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Impact of The Cultivation Systems And Straw on The Soil Surface on The Edaphic Entomofauna In Common Bean Crops

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ABSTRACT

Background: For sustainable management of agroecosystems, it is important to understand the effects of the techniques used in crops on its biotic and abiotic components. Arthropods are the main group of organisms in agroecosystems and they can live in the plant canopy, on the soil surface or underground. Among the most important practices used in crops are the cultivation system and the mulch use. Common bean (*Phaseolus vulgaris* L.) crops have an economic importance, as food and due to the extension of cultivated area. In common bean crops, researches on the impact of cultural practices on the arthropod community are scarce, especially in regions with a tropical climate. **Objective:** Thus, the aim of this study was determining the impact of the cultivation systems and the straw on the soil surface on the edaphic entomofauna in common bean crops using multivariate analyzes. The cultivation systems used were no-tillage and conventional tillage with or without corn straw on the soil surface. During the common bean cultivation, the richness (number of species) and abundance (individuals per sample) of arthropods of the soil inside the rhizosphere of the plants were monitored using Berleze funnel. **Results:** In the no-tillage system, the richness and abundance of detritivorous arthropods, predators and herbivores were higher in the soil interior. The presence of straw on the soil surface increased the richness of arthropod species underground and the abundance of detritivorous arthropods. In bean crops under no-tillage the larval attack of the *Cerotoma arcuata* was greater. The main underground detritivorous arthropods were Collembola, mites and Syrphidae larvae, and the natural enemies predatory ants, mites and Staphylinidae. **Conclusion:** In summary, the no-tillage use brought benefits to the soil, since it increased the abundance and richness of detritivorous species. It also brought benefits for the natural biological control by increasing the richness of predator species. However, in no-tillage common bean crops, farmers should monitor soil pests, especially *C. arcuata* larvae that reached higher densities in this cropping system. Also, the existence of straw on the soil in common bean crops was beneficial to increase the abundance and richness of detritivorous arthropod species.

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INTRODUCTION

For the sustainable management of agroecosystems it is important to understand the effects of the techniques used in crops on its biotic and abiotic components (Dent, 2000; Pedigo and Rice, 2006; Radcliffe *et al*., 2008). Among the biotic components arthropods are the main group. Regarding the place where the arthropod communities live in the crops, it can be divided into species that live in the plant canopy, species that live on the soil surface and species that live underground. The underground arthropod community in crops has species that belong to different guilds such as detritivorous, herbivores and natural enemies (Gullan and Cranston, 2014).

The underground detritivorous arthropods have important functions, for example, they participate in organic matter decomposition, humus production, nitrogen and carbon cycling, and have a positive effect on plant performance (Cragg and Bardgett, 2001; Wickings and Grandy, 2011). Herbivorous arthropods feed on plant roots and can cause economic damage if their populations reach economic damage levels (Dent, 2000; Pedigo and Rice, 2006). Underground natural enemies in turn, can control pest populations in the soil as well as in the plant canopy (Flint *et al*., 1998; Ramos *et al*., 2012).

Among the practices used in crops are the cultivation system and the mulch use over the soil. The basic systems of cultivation are no-tillage and the conventional tillage system. In the no-tillage system the soil is not stirred as occurs in the conventional tillage, therefore, there is a great soil and water conservation (Phillips *et al*., 1980; Derpsch *et al*., 1986; Liu *et al*., 2014). On the other hand, mulching can reduce thermal amplitude, improve physico-chemical characteristics and reduce soil erosion (Tu *et al*., 2006).

In this context the dilemma arises: how, when and how much can the planting system (no-tillage and conventional tillage) and the presence of straw on the soil impact the entomomofauna in the crops? On the one hand, soil disturbance in crops can negatively impact some species that live underground, such as detritivorous and natural enemies species. Consequently, these impacts can cause damages in the soil structure and chemical composition (Cragg and Bardgett, 2001; Wickings and Grandy, 2011). On the other hand, the no-tillage can positively impact species of herbivorous arthropods that live in the soil, species which, who can reach high densities and cause great economic losses (Levine and Oloumi-Sadeghi, 1991, Pereira *et al*., 2007). Therefore, knowing the impacts of the cultivation system, we can propose to farmers which practices he must use; so, he can benefits from the advantages of each cultivation system, but preventing any problem possibility that may arise from his adoption.

