

THE INFLUENCE OF FERTILIZATION ON THE DRY MATTER YIELD OF *FESTUCA RUPICOLA* GRASSLAND

Ioana GHEȚE, Ioan ROTAR, Florin PĂCURAR, Roxana VIDICAN, Anca PLEȘA, Ioan
GAGA

*Faculty of Agriculture. Department of Plant Crops. University of Agricultural Sciences and
Veterinary Medicine Cluj-Napoca, Manăstur street, 3-5, 400372, Romania.

*Corresponding author, e-mail: ioan.rotar@usamvcluj.ro

Abstract

Sown (temporary) grasslands are valuable agricultural crops due to the high yield of dry matter they achieve, but equally to the quality of the fodder obtained. In the present paper, we aimed to study the influence of organic and mineral fertilization on dry matter yield on a *Festuca rupicola* type of grassland from Turda, Cluj County. To answer the objectives of this research, an experience with 6 experimental variants, in four repetitions (blocks), was installed. The productivity of *Festuca rupicola*'s grassland increases proportionally as increases the amounts of fertilizers applied. We recommend a management plan which should contain adequate maintenance and a system of sustainable use and fertilization.

Keywords: Turda, productivity, *Festuca rupicola*'s grassland, fertilization, organic input

INTRODUCTION

Cultivated grass and leguminous species that are treated as agricultural crops benefit from free ecological niches, which makes their productivity under conditions of high trophicity remarkable.

In the competitive hierarchy of semi-dry grasslands, monocotyledonous species such as grasses are stronger competitors than forbs (PARTZSCH *et. al*, 2018).

More frequent and severe drought events are expected to have a negative impact on herbage

production and fodder quality of permanent grassland (HOFFSTÄTTER-MÜNCHBERG *et al.*, 2011). As man-made habitats, nutrient-poor dry grasslands harbor numerous species whose original habitats (floodplains, peatlands, and rocky outcrops) have been largely destroyed (BAUR, 2004).

Festuca taxa are important grassland species in the Pannonian vegetation, and they are a dominant component of the Pannonian vegetation where conditions are too extreme (FURÉSZ *et. al*, 2022

The Transylvanian Depression is famous for its extensive grasslands of various types, most of which have been used traditionally, until now, being manually mowed or extensively grazed (LOOS *et. al*, 2021).

MATERIAL AND METHOD

Our experiment was designed according to the method of randomized blocks, in four repetitions (blocks), with 6 experimental variants. The type of grassland was *Festuca rupicola*, and the area of an experimental plot was 20 m² (Figure 1). The experimental variants were the following: V1-control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Fertilization of the experimental variants was carried out in each experimental year (ie: the springs of 2018, 2019, 2020, 2021). Both mineral fertilizers and manure were applied annually at the optimal time. Biomass was harvested from each experimental variant with a mower (BCS 630 WS mower). The mowing height was 4 cm above the ground. Biomass harvesting was carried out only once a year at the optimal mowing time. The experiments were located on the surface of some grasslands at the Turda Agricultural Research and Development Station (ARDS Turda). The experiments were

Regarding these, we established to study the influence of organic and mineral fertilization on dry matter yield on a *Festuca rupicola* type of grassland from Turda, Cluj County, Romania.

located at an altitude of 398 m (according to the data taken with GPS GARIN GASPAM 66S), having the following coordinates: 46° 35' 15.0" N 23° 57' 49.3" E.

The experiments were carried out on an argiloiluvial chernozem soil type that has a sequence of Am-Bty-C horizons. In 2017, before the start of the experiments, a description of the soil profile was carried out and physico-chemical data were collected. The analyzes were carried out by the Office of Pedological and Agrochemical Studies in Cluj-Napoca, supported by colleagues from ARDS Turda.

The experimental data on the productivity of the grassland for each experimental year were processed with the analysis of variance, which is a statistical-mathematical method of processing the obtained data. Analysis of variance allows the simultaneous study of the variability of several experimental variants. This method presents an economic efficiency for experimentation, as it allows the identification of significant effects between variants, based on a small number of measurements. The

processing of these data was carried out with the PoliFact program.



Fig. 1 Protocol of the experiment with organic and mineral fertilizers
(V- fertilization variant; R-replication)

RESULTS AND DISCUSSIONS

As part of our experience, it was aimed to increase the yield of dry matter (DM) by applying organic and mineral fertilizers, experienced in the nemoral zone - the Transylvanian Plain on a type of *Festuca rupicola* grassland. The DM harvest of semi-natural grassland and especially of this type of grassland is different from one site to another, being between 2 and 13 t/ha⁻¹ DM (ELSASSER, 2004). As expected, since the first year (2018), the effect of organic and mineral fertilizers on the dry matter harvest can be observed, through the yield increases achieved by the

fertilized variants, compared to the control variant.

