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Effect of the tillage systems on weed flora composition

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SUMMARY – The changes from a conventional crop to a conservation tillage system can lead to shifts in weed species composition of a given zone. Generally, weeds that emerge are tolerant to management practices used in agricultural areas. In many cases, this can lead to the development of weed infestation that is hard to control, and ultimately to crop yield losses due to interference by tolerant weeds. A better understanding of crop production effects on weed species shifts can lead to the development of improved weed management strategies. Conventional tillage practices also influence species composition of the agricultural plant community. The influence of three different tillage systems (traditional tillage, minimum tillage and direct drilling) in weed species composition of an agricultural field in Alcalá de Henares was compared in an experiment throughout twelve years. A preliminary evaluation of weed species in each tillage system shows better control of weed flora by direct drilling with respect to other systems. A study has also been performed about the changes produced in the composition of more important weed species for each tillage system.

Keywords: Tillage system, weed.

RÉSUMÉ – *"Effet des systèmes de labour sur la composition de la flore adventice". Le remplacement d´un système de culture conventionnel par un labourage de conservation, peut modifier la composition de la flore adventice d'une zone déterminée. Les mauvaises herbes qui émergent sont en général tolérantes aux pratiques de contrôle employées dans une zone agricole, ceci peut donner lieu à une infestation par des mauvaises herbes difficiles à contrôler, et à des pertes de production des cultures dues à l'interférence de ces espèces tolérantes. Une meilleure compréhension des changements qui se produisent quant à la composition de la flore adventice, donne lieu à une meilleure stratégie de contrôle des mauvaises herbes. Les pratiques traditionnelles de labourage ont une influence sur la composition des mauvaises herbes présentes dans les systèmes agricoles. L´influence de trois systèmes différents de labourage (labourage traditionnel, labourage minimal et ensemencement direct), sur la composition de la flore adventice, a été comparée dans une expérience menée dans une propriété à Alcala de Henares, pendant 12 ans. Une prospection préliminaire des mauvaises herbes présentes dans chaque type de labourage a mis en évidence un meilleur contrôle des espèces en ensemencement direct par rapport aux labourages traditionnel et minimal. On a aussi étudié la composition de la flore adventice dans chacun des système de labourage, en montrant les changements produits sur les espèces de mauvaises herbes prédominantes de chaque système de labourage.*

Mots-clés : *Système de labourage, mauvaises herbes.*

Introduction

The European agricultural situation is changing quickly due to the pressure of economic factors and to the increase of sensitivity to environmental problems. Nowadays, integrated pest management could be a possible solution to reduce the inputs of herbicides and to increase the use of alternative methods that control weed flora.

The different tillage systems can influence the composition of weed species of agricultural plant communities. Changes from traditional tillage to a conservation tillage system can lead to shifts in weed species composition (Ball and Miller, 1993).

In many cases an infestation of weeds may occur, which is difficult to control. This can lead to losses in crop production due to the interference of weed species tolerant to agricultural practices.

Several researchers have observed the effect of the tillage system on weed flora composition and valued the long term dependence of the crop system used and the duration of the experiment.

Some studies show changes in weed species composition as a consequence of tillage practices (Cussans, 1975). There is not a common position among authors about which system best controls the weed flora. Some species display greater capacity of infestation when the intensity of tillage is reduced (Buhler *et al*., 1994; Derksen *et al*., 1994; Légère *et al*., 1997). Catalán *et al.* (2001) described an inverse relation between diversity of weed species and the environment alteration.

Otherwise, conservation tillage system is believed to worsen weed problems by higher weed emergence promoted by concentration of seed in soil and shifts of the weed community towards increased abundance of troublesome species, e.g. grasses and perennials (Bàrberi and Lo Cascio, 2001). Several researchers have observed that changes on weed species composition could occur by adoption of conservation tillage system (Ball and Miller, 1993).

