ANALYSIS OF THE VEGETATION OF EX-ARABLE GRASSLAND FROM PANNONIC PLAIN AREA – WESTERN ROMANIA (CASE STUDY)

Veronica SĂRĂȚEANU[1], Otilia COTUNA[1,2], Carmen Claudia DURĂU[1], D. RECHIȚEAN[2]
[1]Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timişoara, Romania
[2]Station of Agricultural Research and Development Lovrin, Timiş, România
Corresponding author: veronica.sarateanu@gmail.com, cotunaotilia@yahoo.com, sch_carmen_1999@yahoo.com

Abstract. *The abandonment of the arable land is a common phenomenon in Romania mostly in hill and mountain area, but sometimes is present in lowland area on small patches of land or on fields characterised by features that make their cultivation difficult. The succession of the ex-arable land to grassland is very frequent, but the duration of the process is dependent by many variables. The duration of the succession from abandoned arable land to grassland is important in the ecological restoration of these land surfaces, because in this way these fields can provide again ecological and economical services. The purpose of this research is to evaluate an ex-arable grassland surface uncultivated by 7 years for the assessment of the progress of the vegetation succession. The researches were developed on an ex-arable grassland plot from Sacoșu Turcesc, Timiș County abandoned from cultivation since 2012. The plot is bordered on a side by the road, on other side by railroad and on other side by arable land. The vegetation data were collected in 2018. Vegetation surveys were done using the linear point quadrate method [DAGET & POISSONET, 1971]. There was analysed the considering the following aspects: floristic composition based on the main grassland functional groups (grasses, legumes, forbs, rushes and sedges and shrubs and trees); biodiversity (species richness, Shannon index and Simpson index); ecological spectres (phytogeographical elements, life-forms, and indicator values for light, temperature, moisture, soil pH and nitrogen); and typological classification of the vegetation. The results regarding the floristic composition had evidenced a vegetation cover specific for permanent grassland, the perennial grasses being dominant. The results regarding biodiversity were highlighted high values. The structure of the vegetation by biogeographical elements shows high complexity, but the number and contribution of the adventive species was very low, contrary to our expectations. The vegetation structure by life-forms was from far dominated by the hemicryptophyte species, as is in the case of permanent grasslands. The indicator values for nitrogen suggest the former cultivation of the land due to the presence of some species with high and very high demands for this element, but this situation can be found also in the case of eutrophic and even mesotrophic permanent grasslands. The successful and rapid succession process can be associated with the soil seed-bank and to the vicinity of the vegetation stripes from the edge of the road and railroad.*

Keywords*: ex-arable grassland, succession, biogeographical elements, ecological indicator values.*

INTRODUCTION

The importance of the topic comes from the fact that arable land surfaces were remained uncultivated for long time periods that determined the appearance of the of the phenomenon of vegetation succession, this being interesting from scientific and practical point of view, mainly for the development of the ecological restoration works, thus the pieces of information brought by these investigations are very useful.

According with SCHMID *et al.* (2017) ex-arable successional grasslands have a great importance for the conservation of semi-natural grasslands from the point of view of the landscape and grassland species, and can be classified as: Early-successional (the ones abandoned by 5-14 and those abandoned by 15-49 years); Mid-successional (abandoned by 50-279 years); and Late-successional or old (abandoned by more than 280 years).

The researches of BOECKER *et al*., (2015) in Hungary on ex-arable grasslands from the steppe region have highlighted that after 20-40 years the parameters of the soil and vegetation are similar with the ones from permanent grasslands due to spontaneous recolonization with grassland species. Researches developed also in Hungary in Hortobágy National Park highlighted that the spontaneous succession and active restoration was effective for ex-arable grassland vegetation [VALKÓ *et al.,* 2016]. The results obtained by BALÁZS *et al*. (2020), also in Hungary, highlights that the recovery of the ex-arable grassland by succession is slow on the mounds formations there being necessary the application of a proper management. Other researches [KÄMPF *et al*., 2016] applied in Western Siberia on forest steppe ex-arable grasslands highlighted that even after 24 years the grassland wasn't recovered totally doe to the high rate of the ruderal species.