Regarding the reports about the impact of the existence of straw on the soil surface on the entomofauna, they are controversial. Some authors (Howard and Oropeza, 1998, Cranshaw *et al*., 2001) reported positive effects of the presence of straw on the soil. They believe that the straw can serve as shelter and food for soil arthropod. However, other authors (Doring *et al*., 2006, Zehnder *et al*., 2007, Silva Filho *et al*., 2014) reported that the presence of straw on the soil could reduce arthropod populations by hindering the location of its host or even by modifying the microclimate in the crops.

Common bean (*Phaseolus vulgaris* L.) crops have economic importance, as food – as protein source – and due to the extension of cultivated area (Rapassi *et al*., 2003). In common bean crops, researches on the impact of cultural practices on the arthropod community are scarce, especially in regions with a tropical climate. In addition, the studies carried out on the impact of cultural practices on arthropods in crops generally addresses few species or even only one guild of these organisms (Pereira *et al*., 2010). One of the tools that can be used in studies of arthropod communities is multivariate analysis. These analyzes allow a joint analysis of treatments on the entire arthropod community and also determine which species are responsible for the variation of treatments on entomofauna (Kedwards *et al*., 1999; Pereira *et al*., 2010). Thus, the aim of this study was determining the impact of the cultivation systems and the straw on the soil surface in the edaphic entomofauna in common bean crops using multivariate analyzes.

MATERIAL AND METHODS

Description of Area and Assembling the Experiment:

The work was carried out on Red-Yellow Cambic Podzolic soil, terrace phase in area of 2178 m^2 (49.5 x 44.0 m) at Federal University of Viçosa, Coimbra, State of Minas Gerais, Brazil (20º51'24"S, 42º48'10"W, altitude of 720m and high-altitude tropical climate). In 1998, this area was divided in two parts: one of them has since been cultivated under the no-tillage system and the other is cultivated in the conventional system. Since then, in the spring-summer planting season the whole area is grown with corn. In half area, the corn is harvested for silage, leaving no straw on the soil surface. In the other half, only the grains of the corn are harvested and the straw (the aerial part of the plants) is left on the ground as mulch. Thus, the area has four subdivisions: (1) no-tillage with straw on the soil surface, (2) no-tillage without straw on the soil surface, (3) conventional tillage with straw on the soil surface, and (4) conventional tillage without straw on the soil surface.

These four environments were the treatments. For the beginning of this work, common bean crop was carried out in these four subdivisions. The common bean cultivation period was from April to August 2002. In the no-tillage areas (10 days before the common bean planting), weed desiccation was performed with the application of glyphosate + 2,4-D herbicide mixture (1440 + 670 g ha^{-1}). Whereas in the areas of conventional tillage two days before the common bean planting, a plowing and two harrowing were carried out. The variety of common beans used was the "Meia Noite". The common bean planting was carried out on April 23, 2002. The spacing used was 0.45 m between rows with density of 15 plants per row meter. The cultivation was performed according to Vieira *et al*. (1998) and there were no pesticides applied.

Therefore, there were four treatments: (1) common bean crop in no-tillage with straw on the soil surface, (2) common bean crop in no-tillage without straw on the soil surface, (3) common bean crop in conventional tillage with straw on the soil surface and (4) common bean crop in conventional tillage without straw on the soil surface. Five replicates were used for each treatment. Each repetition consisted of 108.9 m^2 (11 x 9.9 m) with 22 rows of 11 m each one.

Evaluation of the Underground Entomofauna:

The underground arthropod populations were sampled at 20, 28, 35, 43 and 84 days after the common bean planting. To perform the samplings in each repetition one plant was selected randomly. The stem of this plant was cut close to the soil in such a way that the aerial part of the plant was eliminated. With the use of a handle digger a soil sample in cube format of 10 cm of side, containing in the central part the common bean plant was collected. This material containing the plant roots and soil was placed in a five-liter plastic bag and transported to the laboratory.

In the laboratory, each sample was placed in a Berleze funnel (40 cm diameter x height 42 cm) for 48 hours. At the bottom of the funnel was placed a 500 mL plastic pot containing 70% ethanolic solution to collect arthropods (Wardle *et al*., 1993; Picanço *et al*., 1999). The collected arthropod specimens were examined under a stereomicroscopic microscope (Motic Instruments Inc., Richmond, Canada, model K-401-L) using 12 times magnifications. These specimens were separated into morphospecies and counted their numbers by morphospecies.

