Herbigation* in a Vineyard: Efficacy and Persistence of Five Pre-emergence Herbicides in a Sandy Soil**

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The persistence of simazine, oxadiazon, napropamide, oryzalin and acetochlor in a sandy soil was monitored over a period of 60 days by means of a bio-assay. Sixty days after application 3% of simazine, 5% of acetochlor, 6% of oxadiazon, 53% of oryzalin, and 54% of napropamide, initially present, were detected in the 0-300 mm soil layer. Simazine, oxadiazon, acetochlor and napropamide leached. Oryzalin was resistant to leaching and showed the highest efficacy and therefore is the most suitable for use on sandy soils. The herbicides were more efficacious when applied in a 5 mm herbigation than in a 16 mm herbigation. The criteria established for herbigation on a sandy soil could be used as a guideline for light-textured soils.

Most weed seeds germinate in the 0-100 mm soil layer. Therefore the efficacy of a pre-emergence herbicide is determined by the amount of herbicide that is adsorbed to the 0-100 mm soil layer during application as well as its persistance in this soil layer. Evaluation of herbicide efficacy in relation to soil persistence facilitates the correct use of split-dosages (Fourie, 1992) and creates a better understanding of the weed-control performance of pre-emergence herbicides. Effective weed control was achieved on a sandy loam soil with simazine [2-chloro-4,6-di(ethylamino)-1,3,5-triazine], Oryzalin (3,5-dinitro- N^4,N^4-dihydropropylsulfanilamide), napropamide [2-(∝-naphthoxy)-N, N-diethylpropionamide] and oxadiazon [2-tert-butyl-4-(2,4-dichloro-5-isopropoxyphenyl)-1,3,4-oxadiazoline-5-one], applied with 20 mm of irrigation water through a microjet irrigation system (Fourie, 1988). However, soil texture and organic matter (Ogg *et al.*, 1983) as well as the amount of water used during herbigation has a great influence on the performance of soil-applied herbicides (Ogg *et al.*, 1983; Todd & Klocke, 1984; Ogg, 1986). The results of Fourie (1988, 1992) could therefore not be implemented as such on sandy soils, which are common in the Hex River Valley, the major table-grape region of South Africa.

To ensure optimal herbigation on an irrigated sandy soil, the efficacy and dissipation rate of simazine, oryzalin, napropamide, oxadiazon and acetochlor [2-chloro-N-(ethoxymethyl)-6^1-ethyl-0-acetotoluidide] as well as the correct herbigation volume must be determined.

MATERIALS AND METHODS

The investigation was carried out in an 18-year-old Barlinka vineyard trained onto a slanting trellis system. The vines were growing on a sandy soil at the Hexvallei Experimental Farm in De Doorns. Soil analyses, done according to standard Nietvoorbij procedures, are presented in Table 1. The irrigation system used for this experiment consisted of irrigation lines with a diameter of 20 mm, mounted 3 m apart on a wire 450 mm above the surface. Microjets (360°) delivering 48 $l.ha^{-1}$ at a pressure of 200 kPa were mounted 3 m apart on top of the irrigation line with the microjets on adjacent lines in alternating positions. Each experimental plot consisted of an area of 198 m^2 and was replicated five times in a randomised block design. During the second week of November each of five pre-emergence herbicides (Table 2) was injected into a separate irrigation system by means of a diaphragm pump. The pressure in the system was 200 kPa. In the 1987/88 growing season the herbicides were applied during the first 20 minutes of a 16 mm irrigation. During the following two seasons herbicides were applied with 5 mm of irrigation water. For the duration of the trial (up to 60 days after application), 25 mm of irrigation water was applied weekly. Rainfall over this period amounted to 24 mm, 27 mm and 6,6 mm for the 1987/88, 1988/89 and 1989/90 growing seasons, respectively. The vines were monitored visually for any phytotoxicity symptoms on the leaves. A mixture of *Digitaria, Eragrostis* and *Setaria* species were sown one day before herbigation during all three seasons, to ensure an adequate seed bank in the experimental plots.

