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COMPARATIVE BIODIVERSITY BETWEEN NO-TILL AND CONVENTIONAL TILL ON A CROP ROTATION

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ABSTRACT

The technological development that agriculture has suffered in recent decades has affected biological diversity in agricultural fields. In particular, the life on the soil surface, that is mainly constituted by invertebrates. This loss of biodiversity entails the disappearance of natural processes that this organisms support. For this reason, it is necessary to implement agronomic management that reduces impacts on agricultural soils. One of these alternatives is no-tillage system, which is characterized by the absence of soil ploughing and the maintenance of crop residues on soil surface. In this sense, the present work has compared the existing biodiversity in a crop rotation (sunflower-wheat-legume) between plots under no-tillage and plots under conventional tillage systems. With this objective, insects, arachnids, crustaceans and myriapods have been captured through pitfall traps. Four plots have been sampled, 2 under no-tillage and 2 under conventional tillage. In each plot have been placed 4 sampling areas, consisting of 5 pitfall traps each. The catches made have shown higher biodiversity values in no-tillage compared to conventional tillage. These differences have been significantly higher in terms of number of species captured and with respect to the biodiversity indices of Margalef, Simpson and Shannon. However, the increases in number of individuals captured has not been significant as well as the uniformity indices of Pielou and Simpson.

Keywords: *Biodiversity, Arthropods, no tillage, biodiversity indices, pitfall traps.*

INTRODUCTION

Traditionally, the agricultural activity has led to the realization of a series of tasks on the ground. The technological development that agriculture has suffered in recent decades, has strengthened these tasks, decisively affecting the biodiversity that inhabits them. This biodiversity located in the soil is not reduced to the edaphic profile, there is a part of it that lives on its surface, called epigeous fauna, which includes mostly invertebrates. The taxonomic composition within the invertebrates has in the arthropods (insects and arachnids, although also some crustaceans and myriapods) the majority group, both in abundance and in diversity.

The loss of the biodiversity of the faunal community that lives on the ground entails the disappearance of the processes that it sustains. In general, a rich and diverse epigeous fauna provides a greater number of benefits on the soil than the damages it can generate. In fact, high values of biodiversity in the surface of the soil benefit agricultural production, as shown by the works with arthropods on cereal crops by Edwards and Lofty (1978). Among the benefits, it stands out in the first place the maintenance of a complex trophic chain, which sustains the stability of the ecosystem and prevents the proliferation of pests through predatory organisms. And secondly, the decomposition and availability of nutrients carried out by the action of saprophagous fauna.

In view of the need to avoid or reduce the pernicious effects caused by conventional agriculture on biodiversity, the implementation of sustainable agronomic measures, such as those derived from the application of Conservation Agriculture (CA), is necessary. The reduction of the tillage of the ground and the implantation of vegetal covers, allowing to increase the general biodiversity that occurs in them (Cantero, 2005). These measures have repercussions from the general scope of the group of macroarthropods to more specific taxonomic groups, such as the coleoptera (beetles). In the work of House and Parmelee (1985), the biodiversity observed under direct sowing conditions is compared with that existing in conventional crops, detecting higher values of the same in the first case.

The main component among the macroarthropods of the soil surface is that of insects, where the most diverse life forms and life models are found. Among the different groups of insects on the surface of the soil, it has been shown that the application of CA positively affects the populations of coleoptera, and more specifically, staphillid and carabid beetles. While the diversity and density of carabids decreases in those areas where agricultural practices are most intense (Holland and Luff, 2000), species richness and diversity of staphylinids are increased with reduced tillage and fewer applications (Krooss and Schaefer, 1998). Shearin et al. (2007) in herbaceous crops, calculated a 50% reduction in the activity of coleoptera under tillage conditions over non-tillage, while Fereres (1997), Andersen (1999) and Marasas et al. (2001) also demonstrated the population benefit of carabids and staphylinids in soils without tillage. As for the ants, it seems that the implementation of CA measures does not have such a clear impact. Occasionally, a population increase in tillage crops has been detected with respect to non-tillage crops (Campos et al., 2002). This circumstance may be due to the greater effort that ants must make in the search for food under tillage conditions due to an environment with less availability of resources, which causes a greater frequency in the capture of individuals in the samplings.