The cultivation of the land affects the biological community from the soil and implicitly the mycorrhizae and endophyte fungi, thus after 30 years of land abandonment (in Netherlands) there was determined a shift of plant associated microbial communities from bacteria dominated ones to fungi dominated ones [HANULA *et al*., 2017]. Some grassland plants species groups as are orchids are restoring more difficult in ex-arable grassland because of the specific mycorrhiza that are missing in long time cultivated land [VOGT-SCHILB *et al.*, 2020]. KULMATISKI *et* BEARD (2018) were found that after 13 years from the abandonment the ex-arable grasslands from shrub-steppe from Washington area (U.S.A.) are poor in species and are dominated by alien short-lived weed species.

Some solutions in the fastening of the succession process were proposing the use of top soil [CARBAJO *et al*., 2011] and hay, and even turf from late successional grasslands rich in species [KARDOL *et al*, 2009]. Other methods proposed for the driving succession in the abandoned fields were using complex seed mixtures [VAN DER PUTTEN *et al.*., 2000]. Researches developed by MARTEINSDÓTTIR (2014) and MARTEINSDÓTTIR *et* ERIKSSON (2014) in Sweden found that local and regional processes are filtering the species from the regional species pool to the local species communities, but this process can be influenced by the age of the species communities and other different species filters that intervene during the succession process.

Other ecological factor than soil that can influence the ex-arable grassland succession is climate. Thus, the increase of the summer drought frequency can influence the successional development of the ex-arable grasslands (MORECROFT *et al*., 2004).

MATERIAL AND METHODS

The purpose of the work is to evaluate a grassland vegetation sward developed on an ex-arable land surface uncultivated by 7 years ago for the assessment of the vegetation succession progress.

The analysed grassland surface is represented by an ex-arable land privately owned that wasn't cultivated from 2012 till to 2018 located in the lowland area of western Romania (Sacoșu Turcesc, Timiș County). One side of the analysed grassland is bordered by to the railroad, other side by road and other by arable land, the plot having a relatively triangular shape.

The altitude of the investigated grassland plot is 94 m a.s.l. and the soil is a lightly alkalised chernozem. The multiannual temperature in the analysed location is 10.9 ºC and the rainfall amount 585.8 mm (climate data from Meteorological Station Timișoara).

Linear point quadrate method [DAGET & POISSONET, 1971 cited by SĂRĂȚEANU *et al.*, 2011a] was applied for the analysis of the vegetation sward. Some of the considered vegetation parameters were the following: floristic composition (grasses, legumes and forbs as species number and specific contribution – CS % considered as coverage rate too) [DAGET & POISSONET, 1971], biodiversity (Shannon index – *H'* and Simpson index *D*) [after BEALS *et al.*, 2000 cited by SĂRĂȚEANU *et al.*, 2011b] and pastoral value – VP (0 – 100 scale) [DAGET & POISSONET, 1971]. The other aspects of the vegetation analysed were the ecological spectres for phytogeographical elements, life-forms [SANDA *et al.*, 1983], and ELLENBERG's (1979) light, temperature, moisture, soil pH and nitrogen indicator values adapted for the Romanian grassland species by KOVACS (1979).

Vegetation was classified considering the typological framing of the Romanian grasslands elaborated by ȚUCRA *et al.* (1987).

RESULTS AND DISCUSSIONS

In the sward of the analysed plot were settled numerous perennial species during the abandonment from cultivation, nowadays they being dominant in the vegetation sward, the general appearance of the analysed plot being as permanent grassland. This was the main reason for the typological characterization of vegetation of the analysed ex-arable grassland. Thus, the typological characterisation [according with ȚUCRA *et al.,* 1987] of the vegetation cover was chosen because it was considered that this system is more suitable to characterize the grassland vegetation community that is a dynamic succeeding and evolving agro-ecosystem, instead of vegetation association classification that is more suitable for the stable ecosystems found in climax stage. According with the European scientists interested in typological approach, this system combines the ecological and agronomical approach in the analysis of the grassland and this being the reason for its considerations as suitable diagnose tool for the grasslands in the context of CAP. The interaction between the ecological and production and management data influences the evolution of the vegetation sward [KRAUSE *et al.*, 2015].

The analysed vegetation is framing from typological point of view in the nemoral zone, subzone of subthermophilus - thermophilus oak forest, series *Poa pratensis* ssp. *angustifolia*, type *P. pratensis* ssp. *angustifolia – Festuca valesiaca* with medium productivity (VP between 25 – 50). This grassland type can be found on chernozems and brown-reddish soils, dry to moderate moist, usually on flat plains.