The collected specimens were sent to taxonomists for identification. The collected mites were identified by Dr. Jeferson Luiz de Carvalho Mineiro of the Biological Institute (Campinas-SP, Brazil). The Collembola were identified by Dr. Elisiana Oliveira of the National Institute of Amazonian Research (Manaus-AM, Brazil). The Coleoptera were identified by Dr. Antônio Domingos Brescovit from Instituto Butantan (São Paulo-SP, Brazil). The ants were identified by Dr. Cidália Gabriela Santos Marinho of the Federal University of Viçosa (Viçosa-MG, Brazil). The other arthropods were identified at the family level and, when was it possible, up to genus and species using taxonomic keys and reference collection of the Museum of Entomology at the Federal University of Viçosa.

After identifying the arthropods, they were separated by guilds (detritivorous, herbivorous and predators). Later on, we performed analyzes of the experimental data to determine the treatments effects on the richness and abundance of the arthropod species in soil interior in the common bean crops.

Determination of Treatments Effect on the Richness of Arthropods:

The arthropod richness of each guild (detritivorous, herbivorous and predators) and total in each treatment was represented in terms of the total number of species observed in each treatment. The total number of species per guild was also represented in all treatments.

Determination of Treatments Effect on the Abundance of Arthropods:

In these analyzes two processes of species selection that represented the treatments effects on the abundance of underground arthropods in the common bean crops were carried out. In the first process were selected the species that occurred in all treatments with higher frequency than 10%. The total occurrence frequency for each of these species in the experiment was represented (Pereira *et al*., 2010).

Subsequently, the data of the densities (arthropods per sample) of the species in each replicate were submitted to the PROC STEPDISC procedure with STEPWISE selection in SAS to select the species that most explain the observed total variance (SAS, 2001; Pereira *et al*., 2010). These species were selected according to two criteria: 1) the significance level of the F test of the covariance analysis (the selected species are covariables and the treatments are dependent variables) and 2) the partial square correlation (which predicts the effects of the treatments from the species) (SAS, 2001; Pereira *et al*., 2010). These species were considered the most important because they represent the variation observed among treatments.

The density data of the selected species were submitted to the analysis of canonical variables (CVA). This indirect ordering technique reduces the size of the original data set into a set of variables that may be used to graphically illustrate the relative positions and orientations of the mean responses of the arthropod community in each treatment (Kedwards *et al*., 1999). The significance of the difference (indicated by the ordering) between the treatments was determined by comparing the treatments two by two in the approximate F test ($p < 0.05$), using the Mahalanobis distance between the respective classes of canonical means. The analyzes were performed using the SAS CANDISC procedure (SAS, 2001).

The abundance data of the main species that led to the emergence of differences between treatments were individually submitted to analysis of variance by time-repeated measurements (Hurlbert, 1984; Stewart-Oater *et al*., 1986; Green, 1993; Paine, 1996). These analyzes were performed using the SAS ANOVA procedure with the PROFILE specification, as suggested by von Ende (1993). The canonical correlations (PROC CANCOR; SAS Institute, 2001) and the simple correlations (PROC COR, SAS Institute, 2001) were made to verify the interrelation of the responses between herbivorous pests and predators on soil surface depending on the treatments. Normality and homogeneity of the variances were tested using the UNIVARIATE procedure (SAS Institute, 2001).

We calculated the mean densities (± standard error) of the most important species (*Hypogastrura* sp., *C. arcuata*), Syrphidae, *Cheyletus* sp., Galumnidae, *Hypoaspis* sp., *Neivamyrmex* sp., *Pachycondyla* sp., *Solenopsis* sp. and Staphylinidae) for each sampling date. The density data of these species for each treatment over time were represented in curves. The comparison between the treatments was performed by the intersection comparison of the standard errors (Pereira *et al*., 2010).

Results:

We observed 49 species of arthropods located underground on areas which common beans were grown. Among these species, 10 (20.41%) were herbivorous, 20 (40.82%) were detritivorous and 19 (38.77%) were predators. We found that the total richness of arthropods and the richness of detritivorous arthropods were higher in no-tillage than in conventional tillage. The richness of herbivorous arthropods and predatory arthropods in no-tillage were equal to or greater than those observed in conventional tillage. The total richness of arthropods and the riches of detritivorous, herbivorous and predatory arthropods were higher when the bean was cultivated with straw than when it was cultivated in soil without straw (Table 1).

