INTEGRATED WEED MANAGEMENT AND THEIR FREQUENCY AND DENSITY IN OLIVE GROVES IN SOUTH-WESTERN PART OF ALBANIA

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Abstract: ***Weed flora was surveyed during 2000*** *and 2001 in ten established olive groves located in the area Vlora in southwestern Albania. Also, the effectiveness of six weed management treatments [soil tillage, straw mulches, cover crop (a mixture of rye with peas) and grazing, as well as glyphosate and diuron application] on weed flora, olive yield and fruit quality was investigated in two locations during 2000, 2001 and 2002. More than 80 weed species were recorded representing a total of 14 families, in which the families Poaceae, Fabaceae, Asteraceae, Ranunculceae and Rosaceae were the predominant. Glyphosate application provided the highest and most consistent weed control (96 to 98%), whereas diuron gave sufficient weed control (77 to 78%). The soil straw mulches provided acceptable weed control (85 to 92%). However, the cover crop and the grazing did not sufficiently control of weeds (47 to 73%). The highest fruit and oil yield (50 and 63%, respectively, greater than that of the untreated control) were produced by the trees treated with the straw mulch as a result of the highest mean fruit weight each year, followed by the soil tillage treatment. However, olive trees in plots where treated with glyphosate or grazing provided lower or equal, respectively, fruit and oil yield than the untreated plots (control). The results of this study indicated that certain non-chemical weed control methods such as the straw mulches can be successfully implemented in established olive groves providing satisfactory control of weeds and promoting highest fruit and oil yield.*

INTRODUCTION

Olive (*Olea europaea* L.) tree is one of the most extensively cultivated crops in the Mediterranean basin while its cultivation goes back to ancient times (Loumou & Giourga 2003). This longevous tree integrates and identifies economically, socially and culturally the inhabitants of the basin and determines its rural landscape. In the southern Europe, Greece, Albania, Italy, Spain and Portugal dominate the world olive market. These countries produce and consume above of the 70% of the world's olive oils (Albanian Ministry of Agriculture and Food 1996; IOOC Economic Committee 2000). Especially in Albania, olives are grown on about 45 thousand ha, of which 17% is in Vlora region (Albanian Ministry of Agriculture and Food 1996).

The weed competition can significantly limit the olive tree production depending largely on weed flora and density, as well as on growth conditions between and within growing seasons. Consequently, the effective weed management is required to obtain profitable yields (Saaverda & Pastor 1996). A number of weeds are known to occur in olive groves depending largely on location and cultural practices and weed management system. In olive groves where tillage comprises a common practice, annual weed species are more prominent than perennial ones (SAAVERDA & PASTOR 1996).

Weed control in olive groves is considered critical for optimum tree growth and development as it enhances the development of newly planted trees and improves the growth and yield of established trees reducing weed competition for water and nutrients (ELMORE *et*

al. 2004). Weeds can also serve as hosts for other pests, whereas in certain cases they may hinder fruit harvest. Therefore, to obtain profitable yields and high quality products weeds must be controlled effectively. Weeds in established olive groves are normally controlled between tree rows by disking or mowing and by a basal treatment of herbicide applied around each tree or in a strip application down the tree row (ELMORE *et al.* 2004). Cultural practices such as soil tillage provide effective control of most annual weeds. However, tillage operations may move buried weed seeds to the soil surface where they can easily germinate and may actually spread infestations of perennial weeds by promoting vegetative propagation particularly in irrigated orchards (ELMORE *et al.* 2004). Most annual weeds are effectively controlled by the herbicides applied in autumn such as diuron or simazine. On the contrary, most of the perennial weeds survived from the autumn treatments and they are controlled by directed postemergence applied herbicides such as glyphosate. However, concerns about groundwater and surface water contamination often restrict herbicide use and encourage development of practices that help reduce herbicide input and production costs without compromising yield (LIU & O'CONNELL 2002, 2003).

Organic mulches such as sawdust, cereal straw and hay, green waste, and wood chips or synthetic mulches of polyethylene, polypropylene or polyester can be used around young trees as alternative methods of weed control in olive groves besides cultivation and herbicide application (ELMORE *et al.* 2004). Mulches reduce weed seed germination by blocking light and prevent seedling emergence on the soil surface providing a physical barrier for the emerging weeds. Winter annual cover crops are normally fall-seeded cereal crops (e.g. wheat, oat, cereal rye, barley) or mixtures with legumes which are planted to suppress and replace the resident weed vegetation on the orchard floor (ELMORE *et al.* 2004). Sheep grazing is also an environmentally beneficial method of weed management in olive groves, but inappropriate stocking and shepherding can often lead to overgrazing and soil erosion (BEAUFOY 2001).

