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CHEMICAL WEED CONTROL IN FRUIT CROPS

EXPERIMENTS CONDUCTED IN 1956—60

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Introduction

Weed control by conventional tillage methods in fruit crops is difficult and expensive. In addition, cultivation always causes some injuries to the roots of the fruit trees, bushes and canes. This detrimental effect can be avoided by chemical methods, first studied in Finland in the 1940's and early 1950's, under the auspices of the Department of Horticulture. The chemicals used in those early experiments were chlorate compounds, of which potassium chlorate produced satisfactory results in apple orchards (MEURMAN 1950, SÄKÖ 1956). In 1956—60 the experiments were continued at the Department of Horticulture and the Department of Plant Husbandry, with several new herbicides. Apart from apple orchards, experiments were carried out among black currants, red currants, gooseberries and raspberries, but only under well- established mature plants, however.

The experiments of 1956—60 were located on sandy soils in the two districts of Piikkiö and Tikkurila (approx. lat. 60° 20′ N), where the mean annual precipitation ranges from 595—708 mm and the mean temperatures (°C) of the growing season vary as follows: May 9.0—9.4, June 13.5—13.8, July 16.7—17.6, Aug. 15.0—15.4 and Sept. 10.5—10.7.

The main weed species in the experimental fields were as follows:

Annuals (and biannuals):

spear grass, *Poa annua L.*
chickweed, *Stellaria media* L. Vill.
dead nettles, *Lamium* sp.
hemp nettles, *Galeopsis* sp.
groundsel, *Senecio vulgaris* L.
lamb's-quarters, *Chenopodium album* L.
mayweeds, *Matricaria* sp.
plantains, *Plantago* sp.
shepherd's purse, *Capsella bursa-pastoris* (L.) Medic.
smartweeds, *Polygonum* sp.
wild pansies, *Viola* sp.
worm-seed mustard, *Erysimum cheirantoides L.*

Perennials:

Canada thistle, *Cirsium arvense* (L.) Scop.
coltsfoot, *Tussilago farfara* L.
common horsetail, *Equisetum vulgare* L.
couch grass, *Elytrigia repens* C. syn. *Agropyron repens* (L.) P.B.
dandelion, *Taraxacum vulgare* (Lam.) Schrk., coll.
goutweed, *Aegopodium podagraria* L.
perennial sow thistle, *Sonchus arvensis L.*

The chlorates were applied in granular form to the wetted foliage of the weeds, and the other herbicides were sprayed (1000 l/ha) on the dry weed stand. The soil was left uncultivated for a period of two years or more. There were 2—6 replicates in each treatment. Injuries to the weeds as well as to fruit trees, bushes and canes were estimated visually, applying the scale 0—10 (0 = uninjured, 10 = killed) with an accuracy of ½ in each replicate. The mean values of injuries are given in the following tables with an accuracy of ¼ in the case of 2 replicates and an accuracy of 0.1 in the case of 3—6 replicates. The results according to the types of herbicides are discussed on the following pages.

Contact herbicides

Among contact herbicides, i.e. compounds that are absorbed through the leaves but do not translocate or sterilize the soil, oils such as petrol, diesel oil, crude oil, etc. are commonly used under orange trees in California and in other countries with a dry and warm climate (Johnston and Sullivan 1949). Some experiments with oils have also been conducted in temperate climates, under apples, pears and stone fruits (e.g. Bloxom 1958, Gurtis 1958, Degman and Benson 1958, Loewell and Mohs 1958, Schubert 1959, Mulder 1960). The oils may be fortified by aromatic extracts or by other contact herbicides, such as 4, 6-dinitro-o-*sec.*-butylphenol or d i n o s e b. To reduce costs the oil may be »diluted» with water by using an oil soluble-emulsifier.

The oils tested in the present study were 1) petrol, 2) diesel oil, 3) stove oil, and 4) waste oil (used lubricating oil). All these proved effective against annual weeds in their early stages, while their effect on more developed weeds was less pronounced. Satisfactory results on the tops of all the weeds were achieved by fortifying the oil with aromatic extract (Good-Rite Octone 100 g/10 l) or dinoseb (Sevtox 100 g/10 l.) Diluting the oil with water and an oil-soluble emulsifier (Triton X-100, 200 g/10 l) diminished the herbicidal effect. However, satisfactory results were once

Table 1. Weed control experiments with oils in apple orchards. Treatments carried out on July 21, 1958. Injuries to the foliage of weeds estimated one week after treatments, using the scale 0—10.

Taulukko 1. Öljyvalmisteiden vaikutus rikkaruohonversoihin omenatarhassa. Teho rikkaruohoihin arvioitu silmävaraisesti asteikolla 0—10. Arviointi suoritettu viikon kuluttua käsittelystä.

Treatment — *Koejäsen*	Petrol *Petroli*	Diesel oil *Dieselöljy*	Stove oil *Lämmitysöljy*	Waste oil *Jäteöljy*
Oil without additives — *Pelkkä öljy*	6	—	7	2
— + aromatics —				
— + *aromattinen rikaste*	$9^1/_2$	$9^3/_4$	$8^3/_4$	—
— + dinoseb	$9^1/_2$	$9^3/_4$	$9^1/_2$	$5^1/_2$
— + aromatics + dinoseb —				
— + *aromaattinen rikaste + dinoseb*	—	$9^3/_4$	$9^3/_4$	—
Oil as emulsion (oil 25 % + water 75 %) — *Öljy emulsiona (öljyä 25 % + vettä 75 %)*	—	—	4	—
— + aromatics —				
— + *aromaattinen rikaste*	—	—	8	—
— + dinoseb	—	—	8	—
— + aromatics + dinoseb —				
— + *aromaattinen riksate + dinoseb*	—	—	10	—

more attained when the diluted oil was fortified with an aromatic extract or with dinoseb. (Table 1). The underground parts of the perennial weeds were not injured by one spraying with oil. The rhizomes in the sprayed plots developed new green growth in about 2—3 weeks after the treatment (Fig.4). Sprayings at about fortnightly intervals all through the growing season did not eliminate the hydrocarbon resources of the rhizomes. During the following winter, however, the rhizomes of most of the broad leaf perennials were largely destroyed. Only the rhizomes of couch grass and common horsetail survived, and these, in fact, proved so tough that there was hardly any diminishing of their growing vigour even after a second summer of spray treatment and the subsequent winter. Since couch grass is one of the most important perennial weeds in Finland, it is clear that under our conditions oils cannot be profitably used as a herbicide in fruit crops. Despite some promising results the same conclusion seems to have been reached in other countries with temperate climates.

Apple trees were not injured by oils except in cases where the leaves had been wetted by drifting spray. No experiments were performed with bush or cane fruits. Because the branches of these plants usually hang very low, the spraying of bush and cane fields with compounds liable to injure the leaves would no doubt prove a rather hazardous practice.