The change from a traditional to a conservation tillage system alters the disturbance regime, which can lead to shifts in weed species composition. Several researchers have described predominant weeds of different tillage systems, like *Lolium* spp. in the minimum tillage system (Bàrberi *et al*., 2001); *Poligonum* spp. in the traditional tillage system (Légère *et al*., 1993; Liebman *et al*., 1996) or *Fumaria officinalis* L. and *Lamium amplexicaule* L. (Navarrete *et al*., 2000). These species shifts generally result in the emergence of species tolerant to existing weed management practices (Wrucke and Arnold, 1985; Radosevich and Holt, 1984). Liebman and Davis (2000) suggested that a possible solution for weed problems would be the combination of different soil tillage systems to avoid the establishment of predominant weeds species. Nevertheless, other authors have suggested that tillage does not produce any selective effect on the composition of weed flora (Roberts, 1964).

The objective of this study was to examine the changes in weed species composition of an agricultural area, as a result of the adoption of changes in the tillage system. This research also examined the presence of weed flora that was predominant in each tillage system.

Material and methods

Field trials were located in Alcalá de Henares, in the field "La Canaleja", with an average total annual rainfall of 470 mm and an altitude of 610 m. Three different tillage system treatments have been performed over a period of 12 years. The experiment was initiated in 1994 and the treatments applied were: (i) no-tillage (direct drilling); (ii) minimum tillage (chisel ploughing); and (iii) traditional tillage (mouldboard ploughing).

In the year 2005, the field plots were not seeded, leaving them in fallow, and maintaining the tillage treatments for the control of weeds: mouldboard ploughing and chisel ploughing, in traditional and minimum tillage respectively, and herbicide treatment with direct drilling (no-tillage).

The experiment consisted of 60 trials divided into four randomized complete blocks with three tillage systems and five replications.

In order to study the influence of weed flora in the effectiveness of the three tillage systems, we made a first identification of weed species present in the experiment (Table 1). Twenty samples were taken per plot with a quadrant of 0.25 m^2. All species found in each sample were identified. Total weed density was then referred to a unit area (1 m^2).

An analysis of variance (ANOVA) was carried out on the relative densities of the main species and on total weed density for each tillage system. To homogenize error variances, relative densities and total weed density were respectively arcsine- and square root- transformed prior to ANOVA. Significantly different means were compared by a Newman-Keuls multiple range test at a significance level of 95% ($p \leq 0.05$).

All statistical analyses were performed using the software package STATGRAPHICS® (Statgraphics Plus for Windows, 1998).

Table 1. Weed flora identified in the field "La Canaleja" (experimental tillage systems)

Amaranthus spp.	*Fumaria* spp.	*Roemeria* sp.
Anacyclus clavatus	*Gallium murale*	*Senecio vulgaris* L.
Buglossoides arvensis	*Hypecoum procumbens*	*Sonchus* sp.
Cardaria draba	*Lactuca* spp.	*Stellaria media* L.
Cirsium arvense	*Lamium amplexicaule*	*Trigonella polycerata*
Convolvulus spp.	*Lolium rigidum* L.	*Verónica heredifolia*
Descurainia sophia	*Papaver* sp.	*Vicia sativa* L.
Diplotaxis erucoides	*Polygonum aviculare*	

Results and discussion

Different tillage systems have a profound effect on weed population dynamics and management, and there are huge differences between mouldboard ploughing and reduced or no-tillage systems.

The influence of tillage on species composition was observed in the number of plants present in each sample plot taken in the experimental field. The analysis of variance conducted on the total number of weeds revealed that tillage system was significant (Table 2.i).

Results from this study illustrated that minimum tillage (chisel ploughing) was the system with more presence of weeds. Significant differences were found regarding the number of plants between chisel ploughing and mouldboard ploughing and direct drilling in all experiment, although traditional tillage did not present significant differences with direct drilling (Table 2.ii). All tillage systems studied presented similar results in all blocks; nevertheless, the first block presented a higher number of weed species than the other blocks (data not shown). This result could be due to the different types of soil.

