WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.10 (1): 866-879. 2012

www.world-food.net

The influence of mineral and organic long-term fertilization upon the floristic composition of *Festuca rubra* L.-*Agrostis capillaris* L. grassland in Apuseni mountains, Romania

Florin S. Pãcurar*, Ioan Rotar, Anca D. Bogdan, Roxana M. Vidican and Laura M. Dale
*Department of Grassland and Forage Crops, University of Agricultural Science and Medicine Veterinary, Cluj Napoca, 3-5, Calea Manaştur, 400372 Cluj, Romania.*e-mail:fpacurar@gamil.com*

Received 18 November 2011, accepted 3 January 2012.

Abstract

The semi-natural grasslands in Apuseni Mountains are particularly important for the sustainable development of this region. The future development strategies must take into consideration the conservation of grassland plant diversity. In Apuseni Mountains there are numerous caves and a traditional landscape, these forming the area's wealth. Their joining with agro-tourism and performing a sustainable agriculture would significantly level up the wellbeing of the local population, who are in need of new income sources considering that the wood resources are more and more reduced. In Gârda de Sus there are considerable areas of semi-natural grasslands which lately have been traditionally used. Nowadays, some of them have been abandoned and others irrationally intensified. Therefore, the objective of this paper was to evaluate the effects of mineral and organic fertilization upon the sward in order to recommend certain versions which have minor repercussions upon the plant diversity. The research was carried out in Apuseni Mountains, in an experimental field with two experiences: one with mineral fertilizers (T_1 control, T_2 50N25P25K, $T_3$100N50P50K, T_4 150N75P75K) and the other with organic fertilizers (T_1 control, T_2 10 t ha^{-1} manure, T_3 20 t ha^{-1} manure, T_4 30 t ha^{-1} manure). Administrating mineral fertilizers on the *Festuca rubra* L.- *Agrostis capillaris* L. grassland induced the installation of *Festuca rubra* L. and *Trisetum flavescens* L. at 50N25P25K treatment, whereas 100N50P50K and 150N75P75K treatments induced the installation of *Agrostis capillaris* L. and *Trisetum flavescens* L. grassland subtype. The plant diversity decreased as the system was intensified, especially at the treatment with 100N50P50K and 150N75P75K. Administrating 50N25P25K did not induce any significant changes in plant diversity. Giving organic fertilizers caused installation of *Festuca rubra* L. and *Trisetum flavescens* L. at the treatment using 10 t ha^{-1} manure and *Trisetum flavescens* L. at using 20 and 30 t ha^{-1} manure. The treatment with 10 t ha^{-1} manure induced a growth of the plant diversity and by raising the manure quantity did not cause important changes with respect to the species' number. For future management actions that are meant to maintain the plant diversity in Apuseni Mountains, the organic fertilization with 10 t ha^{-1} manure quantities annually administrated or once in two years is recommended first of all, and, secondly, the fertilization with 50N25P25K performed annually or once in two years.

Key words: Mountainous grassland, mineral fertilization, organic fertilization, plant diversity, frequency of the species, abundance of the species, floristic composition, traditional management, România, Apuseni Mountains.

Introduction

Mountain grasslands include some of the most important high nature value areas in Europe, and high-biodiversity mountain farmland can increase tourism incomes and is a potential seed source for local biodiversity restoration [1]. The grassland system can provide ecosystem services such as soil conservation, water quality protection, biodiversity conservation, medicinal plants, pleasing landscapes, soil carbon storage and greenhouse gas mitigation [2]. Grassland biodiversity is an important consideration in many agri-environmental policies [3]. Overall, the biological diversity in temperate grasslands, both in terms of functional diversity and species richness, does play a critical role in maintaining ecosystems functioning and ecosystem services and its ongoing reduction will most likely affect human wellbeing [4]. In the world summit, the parties declared that their goal was "to achieve by 2010 a significant reduction in the current rate of biodiversity loss at the global, regional and national level" [5]. The grasslands in Europe suffer a dramatic loss of biodiversity features because of fertilization, land abandonment or the transformation of grassland into cropland [6]. The first systematic assessment of Europe's most vulnerable habitat types and species has already shown that grasslands in particular have an unfavourable conservation status[7]. In less-favoured areas, this can take form of preserving plant diversity, e.g. through low-input farming system [8]. Semi-natural grasslands need a management system which supports biodiversity conservation [9]. Being one of the most diverse plant communities, mountain meadows are the habitat for many rare species [10]. However, in habitats with low soil nutrient availability, richness and diversity can be positively affected by moderate intensification[11]. Furthermore, a minimum intensity is needed to maintain characteristic species composition [12]. Manure fertilization contributes to grasslands phyto-diversity, while spring overgrazing or frequent mowing are disadvantageous [13]. Questions remain as to what level of organic fertilization optimally maintains the plant diversity of meadows. Organic fertilization and rational use of fertilizers can produce substantial increases of the production and biodiversity and fodder quality improvement [14]. In the central part of Apuseni Mountains, fertilization by manure is the most important component of the traditional management that means to increase the biomass yield, species diversity and identity of the cultural landscape maintenance in this area [9]. The most significant influence on species diversity is presented by the intensity of fertilization and the mineral fertilizers used. Nitrogen fertilization, particularly in higher doses, influences rapidly and considerably the stand condition[15]. The administration of technological inputs produces a considerable decrease of the plant diversity, especially with larger quantities of fertilizers [9]. Nowadays, in Romania, on the grasslands of Apuseni Mountains, a management that involves manual labour, with horses-drawn carts and great consumption of time still is performed [18]. This type of management has created over time great plant diversity [18]. The meadows present within the perimeter of the Gârda de Sus commune, Apuseni Mountains, Romania, are highly plant diversified [18], due to traditional management performed over long periods of time. Most of the traditional management techniques use organic fertilization via manure combined with the mixed uses [16]. The recent changes (access roads improvement, better livelihood etc.) will influence the grasslands maintenance manner. Out of landowners initiative to save time associated to livestock decrease, they will perform fertilization with mineral fertilizers and organic fertilizer in larger and larger quantities. Our paper's objective was to evaluate the effects of mineral and organic fertilization upon the sward in order to recommend certain versions which have minor repercussions upon the plant diversity.

Materials and Methods

The experimental field is located in the Ghetari, Gârda de Sus village, Alba County, Apuseni Mountains, at 1130 m elevation and it was founded in 2001, using the random blocks method. The field is composed of two experiments, one with mineral fertilizers and the other with organic fertilizers. The mineral experiment included 4 treatments in 4 replications (T_1 control, T_2 50N 25P 25 K, $T_3$100N 50P 50K, $T_4$150N 75P75K) and the organic experiment 4 treatments in 4 replications (T_1 control, $T_2$10 t ha^{-1} manure, T_3 20 t ha^{-1} manure, $T_4$30 t ha^{-1} manure). Each plot measures 10 m^2. The technological inputs administration took place annually in early spring, the mineral fertilizer was the complex type NPK 20:10:10, and the organic fertilizer came from cattle and horses having the following elements content: 0.40 N, 0.39 P and 0.45 K. The experimental field was placed on Terra Rossa soil having the following features: soil pH 5.34, N total 0.212%, P mobile 3 ppm, K 25 ppm. Thus, a medium supply in N and extremely low in P and K are noticed. The floristic studies were performed according to Braun-Blanquét method. For floristic data we have used PC-ORD program which performs multivariate analysis of ecological data entered in spreadsheets [19]. Our emphasis is on nonparametric tools, graphical representation, randomization tests and bootstrapped confidence intervals for analysis of community data. We also used the MRPP (Multi Response Permutation Procedures), which is a nonparametric procedure for testing the hypothesis of no differences between two or several groups of entities. The method implies the statistic T-test which describes the separation among the groups, meaning the more negative is T, the stronger is the separation. The agreement statistic A describes within - group homogeneity, compared to the random expectation. Also, Non-metric Multidimensional Scaling (NMS) was used, which is an ordination method well suited to data described as not normal or arbitrary, discontinuous, or otherwise questionable scales. NMS is generally the best ordination method for community data. NMDS does not alter the ordination too much and is replacing the correlation coefficient by the frequently used Bray-Curtis index which changes the result considerably [20]. A Monte Carlo test of significance was included. The order-abundance and order-frequency correlations give us a synthetic view and are extremely useful in comparative studies [21].

Results and Discussion

Applying mineral fertilizers on *Festuca rubra* L.-*Agrostis capillaris* L. grassland produced a plant community ordination in 4 floristic groups specific to each treatment (Fig. 1). The control floristic groups differed significantly ($p< 0.01$) from the groups of the other treatments (Table 1). The plant community of 50N25P 25K treatment was different from the treatments with 100N50P50K and 150N75P75K ($p< 0.01$). The plant community of 100N50P50K treatment was very similar to that of the treatment 150N75P75K, but this statement cannot be asserted because it did not show statistical insurance ($T = 0.01$, $A = -0.0005$, $p = 0.467$). In order to obtain statistical insurance, a greater number of replications is needed, but their increase is not always possible, especially in mountain regions where landforms are access-difficult and do not offer a levelled experimental field.

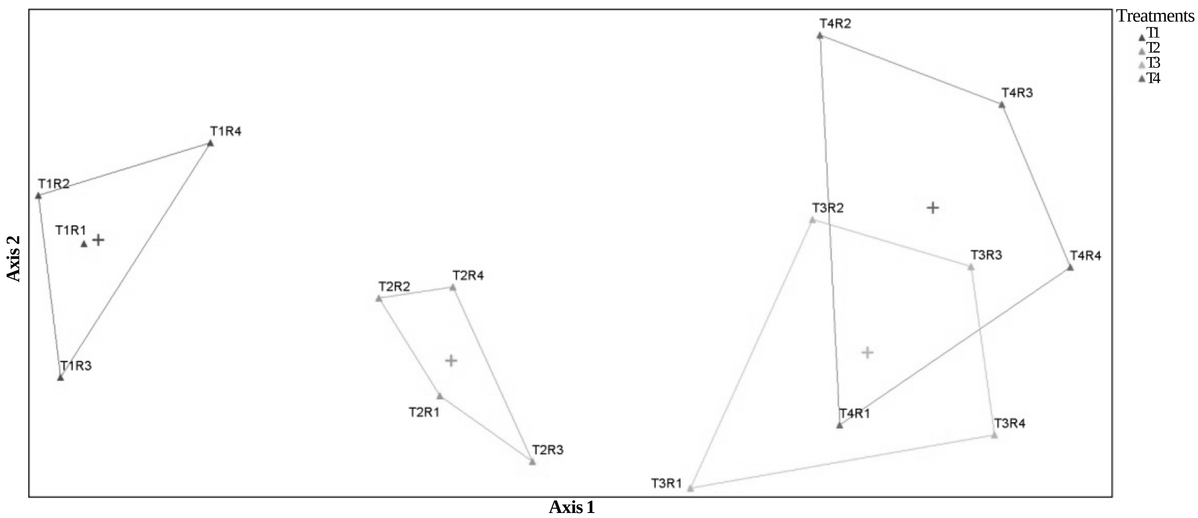

Figure 1. Ordination of floristic composition depending on the mineral treatments (T-treatments, T_1 control, T_2 50N25P 25K, T_3 100N50P50K, $T_4$150N75P75K, R-replication).