Arachnids are the organisms on the surface of the soil that have the greatest benefits in the application of CA measures, since farming negatively affects their presence (Castro et al., 1996). Similarly, it has been proven that soil plowing also negatively affects their populations (Ekschmitt et al., 1997).

In the case of the myriapods (millipedes and centipedes), studies have also been carried out (Wolters and Ekschmitt, 1997) that testify to their sensitivity to the alteration imposed by soil tillage management.

Other arthropods that are also present on the soil surface of cultivated land are crustaceans. Among them, highlights the cochineal moisture, whose abundance in crops under CA, can become pests, as reflected Alfaress (2002) in bean crops under no-tillage conditions of some regions of North America.

With the objective of verifying at a practical level the influence on the biodiversity of the implementation of CA measures in a farm, the existing differences in macroarthropod biodiversity (between plots in conventional tillage (CT) and plots with direct sowing have been studied (NT). In this way it is intended to corroborate the benefits for biodiversity of the application of NT, as well as to verify that the proposed methodology can be applied to evaluate, in an easy and fast way, the evolution of the biodiversity of a certain crop when the tillage is reduced.

MATERIAL AND METHODS

The study of the macroarthropods biodiversity (arthropods with more than 2 mm thickness) has been carried out in a farm of the Rabanales University Campus, located in the vicinity of the city of Córdoba. In this farm, treatments with NT and conventional tillage CT have been carried out during 4 agricultural campaigns. Specifically, the farm has been divided into 4 rectangular plots, 2 for each treatment (Fig. 1).

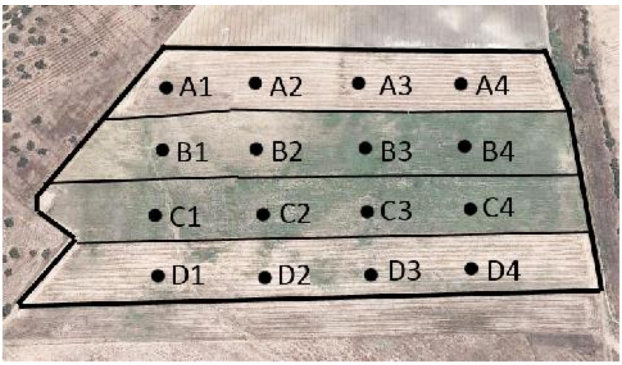

Fig. 1. Parcels of study in the Rabanales farm and sampling points.

There has been a rotation of sunflower-wheat-legume during the four seasons. In the campaign in which the data collection was carried out, plots A and D are planted with wheat, while plots B and C are planted with sunflower. In terms of management, plots A and B have been cultivated using CT, while C and D have been cultivated with NT. In order to have representative blocks for the statistical analysis in each plot, four sampling points have been established, distributed equally along each of them (Fig. 1). Therefore, for each of the treatments (CT and

NT) a total of 8 sampling points have been established, 4 in a plot planted with wheat and another four in a plot planted with sunflower (Table 1).

Table 1. Characteristics of each sampling point.

Sampling	Management	Crop in the last campaign	Bloq
A1	CT	wheat	1
A2	CT	wheat	2
A3	CT	wheat	3
A4	CT	wheat	4
B1	CT	sunflower	1
B2	CT	sunflower	2
B3	CT	sunflower	3
B4	CT	sunflower	4
C1	NT	sunflower	1
C2	NT	sunflower	2
C3	NT	sunflower	3
C4	NT	sunflower	4
D1	NT	wheat	1
D2	NT	wheat	2
D3	NT	wheat	3
D4	NT	wheat	4

Each sampling point is composed, in turn, of five drop traps (plastic cups placed at ground level with preservative liquid) arranged in a straight line and separated by 1 meter of distance (Fig 2.), in a similar direction to the larger side of the plot. As a preservative liquid in each of the fall traps, 40 ml of a 10% dilution of ethylene glycol was poured.
The traps were kept for 4 days. In the collection of the samples, all the individuals corresponding to a sampling point were united in a same bottle, for later analysis in the laboratory.

