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Ecological agriculture: essay of weed control on *Rosmarinus officinalis* L. culture from Castilla-La Mancha (Spain)*

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Resumen: Usano-Alemany, J.; Cuadrado Ortiz, J.; Herraiz Peñalver, D.; Cases Capdevila, Mª. A.; Varela Nieto, F. & Palá-Paúl, J. 2008. Agricultura ecológica: control de malas hierbas en el cultivo de *Rosmarinus officinalis* L. de Castilla-La Mancha (España). *Bot. Complut.* 32: 217-223.

Se presentan los resultados obtenidos en el ensayo del control de malas hierbas en agricultura ecológica de *Rosmarinus officinalis* L., planta aromática y medicinal de interés para Castilla La Mancha. Las diferentes cubiertas vegetales empleadas, restos verdes de *Vicia sativa* L., restos del destilado de plantas aromáticas y paja de cebada, redujeron el número de malas hierbas siendo la cobertura de paja de cebada la más eficaz de las testadas. El control de malas hierbas con este tipo de cubiertas naturales es una buena alternativa frente al uso de herbicidas y otros productos químicos.

Palabras clave: control malas hierbas, agricultura ecológica, *Rosmarinus officcinalis, Vicia sativa*.

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An essay of the weed control on ecological agriculture has been carried out. Three different cover managements have been tested: fresh plants of *Vicia sativa*, distil plant residues from aromatic plants and barley straw, on the tillage of an aromatic and medicinal plant from Castilla La Macha Province: *Rosmarinus officcinalis* L. All the cover managements were found to reduce weeds in all the tested tillage, although the barley straw cover showed to be the most efficient one. This type of covers used as weed control could be considered as an effective alternative to the use of herbicides.

Key words: weed control, organic farm, ecological agriculture, *Rosmarinus officcinalis, Vicia sativa,* integrated weed management.

INTRODUCTION

Nowadays, weed science is a diverse field that relies upon the fundamental disciplines of chemistry, ecology, genetic, and physiology, among others, to generate theories and empirical information about the biology of the weedy plants (Aibar 1995, Holt 2004). According to Ross and Lembi (1999), weed control may be defined as the suppression of a weed to the level where the economic effect is minimized but the weed is not necessarily eliminated. Besides, this control requires the development of different tools and techniques as manipulating crop cultivar, density, row spacing, and timing of production practices (Radosevich *et al*. 1997, Ross & Lembi 1999). To be economically viable, the cost of a weed control program cannot exceed the value of the crop or land which the weed being managed (Auld *et al*. 1987).

Most of the times, the weed control is directly related to the use of different kind of chemical products, pesticides, herbicides etc. In fact, there is a wide range of effective herbicides available. Some of them have been a key to the successful development and wide adoption of simplified, cost-saving and soil-conserving

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tillage systems (Lyon *et al*. 1996, Denton & Tyler 2002).

However, in several countries, consumer aversion towards pesticides and theirs negative environmental impacts have resulted in serious governmental restrictions on herbicide availability and their use in the European Union, EU Agricultural Pesticides Directive 91/414EEC, (Watts & Macfarlane 1997). Besides, the use of these products is not allowed in ecological agriculture, so different studies have been carried out looking for an alternative in the weed control or soil erosion in this kind of tillage (Holt 2004; Kurstjens 2000, 2007; Yanosek *et al*. 2006).

The ecological agriculture in Spain has increased in the last 10 years. Although it could be thought that the production of this tillage is easier and cheaper, the cost is normally higher. In this type of activity, only natural resources can be used to combat pests, weeds, parasites, etc. (CEE 2092/91). So many times the crop production is reduced and also the benefits that could be obtained. This is one of the reasons because the products generated by ecological procedures are more expensive than those obtained by conventional agriculture. Weeds represent an important variable in maize production, both economically and ecologically. Weed competition can cause yield reductions of up to 70% in maize grain yields (Teasdale 1995).