The control floristic composition was represented by *Festuca rubra* L. - *Agrostis capillaris* L. grassland type, having the following plant structure on economic groups: Poaceae 32.79%, Fabaceae 10.88%, Cyperaceae - Juncaceae 0.63% and 61.00% plants of other botanical families.

Administrating 50N25P25K caused the installation of *Festuca rubra* L. - *Trisetum flavescens* L. grassland subtype. This subtype was identified in this study area as having a medium nitrophilous character exploited through mowing [18]. The *Festuca rubra* L. - *Trisetum flavescens* L. subtype was composed of 58.81% Poaceae, 5.94% Fabaceae, 0.50% Cyperaceae-Juncaceae and 44.75% plants of other botanical families. This subtype induced the presence of 17.50% of *Festuca rubra* L., which had the same value as the control and the species *Trisetum flavescens* L. which showed a significant share increase in comparison to the control ($p<0.001$). The species *Agrostis capillaris* L. had a share increase comparative to the control, but the differences did not have statistical insurance ($p>0.05$). Poaceaes showed a significant evolution comparative to control ($p<0.001$), increase was especially due to *Trisetum flavescens* L. Fabaceaes experienced a significant decrease comparative to control ($p<0.05$), and the plants of other botanical families were reduced, but with no statistical insurance.

Enlarging the mineral fertilizer quantities (100N50P50K and 150N75P75K) produced the installation of *Agrostis capillaris* L. - *Trisetum flavescens* L. subtype (Table 2). This subtype was identified in our study area as having a moderate acidophilous and moderate nitrophilous character and was exploited through mowing [18]. *Agrostis capillaris* L. - *Trisetum flavescens* L. subtype was marked by a large share of the species *Agrostis capillaris* L. (38.13- 50.00%), a medium share of the species *Trisetum flavescens* L. (20.94-25.00%), and the species *Festuca rubra* L. had a share not greater than 7.00%. The share of the species *Agrostis capillaris* L. significantly increased ($p<0.001$) comparative to the control. The same evolution was owned by the species *Trisetum flavescens* L. ($p<0.001$) in prejudice of the species *Festuca rubra* L. which slightly decreased ($p<0.01$).

Within this subtype, Poaceaes had a share of 70.81-70.44%, Fabaceaes 2.75-3.75% and experienced a distinct significant decrease ($p<0.01$). Cyperaceae-Juncaceaes had a share of 0.25-0.38%, experiencing a decrease comparative to control ($p<0.05$), and the plants of other botanical families comprised 26.31-37.38%, a decrease comparative to control being recorded ($p<0.01$).

Certain plant species correlated to the control type, *Festuca rubra* L. - *Agrostis capillaris* L., like: *Arnica montana* L., *Briza media* L., *Hieracium aurantiacum* L., *Polygala vulgaris* L., *Plantago media* L., *Plantago lanceolata* L., *Scabiosa columbaria* L. (Fig. 2). Other species showed the greatest presence within the type *Festuca rubra* L. - *Trisetum flavescens* L. (the treatment with 50N 25P 25K), species like: *Alchemilla vulgaris* L., *Cynosurus cristatus* L., *Gymnadenia conopsea* L., *Hypericum maculatum* Crantz, *Lotus corniculatus* L., *Luzula multiflora* Ehrh., *Trifolium pratense* L. etc. Within the *Agrostis capillaris* L.- *Trisetum flavescens* L. subtype (100N50P 50K, respectively 150N75P75K) nitrophilous species *Achillea millefolium* L., *Centaurea pseudophrygia* C. A. Mey., *Festuca pratensis* L., *Leontodon autumnalis* L., *Rumex acetosa* L., *Veronica chamaedrys* L., *Vicia cracca* L. etc.

Within the plant community of the *Festuca rubra* L. - *Agrostis capillaris* L. type (control), the greatest abundance, besides the dominant species was for *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Colchicum autumnale* L., *Pimpinella major* L., *Plantago media* L., *Potentilla erecta* L., *Trifolium pratense* L. etc; and the lowest abundance was recorded for the species *Achillea millefolium* L., *Cynosurus cristatus* L., *Gymnadenia conopsea* L., *Hieracium aurantiacum* L., *Leontodon autumnalis* L., *Prunella vulgaris* L. etc. (Fig. 3). Concerning the species frequency within this type, certain species with low frequency were noticed: *Achillea millefolium* L., *Arnica montana* L.,

Table 1. The pairwise comparison with MRPP (T the t test, A group homogeneity, p the statistical significance).

Treatments	T	A	P
Control vs 50N 25P 25K	-4.14305848	0.29085080	0.00585269
Control vs 100N 50P 50K	-4.25395227	0.41111402	0.00590217
Control vs 150N 75P 75K	-4.28359446	0.45873632	0.00581186
50N 25P 25K vs 100N 50P 50K	-3.65821275	0.29739702	0.00758772
50N 25P 25K vs 150N 75P 75K	-3.99902184	0.38020013	0.00624498
100N 50P 50K vs 150N 75P 75K	0.01103128	-0.00054695	0.46777252

Table 2. The floristic structure of the grassland types under the influence of mineral inputs (dominant species and economic groups).

		Treatments/Signif.							
		Control	Signif.	50N 25P 25K	Signif.	100N 50P 50K	Signif.	150N 75P 75K	Signif.
	Grassland type	F.r-A.c	-	F.r-T.f	-	A.c-T.f	-	A.c-T.f	-
Dominant and co-dominant species	*Agrostis capillaris* L.	12.81	Mt.	17.50	ns	38.13	***	50.00	***
	Festuca rubra L.	17.50	Mt.	17.50	ns	7.56	00	7.00	00
	Trisetum flavescens L.	0.50	Mt.	22.50	***	25.00	***	20.94	***
Economic groups	Poaceae	32.19	Mt.	58.81	***	70.81	***	78.44	***
	Fabaceae	10.88	Mt.	5.94	0	3.75	00	2.75	00
	Cyperacea and Juncaceae	0.63	Mt.	0.50	ns	0.38	ns	0.25	0
	OBF	51.00	Mt.	44.75	ns	37.38	ns	26.31	00

Fr-Ac= *Festuca rubra* L.- *Agrostis capillaris* L., F.r-T.f = *Festuca rubra* L.- *Trisetum flavescens* L., A.c-T.f= *Agrostis capillaris* L. - *Trisetum flavescens* L., Mt.=control,
* = *p<0.05*, ** = *p<0.01*, *** =*p<0.001*, 0 = *p<0.05*, 00 = *p<0.01*, 000 =*p<0.001*, ns not significant