Chlorates

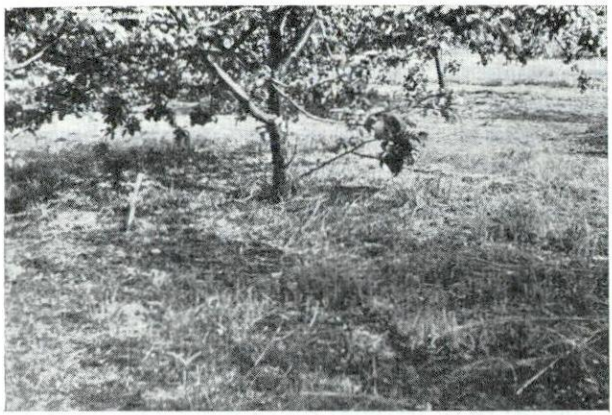
Chlorates are non-selective soil sterilants, but can also be absorbed through the leaves and translocated to some extent. Being easily soluble they are readily leached into the soil. As already stated, weed control experiments with chlorates were conducted in apple orchards in Finland in the 1940's and also in the early 1950's (MEURMAN 1950, SÄKÖ 1956). Similar experiments were also carried out in Sweden at a somewhat later date (NILSSON 1957). Judging by the results, potassium chlorate seems to be relatively harmless to mature apple trees, decomposing into potassium chloride which has a fertilizing effect. Even repeated treatments do not result in excessive accumulation of potassium chlorate or chloride. Experiments in Finland proved, on the other hand, that sodium chlorate may cause injuries to apple trees, at least in repeated treatments. Probably the decomposition compound of sodium chlorate, sodium chloride, is too toxic to the trees and accumulates in the soil in repeated treatments.

In the present study three chlorate products were used: *Fekabit* (potassium chlorate 99 %), *Klorea* (sodium chlorate 40 % + borax 57 % + monuron 1 %) and *Rikkaruohontuho* (sodium chlorate 45 % + sodium chloride 55 %). The rates of application ranged from 2—5 kg/ha. The results (cf. Tables 2 and 5, Fig. 4) showed that all the chlorate products had a satisfactory effect on annual weeds and on tops of broad leaf perennials and common horse tail. However, on the tops of couch grass the chlorates were rather ineffective. Apparently this can be partly accounted for by the rainless season which followed the treatment period, preventing the chlorates from dissolving. Comparatively, *Klorea* proved the most effective of the compounds with *Fekabit* coming second and *Rikkaruohontuho* third (Table 2).

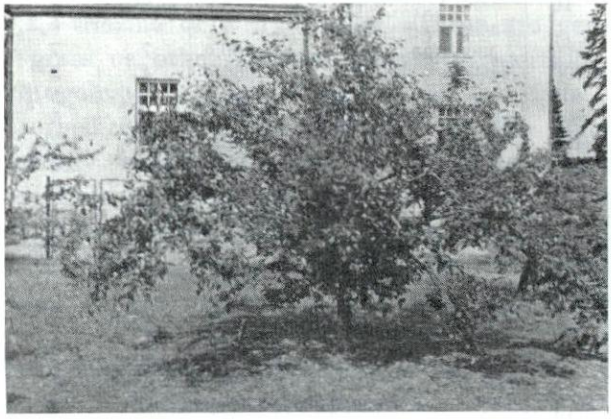
The effect of the chlorates on the rhizomes varied. Those of couchgrass and common horsetail generally survived to a large extent. On the other hand, the rhizomes of several broad leaf perennials, such as Canada thistle, perennial sow thistle and coltsfoot were almost completely destroyed. Some broadleaved perennials (dandelion and goatweed) proved moderately resistant.

The surviving rhizome fragments began to develop new green growth at the latest 8—12 months after the treatment, with the result that the weed stands of plots treated with chlorates recovered almost fully in the summer following the treatment (Fig. 4). *Klorea* proved to be the compound with the most lasting effect, *Fekabit* coming second and *Rikkaruohontuho* third (Table 2).

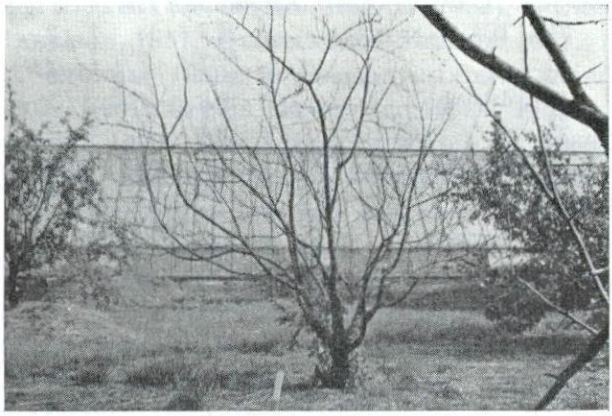
In experiments made in Tikkurila in 1957—58, chlorates caused some mild chlorosis in the leaves of apple trees (Table 2). The trees in question



Potassium chlorate — *Kaliumkloraatti 396 kg/ha*



Simazine 25 kg/ha



Monuron 40 kg/ha

Fig. 1. Weed control experiment in apple orchard.
Tikkurila 1959.
Kuva 1. Rikkaruohontorjuntakoe omenatarhassa. Tikkurila 1959.

Table 2. Weed control experiments with various herbicides in apple orchards in 1957. Injuries to the weeds and to the apple trees estimated at the end of the growing seasons, using the scale 0—10 (0 = uninjured, 10 = killed).

Taulukko 2. Rikkaruohontorjuntakokeet omenatarhoissa 1957. Rikkaruohojen ja omenapuiden vioittuminen arvioitu asteikolla 0—10. Havainnot suoritettu kasvukausien lopulla (0 = vioittumaton, 10 = kuollut).