From the point of view of biodiversity, the analysed successional grassland plot has a high species richness value (S = 76 species). A high biodiversity was characterised by the calculated Shannon index (*H'* = 3.06) too. According with the Simpson dominance index there was determined a low value (D = 0.07) that highlights the presence of a homogenous vegetation with numerous species with similar population sizes.

Taking in consideration the succession stages classification elaborated by SCHMID *et al.*, (2017) the studied ex-arable grassland can be framed in the Early-successional stage, this meaning an arable field abandoned by 5-14. According with the literature the grasslands framing in this category are populated usually by few grassland species. The results obtained in this research are in contradiction with many literature data because after 7 years from the last cultivation, the ex-arable grassland plot contains a great number of species characteristic for grassland. According with SOJNEKOVÁ M. *et* CHYTRÝ M. (2015) the spontaneous succession in ex-arable dry grasslands from Central Europe can be very effective in the condition of the presence in vicinity of the ancient permanent grasslands that act as source for the target species. This condition isn't fulfilled by our ex-arable grassland plot, but the presence in vicinity of a railroad and a road with the specific vegetation stripes from nearby could be the source of grassland species that determinate the rapid succession of the vegetation. Quick succession results (13 years) of ex-arable grassland have been obtained in Slovenia (ČARNI *el al.*, 2007) and in Poland after 5 years from abandonment (SOSNOWSKA, 2018).

Considering the specific contributions of the present taxa from the sward, the most abundant grasses species were the following: *Agropyron repens* (L.) Beauv. (CS% = 16.28%), *Alopecurus pratensis* L. (CS% = 13.02), *Cynodon dactylon* (L.) Pers. (CS% = 7.32%), *Poa pratensis* L. (CS% = 7.32%), *Bromus hordeaceus* L. (CS% = 6.51%), *Bromus sterilis* L. (CS% = 4.88%), *Calamagrostis epigeios* (L.) Roth (CS% = 3.58%) and *Dactylis glomerata* L. (CS% = 3.26%).

The most abundant legumes species as CS% was *Medicago lupulina* L. (CS% = 3.26%), the other species found having a smaller contribution, but they were compensating with numerous species, respectively 11.

Regarding the forbs species, the greatest participation rate in the grassland was determined in the case of *Dipsacus laciniatus* L. with CS% = 6.51%, but most of the species have a low rate, also they compensate with a high number of species, respectively 50.

The shrubs species with the highest contribution were *Rosa canina* L. and *Prunus spinosa* L. both having CS% = 3.26%, the other shrub species determined there were *Cornus sanguinea* L. and *Rubus caesius* L.