Weed surveys are useful tools for determining the occurrence and relative importance of weed species in crop production systems. This knowledge is essential in setting priorities for weed management or research (LOUX & BERRY 1991). However, surveys on weed flora and experimental data on weed management practices in established olive groves throughout the world are limited in the literature. The objectives of this study were i) to determining the most frequently observed weed species and ii) to evaluate the effectiveness of six different weed management practices, in established olive groves in Vlora region (southwestern Albania).

MATERIALS AND METHODS

WEED SURVEY

One survey of weed flora was conducted in ten olive tree groves at the area of Shamogjin in Vlora, southwestern Albania during 2000 (Year 1) and 2001 (Year 2). The Vlora region is located on the coast of the Adriatic at $19^0$29'29'' E, $40^0$25'31'' N and at an altitude of 0 to 200 m (Fig. 1). Total rainfall ranges from 1000 to 1500 mm each year, while temperatures below 0 ^oC are rarely recorded during winter. The soil was a loamy soil (Calcic Luvisol) whose physicochemical characteristics were clay 254 g kg^{-1}, silt 440 g kg^{-1}, sand 306 g kg^{-1}, organic matter 7 g kg^{-1}, and pH (1:2 H_2O) 7.2. Vlora region involves a lot of olive, citrus fruits and grapes due to the mild wet winters and the low incidence of frost. Mechanical cultivation is the main weed management system applied in established olive groves in all southerly Albania and especially in Vlora region.

In the area of the survey, five weed management untreated fields were randomly selected each year from a list of olive producers. The distance among the selected field was greater than 1 km. The fields were surveyed during 1 to 31 May in each year to determine the weed species observed. This period was preferred because it provides information on the whole

weed flora of this area. Also, conducting the survey during that period provided the advantage of easier species identification, since most of the plants were at the early flowering stage. In each randomly selected field, the number of individuals of each weed species was determined in five permanently marked areas of 12 m^2 (4 x 3 m) which were randomly placed along an inverted W pattern. The distance between sampling areas was determined by the size and the shape of each field with greater distances between the areas being used in larger fields. In each sampling area, identification and density of weed species was performed. The plant or stem number were counted for broadleaved or grass and shrub species, respectively. The weed species which could not be identified were submitted for identification to the Systematic Department in the Agricultural University of Tirana.

In each year, data were summarized using plant or stem density and species frequency over all surveyed fields. Density was the mean number of plants or stems per m^2 for each weed species expressed over all fields surveyed each year. Frequency was the weed number expressed as percentage of the total number of weed plants or stems in the five fields surveyed. Different olive groves were surveyed each year. However, the total relative frequency (TRF) expressing the ratio of mean frequency of each species by the number of fields where each species was present to the total number of fields surveyed was calculated to give an overall indication of the weed composition and prevalence in olive groves in the area of Vlora.

WEED MANAGEMENT

A field experiments was conducted in 2000 (Year 1) and repeated in 2001 (Year 2) and 2002 (Year 3) at two locations (Loc 1 and Loc 2) of the same area (Shamogjin) where weed flora was conducted. The experiments were established in two twenty years-old olive groves with the cultivar 'Kalinjot' growing in a conventional system including mechanical cultivation in early spring for weed control. Olive trees were spaced 8 by 8 m. Different olive groves were treated ach year, while a randomized complete block design with five replicates was set up in each grove. The examined treatments were: cover crop [a mixture of rye (*Secale cereale* L.) with peas (*Pisum sativum* L.)], glyphosate, diuron, grazing, soil tillage and straw mulch. Untreated plots were used as controls. Each plot included 25 olive trees covering a 240 m^2 area. A tree row served as a buffer between replications. According the survey conducted in the same area, the dominant weed species in the experimental fields are presented in the Table 1.