Product *Valmiste*	kg/ha	Active substance *Vaikuttava aine*	kg/ha	Weeds *Rikkaruohot*		Apple trees *Omenapuut*	
				1957	1958	1957	1958
Exp. 1. Treatment May 28—31, 1957. — *Koe 1. Käsittely 28—31/5 1957.*							
Juolav. Tuho	56	TCA	49.8	6 1/2	3 1/2	1	1/4
»	110	»	99.0	8 1/4	5	1	1/4
Dowpon	54	dalapon	45.9	8 1/4	5 1/2	1	1/4
»	108	»	90.8	8 3/4	6	1	1/4
Weedazol	8	amitrole	4.0	3	1	0	0
»	16	»	8.0	6 3/4	3	0	0
Klorea	500	$NaClO_3$ + borax + monuron	500.0	7	7	3	3
Rikkar. Tuho	200	$NaClO_3$ + NaCl	200.0	4	3	2	1/2
»	400	»	400.0	5 3/4	5 1/2	3	1
Fekabit	200	$KClO_3$	198.0	6 1/2	5	2	1/2
»	400	»	396.0	7 3/4	7 1/2	3	1
Prim. Sim.	50	simazine	25.0	10	10	1/2	0
Exp. 2. Treatment July 5—6, 1957. — *Koe 2. Käsittely 5—6/7 1957.*							
Juolav. Tuho	50	TCA	45.0	6 1/2	3 1/2	0	1/4
»	100	»	90.0	8	5 1/2	1/4	1/4
»	150	»	135.0	9	6 1/2	1/4	1/4
Dowpon	25	dalapon	21.3	5 1/2	4 3/4	1/4	1/4
»	50	»	42.5	6 1/2	5 3/4	1/4	1/4
»	100	»	85.0	9	6 1/4	1/4	1/4
Weedazol	4	amitrole	2.0	4 1/2	0	0	0
»	8	»	4.0	6 1/2	1	0	0
»	16	»	8.0	8	3	0	0
Exp. 3. Treatment Sept. 11, 1957. — *Koe 3. Käsittely 11/9 1957.*							
Juolav. Tuho	25	TCA	22.5	8	2	0	0
»	50	»	45.0	8 1/4	3 1/2	0	1/4
»	100	»	90.0	8 1/2	5	0	1/4
Dowpon	12 1/2	dalapon	10.6	7 1/2	2 1/2	0	1/4
»	25	»	21.3	8	4	0	1/4
»	50	»	42.5	9	5	0	1/4
Weedazol	4	amitrole	2.0	6	2	0	0
»	8	»	4.0	7	2 1/2	0	0
»	16	»	8.0	7 1/4	3	0	0
Telwar W	25	monuron	20.0	9 1/2	8	0	0
»	50	»	40.0	9 3/4	9 1/4	0	0
»	75	»	60.0	10	9 3/4	0	0
Baron	300	erbon	123.9	9 3/4	9	0	7
Techn. (18½%)	25	neburon	4.6	0	4 1/2	0	0
»	50	»	9.3	1/4	6 1/2	0	0

were, however, rather small in size and in poor condition at the start of the experiment, apparently suffering from a deficiency of magnesium. In the case of the sodium chlorate products, the injuries were no doubt partly caused by the other compounds involved, notably sodium chloride *(Rikka-*

ruohontuho) and borax *(Klorea)*. Judging by the experiments the latter compound in particular seems to be toxic to the trees. In experiments carried out in 1959—60, in which the potassium chlorate product *Fekabit* was used, this caused chlorosis only on a couple of trees that were smaller than normal (Tables 3—4).

Chlorate experiments were not made among bush or cane fruits. On the basis of earlier experience these are known to be susceptible to chlorate compounds.

»Couch grass herbicides»

The so-called couch grass herbicides referred to in this article are sodium trichloroacetate or T C A, sodium 2,2-dichloropropionate or d a l a p o n, and 3-amino-1,2,4-triazole or a m i t r o l e. These are generally used to control couch grass or other grasses. However, amitrole in particular, is also effective against broadleaved weeds and horsetails.

TCA is absorbed into the rhizomes through the soil. Being easily soluble, it is readily leached into the soil, where it usually decomposes in a few weeks. Dalapon resembles TCA in its effect, but it is absorbed through the leaves as well and is able to translocate from the leaves into the rhizomes. Amitrole, on the other hand, has almost no effect at all through the soil, but it is easily absorbed through the leaves and translocated.

TCA has been tried in fruit crops, for example, in U.S.A. (Carlson and Moulton 1949), in Belgium (Rapport Generale 1957), in Germany (Kruger 1959) and in Holland (van Oorschot 1958, van der Zweep 1958). Dalapon has been tried in Canada (Res. Rep. W. 1959), in U.S.A. (Davidson et al. 1955, Harrison 1957, Degman and Benson 1958, Burrel 1959, Chappel 1959, Schubert 1959), in Germany (Loewell and Mohs 1958, Loewell 1959), in Great Britain (Robinson 1958a, 1958b, 1958c, 1959a, 1959b, Sutherland 1960, Wood and Sutherland 1960), in Holland (van Oorschot 1958, Mulder 1960), in Sweden (Nilsson 1957) and in New Zealand (Porter 1959). Amitrole has been tried in Canada (Res. Rep. E. 1959), U.S.A. (Bloxom 1958, Curtis 1958, Degman 1958, Steinbacher 1958, Berry 1959, Burrel 1959, Leefe 1959, Schubert 1959, Chappel and Williams 1960), in Belgium (Dermine 1958), in Germany (Loewell and Mohs 1958, Loewell 1959), in Great Britain (Watson and Haes 1959, Sutherland 1960, Wood and Sutherland 1960) and in New Zealand (Porter 1959). In the present study a TCA product *Juolavehnäntuho* (80 % wettable powder), a dalapon product *Dowpon* (85 % wettable powder) and an amitrole product *Weedazol* (50% wettable powder) were used. The results (Tables 2, 3 and 5, Fig. 4) were as follows:

T C A was effective against all annuals and, in addition, against couch grass. A statisfactory effect on couch grass was obtained by using about 25—50 kg/ha (Table 2). It should, however, be kept in mind that all the experiments were situated on sandy soils, where TCA is known to be highly active. Judging by the previous experience under Finnish conditions (LÄHDE 1955, MUKULA 1958), considerably larger quantities of TCA, up to 100—150 kg/ha, will be required for the control of couch grass in non-cultivated clay and organic soils.

In the common horsetail TCA destroyed only the green shoots. In about 2—3 months, or at the latest in the summer following the treatment, new green growth of horsetail began to emerge on the treated plots. In broadleaved perennials TCA gave rise only to a passing chlorosis and to retarded growth. In consequence, all the TCA plots were overrun by a heavy growth of Canada thistle, perennial sow-thistle and dandelion, at the latest in the summer following the treatment.

In apple trees TCA caused slight temporary chlorosis. In the case of larger doses the apples failed to ripen, and the opening of the buds was delayed in the spring following the treatment. It seems, therefore, justifiable to assume that under Finnish conditions TCA is not suitable for the control of weeds in apple orchards. No experiments were made among bush or cane fruits. Judging by previous experience, they are more susceptible to TCA than apple trees.

Dalapon proved a little more effective than TCA. It had a more rapid action and an amount of only 20 kg/ha (Table 2) was required to produce a satisfactory effect on couch grass. Here, too, it should be noted that the plots were on sandy soils. According to previous experience, under Finnish conditions some 50—100 kg/ha of dalapon is needed for the control of couch grass in non-cultivated clay and organic soils (MUKULA 1958).

