

POSSIBILITIES TO IMPROVE THE PERMANENT GRASSLANDS OF *Dichanthium ischaemum* (L.) Roberty FROM THE MOLDAVIAN FOREST STEPPE

Adrian-Ilie NAZARE¹, Mihai STAVARACHE² Costel SAMUIL¹, Vasile VÎNTU¹

email: adrian.nazare@uaiasi.ro

Abstract

The enhancement of permanent meadows involves conducting complex research, in order to know the limiting factors in the optimal development of vegetation, specific improvement measures to be taken to increase production capacity, feed quality and grazing capacity. The quantity and quality of the vegetation of the permanent meadows are largely conditioned by the characters of the seasonal conditions, to which are added the anthropogenic influences through the exploitation system. The objectives of this study were to highlight the influence of harvesting phenophase and fertilization with mineral or organic fertilizers on the productivity and quality of the forage, with important implications for obtaining high quality forage, depending on the type of fertilizer and the size of application doses. The experience field was organized on a permanent grassland of *Dichanthium ischaemum* (L.) Roberty, in Andrieșeni locality, Iași county, framed between the parallels 47°30'45.2"N and 27°15'42.0" E. The experimental factors were represented by the harvesting phenophase, with three graduations: a₁-harvesting at plants height of 15-18 cm, a₂-harvesting at the ear formation (control), a₃-harvesting to full flowering and fertilization with seven graduations: b₁- unfertilized (control), b₂- N₅₀P₅₀ kg/ha⁻¹ annually, b₃- N₇₅P₇₅ kg/ha⁻¹ annually, b₄- N₁₀₀P₁₀₀ kg/ha⁻¹ annually, b₅-10 t/ha⁻¹ sheep manure annually, b₆-20 t/ha⁻¹ annually and b₇-30 t/ha⁻¹ annually sheep manure applied at two years. From the results obtained on the *Dichanthium ischaemum* meadow, it was found that its productivity is very low, and the level of dry matter production can increase considerably depending on the harvesting phenophase and the fertilization used. The harvesting phenophase and the applied fertilization had a marked influence on the quality of the fodder obtained from this type derived from meadows, materialized by changes in the chemical composition with implications on the value of use

Key words: permanent grasslands, harvesting phenophase, organic and mineral fertilization, forage quality, productivity

The very strong influences of the anthropic factor determined a great variability of the meadows, both from the point of view of the floristic composition of the vegetal cover, as well as of the production and quality of the forage.

Dichanthium ischaemum meadows have a wide ecological range and form a type derived from meadows in steppe, forest-steppe and oak forest areas, where certain species, such as *Festuca valesiaca*, *F. rupicola* and *Agrostis capillaris* lose their dominance, being replaced by *Dichanthium ischaemum*, the main cause being excessive grazing (Vîntu V. *et al*, 2004; Samuil C. *et al*, 2019). The application of fertilizers on meadows, regardless of their nature (mineral or organic), determines with the increase of production and the improvement of the main quality indices of the forage (Vîntu V. *et al*, 2008; Samuil C. *et al*, 2008; Yu Y.W. *et al*, 2011; Samuil C. *et al*, 2018). Many

long-term studies report the positive effect of nitrogen fertilization on permanent grasslands, by increasing concentrations of crude protein and crude fat as a result of nitrogen-induced changes in floristic composition and which have significantly contributed to forage quality. (Vîntu V. *et al*, 2011; Delevatii L.M., 2019; Simić A. *et al*, 2020; Mrázková M. *et al*, 2020; Ding G. *et al*, 2021).

The stage of development is an essential factor that determines changes in forage quality, being influenced by the management of forage crops (Adesogan A.T. *et al*, 2009; Baranova A. *et al*, 2019; Reine R. *et al*, 2020).

The forage value of the species is strongly influenced by the stage of their growth when they are harvested or grazed (Ball D.M. *et al*, 2001; Bumb I. *et al*, 2016).

The paper presents the experimental results, from 2020 obtained on a meadow of *Dichanthium*

¹ Iași University of Life Sciences, Romania

² Research and Development Station of Meadows, Vaslui, Romania

ischaemum (L.) Roberty, where the effect of the harvesting phenophase under the influence of organic and mineral fertilization on feed productivity and quality was followed.