Efficacy trial: Weed dry mass per m^2 was determined and number of weeds per m^2 counted 30 days and 60 days after herbigation. The dry mass was determined during both the 1987/88 and 1988/89 growing seasons, while the number of weeds was counted during the 1988/89 growing season only.

Herbicide persistence: Soil samples were taken during the 1989/90 growing season from the 0-50 mm, 50-100 mm, 100-150 mm and 150-300 mm soil layers 1 day, 15 days, 30 days and 60 days after herbigation. Each soil sample was a composite of three subsamples selected randomly in a

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TABLE 1
Analyses of the 0-300 mm soil layer of a sandy soil used for a herbigation experiment at Hexvallei Experimental Farm in De Doorns.

pH	Organic matter	Electrical conductivity	Clay	Silt	Sand	Bulk density	Exchangeable Cations (me/100 g)			
(KCl)	(%)	($mS.m^{-1}$)	(%)	(%)	(%)	($kg.m^{-3}$)	K	Ca	Mg	Na
4,5	1,14	69	4,5	2,8	92,7	1450	1,57	4,24	1,22	0,70

TABLE 2
The effect of five pre-emergence herbicides, applied during the first 20 minutes of a 16 mm irrigation, on the weed dry mass per m² measured 30 days and 60 days after application on a sandy soil in De Doorns (1987/88 growing season).

Treatments	Formulation	Active ingredient per ha (g)	Days after application[1]			
			30		60	
			Dry mass (g)	Weed control (%)	Dry mass (g)	Weed control (%)
Control	–	–	35,51	0,0	326,53	0,0
Oryzalin	SC[2]	1680	6,41	82,0	54,48	83,3
Napropamide	SC	2700	4,08	88,5	78,74	75,9
Oxadiazon	SOL[3]	1440	9,71	72,7	221,14	32,3
Simazine	SC	3000	6,65	81,3	230,89	29,3
Acetochlor	SOL	1800	12,53	64,7	163,79	49,8
D-value ($p \leq 0,05$)			25,21	–	128,55	–

[1] Total amount of water: Day 1 = 16 mm.
Day 30 = 122 mm.
Day 60 = 240 mm.
[2] SC = suspension concentrate.
[3] SOL = solution.

TABLE 3
The effect of five pre-emergence herbicides, applied during the first 20 minutes of a 5 mm irrigation, on the weed dry mass per m² measured 30 days and 60 days after application on a sandy soil in De Doorns (1988/89 growing season).

Treatments	Formulation	Active ingredient per ha (g)	Days after application[1]			
			30		60	
			Dry mass (g)	Weed control (%)	Dry mass (g)	Weed control (%)
Control	–	–	18,65	0,0	118,50	0,0
Oryzalin	SC[2]	1680	0,95	94,9	4,70	96,0
Napropamide	SC	2700	0,99	94,7	6,41	94,6
Oxadiazon	SOL[3]	1440	4,23	77,3	29,91	74,5
Simazine	SC	3000	2,18	88,9	38,68	67,4
Acetochlor	SOL	1800	1,66	91,1	15,53	86,8
D-value ($p \leq 0,05$)			4,64	–	27,08	–

[1] Total amount of water: Day 1 = 5 mm.
Day 30 = 105 mm.
Day 60 = 232 mm.
[2] SC = suspension concentrate.
[3] SOL = solution.

plot. The presence of the different pre-emergence herbicides was determined by means of the bio-assay described by Fourie (1992). *Avena sativa* L. (oats) was used to bio-assay for oxadiazon, oryzalin and acetochlor, whereas *Hordeum vulgare* L. (barely) was used for simazine and napropamide.

All data were analysed using standard analyses of variance methods (Snedecor & Cochran, 1982). Students' least significant difference at the 5% level was used to compare treatment means.