The frequency of occurrence of detritivorous arthropods were: Collembola Entomobryidae and *Hypogastrura* sp., larvae of Coleoptera: Scarabaeidae and Diptera: Syrphidae. The most frequent herbivorous were the larvae of Coleoptera: Chrysomelidae *Colaspis* sp. and *Cerotoma arcuata* (Olivier). The most frequent predators were the mites *Cheyletus* sp. (Cheyletidae) and *Hypoaspis* sp. (Laelapidae); the ants (Hymenoptera: Formicidae) *Neivamyrmex* sp., *Pachycondyla* sp. and *Solenopsis* sp. and larvae of Coleoptera: Staphylinidae (Fig. 2). The arthropod species that best explained the variation observed between the treatments were *Hypogastrura* sp., *C. arcuata* (larvae), Syrphidae (larvae), *Cheyletus* sp., Galumnidae, *Hypoaspis* sp., *Neivamyrmex* sp., *Pachycondyla* sp., *Solenopsis* sp. and Staphylinidae (larvae) (Table 2). Therefore, these were the most important arthropod species in the soils of the common bean crops because they represented a variation observed among the treatments.

In the canonical correlation analysis we verified the existence of two significant axes and they explained 81% of the observed variations of the treatments on the underground entomofauna on that basis of the cultivation system (no-tillage or conventional tillage) and the existence or not of straw on the soil. The species that contributed most positively to the divergence among treatments in canonical axis 1 were: *Cheyletus* sp., Galumnidae and *Pachycondyla* sp. Whereas Entomobryidae, *Hypogastrura* sp. and *Neivamyrmex* sp. contributed negatively to the explanation of the canonical axis 1.

In the canonical axis 2, Syrphidae (larvae) and *Neivamyrmex* sp. were the species that most contributed positively to the divergence between treatments. While Entomobryidae and Galumnidae were the species that most contributed negatively in the explanation of the data of the canonical axis 2 (Table 3). The ordering diagram showed the existence of differences in the underground entomofauna of the common bean crops, depending on the cultivation system (no-tillage or conventional tillage) and the presence or absence of straw on the soil (Fig. 2).

In the repeated measure analysis, it was found significant interaction ($P < 0.05$) between treatments and time after planting on the abundance of Entomobryidae, *Hypogastrura* sp., Syrphidae (larvae), Galumnidae, *Hypoaspis* sp., *Neivamyrmex* sp. and *Pachycondyla* sp.. However, this interaction was not significant ($P > 0.05$) on the abundance of *Cheyletus* sp., *Solenopsis* sp., Staphylinidae (larvae) and *C. arcuata* (larvae) ($P > 0.05$).

We observed greater abundance of the herbivorous *C. arcuata* (larvae) in no-tillage than in conventional tillage (Fig. 3A). The same occurred with the abundance of the detritivorous Entomobryidae, *Hypogastrura* sp., Syrphidae (larvae) and Galumnidae (Fig. 3B, 3C, 3D and 3E) and the predators *Cheyletus* sp., *Hypoaspis* sp. and Staphylinidae (larvae) (Fig. 4A, 4B and 4F). The abundance of predatory ants *Neivamyrmex* sp., *Pachycondyla* sp. and *Solenopsis* sp. were similar in the two crop systems (Fig. 4C, 4D and 4E).

In addition, greater abundance of the detritivorous Entomobryidae, *Hypogastrura* sp., Syrphidae (larvae) and Galumnidae on common bean crops with straw on the soil than when there was no straw (Fig. 3B, 3C, 3D and 3E). On the other hand, the abundance of the herbivore *C. arcuata* (larvae), and the predators *Cheyletus* sp., *Hypoaspis* sp., *Neivamyrmex* sp., *Pachycondyla* sp., *Solenopsis* sp. and Staphylinidae (larvae) did not vary due to the presence of straw on the soil (Fig. 3A, Fig. 4A, 4B, 4C, 4D, 4E and 4F).

Discussion:

The underground entomofauna varied quantitative and qualitatively in function of the cultivation system and the presences of straw over the soil. In the underground entomofauna there are both beneficial species (e.g. detritivorous and natural enemies) and also species that can cause economic damages (e.g. pests), therefore it is important the management of both cultivation system and the existence of straw on the soil. Only this way the benefits to the environment can be achieved and losses in production can be the reduced.

The community of arthropods that live underground in common bean crops is rich and is composed mainly of beneficial species, since 79.59% of them are detritivorous or predator species. In this context it is important to emphasize the role of detritivorous arthropod species which participate in the organic matter cycle in agroecosystems and therefore, important in the cycling of nutrients in crops (Cragg and Bardgett, 2001; Wickings and Grandy, 2011). Additionally, predators are agents of natural biological control of pests (Flint *et al*., 1998). Herbivorous arthropod in turn, can cause crop damage when they reach high densities and consequently, ended up become pests (Pedigo and Rice, 2006). Therefore, this little-known – in pest management matters – arthropods community must be properly managed in order to preserve the beneficial species (detritivorous and predators) and appropriate practices should be adopted to prevent herbivorous species from reach pest status.