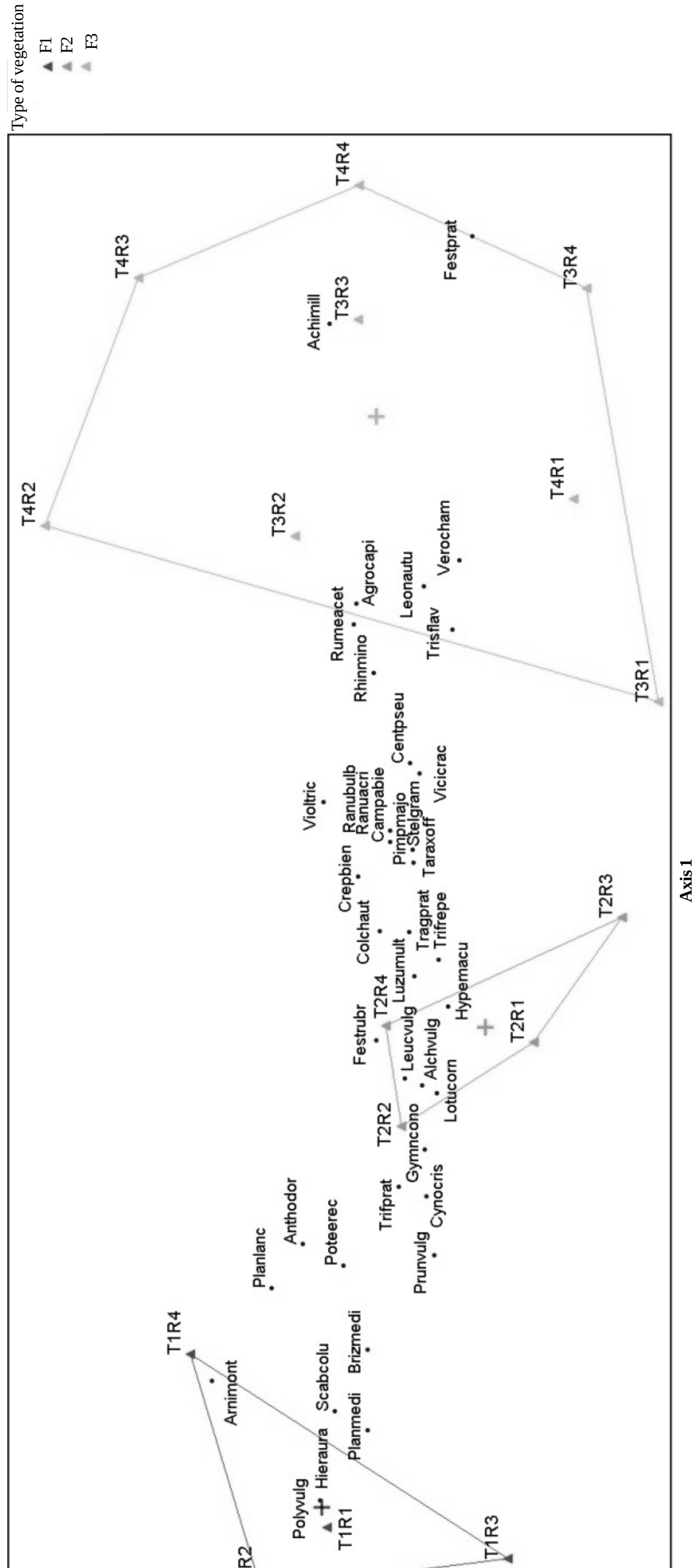

Figure 2. Ordination of floristic composition on type and species depending on the mineral treatments (T-treatments, R-replication, F-grasslands types, F1- *Festuca rubra* L. *Agrostis capillaris* L., F2= *Festuca rubra* L. *Trisetum flavescens* L., F3= *Agrostis capillaris* L. *Trisetum flavescens* L., Achimill = *Achillea millefolium* L., Agrocapi= *Agrostis capillaris* L., Alchvulg= *Alchemilla vulgaris* L., Anthodor= *Anthoxanthum odoratum* L., Arnimont = *Arnica montana* L., Brizmedi = *Briza media* L., Campabie= *Campanula abietina* Griseb., Centpseu = *Centaurea pseudophrygia* C. A. Mey., Colcautu = *Colchicum autumnale* L., Crepbien = *Crepis biennis* L., Cynocris = *Cynosurus cristatus* L., Festprat = *Festuca pratensis* L. , Festrubr= *Festuca rubra* L. , Gymncono = *Gymnadenia conopsea* L., Hieraura = *Hieracium aurantiacum* L., Hypemacu= *Hypericum maculatum* Crantz, Leonautu =*Leontodon autumnalis* L., Leucvulg =*Leucanthemum vulgare* Lam., Lotucorn = *Lotus corniculatus* L., Luzumult = *Luzula multiflora* Ehrh., Pimpmajo = *Pimpinella major* L., Planlanc = *Plantago lanceolata* L., Planmedi = *Plantago media* L., Polyvulg = *Polygala vulgaris* L., Poteerec = *Potentilla erecta* L., Prunvulg = *Prunella vulgaris* L., Ranuacri = *Ranunculus acris* L., Ranubulb = *Ranunculus bulbosus* L., Rhinmino = *Rhinanthus minor* L., Rumeacet = *Rumex acetosa* L., Scabcolu = *Scabiosa columbaria* L., Stelgram = *Stellaria graminea* L., Taraoffi = *Taraxacum officinale* Weber ex F.H.Wigg., Tragprat = *Tragopogon pratensis* L., Trifprat = *Trifolium pratense* L., Trifrepe = *Trifolium repens*, L., Trisflav= *Trisetum flavescens* L., Verocham = *Veronica chamaedrys* L., Vicicrac= *Vicia cracca* L., Violtric = *Viola tricolor* L.)

Cynosurus cristatus L., *Gymnadenia conopsea* L. etc.; and others with great frequency, *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Pimpinella major* L., *Potentilla erecta* L., *Trifolium pratense* L. etc (Fig. 4).

In the plant community of the *Festuca rubra* L.- *Trisetum flavescens* L. subtype (the treatment with 50N25P25K) the largest share was shown by the species *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Colchicum autumnale* L., *Pimpinella major* L., *Trifolium pratense* L., *Veronica chamaedrys* L., and the lowest abundance was owned by the species *Anthoxanthum odoratum* L., *Briza media* L., *Gymnadenia conopsea* L., *Plantago lanceolata* L., *Viola tricolor* L. etc. (Fig. 5). The most frequent species of this subtype were *Agrostis capillaris* L., *Centaurea pseudophrygia* C. A. Mey., *Colchicum autumnale* L., *Pimpinella major* L., and the smallest frequency was shown by the species *Anthoxanthum odoratum* L., *Cynosurus cristatus* L., *Plantago lanceolata* L., *Scabiosa columbaria* L. (Fig. 6).

Regarding the plant community of the *Agrostis capillaris* L.- *Trisetum flavescens* L. grassland subtype (100N50P50K, respectively, 150N75P75K) the most abundant species were *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Pimpinella major* L., *Rumex acetosa* L., *Veronica chamaedrys* L., *Vicia cracca* L., and the poorest represented species *Anthoxanthum odoratum* L., *Festuca pratensis* L., *Gymnadenia conopsea* L., *Luzula multiflora* Ehrh., *Plantago media* L., etc (Fig. 7). The most frequent species of this subtype were *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Colchicum autumnale* L., *Festuca rubra* L., *Pimpinella major* L., *Rumex acetosa* L., *Trifolium pratense* L., *Veronica chamaedrys* L., *Vicia cracca* L., and the lowest represented were *Anthoxanthum odoratum* L., *Festuca pratensis* L., *Gymnadenia conopsea* L., *Leucanthemum vulgare* Lam., *Plantago lanceolata* L., *Plantago media* L., *Viola tricolor* L. (Fig. 8).

The control plant diversity was represented by 34 species, which are being reduced, as the system was intensified, down to 24.25 species at the treatment with 150N75P75K ($p<0.001$;

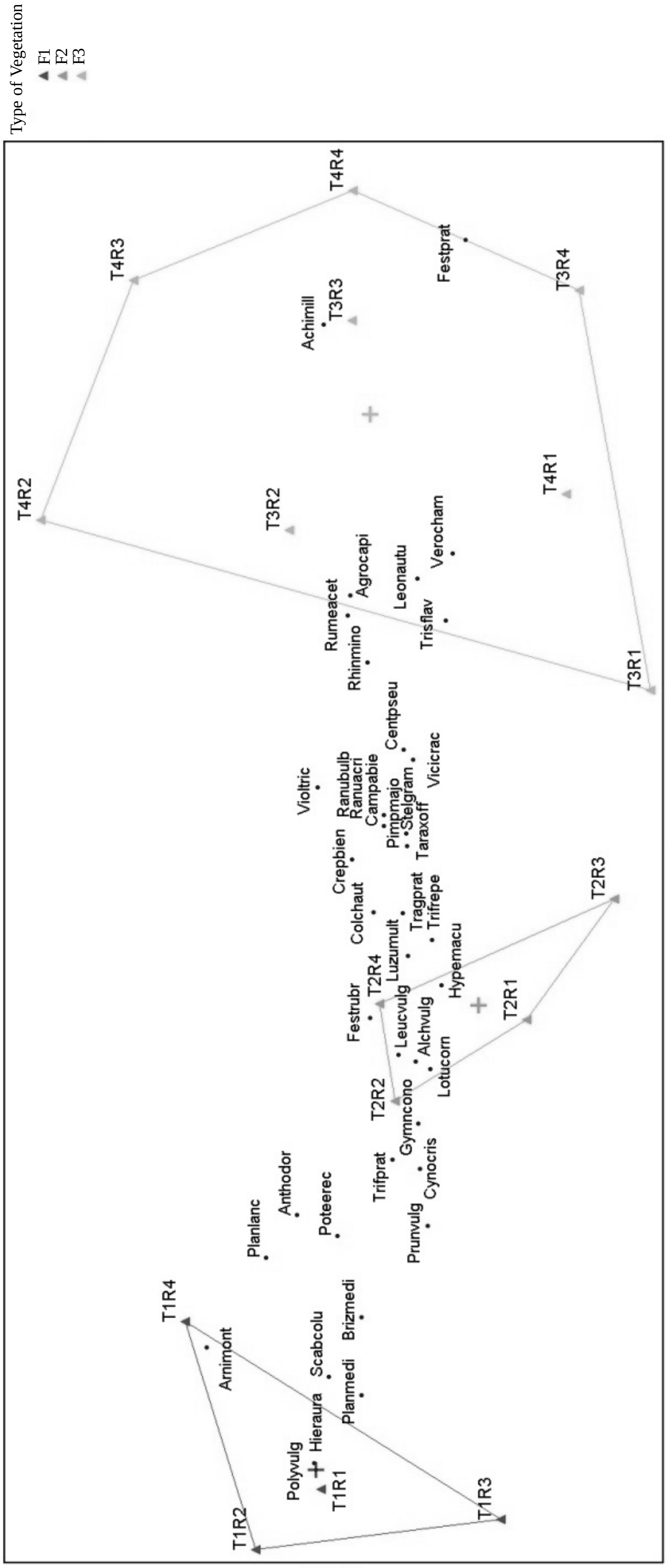

Figure 3. Species abundance in *Festuca rubra* L.-*Agrostis capillaris* L. grassland (control, Rankabund = Rank abundance of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

Table 3). Even the treatment with 50N 25P 25K produces a slight decrease of the species number ($p<0.05$). If the Shannon Index is taken into consideration, the same trend of decrease was noticed, with a single difference. In plant community of treatment with 50N25P25K, the abundance was lower than the control and did not have significant differences ($p>0.05$) and for the other treatments, statistically insured differences were noticed ($p < 0.01$; $p<0.001$).

Administrating organic fertilizers produced a vegetation ordination in 4 floristic groups specific to each treatment (Fig 9). Control floristic composition was much differentiated from the swards structure of all applied treatments ($p<0.01$; Table 4).

The floristic composition of the 10 t ha^{-1} manure treatment differed very much from the one of the treatments with 20 and 30 t ha^{-1} manure ($p<0.01$, respectively, $p<0.0.5$). The plant community of the 20 t ha^{-1} manure treatment did not differentiate from that of the treatment with 30 t ha^{-1} manure ($T = 0.9109$, $A = -0.0596$), this statement not being totally asserted because it did not have statistical insurance ($p>0.05$).

Control type was represented by *Festuca rubra* L.- *Agrostis capillaris* L. composed by 51.31% Poaceae, 10.75% Fabaceae, 1.06% Cyperaceae-Juncaceae and 38.13% plants of other botanical families (Table 5). Administrating 10 t ha^{-1} manure caused the installation of *Festuca rubra* L.- *Trisetum flavescens* L. type with 39.06% Poaceae, 15.38% Fabaceae, 0.38% Cyperaceae-Juncaceae and 49.63% plants of other botanical families. This type of plant community is marked by the species *Festuca rubra* L. which experienced a share decrease ($p<0.01$), by the species *Trisetum flavescens* L. which increased its share comparative to control ($p<0.01$) and by the species *Agrostis capillaris* L. which was slightly reduced ($p<0.005$).

