WEED CONTROL IN VEGETABLES

By A. B. WEBSTER, Department of Agriculture, Levin

SUMMARY

EXPERIMENTS with 23 herbicides on 11 kinds of vegetable at different stages of growth are described and results are given. A logarithmic plot sprayer was used in most of the trials. Conclusions are drawn from trials with older products and indications of the usefulness of newer materials are given. It appears that the best selective herbicides for vegetables will be found among the substituted triazines. Of those used the most promising are propazine and ipazine.

This paper summarises the results that have been obtained in experiments on the use of herbicides on vegetable crops during the past two seasons at the Horticultural Research Station, Levin. The bulk of the work was done during the 1960-61 season using a logarithmic plot sprayer. Other work includes yield trials on carrots and cabbage during 1959-60 and trials with SMCA on several brassicas in 1960-61. The materials used in the trials are listed in Table 1.

All the materials listed in Table 1 and 2 were used on nine vegetable crops—beetroot, carrots, cabbage, french beans, lettuce, onions, peas, sweet corn, and turnips—sown at the end of September. EPTC and 2,6-DBN were sprayed on to the soil and rotary-hoed in 1 in. deep before the seed was sown. All the other germinating-seed herbicides plus 2,6-DBN were applied the day after sowing. The non-selective contact herbicides were applied six days after sowing the seed and the selective contact materials four weeks after sowing, when the weeds were nearly 3 in. high. All the materials in these experiments and those on tomatoes and celery were applied with a logarithmic plot sprayer at 36 gallons per acre at 2 m.p.h. The sprayer had an 8-1 dilution ratio. All treatments were in duplicate. The weather was fairly dry after all applications.

Tomatoes and celery were sprayed with a selection of materials (a) two weeks after planting, (b) a day after planting, and (c) a day before planting. The applications were given in duplicate. The weather was very dry for several weeks after planting. This is rather unusual, especially with celery, which is usually watered. The lack of moisture in our trials could well have affected the results and made certain treatments appear more favourable than they really are.

The yield trials on carrots and cabbage were sown and planted respectively in August and September 1959.

All the experiments mentioned in this paper were on Levin silt loam (type No. 76).

The weed population was fairly constant over the whole of the experimental area and included:

Spurrey (*Spergula arvensis*)
Redshank (*Polygonum persicaria*)
Twin cress (*Coronopus didymus*)
Fumitory (*Fumaria officinalis*)
Fathen (*Chenopodium album*)
Groundsel (*Senecio vulgaris*)
Broad-leaved plantain (*Plantago major*)
Black nightshade (*Solanum nigrum*)
Speedwell (*Veronica* sp.)
Thistle seedlings (*Cirsium* sp.)
Docks (*Rumex* sp.)
Grasses (chiefly *Poa annua*)
Chickweed (*Stellaria media*)

The list gives the weeds in their approximate order of prevalence. In the results only species which are resistant to the various materials are noted.

