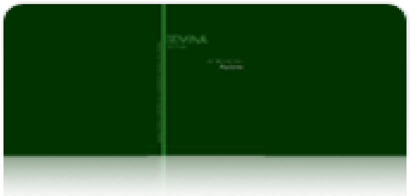

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Biological and microbiological attributes in Oxisol managed with cover crops

Atributos biológicos e microbiológicos em Latossolo Vermelho manejado com plantas de cobertura

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Abstract

The inclusion of winter cover crops and fertilization with nitrogen to the soil can have an effect on their biological and microbiological attributes. The aim of this study was to evaluate biological and microbiological attributes in soil under different winter cover crops and nitrogen doses. The experiment was conducted at the Frederico Westphalen-RS campus of the Federal University of Santa Maria (UFSM) in a Rhodic Hapludox soil. The experimental design was a randomized block in factorial arrangement (2 x 10): 10 winter cover crops systems (Fallow [control], black oats, white oats, ryegrass, forage turnip, vetch, white lupine; black oat + forage turnip; black oat + vetch and black oat + vetch + fodder turnip), and two nitrogen rates in the form of urea applied in successive crops of beans common and maize, with four replications. We assessed the biological attributes (Margalef's richness, Simpson's dominance, Shannon's diversity and abundance of organisms) and microbiological (carbon and nitrogen microbial biomass, basal respiration, metabolic quotient and microbial quotient of the soil). The fallow with wild species and white lupine showed greater Simpson's dominance and abundance of organisms due to the increase in the number of individuals of the order Collembola. Vetch improved the biological attributes of the soil with increase in Collembola abundance and diversity of organisms of soil fauna. The application of nitrogen favored the microbial biomass carbon and reduced the metabolic quotient.
Key words: Management. Soil fauna. Soil quality.

Resumo

A inclusão de plantas de cobertura de inverno e adubação com nitrogênio (N) ao solo pode exercer efeito nos seus atributos biológicos e microbiológicos. O objetivo deste trabalho foi avaliar atributos biológicos e microbiológicos em solo submetido a diferentes plantas de cobertura de inverno e doses de nitrogênio. O trabalho foi conduzido no *campus* de Frederico Westphalen, RS da Universidade Federal de Santa Maria de abril de 2010 a outubro de 2013 em Latossolo Vermelho distrófico típico. O delineamento experimental foi em blocos ao acaso em arranjo fatorial (10 x 2) sendo 10 sistemas de plantas de cobertura de inverno: Pousio (testemunha com espécies espontâneas); Aveia preta; Aveia branca; Azevém; Nabo forrageiro; Ervilhaca; Tremoço branco; Aveia preta + Nabo forrageiro; Aveia

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preta + Ervilhaca e Aveia preta + Nabo forrageiro + Ervilhaca, e duas doses de nitrogênio na forma de ureia aplicados nos cultivos sucessivos de feijão e milho, com quatro repetições. Avaliaram-se os atributos biológicos da fauna edáfica (riqueza de Margalef, dominância de Simpson, diversidade de Shannon e densidade de organismos) e microbiológicos (carbono da biomassa microbiana, nitrogênio da biomassa microbiana, respiração basal, quociente metabólico e quociente microbiano do solo). O Pousio com espécies espontâneas e o tremoço resultaram em maior dominância de Simpson e densidade de organismos decorrente do aumento no número de indivíduos da ordem Collembola. A ervilhaca melhorou os atributos biológicos do solo com aumento no número de Collembola, abundância, riqueza e diversidade de organismos da fauna edáfica. A aplicação de nitrogênio favoreceu o carbono da biomassa microbiana e reduziu o quociente metabólico.
Palavras-chave: Fauna edáfica. Manejo. Qualidade do solo.

Introduction

The use of winter cover crop species in rotation system is of major importance for the soil quality in farming areas using no-tillage management system (SILVA et al., 2013a). Addition of large amounts of residues through cover species, either in single or mixed crops, promotes a reduction of the soil thermal range (FURLANI et al., 2008). Cover crops may recycle nutrients; thus, the use of leguminous plants, which have a satisfactory performance in biomass production, can yield benefits to the soil (CAVALCANTE et al., 2012), contributing to the chemical, physical and biological soil quality.