In each year, the entire experimental area of both groves was tilled in late autumn using a disk cultivator at a depth of 20 cm. The mixture of rye with peas for cover crop was planted on November 30 at a seeding rate of 200 kg ha^{-1} and 150 kg ha^{-1}, respectively. Straw mulches (wheat straw) was applied between tree rows at a rate of 25 Mg ha^{-1} during December (before weed germination). Diuron was applied preemergence on February 25 at a rate of 3.2 kg ai ha^{-1}. Glyphosate was applied postemergence on April 26 when most weeds were 15-20 cm high at a rate of 1.8 kg ai ha^{-1}. A propane-pressurized hand-field plot sprayer (AZO-SPRAYERS, P.O. Box 350-6710 BJ EDE, the Netherlands), with a 2.4-m wide boom fitted with six 8002 flat fan nozzles (Teejet Spray System Co., P.O. Box 7900, Wheaton, IL 60188) was calibrated to deliver 500 L ha^{-1} of water at 250 kPa pressure. Soil tillage was done between trees on March 04 using a three wheeled tractor and by hand under the olive trees to the depth of 20 cm. Grazing was done twice monthly from March to May by controlled shepherding 48 sheep for two hours inside the treated area. The efficacy of treatments was assessed on June 10 of each year by determining weed species and weed density in each plot. Determination was done in the marked area of 12 m^2 (3 x 4 m) in the centre of each plot. The weeds species were grouped in grasses, broadleaf and shrubs. Olive fruit and oil yield per tree, mean fruit weight and oil acidity were determined for each treatment. Determination of these parameters was

done by harvesting ten randomly selected olive trees of each treatment replication. The experiment was repeated at the same area following exactly the same procedures.

DATA ANALYSES

Weed data of the weed management experiment were analyzed separately for grasses, broadleaf weeds or shrubs using a combined over year and location ANOVA. Homogeneity of variances was examined with Bartlett's test. Data were log(x+1)-transformed prior to ANOVA to reduce their heterogeneity, but the mean values presented are back transformed for the purpose of their presentation. Olive fruit and oil yield, mean fruit weight and oil acidity data were also analyzed using a combined over year and location ANOVA.

The Statistical Package for the Social Sciences (SPSS, version 15) program was used to conduct the ANOVAs (Statistical Package for the Social Sciences 1998). Treatment mean differences were separated by the Duncan's test at the 0.05 probability level.

RESULTS

WEED SURVEY

During the survey, more than 80 weed species were identified in the 10 fields surveyed, represented 14 botanical families (Table 1). However, more weed species were identified belonged to families Poaceae, Asteraceae or Fabaceae. In particular, the 43.1% of the total number of the recorded weed species belonged to the family Poaceae, whereas the 16.6 and 10.8 belonged to families Fabaceae and Asteraceae, respectively. However, 28.4% of recorded weed species belonged to the families Acanthaceae, Apiaceae, Araceae, Boraginaceae, Brassicaceae, Caryophyllaceae, Dipsacaceae Polygonaceae, Papaveraceae, Ranunculaceae and Rosaceae. Regarding to the total relative frequency (TRF) the predominant families were Poaceae, Fabaceae, Asteraceae, Ranunculaceae, Papaveraceae and Rosaceae. In particular, the total relative frequency of Poaceae family species was 48.7%, whereas for the families Fabaceae, Asteraceae, Ranunculaceae or Rosaceae was 18.2, 10.8, 7.3 or 3.4%, respectively.

The weed species *Koeleria gracilis*, *Poa annua*, *Bromus tectorum* and *Bromus sterilis* were the most common grasses recorded during the survey (species with the greatest TRF values) (Table 1). *Trifolium pratens* or *Centaurea solstitialis* was the most common species of the family Fabaceae or Asteraceae, respectively. Moreover, occurrence of the annuals *Nigella sativa*, *Papaver rhoeas* and *Stellaria media*, as well as the perennial shrubs *Rubus ulmifolius* and *Dittrichia viscosa* was greatly recorded.

WEED MANAGEMENT

The ANOVAs performed for the weed control data indicated that the grass weed control was affected by year ($P < 0.001$), location ($P < 0.05$), treatment ($P < 0.001$) and their interaction ($P < 0.05$). The broadleaved weed control or the total weed control was affected by year ($P < 0.05$ or 0.001, respectively), treatment ($P < 0.001$) and their interaction ($P < 0.001$). Thus, new ANOVAs were performed separately for each year for grass, broadleaved and total weed data and the means are presented separately for each year (Tables 2, 3 and 4). However, the control of shrubs was affected only by treatment ($P < 0.001$); so the treatment effects are presented (Table 3).