The economic groups share was different from the control, but without statistical insurance. Treatments with 20 and 30 t ha^{-1} manure produced *Trisetum flavescens* L. subtype, where Poaceaes comprised 34.56-41.58%, Fabaceaes 12.13-15.13%; Cyperaceae-Juncaceaes 0.0-0.13% and plants of other botanical families 60-61.63 % (Table 5). This type is marked, first of all, by the species *Trisetum flavescens* L. which significantly increased comparative to control ($p<0.001$ and $p<0.01$). The type was reported to be present on fertilized lands, at the slopes base on slightly acid soils[22]. In Apuseni Mountains, the association *Trisetum flavescens* was encountered on organically fertilized lands [23]. Poaceaes were reduced with 20 t ha^{-1} manure towards the control, but without statistical insurance and at the treatment with 30 t ha^{-1} manure the difference was significant ($p<0.05$). Fabaceaes experienced a slight increase comparative to control, but without statistical insurance ($p>0.05$). Cyperaceaes-Juncaceaes decreased and showed statistical insurance at the treatment with 30 t ha^{-1} manure ($p<0.05$). The plants of other botanical families

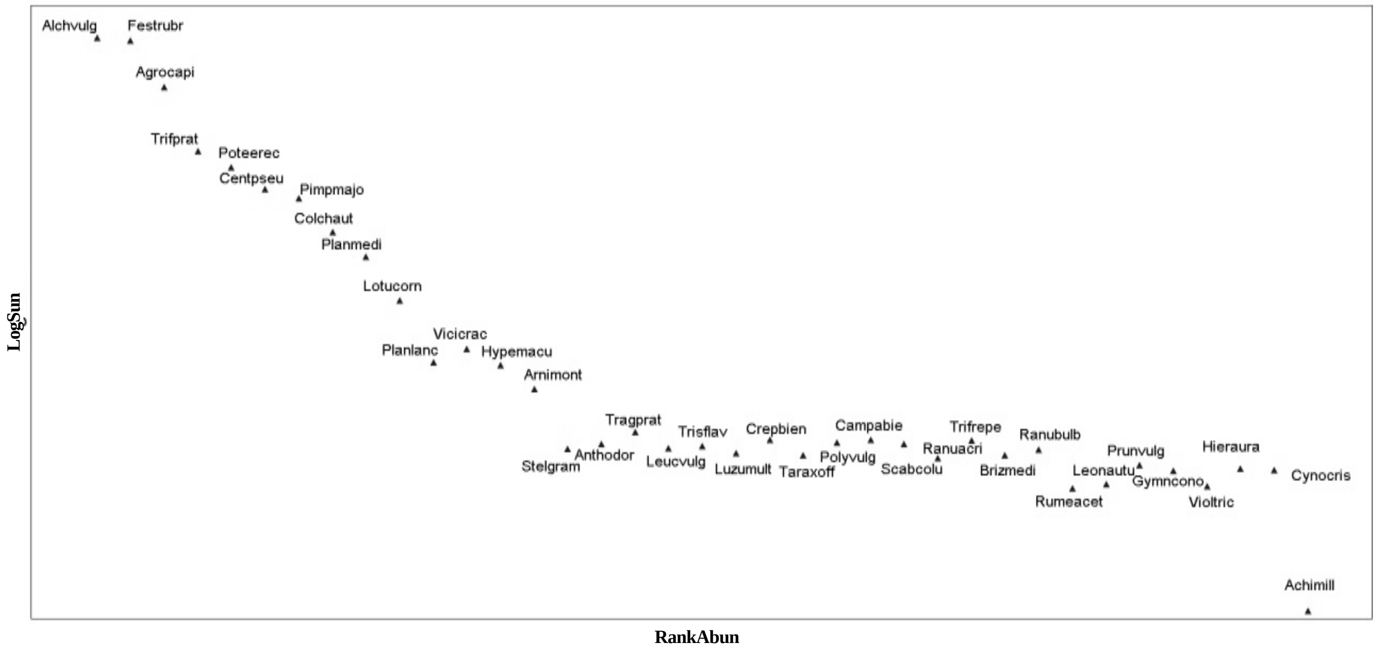

Figure 4. Species frequency in *Festuca rubra* L.-*Agrostis capillaris* L. grassland (control, Freq = Frequency of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

had a strong increase up to 61.63% ($p<0.01$).

In the plant community of the *Festuca rubra* L. - *Agrostis capillaris* L. grassland type (control) certain specific species correlated with this type, like *Arnica montana* L., *Briza media* L., *Hieracium aurantiacum* L., *Polygala vulgaris* L., *Plantago media* L., *Scabiosa columbaria* L., *Potentilla erecta* L. etc. (Fig. 10).

Certain species correlated with the *Festuca rubra* L. -*Trisetum flavescens* L. grassland type (10 t ha^{-1} manure): *Alchemilla vulgaris* L., *Colchicum autumnale* L., *Festuca rubra* L., *Gymnadenia conopsea* L., *Leucanthemum vulgare* Lam., *Luzula multiflora* Ehrh., *Taraxacum officinale* Weber ex F.H. Wigg., *Trifolium pratense* L., *Trifolium repens* L. etc. (Fig. 10).

Within the plant community of the *Trisetum flavescens* L. grassland type (20 t and 30 t ha^{-1} manure) the species, like *Achillea millefolium* L., *Agrostis capillaris* L., *Centaurea pseudophrygia* C. A. Mey., *Festuca pratensis* L., *Leontodon autumnalis* L., *Ranunculus acris* L., *Rumex acetosa* L., *Stellaria graminea* L., *Vicia cracca* L. etc., prefering large quantities of organic fertilizers were present.

In the plant community of the *Festuca rubra* L. - *Agrostis capillaris* L. grassland type (control) the most considerable shares, besides the dominant species, were *Alchemilla vulgaris* L., *Lotus corniculatus* L., *Potentilla erecta* L. *Trifolium pratense* L. etc., and the lowest shares were shown by the species: *Arnica montana* L., *Briza media* L., *Hieracium aurantiacum* L., *Hypericum maculatum* Crantz, *Prunella vulgaris* L., *Polygala vulgaris* L. etc (Fig. 11). The most frequent species of this semi-natural grassland type were: *Alchemila vulgaris* L., *Leontodon autumnalis* L., *Lotus corniculatus* L., *Potentilla erecta* L., *Trifolium pratense* L., and the poorest presentation were for the species: *Arnica montana* L., *Briza media* L., *Hieracium aurantiacum* L., *Hypericum maculatum* Crantz, *Taraxacum officinale* Weber ex F.H. Wigg. etc (Fig. 12).

Within the plant community of the *Festuca rubra* L.- *Trisetum flavescens* L. grassland type (10 t ha^{-1} manure) the most dominant species were the following: *Agrostis capillaris* L., *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Pimpinella major* L., *Trifolium pratense* L., *Trifolium repens* L., *Vicia cracca* L. etc., and the lowest participation was specific to the following species: *Festuca pratensis* L., *Carlina acaulis* L., *Hieracium aurantiacum* L., *Polygala vulgaris* L. etc (Fig. 13). The most frequent species out of these types plant community were: *Alchemila vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Vicia cracca* L., and less frequent were: *Agrostis capillaris* L., *Festuca rubra* L., *Trifolium pratensis* L. etc. (Fig. 14).

The plant community of the *Trisetum flavescens* L. type (20 and 30 t ha^{-1} manure) had in its structure, besides the most dominant species, the following: *Alchemilla vulgaris* L., *Centaurea pseudophrygia* C. A. Mey., *Pimpinella major* L., *Trifolium pratense* L., *Veronica chamaedrys* L., *Vicia cracca* L., and the ones with the poorest share were: *Carlina acaulis* L., *Festuca pratensis* L., *Prunella vulgaris* L., *Ranunculus bulbosus* L., *Rhinanthus minor* L. etc. (Fig 15). The most frequent species within this type were: *Agrostis capillaris* L., *Veronica chamaedrys* L., *Vicia cracca* L., and least frequent were: *Gymnadenia conopsea* L., *Leontodon autumnalis* L., *Lotus corniculatus* L., *Luzula multiflora* Ehrh., *Prunella vulgaris* L. etc. (Fig. 16).

Administrating organic fertilizers caused some changes in the plant diversity level. Control plant community was represented in average by 29.75% species that slightly rised at 10 t ha^{-1} manure application (*Festuca rubra* L.- *Trisetum flavescens* L. grassland type), after which they were reduce at the treatment with 20 and 30 t ha^{-1} manure (*Trisetum flavescens* L. grassland type) down to 26.75. This evolution of the species number did not show statistical insurance, thus the results cannot be

Table 3. The effect of mineral fertilization upon the plant diversity.

Biodiversity index	Treatments			
	Control F.r-A.c	50N 25P 25K F.r-T.f	100N 50P 50K A.c-T.f	150N 75P 75K A.c-T.f
Specie's number	34	30.75^{0}	25^{000}	24.25^{000}
Shannon Index	2.58	2.37^{ns}	2.12^{00}	1.86^{000}

T-treatments, Fr-Ac= *Festuca rubra* L.- *Agrostis capillaris* L., F.r-T.f = *Festuca rubra* L.- *Trisetum flavescens* L., A.c-T.f= *Agrostis capillaris* L. - *Trisetum flavescens* L., ^{0}= $p<0.05$, ^{00}= $p<0.01$, ^{000}=$p<0.001$, ^{ns} not significant