In this paper we present our contribution to the weed control on ecological agriculture of *Rosmarinus officinalis* L. tillage. Different reasons have been considered to choose this species, first of all because it is a wild species from the province where the experiment has been carried out. Secondly, because it could grow under poor soils preventing erosion, so it is a good species to be introduced in lands where overexploitation of conventional agriculture has degraded the soil as in few localities from "Castilla La Mancha" (where the study has been done). Finally, because its essential oil production generates benefits derived from their sale to different industries.

Three different cover treatments have been tested in comparison to a control one to prevent the apparition of undesirable weeds in the tillage of this species. As far as we know this is the first report about the weed control in *Rosmarinus officinalis* culture using cover management. This paper can also be considered as an alternative to the herbicides and the use of these cover crops in combination with interrow tillage as an effective alternative of weed control.

MATERIAL AND METHODS

All the experiments have been carried out at the Agrarian Research Center of "Albadalejito", Cuenca province (Spain). A small part of the available field extension of this centre is dedicated to the tillage of different aromatic and medicinal plants. In this study, three plots of 60 m^2 (6x10 m) have been used. In each area there were 5 different rows with plants of *Rosmarinus officinalis*. All the plants used in this experiment have been obtained from wild populations and maintained under natural conditions. The separation between each plant was 0.5 m and between rows 1.2 m.

Cover management was selected to test the interrow weed control of three different treatments, fresh plants of *Vicia sativa* L., distil plant residues from aromatic plants and barley straw. The soil of three interrows per treatment was completely covered. Only the control interrows were not covered by anything (Fig. 1). The cover process of distil plant residues and barley straw was carried out at the beginning of the spring and before the seasonal rains of the zone. The same experiment has been done four times in three different years (2005-07). In the case of *Vicia sativa*, seeds of this species were interrow sowed each October during the different years of experimentation. To avoid the competition of this species with the crop, the plants were cut and used as cover in the same interrow as it has just been mentioned for the other treatments. Before each essay the interrows were clean up and new covers were used.

The efficiency of each treatment was evaluated in comparison with the control. The experiment was arranged in a split-plot randomized complete block design with three replications at each site. A square of 2500 cm^2 (50x50 cm) was established on each interrow. Three measures were made per interrow to register the number of weeds developed inside the squares.

Table 1
Weeds identified in the control and weed management plots.

Nº	*Weed*
1	*Capsella bursa-pastoris* Medik.
2	*Chenopodium* sp.
3	*Convolvulus* sp.
4	*Convolvulus arvensis* L.
5	*Cynodon dactylon* Pers.
6	*Equisetum palustre* L.
7	*Erodium ciconium* (L.) L'Hér.
8	*Eruca vesicaria* (L.) Cav.
9	*Fumaria officinalis* L.
10	*Galium aparine L.*
11	*Lamium amplaexicaule* L.
12	*Papaver rhoeas* L.
13	*Phalaris* sp.
14	*Polygonum convolvulus* L.
15	*Polygonum aviculare* L.
16	*Portulaca oleracea* L.
17	*Sinapis alba* L.
18	*Veronica* sp.

Figure 1— Different interrow covers and weeds inventory.

Although the aim of this paper was to evaluate the weed control of the three selected treatments, the species that grew in the plots have tried to be identified. Few of them could only be identified at the genus range because the plants were not completely developed to know the correct species.

RESULTS AND DISCUSSION

The genus and species of the weeds detected in this study appear in Table 1, where all the taxa have been arranged in alphabetic order. All of them are wild and very common species with a wide distribution in Castilla La Mancha and also in Spain. Most of them are considered as ruderal species that colonize disturbed areas or lands because the human influence has modified their natural distribution. The results obtained after each treatment are summarized in Tables 2-5, where all the data have been included: the treatment, the interrow used, the number of species detected in each replication, its mean, the mean of each season and the identified taxa per interrow.