We observed that the total richness of arthropods and the richness of detritivorous arthropods were greater in no-tillage than conventional tillage. The richness of herbivorous arthropods and predatory arthropods in no-tillage were equal to or greater than those observed in conventional tillage. The lowest arthropod richness in conventional tillage is due to the fact that the soil layers rotation by plowing and harrowing causes death to these organisms (Neave and Fox 1998). As reported in several studies, no-tillage has benefits in soil and water conservation (Phillips *et al*., 1980; Derpsch *et al*., 1986; Liu *et al*., 2014) besides; in this study we have observed that it also preserve species of beneficial organisms such as detritivorous and predatory arthropods. On the other hand, the number of herbivorous species that can become pests if they reach high densities is also higher in no-tillage. Although no-tillage use brings many benefits to farmers and the environment, we should monitoring herbivorous arthropod species to detect when they reach pest status. Therefore we are able to control these pests before they cause any economic damage.

We observed that a total arthropods richness and detritivorous, herbivorous and predatory arthropods richness were higher when the common bean was cultivated in soil with straw. This higher arthropod richness underground occurred due to the straw of the corn that remained on the soil favors the detritivorous arthropod due to it uses as shelter and food for these organisms (Jørgensen and Hedlund, 2013). However, straw can favor the populations of herbivorous arthropods and predators because they serve as a shelter and make the soil microclimate more pleasant for these organisms (Hakeem *et al*., 2014). Thus, the straw can reduce the thermal amplitude and increase the humidity of the superficial layers of the soil (Dahiya *et al*., 2007), conditions that may favor arthropod populations.

Regarding the abundance of underground arthropods, we verified a greater effect of the cultivation system than the existence of straw on the soil. The straw had a positive effect only on the abundance of detritivorous arthropods (Entomobryidae, *Hypogastrura* sp., Syrphidae e Galumnidae), probably due to the straw use as food (Cragg and Bardgett, 2001; Wickings and Grandy, 2011; Jørgensen and Hedlund, 2013).

The impact of the cultivation system on the abundance of underground arthropods in common bean crops was high and it had an effect on detritivorous, predators and herbivores. In this context the abundance of arthropods of all three guilds was higher in no-tillage than in conventional tillage. This greater abundance of arthropods is due to the preservation of the soil structure in non-tillage soil and consequently, favoring these populations. On the other hand, in the conventional tillage the plowing and harrowing cause great mortality to the arthropods that lives underground (Neave and Fox 1998). The larger numbers of detritivorous arthropods and predators in no-tillage is beneficial. Detritivorous arthropods such as Collembolla, mites and larvae of Diptera (Syrphidae) participating in organic matter decomposition, humus production, nitrogen and carbon cycling and have a positive effect on plant performance (Cragg and Bardgett, 2001; Wickings and Grandy, 2011). Besides, predators are generally the main agents of natural pest control in agroecosystems (Miranda *et al*., 1998; Gonring *et al*., 2003ab; Pereira *et al*., 2007; Picanço, *et al*. 2011; Ramos *et al*., 2012).

The main detritivorous arthropods in the common bean were Entomobryidae and *Hypogastrura* sp., Syrphidae and Galumnidae; and *Cheyletus* sp., *Hypoaspis* sp., *Neivamyrmex* sp., *Pachycondyla* sp., *Solenopsis* sp. and Staphylinidae were the main predatory arthropods in soils of this crop. In this context, it is essential to adopt practices that provide the preservation of these beneficial arthropods. Among these practices are the use of no-tillage and straw on the soil as demonstrated in this study and the use of physiological and ecological selectivity strategy. According to the physiological selectivity, pesticides that are not toxic to non-target organisms such as predators and detritivorous should be used (Faleiro *et al*. 1995; Picanço *et al*. 1998). In the ecological selectivity, pesticides must be applied in a way to reduce the contact of these products with the non-target organisms (Dent, 2000; Picanço *et al*., 2011; Ramos *et al*., 2012).

The fact that the larvae of *C. arcuata* were the main species of herbivore in the soils where the common beans were cultivated indicates that the farmers should be alerted about this species in programs of integrated pest management. Therefore, they should monitor the intensity of attack of these larvae on common bean crops and make a control decision when their populations reach the level of economic damage (Dent, 2000; Pedigo and Rice, 2006; Fernandes *et al*., 2010).