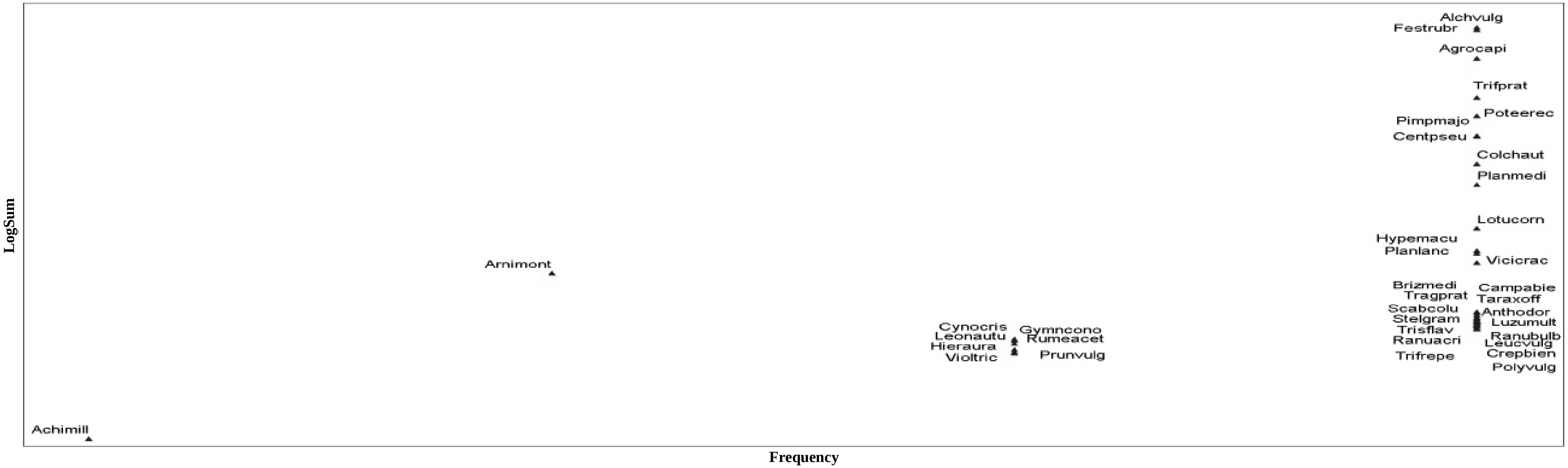

Figure 5. Species abundance in *Festuca rubra* L.-*Trisetum flavescens* L. grassland (treatment with 50N 25P 25K, Rankabund = Rank abundance of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2)

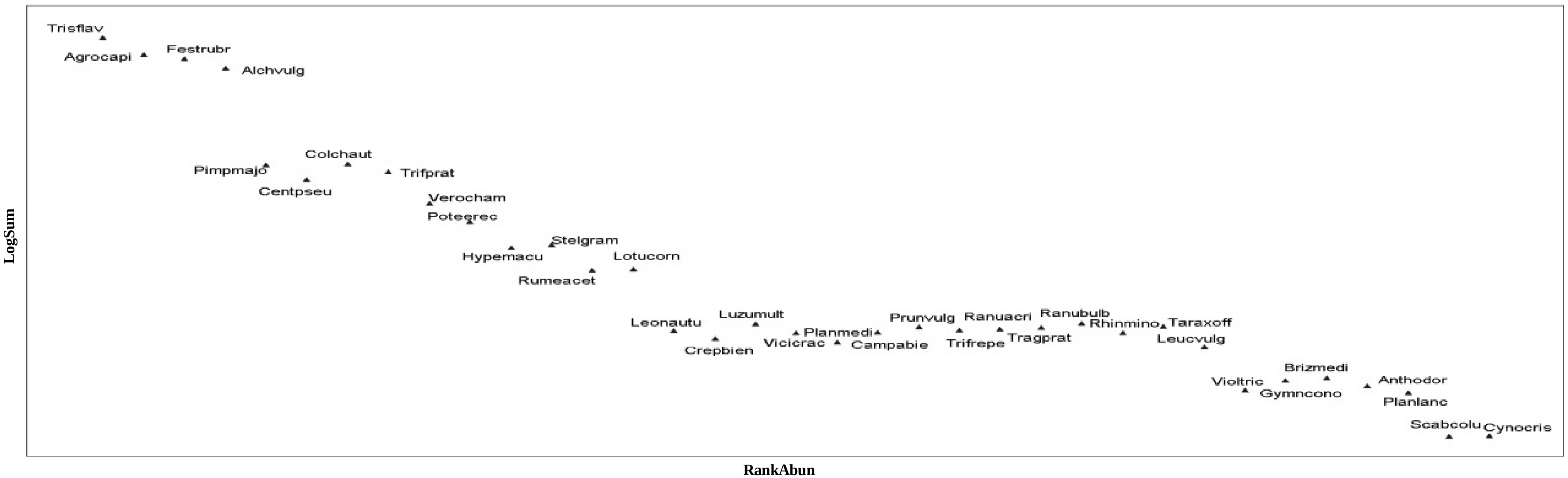

Figure 6. Species frequency in *Festuca rubra* L.-*Trisetum flavescens* L grassland (treatment with 50N 25P 25K, Freq = Frequency of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

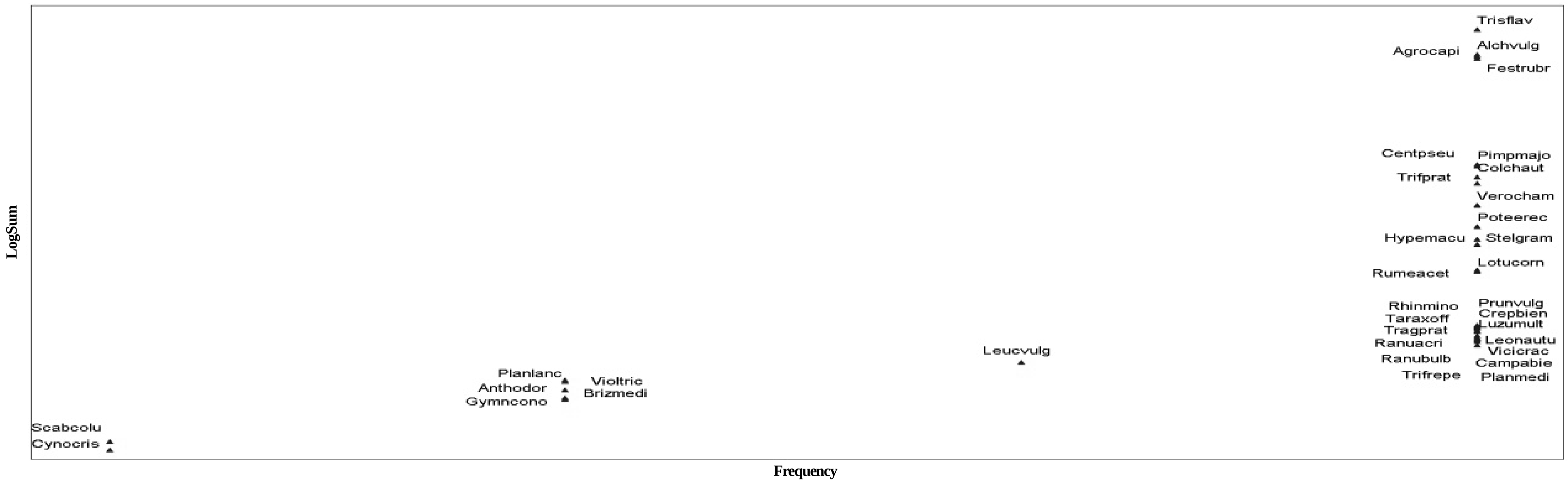

Figure 7. Species abundance in *Agrostis capillaris* L.- *Trisetum flavescens* L. grassland (treatments with 100N 50P 50K and 150N 75P 75K, Rankabund = Rank abundance of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

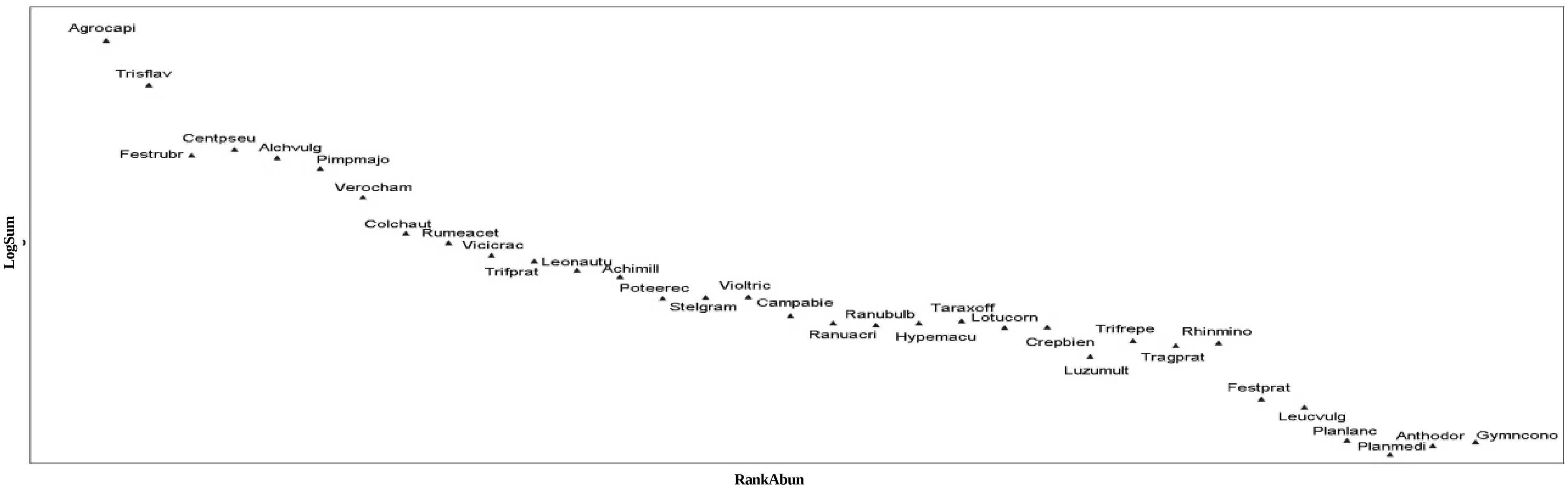

Figure 8. Species frequency in *Agrostis capillaris* L.- *Trisetum flavescens* L. grassland (treatments with 100N 50P 50K and 150N 75P 75K, Freq = Frequency of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

confided. If the Shannon Index was to be analysed, it was noticed that at control this was 2.26 and increases up to 2.62 at the treatment with 10 t ha^{-1} manure (*Festuca rubra* L. - *Trisetum flavescens* L. grassland type, $p<0.001$). Increasing the manure quantity up to 20 t ha^{-1} produced a slight increase of the Shannon Index, but with no statistical insurance ($p>0.05$). The treatment with 30 t ha^{-1} manure generated a rise of the Shannon Index up to 2.43 ($p<0.05$; Table 6), with significant statistical insurance. Similar results were obtained for an *Agrostis capillaris* L. grassland in the Moldavian region (Romania), where administrating organic fertilizers caused a slight increase of the species number [24].