With respect to biological changes, cover crops on farming areas can stimulate the soil faunal community. Silva et al. (2013a) observed an increase of individuals of edaphic fauna by the combined use of turnip + black oat, and vetch + turnip + black oat and concluded that the biological activity is influenced by the soil cover method. However, lesser amounts of crop residues remaining on the soil diminish the soil fauna (GATIBONI et al., 2009). Therefore, cover crops can stimulate soil fauna, and studies that demonstrate which cover species can favor such fauna for longer soil protection periods are important.

Changes in the soil surface can also affect the microbial activity. According to Kuwano et al. (2014), cover crops that enable the entry of more residues increase the microbial and enzymatic activity. Mazurana et al. (2013) found increased C contents of microbial biomass because of the increased amount of plant residues in consolidated no-tillage lands. Graham et al. (2002) reported that microbial growth is limited by the lack of nutrients in soil, but nitrogen addition may increase biomass, which in turn will immobilize the element in its cellular constitution. According to Coser et al. (2007), nitrogen fertilization can alter the soil microbiological properties, such as carbon and nitrogen of microbial biomass, besides basal respiration and metabolic quotient; however, application of nitrogen in land cover did not cause an effect on the microbial biomass nitrogen (TIQUIA et al., 2002).

The use of cover crops, single or mixed, may provide valuable information for determination of the beneficial effects of the used species (LANZANOVA et al., 2010), mainly regarding the improvement of soil quality. There are few works on the influence of different cover crop systems associated with nitrogen doses on the soil biological activity. In this context, this work aimed to assess the biological and microbiological properties in soil subjected to different winter cover crops and nitrogen doses applied to the summer crop.

Material and Methods

The work was conducted in the experimental field of the Federal University of Santa Maria, Frederico Westphalen campus, northern region of the state of Rio Grande do Sul. The climate in the region is subtropical Cfa, according to Köppen classification, with annual rainfall ranging from

1900 to 2200 mm and average annual temperature around 18 ºC (ALVARES et al., 2013). The soil of the experimental area is Rhodic Hapludox soil. The experiment consisted of different cover crop systems, grown in the autumn/winter period, involving a succession system: winter cover crops + common bean (*Phaseolus vulgaris* L.) + short-cycle maize (*Zea mays* L.) in spring/summer.

The experimental design consisted of randomized blocks in a 10 x 2 factorial arrangement with 10 systems of winter cover crops and two doses of nitrogen applied in common bean crops and winter maize, with four replications. The cover systems were: Fallow (control, grown with spontaneous, wild species) – FL; Black oats (*Avena strigosa* L.) – BO; White oats (*Avena sativa* L.) – WO; Ryegrass (*Lolium multiflorum* L.) – RG; Forage turnip (*Raphanus sativus* L.) – FT; Vetch (*Vicia sativa* L.) – VT; White lupine (*Lupinus albus* L.) – WL; Black oats + forage turnip – BOFT; Black oat + Vetch – BOVT; and Black oat + Forage turnip + Vetch – BOFTVT. Treatments with nitrogen involved parcels that received 150 kg ha^{-1} of urea-based nitrogen (45%) (of which 50 kg ha^{-1} in the common bean and 100 kg ha^{-1} in maize, as recommended by the CQFS (2004)) and a control without nitrogen supply. The experiment was conducted in a period of three years with winter cover crop systems and two years with summer crops in succession common bean and winter maize. In October 2013, after the third year of cover crop cultivation, the biological and microbiological properties of topsoil (0.0-0.10 m of depth) were assessed.

The biological parameters were determined by collecting soil organisms with the aid of PROVID-type traps (ANTONIOLLI et al., 2006), it is the principle of gathering based on the trap Tretzel. The soil organisms found in the traps were identified and grouped according to class or order under 60-x magnification stereomicroscope. To facilitate the interpretation in each group, the organisms were separated according to their function (functional group) following Silva et al. (2013b). Subsequently, the following was calculated: organisms' density, number of groups and biodiversity indices: Margalef's richness, Simpson's dominance and Sannon's diversity (ODUM, 1986).

The soil samples for the microbiological analysis were immediately placed into a Styrofoam box containing ice. In the laboratory, the samples were sieved through a 10-mesh screen to remove root fragments and plant remains. Following this, the soil microbial biomass carbon (SMB-C) and nitrogen (SMB-N) were determined by the fumigation-extraction method (JENKINSON; POWLSON, 1976).

