THE RESIDUAL TOXICITY OF MONURON, SIMAZINE, AND 2,3,6-TBA

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SUMMARY

MONURON, simazine, and 2,3,6-TBA are used to give complete suppression or to control pernicious weeds or for selective weed control on tolerant crops. High rates of these materials are often used, and it is important that the grower should have some idea as to when the land can be used for susceptible crops without fear of damage caused by these materials. The organic matter status of the soil and the amount of cultivation given the land after the herbicides have been applied could have a pronounced effect on their effective life.

This paper records the results obtained in the first year of an experiment designed to elucidate this problem.

EXPERIMENTAL DETAILS

A uniform piece of land (soil type, Levin Silt Loam, No. 76) in the north-east corner of the Horticultural Research Station, Levin, was laid out in plots. Previously it had been cropped with berry fruit for several years. Fowl manure from a deep litter house in which peat had been used as litter was spread over half the main plots in January 1960 at the rate of 2 tons per acre. The whole area was then rotary hoed 6 in. deep. This treatment provided a considerable difference in soil fertility as indicated by the soil test results (sampling depth 0 to 6 in):

	pH	Ca	K	P
With fowl manure	5.4	8	22	23
Without	5.4	7	8	5

The herbicides were applied to the sub-sub-plots on 17 March. On the sub-plots were arranged factorially the cultivation and sowing date treatments. There were three replicates.

The application rates of the herbicides were:

(1) Monuron, 4 lb a.i. per acre in 40 gallons of water at 1 m.p.h.
(2) Simazine, 4 lb a.i. per acre in 40 gallons of water at 1 m.p.h.
(3) 2,3,6-TBA, 20 lb a.i. per acre in 40 gallons of water at 1 m.p.h.
(4) Hand weeded control

The cultivation treatments were:

(a) no cultivation, and
(b) cultivation with a rotary hoe 6 in. deep before sowing seed.

In the later stages of the experiment it was necessary to cultivate the "no cultivation" plots to a depth of 1 in. with a hand hoe so that there was sufficient tilth for sowing the seeds.

The dates on which the cultivations were done and seeds sown were:

S 1, 11 April 1960. One month after application of herbicides
S 2, 8 August 1960. Five months after application of herbicides
S 3, 8 December 1960. Nine months after application of herbicides
S 4, 1 May 1961. Fourteen months after application of herbicides

One-third (S 1) of the plots received the cultivation treatments and were sown with seeds in April. Another third (S 2) were treated and sown in August. In December, the remaining plots (S 3) were cultivated for the first time, and the S 1 and S 2 plots received further cultivation treatments. Seed was sown in all the plots. In May 1961 all plots received further cultivation treatments and were sown with seed.

The seeds used in the trial were:

Perennial ryegrass (*Lolium perenne*)
Lettuce (*Lactuca sativa* var. "Great Lakes")
Turnip (*Brassica rapa* var. "Snowball")
Peas (*Pisum sativum* var. "W. F. Massey")

TABLE 1—COMPARISON OF ORGANIC MATTER PRESENT AND ABSENT. FRESH WEIGHT OF PRODUCE IN POUNDS. TOTALS OF 18 PLOTS.

	Lettuce		Turnip	
	No Organic Matter	Organic Matter	No Organic Matter	Organic Matter
Monuron	0.77	21.55	0.20	54.20
Simazine	0.00	0.00	0.00	0.00
2,3,6-TBA	3.36	19.21	62.10	101.05
H.W.C.	6.01	27.10	82.65	214.90
	Ryegrass		Peas	
Monuron	0.00	1.85	0.05	0.65
Simazine	0.02	0.91	0.05	0.05
2,3,6-TBA	6.35	4.75	0.46	0.51
H.W.C.	3.56	5.50	1.57	2.96

TABLE 2—COMPARISON OF CULTIVATION WITH NO CULTIVATION. FRESH WEIGHT OF PRODUCE IN POUNDS. TOTALS OF 18 PLOTS

	Lettuce		Turnip	
	No Cultivation	Cultivation	No Cultivation	Cultivation
Monuron	11.35	10.97	26.60	27.80
Simazine	0.00	0.00	0.00	0.00
2,3,6-TBA	11.37	11.20	82.05	81.10
H.W.C.	18.85	14.26	145.55	152.00
	Ryegrass		Peas	
Monuron	0.65	1.20	0.15	0.55
Simazine	0.90	0.03	0.05	0.00
2,3,6-TBA	6.40	4.67	0.51	0.46
H.W.C.	5.66	3.40	2.46	2.07

TABLE 3—COMPARISON OF EFFECTS OF DIFFERENT PERIODS BETWEEN APPLICATION AND SOWING FIRST CROP. FRESH WEIGHTS OF PRODUCE IN POUNDS. TOTALS OF 12 PLOTS. SOWN, 8/12/60; HARVESTED, 16/2/61.