Generally, all weed management treatments reduced grass weed population, compared with the control (untreated plots). However, in all years, the application of glyphosate caused the greatest reduction which ranged from 98 to 99% (Table 2). The application of diuron caused very good control of grasses which ranged from 78 to 93%. Among the non-chemical treatments, the straw mulches provided the greatest grass weed suppression, which ranged from 74 to 94%. The cover crop, grazing and soil tillage treatments achieved partial grass

suppression, except of the cover crop treatment at Loc 1 in Year 1 which provided very good grass weed suppression (97%).

Table 1.

Frequency and density of weed families or species recorded at five fields in 2000 (Year 1) and five fields in 2001 (Year 2) (means are averaged across fields).

	Year 1		Year 2		
Species per family	Density	Frequency	Density	Frequency	TRF†
	plants or stems m^{-2}	%	plants or stems m^{-2}	%	
Acanthaceae	**1**	**0.1**	**4**	**0.5**	**0.06**
Apiaceae	**6**	**1.3**	**4**	**1.3**	**0.91**
Ammi visnaga	1	0.1	1	0.1	0.02
Daucus carota	2	0.6	2	0.2	0.28
Eryngium campestre	1	0.2	1	0.1	0.05
Torilis nodosa	2	0.4	1	0.1	0.18
Araceae	**2**	**0.5**	**2**	**0.2**	**0.14**
Arum italicum					
Asteraceae	**50**	**10.8**	**45**	**5.7**	**8.25**
Achillea nobilis	2	0.5	6	0.7	0.24
Bellis perensis	1	0.2	2	0.2	0.06
Carthamus lanatus	1	0.1	0	0.0	0.01
Centaurea colcitrapa	0	0.0	2	0.2	0.01
Centaurea solstitialis	18	3.7	4	0.4	1.64
Cichorium intybus	4	1.1	5	0.6	0.51
Conyza spp.	2	0.6	4	0.7	0.33
Echinops ritro	1	0.1	1	0.1	0.02
Helminthia achoides	0	0.0	5	0.8	0.08
Matricaria spp.	0	0.0	2	0.2	0.01
Matricaria chamomilla	9	1.7	5	0.6	0.58
Miosperum spp.	3	0.8	0	0.0	0.08
Picris echioides	0	0.0	3	0.3	0.02
Scolymus spp.	6	1.2	0	0.0	0.18
Scolymus hispanicus	1	0.2	2	0.2	0.06
Silybum marianum	1	0.1	1	0.2	0.05
Sonchus spp.	0	0.0	1	0.1	0.01
Sonchus asper	1	0.2	2	0.3	0.08
Tanacetum vulgare	1	0.2	1	0.1	0.03
Turilaga farfara	0	0.0	1	0.1	0.01
Boraginaceae	**16**	**3.7**	**14**	**1.8**	**2.20**
Heliotropium europaeum					
Brassicaceae	**1**	**0.2**	**0**	**0.0**	**0.02**
Sinapis arvensis					
Caryophyllaceae	**10**	**2.6**	**15**	**2.2**	**1.68**
Stellaria media					
Dipsacaceae	**23**	**6.1**	**13**	**1.8**	**3.16**
Dittrichia viscosa					
Fabaceae	**70**	**16.6**	**160**	**19.8**	**18.2**
Lotus corniculatus	1	0.1	3	0.4	0.08
Medicago spp.	9	2.5	0	0.0	0.38
Medicago arabica	6	0.9	13	1.5	0.48
Medicago arbicularis	0	0.0	3	0.4	0.04
Melilotus spp.	0	0.0	1	0.1	0.01
Trifolium spp.	49	12.0	3	0.4	3.72
Trifolium angustifolium	0	0.0	12	1.7	0.26
Trifolium campestris	0	0.0	33	3.7	0.56
Trifolium pratens	2	0.3	9	13	2.00
Trifolium repens	1	0.2	25	3.3	0.88
Trifolium resupinatum	0	0.0	53	6.5	0.98
Vicia spp.	2	0.5	3	0.5	0.15
Vicia cracca	1	0.1	1	0.1	0.02

