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CHEMICAL CONTROL OF WEEDS IN THE AROMATIC CROPS LAVENDER, OREGANO AND SAGE

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SUMMARY

Irrigated aromatic crops are plagued with competition by a large number of weed species. A comprehensive chemical weed control program in aromatic crops was started in 1996 at the Agricultural Research Institute in co-operation with the National Agricultural Research Foundation (NAGREF). Pre-emergence herbicides applied to lavender (*Lavandula angustifolia* Mill.), oregano (*Origanum dubium* Boiss.) and sage (*Salvia fruticosa* Mill.) few days after planting reduced significantly the dry weight of weeds. Although some of the herbicides tested often caused foliar damage to the crops they did not affect yield or oil content compared with the untreated control. For lavender, herbicide treatments were aclonifen (2750 to 3000 g a.i./ha), chloridazon 2000 to 3000 g a.i.), chlorthal dimethyl (7500 to 9000 g a.i.), fluorochloridone (500 to 700 g a.i.), linuron (700 to 800 g a.i.), oxadiazon (750 to 1000 g a.i.) and oxyfluorfen (500 to 750 g a.i.).

In oregano, the same herbicides were used, except linuron, which was substituted by diuron (800 to 1000 g a.i./ha), while for sage the herbicide lenacil (1200 to 1600 g a.i.) was included in addition to aclonifen, chloridazon, DCPA, oxadiazon and oxyfluorfen, whose rates were as above.

ΠΕΡΙΛΗΨΗ

Στα αρωματικά φυτά, σαν αρδευόμενες καλλιέργειες, η παρουσία πυκνής βλάστησης ζιζανίων με το συναγωνισμό τους για νερό, λίπασμα και φως, προκαλούν πολύ συχνά σοβαρή ποσοτική και ποιοτική μείωση στην παραγωγή. Το Ινστιτούτο Γεωργικών Ερευνών, σε συνεργασία με το Εθνικό Ίδρυμα Αγροτικής Έρευνας (ΕΘΙΑΓΕ) της Ελλάδας άρχισε το 1996 πρόγραμμα καταπολέμησης των ζιζανίων σε διάφορες οικονομικής σημασίας καλλιέργειες αρωματικών φυτών.

Υπολειμματικά ζιζανιοκτόνα που χρησιμοποιήθηκαν σε καλλιέργειες λεβάντας, ρίγανης και φασκόμηλου μερικές μέρες μετά τη μεταφύτευση τους αλλά πριν τη βλάστηση των ζιζανίων, καταπολέμησαν τα ζιζάνια χωρίς να επηρεάσουν την παραγωγή και περιεκτικότητά των φυτών σε λάδι. Μερικά όμως από τα ζιζανιοκτόνα προκάλεσαν φυτοτοξικότητα. Στη λεβάντα, τα ζιζανιοκτόνα που χρησιμοποιήθηκαν ήταν: ακλόνιφεν (2750 έως 3000 γρ δραστικής ουσίας στο εκτάριο), χλωριταζόν (2000 έως 3000 γρ), χλώρθαλ–νταϊμήθαϊλ (7500 έως 9000 γρ) φλουροχλωριτόν (500 έως 700 γρ), λινιουρόν (700 έως 800 γρ), οξανταϊαζόν (750 έως 1000 γρ) και οξυφλουορφέν (500 έως 750 γρ).

Στη ρίγανη χρησιμοποιήθηκαν όλα τα πιο πάνω, εκτός από το λινιουρόν το οποίο αντικαταστάθηκε με το ντιουρόν (800 έως 1000 γρ), ενώ για το φασκόμηλο, το λενασίλ (1200 έως 1600 γρ) δραστικής ουσίας το εκτάριο συμπεριλήφθηκε μαζί με τα ακλόνιφεν, χλωριταζόν, χλώρθαλ–νταϊμήθαϊλ, οξανταϊαζόν και οξυφλουορφέν.

