

ON THE GROWTH AND DEVELOPMENT PROCESS OF GRASS MIXTURES AND LEGUMES FOR RIPARIAN GRASSLAND RENOVATION

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Abstract

The availability of solar radiation is a key environmental factor in the development of plant species, the intensity and regime of light being important for plant morphology and production, directly influencing the dominant species during a certain period of a season. To study the development of vegetation in riparian grasslands, 36 experimental plots were established. The experiment was located in Mogoșești village, Dragomirești commune, Dâmbovița county, approximately 1 km from the Dâmbovița river, where the environmental conditions are similar to the areas occupied with grasslands near the Dâmbovița River. Two variants were considered: fertilized and unfertilized. The plots were sown with various varieties, combined, of Medicago Sativa, Lotus Corniculatus, Lolium, Festuca, Poa, etc. Vegetative growth was good, including on some plots in the unfertilized lot; however, in the absence of fertilization and deficiencies in the microelements necessary for plant development, the vegetation in the unfertilized plots showed lower LAI values, and lower density, and lower quantities of dry matter.

Key words: leaf area, quantitative analysis, crop growth, development stages, fertilization.

INTRODUCTION

In the field of grassland sciences, to address the new challenges arising from climate change and increasingly significant human disturbances, an increasing number of studies have been conducted on topics such as biodiversity conservation, grassland restoration, as well as the sustainable use and management of grassland resources and the enhancement of their multifunctional role (Bărbulescu et al., 1991; Culicov et al., 2024; Wang et al., 2025). In his long-term study (from 1900-), Zhao (2023) showed that ecology and environment-related topics such as biodiversity conservation, land use and soil erosion, climate change, and paleoenvironment have developed rapidly. The increase in the ranking of biodiversity conservation during the study period was the fastest. The ranking of technology-related topics such as remote sensing and numerical modeling has also increased in recent decades. The place of traditional themes (e.g., biological nitrogen fixation, grazing, plant nutrition, germplasm and

reproduction, fodder cultivation, and animal production) has recorded a sharp decrease. The assessment of the resilience of meadows and pastures depends on a good understanding of the interactions of environmental factors, the type and properties of vegetation, and anthropogenic activity (Merengo et al., 2025). Vegetation has spontaneously settled on the vast majority of riparian grasslands without direct human intervention, and consequently, it has a diverse characteristic also due to the dynamic nature of ecopedoclimatic conditions. It presents seasonal fluctuations in terms of floristic composition, which generates varied aspects during the vegetation season, depending on the phenology of the component species (Dunea et al., 2021; Vîntu et al., 2024). The bibliographic study using the resources of the Clarivate Web of Science database (bibliographic analysis carried out in April 2023) showed that the field of study of riparian grasslands is increasingly being approached. Using the syntax “*riparian grassland*” in search, yielded 1231 articles, of which 4 are in the highly cited category.

Generally, these articles mainly refer to the interaction of land use/cover (LULC) with water pollution levels or other environmental processes. For a more specific search, the term riparian grassland canopy was used, yielding 91 articles (88 articles, 8 proceedings, 1 chapter, and 1 review article). Finally, the phrase that generally characterizes the objectives of the present study was used, namely “*riparian grassland canopy growth and development*”. The search results summarized in a single article that referred to a poplar plantation regarding the management of growth factors. For this reason, the addressed topic regarding the study of the agronomic potential of riparian grasslands presents perspectives in terms of the originality of the subject and the involvement of modern technologies for monitoring and modeling the growth and development of the specific vegetation cover of these important agro-ecosystems for biodiversity conservation, carbon storage and socioeconomic support of rural communities. Riparian grasslands are a special type of grassland that exists in the transition zone between terrestrial (land-based) ecosystems and aquatic (water-based) ecosystems like rivers, streams, lakes, and wetlands. These areas have a unique combination of characteristics due to their proximity to surface waters, making them distinct from the drier upland grasslands. Key characteristics of riparian grasslands can be summarized as: a higher soil moisture content compared to adjacent uplands, influenced by the nearby water body and potentially by seasonal flooding or a higher water table, a potentially higher fertility of the soils in riparian areas - they are often alluvial, being formed from sediments deposited by the adjacent water (such soils can be very fertile and may have different textures and drainage properties compared to upland soils), a greater diversity of plant species than upland grasslands (existence of a mix of grasses adapted to moist conditions, sedges, bullrushes, and various herbaceous plants from other botanical species; in some cases, they might even have scattered shrubs or trees, blurring the line with riparian woodlands or shrublands), a denser vegetation (typically more lush and dense due to the increased water availability), a proper microclimate (riparian areas tend to be cooler and shadier than adjacent uplands due to the

proximity to water and the often denser vegetation; this creates a unique microclimate that influences the types of plants and animals that can thrive there).