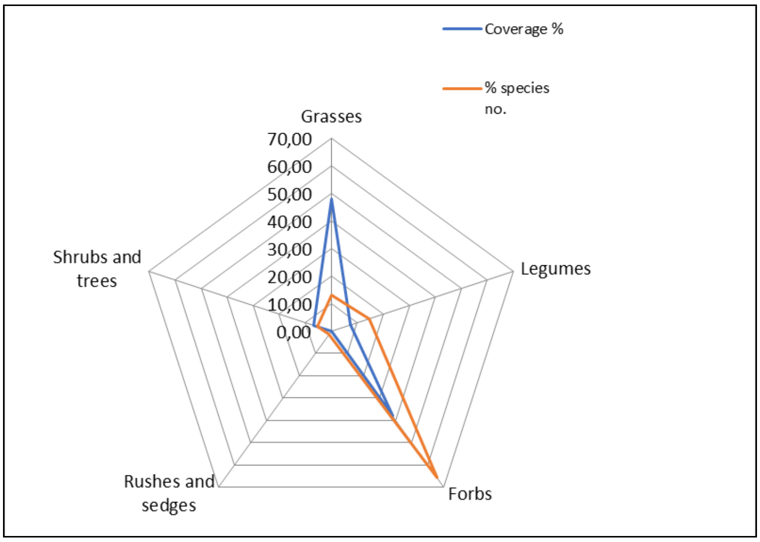

Figure 1. Floristic composition of the ex-arable grassland from Sacoșu Turcesc

The use of biogeographical elements analysis in vegetation research can be helpful in the research of the ecological and historical drivers implied in the distribution of the species [LENORMAND *et al*., 2018]. In Figure 2 is represented the diagram of the phytogeographical elements from the analysed ex-arable grassland plot considering the species number and their contribution rate in the vegetation sward. There were determined 18 phytogeographical elements, the most abundant being the Eurasian ones both as rate of the species numbers (44%) and coverage rate (28.97%). The adventive species rate from the total species number from this plot was very low (2.67%) and their contribution rate too (0.83%) according with our expectations due to the former disturbance by the cultivation of land. The adventive species determined here were *Erigeron anuus* L. (Pers.) and *Helminthoteca echioides* (L.) Holub. The structure of the vegetation according with the phytogeographical elements is highly complex an comprises various elements from Mediterranean (e.g., Eua (Med), Euras (Submedit), Pont-Med, Pont-Med-Eua, Atl-Med, Eur-Med) to circumpolar (e.g., Circ. and Circ (bor)).

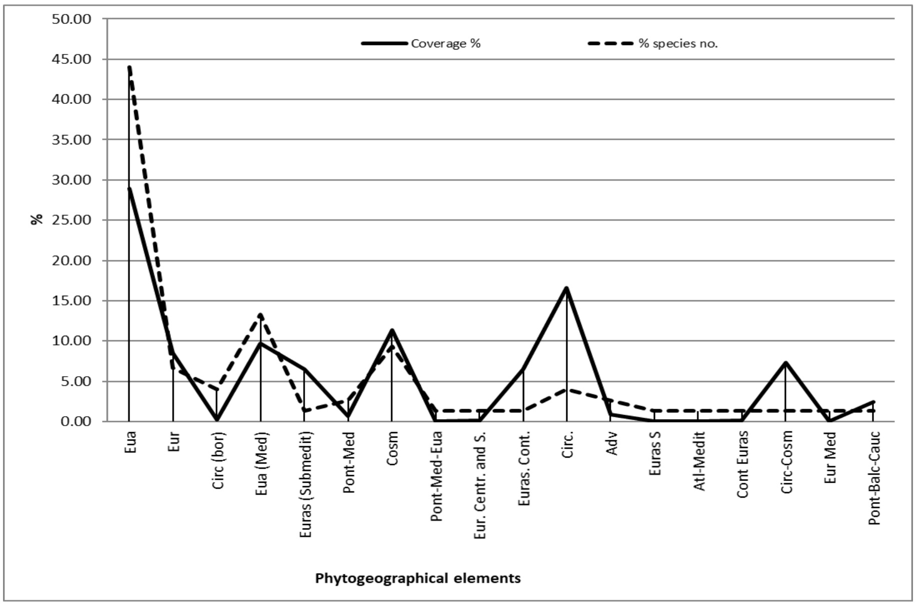

Figure 2. Diagram of the phytogeographical elements of the ex-arable grassland from Sacoșu Turcesc

In Figure 3 is presented the diagram of the Raunkiaer's life-forms [after SANDA *et al.*, 1983] of the analysed successional grassland plot considering the number of species and their contribution rate. From far the most dominant species were the hemicryptophytes (H) both as rate from the total species number (44.74%) and participation rate (34.43%), but there were present numerous other intermediary variants of the hemicryptophytes (e.g., H-Ch, HH-H, (G)H, HH, TH-H, H-TH and T-H), they being represented in general by perennial species. Contrary with our expectations the annual weeds represented by the therophytes (Th) have a relatively low rate from the total species number (13.16%) and a low coverage rate (6.18%) and their variants (T, TH-Th).

The results obtained by ČARNI *el al.* (2007) in Slovenia showed the presence of the hemicryptophyte grasses after 13 years of succession, but our results show the dominance of this life-form from the 7^{th} year of succession. This fact can be attributed to the presence in the vicinity of the analysed plots of the road and railroad adjacent vegetation stripe.

Ellenberg's indicator values (EIV) are considered by BARTELHEIMER *et* POSCHLOD (2015) as numerical system useful for the classification of the habitat niches of the species and their presence along gradients.