INTRODUCTION

The cultivation of aromatic plants is greatly favored by the soil and climatic conditions prevailing in Cyprus. The Ministry of Agriculture, Natural Resources and Environment initiated a Project for the Development of Aromatic and Medicical Plants Cultivation in 1992. Since then, farmers have shown enthousiastic response to the project. However, they face several problems which need to be solved. The Agricultural Research Institute undertook a research program in which, among other studies, the control of weeds was involved, since weeds constitute a serious problems and, if left unchecked, can smother the crops.

The usual practice of growing aromatic

plants is to raise seedlings in soil blocks and transplant them to their permanent position. Since most aromatic plant species are perennials they grow and almost cover the whole soil surface, rendering the control of weeds by mechanical means impossible.

Limited research in the chemical control of weeds has been carried out on aromatic plant species, e.g. sage and oregano (Bouverat–Bernier and Gallotte, 1989; 1992), lavender (Nagy *et al.*, 1987) and marjoram (Gallotte and Bouverat-Bernier, 1992). In Cyprus, several herbicides in 15 aromatic plant species were screened in an earlier study (Vouzounis, 1997). The present work was undertaken in order to select herbicides that would satisfactorily control weeds in lavender, oregano and sage.

MATERIALS AND METHODS

Several pre-emergence herbicides were tested for their suitability and effectiveness in three aromatic plant species. Field trials initiated in autumn 1996 with lavender and sage at Derynia and Lythrodontas, and with oregano at Lefkara, were completed in 1998. The soil at Lefkara was a clay loam (39% clay, 22% silt and 39% sand), while at Lythrodontas and Derynia it was a clay (43% clay, 18% silt and 39% sand).

Plot size was either 4x6 or 4x5 m. The experimental design was a randomized complete block with four replications. The pre-emergence herbicides were applied twice a year in late autumn and early spring, post-planting of the crops (Tables 1, 2 and 3).

Herbicides were applied as a solution at the rate of 500 l water/ha using a knapsack sprayer fitted with a flat fan nozzle. Two to three weeks after application the crops were inspected for symptoms of toxicity, a second inspection being made two to three weeks later.

Three weeks after the application of herbicides the plots were sampled for weeds. Sampling consisted of collecting all weed species from an area of 15 m^2 in each plot. Weed species in each plot were also recorded. The mass of weeds was brought into the laboratory where the roots and dead parts of the plants were cut off and discarded. The live parts were dried to constant weight at 95 °C. The weeds remaining in the plots after sampling were removed by hand.

Oregano was harvested in early June and sage in spring. For both crops yield records were taken by harvesting two plants at random from the middle of each plot from which total fresh weight (stems, leaves and flowers), marketable air-dried yield (leaves and flow-

Table 1. Effect of herbicides on the dry weight of weeds, and flowers and on the oil content of transplanted Lavender

Herbicide	Rate (kg a.i./ha)	Dry weight of weeds (g/15m^2)*	Dry weight of flowers (g/2 plants)	Oil content (%)
Aclonifen	2.75	2.47 cdef	100.67bcd	6.07 ab
	3.00	2.31 cdef	107.67bcd	6.62 a
Chloridazon	2.00	3.94 cde	142.33 abcd	6.65 a
	3.00	3.24 cdef	107.00 bcd	5.87 ab
DCPA	7.50	7.89 b	156.20 abc	5.75 ab
	9.00	5.26 c	164.00 ab	5.85 ab
Fluorochloridone	0.50	2.32 cdef	144.33 abcd	5.62 ab
	0.75	2.31 cdef	144.67 abcd	6.55 a
Linuron	0.70	4.64 cd	135.67 abcd	5.07 b
	0.80	4.77 cd	92.33 cd	5.06 b
Oxadiazon	0.75	2.33 cdef	156.33 abc	6.42 a
	1.00	2.13 def	156.00 abc	6.09 ab
Oxyfluorfen	0.50	0.71 f	185.00 a	6.16 ab
	0.75	0.69 f	164.50 ab	6.03 ab
Untreated		15.85 a	88.00 d	5.82 ab

*Data were transformed to $1/(x+0.01)^{-2}$ before analysis; Means within column followed by the same letter are not significantly different at $P \leq 0.05$ based on Duncan's New Multiple Test.