RESULTS AND DISCUSSION

Herbicide efficacy: Weed control of 90% and higher was considered to be acceptable as this is the minimum level of weed control considered by the Registrar: Act 36 of 1947 of the Republic of South Africa to be acceptable. Although the weed dry mass measured on some of the herbicide treatments was significantly lower than that of the control, it is clear that a herbigation of 16 mm should not be used on a sandy soil (Table 2). Lowering the herbigation to 5 mm improved the efficacy of all the herbicides (Table 3). Thirty days after application the percentage weed control achieved with acetochlor, oryzalin, simazine, napropamide and oxadiazon improved by 26%, 13%, 7%, 6% and 5% respectively (Tables 2 and 3). The improved performance measured 60 days after application is even more noteworthy.

Despite the lower application volume used, the percentage weed control achieved with oxadiazon and simazine was still below the acceptable level of 90%. Acetochlor gave acceptable control up to 30 days after application, but the efficacy of the herbicide 60 days after application was not satisfactory. Oryzalin and napropamide controlled the weeds effectively up to 60 days after application.

When using the number of weeds as a criterion for the percentage weed control (Table 4), simazine and oxadiazon seem to perform much better. The efficacy of oryzalin, napropamide, simazine and acetochlor were all on the same level 30 days after application. However, if the size of the average weed is calculated (dry mass : weed number), the higher figure for simazine indicates that the weeds present in this treatment might have germinated earlier.

Application efficiency: The percentage of herbicide that reached the soil is shown in Tables 5 to 9. In a previous study (Fourie, 1992) simazine, napropamide and oryzalin were applied as wettable powders, whereas in the present study these herbicides were applied as suspension concentrates. This change in formulation undoubtedly contributed to the increased application efficiency noted for simazine (17%), napropamide (26%) and oryzalin (23%) in comparison to the results of Fourie (1992). In both studies the herbicides formulated as solutions had the highest application efficiencies. These results as well as the results of Fourie (1992) support the view of Callihan (1974) and Ogg (1976), suggesting that precipitation of wettable powders and to a lesser extent suspension concentrates do occur in the irrigation lines during application.

Climatic conditions during application, and more specifically high air temperatures (>30°C) and low relative humidity (<15%), greatly increase evaporation (Frost & Schwalen, 1955; Jensen, 1980 as quoted by Ogg, 1986). According to Burnside, Fenster & Wicks (1963) and Hilton *et al.* (1974), volatilization of simazine and atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-S-triazine] is highly improbable due to their low vapour pressures. In contrast, when atrazine was applied through a sprinkler irrigation system with the day temperature at 35°C and relative humidity at 30%, the evaporation loss was 10%, (Crutchfield, Clark & Wiese, 1977). These climatic conditions correspond with the conditions that prevailed during application in the present study. Therefore, although volatilization of simazine, napropamide and oryzalin is nor-

TABLE 4
The effect of five pre-emergence herbicides, applied during the first 20 minutes of a 5 mm irrigation, on the weed number per m^2 recorded 30 days and 60 days after application on a sandy soil in De Doorns (1988/89 growing season).

Treatments	Formulation	Active ingredient per ha (g)	Days after application[1]			
			30		60	
			Weeds per m^2	Weed control (%)	Weeds per m^2	Weed control (%)
Control	–	–	69	0,0	130	0,0
Oryzalin	SC[2]	1680	4	94,2	7	94,6
Napropamide	SC	2700	5	92,8	10	92,3
Oxadiazon	SOL[3]	1440	8	88,4	17	86,9
Simazine	SC	3000	3	95,7	16	87,7
Acetochlor	SOL	1800	5	92,8	15	88,5
D-value ($p \leq 0,05$)			15	–	21	–

[1] Total amount of water: Day 1 = 5 mm.
Day 30 = 105 mm.
Day 60 = 232 mm.
[2] SC = suspension concentrate.
[3] SOL = solution.

mally not expected during application, part of the loss found in the present study was probably due to this phenomenon.

With the exception of napropamide, all the herbicide detected one day after a herbigation of 5 mm occurred in the 0-100 mm soil layer (Tables 5 to 9). Despite the fact that 20% of the napropamide was present in the 100-300 mm soil layer 1 day after application (Table 8), the application volume should not be reduced any further because photodecomposition on the soil surface could inactivate an even greater percentage. A loss of as much as 50% of the applied napropamide by photodecomposition could occur after a period of 4 days (Hilton *et al.,* 1974).