The analysis of the Ellenberg's indicator values for light (L) (after KOVACS, 1979) of the analysed grassland plot (Figure 4) highlights the dominance of the species with medium to high demands for light (L7) both as coverage rate (50.78%) and as rate from the total number of species (48.57%) followed by the species with very high demands for light (L8) (coverage % = 23.34; % species no = 27.14). There were present species with extremely high demands for light (L9) and some species with medium demands (L4 and L5) and even a species indifferent for the light intensity (L0) as is *Mentha arvensis* L.

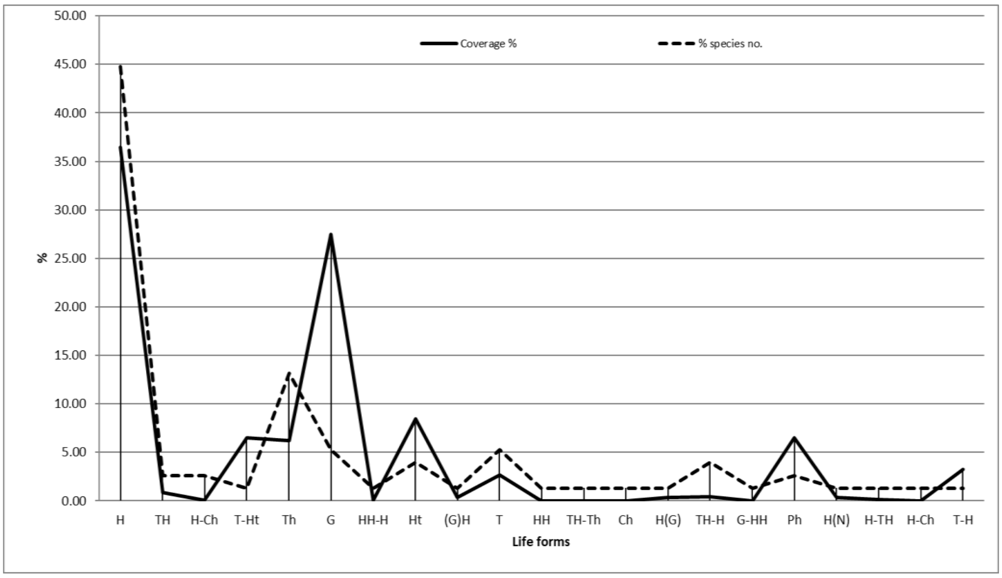

Figure 3. Diagram of the life forms of the ex-arable grassland from Sacoșu Turcesc

Analysing Ellenberg's indicator values for temperature (T) [after KOVACS, 1979] diagram (Figure 5) there was highlighted the dominance of the species indifferent for this ecological factor (T0) both as coverage rate (43.32%) and as rate from the total number of species (39.19%) followed by the moderate thermophilic species (T5) and the species with moderate to high demands for temperature (T6 and T7), there was determined also a highly thermophilic species (T9), respectively *Helminthoteca echioides* (L.).

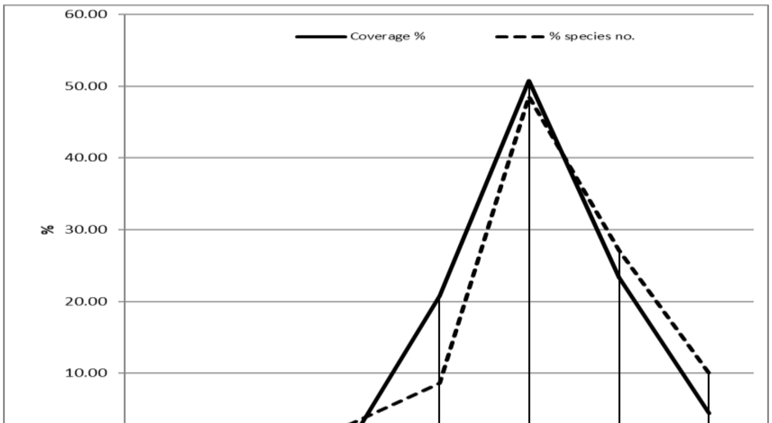

Figure 4. Diagram of the light indicator values of the ex-arable grassland from Sacoșu Turcesc

In Figure 6 is represented the diagram with Ellenberg's indicator values for moisture (U) (after KOVACS, 1979) for the analysed successional grassland from Sacoșu Turcesc. The species from the sward have various demands there being found species that fit to almost all U values of the 0-9 scale, but the highest coverage rate had the mesophytes (U5), respectively 37.47%, and the highest number of species rate had the low xero-mesophytes (U4), respectively 27.03%. A relatively high coverage rate (43.32%) and high rate from the total number of species (39.19%) was determined in the case of the species indifferent for the temperature factor (T0).