MATERIAL AND METHOD

The experience was organized on a permanent grassland of *Dichanthium ischaemum* (L.) Roberty, situated in Moldavian forest steppe, on the territory of Andrieșeni locality, Iași county, between the geographical coordinates 47°02' N latitude and 27°22' - eastern longitude, on a slightly inclined ground, with SE exposition.

The experience is bifactorial, arranged in randomized plots in three replicates, with the objectives of determining the quantitative value of forage and highlighting the value of elements that express the nutritional value of forage (CP, ADF, NDF, RFQ) on developmental phenophases, under the influence of organic and minerals fertilization in different doses.

The experimental factors were represented by the harvesting stage, with three graduations: a₁-harvested at plant height of 15-18 cm, a₂-harvested at the ear formation (control) and a₃-harvested to full flowering and fertilization with seven graduations: b₁-unfertilized (control), b₂-N₅₀P₅₀ kg·ha⁻¹ annually, b₃-N₇₅P₇₅ kg·ha⁻¹ annually, b₄-N₁₀₀P₁₀₀ kg·ha⁻¹ annually, b₅-10 Mg ha⁻¹ sheep manure applied annually, b₆-20 Mg·ha⁻¹ sheep manure applied annually and b₇-30 Mg·ha⁻¹ sheep manure applied at two years.

Fertilization was done with two types of fertilizer: organic represented by well fermented sheep manure (older than two years) and mineral represented by complex fertilizer with nitrogen and phosphorus (N₂₀P₂₀). The manure and mineral fertilizers were manually applied very early in the spring, at the beginning of plant growth.

Production was expressed in dry matter; nitrogen content was determined by Kjeldahl method, and NDF and ADF content were determined by Van Soest method. RFQ (Relative Forage Quality) was calculated using the Equation 1 (Ward R. and Ondarza M.B., 2008; Linn J.G. and Martin N.P., 2012).

The results were statistically analyzed by the analyses of variance and limit differences. We also determined the correlation equations and the significance of the square regression between the type of fertilization, harvest phenophase and the feed content in CP and dry matter.

$$RFQ = \frac{(4,898 + 89,796 \cdot (1,085 + 0.0124 \cdot ADF)) \cdot \frac{120}{NDF}}{1.23}$$

Equation 1. **Relative Forage Quality**

RESULTS AND DISCUSSIONS

A large part of the permanent grasslands in the Moldavian forest-steppe are in different stages of degradation and with a low productive yield.

The quantity and quality of the vegetation of

the permanent meadows of *Dichanthium ischaemum* are largely conditioned by the characteristics of the seasonal conditions, to which are added the anthropogenic influences through the exploitation system.

From the results obtained during the experimentation on the *Dichanthium ischaemum* meadow it was found that the productivity can be increased if the necessary measures for improvement are applied. The year 2020 can be considered a dry year for the studied meadow by *Dichanthium ischaemum*, the yields being small due to the uneven distribution of rainfall during the vegetation period, as well as the severe drought that occurred at the beginning of the vegetation period (April), but also in summer, in July and August, which had a negative influence on the production obtained, which in 2020 resulted only from the first cycle.

In 2020, the harvesting of the meadow studied by *Dichanthium ischaemum* at the height of the plants of the dominant species of 15-18 cm led to obtaining high production increases of dry matter with statistical assurance in all fertilized variants, the production values being correlated with large amounts of precipitation from May and June which had a complex effect on vegetation. Mineral fertilization in different doses generated production increases between 0.67 t/ha DM and 1.71 t/ha DM, depending on the doses used (N₅₀P₅₀ and N₁₀₀P₁₀₀, which represent 64.3% and 163.9%). It is notable in this phenophase, the very significant statistically assured production increases brought by the organic fertilization with sheep manure in the researched doses, which are between 78.6% and 166.5% (table 1).

In terms of production, in 2020, in the phenophase in which the harvest was carried out at the ear formation, all fertilized varieties regardless of their nature generated quantitative increases that ranged depending on the type of fertilizer and the amount applied.