Soil basal respiration (SBR) was determined during 10 days of incubation (JENKINSON; POWLSON, 1976); the metabolic quotient (qCO_2) was calculated by the ratio between C-CO_2 from basal respiration, and the microbial biomass C of the samples, according to Anderson and Domsch (1993). The microbial quotient (qMic) was calculated by the ratio between the SMB-C and total organic carbon. Organic carbon was determined by the Claessen's method (CLAESSEN, 1997).

The results were assessed by analysis of variance, and the means were compared using the Scott-Knott's test at 5% significance level, using the SISVAR statistical software (FERREIRA, 2011). The biological soil features were also analyzed by principal component analysis (PCA) using the Infostat software.

Results and Discussion

The analysis of soil organisms indicated presence of Acarina, Aranae, Coleoptera, Collembola, Diptera, Hemiptera, Hymenoptera, Orthoptera, and larvae of Coleoptera. However, there was no significant interaction between factors (cover crops x nitrogen dosage). Only the cover crops showed a significant effect on the edaphic fauna parameters, in which the number of individuals of the order Collembola was greater in FL, VT and WL (Table

1). This result may indicate higher preference of this order for leguminous plants, possibly because of its higher N contents (CAVALCANTE et al., 2012), resulting in a lower C/N ratio, which enables a rapid decomposition of plant biomass. Chauvat et al. (2003) reported that cover crops diversity could influence the distribution of communities of the order Collembola, which justifies the results found in this work for the FL cover system, which had a larger amount of plant species in its composition.

Table 1. Density of individuals per functional group (and respective rate of occurrence) and taxonomic group; total density and number of groups of the soil fauna in the following cover crop systems: fallow (FL), black oats (BO), white oats (WO), ryegrass (RG), forage turnip (FT), vetch (VT), white lupine (WL), black oat + forage turnip (BOFT), black oat + vetch (BOVT) and black oat + vetch + forage turnip (BOVTFT).

Group	Cover crop systems									
Functional	FL	BO	WO	RF	FT	VT	WL	BOFT	BOVT	BOVTFT
Microphages	607 (93)	87(66)	135 (77)	76 (70)	157 (71)	381 (89)	458 (90)	40 (47)	337 (89)	159 (78)
Collembola	607±189*a	87±55b	135±103b	76±17b	157±69b	381±205a	458±204a	40±12b	337±263b	159±123b
Social	11 (1.6)	12 (9)	6 (3)	6 (5)	6 (2,7)	24 (5.6)	10 (2)	10 (12)	10 (2.6)	11 (5.4)
Hymoptera	11±3.8^{ns}	12±4.0	6±2.7	6±2.7	6±1.8	24±6.5	10±4.5	10±2.3	10±1.1	11±3.4
Predators	5 (0.8)	8 (6)	9 (5)	5 (4.6)	11 (5)	5 (1.2)	5 (1)	4 (4.7)	6 (1.6)	8 (3.9)
Coleoptera	4±1.4^{ns}	6±1.0	7±2.4	3±0.9	6±1.0	3±0.8	4±1.4	2±0.6	3±0.9	4±1.2
Aranae	1±0.7^{ns}	2±0.5	2±0.6	2±0.8	5±2.8	2±0.4	1±0.2	2±0.6	3±0.9	4±1.1
Herbivorous	12 (1.8)	1(0.8)	- (0)	4 (3.7)	22 (9.9)	2 (0.5)	10 (2)	5 (5.8)	- (0)	1 (0.5)
Hemiptera	6±5.3^{ns}	-	-	-	21±17.2	-	8±7.6	4±4.0	-	-
Orthoptera	6±2.4a	1±0.3b	-	4±1.2a	1±0.2b	2±0.9b	2±0.4b	1±0.3b	-	1±0.4b
Other	22 (3)	24 (18)	26 (15)	18 (17)	26 (12)	17 (4)	26 (5,1)	27 (31)	28 (7,3)	26 (13)
Acarina	9±5.4^{ns}	2±1.0	9±4.8	7±0.9	6±1.9	6±1.6	9±4.6	5±1.8	6±2.6	4±1.4
Diptera	12±4.0^{ns}	21±6.4	16±4.9	10±4.8	20±4.0	8±2.0	16±3.4	21±2.9	21±5.3	20±3.9
Larvae	1±0.3^{ns}	1±0.6	1±0.3	1±0.5	-	3±0.8	1±0.3	1±0,.2	1±0.3	2±0.7
Density Total	654±19a	130±50b	174±104b	108±16b	220±68,4b	427±209a	508±215a	85±13b	380±263b	203±125b
Groups	9	8	7	8	8	8	9	9	7	8