TABLE 1—RATES OF HERBICIDES WHICH ALLOWED NORMAL CROP GROWTH IN LB A.I. PER ACRE. MEAN OF TWO REPLICATES

Material	Beetroot	Carrot	Cabbage	French bean	Lettuce	Onion	Pea	Sweet corn	Turnip	Celery	Tomatoes
Chlorpropham	5.1	8.5	5.4	8.2	7.4	8.2	6.3	8.2	6.6	1 7.0	1 5.0
CDEC	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	1 16.8	16.0
CDAA	17.5	14.3	16.4	16.4	—	17.6	17.0	16.4	17.6	1, 2 16.9	x
Amiben	4.3	5.6	5.4	8.4	4.4	4.8	—	8.4	6.2	1, 2, 3 8.3	1, 2 8.0
Fenuron	3.2	3.0	2.0	2.6	—	3.4	2.6	2.0	2.0	1, 2 4.3	x
Monuron	—	—	—	—	—	—	2.2	—	—	x	x
Diuron	3.8	3.8	—	3.8	—	—	4.2	3.8	3.1	x	x
Neburon	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	x	1, 2, 3 4.2
Simazine	1.0	0.6	0.8	1.0	0.6	0.8	1.3	2.8	1.2	x	1 4.3
Atrazine	0.4	0.5	0.7	0.8	0.4	0.6	1.9	4.2	0.5	x	—
Propazine	0.6	1.4	1.1	0.9	0.3	1.2	1.6	4.0	0.7	x	1, 2 4.1
Trietazine	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	1, 2, 3 4.3	1 4.2
Ipazine	0.8	2.0	1.6	1.2	0.4	1.7	2.6	4.2	0.8	1, 2, 3 4.4	1 2.0
OMU/BIPC	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	x	x
2,6-DBN post-s	—	—	2.8	4.3	—	1.1	4.2	3.3	2.6	1 5.3	1 8.6
2,6-DBN pre-s	—	—	0.7	1.3	—	—	1.5	1.0	0.7	x	x
EPTC	6.2	7.9	10.4	5.8	—	—	5.0	11.0	13.1	x	x
Endothal	2.6	3.0	1.0	2.5	1.5	3.0	2.2	2.5	1.0	x	x
PCP	6.3	6.4	0.7	6.7	6.4	6.5	6.8	7.1	0.6	x	x
SMCA	—	21.4	30.8	—	—	—	16.4	15.4	30.8	x	x
Dacthal	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	1, 2, 3 8.1	1, 3 8.0
Dicryl	3.0	8.2	3.7	1.2	—	4.9	1.8	—	5.8	1, 2, 3 8.4	3 8.0
Karsil	—	8.2	—	—	—	1.4	2.9	—	—	1, 2, 3 8.2	8.4
Solan	—	8.0	1.1	3.5	4.9	4.6	5.6	2.5	2.2	1, 2, 3 8.5	1, 2, 3 8.7

1 = applied two weeks after planting
2 = applied one day after planting
3 = applied one day before planting
All readings were taken two months after application of herbicides.

RESULTS

The results of the trials were observed over a period of two months or more, after application of the herbicide. They are summarised in Tables 2, 3 and 4 and then the best materials for each crop are briefly discussed.

It must be emphasised that these were preliminary trials and the results are an indication only. Further detailed yield trials comparing the most promising materials at three rates each with a hand weeded control must be carried out on different soil types and under different weather conditions before firm recommendations can be given.

TABLE 2—RATES OF HERBICIDES WHICH GAVE VARIOUS DEGREES OF WEED CONTROL AFTER TWO MONTHS IN LB A.I. PER ACRE

Material	In seedbed Complete	Good	Effective	Tomato Good	Celery Good
Chlorpropham	7.6	4.1	2.0	0.7	3.0
CDEC	—	—	16.0	1.2	10.0
CDAA	18	18	14	—	9.5
Amiben	7.8	3.8	2.5	0.6	3.6
Fenuron	3.8	3.4	2.5	—	1.25
Monuron	—	—	4	—	—
Diuron	—	—	4.2	—	—
Neburon	—	—	4.2	0.3	—
Simazine	1.3	0.6	0.5	0.5	—
Atrazine	0.7	0.5	0.3	0.3	—
Propazine	1.6	0.8	0.5	0.4	—
Trietazine	—	—	4.0	0.3	1.0
Ipazine	2.1	0.6	0.4	0.3	1.0
OMU/BIPC	—	—	2.0	—	—
2,6-DBN post-s	5.8	2.1	1.6	0.9	2.8
2,6-DBN pre-s	3.3	1.0	0.6	—	—
EPTC	13	10	7	—	—
Endothal	2.0	1.4	1.0	—	—
PCP	3.2	2.7	1.1	—	—
SMCA	32.0	26.0	19.5	—	—
Dacthal	—	—	8.0	0.6	—
Dicryl	8.1	7.7	4.0	0.6	1.7
Karsil	7.7	1.3	0.8	1.0	1.2
Solan	—	—	8.0	0.6	1.3

BEETROOT

There has never been a suitable herbicide for this crop and our experiments have not pointed the way to any startling development. Quite a few materials have been noted as being possible, but in all cases there is only a small difference between the rates which effectively control the weeds and those which kill the crop.