Persistence in Soil

Simazine: Only 3% of the simazine detected in the 0-300 mm soil layer one day after application could be found in the soil 60 days after application (Table 5). Clearly this indicates that an accumulation of simazine, because of repetitive use, is most unlikely in this soil layer. The presence of simazine in the 50-100 mm and 150-300 mm soil layers 30 days after application, as well as the amount detected in the 100-150 mm soil layer 60 days after application, show that leaching did occur. This supports the data of other researchers showing that simazine moves to a greater or lesser extent in different soils (Burnside, Schmidt & Behrens, 1961; Burnside, Fenster, Wicks, 1963; Harris, 1966; Hall & Hartwig, 1990; Fourie, 1992). The high dissipation rate detected between 30 days and 60 days after application could most probably be attributed to leaching of the chemical from the 0-300 mm soil layer. Therefore, contamination of ground water could probably occur in this soil type. Chemical and microbial breakdown, as well as the herbicide being taken up by germinating weeds, must have contributed to the dissipation of simazine.

Oxadiazon: Sixty days after application only 5,8% of the original amount of oxadiazon that reached the soil could still be detected in the 0-300 mm soil layer (Table 6), suggesting that accumulation of this herbicide in this soil layer because of repetitive use is highly improbable. The presence of oxadiazon in the 50-100 mm and 150-300 mm soil layers 15 days after application is a clear indication that leaching occurred during the preceding period. The fact that an increase in the herbicide concentration was detected in the 150-300 mm soil layer between 15 days and 30 days after application suggests that some of the chemical could have leached out of the 0-300 mm soil layer. Therefore the high dissipation rate experienced in this study could be attributed *inter alia* to leaching. According to Hilton *et al.* (1974) and Horowitz & Bucsbaum (1978), oxadiazon is strongly adsorbed by soil colloids and is therefore resistant to leaching. Although the herbicide was found to be nearly immobile in soils with a clay content of 11% and higher, migration of oxadiazon was detected in a Lakeland sandy loam with a clay content of 12 % and a silt content of 16,4% (Ambrosi & Helling, 1976). Leaching of oxadiazon also occurred on a sandy loam soil with a clay content of 18% and a silt content of 12,2% (Fourie, 1992). The present results, considered in conjunction with those quoted from the literature, suggest that the migration pattern of oxadiazon is influenced greatly by soil texture.

Napropamide: From the data recorded in Table 7 it is clear that leaching did occur to a greater or lesser extent up to 60 days after application. Despite this, 54% of the napropamide that reached the 0-300 mm soil layer could still be detected 60 days after application, clearly showing

TABLE 5
The occurrence of simazine at different soil depths over time after application of 3000 g active ingredient per ha by a 5 mm herbigation on a sandy soil in De Doorns (1989/90 growing season).

Soil layer (mm)	Days after application[1]							
	1		15		30		60	
	Active ingredient ($g.ha^{-1}$)[2]	Applied simazine remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied simazine remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied simazine remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied simazine remaining (%)
0 – 50	1762	58,7	1387	46,2	667	22,2	0	0,0
50 – 100	101	3,4	0	0,0	130	4,3	0	0,0
100 – 150	0	0,0	0	0,0	0	0,0	58	1,9
150 – 300	0	0,0	0	0,0	109	3,6	0	0,0
Total	1863	62,1	1387	46,2	905	30,1	58	1,9
D-value ($p \leq 0,05$)	435	–	58	–	254	–	15	–

[1] Total amount of water: Day 1 = 5,0 mm; Day 15 = 61,6 mm; Day 30 = 111,6 mm; Day 60 = 211,6 mm.
[2] Active ingredient ($g.ha^{-1}$) = $mg.kg^{-1}$ active ingredient measured by bio-assay x bulk density x volume of soil layer.ha^{-1} x 10^{-3}.

TABLE 6
The occurrence of oxadiazon at different soil depths over time after application of 1440 active ingredient per ha by a 5 mm herbigation on a sandy soil in De Doorns (1989/90 growing season).