Larvae (Coleoptera larvae). Values in parentheses represent the percentage of the density of the functional group in the cover crop; for taxonomic groups: mean ± standard deviation; *means followed by the same letter on the row are not significantly different by the Scott-Knott's test at P<0.05; ^{ns} Not significant by the Scott-Knott's test at P<0.05. – : not included in the analysis (zero).

FL and RG favored the density of individuals of the order Orthoptera, when compared with the other systems (Table 1). Carvalho et al. (2012) found few research works in the literature on the order Orthoptera in the state of Rio Grande do Sul and Brazil. However, habitat characteristics that maximize the diversity of these organisms include habitat space heterogeneity, the existence of various plant species as food source and plants with high nutritional value (JOERN, 2005). These characteristics are similar to the fallow area in this work, which showed a community of wild plants.

Total individuals density was also higher in FL, VT and WL cover crops (Table 1). According to Chauvat et al. (2003) this variable is influenced by the quality of the plant residues. In this regard, it has been observed that leguminous plants allow for a larger relative density of invertebrates in the soil (SANTOS et al., 2008), as a result of the lower C/N ratio (SILVA et al., 2009), and the use of consortia of different cover crops increases the total individuals density (SILVA et al., 2013a). Such evidences can explain the larger amount of individuals in FL, because of the higher diversity of plant species in this system, which act as a consortium of wild plants, and in WL and VT for being leguminous plants.

The BO, RG, VT, BOFT and BOVTFT systems showed higher values for the Margalef's richness index (Table 2). According to Frouz et al. (2008), plants play a key role in the establishment of the habitat physical structure, besides being part of the food chain of soil organisms. Vicente et al. (2010) commented that the greatest richness is the availability of a microhabitat provided by vegetation differences, justifying the results found for BOFT and BOVTFT.

Table 2. Margalef's richness (Richness), Simpson's dominance (Dominance) and Shannon's diversity (Diversity), in the following cover crops: fallow (FL), black oat (BO), white oat (WO), ryegrass (RG), forage turnip (FT), vetch (VT), white lupine (WL), black oat + forage turnip (BOFT), black oat + vetch (BOVT) and black oat + vetch + forage turnip (BOVTFT).

Index	FL	BO	WO	RF	FT	VT	WL	BOFT	BOVT	BOVTFT
Richness	1.94a	3.05a	2.35b	2.76a	2.34b	2.96a	2.53b	2.87a	2.43b	3.15a
Dominance	0.80a	0.40b	0.46b	0.52b	0.52b	0.56b	0.70a	0.33b	0.49b	0.40b
Diversity	0.19b	0.53a	0.46a	0.35b	0.43a	0.40a	0.28b	0.58a	0.45a	0.44a

*Means followed by the same letter on the row are not significantly different by the Scott-Knott's test at $P<0.05$.

The FL and WL showed the highest index of Simpson's dominance (Table 2). This result is associated with more individuals of the order Collembola, which represented 92% and 90% of the total sample in the respective systems. In this case, such order might have been favored by wild plant residues in the FL and rapid decomposition of WL, as a function of its low C/N ratio (SILVA et al., 2009). According to Lavelle (1996), because of the conditions imposed by the habitat, functional groups of the soil fauna can be replaced by opportunistic, or highly adaptable, organisms, which, consequently, will increase dominance.

The BO, WO, FT, VT, BOFT, BOVT and BOVTFT cover crops showed the highest index of Sannon's diversity (Table 2). Gatiboni et al. (2009) observed that a greater availability of crop residues caused a reduced diversity of soil fauna, especially because of the relative increase of Collembola. These results corroborate those found in this study, where the reduced number of organisms of the order Collembola in the BO, WO, FT, BOFT, BOVT and BOVTFT systems resulted in an increased diversity.