Table 2. Effect of herbicides on the dry weight of weeds and yield and on the oil content of transplanted Oregano

Herbicide	Rate (kg a.i./ha)	Dry weight of weeds (g/15 m²)*	Yield: Fresh weight of stems, leaves and flowers (g/2 plants)	Yield: Dry weight of leaves and flowers (g/2 plants)	Oil Content (%)
Aclonifen	2.75	7.22 b	1040.00 a	294.5 ab	11.55 ab
	3.00	6.94 b	1091.3 a	296.3 ab	9.85 b
Chloridazon	2.00	5.23 c	1291.3 a	296.8 ab	10.75 ab
	3.00	4.68 c	1068.8 a	265.5 b	12.70 ab
DCPA	7.50	7.41 b	1302.5 a	315.3 ab	12.20 ab
	9.00	6.68 b	1022.5 a	240.3 b	13.03 a
Diuron	0.80	3.52 d	1346.3 a	316.0 ab	12.55 ab
	1.00	2.93 de	1208.8 a	290.5 ab	12.18 ab
Fluorochloridone	0.50	2.93 de	1320.0 a	295.0 ab	12.76 ab
	0.75	2.93 de	1165.0 a	269.0 b	11.43 ab
Oxadiazon	0.75	2.47 ef	1463.8 a	329.0 ab	11.08 ab
	1.00	1.70 f	1296.3 a	303.0 ab	12.43 ab
Oxyfluorfen	0.50	0.63 g	1238.8 a	306.3 ab	10.95 ab
	0.75	0.10 g	1003.5 a	265.0 b	10.73 ab
Untreated		10.00 a	1212.5 a	290.0 ab	11.88 ab

*Data were transformed to $(x+0.01)^{-1/2}$ before analysis. Means within columns followed by the same letter are not significantly different at $P \leq 0.05$ based on Duncan's New Multiple Range Test.

Table 3. Effect of herbicides on the dry weight of weeds and yield and on the oil content of transplanted Sage

Herbicide	Rate (kg a.i./ha)	Dry weight of weeds (g/15 m²)*	Yield: Fresh weight of stems, leaves and flowers (g/2 plants)	Yield: Dry weight of leaves and flowers (g/2 plants)	Oil Content (%)
Aclonifen	2.75	19.51 bcd	1448.3 cd	252.3 ab	2.32 ab
	3.00	19.29 bcde	1474.0 cd	201.3 b	2.19 ab
Chloridazon	2.00	19.75 bcd	1718.3 abc	330. 3 a	2.60 a
	3.00	13.19 defg	1900.0 abc	186.7 b	1.82 ab
DCPA	7.50	22.69 abc	1125.3 d	204.0 b	2.35 ab
	9.00	25.15 ab	1012.0 d	173.0 b	2.64 a
Lenacil	1.20	18.03 cdef	1800.3 abc	234.3 ab	1.94 ab
	1.60	11.47 fg	2066.7 ab	261.7 ab	2.22 ab
Oxadiazon	0.75	9.64 g	1800.0 abc	262.3 ab	1.87 ab
	1.00	9.70 g	1537.3 bcd	230.7 ab	1.69 b
Oxyfluorfen	0.50	0.10 h	1730.0 abc	290.3 ab	1.91 ab
	0.75	0.10 h	2173.3 a	243.3 ab	2.00 ab
Untreated		29.07 a	971.3 d	188.0 b	1.90 ab

*Data were transformed to $(x+0.01)^{-1/2}$ before analysis. Means within column followed by the same letter are not significantly different at $P \leq 0.05$ based on Duncan's New Multiple Test.

ers) and oil content (%) were recorded, while for lavender marketable air dried yield (flowers only) and oil content (%) were recorded. The data was analyzed using the analysis of variance method.