Vicia villosa	0	0.0	1	0.1	0.01
Papaveraceae	**3**	**0.8**	**61**	**8.4**	**3.68**
Papaver rhoeas					
Poaceae	**195**	**43.1**	**437**	**54.3**	**48.7**
Agropyron repens	0	0.0	9	1.2	0.18
Agrostis spp.	6	1.4	0	0.0	0.21
Agrostis alba	0	0.0	14	1.7	0.34
Agrostis vulgaris	0	0.0	1	0.1	0.01
Alopecurus spp.	16	4.5	0	0.0	0.90
Alopecurus agrestis	0	0.0	1	0.1	0.01
Alopecurus myosuroides	0	0.0	14	1.8	0.27
Alopecurus pratensis	0	0.0	2	0.2	0.01
Alopecurus utriculatus	0	0.0	4	0.6	0.09
Apera spica-venti	0	0.0	40	4.5	0.68
Arrhenatherum elatius	0	0.0	25	2.7	0.27
Avena spp.	1	0.2	3	0.5	0.14
Avena sterilis	0	0.0	10	1.3	0.26
Briza maxima	10	2.5	3	0.4	0.73
Bromus spp.	22	4.9	5	0.5	1.35
Bromus arvensis	0	0.0	3	0.4	0.02
Bromus erectus	0	0.0	8	1.2	0.12
Bromus sterilis	9	2.0	27	3.4	1.62
Bromus tectorum	8	1.7	34	4.4	2.14
Cynodon dactylon	7	1.2	22	2.5	0.74
Dactylis glomerata	0	0.0	2	0.3	0.02
Festuca spp.	7	1.6	0	0.0	0.24
Festuca arundinacea	0	0.0	4	0.5	0.03
Festuca elatior	0	0.0	4	0.5	0.05
Festuca ovina	10	1.6	0	0.0	0.08
Festuca varia	0	0.0	3	0.4	0.02
Holcus lanatus	1	0.1	0	0.0	0.01
Hordeum murinum	0	0.0	2	0.3	0.02
Koeleria gracilis	38	8.1	76	10.1	9.10
Lagurus ovatus	3	0.5	18	2.2	0.81
Lolium spp.	6	1.0	22	2.7	0.93
Maynaldia villosa	0	0.0	1	0.1	0.01
Phalaris spp.	1	0.1	4	0.6	0.11
Phleum pratense	0	0.0	27	3.3	0.83
Poa spp.	28	6.7	0	0.0	1.34
Poa annua	19	4.4	25	3.1	3.00
Poa bulbosa	0	0.0	4	0.5	0.05
Poa pratensis	2	0.5	6	0.7	0.18
Poa trivialis	0	0.0	6	0.9	0.09
Polypogon monspeliensis	0	0.0	6	0.6	0.06
Sorghum halepense	0	0.0	4	0.4	0.04
Polygonaceae	**10**	**2.3**	**8**	**1.0**	**2.31**
Polygonum aviculare					
Ranunculaceae	**13**	**2.8**	**14**	**18**	**7.28**
Nigella sativa					
Rosaceae	**28**	**8.0**	**12**	**1.7**	**3.40**
Rubus ulmifolius					

†TRF, total relative frequency: the ratio of mean frequency of each species by the number of fields where each species was present to the total number of fields surveyed.

In all years, the greatest broadleaved weed control (96 to 99%) was achieved again by the application of glyphosate (Table 3). Straw mulches in three years and soil tillage in Year 2 and Year 3 caused sufficient weed suppression which ranged from 89 to 95% and 87 to 88%, respectively. However, the application of diuron in three years and soil tillage in Year 1 caused partial weed control (67 to 81% and 43%, respectively). The cover crop and grazing treatments

achieved again partial broadleaved weed suppression.

Table 2.

Stem number of grass weeds at early June as affected by various management treatments in olive groves at two locations in 2000 (Year 1), 2001 (Year 2) and 2002 (Year 3).

	Year 1				Year 2				Year 3			
Treatments	Loc 1		Loc 2		Loc 1		Loc 2		Loc 1		Loc 2	
	stems m^{-2}											
Cont rol	107	ab†	132	a	268	a	248	a	173	a	174	a
Cover crop	3	gh	61	ab	52	bc	69	bc	60	b	47	b
Glyphosate	2	h	1	h	4	d	4	d	3	d	1	d
Diuron	24	cde	22	de	48	bc	48	bc	12	c	12	c
Grazing	54	abcd	80	ab	43	bc	78	b	68	ab	85	ab
Soil tillage	44	bcd	59	abc	33	bc	24	c	50	b	74	ab
Straw mulches	8	fg	12	ef	56	bc	65	bc	10	c	10	c
CV, %	20.5				19.6				19.3			

†Means in each year columns followed by the same latter indicate no significant differences according to Duncans' test at 5% level of significance.