The crop systems and the applied dosages of nitrogen showed significant differences only for SMB-N and SBR (Table 3). Application of 150 kg ha^{-1} of N influenced positively the SMB-N in the majority of the cover crops assessed, with reduced values regarding the FT, VT and WL systems (Table 3). Graham et al. (2002) reported that nitrogen addition could increase microbial biomass, which in turn would immobilize the element in its cellular constitution. However, Černý et al. (2003) asserted that the application of nitrogen in maize resulted in a reduction of 22-30% of SMB-N. Tiquia et al. (2002) did not observe an effect of nitrogen on soil mulching and on SMB-N. According to these findings, the fallow (FL) and white oat (WO) cover crops did not present significant differences in the SMB-N values with or without nitrogen application.

SMB-N showed high variability regarding the different cover crops in this study, with values ranging from 15.20 mg kg^{-1} in the combined cover crop comprised of black oat + vetch + forage turnip (BOVTFT) to 48.85 mg kg^{-1} in the vetch (VT) cover crop without application of nitrogen. When the soil was fertilized with 150 kg ha^{-1} of N, the cover crops heterogeneous behavior remained, but with higher values in the combined cover crops (BOFT, BOVT and BOVTFT) and lower in WO.

The C/N ratio of forage turnip, vetch and white lupine indicates that mineralization tends to be higher than the immobilization of nitrogen during decomposition of crop residues (VIOLA et al., 2013). However, Gatiboni et al. (2011) emphasize that the total amount of crop residues may affect the microbial biomass as much as the C/N ratio of residues, once vetch, despite presenting a higher N concentration in its composition, decomposed rapidly, sustaining a smaller microbial biomass when compared to the residues of rye and oat. The soil microbial biomass and the addition of nitrogen to this system can speed up its decomposition of vetch, increasing N mineralization and reducing such immobilization, which are reflected in the lower values of SMB-N

Soil microbial activity represented by soil basal respiration (SBR) was not influenced by the application of nitrogen in this study (Table 3), agreeing with the results of Delbem et al. (2011) who did not find any differences in the C-CO_2 released from the soil under *Brachiaria brizantha* cv. Xaraés, subjected to different nitrogen sources and dosage.

Table 3. Nitrogen contents in soil microbial biomass (SMB-N) and soil basal respiration (SBR), in the following cover crops: fallow (FL), black oat (BO), white oat (WO), ryegrass (RG), forage turnip (FT), vetch (VT), white lupine (WL), black oat + vetch (BOVT), black oat + vetch + forage turnip (BOVTFT), subjected to zero and 150 kg ha^{-1} of nitrogen.

Cover crops	SMB-N (mg kg^{-1} of N)				SBR (mg kg^{-1} h^{-1} of C-CO_2)			
	Doses of Nitrogen (kg ha^{-1})				Doses of Nitrogen (kg ha^{-1})			
	------ 0 ------		------ 150 ------		------ 0 ------		------ 150 ------	
FL	32.10	dA*	31,12	eA	0.83	aA	0,91	aA
BO	28.75	eB	44.30	bA	0.39	bA	0.45	bA
WO	23.09	fA	22.30	gA	0.58	bA	0.67	bA
RG	16.28	gB	30.66	eA	0.49	bA	0.71	bA
FT	41.91	cA	34.06	dB	0.93	aA	0.39	bA
VT	48.85	aA	28.73	eB	0.40	bA	0.63	bA
WL	29.80	eA	25.29	fB	0.65	bA	0.55	bA
BOFT	44.82	bB	52.19	aA	0.53	bA	0.89	aA
BOVT	23.83	fB	46.02	bA	0.93	aA	0.70	bA
BOVTFT	15.20	gB	39.90	cA	0.74	aA	0.88	aA
CV(%)	2.22				4.65			

* Means followed by the same lower case letter in the column and upper case letter on the row, within each parameter, are not statistically different by the Scott-Knott's test at $P<0.05$.

The higher SBR was found in the FL, FT, BOVT and BOVTFT systems without nitrogen application and, with application of 150 kg ha^{-1} of N, in the FL, BOFT and BOVTFT cover crops. These results indicate that FL and the combined use of black oat with other cover crops can still bring enough carbon to be degraded by the soil microbial community, when compared to the other cover crop systems assessed.