Soil layer (mm)	Days after application[1]							
	1		15		30		60	
	Active ingre-dient (g.ha^{-1})[2]	Applied oxadiazon remaining (%)	Active ingre-dient (g.ha^{-1})	Applied oxadiazon remaining (%)	Active ingre-dient (g.ha^{-1})	Applied oxadiazon remaining (%)	Active ingre-dient (g.ha^{-1})	Applied oxadiazon remaining (%)
0 – 50	1129	78,4	760	52,8	58	4,0	0	0,0
50 – 100	0	0,0	80	5,5	0	0,0	22	1,5
100 – 150	0	0,0	0	0,0	0	0,0	0	0,0
150 – 300	0	0,0	65	4,5	109	7,6	0	0,0
Total	1129	78,4	905	62,8	167	11,6	22	1,5
D-value ($p \leq 0,05$)	399	–	225	–	138	–	29	–

[1] Total amount of water: Day 1 = 5,0 mm; Day 15 = 61,6 mm; Day 30 = 111,6 mm; Day 60 = 211,6 mm.
[2] Active ingredient (g.ha^{-1}) = mg.kg^{-1} active ingredient measured by bio-assay x bulk density x volume of soil layer.ha^{-1} x 10^{-3}.

TABLE 7
The occurrence of napropamide at different soil depths over time after application of 2700 g active ingredient per ha by a 5 mm herbigation on a sandy soil in De Doorns (1989/90 growing season).

Soil layer (mm)	Days after application[1]							
	1		15		30		60	
	Active ingre-dient (g.ha^{-1})[2]	Applied napropa-mide remaining (%)	Active ingre-dient (g.ha^{-1})[2]	Applied napropa-mide remaining (%)	Active ingre-dient (g.ha^{-1})[2]	Applied napropa-mide remaining (%)	Active ingre-dient (g.ha^{-1})[2]	Applied napropa-mide remaining (%)
0 – 50	1263	46,8	1161	43,0	719	26,6	653	24,2
50 – 100	36	1,3	51	1,9	80	3,0	80	3,0
100 – 150	116	4,3	58	2,1	116	4,3	36	1,3
150 – 300	218	8,1	108	4,0	132	4,9	108	4,0
Total	1633	60,5	1378	51,0	1047	38,8	877	32,5
D-value ($p \leq 0,05$)	631	–	508	–	297	–	109	–

[1] Total amount of water: Day 1 = 5,0 mm; Day 15 = 61,6 mm; Day 30 = 111,6 mm; Day 60 = 211,6 mm.
[2] Active ingredient (g.ha^{-1}) = mg.kg^{-1} active ingredient measured by bio-assay x bulk density x volume of soil layer.ha^{-1} x 10^{-3}.

that napropamide is much more persistent in soil than oxadiazon and simazine. This supports the data of Fourie (1992). The dissipation rate of 46% over a period of 60 days corresponds well with the dissipation rates mentioned by Hilton *et al.* (1974) and Gerstl & Yaron (1983a).

Wu *et al.* (1975) and Gerstl & Yaron (1983b) also found that napropamide migrated in the soil. Jury, El Abd & Resketo (1986) found that 73% of the napropamide applied to a sandy loam soil stayed in the 0-100 mm soil layer after the application of 230 mm of water over a period of two weeks. However, trace concentrations were detected as deep as 1,8 m. The fact that more migration of napropamide occurred in the sandy soil than in the sandy loam soil (Fourie, 1992) correlates with the data of Wu *et al.*(1975).

Oryzalin: From the data presented in Table 8, it is clear that leaching did not occur beyond a depth of 100 mm. Similar results were obtained on a sandy loam soil (Fourie, 1992). The dissipation rate of 47% over 60 days corresponds well to the 50% recorded over a period of 1,5 to 2 months by Gingerich & Zimdahl (1976). The loss of active ingredient measured in the present study is probably caused by chemical or microbial breakdown. This resistance to leaching makes oryzalin extremely suitable for pre-emergence weed control on sandy soils.