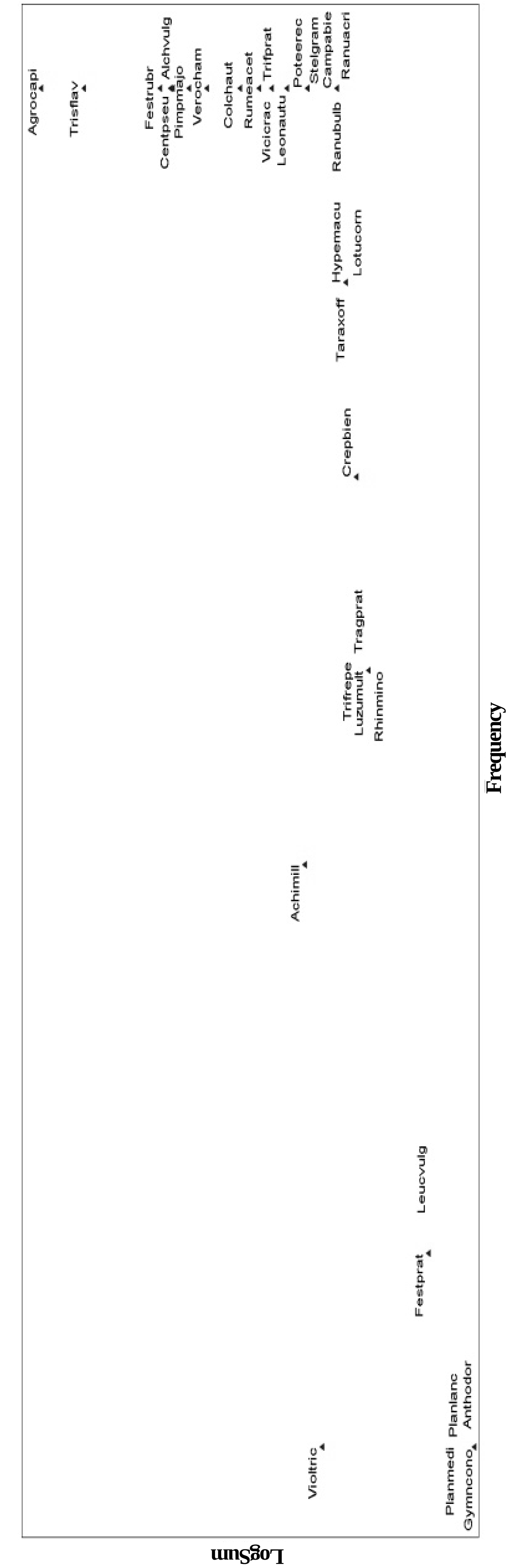

Figure. 9. Ordination of floristic composition depending on the organic treatments (T-treatments, T_1- control, T_2-10 t ha^{-1} manure, T_3- 20 t ha^{-1} manure, T_4-30 t ha^{-1} manure, R-replication).

Conclusions

The mineral and organic fertilizers administration on the *Festuca rubra* L. - *Agrostis capillaris* L. grassland type produced important changes within the sward depending on the applied treatments. Administrating 50N25P 25K and 10 t ha^{-1} manure generated the installation of *Festuca rubra* L. - *Agrostis capillaris* L. grassland type. The treatments with 100N50P50K and 150N75P 75K caused the occurrence of *Agrostis capillaris* L. - *Trisetum flavescens* L. grassland type, whereas the administration of 20 and 30 t ha^{-1} manure produced the installation of *Trisetum flavescens* L. grassland type. Administrating 50N 25P25K mineral fertilizers did not produce any major changes in the sward, whereas 100N 50P 50K and 150N 75P 75K led to a significant decrease of the plant diversity. Administrating organic fertilizers induced plant diversity growth, especially at the treatment with 10 t ha^{-1} manure. For future management actions that are meant to maintain the plant diversity in Apuseni Mountains, the organic fertilization with 10 t ha^{-1} manure quantities annually administrated or once at two years is recommended first of all, and, secondly, the fertilization with 50N25P25K performed annually or once at two years.

Acknowledgments

This research was performed under PN II IDEI, code 1501 financed by CNCSIS and POSDRU/89/1.5/S/62371 financed by the European Community.

References

[1]Hopkins, A. 2011. Mountainous farming in Europe, Grassland Science in Europe **16**:3-12.

[2]Sanderson, M. A. and Wätzold, F. 2010. Balancing trade-offs in ecosystem and service in grassland management. Grassland Science in Europe **15**:639-648.

[3]Orth, D., Begon, M. and Sabatier, J. 2010. Could the grassland production costs be an argument for biodiversity? Grassland Science in Europe **15**:720-722.

[4]Weigelt A., Vogel, A. and Scherer-Lorenzen, M. 2010. Ecosystem service and functions of biodiversity in grassland. Grassland Science in Europe **15**:649-651.

[5]United Nations 1992. Convention on Biological Diversity. 26 p.

[6]European Environment Agency 2007. Europes Environment: The fourth assessment. EEA-Publications Office, Copenhagen, 452 p.

[7]Bruchmann, I. and Hobohn, C. 2010. Halting the loss of biodiversity: Endemic vascular pants in grasslands of Europe. Grassland Science in Europe **15**:776-778.

[8]Duru, M., Cruz, P., Martin, G. and Theau, J. P. 2010. A method to assess the management of permanent grasslands at farm level. Grassland Science in Europe **15**:788-790.

[9]Rotar, I., Pãcurar, F., Vidican, R. and Morea, A. 2010. The organic-mineral fertilization of *Festuca rubra* L. grassland in Apuseni Mountains.

Romanian Journal of Grassland and Forage Crops. Edn. Academic Press, Cluj Napoca **2**:55-60.
[10]Zarzycki, J. and Misztal, A. 2010. Abandonment of farming practices: Impact on vegetation. Grassland Science in Europe **15**:133-135.
[11]Cŏp, J., Eler, K. and Vidrih, M. 2010. Distinct response of two grassland communities to different management regimes. Grassland Science in Europe **15**:657-659.
[12]Tonn, B. and Briemle, G. 2010. Minimum management intensity for maintaining and improving biodiversity of a mesotrophic semi-natural grassland. Grassland Science in Europe **15**:747-749.
[13]Nettier, B., Dobremez, L., Orsini, M., and Fleury, P. 2010. Practices and motivation of farmers who sign contracts to preserve grassland biodiversity. Grassland Science in Europe **15**:714-715.
[14]Vîntu, V., Samuil, C., Sârbu, C., Saghin, G. and Iacob, T. 2008. The influence of grassland management on biodiversity in the mountainous region of NE Romania. Grassland Science in Europe **13**:183-185.
[15]Fiala, J. 2002. Development of ecological and yield stability of semi-natural frassland by its long-term fertilization and utilization. In Zbornik z medzinarodnej vedeckej konferencie Ekologia travneho porastu VI. Banska Bystrica **10-11.12**:124-137.
[16]Gârda, N. 2010. The Study of Some Mountainous Landscape Elements (with special regard to grasslands ecosystems in Gârda de Sus commune, Apuseni Mountains). Doctoral thesis, USAMV Cluj-Napoca, pp. 224-227.
[17]Morea, A. 2008. Cercetari asupra evolutiei biodiversitatii si productivitatii in pajistile de *Festuca rubra* L. din etajul boreal (cu privire speciala asupra Muntilor Apuseni). Doctoral thesis, USAMV Cluj Napoca. pp. 85-101.
[18]Auch, E. 2006. Überlebensstrategien waldnutzender Familienwirtschaften im Apuseni-Gebirge, Rumänien sustainable Livelihoods Analyse und Handlungsempfehlungen. Schriften aus dem Institut für Forstökonomie der Universität Freiburg, Band 27, Freiburg.
[19]McCune, B. and Grace, J. B. 2002. Analysis of Ecological Communities. MJM Press, pp. 182-218.
[20]Wildi, O. 2010. Data Analysis in Vegetation Ecology. A John Wiley & Sons. Ltd. Publication. pp. 47-50.
[21]Cristea, V., Gafta, D. and Pedrotti, F. 2004. Fitosociologie. Presa Universitarã Clujeanã, Cluj-Napoca.
[22]Tucra, I., Kovacs, A. J., Rosu, Ciubotaru, C. C., Chifu, T., Neacsu, M., Bãrbulescu, C., Cardasol, V., Popovici, D., Simtea, N., Motcã, Gh., Dragu, I. and Spirescu, M. 1987. Principalele tipuri de Pajisti din R.S. România. Bucuresti, pp. 12-34.
[23]Pal, F. J. 2010. Aries Valley grasslands between Lupta and Turda. Cluj University Press, pp. 80-85.
[24]Vîntu, V., Samuil, C., Rotar, I., Moisuc, A. and Razec, I. 2011. Influence of the management on the phytocoenotic biodiversity of some Romanian representative grassland types. Not. Bot. Hort. Agrobot. Cluj **39(1)**:119-125.

Table 4. The pairwise comparison with MRPP (T the t test, A group homogeneity, p the statistical significance).

Treatments	T	A	P
control vs 10 t ha^{-1} manure	-4.04161127	0.27468564	0.00610061
control vs 20 t ha^{-1} manure	-4.10028142	0.44153932	0.00668743
control vs 30 t ha^{-1} manure	-4.27548712	0.46160655	0.00597436
10 t ha^{-1} manure vs 20 t ha^{-1} manure	-2.02769523	0.12006600	0.04461151
10 t ha^{-1} manure vs 30 t ha^{-1} manure	-3.00087974	0.17128965	0.01249794
20 t ha^{-1} manure vs 30 t ha^{-1} manure	0.91097218	0.05960591	0.81752838

Table 5. The floristic structure of the grassland types under the influence of organic inputs (dominant species and economic groups).