The riparian grasslands significantly contribute to biodiversity conservation by offering a habitat for various plant and animal species, while also impacting soil stability and the hydrological cycle (Dincă and Dunea, 2018; Yang et al., 2019). These grasslands are vital in protecting aquatic ecosystems, as they act as buffers against eutrophication caused by agricultural activities. By filtering and reducing pollutants like phosphorus and nitrogen, riparian grasslands help prevent water quality degradation having the potential to safeguard the aquatic environments (Dunea et al., 2019; Dunea et al., 2021). Additionally, riparian grasslands are important for carbon storage, aiding in climate change mitigation and creating a favorable microclimate for nearby areas (Wang et al., 2025).

In this complex context, the current study examined the growth and development of various grasses and legumes suitable for riparian grasslands under fertilization while all plots received equal conditions in terms of humidity. The research assesses the impact of these plant species on biodiversity, biomass productivity, and soil stability, considering their effects on water retention and nutrient use efficiency. The study also explores the adaptability of the tested species to the dynamic conditions of riparian microclimatic conditions and their ecological interactions, aiming to identify the optimal combinations for improving fodder quality and maintaining long-term soil fertility (Musat et al., 2023). In a previous study (Dincă et al., 2023), we presented the forage yield and chemical composition of the material collected from the tested variants, both in unfertilized and fertilized conditions.

These approaches promote sustainable development and ensure the productivity of riparian grasslands with minimal human intervention.

MATERIALS AND METHODS

Study Site Description and Experimental Design

The current results were obtained from field experiments performed on plots near Dambovită

River riparian area in Dragomiresti village (Lat. N44°53'7.40", Long. E 25°24'6.89"). The full description of the methodology including field preparations and operations, and plots monitoring were presented in Dincă et al. (2023). A total of 36 experimental plots was arranged in 6 randomized blocks, 3 fertilized and 3 unfertilized with 3 repetitions ($6 \times 2 \times 3$) (Table 1 and Figure 1).

Table 1 Species used for field experimental trials

Species	Percentage (%)
V1	
<i>Medicago sativa</i> -Valahia variety	100%
V2	
<i>Medicago sativa</i> - Pomposa variety	100%
V3	
<i>Lotus corniculatus</i> - Leo variety	100%
V4	
<i>Lolium perenne</i> 1	45%
<i>Festuca rubra</i>	25%
<i>Lolium perenne</i> 2	30%
V5	
<i>Festuca arundinacea</i> - Variety 1	37%
<i>Poa pratensis</i>	9%
<i>Lolium perenne</i>	9%
<i>Festuca arundinacea</i> - Variety 2	37%
<i>Festuca arundinacea</i> - Variety 3	8%
V6	
<i>Festuca rubra</i> - Adio	10%
<i>Lolium perenne</i> - Solen	25%
<i>Lolium perenne</i> - Nira	10%
<i>Lolium perenne</i> - Pinia	5%
<i>Poa pratensis</i> - Appalachian	8%
<i>Festuca arundinacea</i> - Rendition	3.90%
<i>Festuca arundinacea</i> - Kora	1.10%
<i>Lolium multiflorum</i> - Kajana	4.60%
<i>Lolium multiflorum</i> - Mowestra	32.40%

For the monitoring of environmental factors, soil moisture, and rainfall regime, the automatic DeltaLink GP2 data acquisition (Delta-T Devices, Cambridge, UK) system was used. It was equipped with soil moisture sensors and a rain gauge for precipitation measurements (Figure 2).