In the first year, the highest dry matter harvest, compared to the control, is obtained in the case of the variant with 10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀, of 3.58 t/ha⁻¹ DM (150.5%), and the weakest in the variant with 10 t/ha⁻¹ manure, of 2.53 t/ha⁻¹ (106.3%; table 1).

In the variant with 10 t/ha⁻¹ manure, the difference in yield compared to the control is insignificant, on the other hand, in the case of the variants V4 with N₅₀P₂₅K₂₅, V5 (N₁₀₀P₅₀K₅₀) and V6 (10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀) the differences are statistically ensured.

The effect of manure on the DM harvest is minimal in the first year and maximal in the second year, after which it gradually decreases, a fact observed over time by numerous researchers in this field (VÎNTU, *et. al.*, 2011, SAMUIL *et. al.*, 2017, MOTCĂ, 1978 etc.).

The productivity of *Festuca rupicola* grassland was low to medium which can support a grazing capacity between 0.4-0.6 LU/ha, according to specialized studies in this field (ROTAR *et al.*, 2010). The productive potential of this type of grassland varies

according to ecological factors, season (altitude, state of supply with mineral elements, etc.), floristic composition and applied management (especially fertilization-PORQUEDDU *et al.*, 2008).

The assignment of an agronomic value to each plant entity in grassland (genus, species, subspecies) may be relevant for some studies that aim to evaluate the productive potential of semi-natural grassland (ROGERRO *et al.*, 2002).

Table 1

The influence of fertilizers on dry matter harvest, year 2018

Variant	t/ha ⁻¹	%	Difference	Significance
V1	2.38	100.0	0.00	Mt.
V2	2.53	106.3	0.15	-
V3	2.60	109.5	0.22	-
V4	2.70	113.7	0.33	*
V5	2.83	118.9	0.45	**
V6	3.58	150.5	1.20	***
DL (p 5%) 0.24		DL (p 1%) 0.33		DL (p 0.1%) 0.46

Legend: V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 2

The yield differences among variants and their significance

Variations in increasing order of harvest	Dry matter harvest t/ha ⁻¹	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		t/ha ⁻¹				
		2.53	2.60	2.70	2.83	3.57
V 1	2.38	0.15	0.22	0.33	0.45	1.20
V 2	2.53		0.07	0.18	0.30	1.05
V 3	2.60			0.10	0.23	0.97
V 4	2.70				0.13	0.87
V5	2.83					0.75
V6	3.57					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 3

The yield differences among variants and their significance

The error of the means $SX = 0,08(t/ha^{-1})$					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.24	0.25	0.26	0.27	0.27

It is known that manure has a staggered effect in more years. Between the application of $10 t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$ and $10 t/ha^{-1}$ manure + $N_{100}P_{50}K_{50}$ a significant difference of $0.98 t/ha^{-1}$ DM is noticed. In the variants treated with organic and mineral fertilizers, the harvest is primarily due to the mineral fertilizers and, to a small extent, the organic ones.

In the second year of experiment (2019) the highest harvest of DM ($3.95 t/ha^{-1}$ DM) is achieved by the application of $10 t/ha^{-1}$ manure + $N_{100}P_{50}K_{50}$, with an additional harvest of $1.75 t/ha^{-1}$ DM, compared to the untreated variant, statistically very significant difference (table 4). The minimum increase compared to the control is registered when applying $10 t/ha^{-1}$ manure (126.1%), where the difference of $0.58 t/ha^{-1}$ is very significant. The dry matter harvest noticed in the variants with $10 t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$ ($2.88 t/ha^{-1}$ DM) is achieved on account of the mineral fertilizers applied as well as the manure applied one year later. These variants achieved a significant harvest of DM, a fact also confirmed by ROTAR *et al.* (2003), who state that organo-

mineral fertilization, in moderate doses, considerably increases the yield of DM.

The high level of the harvest is the result of the applied treatments, but also largely of the climatic conditions, which were very favourable for the growth of the grass in 2019. In a study carried out by SAMUIL *et al.*, in 2010, the productions obtained show that the chemical fertilizers applied $N_{200}P_{100} kg/ha^{-1}$ to a mixture consisting of *Medicago sativa* with a participation percentage of 70% and *Dactylis glomerata* 30% can be obtained a harvest of $11.66 t/ha^{-1}$ DM.

Thus, in the second experimental year (2019) all the experimental variants register increases in production compared to the control ($p > 0.05$). The highest increase in production is recorded in variant V6 where $10 t/ha^{-1}$ manure + $N_{100}P_{50}K_{50}$ was applied (179.5 %), followed by variants V5 ($N_{100}P_{50}K_{50}$) and V3 ($10 t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$).