The materials which showed some promise were CDAA, fenuron, monuron, diuron, simazine, atrazine, ipazine, and dicryl. Possibly the answer to this problem lies in a mixture of a substituted urea and a substituted triazine; that is diuron and simazine or ipazine.

CABBAGE SEEDBED

Very good results were obtained with ipazine at ½ to ¾ lb a.i. per acre and SMCA at 20 lb a.i. per acre. Fathen was resistant to SMCA at this rate while twin cress and spurrey were not completely killed.

Good results were obtained with CDAA and propazine and fairly good results with amiben, atrazine, 2,6-DBN applied at least one week pre-sowing and dicryl.

Further work should be done with ipazine and possibly propazine.

CARROTS

Chlorpropham at 4 lb a.i. per acre, amiben at 4 lb a.i. per acre, propazine at ¾ to 1 lb a.i. per acre, and ipazine at rates similar to propazine gave very good results. In a previous yield trial chlorpropham was the only chemical herbicide to equal the yield of the hand weeded control. In the same trial amiben at 4 lb a.i. per acre checked the newly germinated seedlings, though this has not been noted elsewhere. Propazine and ipazine will replace chlorpropham for this crop if they can be shown to be less affected by weather and soil conditions.

Other germinating-seed herbicides which showed some promise were diuron, atrazine, and EPTC, but there was not as large a difference between

TABLE 3—SUITABILITY OF VARIOUS SELECTIVE HERBICIDES FOR VEGETABLE CROPS

	Beetroot	Carrot	Cabbage	French beans	Lettuce	Onion	Pea	Sweet corn	Turnip	Celery	Tomatoes
Chlorpropham	U	xxx	U	xxx	xx	xxx	xx	xxx	U	U	x
CDEC	U	U	U	U	U	U	U	U	U	xx	xx
CDAA	x	U	xx	xx	U	U	xx	xx	U	xx	—
Amiben	U	xxx	x	xxx	U	x	U	xxx	x	x	x
Fenuron	x	U	U	U	U	U	U	U	U	x	—
Monuron	x	U	U	U	U	U	U	U	U	—	—
Diuron	x	x	U	x	U	U	x	x	U	—	—
Neburon	U	U	U	U	U	U	U	U	U	—	xxx
Simazine	xx	U	U	xx	U	U	xx	xxx	xx	—	x
Atrazine	x	x	x	x	x	x	xx	xxx	x	—	U
Propazine	U	xxx	xx	xx	U	xxx	xxx	xxx	U	—	xxx
Trietazine	U	U	U	U	U	U	U	U	U	xxx	xx
Ipazine	x	xxx	xxx	xxx	U	xxx	xxx	xxx	x	xxx	xx
OMU/BIPC	?	?	?	?	?	?	?	?	?	—	—
2,6-DBN post-s	U	U	U	xx	U	xx	xx	xx	xx	x	x
2,6-DBN pre-s	U	U	x	xx	U	U	xx	xx	x	—	—
EPTC	U	x	U	x	U	U	U	x	x	—	—
Endothal	U	x	U	U	U	x	U	U	U	—	—
PCP	U	U	U	U	U	U	U	U	U	—	—
SMCA	U	x	xxx	U	U	U	U	U	xxx	—	—
Dacthal	U	U	U	U	U	U	U	U	U	U	x
Dicryl	x	xxx	x	U	U	x	U	U	x	xxx	U
Karsil	U	xxx	U	U	U	U	xxx	U	U	xxx	U
Solan	U	xxx	U	x	U	x	x	U	x	xxx	xxx

xxx = Very good
xx = Good
x = Fair
U = Useless
? = Not tried at high enough rate
— = Not tried

rates which killed crop and weeds as in those mentioned above.

Endothal gave good results at 2 lb a.i. per acre when applied eight days after sowing, but see comments about this material under onions.