		Treatments/Signif.							
		Control	Signif.	10 t ha^{-1} manure	Signif.	20 t ha^{-1} manure	Signif.	30 t ha^{-1} manure	Signif.
	Grassland type	F.r-A.c		F.r-T.f		T.f		T.f	
Dominant and co-dominant species	*Agrostis capillaris* L.	15.94	Mt.	11.25	0	12.81	ns	12.81	ns
	Festuca rubra L.	32.50	Mt.	14.38	00	7.56	000	3.31	000
	Trisetum flavescens L.	1.63	Mt.	12.81	**	20.00	***	16.88	**
Economic groups	Poaceae	51.31	Mt.	39.06	ns	41.38	ns	34.56	0
	Fabaceae	10.75	Mt.	15.38	ns	12.13	ns	15.13	ns
	Cyperacea and Juncaceae	1.06	Mt.	0.38	ns	0.13	ns	0.00	0
	OBF	38.13	Mt.	49.63	ns	60.00	**	61.63	**

Fr - Ac = *Festuca rubra* L.- *Agrostis capillaris* L., F.r - T.f = *Festuca rubra* L. - *Trisetum flavescens* L., T.f = *Trisetum flavescens* L., Mt. = control, *=*p<0.05*, **=*p<0.01*, ***=*p<0.001*, ^{0}=*p<0.05*, ^{00}=*p<0.01*, ^{000}=*p<0.001*, ^{ns} not significant)

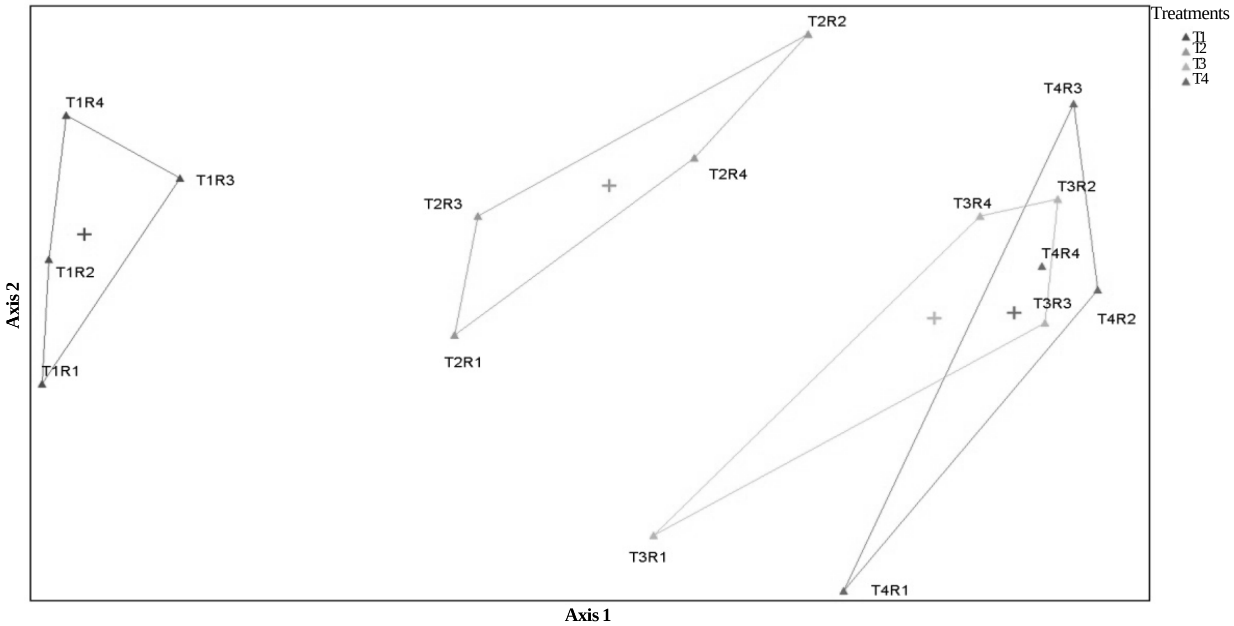

Figure 10. Ordination of floristic composition on types and species depending on the organic treatments (T-treatments, T_1- control, T_2-10 t ha^{-1} manure, T_3- 20 t ha^{-1} manure, T_4-30 t ha^{-1} manure, R-replication, F-grasslands types, F1 = *Festuca rubra* L. *Agrostis capilllaris* L., F2 = *Festuca rubra* L. *Trisetum flavescens* L., F3 = *Trisetum flavescens* L.).

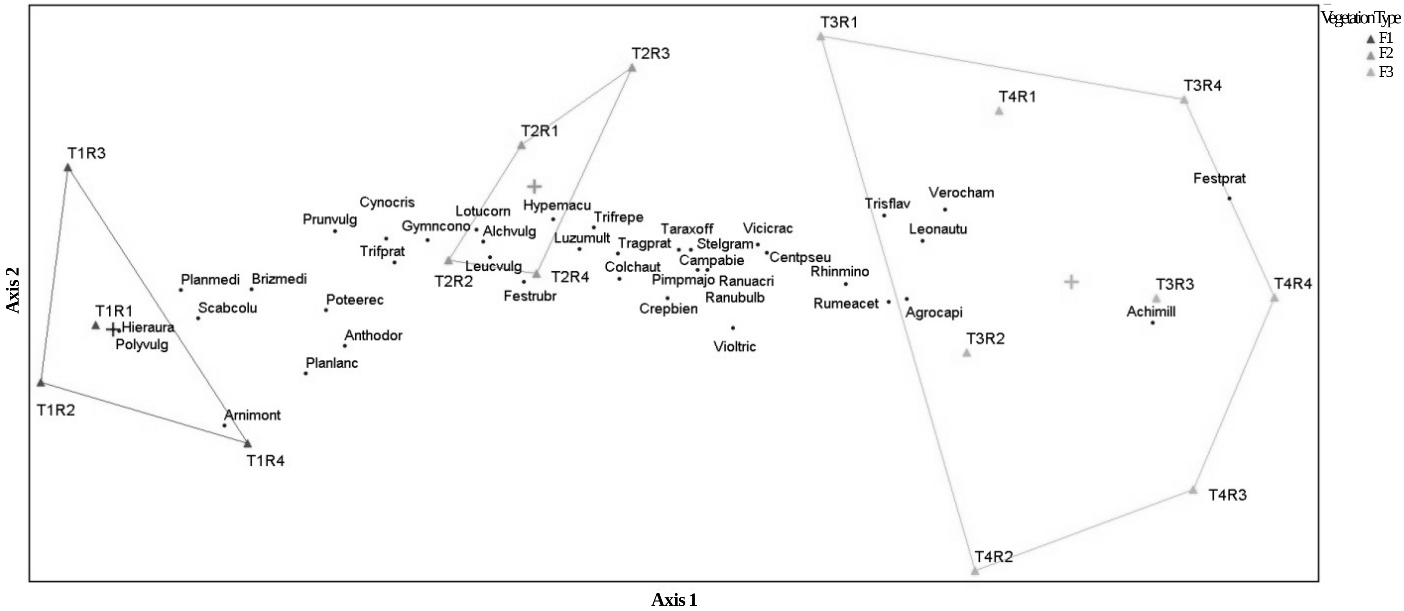

Figure 11. Species abundance in *Festuca rubra* L.-*Agrostis capillaris* L. grassland (control, Rankabund = Rank abundance of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2.

Table 6. The effect of organic fertilization upon the plant diversity.

Biodiversity index	Treatments			
	Control	10 t ha^{-1} manure	20 t ha^{-1} manure	30 t ha^{-1} manure
Specie's number	29,75	33.00^{ns}	28,00^{ns}	26,75^{ns}
Shannon Index	2.26	2.62***	2.37^{ns}	2.43*

T-treatment, Fr-Ac = *Festuca rubra* L.- *Agrostis capillaris* L., F.r-T.f = *Festuca rubra* L.- *Trisetum flavescens* L., T.f = *Trisetum flavescens* L., *=*p<0.05*, **=*p<0.01*, ***=*p<0.001*,^{0}=*p<0.05*, ^{00}=*p<0.01*, ^{000}=*p<0.001*, ^{ns} not significant

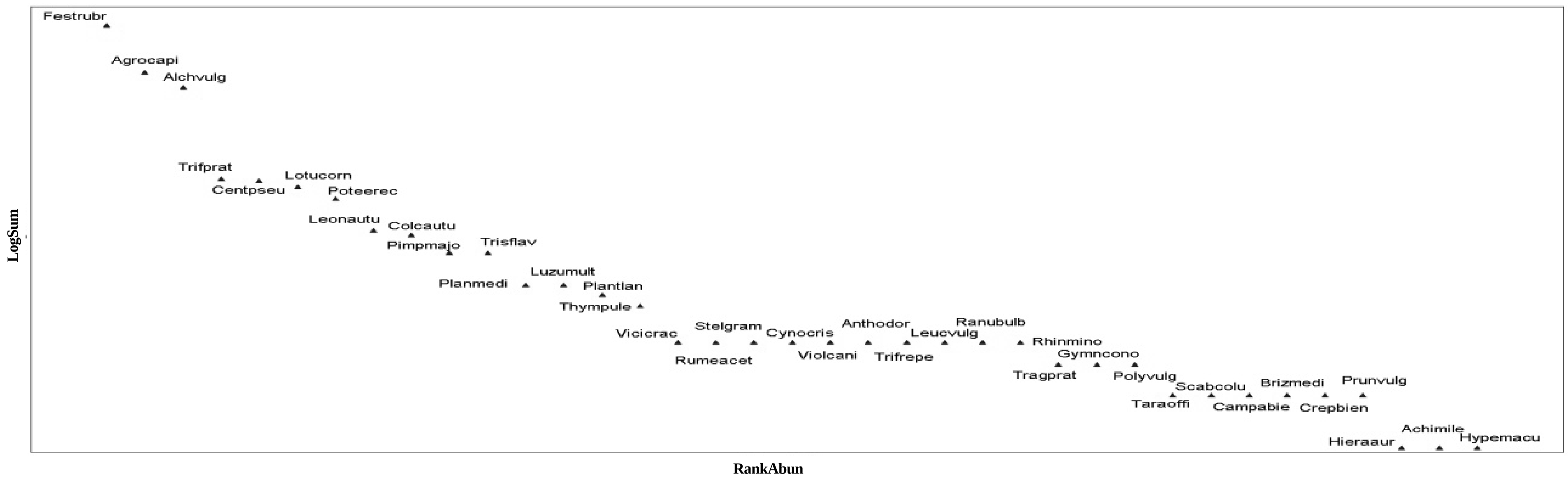

Figure 12. Species frequency in *Festuca rubra* L. - *Agrostis capillaris* L. grassland (control, Freq = Frequency of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