The isolate effect of the soil cover crop systems showed significant differences on SMB-C, which were higher in FL, FT, VT and BOVTFT systems (Table 4). Absence of plowing and presence of more roots, which increase the entry of the carbonated substrates into the system, may have favored the SMB-C and SBR in the fallow cover.

The highest SMB-C in the FT, WL and BOVTFT covers may be related with the decomposition rate of dry matter from plants of the family *Fabaceae* and *Cruciferae,* which is higher when compared to the grasses. According to Viola et al. (2013), the lower decomposition rates may be due to high lignin concentration, which provides more resistance to the action and penetration of decomposing microorganisms. When comparing the isolate effect of nitrogen application, the SMB-C was higher with the application of 150 kg ha^{-1} of N. Results from researches on the effect of nitrogen application to the soil show a neutral effect (CHU et al., 2005), of increase (RAIESI, 2004) and inhibition of SMB-C (FISK; FAHEY, 2001). The higher SMB-C found in this work may favor the temporary immobilization of nutrients, where the microbial biomass would work as a storage compartment and, consequently, would provide fewer losses of nutrients by the soil-plant system (GAMA-RODRIGUES et al., 2005).

Table 4. Soil microbial biomass carbon contents (SMB-C), metabolic quotient (qCO_2), organic carbon and microbial quotient (qMic) in the following cover crop systems: fallow (FL), black oat (BO), white oat (WO), ryegrass (RG), forage turnip (FT), vetch (VT), white lupine (WL), black oat + forage turnip (BOFT), black oat + vetch (BOVT), and black oat + vetch +forage turnip (BOVTFT).

Cover crops	SMB-C (mg C microbial kg^{-1})	qCO_2 (mg C-CO_2 g^{-1} SMB-C h^{-1})	Organic carbon (g kg^{-1})	qMic (%)
FL	299.86 A*	3.14 B	14.1 A	2.2 B
BO	199.18 B	2.11 B	13.5 A	1.5 B
WO	215.29 B	2.97 B	13.3 A	1.7 B
RG	228.89 B	3.07 B	13.1 A	1.7 B
FT	322.79 A	2.42 B	11.3 A	2.9 A
VT	195.43 B	2.95 B	12.3 A	1.7 B
WL	287.96 A	2.21 B	16.3 A	1.9 B
BOFT	221.37 B	3.54 A	13.4 A	1.8 B
BOVT	196.15 B	4.50 A	11.7 A	1.8 B
BOVTFT	328.99 A	2.62 B	12.3 A	2.7 A
N(kg ha^{-1})				
0	203.87 B	3.43 A	12.2 A	1.7 B
150	295.31 A	2.47 B	14.0 A	2.2 A
CV(%)	15.34	12.73	6.42	13.99

*Means followed by the same letter in the column, for each cover crop system and nitrogen dosage are not different by the Scott-Knott's test at $P<0.05$.

The lowest metabolic quotient (2.47 mg C-CO_2 g^{-1} SMB-C h^{-1}) occurred with application of 150 kg ha^{-1} of N (Table 4). Among the soil cover systems, the BOFT and BOVT combined crops showed a significantly higher qCO_2 when compared to the other systems (Table 4). According to Anderson and Domsch (1993), a lower qCO_2 indicates a more stable environment or closer to a balanced condition. According to Cunha et al. (2011), systems that promote lower qCO_2 values should be chosen, because the soil microbial biomass in such systems is balanced, with lower losses of CO_2 through respiration. In this case, the supply of nitrogen to the system tends to reduce the C-CO_2 release to the atmosphere, representing a higher metabolic efficiency of the organisms.