Table 1: Richness (number of species per treatment) of detritivorous, herbivorous and predatory arthropods located underground during the common bean cultivation according to the cultivation system (no-tillage or conventional tillage) and presence of straw on the soil surface.

Guild of Arthropods	Conventional tillage		No-tillage		Total species per guild
	With straw on the soil	Without straw on the soil	With straw on the soil	Without straw on the soil	
Detritivorous	13	12	14	13	19
Herbivorous	4	3	6	3	11
Predators	12	10	11	10	19
Total per treatment	29	25	31	26	49

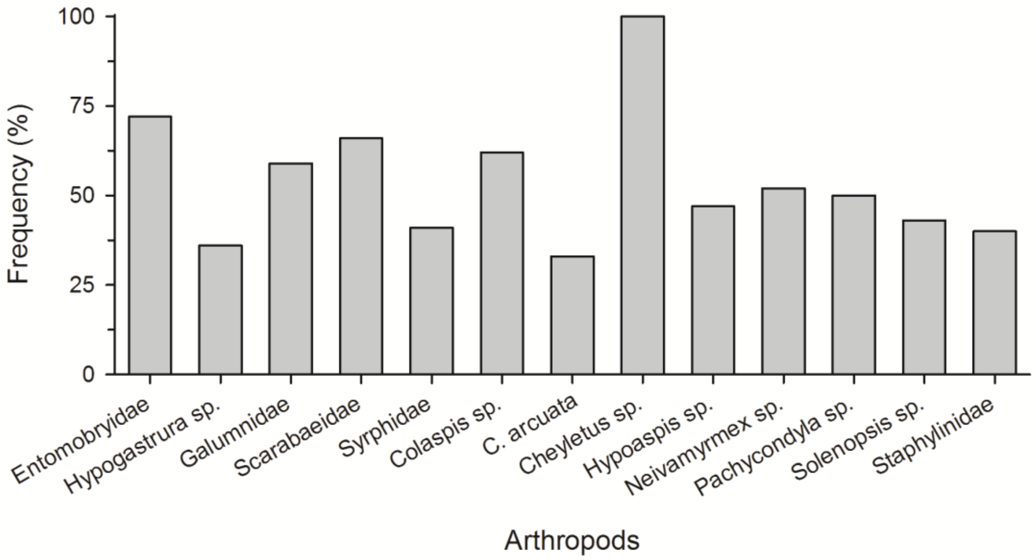

Fig. 1: Frequency (%) of the main underground arthropods during common bean cultivation in all treatments.

Table 3: Selection summary by STEPWISE with STEPDISC procedure-SAS to select underground arthropod species in common bean crops to be included in the analysis of canonical variables, obtaining maximum discrimination between treatments.

Variables added	R^2 partial	Analysis of covariance		Partial square correlation	
		F	*P*	Mean squared canonical correlation	*p*
Detritivorous					
Entomobryidae	0.1071	3.56	0.0174	0.492	<0.0001
Hypogastrura sp.	0.1491	5.32	0.0020	0.449	<0.0001
Herbivorous					
Chrysomelidae (Larvae)	0.1227	4.20	0.0079	0.472	<0.0001
Syrphidae (Larvae)	0.2175	8.62	<0.0001	0.435	<0.0001
Predators					
Cheyletus sp.	0.0731	2.29	0.0842	0.521	<0.0001
Galumnidae	0.8468	176.84	<0.0001	0.282	<0.0001
Hypoaspis sp	0.3353	15.97	<0.0001	0.384	<0.0001
Neivamyrmex sp.	0.2302	9.37	<0.0001	0.424	<0.0001
Pachycondyla sp	0.0989	3.15	0.0292	0.542	<0.0001
Solenopsis sp.	0.1280	4.50	0.0054	0.444	<0.0001
Staphylinidae (Larvae)	0.1094	3.60	0.0165	0.510	<0.0001

Table 4: Canonic axes and their coefficients on the effect of the cultivation system (no-tillage or conventional tillage) and presence or not of straw on the soil in common bean crops.