Results similar to ours were also obtained by PĂCURAR in 2005, during an experiment with organic fertilizers on the Ghețari, Apuseni Mountains, when he showed that in the second year the

dry matter harvest increases simultaneously with the increase the manure amount from 2.70 t/ha⁻¹ DM (semi-natural grassland) to 7.74 t/ha⁻¹ DM (at variant fertilized with 30 t/ha⁻¹ manure), increases ensured from a statistical point of view.

The comparative analysis using the Duncan test at the level of 2019, with the analysis of the

overlap of the experimental treatments over the climatic conditions, shows the beneficial effect of the inputs applied with manure in combination with mineral fertilization (V6-10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀) compared to the control variant (V1), the observed differences being statistically significant (table 5 and 6).

Table 4

The influence of fertilizers on dry matter harvest, year 2019

Variant	t/ha ⁻¹	%	Difference	Significance
V1	2.20	100.0	0.00	Mt.
V2	2.78	126.1	0.58	***
V3	2.88	130.7	0.68	***
V4	2.73	123.9	0.53	***
V5	3.08	139.8	0.88	***
V6	3.95	179.5	1.75	***

DL (p 5%) 0.24;

DL (p 1%) 0.34;

DL (p 0.1%) 0.46

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 5

The yield differences among variants and their significance, year 2019

Variations in increasing order of harvest	DM t/ha ⁻¹	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		DM t/ha ⁻¹				
		2.72	2.78	2.88	3.07	3.95
V 1	2.20	0.53	0.58	0.68	0.88	1.75
V 2	2.72		0.05	0.15	0.35	1.23
V 3	2.78			0.10	0.30	1.18
V 4	2.88				0.20	1.08
V 5	3.07					0.88
V 6	3.95					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 6

The values of significance difference for the various limits of the comparison between variants, year 2019

The error of the means SX == 0,08(t/ha)					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.25	0.25	0.26	0.27	0.27

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Numerous research from our country and beyond, show that the application of mineral fertilizers causes increases in yield on all types of semi-natural grassland (VIDICAN and ROTAR, 2003; VÎNTU *et al.*, 2011; MARUȘCA *et al.*, 2014). Nitrogen is the most important element that, depending on the dose, significantly influences the DM harvest (PĂCURAR, 2005). Phosphorus applied alone causes small increases in yield (BĂRBULESCU *et al.*, 1982). In general, phosphorus fertilizers increase yields, but applied in moderate doses of 50 – 60 kg/ha⁻¹ P₂O₅ and combined with nitrogen-based fertilizers.

In the third experimental year (2020), all the yield increases from the treated variants are significant compared to the control variant. The application of both mineral and organic fertilizers caused minor changes in the dry matter yield (table 7, 8 and 9) compared to the second experimental year. The highest yield is registered with the variant V6-10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀ with a difference of 1.10 t/ha⁻¹, compared to the control (p<0.05). In the other treatments, even if there is an increase in the DM harvest, this does not present statistical assurance (p>0.05).

Table 7

The influence of fertilizers on dry matter harvest, year 2020

Variant	t/ha ⁻¹	%	Difference	Significance
V1	3.00	100.0	0.00	Mt.
V2	3.00	100.0	0.00	-
V3	3.08	102.5	0.08	-
V4	2.78	92.5	-0.22	-
V5	3.30	110.0	0.30	-
V6	4.10	136.7	1.10	***

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 8

The yield differences among variants and their significance, year 2020

Variations in increasing order of harvest	Dry matter harvest t/ha ⁻¹	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		SU t/ha				
		3.00	3.00	3.08	3.30	4.10
V 1	2.78	0.22	0.22	0.30	0.52	1.33
V 2	3.00		0.00	0.08	0.30	1.10
V 3	3.00			0.08	0.30	1.10
V 4	3.08				0.22	1.03
V5	3.30					0.80
V6	4.10					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 9

The values of significance difference for the various limits of the comparison between variants, year 2020

The error of the means $SX = 0.08(t/ha)$					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.36	0.38	0.39	0.39	0.40

In the fourth year of experience (2021) on the *Festuca rupicola* type of grassland, the results obtained highlight significant yield increases when mineral fertilizers are applied. As can be seen from Table 10, in 2021 the application of the dose of $10\ t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$ determined significant harvest increases, an aspect that highlights the high production potential of this

type of grassland in case which meets optimal pedo-climatic conditions for development (Table 11,12).

In the variant V5 fertilized only with mineral inputs ($N_{100}P_{50}K_{50}$), it shows a difference of $0.55\ t/ha^{-1}$ DM compared to the control and it is ensured from a statistical point of view.