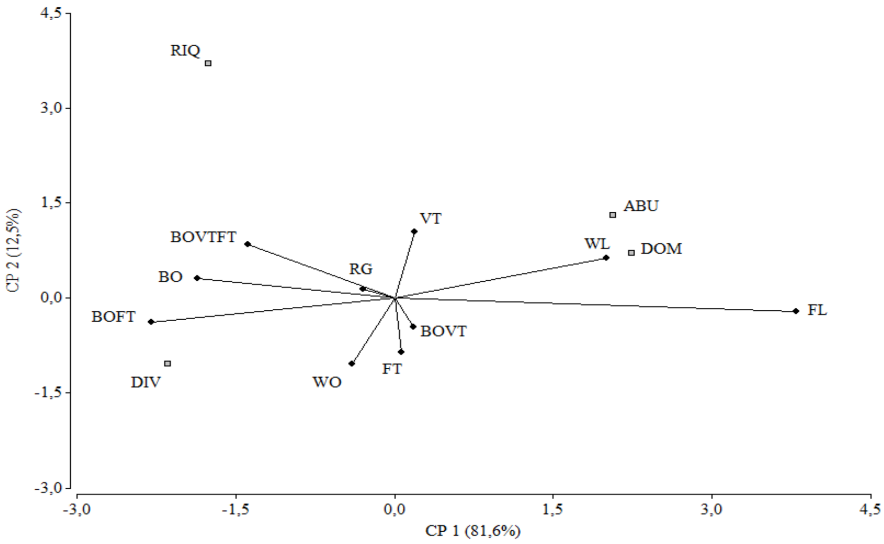
Analyzing the soil organic carbon level, no significant difference was found in the treatments (Table 4). According to Pereira et al. (2010), the use of cover crops may lead to an increase of total organic carbon contents. In this work, it was not observed an increase of organic carbon contents with the application of cover crops, but according to Wardle (1994), by adding organic matter, like the ones provided by the cover crops systems, microbial biomass can increase, even if the organic carbon levels remain unaltered.

The microbial quotient (Cmic:Corg) followed the same trend of the SMB-C, where the highest values were observed in the FT and BOVTFT systems (Table 4). According to Cardoso et al. (2009), microbial quotient expresses how much carbon in the soil is immobilized by microbial biomass. Anderson and Domsch (1993) reported that such relation may vary from 0.3% to 7% and depends on the soil type, management and use, as well as on the cover crop and sampling time. Therefore, as in SMB-C, the quality of plant residues from these covers (FT and BOVTFT) influenced qMic positively, once carbon availability is one of the variables that influences the Cmicrobial:Corganic ratio. The fastest decomposition rate of these plants and the chemical diversity of the organic matter produced by the BOVTFT cover may favor the soil microbiota and C immobilization of the organic substrate in the microbial cells, thus affecting qMic quantitatively.

The Cmic/Corg ratio has also been considered as a good indicator of changes in soil processes. Soils that show higher or lower values might be expressing the occurrence of C accumulation or loss, respectively. Cunha et al. (2011) observed significant differences in cover plants (sunn hemp, velvet bean and dwarf mucuna) regarding the microbial quotient in 0-10 cm layer. According to these authors, these results show the effect of these cover crops on microbial biomass carbon, once they did not differ regarding total organic carbon.

The multivariate model used to assess the relationship between edaphic organisms with changes resulting from the cultivation systems showed a biological variability in the area. In this regard, the Shannon's diversity index showed a tendency of association in the BOFT system, dominance and abundance of individuals showed a tendency of association with WL, and Margalef's richness did not associate with the studied systems (Figure 1). Similar results were described by Silva et al. (2013a), where there was a tendency of association of fauna diversity with combined cover crops. Therefore, the use of combined cover crops seem to favor the edaphic fauna diversity. Regarding dominance, according to Moço et al. (2005), it is primarily due to the effects of plant residues remained on the soil surface, which provide a more favorable environment to the survival of certain groups. In this case, dominance in WL occurred by the abundance of the order Collembola, considered an indicator of soil quality.

Figure 1. Principal component analysis (PCA) between the amount of individuals (AI), Shannon's diversity index (SDI), Margalef's richness index (MRI) and Simpson's dominance index (SDI) in the following cover crop systems: fallow (FL), black oat (BO), white oat (WO), ryegrass (RG), forage turnip (FT), vetch (VT), white lupine (WL), black oat + forage turnip (BOFT), black oat + vetch (BIVT) and black oat + vetch + forage turnip (BOVTFT). UFSM, Frederico Westphalen, 2014.



Conclusion

Concluding, fallow land grown with wild species and white lupine results in greater Simpson's dominance and organisms' density, due to the increased number of individuals of the order Collembola. Vetch enables an increased number of organisms of the order Collembola, density, richness and diversity of the edaphic fauna. Application of nitrogen increases microbial biomass carbon and reduces the soil metabolic quotient.

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