Table 3.

Plant or stem number of broadleaved weeds or shrubs, respectively, at early June as affected by various management treatments in olive groves in 2000 (Year 1), 2001 (Year 2) and 2002 (Year 3) (broadleaved weed means are averaged across two locations, while shrub weed means are averaged across three years and two locations).

	Broadleaved weeds						Shrubs	
Treatments	Year1		Year 2		Year 3			
	plants m^{-2}						stems m^{-2}	
Control	176	a†	210	a	164	a	26	a
Cover crop	54	cd	76	b	34	cd	11	bc
Glyphosate	1	f	8	d	5	e	3	d
Diuron	33	de	52	b	55	bc	12	b
Grazing	77	bc	90	b	81	b	19	a
Soil tillage	100	b	25	c	21	d	7	bc
Straw mulches	19	e	12	d	8	e	7	c
CV, %	16.3		15.8		18.2		23.1	

†Means with each column followed by the same latter indicate no significant differences according to Duncan's' test at 5% level of significance.

The greatest shrub weed control was achieved by the application of glyphosate (89%) (Table 3). Straw mulches and soil tillage caused sufficient suppression (73%), whereas the control provided by the other treatments ranged from 27 to 58%.

In total, the application of glyphosate caused the highest weed control (96 to 98%), whereas the weed control achieved by the application of diuron ranged from 77 to 78% (Table 4). The straw mulches also provided good total weed control (85 to 92%), whereas the cover crop, the grazing and the soil tillage provided partial total weed control (ranged from 47 to 87%).

Table 4.

Total weed plant or stem number at early June as affected by various management treatments in olive groves in 2000 (Year 1), 2001 (Year 2) and 2002 (Year 3) (means are averaged across two locations).

Treatments	Year 1		Year 2		Year 3	
	plants/stems m^{-2}					
Control	318	a†	532	a	386	a
Cover crop	99	C	156	b	106	c
Glyphosate	5	E	23	d	14	e
Diuron	70	C	121	b	85	c
Grazing	170	B	178	b	183	b
Soil tillage	167	B	67	c	96	c
Straw mulches	42	D	82	c	29	d
CV, %	12.2		8.8		8.9	

†Means in each column followed by the same latter indicate no significant differences according to Duncan's' test at 5% level of significance.

OLIVE YIELD AND QUALITY

The ANOVAs performed for the olive yield and quality data indicated that they were affected by year ($P < 0.01$), location ($P < 0.05$) and treatment ($P < 0.01$). However, ANOVAs indicated no significant year x location x treatment interaction; so the treatment effects, averaged across year and location, are presented (Table 5).

Table 5.

Fruit and oil yield, as well as mean fruit weight and oil acidity of olive groves as affected by various weed management treatments (means are averaged across three years and two locations)

Treatments	Fruit yield		Oil yield		Mean fruit weight		Oil acidity	
	Kg per tree				g		pH	
Control	20.3	d†	4.1	d	2.1	d	0.7	a
Cover crop	22.9	c	4.8	cd	2.3	c	0.6	ab
Glyphosate	17.8	e	3.8	ef	2.4	bc	0.5	bc
Diuron	20.1	d	4.2	d	2.3	c	0.4	c
Grazing	16.7	e	3.4	f	2.3	c	0.7	a
Soil tillage	27.5	b	5.9	b	2.5	b	0.5	bc
Straw mulches	30.5	a	6.7	a	2.8	a	0.4	c
CV, %	11.1		10.9		3.5		9.4	

†Means in each column followed by the same latter indicate no significant differences according to Duncan's' test at 5% level of significance

The highest fruit and oil yield were produced by the trees in plots treated with the straw mulches (30.5 and 6.7 kg per tree, respectively), followed by the soil tillage treatment (27.5 and 5.9 kg per tree, respectively) (Table 5). However, olive trees in plots treated with glyphosate or grazing provided lower or equal, respectively, fruit and oil yield than the untreated plots (control). The greatest mean fruit weight was observed in trees located in plots treated with the straw muches and the soil tillage (2.8 and 2.5 g, respectively). The highest oil acidity was observed in the untreated control and grazing treatments (0.7), whereas the lowest in the straw mulches and diuron treatments (0.4).