Acetochlor: Fifty one percent of acetochlor present in the 0-300 mm soil layer one day after application could still be detected 15 days after application whereas 30% was detected after 30 days (Table 9). Approximately 15% of the herbicide leached from the 0-50 mm soil layer into both the 50-100 mm and 100-150 mm soil layers during the first 15 days after application (Table 9). Thereafter no leaching could be detected for the duration of the trial. Although leaching occurred to some extent, it seems that most of the herbicide loss can be attributed to chemical and/or microbial breakdown. Sixty days after application only 5% of the herbicide was still present in the 0-50 mm soil layer. Therefore a buildup of the herbicide because of repetitive use on the same soil is highly improbable.

Efficacy in relation to persistence: It seems that 667 g of simazine per ha in the 0-50 mm soil layer (Table 5) does not give acceptable weed control (<90%) on a sandy soil if weed mass is taken as the criterion for control (Table 3). This is in contrast to the results of Fourie (1992), which showed that a concentration of 341 $g.ha^{-1}$ still controlled the weeds effectively on a sandy loam soil. If, however, the number of weeds is taken as the criterion for weed control, the level of weed control determined 30 days after application is similar for both soil types. The reason for the discrepancy becomes clear if the average growth per weed per day is calculated for the results of both studies. In the case of the present study the average growth per weed per day over the sixty-day period was 1,1 g, whereas in the trial executed on the sandy loam soil it amounted to only 0,06 g. This indicated that weeds germinating in this sandy soil grew much more vigorously than weeds that germinated in the sandy loam soil. The absence of simazine in the 0-100 mm soil layer 60 days after application (Table 6) explains the unsatisfactory weed control at this stage (Table 3 and 4). Despite this, the number of weeds counted in this treatment was only 12,3% of the amount recorded in the control plot (Table 4). This illustrated the importance of applying a pre-emergence herbicide as near as possible to the peak germination time of the weed species to be controlled.

The 58 g of oxadiazon per ha present in the 0-50 mm soil layer 30 days after application (Table 6), did not control

TABLE 8
The occurrence of oryzalin at different soil depths over time after application of 1680 g active ingredient per ha by a 5 mm herbigation on a sandy soil in De Doorns (1989/90 growing season).

Soil layer (mm)	Days after application[1]							
	1		15		30		60	
	Active ingredient ($g.ha^{-1}$)[2]	Applied oryzalin remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied oryzalin remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied oryzalin remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied oryzalin remaining (%)
0 – 50	811	48,3	717	42,7	695	41,4	500	29,8
50 – 100	130	7,7	58	3,4	0	0,0	0	0,0
100 – 150	0	0,0	0	0,0	0	0,0	0	0,0
150 – 300	0	0,0	0	0,0	0	0,0	0	0,0
Total	941	56,0	775	46,1	695	41,4	500	29,8
D-value ($p \leq 0,05$)	268	–	355	–	218	–	138	–

[1] Total amount of water: Day 1 = 5,0 mm; Day 15 = 61,6 mm; Day 30 = 111,6 mm; Day 60 = 211,6 mm.
[2] Active ingredient ($g.ha^{-1}$) = $mg.kg^{-1}$ active ingredient measured by bio-assay x bulk density x volume of soil $layer.ha^{-1}$ x 10^{-3}.

the weeds effectively (Table 3 and 4). This concentration is much lower than the 227 g active ingredient per ha that gave effective weed control on a sandy loam soil 60 days after application (Fourie, 1992). Clearly these results show why oxadiazon controls weeds effectively on a sandy loam soil but fails to do the same on a sandy soil.