Therefore, the mineral fertilization depending on the applied doses determined the obtaining of very significant increases of production, between 0.88 t/ha DM and 1.94 t/ha DM, which represents 84.0% and 185.9%. Also, in this phenophase we find the increases brought by the organic fertilization depending on the applied doses and the time interval from the application, the production values being between 2.30 t/ha DM (10 t/ha sheep manure applied annually) and 3.14 t/ha DM (30 t/ha sheep manure applied every 2 years), with very significant differences compared to the control variant (table 1).

Harvesting in the full flowering phenophase of the dominant species determined in 2020 the

achievement of higher dry matter production compared to the other two phenophases studied.

The high values of the productions obtained in this phenophase can be explained by the high level of precipitations in May and June above the normal average that allowed the better assimilation of nitrogen from the applied fertilizers, generating a good growth and development of the plants (table 1). Analyzing the yields obtained at the interaction between the full flowering phenophase and the fertilization applied in 2020 (table 1), it appears that the application of fertilizers in this phenophase regardless of their nature generated very significant statistically assured production increases compared to the unfertilized variant. Mineral fertilization regardless of the applied dose brought very significant increases in production in this phenophase between 1.15 t/ha DM (N₅₀P₅₀) and 2.55 t/ha (N₁₀₀P₁₀₀), which represent a percentage

of 110.2% and 244.5%. The same finding can be made in the case of fertilization with sheep manure in different doses, which led to obtaining considerable increases in production with statistical assurance, between 1.65 t/ha DM and 2.52 t/ha DM, which represents 158.1% and 241.3% (table 1). Between the applied dose of nitrogen (N kg/ha) and the production of DM obtained on the *Dichanthium ischaemum* meadow, positive correlations were obtained at all three studied harvesting phenophases, the values of the regression coefficient (R²) being distinctly significant (figure 1 a). Distinctly significant positive values of the regression coefficient were also obtained in the case of the correlation between the applied manure doses (t/ha) and the production of DM at all three harvested phenophases studied (figure 1 b).

Table 1

The influence of harvesting phenophase and fertilization on dry matter production for the *Dichanthium ischaemum* (L.) Roberty grassland

Variant		DM production Mg·ha ⁻¹	Difference		Statistical significance
			Mg·ha ⁻¹	%	
a ₁ - harvested at plant height of 15-18 cm	b ₁ -unfertilized	1.18	0.14	113.2	
	b ₂ - N ₅₀ P ₅₀	1.71	0.67	164.3	**
	b ₃ - N ₇₅ P ₇₅	2.29	1.25	219.7	***
	b ₄ - N ₁₀₀ P ₁₀₀	2.75	1.71	263.9	***
	b ₅ -10 Mg·ha ⁻¹ sheep manure applied annually	1.86	0.82	178.6	***
	b ₆ -20 Mg·ha ⁻¹ sheep manure applied annually	2.38	1.33	228.0	***
	b ₇ -30 Mg·ha ⁻¹ sheep manure applied at 2 years	2.78	1.74	266.5	***
a ₂ - harvested at the ear formation (C)	b ₁ -unfertilized (C)	1.04	Control	100	Control
	b ₂ - N ₅₀ P ₅₀	1.92	0.88	184.0	***
	b ₃ - N ₇₅ P ₇₅	2.52	1.48	242.1	***
	b ₄ - N ₁₀₀ P ₁₀₀	2.98	1.94	285.9	***
	b ₅ -10 Mg·ha ⁻¹ sheep manure applied annually	2.30	1.25	220.2	***
	b ₆ -20 Mg·ha ⁻¹ sheep manure applied annually	2.80	1.76	269.1	***
	b ₇ -30 Mg·ha ⁻¹ sheep manure applied at 2 years	3.14	2.09	300.9	***
a ₃ - harvested to full flowering	b ₁ -unfertilized	1.48	0.44	141.7	*
	b ₂ - N ₅₀ P ₅₀	2.19	1.15	210.2	***
	b ₃ - N ₇₅ P ₇₅	3.00	1.96	287.8	***
	b ₄ - N ₁₀₀ P ₁₀₀	3.59	2.55	344.5	***
	b ₅ -10 Mg·ha ⁻¹ sheep manure applied annually	2.69	1.65	258.1	***
	b ₆ -20 Mg·ha ⁻¹ sheep manure applied annually	3.24	2.20	311.0	***
	b ₇ -30 Mg·ha ⁻¹ sheep manure applied at 2 years	3.56	2.52	341.3	***
		LSD 5%	0.43		
		LSD 1%	0.57		
		LSD 0.1%	0.75		