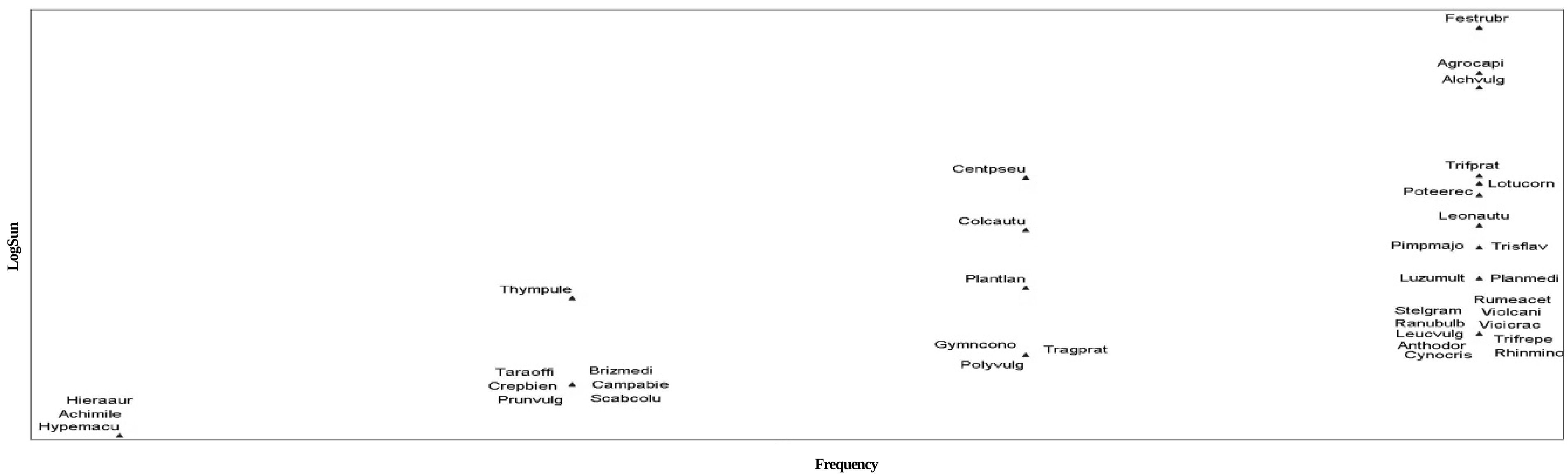

Figure 13. Species abundance in *Festuca rubra L.* - *Trisetum flavescens* L. grassland (treatment with 10 t ha^{-1} manure, Rankabund = Rank abundance of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2.

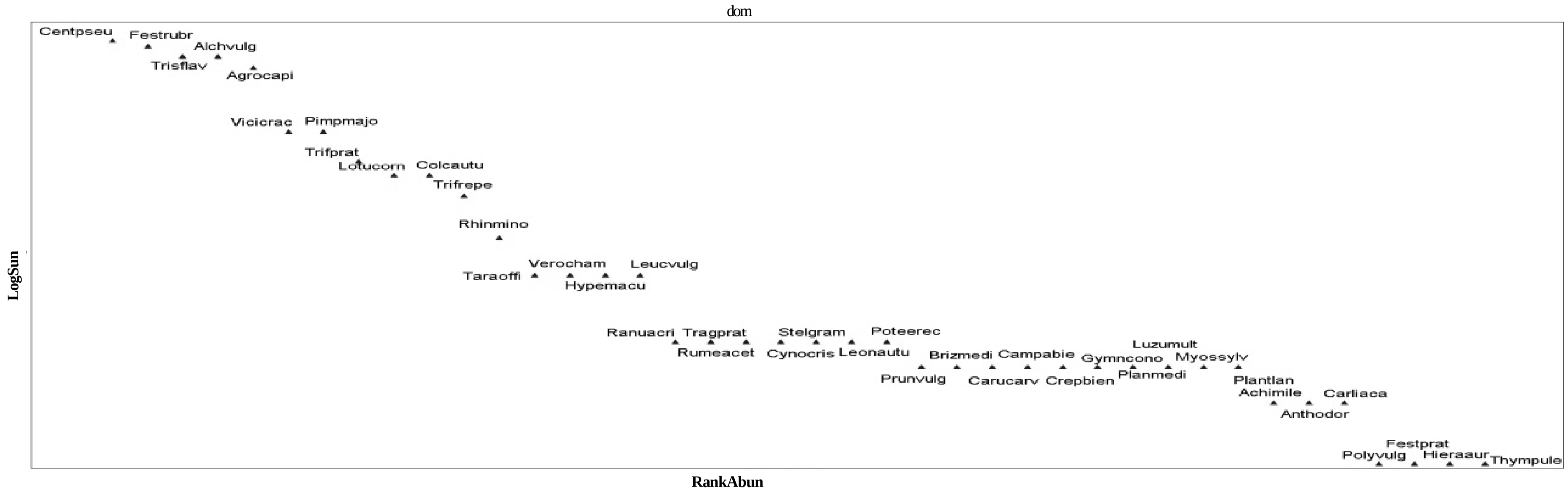

Figure 14. Species frequency in *Festuca rubra* L .- *Trisetum flavescens* L. grassland (treatment with 10 t ha^{-1} manure, Freq = Frequency of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

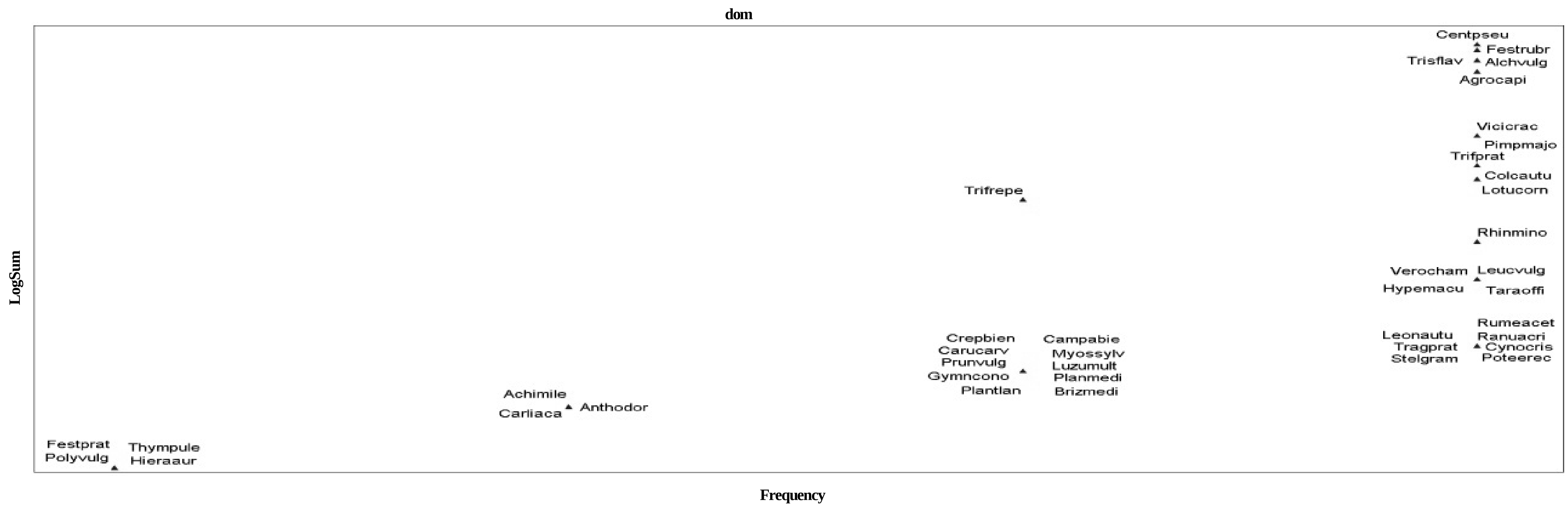

Figure 15. Species abundance in *Trisetum flavescens* L. grassland (treatments with 20 t and 30 t ha^{-1} manure, Rankabund = Rank abundance of the species,Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).

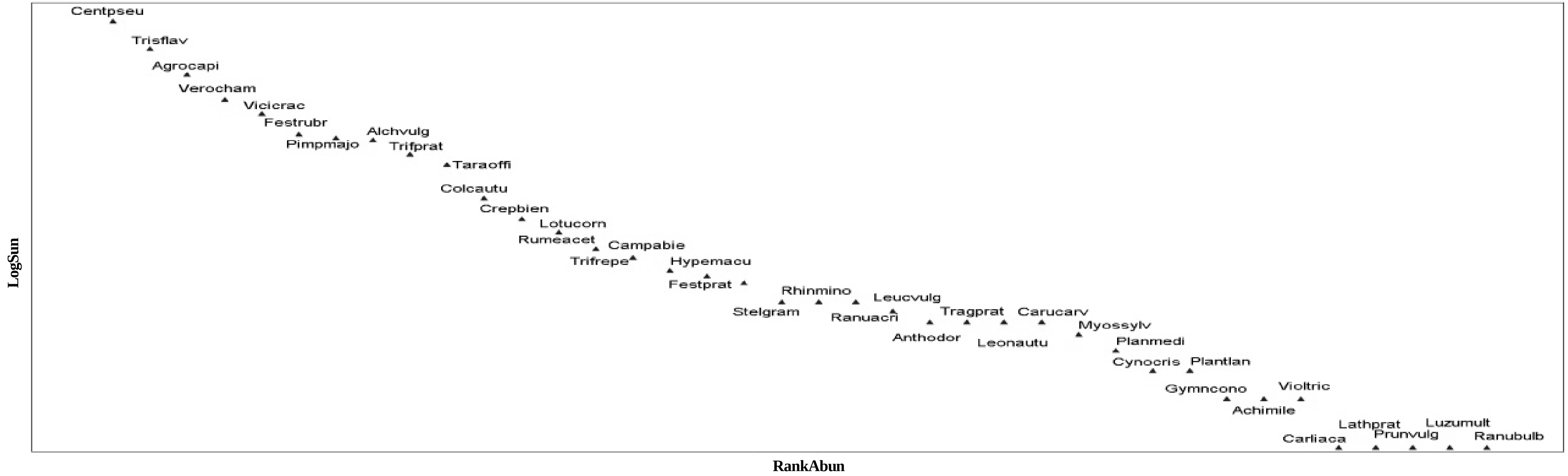

Figure 16. Species frequency in *Trisetum flavescens L.* grassland (treatments with 20 t and 30 t ha^{-1} manure, Freq = Frequency of the species, Logsum = Log base 10 of the species Sum, for species names see legend of Fig. 2).