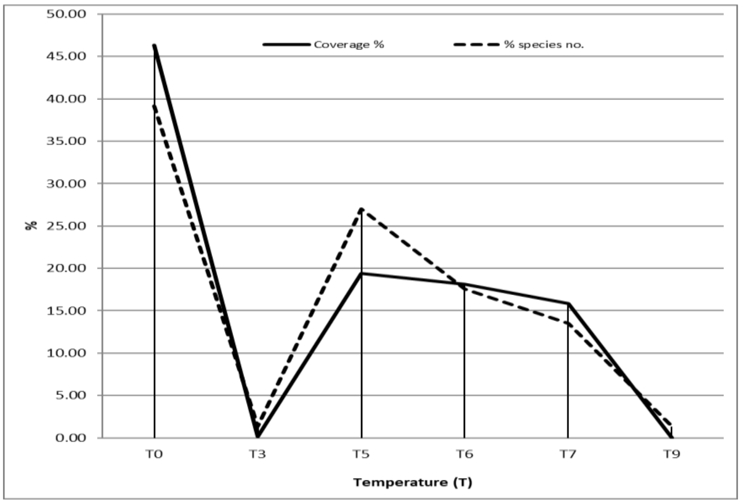

Figure 5. Diagram of the temperature indicator values of the ex-arable grassland from Sacoșu Turcesc

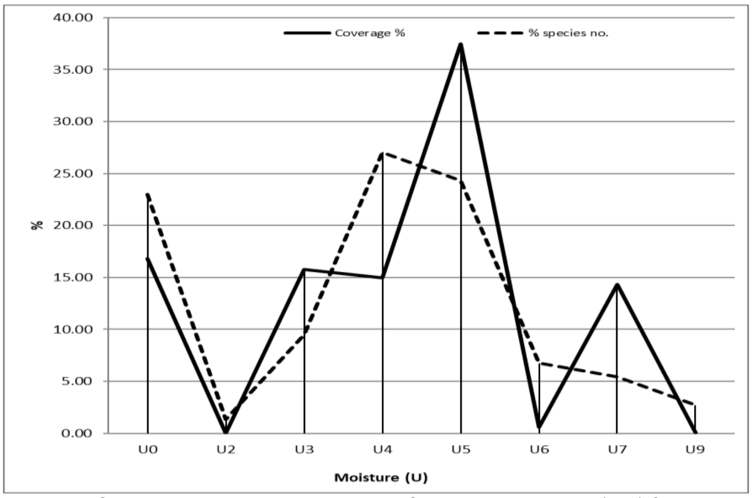

Figure 6. Diagram of the moisture indicator values of the ex-arable grassland from Sacoșu Turcesc

The demands the soil reaction (R) of the vegetation of the analysed ex-arable grassland (Figure 7) show that most of the plant species are indifferent for this ecological factor (R0) both as coverage rate (76.60 %) and as rate from the total species number (58.11 %), these species being followed by the ones with demands for low alkaline soils (R7) and for alkaline soil (R8).

Regarding the demands of the species from the analysed ex-arable grassland for the soil nitrogen supply (N), they can be characterised according with the Figure 8. The nitrogen demands of the species from the sward for nitrogen are very different, but the most abundant are the ones indifferent for this factor (N0) as rate from the total species number (30.43%) and as coverage rate (26.63%). Due to the former cultivation, there were relatively abundant the species with high nitrogen demands (N7) and very high nitrogen demands (N8) as coverage rates, there being found also nitrophilous species (N9) as *Arctium lappa* L., *Lamium album* L. and *Rubus caesius* L.; the situation can be worse from this point of view in a eutrophic grassland due to the chronic fertilisation [Hautier *et al*., 2014]. In the same time there were found species with low (N1, N2 and N3) and moderate (N4, N5 and N6) demands for nitrogen.