Dalapon appeared to have an effect similar to that of TCA on apple trees, i.e., temporary chlorosis was registered in the leaves of the apple trees, the buds were late in opening, and, in the case of larger dalapon quantities, the apples failed to mature. Raspberries proved especially susceptible to dalapon, even the smallest quantities causing heavy injuries (Table 3). Bush fruits were not experimented with, but judging by the previous experience, they are known to be more susceptible to dalapon than apple trees are. Therefore, it seems that under Finnish conditions dalapon cannot be used for weed control in fruit crops. [1])

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[1]) *Erbon* or 2, 4, 5-trichlorophenoxyethyl ester of 2,2 dichloropropionic acid proved even more toxic to apple trees than dalapon (Table 2).

Table 3. Weed control experiment with dalapon and amitroe on raspberries. Treatments carried out on June 8, 1956. Injuries to the weeds and to the raspberry canes estimated at the end of the growing seasons, using the scale 0—10 (0 = uninjured, 10 = killed).

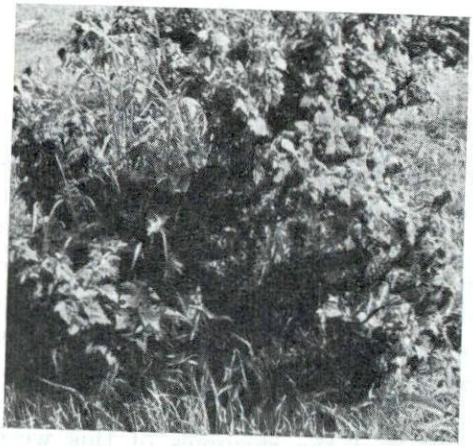
Taulukko 3. Dalapon- ja amitrolikoe vadelmatarhassa. Käsittely suoritettu 8. 6. 1956. Rikkaruohojen ja vadelmapensaiden vioittuminen arvioitu asteikolla 0—10 (0 = vioittumaton, 10 = kuollut). Havainnot tehty kasvukausien lopulla.

Product *Valmiste*	kg/ha	Active substance *Vaikuttava aine*	kg/ha	Weeds *Rikkaruohot*		Raspberries *Vadelmat*	
				1959	1960	1959	1960
Dowpon	20	dalapon	17	3	1	1	3
»	40	»	34	8	5	3	7
Weedazol	8	amitrole	4	5	3	0	0
»	16	»	8	7	5	0	0

A m i t r o l e killed the green shoots of all the weeds. Satisfactory results were obtained with 4—8 kg/ha of amitrole (Table 2). The rhizomes of Canada thistle, perennial sow-thistle, dandelion, goutweed and coltsfoot were almost completely killed when larger quantities of amitrole (8—16 kg/ha) were used, but only where there was a good green shoot stand before the treatment. A smaller dosage of amitrole prevented the re-growth of broadleaved perennials for some two months after treatment, or at the latest until the beginning of the growing season following the treatment. Amitrole had a similar though somewhat slighter effect on the rhizomes of common horsetail. No complete killing of the rhizomes of this weed was noted in any of the experiments, but, on the other hand, amitrole was the only compound in question with any noticeable effect on the rhizomes of horsetail. The rhizomes of couch grass seemed to resist amitrole to a considerably greater degree, nor, in this case, was the toxicity of the compound increased by an increase in the rate of application. The re-growth of couch grass was, therefore, retarded only for some two months, irrespective of the rate of application (Fig. 4). Annually administered amitrole treatment did not seem to succeed in killing off the rhizomes of couch grass (Table 5). Amitrole did not cause injuries to apple trees, except in cases where the leaves had been wetted by the spray. This was also the case with raspberry canes (Table 3). The spraying of raspberries without injuring the leaves proved exceedingly difficult in practice. There were no experiments with bush fruits. Since the branches of the bushes generally hang very low, it is obvious that spraying them with a herbicide like amitrole, which is so hazardous to the leaves, would be rather questionable.

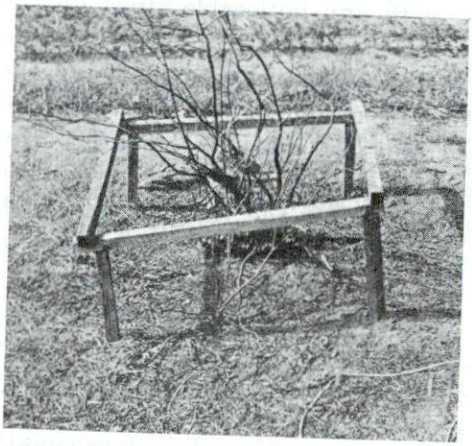
Urea herbicides

Urea herbicides are soil-sterilizing compounds with a long-lasting (»permanent») effect. In larger amounts they are highly toxic to the trees, bushes and canes, but the relatively insoluble urea derivatives, such as 3-(*p*-chlorophenyl)-1,1-dimethylurea or monuron, 3-(3,4-dichlorophenyl) -1,1-dimethylurea or diuron, and 3-(3,4-dichlorophenyl)-1-methyl-1-*n*-butylurea or neburon, are mostly absorbed in the top soil to a depth of 1—2 inches, without leaching deeper into contact with the roots of the trees. The water solubility of monuron is 250 p.p.m., that of diuron 42 p.p.m., and that of neburon 4.8 p.p.m. Large scale experiments carried out by Gilberth and Holm (1952), Holm and Gilberth (1954) and Holm *et al.* (1959) in U.S.A. have proved that apples and sour cherries resist



Untreated — *Käsittelemätön*

Simazine 25 kg/ha



Monuron 40 kg/ha

Fig. 2. Weed control experiment on black currant. Tikkurila 1959.
Kuva 2. Rikkaruohontorjuntakoe mustaherukkatarhalla. Tikkurila 1959.

considerably heavy doses of monuron and diuron, providing the sprayed area does not extend further than a reasonable distance from the tree trunks, where the »feeder roots» are not present near the soil surface. Additional experimentation, including the use of smaller amounts of urea herbicides against annual weeds under bush fruits and raspberries has given varying results (Res. Rep. E. 1959 in Canada; HALL 1955, HEMPHILL 1955, BLOXOM 1958, CURTIS 1958, DEGMAN 1958, STEINBACHER 1958, BERRY 1959, CHAPPEL and BROWN 1959 in U.S.A; Rapport Generale 1957, DERMINE 1958 in Belgium; ROBINSON 1958b, 1958c, WOOD and SUTHERLAND 1960, SUTHERLAND 1960 in Great Britain.)

