not designed to identify any interaction between the use of herbicides and either the establishment and maintenance of the crop by mechanical methods, or the more traditional system of using hand labour for thinning and subsequent hand-weeding. Nevertheless the scale of yield increases often encountered in these trials (where no hand labour was used at all) indicate that there is not likely to be any incompatibility between the use of chemicals for weed control and the complete mechanization of beet production.

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