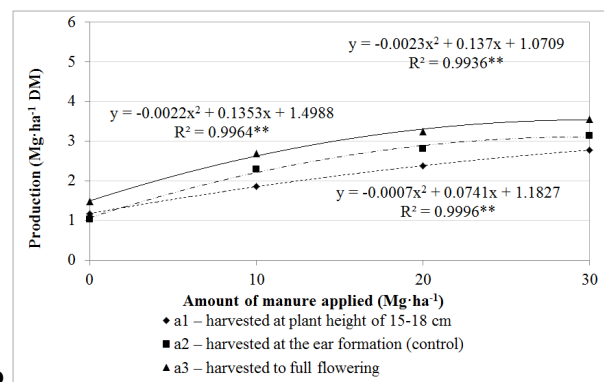
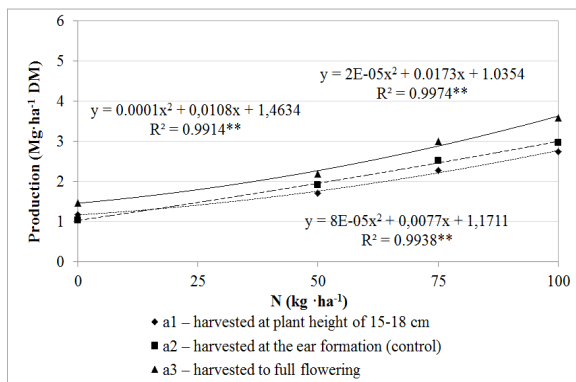


Figure 1 Correlations between the amount of fertilizer applied and the dry matter production, for the *Dichanthium ischaemum* (L.) Roberty grassland in 2020

Analyzing the influence of the interaction of the studied factors on the crude protein content in the fodder obtained from the *Dichanthium ischaemum* meadow in 2020 (table 2), it is found that the values of the forage content in CP are different depending on the fertilization variants used, and at the same doses, depending on the harvesting phenophase. Harvesting at the height of the plants of the dominant species of 15-18 cm on the background of applied fertilizers determined an increase in the feed content in crude protein in 2020 in most experimental variants, the highest crude protein content in this phenophase, of 10.77 g·100 g⁻¹ DM being recorded in the version fertilized with N₁₀₀P₁₀₀, with a very significant difference from the control variant (table 2). It is found that in this phenophase, the feed has a high content of crude protein, the values being correlated with the young stage of the plants, but especially with the assimilation of nitrogen from the fertilizer. The results obtained in the other two studied phenophases (harvested to ear formation and fully flowering) also show the decrease of the feed content in crude protein (CP) as a result of the advancement in vegetation of the plants in the vegetal cover, the values of the crude protein content being between 7.80 g·100 g⁻¹ DM (control) and 10.63 g·100 g⁻¹ DM (30 t/ha manure applied at intervals of 2 years) in the phenophase of ear formation of the dominant species and between 7.14 g·100 g⁻¹ DM (control) and 9.45 g·100 g⁻¹ DM (30 t/ha manure applied at intervals of 2 years) in the full flowering phenophase of the dominant species (table 2), the increases being more accentuated in the variants fertilized with mineral and organic fertilizers in high doses. Also, the high values of the forage content in crude protein in these phenophases are correlated with the modification of the floristic structure, by increasing the share of legumes in the vegetal cover. The influence of the interaction between harvesting and fertilization phenophase on the quality of forage obtained from the *Dichanthium ischaemum* (L.) Roberty meadow in 2020, highlights that the harvesting in different phenophases and the administration of mineral and organic fertilizers in the planned doses produced important changes in cell wall structure (ADF and NDF), as shown in table 2. It is found that the values of the forage content in NDF

(hemicellulose, cellulose and lignin) vary depending on the harvesting phenophase and the nature of the fertilizer in the applied quantities, being between 58.99 g·100 g⁻¹ DM and 72.29 g·100 g⁻¹ DM depending on the interaction of the two factors studied, the lowest values of forage content in NDF being recorded in the young phenophase in which the harvest was performed at the height of plants of the dominant species of 15-18 cm with very significant negative differences (table 2).