In the present study monuron and neburon were tried, monuron in the form of commercial product *Telvar* (80 % wettable powder), and neburon as a technical sample (18.5 % wettable powder) supplied by the manufacturer (du Pont de Nemours & Co., USA). The results (Tables 2, 4 and 5, Fig. 4) were as follows:

M o n u r o n proved extremely effective against most weeds. Approximately 8—20 kg/ha seemed a sufficient quantity. In dry soil, however, monuron proved to be poor in effect. Treatment carried out in the spring began to take proper effect only after some 25—50 mm of rain. On the other hand, application made in the autumn began to be fully effective immediately at the start of the growing season the following spring. The melting snow turning into water seemed to leach the herbicide to a depth of at least some cm and within reach of the weed roots and rhizomes. — The plantains, of the annual weeds, and the common horsetail, of the perennials, proved resistant to monuron. — The effect of the above dosage of monuron lasted approximately three years (cf. Fig. 4).

Monuron often caused severe injuries to apple trees (Tables 4 and 5, Fig. 1); in some cases it even killed them. Admittedly the quantities of monuron applied were rather large, up to 40 kg/ha, but nevertheless i t s e e m s t h a t i n F i n n i s h c o n d i t i o n s m o n u r o n i s t o o t o x i c a c o m p o u n d f o r a p p l e t r e e s. Black currants and raspberries usually died even after the smallest doses of monuron, 8 kg/ha (Table 4, Figs. 2 and 3). No experiments were carried out with red currants or gooseberries.

N e b u r o n was tried out in only one experiment. This was with apple trees (Exp. 3, Table 2). The rates of application were 4.6—9.3 kg/ha. In the year of treatment the compound had no effect on couch grass or other perennials. Satisfactory results were, however, achieved against most annuals. Towards the end of the year following the treatment the perennials also began to die off to a satisfactory extent, if not completely. Only the common horsetail proved resistant to neburon. The herbicide seemed to remain effective for a long time, two years at least.

Table 4. Weed control experiments with simazine and monuron on apples and small fruits in 1958—59. Injuries to the plants estimated at the end of the growing seasons, using the scale 0—10.

Taulukko 4. Simatsiini- ja monuronkokeet omena- ja marjatarhoissa 1958—59. Kasvien vioittuminen arvioitu asteikolla 0—10. Havainnot suoritettu kasvukausien lopulla.

Product *Valmiste*	kg/ha	Active substance *Vaikuttava aine*	kg/ha	Weeds *Rikkaruohot*		Apple trees *Omenapuut*		Fruit bushes [1] *Marjapensaat* [1]		Raspberries *Vadelmat*	
				1958	1959	1958	1959	1958	1959	1958	1959
Exp. 1. Treatment May 8, 1958. — *Koe 1. Käsittely 8/5 1958.*											
Prim. Sim.	5	simazine	2.5	1	0	—	—	0	0	0	0
»	10	»	5.0	3	1	—	—	0	0	0	0
»	25	»	12.5	5	3	—	—	0	0	0	0
Exp. 2. Treatment Dec. 5, 1958. — *Koe 2. Käsittely 5/12 1958.*											
Prim. Sim.	10	simazine	5.0	7	4	—	—	0	0	0	0
»	25	»	12.5	7	8	0	0	0	0	1½	½
»	50	»	25.0	9	10	1½	¼	½	½	3	1
Telwar W	10	monuron	8.0	6	5	—	—	3	7	3	2
»	25	»	20.0	7	9	3	1	9	10	7	6
»	50	»	40.0	9	10	5	3	10	10	9	8
Exp. 3. Treatment Apr. 18, 1959. — *Koe 3. Käsittely 18/4 1959.*											
Prim. Sim.	10	simazine	5.0	4	3	—	—	0	0	0	0
»	25	»	12.5	6	8	0	0	0	0	½	½
»	50	»	25.0	9½	10	¼	0	1	1	1½	1
Telwar W	10	monuron	8.0	3	5	—	—	7	9	2	2
»	25	»	20.0	6	9	1	0	10	10	5	6
»	50	»	40.0	8	10	3	1	10	10	7	8
Exp. 4. Treatment May 7, 1959. — *Koe 4. Käsittely 7/5 1959.*											
Prim. Sim.	25	simazine	12.5	1	4	0	1	0	0	—	—
»	50	»	25.0	3	7	1	2	0	½	—	—

[1]) Gooseberries in Exp. 1, black currants in Exp. 2 and 3, gooseberries and red currants in Exp. 4. — *Karviaismarja kokeessa 1, mustaviinimarja kokeissa 2 ja 3, karviaismarja- ja punaviinimarja kokeessa 4.*

Neburon did not injure apple trees. It seems, however, that, owing to its slow action, the usefulness of neburon in the particular control of orchard perennials is questionable.

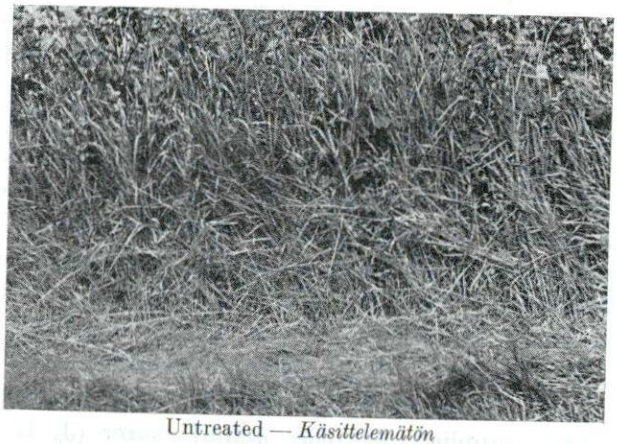
Triazines

Triazines comprise a group of compounds with herbicidal properties similar to those of the urea derivatives. The most insoluble triazines, such as 2-chloro-4,6-*bis* (ethylamino)-1,3,5-triazine or simazine (water solubility 5 p.p.m.), and 2-chloro-4-isopropylamino-6-ethylamino-1,3,5-triazine or atrazine (water solubility 70 p.p.m.), have a long-lasting soil-sterilizing effect. Atrazine can be absorbed into the plants through

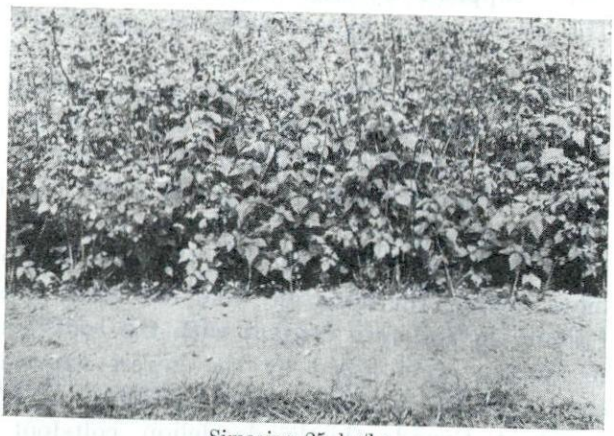
the leaves, too. Both compounds are less active in regard to weeds than urea herbicides, but they are also less hazardous for the trees, bushes and canes. During the last few years the possible use of simazine in fruit crops has been considered, especially in Central Europe (Rapport Generale 1957, LOEWELL and MOHS 1958, STETTMEIER 1958, ROBINSON 1958b, KARNATZ 1959a, 1959b, WOOD and SUTHERLAND 1960) and in North America (BLOXOM 1959, CHAPPEL and BROWN 1958, BERRY 1959, Res. Rep. W. 1959). Much attention has also been paid to atrazine, but few results concerning the use of this compound have been published as yet (Res. Rep. E. 1959). In the present study simazine was used in the form of the commercial product *Primatol Simatsin* (50 % wettable powder), and atrazine was used in the form of a technical sample with the code number *A-361* (50 % wettable powder), supplied by the manufacturer (J. R. Geigy A. G., Switzerland). The results of the experiments were as follows (Tables 2 and 4—5, Fig. 4):