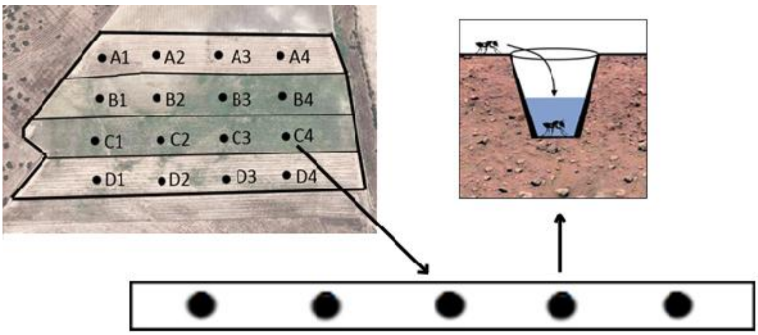

Fig. 2 Schematic of the placement of the fall traps.

Once the samples had been taken to the laboratory, the contents of each vial were filtered through a 2 mm light sieve. The arthropods retained in the sieve have been visually checked and separated by pseudospecies. That is, those individuals with a similar appearance have been cataloged within the same pseudospecies. This methodology generates a margin of error, being able to consider within the same pseudospecies individuals of different species with very similar appearance. Or, catalog in pseudospecies different individuals that, being of the same species, have a different aspect due to sex or stage of development. But it is a good approximation for a comparative study of biodiversity like the one contemplated here, avoiding a great work of taxonomic determination in the laboratory. Above all, considering the high number of individuals captured (1730).

Once both the number of pseudospecies and the number of individuals for each pseudospecies in each sampling point have been quantified, a biodiversity calculation has been made in each one of them through several indexes of biodiversity and equitability (Table 2).

Table 2. Indices studied

Index	Simbols	Fórmule
Margalef´s Biodiversity Index	I	I = (S - 1) / Ln N
Simpson´s Biodiversity Index	D	D = 1 / (Pi)²
Shannon´s Biodiversity Index	H	H = - (Pi * Ln Pi)
Pielou's Uniformity index	J	J = H / ln (S)
Simpson´s Uniformity index	E	E = D / S

S is the number of species. Pi the proportion of individuals of species i with respect to the total of individuals N. That is, the relative abundance of species i: ni / N. nor is the number of individuals of species i. N is the number of all individuals of all species.

With the aim of observing the statistical significance of the results, an analysis of variance was performed for each of the indices studied, through the Statistic 9 software. Specifically, by means of the variance analysis option from a design in blocks. Subsequently, a Tukey HSD Test was performed at $p \leq 0.05$, to verify the existence of significant differences between the results of biodiversity in plowing and direct sowing.

RESULTS AND DISCUSSION

Table 3 shows the data of the number of pseudospecies and individuals in each sampling point. In addition, the results of the calculation of the different indexes of biodiversity and equitability that have been studied are included.

Table 3. Results obtained in each sampling.

Muestreo	Pseudospecies	Individuals	Margalef	Simpson	Shannon	U. Pielou	U. Simpson
A1	24	246	4.1777683	3.4482051	1.6701279	0.525519	0.1436752
A2	20	263	3.4098124	2.175331	1.2718646	0.4245588	0.1087665
A3	24	202	4.3328636	4.0344077	1.9013572	0.5982772	0.1681003
A4	20	113	4.0191329	3.8894303	1.8659154	0.6228578	0.1944715
B1	14	42	3.478103	7.8053097	2.3089872	0.8749287	0.5575221
B2	23	56	5.4653609	10.594594	2.7068928	0.8633065	0.4606345
B3	15	74	3.2527389	7.7344632	2.2695377	0.8380707	0.5156308
B4	17	91	3.5469958	3.251276	1.8034993	0.6365561	0.1912515
C1	18	41	4.5778026	7.5381165	2.4457261	0.8461631	0.4187842
C2	17	33	4.5759946	10.572815	2.5908075	0.9144413	0.6219303
C3	25	53	6.0448955	12.160173	2.8349691	0.8807326	0.4864069
C4	25	65	5.7493467	8.6048879	2.6434541	0.8212352	0.3441955
D1	26	101	5.4169766	5.8458452	2.4179419	0.7421333	0.2248402
D2	37	111	7.6440745	5.9781659	2.6481964	0.7333859	0.161572
D3	32	137	6.3008374	10.799194	1.9321299	0.5574948	0.3374748
D4	30	102	6.2703071	5.5281615	2.2469939	0.6606479	0.184272

The analysis of variance was made to the data in Table 3, which allowed us to study the existence of differences between the different managements, with the results obtained being those shown in Fig. 3.