RESULTS AND DISCUSSION

Effect on weeds

All treatments were effective against weeds in all trials and reduced significantly the dry weight of weeds. Their overall effects over the 3-year period of the trials are shown in Tables 1, 2 and 3. There were also differences among herbicide treatments, which were more or less consistent in all trials. In this respect the most effective treatments were both rates of oxadiazon and oxyfluorfen, which controlled a wider range of weeds and persisted for a longer period than most of the other herbicides tested. Oxyfluorfen gave better control of weeds compared to oxadiazon, which failed to control *Stellaria media*. Linuron was not used in oregano and sage because it proved toxic in screening trials (Vouzounis, 1997). For the same reasons, diuron and fluorochloridone were not included in the sage trials.

The weed species found in the experimental fields were the following: *Anagallis arvensis* L., *Anthemis arvensis* L., *Avena sp., Calendula arvensis* L., *Capsella bursa-pastoris* (L.) Medicus, *Centaurea cyanus* L., *Chenopodium murale* L., *Chrysanthemum coronarium* L., *Fumaria officinalis* L., *F. parviflora Lam., Lamium purpureum* L., *Malva sylvestris* L., *Scandix pecten-veneris* L., *Sinapis arvensis* L., *Sonchus oleraceus* L., *Stellaria media (L)* Vill., *Urtica urens* L. *and Veronica arvensis* L.

Effect on yield

Several herbicide treatments in the lavender and sage trials resulted in a significant increase in yield (air-dried flowers) in lavender (Table 1) and total fresh yield (stems, leaves and flowers) in sage (Table 3). In oregano, there were no treatment effects either on fresh or dry weight (Table 2). The lower yields from the untreated control in lavender and sage are attributed to damage due to weed competition, since weeds in the untreated plots remained for a longer period than in the treated ones. This conclusion is supported by findings of several workers (Glasgow *et al.*, 1976; Weaver, 1984; Cousens, 1985; Forcella, 1987) who, working with other crops, reported serious yield losses due to the presence of weeds. A second important reason for the above differences is the different way of irrigation, since lavender and sage were drip- irrigated while oregano was irrigated by sprinklers. None of the treatments affected significantly the oil yield content of any crop (Tables 1, 2 and 3).

Effect on the crop

Some herbicides showed no phytotoxicity in either soil type, except the following:

a) Aclonifen caused evident leaf chlorosis in all three crops but in oregano symptoms were more severe and appeared as extensive leaf chlorotic spots. Plants in all crops were stunted for several weeks giving the impression that the crops would fail. Eventually, however, the plants recovered and, even where the high rate was used, the reduction in yield was not significant.
b) DCPA caused slight leaf chlorosis and growth inhibition in sage.
c) Diuron caused moderate to severe leaf chlorosis but yield was not affected.
d) Fluorochloridone produced moderate to severe vein bleaching in crops and resulted in numerically lower yield than DCPA, oxadiazon and oxyfluorfen.
e) Linuron caused slight growth inhibition to lavender while with the higher rate damage was more severe and yield was the lowest among herbicide treatments.

In conclusion, it can be said that the best herbicides selected in the present work are the lower rates of oxyfluorfen and oxadiazon followed by chloridazon and DCPA, which can be used in all three crops, and also the herbicide lenacil which can be used in sage. Oxyfluorfen and oxadiazon having a wide spectrum of weed control perform equally well. However, in the course of the trials weaknesses of certain herbicides against important weeds were observed. The most notable was *Stellaria media* which is very resistant to oxadiazon, and which, being a common and widespread weed, is a potential problem, should oxadiazon be used continuously in the same fields. The above example stresses the need to alternate the use of herbicides to avoid the build-up of resistant species.

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