S i m a z i n e was quite ineffective under dry conditions. Well-established perennial weeds were killed only after some 100—150 mm of rain. In fact, the application made in the spring of 1959 did not take effect before the spring of 1960, owing to the dry summer in 1959. In the case of the late autumn treatment, however, the effect of simazine was excellent immediately at the beginning of the next growing season. Apparently the melting snow washed the simazine (like monuron) down in the soil to a depth of some cm and into contact with the roots and rhizomes of weeds. All the annuals were killed by the lowest experimental dosage, 2½ kg/ha. Most perennials required a dosage of 12½—25 kg/ha. Horsetail proved fully resistant, Canada thistle, dandelion, coltsfoot and goatweed were moderately resistant. The residual effect of simazine in the soil seemed to be of very long duration (Fig. 4). In cases where the application was sufficient to destory the weeds, new weeds have not grown on the treated area up to the time of writing this paper, although almost four years have passed since the first treatment. After applications of smaller simazine quantities, with insufficient effect, the stand began to recover in 1 or 2 years after the treatment.

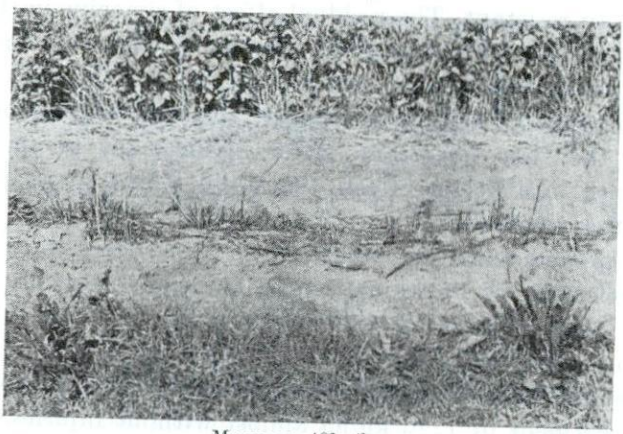
Simazine proved relatively non-toxic to apple trees, but in 1959, however, an application of 25 kg/ha caused injuries, especially in trees that were smaller than normal, as evidenced by the discoloration of the leaf edges and the withering of individual branches (Tables 4—5). As for bush fruits (Table 4), black currants, red currants and gooseberries survived a simazine treatment of 12½ kg/ha almost without injuries. However, an application of 25 kg/ha caused relatively serious injuries to these plants. Raspberries proved considerably more susceptible to simazine. An application of 12½ kg/ha always caused some discoloration of the leaf edges,



Untreated — *Käsittelemätön*



Simazine 25 kg/ha



Monuron 40kg/ha

Fig. 3. Weed control experiment on raspberry. Tikkurila 1959.

Kuva 3. Rikkaruohontorjuntakoe vadelmatarhassa. Tikkurila 1959

Table 5. Weed control experiments with various herbicides in apple orchards in 1959. Injuries to the plants estimated at the end of the growing seasons, using the scale 0—10.

Taulukko 5. Rikkaruohontorjuntakokeet omenatarhoissa 1959—60. Kasvien vioittuminen arvioitu asteikolla 0—10. Havainnot suoritettu kasvukausien lopulla.

Product *Valmiste*	kg/ha	Active substance *Vaikuttava aine*	kg/ha	Weeds *Rikkaruohot*		Apple trees *Omenapuut*	
				1959	1960	1959	1960
Exp. 1. Treatment May 15—16, 1959. — *Koe 1. Käsittely 15—16/5 1959.*							
Fekabit	400	$KClO_3$	396.0	6.0	0.2	0.2	3.8
Prim. Sim.	50	simazine	25.0	4.0	7.0	0.8	1.2
Telvar W	50	monuron	40.0	8.8	9.6	2.0	3.8
Weedazol [1]	15	amitrole	7.5	0.6	4.0	(0.8)	$(1.6)_2$
Dowpon	50	dalapon	42.5	5.4	0.2	0.6	0.4
Weedazol +	15	amitrole +	7.5	8.6	5.6	0.6	1.2
Prim. Sim.	20	simazine	10.0				
Dowpon +	15	dalapon +	7.5	9.0	6.8	0.0	1.8
Prim. Sim.	40	simazine	20.0				
Exp. 2. Treatment May 16, 1959. — *Koe 2. Käsittely 16/5 1959.*							
Fekabit	400	$KClO_3$	396.0	8	4	1/4	1/2
Weedazol [1]	15	amitrol	25.0	8	9	0	0
Dowpon	50	dalapon	42.5	9	4	1 1/2	1/4
Weedazol +	15	amitrole +	7.5	10	10	0	0
Prim. Sim.	20	simazine	10.0				
Dowpon +	15	dalapon +	7.5	10	10	1/2	1/4
Prim.Sim.	40	simazine	20.0				
Exp. 3. Treatment Sept. 23, 1959. — *Koe 3. Käsittely 23/9 1960.*							
Fekabit	400	$KClO_3$	396.0	—	9.6	—	0.0
Prim. Sim.	10	simazine	5.0	—	2.8	—	0.0
»	20	»	10.0	—	6.0	—	0.0
»	50	»	25.0	—	7.2	—	0.6
A—361	50	atrazine	25.0	—	8.6	—	0.0
Weedazol	15	amitrole	7.5	—	1.2	—	(0.2) [2]
Dowpon	50	dalapon	42.5	—	0.0	—	1.6
A—513	50	amitrole +	10.0	—	8.0	—	0.0
		simazine	20.0				
A—844	50	amitrole +	5.0	—	8.4	—	0.2
		simazine	22.5				

[1]) Treatment repeated in spring 1960. — *Käsittely uusittu keväällä 1960.*
[2]) Spray drift injuries to the leaves. — *Liuosta roiskunut lehdille.*

and 25 kg/ha withered off whole canes. In the year following the treatment the raspberries usually recovered, however, and, despite temporary injury, their growth increased considerably, apparently as a result of the control of the weeds.