Variables (species of arthropods)	Canonical axes	
	1	2
Detritivorous		
Entomobryidae (Collembola)	-0.337	-0.649
Hypogastrura sp.	-0.276	0.331
Herbivorous		
Larva de Chrysomelidae	0.439	0.256
Larva de Syrphidae	0.091	1.369
Predators		
Cheyletus sp.	1.285	0.040
Galumnidae (Acari)	1.046	-0.592
Hypoaspis sp	0.422	0.610
Neivamyrmex sp.	-0.071	0.602
Pachycondyla sp.	0.873	-0.238
Solenopsis sp.	0.127	-0.267
Staphylinidae (Larvae)	0.232	-0.098
F	1.05	0.74
df (numerator; denominator)	44/315.8	30/244.3
P	0.03965	0.07290
Partial canonical correlation	0.60	0.81

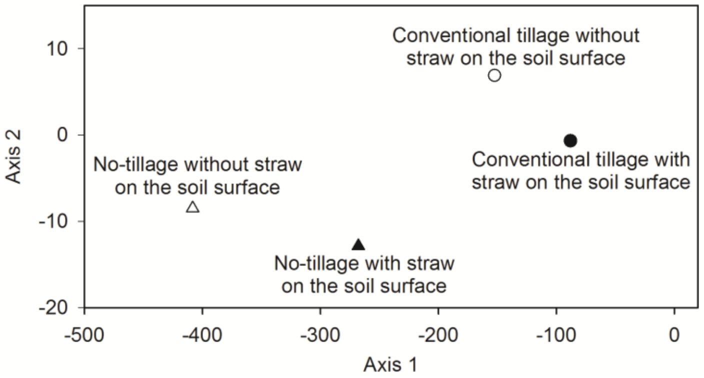

Fig. 2: Ordination (CVA) diagram showing the total effect of the cultivation system (no-tillage or conventional tillage) and presence or not of straw on the soil in common bean crops. All treatments differed according to the F test ($P < 0.05$), based on Mahalanobis distance between the means of the classes.

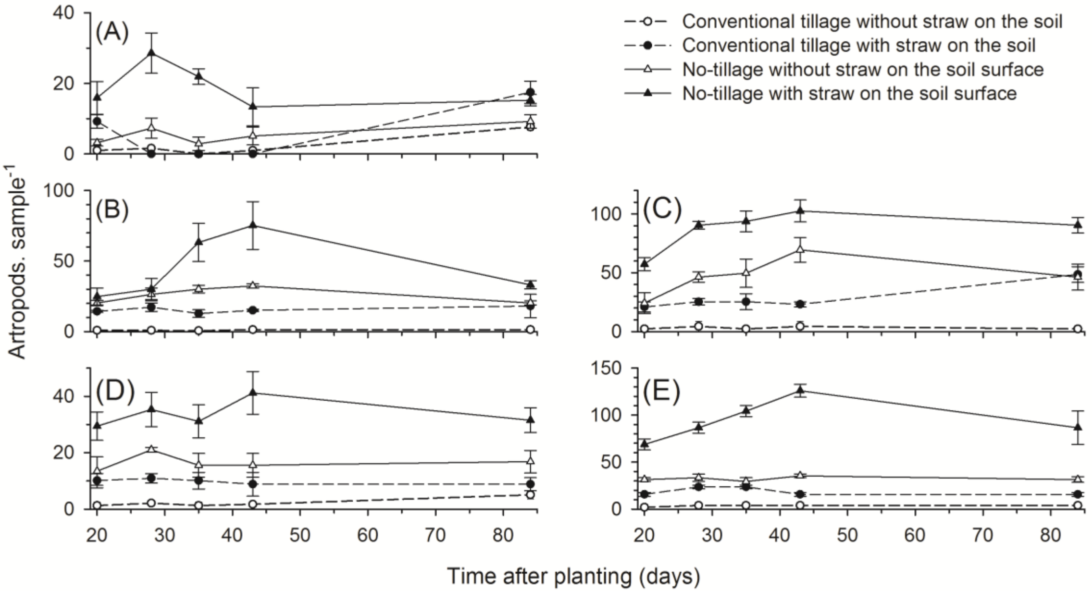

Fig. 3: Abundance (mean ± standard error) of the herbivore (A) *Cerotoma arcuata* (larvae) and detritivorous (B) Entomobryidae, (C) *Hypogastrura* sp., (D) Syrphidae (larvae) and (E) Galumnidae, in the soil interior depending on the cultivation system (no-tillage or conventional tillage) and presence of straw on the soil surface in common bean crops.