DISCUSSION

WEED SURVEY

In survey, the families Poaceae, Fabaceae, Asteraceae, Ranunculaceae and Rosaceae were the predominant ones. In general, species of the other families were found less frequently than species of the abovementioned families. SIMILARLY, UREMIS (2005) reported that Poaceae, Asteraceae and Fabaceae were the most common families identified during a survey conducted in olive groves in Hatay, Turkey.

The survey data indicated that the co-dominance by several species, rather than the dominance by a single species, was the common feature of olive groves weed communities, agreeing with the results reported by SAAVEDRA and PASTOR (1996) surveyed 49 olive tree groves in southern Spain. Variation between the individual species, not only in the population densities of each weed species, but also in the total densities of the weed communities is probably the result of differences in farm management practices influencing weed population growth. The number of coexisting species in the weed communities of olive groves and their relative densities are important considerations in weed management. Multi-species weed communities will be more difficult to manage effectively with single herbicides owing to the differing herbicide tolerances of the species.

WEED MANAGEMENT

Among weed management treatments, the glyphosate application showed the highest level of total weed control. This fact indicates that glyphosate application is an effective and reliable option for weed control in olive groves. DASTGHEIB and FRAMPTON (2000), in a survey of weed management practices in apple orchards and vineyards in New Zealand, reported that glyphosate was the most popular herbicide among the registered herbicides. The application of diuron was not effective on all annual or perennial broadleaf and grass weeds recorded in olive groves. Also, the degree of control and duration of effect vary considerably with the amount applied, soil texture, rainfall and other conditions. The cases of resistant to glyphosate weeds in groves (PEREZ & KOGAN 2003) as well as the new weed problems which can develop when diuron is applied over several years due to a gradual shift in the weed populations present (TORKOWSKI *et al*. 2000) leads to the necessity for the use of alternative methods of weed management in olive groves, beside herbicide application. The sufficient weed suppression and the highest fruit and oil yield produced by the trees in plots treated with the straw mulches showed that this treatment could be used as alternative to chemical control method in olive groves. RAMAKRISHNA *et al*. (2006) reported that straw mulches appear as an interesting option for weed suppression in olive groves providing benefits in fruit tree production such as improved soil structure, reduced soil compaction and increased soil organic matter resulting in promotion of tree growth and increase of yields. Total weed suppression provided by cover crop or soil tillage treatment was partial. Except of the partial weed suppression, competition with olive trees for available water may be a concern and it is important to take into account before the cover crop establishment. Similarly, mechanical weed control has the disadvantages of being short lived and potentially damaging tree roots and trunks (LIPECKI & BERBEĆ 1997). The sheep grazing provided the lowest weed control among all treatments examined. However, grazing can cause damage to trees (GIOURGA *et al*. 1998) and promote the spread of weeds (WOLDU & SALEEM 2000).

OLIVE YIELD AND QUALITY

The highest fruit and oil yield were produced by the trees treated with the straw mulches and the soil tillage treatment. This fact could be partially attributed to the greater mean fruit weight recorded in these treatments. Organic mulchs used to control weeds has been

reported to be beneficial to tree fruit growth and yield (CHILDERS *et al.* 1995). Merwin *et al.* (1995) have reported that the mulched plots produced higher fruit yields than plots maintained with herbicides or cultivation. According to RAMAKRISHNA *et al.* (2006), the straw mulches was effective in suppressing weed infestations in groundnuts and plants in straw mulched plots were generally tall, vigorous and reached early flowering. Use of straw as mulches in orchards and appropriate mixtures as cover crops seem attractive and environment friendly options for weed control in olive groves with beneficial effects in fruit yield. Thus, they could be considered as viable alternatives of weed control reducing considerably herbicide inputs.

The results of this study indicated that the most abundant weed species in olive groves in the area of Vlora (southwestern Albania) belonged to the families Poaceae, Fabaceae, Asteraceae, Ranunculaceae and Rosaceae. This knowledge could be very useful for setting weed management and research priorities. Herbicides still remain the most effective and reliable method of weed control in olive orchards, but certain non-chemical weed suppression methods, such as straw mulches, could effectively minimize weed density in olive groves assisting tree growth, promoting yield and reducing heavy reliance on herbicides. This environmentally sound weed control practice is particularly welcome into integrated weed management programs, where the main aim is not to eliminate all weeds but to keep them at a threshold that is economical and manageable.

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