Atrazine was received for experiments in 1959 only, and it was tried solely in an apple orchard (Table 5). The compound proved considerably more rapid in its effect than simazine, obviously because it is more easily soluble than the latter, and may, to some extent, be absorbed through

the leaves. It appeared that far smaller quantities of atrazine than of simazine would be needed. However, it is not yet possible to draw exact conclusions on this point. — The effect of atrazine seems to be of long duration. No injuries were found in apple trees.

Mixtures of herbicides with different mode of action

If the orchard or bush or cane fruit field has already been heavily overrun by perennial weeds, it is questionable whether it can be cleared by using only soil-sterilizing herbicides. The eradication of well-established perennials always necessitates such heavy applications of herbicides that the resistance of the trees, bushes and canes is severely tested. The use of large quantities of urea and triazine herbicides also leads to a long-lasting residue in the soil, which makes it impossible to renew an old orchard or to adapt it for other cultivation if need be. On the other hand, as is apparent from the above experiments, compounds that do not sterilize the soil will not, under Finnish conditions, eradicate the most important perennial weed, the couch grass. However, if the weed stand in an area were first to be destroyed with some non-sterilizing herbicide, for example amitrole, it might be possible to prevent the re-growth of the weeds with a smaller quantity of some soil-sterilizing compound, for example simazine, a method which LOEWELL and MOHS (1958), LOEWELL (1959), and CHAPPEL and BOWER (1960), have also been studying in recent years.

This question was studied in experiments organised in apple orchards in 1959, when mixtures of amitrole and simazine, as well as dalapon and simazine, were used. (When these experiments were planned the toxicity of dalapon to apple trees under Finnish conditions was not known as then.) The quantity of amitrole used in the mixtures was 5—10 kg/ha, that of dalapon 32 kg/ha and that of simazine 10—22½ kg/ha. To begin with, the experiments were carried out by mixing *Weedazol*, *Primatol Simatsin* and *Dowpon* products in varying proportions. Later, J.R. Geigy A.G. sent at our request technical samples under the code name *A-513* (amitrole 10 % + simazine 40 %) and *A-844* (amitrole 5 % + simazine 45 %). The results (Table 5, Fig. 4) were as follows:

Amitrole/simazine mixtures killed the weeds much more quickly than simazine alone. Their effect remained satisfactory for the first two growing seasons (Fig. 4). It would seem that under more rainy conditions the proportion of simazine in the mixtures could be considerably decreased to a much lower percentage than in the present experiments. — In apple trees the mixtures of amitrole and simazine did not cause injuries. The dalapon/simazine mixtures had the same rapid

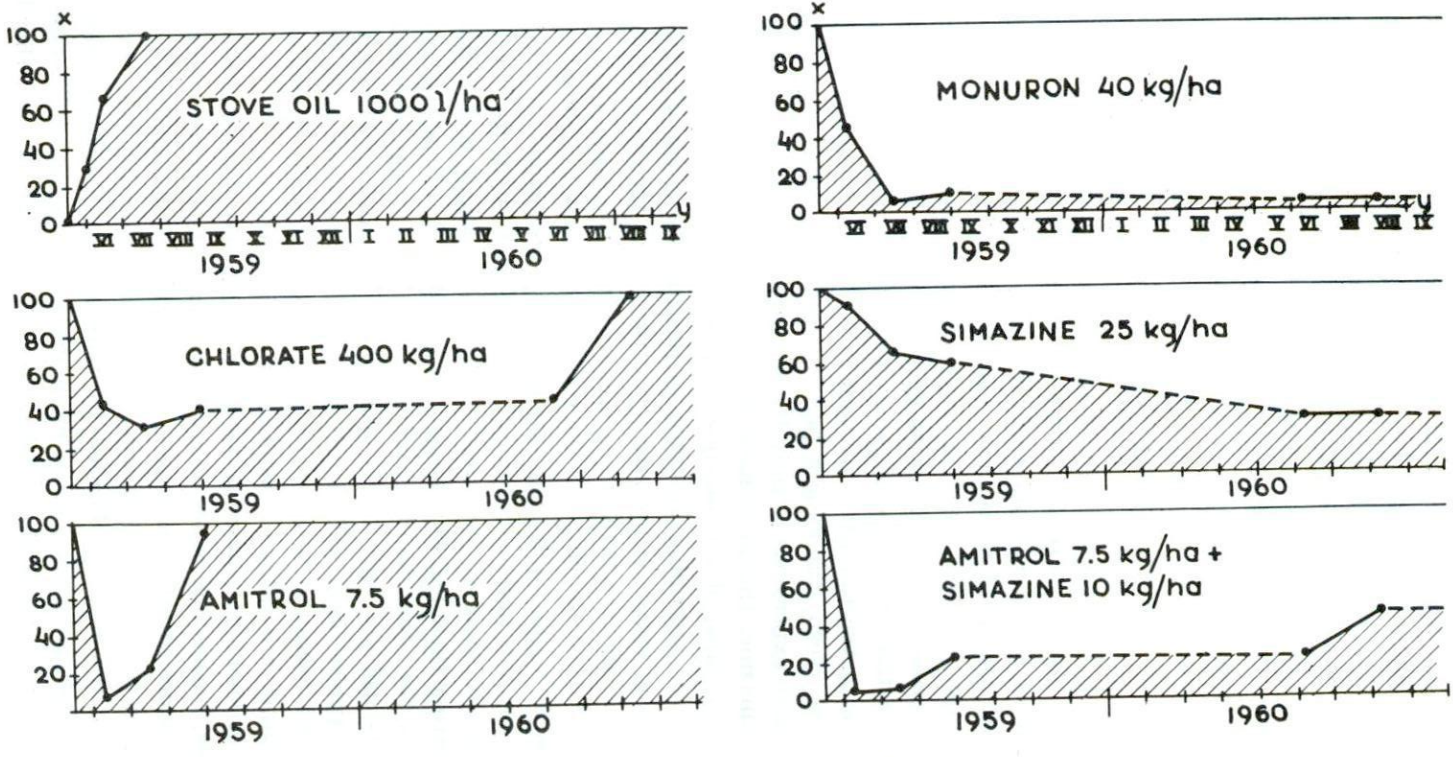


Fig. 4. The effect of various herbicides on weed stand. Piikkiö 1959—60. X = relative abundance of green growth; Y = length of period (months and years).

Kuva 4. Eräiden torjunta-aineiden vaikutus rikkaruohojen kokonaismäärään. Piikkiö 1959—60. X = rikkaruohokasvuston runsaus suhdelukuina; Y = aika (vuodet ja kuukaudet). Stove oil = lämmitysöljy; potassium chlorate = kaliumkloraatti.

action on the weeds as the amitrole/simazine mixtures had, their effect remaining satisfactory during the first two growing seasons. They had, however, a slighter effect on broad leaf perennials. In addition, the toxicity of dalapon to apple trees was evident even in the mixtures. It seems, therefore, that mixtures of dalapon and simazine cannot be considered for the weed control of our fruit crops.