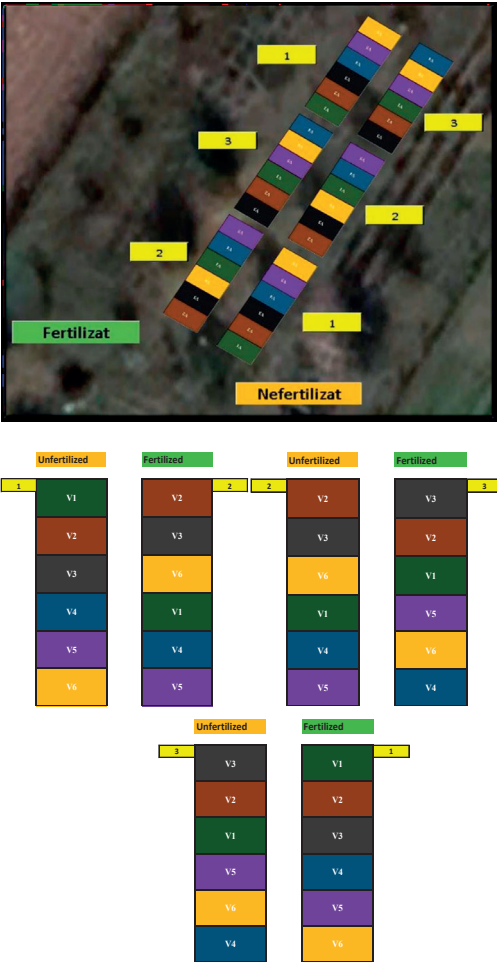


Figure 1. The spatial arrangement of the experiment



Figure 2. Soil moisture sensor and rain gauge

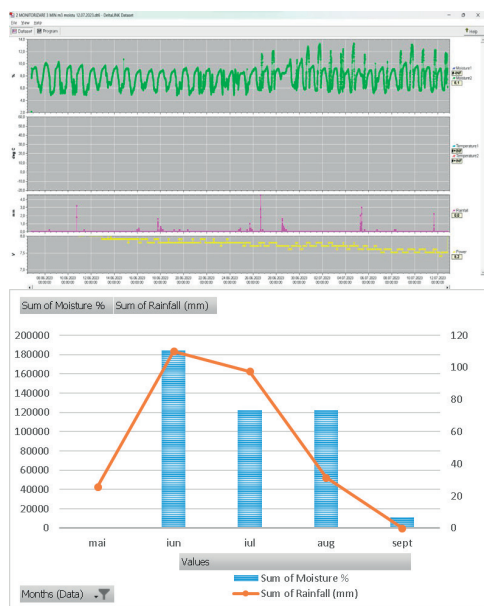


Figure 3. DeltaLINK 3.9 Data acquisition interface and the results of field microclimate monitoring (soil moisture and precipitations)



Figure 4. Height measurements of the uniform and mixed canopies and biomass sampling

Figure 3 presents the soil moisture and precipitation regime during the vegetative growth period. Samplings of biomass and height measurements were performed several times during the

vegetation season, respectively at each cutting cycle (Figure 4).

Leaf area index was measured with a Delta-T Devices SS1 SunScan System that included the SunScan Probe and the BF5 Reference PAR Sensor that was placed outside the canopies. The probe has 64 PAR (Photosynthetically Active Radiation) sensors, connected via RS-232 cable to a Trimble PDA device (<https://delta-t.co.uk/product/sunscan/>).

The system measures photosynthetically active solar radiation, automatically calculating the LAI based on the PAR fluxes ratio and providing precise information about how vegetation intercepts direct and diffuse light (Figure 5).

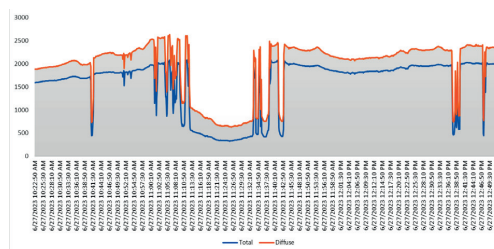


Figure 5. PAR total and PAR diffuse amounts ($\mu\text{mol m}^{-2} \text{s}^{-1}$) recorded during the sampling performed in 27.06.2023 in the experimental field

In this paper, we present the results obtained at the first cutting cycle performed on 27 June 2023, in the first year of cropping.

The microclimate conditions recorded at the time of measurements were as follows:

- PAR radiation: $1060 \mu\text{mol/m}^2 \cdot \text{s}$, 891 W/m^2 ;
- Wind speed: 2.7 m/s ;
- Atmospheric temperature: 34.2°C ;
- Atmospheric humidity: 49% ;
- Soil temperature: 24°C .

RESULTS AND DISCUSSIONS

The application of one level of fertilization (120 g m^{-2}) in each variant i.e., 16% (N) total nitrogen, 4.7% (N) nitric nitrogen, 11.3% (N) ammoniacal nitrogen, 5.2% (P_2O_5) phosphorus pentaoxide soluble in neutral ammonium citrate solution and water, 3.4% (P_2O_5) soluble phosphorus pentaoxide, 5.2% (K_2O) soluble potassium oxide, 3% (MgO) total magnesium oxide, 26% (SO_3) total sulfur trioxide, 4% (Fe)

total iron provided the increasing of the measured canopy indicators mostly in each tested variant showing benefits to the growth and development of the canopies.

Canopy height

Clear differences were noted between the fertilized and unfertilized variants, with the fertilized ones having higher heights of the canopy in each variant (Figure 6).