The *Vicia sativa* cover (Table 2) seems to be effective as weed control in comparison with the control results (Table 5). The number of species detected in each interrow is lower that in the control. Only interrow 1 showed a higher mean during the first season (june-05), although the season mean was always lower than the control one. Besides, it is worth noting that the number of weeds decreased each season. Although it could be caused by environmental factors, the number of species was also reduced in the control, probably due to the decrease of seedbed of the soil. During each season the cover impedes the germination of new plants that could renew the seedbed, so during the different tested seasons the number of species gradually diminishes. Other important point to remark is the diversity of the

Table 2
Weed control on *Rosmarinus officinalis* culture using *Vicia sativa* cover.

Date	*Irow*	*VS1*	*VS2*	*VS3*	*Mean*	*VS-SM*	*Sps*
June-05	1	12	10	14	12.0		2-8-16
June-05	2	1	0.0	1	0.7	6.2	2
June-05	3	11	4	3	6.0		2-3-8
May-06	1	10	12	8	10.0		1-3-12
May-06	2	1	3	1	1.7	4.2	12
May-06	3	2	0.0	1	1.0		12
May-07	1	0.0	4	4	2.7		11-12-18
May-07	2	7	0.0	2	3.0	2.8	9-11-12
May-07	3	1	2	5	2.7		1-8-11-12
June-07	1	1	1	3	1.7		4
June-07	2	0.0	1	0.0	0.3	0.9	12
June-07	3	0.0	0.0	2	0.7		4

Irow= interrow; VS= *Vicia sativa* cover: SM= Seasonal mean; Sps= identified taxa according to the numbers of Table 1.

identified species. As we have above mentioned, most of them are ruderal and need sunny open areas to grow up, so the *Vicia sativa* cover reduces their germination and their diversity. All the interrows of *Vicia sativa* cover showed a lower diversity of species in comparison with the control one for each season.

The use of this cover is effective to reduce the weeds. Nevertheless, the interrow cultivation has previously been criticised by other authors saying that frequent interrow cultivation is also associated with increased soil erosion as soil particles are more susceptible to displacement after tillage (Dabney *et al*. 1993, Fuller *et al*. 1995). To reduce this effect we chose *Vicia sativa* that belongs to the *Leguminosae* family and it is wide known that legume cover crops improve soil nutrient status through addition of organic nitrogen (Holderbaum *et al*. 1990, Brown *et al*. 1993, Brandsaeter & Netland 1999) via fixed atmospheric nitrogen which improves soil physical properties (McVay *et al*. 1989, Latif *et al*. 1992). Incorporating legume cover crops can also increase the yield of the succeeding crops (Bollero & Bullock 1994, Decker *et al*. 1994). In addition, cover crops can suppress weed density by competing for light (Teasdale 1993), water and nutrients (Mayer & Hartwig 1986) and through the production of allelopathic compounds (White *et al*. 1989).

With respect to the distil residues cover (Table 3) it also seems to be an effective weed control in comparison with the control results (Table 5). However, the effect of this cover showed similar results in the different seasons. In fact the mean of species was similar during all the experiment. In this case we can say that the use of cover during different seasons does not cause the gradually weed reduction observed with *Vicia sativa* cover. Nonetheless, both the number of species per interrow and the diversity of this cover are lower than the control one in all the analyzed seasons.

This type of cover was selected for two different reasons, first of all to check its effect as weed control, and secondly to look for any utility to the distil residues. Nowadays, Castilla La Mancha is one of the most productive regions of aromatic plants. After the oil extraction these residues are burned or accumulated, so the use as weed control cover could be an alternative. In fact, we are carrying out a research project to evaluate different alternatives and to choose the best one for the reutilization of these residues.

Finally, a similar pattern to the *Vicia sativa* has been detected in the same cover management with barley straw. This type of cover (Table 4) also seems to be an effective weed control in comparison with the control results (Table 5). In fact this cover showed the best results. The mean of each season is significantly different to the control one. Besides, the use of this

Table 3
Weed control on *Rosmarinus officinalis* culture using distil residues.