Discussion and conclusions

Judging by the results, amitrole, simazine and atrazine seem to be the most promising of the herbicides experimented with in fruit crops. Amitrole gives a quick and good temporary control, but it does not eradicate the most important perennial weed in our fruit crops, the couch grass; it prevents the re-growth of couch grass only for some two months. Simazine is slower in action, but it eradicates most of the common weeds in our fruit crops, with the exception of horsetail. It also prevents the development of a new weed stand for a period of at least three years. Atrazine, regarding which experience is more limited, seems to have an action similar to that of simazine, though somewhat more rapid and stronger. It seems that the best control of well-established perennial weeds could be achieved with a mixture containing amitrole to destroy the green growth of the weed stand, and simazine (or possibly atrazine) to prevent the re-growth of the rhizomes and the invasion of new weeds in the area. In this respect the results are in agreement with the conclusions made by LOEWELL (1959).

Amitrole is mainly absorbed through the leaves which makes it very difficult to use this herbicide among fruit bushes and canes. The branches of these usually hang so low that spraying the weeds underneath them without wetting their leaves is extremely difficult or altogether impossible. Simazine, on the other hand, is mainly absorbed through the soil, which facilitates its use not only under fruit trees, but also under fruit bushes and canes. Apples seem sufficiently resistant to simazine, and the same is true of red currants, black currants and gooseberries. Raspberries, on the other hand, are rather susceptible to this herbicide.

The experiments conducted so far have been made under well-established mature trees, bushes and canes with an abundant stand of perennial weeds. It might be more suitable to start the application of herbicides in younger plantations, in the summer following the year of planting, i.e., before the area has been too heavily invaded by perennials. Admittedly fruit trees and berry bushes are known to be more susceptible at an early stage than when mature, at least to soil-sterilizing compounds, but, on the other hand,

the required amounts of herbicides are smaller in young plantations, being perhaps only some 1/5—1/10 of the amounts used in the above experiments. In this case we only have to fight against annuals, or the seedlings of perennials, which are comparable to the annuals — assuming naturally that the plantation has originally been established on soil free from perennials. Further points to be examined are the resistance of other fruit trees in addition to apple, the possible differences in the resistance of different tree, bush and cane fruit varieties, the significance of the type of soil, date of treatment, climatic conditions and various measures of crop husbandry. In particular, the combination of chemical treatment and cultivation, which is the method recommended by LOEWELL (1959), should be studied.

In considering the suitability of the herbicidal products under experiment account must be taken of the fact that they were all wettable powders, i.e., for use as sprays. In practice, this makes the distribution of the herbicide considerably more difficult, especially when used on a small scale, when a sprayer is not usually available. In regard to small areas in perticular, it may be too difficult for the farmer to calculate the amount of the solution required. Matters would be considerably improved if the compounds were made available in granular form, spreadable when dry, so the amount needed per small area unit, perhaps even per individual tree or bush, would be more easily calculable. The use of the soil-sterilizing compounds at least would in this way be safer, with more reliable results, i.e., the risk of injuries to trees, bushes and canes from too great an application could be avoided, as well as the inadequate effect on weeds of too small an application of herbicide. It is true that an even distribution is not easily obtained with granular products, but this disadvantage should not be as hazardous as a wrongly calculated dosage. The granulation of amitrole and such compounds, which are only absorbed through the leaves would, of course, be out of the question. However, the risk of injuries from an unnecessarily great application does not exist here.

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Selostus

RIKKARUOHOJEN KEMIALLINEN TORJUNTA HEDELMÄ- JA MARJATARHOISSA

Vuosina 1956—60 suoritetut kokeet

J. Mukula ja J. Säkö

Maatalouden tutkimuskeskus

Kasvinviljelylaitos, Tikkurila ja Puutarhantutkimuslaitos, Piikkiö

Kasvinviljelylaitoksella Tikkurilassa ja Puutarhantutkimuslaitoksella Piikkiössä on suoritettu hedelmä- ja marjatarhojen kemiallista rikkaruohontorjuntaa koskevia tutkimuksia. Kokeilluista torjunta-aineista näyttävät amitroli, simatsiini ja atratsiini lupaavimmilta.

Amitroli antaa nopean ja hyvän torjuntatuloksen, mutta ei tapa hedelmä- ja marjatarhojemme tärkeintä juuririkkaruohoa, juolavehnää juurakkoineen, vaan estää sen jälleenkasvun vain noin kahden kuukauden ajaksi. Simatsiini vaikuttaa hitaammin, mutta tappaa kortteita lukuunottamatta yleisimmät hedelmä- ja marjatarhojemme rikkaruohot juurakkoineen sekä pystyy estämään maan uudelleen rikkaruohottumisen ainakin kolmen vuoden ajaksi. Atratsiini, jonka kohdalla kokemukset ovat vähäisempiä, näyttää vaikutustavaltaan simatsiinin kaltaiselta, mutta tehoaa sitä jonkin verran nopeammin ja voimakkaammin. Todennäköisesti paras torjuntatulos voitaisiin saada seoksella, jossa amitroli tapaa rikkaruohojen versot ja simatsiini (tai mahdollisesti atratsiini) estää juurakoiden jälleenkasvun sekä alueen uudelleen rikkaruohottumisen.

Amitroli vaikuttaa kasveihin miltei yksinomaan lehtien kautta, mikä ominaisuus suuresti vaikeuttaa sen käyttöä marjapensaiden alustalla. Näiden oksathan riippuvat tavallisesti niin matalalla, että kasvualustan rikkaruohojen ruiskuttaminen roiskuttamatta liuosta myös pensaiden lehdille on erittäin vaikeata tai suorastaan mahdotonta. Simatsiini puolestaan vaikuttaa kasveihin miltei yksinomaan juurien kautta, mikä ominaisuus taas helpottaa sen käyttöä marjatarhassa. Omenapuiden kestävyys näyttää simatsiinille olevan riittävän hyvä, samoin musta- ja punaherukan sekä karviaisen. Sen sijaan vadelma on simatsiinille arveluttavan arka.

Seuraavat rikkaruohontorjunta-aineet joko vioittavat puita ja pensaita tai tehoavat rikkaruohoihin edellä mainittuja aineita heikommin: aromaattiset öljyt, natriumkloraatti, natriumkloraatin ja natriumkloridin seos, natriumkloraatin, booraksin ja monuronin seos, kaliumkloraatti, TCA, dalapon, erbon, monuron, neburon sekä dalaponin ja simatsiinin seos.