Table 2. (i). Effect of the tillage system on the total density of weeds sampled (plants/m^2). ANOVA on total density weeds by tillage systems. Data are shown as square root-transformed (total weed density was referred to unit area 1 m^2)

FV	SS	df	MS	F-ratio	p-value
Tillage system	351.77	2	175.88	11.41	0.0001
Error	878.58	57	15.41		
Total	1230.35	59			

Table 2.(ii). Mean (plants/m^2) and standard deviation of total weed density of three different tillage systems in a field experiment in La Canaleja, Madrid (Spain). Different letters show significant differences according to Newman-Keuls multiple range test ($p \leq 0.05$)

Tillage system	Mean	Standard deviation
Direct drilling	15.52 b	0.87
Mouldboard ploughing	16.81 b	0.81
Chisel ploughing	21.20 a	0.93

Changes in tillage practices can lead to shifts in weed species composition of the agricultural community (Ball and Miller, 1993). The higher content of organic matter and crop residues, in reduced or no-tillage system decreases herbicide efficacy (Berti and Sattin, 1994). In these systems, annual

grasses and perennial weeds could cause great problems; however, short-living weeds are favoured. Annual dycotiledons producing seeds with high longevity will decline with reduced tillage systems. Annual grasses remain a problem in these conditions (Bàrberi *et al.*, 2001).

One negative factor associated with the shift to conservation tillage systems is the likely need for increased herbicide inputs to prevent infestation increases. Therefore, a no-tillage system seems to be difficult to carry out over a long period without a very intense herbicide use (Berti and Sattin, 1994).

Twenty-three weed species have been identified in this piece of research study. An analysis of variance on the relative density of weeds confirmed that there were four main weed species which differed significantly between tillage systems. These weed species were the following: *Cardaria draba* L., *Hypecoum procumbens* L., *Lolium rigidum* L. and *Lamium amplexicaule* L.

Table 3 shows the influence of the tillage system on the relative density of the main weed species cited. The relative density of this species decreased with no-tillage or direct drilling for *Cardaria draba*, *Hypecoum procumbens* L. and *Lolium rigidum* L. However, *Lamium amplexicaule* L. was mainly favoured by this treatment. This could be due to the fact that tilled soil favoured the elimination of the weed. The relative density of *Hypecoum procumbens* L.*, Lolium rigidum* L. and *Cardaria draba* L. was lower in direct drilling than in minimum tillage. Significant differences were also found between the two types of tilled soil, traditional and minimum tillage in the case of *Hypecoum* and *Lolium* spp., both weeds presenting a relative density number of plants in the minimum tillage system, twice as much as in the traditional tillage system.

Table 3. Relative density (plants/0.25 m^2) of main weed species found in each tillage system. Data are shown as arcsine-transformed (relative density) means to allow direct interpretation of standard errors. Different letters show significant differences according to Newman-Keuls multiple range test ($p \leq 0.05$)

Tillage system	*C. draba*	*H. procumbens*	*L. amplexicaule*	*L. rigidum*
Direct drilling	0.171 a	9.79 a	45.24 a	6.52 a
Mouldboard ploughing	34.89 b	16.42 b	6.05 b	15.89 a
Chisel ploughing	26.90 b	30.50 c	13.38 b	38.71 b

Minimum tillage (chisel ploughing) seemed to be the least effective treatment for the control of weed species with relevant importance like *Lolium rigidum* L., one of the more troublesome weeds for cereal crops in the Mediterranean area. Our results agree with those obtained by Bàrberi *et al.* (2001) regarding *Lolium* spp.

In general, large differences can be observed between direct drilling and tillage systems (mouldboard and chisel ploughing), where the density of weeds prior to tillage plots, except for *Lamium amplexicaule* L. that seemed to be favoured by direct drilling. These data are in contrast with the results obtained by Navarrete *et al.* (2000).

Conclusions

Tillage systems have influence on the specialization of weeds under some crop conditions. Significant differences can be observed between direct drilling and other tillage systems used in this study. Direct drilling was the most effective treatment for the control of *Cardaria draba* L., *Hypecoum procumbens* L. and *Lolium rigidum* L. (a problematic weed in cereal crops). Otherwise, mouldboard ploughing was the most effective treatment for the control of *Lamium amplexicaule* L.

The selective pressures placed on weed flora by tillage practices may interact to produce the species compositional changes that often become evident upon adoption of conservation tillage system. Therefore, the importance of careful monitoring and management of the weed flora during the initial period of transition from conventional tillage to conservation tillage is stressed.

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