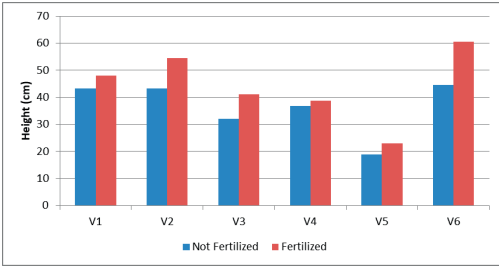


Figure 6. Averaged height measurements (in cm) of the uniform and mixed canopies in the not-fertilized and fertilized variants at the first cutting cycle

Dry matter accumulation

The accumulated dry matter was significantly higher in the fertilized variants compared to the non-fertilized ones, highlighting the benefits of

fertilization, except in *Lotus corniculatus* (V3), which showed a decrease (Figure 7).

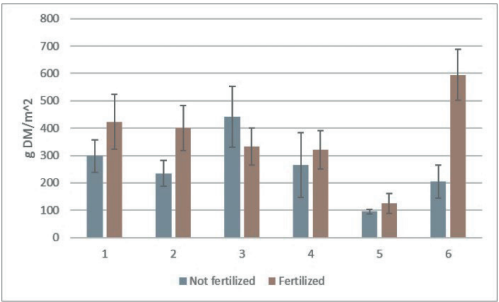


Figure 7. Averaged Dry Matter (DM) accumulation in each tested variant (g DM m⁻²)

Leaf area index

The LAI index indicated that the fertilized variants had a greater ability to intercept light and consequently an increased photosynthetic efficiency. LAI is a vital metric of the growth and development of plant species because it reflects several important aspects of a plant canopy. Therefore, the more leaves a plant has, the higher its LAI, and vice versa. This directly affects the plant's ability to photosynthesize, as leaves are the primary sites where sunlight is captured and converted into energy (Figure 8).

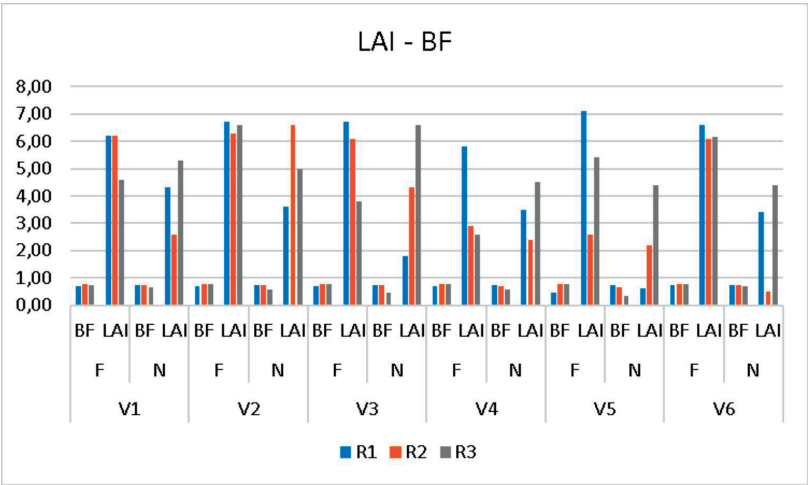


Figure 8. Comparative graph of the LAI (Leaf Area Index) and BF (Beam Fraction) values for the unfertilized (N) and fertilized (F) variants – V1-V6 = number of variant

On the other hand, a high LAI indicates a dense canopy with many overlapping leaves. Conversely, a low LAI suggests a sparse canopy with more gaps between leaves. Canopy density

influences how much sunlight reaches the ground and how much water is intercepted by the leaves (Filip et al., 2024). Overall, the best results in terms of the canopy benefits were

obtained by V1, V2 (alfalfa varieties), and V6 (complex grass mixtures) variants, especially in fertilized conditions.

CONCLUSIONS

By measuring LAI, researchers and growers can gain valuable insights into plant health, growth, and ecosystem functioning. The presented results demonstrate that fertilization significantly influences the development and productivity of grass and legume mixtures, except the bird's-foot trefoil. The data obtained indicate that the application of an optimal fertilization regime significantly improves plant height, biomass, and leaf area index (LAI), fundamental aspects for maintaining a productive and balanced ecosystem. These findings are also supported by the literature (Monteith and Unsworth, 2013), which emphasizes the importance of a high LAI in intercepting active photosynthetic radiation and increasing dry matter yield.

The study confirms the clear benefits of fertilization on vegetation development in riparian grasslands, highlighting both ecological and economic advantages. Increasing plant density contributes to reducing soil erosion, improving water retention capacity, and stimulating beneficial interactions between grass and legume species. These results will provide essential data for the development of effective management strategies, contributing to the formulation of sustainable practices for farmers, authorities, and specialists in the field of environmental protection and regenerative agriculture. Further work will consider the utilization of a mixture between V1, V2, and V6 in different proportions of participation in real riparian grassland conditions.

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