	Lettuce			Turnip		
	S 1	S 2	S 3	S 1	S 2	S 3
Monuron	7.06	10.36	4.90	15.10	21.70	17.60
Simazine	0.00	0.00	0.00	0.00	0.00	0.00
2,3,6-TBA	8.22	8.85	5.50	61.05	34.70	67.40
H.W.C.	15.55	11.11	6.45	113.25	84.20	99.38
	Ryegrass			Peas		
Monuron	0.40	1.45	0.00	0.00	0.60	0.10
Simazine	0.00	0.38	0.55	0.00	0.05	0.05
2,3,6-TBA	2.27	5.50	3.30	0.31	0.41	0.25
H.W.C.	2.20	9.41	2.95	1.02	0.81	2.70

S = Sowing times.

The size of the sub-sub-plots was 6 ft square. Single rows of each of the test plants were sown across each plot with a "Planet Junior" seed drill.

Soil samples from each of three horizons in the soil were taken from each plot on each sowing date, placed in a tin can, and six french bean (*Phaseolus vulgaris* var. "Fardenlosa") seeds sown in each can. The three horizons were 0 to 6 in. deep; 6 to 12 in. deep, and 12 to 18 in. deep.

The crop growth from the first two sowings was so poor on the herbicide plots that crop weights were not recorded. The crop from the third sowing in December was sufficiently large to be weighed. All the produce above ground level from each plot was weighed fresh. The different crops were recorded separately.

RESULTS

Crops Sown in Plots

In the April sowing, which was sown one month after the application of the herbicides, none of the crops became established except in the hand weeded control plots. The seeds germinated in all the plots, but very quickly died. The crop which survived longest was the peas in the simazine plots, but this only reached a height of 3 in. before succumbing completely.

The result of the August sowing was similar to that of the April sowing, though the seedlings did not succumb so quickly. None of the crops in the herbicide plots reached maturity.

The crops sown on 8 December 1960 were cut off at ground level on 16 February 1961 and weighed fresh. The results are summarised in Tables 1, 2, and 3.

Organic matter: The addition of fowl manure to the soil greatly increased the yields of the hand weeded control plots. This must be taken into account in assessing the effects of the organic matter on the persistence of the herbicides. Table 1 shows that soils with fowl manure treated with monuron gave heavier yields than those with no fowl manure, while the reverse was the case with 2,3,6-TBA, though to a more limited extent. As the yields from the simazine plots were so low, no useful comparisons may be drawn at this stage.

Cultivations: Cultivations had a much less marked effect on the yields of the hand weeded control plots. With the exception of turnips the uncultivated plots did better than those rotavated 6 in. deep. The results for lettuce and turnips (Table 2) suggest that the treatments have no effect on the life of monuron, while the pea and ryegrass crops suggest that cultivation reduces its life. Cultivation appears to have no effect on the life of 2,3,6-TBA, while it is too early yet to comment on its effect on simazine.

Time between herbicide application and sowing first seed: Table 3 shows that these treatments had a pronounced effect on the hand weeded control as did the treatments discussed above. Table 4 was prepared to eliminate this difficulty by converting the yields to percentages of the appropriate hand weeded control and adding the yields of the four crops together.

With monuron the best results were obtained with treatment S 2, that is, cultivating and sowing five months after application and then cultivating and sowing again four months later. However, the yield was only just over half that obtained from the hand weeded control. With simazine, the longer it was left undisturbed the better, but the crop was so poor that the importance of this should not be over-emphasised. With 2,3,6-TBA, the time that the first cultivation should be given does not appear to be very important, though the heaviest yields were obtained by delaying cultivation for nine months.

French Beans in Cans

On each of the four occasions when seeds were sown, french beans were sown in soil taken from each plot at three horizons in the soil. They always grew normally in soil from the hand weeded control plots and in soil from

below 6 in. deep in the monuron and simazine plots. In the first two sowings the beans were killed soon after germination when grown in soil taken from the top 6 in. of the monuron and simazine plots. In the third sowing this happened again with soil from the top 6 in. of the simazine plots, but with similar soil from the monuron plots some of the plants managed to survive, though they were not as vigorous as those growing in soil from the hand weeded controls.

The effects of 2,3,6-TBA were apparent in beans grown in soil from each of the three horizons even when the soil samples were taken only one month after applying it. The beans growing in soil from the upper horizon were very severely affected and eventually died. Those growing in soil from the two lower horizons were less severely affected and were not killed. Those growing in soil from the lowest horizon were less affected than those growing in soil from the middle horizon. In subsequent sowings beans growing in topsoil managed to survive and, in the third sowing, grew quite well, though they were obviously affected. It was also evident that the 2,3,6-TBA was present in the lower horizons at these later sowing dates, but in lower concentrations than at the first sowing date.

Weed Growth

Up to the time of the sowing in August, five months after the herbicide applications, there was negligible weed growth except in the hand weeded controls. A few weed seeds had germinated in the monuron and 2,3,6-TBA plots, but they died within a very few days.