Because of its persistence in the soil (Table 8) napropamide gave excellent weed control up to 60 days after application (Tables 4 and 5). The results of Fourie (1988, 1992) as well as the present data indicate that napropamide can be used for the control of *Digitaria, Setaria* and *Eragrostis* species up to 90 days after application. Despite the leaching that occurred during the present trial, napropamide can be used on sandy soils, as no phytotoxicity symptoms were detected on leaves of experimental vines. Effective control of the abovementioned grasses throughout the growing season of the vine should be possible with a split dosage of 1,35 kg active ingredient per ha, applied with a 60-day interval on medium- to light-textured soils. The leaching that occurred during the present study (Table 8), as well as the results of Jury *et al.* (1986), indicate that ground-water contamination could occur if napropamide was applied on a sandy soil. The probable migration of napropamide to the deeper soil layers (>300 mm) should therefore be investigated to ensure that the herbicide can be used on this soil type without any hazard to the environment.

As in the case of napropamide, the weed control efficiency of oryzalin (Tables 3 and 4) can be attributed to the fact that it persisted in the sandy soil (Table 8). The 500 g of active ingredient per ha that gave excellent weed control in the present study correlated well with the amount that was deemed necessary for the control of grass species on a sandy loam soil (Fourie, 1988, 1992). The results of this study, therefore, show that *Digitaria, Setaria* and *Eragrostis* species should be controlled by a monthly application of between 1,0 kg and 1,26 kg of active ingredient per hectare.

In the case of acetochlor, a concentration of 406 g of active ingredient per hectare present in the 0-50 mm soil layer (Table 9) ensured acceptable weed control up to 30 days after application (Tables 3 and 4). The rapid dissipation of the chemical from the 0-50 mm soil layer is the reason that weeds started to break through between 30 days and 60 days after application (Table 4). The dissipation rate detected makes the accumulation of the herbicide in vineyard soils highly improbable. Despite the fact that leaching could be detected between the different soil layers, the herbicide did not seem to move out of the 0-300 mm soil layer. The impact of acetochlor on the environment should, therefore, be negligible. No phytotoxicity symptoms could be detected on the leaves of the vines.

CONCLUSIONS

A herbigation volume of 5 mm should be used on a sandy soil with less than 5% clay to ensure that the herbicide is placed in the 0-100 mm soil layer. The results indicated that the application efficiency is higher with suspension concentrates than with wettable powders as far as a microjet irrigation system is concerned. If possible, the use of a solution is preferable.

The high dissipation rate of oxadiazon and simazine is probably due to leaching. These herbicides should not be used on light-textured soils. Because of the high dissipation rate of acetochlor, acceptable weed control was achieved for only a short period of time. Oryzalin and napropamide gave effective weed control for the duration

TABLE 9
The occurrence of acetochlor at different soil depths over time after application of 1800 g active ingredient per ha by a 5 mm herbigation on a sandy soil in De Doorns (1989/90 growing season).

Soil layer (mm)	Days after application[1]							
	1		15		30		60	
	Active ingredient ($g.ha^{-1}$)[2]	Applied acetochlor remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied acetochlor remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied acetochlor remaining (%)	Active ingredient ($g.ha^{-1}$)	Applied acetochlor remaining (%)
0 – 50	1713	95,2	733	40,7	406	22,6	87	4,8
50 – 100	36	2,0	94	5,2	87	4,8	0	0,0
100 – 150	0	0,0	65	3,6	36	2,0	0	0,0
150 – 300	0	0,0	0	0,0	0	0,0	0	0,0
Total	1749	97,2	892	49,5	529	29,4	87	4,8
D-value ($p \leq 0,05$)	334	–	406	–	152	–	51	–

[1] Total amount of water: Day 1 = 5,0 mm; Day 15 = 61,6 mm; Day 30 = 111,6 mm; Day 60 = 211,6 mm.
[2] Active ingredient ($g.ha^{-1}$) = $mg.kg^{-1}$ active ingredient measured by bio-assay x bulk density x volume of soil layer.ha^{-1} x 10^{-3}.

of the trial because of their persistence in the 0-100 mm soil layer. The immobility and slightly better weed-control capacity of oryzalin makes it the better choice for a sandy soil.

The dissipation rate and herbigation of simazine, napropamide, oxadiazon, oryzalin and acetochlor in heavier soils should be researched. This will facilitate the formulation of guidelines for the practical use of this application technique on all vineyard soils.

LITERATURE CITED

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