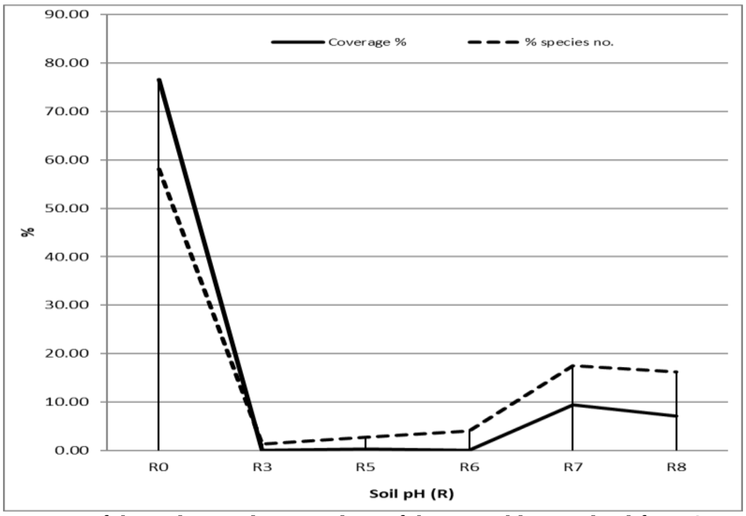

Figure 7. Diagram of the soil pH indicator values of the ex-arable grassland from Sacoșu Turcesc

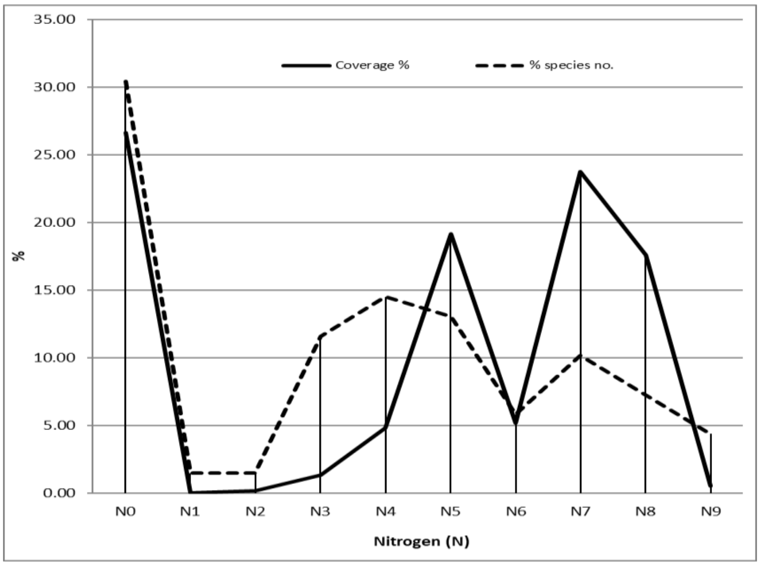

Figure 8. Diagram of the soil nitrogen indicator values of the ex-arable grassland from Sacoșu Turcesc

Pastoral value (VP) determined on a 0 – 100 scale was 37.24 being characteristic for a grassland vegetation sward with low to medium forager value, and is framing in the typological characterisation interval of VP comprised in the interval 25 – 50 [according with ŢUCRA *et al.*, 1987] for this grassland type. Our results are confirmed by other researches from literature [FRACCHIOLLA *et al.*, 2017] that mention the increase of the pastoral value from the early years of abandonment of the cultivate land.

CONCLUSIONS

Analysis of the floristic composition had highlighted a vegetation cover characteristic for a grassland dominated by perennial grasses. Also, there were identified many leguminous species. The biodiversity of the analysed ex-arable grassland from Sacoşu Turcesc is high, the sward being populated with numerous species with similar population effectives. The vegetation structure is very complex from the point of view of the biogeographical elements, but the number and coverage rate of the adventive and invasive species was very low. According with the analysis of the life-forms spectre the vegetation sward is dominated clearly by the hemicryptophytes, this aspect being typical for permanent grasslands. The former cultivation of the land is reflected mostly in the structure of the vegetation from the point of view of the presence of the species with high indicator values for nitrogen, but this situation can be found in eutrophic and mesotrophic permanent grasslands due to the excessive fertilisation or due to the vicinity to highly fertilised cropland. The regeneration of the vegetation sward after abandonment from cultivation is due to the soil seed-bank and the vegetation stripes that border the railroad and road, they being determinant for the formation of a grassland vegetation dominated by perennial species at a very short time interval from the abandonment.

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*** - Meteorological Station Timișoara.