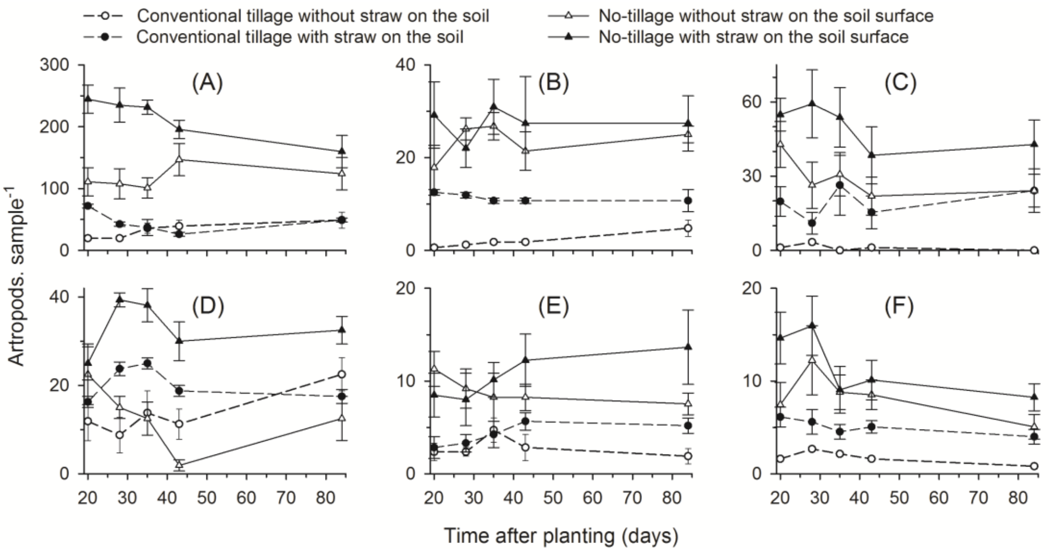

Fig. 4: Abundance (mean ± standard error) of predators (A) *Cheyletus* sp., (B) *Hypoaspis* sp., (C) *Neivamyrmex* sp., (D) *Pachycondyla* sp., (E) *Solenopsis* sp. and (F) Staphylinidae (larvae) in the soil interior depending on the cultivation system (no-tillage or conventional tillage) and presence of straw on the soil surface in common bean crops.

Conclusion:

The most important arthropod species underground common bean crops are the detritivorous *Hypogastrura* sp. (Collembola: Hypogastruridae), Diptera larva: Syrphidae and Acari: Galumnidae; larvae of the herbivore *Cerotoma arcuata* (Olivier) (Coleoptera: Chrysomelidae) and the predators *Cheyletus* sp. (Acari: Cheyletidae), *Hypoaspis* sp. (Acari: Laelapidae), *Neivamyrmex* sp. (Hymenoptera: Formicidae), *Pachycondyla* sp. (Hymenoptera: Formicidae), *Solenopsis* sp. (Hymenoptera: Formicidae) and larvae of the Coleoptera: Staphylinidae. The cultivation system and the existence of straw on the soil have an impact on the composition of the entomofauna inside the soil in common bean crops. These two factors affect both quantitatively and quantitatively the entomofauna within the soil. The total richness of arthropods and the richness of detritavorous arthropods are higher in no-tillage than in conventional tillage. The richness of herbivorous arthropod species and predatory arthropods are the same or greater in no-tillage than in conventional tillage. The total richness of arthropods and the richness of detritivours, herbivorous and predator arthropods are greater when common beans are grown in soil with straw than when it is grown in soil without straw. It’s larger the abundance of detritivorous arthropods Entomobryidae, *Hypogastrura* sp., Syrphidae (larvas) and Galumnidae in no-tillage than conventional tillage. The same is true of the abundance of the herbivore *C. arcuata* (larvae) and the predators *Cheyletus* sp., *Hypoaspis* sp. and Staphylinidae (larvae). The abundance of the predatory ants *Neivamyrmex* sp., *Pachycondyla* sp. and *Solenopsis* sp. is the same in no-tillage and convetional tillage system. The abundance of the detritivorous Entomobryidae, *Hypogastrura* sp., Syrphidae (larvae) and Galumnidae is greater in the bean crops with straw on the soil surface than when there is no straw. The abundance of the *C. arcuata* (larvae), and the predators *Cheyletus* sp., *Hypoaspis* sp., *Neivamyrmex* sp., *Pachycondyla* sp., *Solenopsis* sp. and Staphylinidae (larvae) do not vary due to the presence of straw on the soil. Therefore, the use of no-tillage benefits the soil by increasing the abundance and richness of detritivorous arthropod species. Besides, no-tillage benefits the natural biological control of pests by increasing the populations and richness of predatory arthropod species. However, in no-tillage beans, farmers should monitor soil pests, especially *C. arcuata* larvae that reach higher densities in this cropping system. Also, the existence of straw on the soil in common bean crops was beneficial to increase the abundance and richness of detritivorous arthropod species.

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