Table 10

The influence of fertilizers on dry matter harvest, year 2021

Variant	t/ha^{-1}	%	Difference	Significance
V1	3.03	100.0	0.00	Mt.
V2	3.13	103.3	0.10	-
V3	3.38	111.6	0.35	*
V4	3.21	109.3	0.23	*
V5	3.58	118.2	0.55	**
V6	4.23	139.7	1.20	***

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha^{-1} organic manure; V3-10 t/ha^{-1} organic manure + $N_{50}P_{25}K_{25}$; V4- $N_{50}P_{25}K_{25}$; V5- $N_{100}P_{50}K_{50}$; V6-10 t/ha^{-1} organic manure + $N_{100}P_{50}K_{50}$.

Table 11

The yield differences among variants and their significance, year 2021

Variations in increasing order of harvest	Dry matter harvest t/ha^{-1}	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		DM t/ha^{-1}				
		3.03	3.13	3.38	3.57	4.23
V 1	2.80	0.23	0.33	0.58	0.77	1.43
V 2	3.03		0.10	0.35	0.55	1.20
V 3	3.13			0.25	0.45	1.10
V 4	3.38				0.20	0.85
V 5	3.57					0.65
V 6	4.23					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha^{-1} organic manure; V3-10 t/ha^{-1} organic manure + $N_{50}P_{25}K_{25}$; V4- $N_{50}P_{25}K_{25}$; V5- $N_{100}P_{50}K_{50}$; V6-10 t/ha^{-1} organic manure + $N_{100}P_{50}K_{50}$.

Table 12

The values of significance difference for the various limits of the comparison between variants, year 2021

The error of the means SX = 0.11(t/ha)					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.32	0.33	0.34	0.35	0.35

Regarding the analysis of the dry matter harvest over the entire experimental period (2018-2021), the difference in harvest determined by the application of mineral and organic inputs are, in general, statistically ensured, making only the treatment with mineral fertilization in the dose of N₅₀P₂₅K₂₅, when achieves a difference of only 0.10 t/ha⁻¹ DM and which does not present statistical assurance (table 13,14 and 15). The maximum level of harvest achieved in the variants with high doses of fertilizers is much higher

compared to that noticed in the control variant and presents distinctly significant statistical assurance.

We could thus state that the reaction of the phytocenosis to the application of organic and mineral inputs depends on the climatic conditions of a year and the physical-chemical properties of the soil. The utilization of mineral fertilizers on the type of *Festuca rupicola* grassland is very different from one year to another, depending on the climatic conditions recorded.

Table 13

The influence of fertilizers on DM,the average of the years 2018 - 2021

Variant	t/ha ⁻¹	%	Difference	Significance
V1	2.65	100.0	0.00	Mt.
V2	2.85	107.5	0.20	-
V3	2.98	112.3	0.32	**
V4	2.75	103.8	0.10	-
V5	3.18	119.8	0.53	***
V6	3.95	149.1	1.30	***

DL (p 5%) 0.32;

DL (p 1%) 0.44;

DL (p 0.1%) 0.61

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 14

The yield differences among variants and their significance, the average of the years 2018 - 2021

Variations in increasing order of harvest	dry matter harvest t/ha	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		SU t/ha				
		2.75	2.85	2.97	3.18	3.95
V 1	2.65	0.10	0.20	0.32	0.53	1.30

V 2	2.75		0.10	0.22	0.43	1.20
V 3	2.85			0.13	0.33	1.10
V 4	2.97				0.20	0.97
V5	3.18					0.77
V6	3.95					

Table 15

The values of significance difference for the various limits of the comparison between variants, the average of the years 2018 - 2021

The error of the means $SX = 0.07(t/ha)$					
Distance in classification	2	3	4	5	6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.21	0.22	0.22	0.23	0.23

CONCLUSIONS

The productivity of *Festuca rupicola*'s grassland increases proportionally as increase the amounts of fertilizers applied.

In the first experimental year (2018), the highest dry matter harvest, compared to the control, is obtained in the case of the variant with 10 t/ha^{-1} manure + $N_{100}P_{50}K_{50}$ of 3.58 t/ha^{-1} DM (150.5 %).

In the second experimental year (2019) all the experimental variants recorded increases in production compared to the control ($p > 0.05$). The highest increase in production is recorded in variant V6 where 10 t/ha^{-1} manure + $N_{100}P_{50}K_{50}$ (179.5 %) was applied, followed by variants V5 ($N_{100}P_{50}K_{50}$) and V3 (10 t/ha^{-1} manure + $N_{50}P_{25}K_{25}$).

In the third experimental year (2020), all the yield increases from

the treated variants are significant compared to the control variant.

In the fourth year of experience (2021) on the type of *Festuca rupicola* type of grassland, the results obtained highlight significant yield increases when mineral fertilizers are applied.

Regarding the analysis of the dry matter harvest over the entire experimental period (2018-2021), the difference in harvest determined by the application of mineral and organic inputs are, in general, ensured statistically except for the treatment with mineral fertilization in the dose of $N_{100}P_{50}K_{50}$, when achieves a difference of only 0.10 t/ha^{-1} DM and which does not present statistical assurance.

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