Date	*Irow*	*VS1*	*VS2*	*VS3*	*Mean*	*VS-SM*	*Sps*
June-05	4	3	3	4	3.3		2-3-13
June-05	5	7	4	3	4.7	3.9	2-3-16
June-05	6	5	1	5	3.7		2-3
May-06	4	12	16	15	14.3		2-3
May-06	5	5	5	1	5.0	8.3	3-4-14
May-06	6	8	4	9	7.0		3-9
May-07	4	4	3	4	3.7		2-11
May-07	5	3	4	9	5.0	3.2	2-11
May-07	6	1	1	0	0.7		2-11
June-07	4	1	3	1	1.7		3-8-11-12
June-07	5	3	16	9	5.0	3.9	2-5-11-16
June-07	6	1	1	0.0	0.7		12

Irow= interrow; DR= Distil residues cover: SM= Seasonal mean; Sps= identified taxa according to the numbers of Table 1.

Table 4
Weed control on *Rosmarinus officinalis* culture using barley straw.

Date	*Irow*	*VS1*	*VS2*	*VS3*	*Mean*	*VS-SM*	*Sps*
June-05	7	0.0	10	4	4.7		2
June-05	8	2	7	4	4.3	5.0	2-3-16
June-05	9	12	2	4	6.0		3-6-9-13
May-06	7	1	1	5	2.3		3
May-06	8	1	0.0	0	0.3	5.3	12
May-06	9	20	4	16	13.3		2-14
May-07	7	1	0.0	0.0	0.3		2
May-07	8	0.0	0.0	0.0	0.0	0.1	—
May-07	9	0.0	0.0	0.0	0.0		—
June-07	7	0.0	0.0	0.0	0.0		—
June-07	8	0.0	0.0	0.0	0.0	0.1	—
June-07	9	1.0	0.0	0.0	0.33		4

Irow= interrow; BS= Barley straw cover: SM= Seasonal mean; Sps= identified taxa according to the numbers of Table 1.

cover reduces the presence of weeds in the *Rosmarinus* sp. tillage, during the last season practically all the weeds were eradicated from the covered plots.

Soil and residue manipulation can assist weed management by killing weeds mechanically, interfering in weed lifecycles, facilitating operation and enhancing crop establishment and growth (Kurstjens 2007). However, the efficiency of cover in weed management can be caused for different reasons, the bed seed is gradually reduced, the cover used could have any

Table 5
Weed control on *Rosmarinus officinalis* culture. Control results

Date	*Irow*	*VS1*	*VS2*	*VS3*	*Mean*	*VS-SM*	*Sps*
June-05	10	8	9	10	9.0		2-8-16
June-05	11	10	26	12	16	13.2	2-3-8-16
June-05	12	13	18	13	14.7		2-6-16
May-06	10	12	46	24	27.3		2-9
May-06	11	19	14	16	16.3	17.8	2-12-15
May-06	12	14	10	5	9.7		9-11-12-14
May-07	10	16	7	15	12.7		2-3-11-18
May-07	11	4	6	5	5.0	7.9	2-3-11-18
May-07	12	7	7	4	6.0		2-3-11-18
June-07	10	10	6	10	8.7		4-7-10-11-12-15
June-07	11	11	7	4	7.3	6.6	4-11-12-16-17
June-07	12	4	3	4	3.7		4-11-12-16-18

Irow= interrow; CR= Control results (without cover): SM= Seasonal mean; Sps= identified taxa according to the numbers of Table 1.

allelopathic compound that prevent the germination of other species. Further investigation should be done to study how the cover management affect to the weeds cycle. In the case of the allelopathic compounds the production of the tillage should be also analysed to evaluate possible effects.

Although this is the first report about the cover weed management for *Rosmarinus officinalis*, the interrow cultivation has had good results in the maize tillage (Abdin *et al*. 2000). In fact, the effectiveness of interrow cultivation in suppressing weed density in maize is well documented (Wilson 1993).

According to our results we can sum up that all the cover treatments tested in this experiment were effective in the weed control of *Rosmarinus officinalis* tillage, the barley straw cover being the most effective one. Besides, the use of these cover managements during different seasons reduces the number of weed species that are practically absent in barley straw and *Vicia sativa* covers.

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