Carrots showed great resistance to dicryl, karsil, and solan even at the highest rates applied, 8 lb a.i. per acre. Broad-leaved plantain, twin cress, *Poa annua,* and groundsel were resistant to dicryl. They were not killed at 4 lb a.i. per acre, while other weeds were controlled at 2 lb a.i. per acre. Twin cress was resistant to karsil up to 7.3 lb a.i. per acre; groundsel was resistant up to 6.9 lb a.i. per acre and spurrey up to 1.5 lb a.i. per acre. Other weeds were killed at 0.8 lb a.i. per acre. Solan did not control spurrey and twin cress at 8 lb a.i. per acre, though other weeds were controlled at 4 lb a.i. per acre. The choice between these three materials would appear to depend on the weeds present—and on the price—bearing in mind that only 1½ to 2 lb a.i. per acre are needed of karsil as against 3 to 5 lb a.i. per acre of the other two.

SMCA gave quite good results at about 15 lb a.i. per acre, but not as good as those given by the last three materials mentioned above.

FRENCH BEANS

Very good results were obtained with amiben at 4 lb a.i. per acre, chlorpropham at 4 lb a.i. per acre and ipazine at ¾ lb a.i. per acre. The safety margin with the last material was not quite as good as with the first two, but was probably sufficient for commercial usage.

Materials which gave good results included CDAA, simazine, propazine, and 2,6-DBN applied both pre- and post-sowing. Fairly good materials were diuron, atrazine, EPTC, and solan; 2,6-DBN would give very good results where spurrey is no problem.

LETTUCE

The only two materials to show any promise of usefulness with sown lettuce were chlorpropham and atrazine. Chlorpropham was good, but previous experience has shown that heavy rain after application can cause serious damage. Atrazine was fairly effective, but there was only a small difference between the rates which allowed good growth and which gave good weed control.

ONIONS

CIPC at 4 lb a.i. per acre and propazine and ipazine at ½ to 1 lb a.i. per acre gave the best results. However experience has shown that CIPC at rates much lower than 4 lb a.i. per acre can be lethal to onions if an application is followed by very wet weather.

Another germinating-seed herbicide which did quite well was 2,6-DBN at 1½ to 2 lb a.i. per acre applied post-sowing. Others which warranted further investigation were amiben and atrazine.

Endothal gave good results at rates of about 2 lb a.i. per acre, but this type of weedkiller is apt to be difficult to apply because of inclement weather at the crucial time, and endothal is not the cheapest material of this type.

Both dicryl and solan showed promise of being useful post-emergence selective herbicides for this crop, but further work needs doing before a true assessment of their worth can be made.

The results obtained with ipazine are such that this material should be actively investigated as a selective weedkiller for this crop on a series of soil types and under different climates.

PEAS

Ipazine and propazine gave very good results, as did karsil. Suitable rates would probably be ¾ lb a.i. per acre for ipazine, ¾ to 1 lb a.i. per acre for propazine, and about 1½ lb a.i. per acre for karsil. Of these three materials ipazine had the biggest safety margin.

Other materials which were good included chlorpropham, CDAA, simazine, atrazine, and 2,6-DBN. The last named could be applied either pre-sowing and mixed with the soil or applied post-sowing. Fairly good materials were diuron and solan.

These results warrant further work on ipazine, propazine, and karsil on different soil types and in different climates. Further work could also be done on atrazine, simazine, and 2,6-DBN and a mixture of diuron with a substituted triazine. If satisfactory results could be obtained with one of these germinating-seed herbicides, the crop would not have to be entered with a tractor from sowing to harvesting and this cause of crop damage could be avoided.

SWEET CORN

Sweet corn grew normally at the maximum rates used of atrazine, propazine, trietazine, ipazine, (all at 4 lb a.i. per acre), amiben at 8 lb a.i. per acre, and chlorpropham at 8 lb a.i. per acre. Normal growth was also obtained with simazine at up to 2.8 lb a.i. per acre. However, trietazine gave such poor weed control that it was useless at that rate.