After the August sowing weeds appeared on the 2,3,6-TBA plots and to a less extent on the monuron plots. The weeds that grew on the 2,3,6-TBA plots at this time included twincress (*Coronopus didymus*), fumitory (*Fumaria officinalis*), spurrey (*Spergula arvensis*), mouse eared chickweed (*Cerastium glomeratum*), speedwell (*Veronica persica*), buttercup (*Ranunculus* sp.), and a small unidentified sedge. All the weeds were affected by the 2,3,6-TBA, but growth was most vigorous and least affected on those plots which had received fowl manure and which had been sown with seeds in April. Cultivation had practically no effect on the weed growth.

The commonest weed on the monuron plots was fumitory, while speedwell, groundsel (*Senecio vulgaris*), greater plantain, (*Plantago major*), and sow thistle, (*Sonchus oleraceus*) were also present. The densest weed growth was on plots which had received fowl manure and had been cultivated and sown in April. Plots with fowl manure generally had more weeds than those without as had those that had been cultivated. Weeds grew only on plots in which seeds had been sown in April. Plots in which no seeds had been sown or had only just been sown did not have any weeds.

At this time there were no weeds at all in the simazine plots. In fact, weeds did not become established in these plots until 13 months after application and then they were extremely sparse and very stunted.

As the spring progressed the amount of weed on the 2,3,6-TBA and monuron plots increased until there was a dense growth by the beginning of December when the plots were cleared of all weeds to allow the third sowing to be done. The species present in the plots varied considerably and showed that different weeds have different tolerances to these herbicides. On the monuron plots the most prevalent species were redshank, (*Polygonum persicaria*), ribgrass (*Plantago lanceolata*), and greater plantain. Redshank grew on plots that had been cultivated and had received fowl manure while the plantains grew on unmanured uncultivated plots. Plots which had received only one of these treatments supported both species, though there was a tendency for them to form single species colonies.

On the 2,3,6-TBA plots further seedlings of the weeds that appeared in August germinated and grew more and more normally as the season progressed. Other weeds began to make their appearance, mainly redshank and a few grass weeds.

After the December sowing the growth of weeds on the 2,3,6-TBA plots was rather less than on the hand weeded controls, but the range of species

present was similar. On the monuron plots the range of species was still very limited. The only ones to appear besides the ones which were present before December were docks (*Rumex obtusifolius*), *Poa annua*, creeping bent (*Agrostis stolonifera* var. *compacta*), and speedwell. The growth of these monuron-tolerant species on the monuron plots was as good as or better than their growth in the hand weeded controls. This may be due to the lack of competition from other taller species.

DISCUSSION

Simazine was the most peristent herbicide in the trial at the rates tested. So far there is no indication that any of the cultivation or manurial treatments have affected its persistence. Since this experiment was started it has been shown that simazine can be metabolised by corn (*Zea mays*), and that by growing corn in simazine treated ground, the simazine is absorbed by the corn and removed from the ground so that simazine susceptible crops can then be grown in it. This method of removing simazine from treated soil would appear to offer better prospects than trying to dilute the simazine by mixing it with the soil.

If it is assumed that the weight of crops harvested from the monuron plots is inversely proportional to the amount of monuron remaining in the soil, monuron decomposes quicker on soils well supplied with nutrients and organic matter. Cultivation also aids in its decomposition. The observations on weed growth help to confirm this. Apparently the greater plantain can grow satisfactorily in higher concentrations of monuron than can redshank. Plots that have been manured or have been cultivated had similar populations of both these plants, while plots that had received both treatments grew redshank only and those that were untreated grew plantains only. The results suggest that cultivations to assist the decomposition of the monuron should begin some considerable time before the crop is to be sown. It is possible that with more frequent cultivations the 4 lb a.i. per acre of monuron could have been reduced to a harmless level within nine months on a soil rich in organic matter. The actual time the various treatments need to decompose this amount of monuron has yet to be determined.

On the same assumption regarding crop weights and the amount of herbicide in the soil, 2,3,6-TBA is less persistent on a mineral soil low in organic colloids; that it is unaffected by cultivations and that trying to grow a crop while it is still present in the soil has no effect on its persistence. It would seem that it would take about 12 months for 20 lb. a.i. per acre of 2,3,6-TBA to disappear from a silt loam with little organic matter in it, though this has still to be confirmed. It would disappear from sandy soils in less time and would need a longer period in clay soils.

Conclusions

1. The most persistent herbicide of those tried was simazine, followed by monuron and 2,3,6-TBA.
2. The persistence of monuron may be shortened by adding organic matter to the soil before its application, and by cultivating the soil.
3. The persistence of 2,3,6-TBA is less on soils with low organic content than with high organic content.
4. The weeds most resistant to monuron are fumitory, greater plantain, ribgrass, and redshank in descending order of resistance.