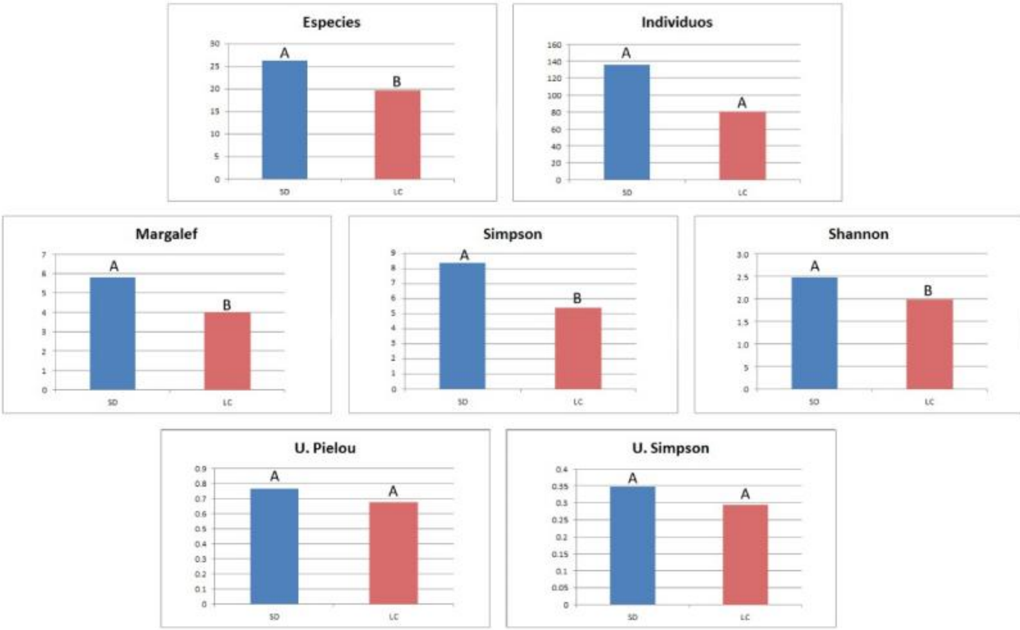

Fig. 3. Statistical significance of the results. The height of each column shows the average of the data obtained for each treatment. The different letters indicate significant differences compared to the Tukey test at p≤0.05.

As can be seen in Fig. 3, there are significant differences in NT with respect to CT in the data referring to species and in the biodiversity indices. On the other hand, as regards individuals and uniformity indices, there is no such significance. In any case, in all the graphs, higher values are observed in NT than in CT. According to what is stated in Martella et al., 2012, where it is indicated that the values for the Shannon index are between 1.5 and 3.5 normally, the macroartropod biodiversity in the NT plots, with an average close to 2 , 5, can be considered intermediate, while for CT, with a value lower than 2, it can be considered as low. The results obtained in the uniformity indices indicate that the distribution of the individuals among the different species is similar in NT and CT. These indices show if the individuals are equitably distributed among the species or there are some much more dominants. For example, the Pielou´s Uniformity index of (according to Martella et al., 2012) adopts values between 0 and 1. Number 1 indicates that all species are equally abundant and 0 indicates the absence of uniformity. Therefore, an average value close to 0.7 for NT and CT, indicates that there is a high level of equality in the distribution of individuals between species for both managements. The results show that the application of Direct Seeding measures in a rotation of arable crops has a positive effect on macroarthropod biodiversity. In fact, the data are significantly superior to the conventional tillage in the three indices studied (Margalef, Simpson and Shannon), as well as in the number of species found, there being a correspondence with what was presented in Cantero (2005) and House and Parmelee (1985).

CONCLUSIONS

It is corroborated that the methodology followed seems to be propitious to evaluate, easily and quickly, the effect on the macroarthropod biodiversity in a crop when applying NT, being able to be used to indicate a greater environmental sustainability of the same with respect to another in CT.

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