Good results were obtained with CDAA and 2,6-DBN applied both pre- and post-sowing. Fairly good results were obtained with diuron and EPTC.

The spectacular results obtained with the substituted triazines (except trietazine) mean that one of these materials will probably be selected as a selective herbicide for sweet corn. The final choice of material will probably depend on availability and price. Confirmatory trials should be carried out with these materials.

TURNIPS

Of the germinating seed herbicides the most promising appeared to be simazine at about ½ to ¾ lb a.i. per acre and 2,6-DBN at about 1½ to 2 lb a.i. per acre. The 2,6-DBN should be applied post-sowing to the surface or it could be very lightly harrowed in. If it is applied pre-sowing and rotary hoed in, it should be used at rates lower than ¾ lb a.i. per acre, but even then results will probably not be very good.

Other materials with a similar action which gave fair results were amiben at 4 lb a.i. per acre and atrazine and ipazine at ½ lb a.i. per acre.

The most promising results were obtained with the contact selective herbicide SMCA at about 15 lb a.i. per acre applied one month after sowing or when the plants had 4 true leaves. Other contact selective materials which showed promise were dicryl and solan at about 4 lb a.i. per acre, but more work must be done to determine the best time to apply these materials.

None of these materials is ideal. Simazine is too long lasting and could do much damage if heavy rain followed application. The same probably applies to atrazine and ipazine.

2,6-DBN is highly volatile and can only be applied to the soil surface when it is fairly cool. It does not kill spurrey very easily.

Fathen is resistant to SMCA, while there appear to be several species resistant to dicryl and solan.

The best materials tried would appear to be 2,6-DBN for use on winter, spring, and late autumn sowings and SMCA for summer and autumn use.

CELERY

Very good results were obtained with trietazine at 1 lb a.i. per acre and ipazine at ½ lb a.i. per acre applied just after planting and with dicryl at 2 lb a.i. per acre and karsil and solan both at 1½ lb a.i. per acre applied after the weeds had germinated and were 2 to 3 in. high. There did not appear to be any weeds especially resistant to the substituted triazines, but there was considerable difference between the post-emergence selectives (see under Carrots).

CDEC and CDAA gave good results, while amiben, fenuron, and 2,6-DBN applied just after planting gave fairly good results.

It would appear that ipazine is the material most likely to be used in the future, provided it does not last too long in the soil and does not build up to levels toxic to crops. Also it should be reiterated that conditions after planting were dry and celery usually receives plenty of water. This extra water may well cause the ipazine to damage the celery. Both these points should be investigated. The post-emergence selectives used in this trial will probably have a place, but their use will depend on the absence of resistant weed species.

TOMATOES

No satisfactory chemical weedkillers have yet been found for use on tomatoes. A few materials in our trial gave very good results and the trial has suggested ways in which this problem could be tackled.

The only germinating-seed herbicides which could be used at all satisfactorily at planting were neburon and propazine. Tomato plants were, however, more resistant to these materials and to many others when they were applied two weeks after planting. Solan gave very good results, but its effect was short lived: it has no residual action. CDEC gave good results, but its effects were rather too short term.

Suggested methods of approach are:

1. Apply CDEC at 4 to 6 lb a.i. per acre just after planting and follow three to four weeks later with neburon at 1 lb a.i. per acre or propazine at 1 lb a.i. per acre, and
2. Plant and then apply solan at 2 to 4 lb a.i per acre together with neburon or propazine at 1 lb a.i. per acre.

Further work is, of course, required to test these suggestions.

CONCLUSIONS

These results show that, in all probability, growers of vegetable crops have available or will shortly have available to them the means of reducing or even eliminating competing weeds from some of their crops with resulting increases in yield and reduced costs of production. The crops for which good selective herbicides appear to exist include carrots, cabbage seedbeds, celery, onions, peas, french beans, sweet corn, turnips, and tomatoes. Crops for which suitable selective herbicides may exist include lettuce and beetroot. Further work is, however, required in most cases before firm recommendations can be made.