The results obtained in the other two studied phenophases (harvested at the ear formation and harvested in the full flowering phenophase) also highlight the decrease of NDF plant content in fertilized variants compared to the unfertilized variant, but also an increase of NDF values due to vegetation advancement of plants in the vegetal cover (table 2).

Examination of the results on the content of forage in ADF (table 2) shows that the phenophase in which the harvest was carried out at a plant height of 15-18 cm on different fertilization plots resulted in a decrease in the values of this parameter in all fertilized variants compared to the control variant, the differences being statistically assured, according to table 2. Thus, the values in this phenophase ranged between 35.81 g·100 g⁻¹ DM su and 41.71 g·100 g⁻¹ DM depending on the doses. With the advancement in vegetation, (the phenophases of ear formation and full flowering of the dominant species), there is a tendency to increase the values of ADF content due to the advanced stage of vegetation, by the accumulation of cell walls (lignin and cellulose), the values obtained varying according to the type of fertilizer and the amount applied, as shown in table 2.

The relative qualitative value of the forage (RFQ) obtained from the *Dichanthium ischaemum* meadow was influenced by the applied fertilization, but especially by the harvesting phenophase, with statistically assured differences, especially in the phenophase in which the harvesting made at the height of the plants of the dominant species of 15-18 cm (table 2).

Thus, the results obtained regarding the RFQ values of the forage, highlight a middle quality class (3) of it in the first studied phenophase, with a tendency to decrease the quality from quality class 3 (medium) to quality class 4 (weak), the

RFQ values being correlated with the high ones of the cell walls (ADF and NDF) as a result of the advanced stage of vegetation (table 2). Between the dose of nitrogen applied and the content of the forage in CP, positive correlations were obtained at all three harvested phenophases studied, the values of the regression coefficient being insignificant and distinctly significant (figure 2 a). Insignificant,

significant and distinctly significant values of the regression coefficient were also obtained in the case of the correlation between the applied manure doses and the forage content in PB at all three studied harvesting phenophases, being highlighted an increase in PB content with increasing doses of manure applied (figure 2 b).

Table 2
The influence of harvesting phenophase and fertilization on forage quality obtained from the *Dichanthium ischaemum* (L.) Roberty grassland

Variant		Quality parameters				
		PB (g·100g ⁻¹ DM)	NDF (g·100g ⁻¹ DM)	ADF (g·100g ⁻¹ DM)	RFQ	
a ₁ - harvested at plant height of 15-18 cm	b ₁ -unfertilized	10.06**	65.24***	39.93***	86.54 ⁰⁰	
	b ₂ - N ₅₀ P ₅₀	10.26***	59.27 ⁰⁰⁰	36.42 ⁰⁰⁰	101.67***	
	b ₃ - N ₇₅ P ₇₅	10.44***	58.99 ⁰⁰⁰	35.81 ⁰⁰⁰	103.28***	
	b ₄ - N ₁₀₀ P ₁₀₀	10.77***	59.37 ⁰⁰⁰	35.83 ⁰⁰⁰	102.59***	
	b ₅ -10 Mg·ha ⁻¹ sheep manure applied annually	10.46***	67.84***	41.71***	80.36 ⁰⁰⁰	
	b ₆ -20 Mg·ha ⁻¹ sheep manure applied annually	10.68***	66.56***	40.87***	83.27 ⁰⁰⁰	
	b ₇ -30 Mg·ha ⁻¹ sheep manure applied at 2 years	11.48***	66.71***	40.74***	83.31 ⁰⁰⁰	
a ₂ - harvested at the ear formation (C)	b ₁ -unfertilized (C)	7.80 ^c	62.68 ^c	38.39 ^c	92.74 ^c	
	b ₂ - N ₅₀ P ₅₀	8.21	63.21	38.54	91.70	
	b ₃ - N ₇₅ P ₇₅	8.68	63.88 [*]	38.56	90.71	
	b ₄ - N ₁₀₀ P ₁₀₀	9.23 [*]	61.68 ^o	36.83***	97.00	
	b ₅ -10 Mg·ha ⁻¹ sheep manure applied annually	9.07	71.30***	42.58 ⁰⁰⁰	75.14 ⁰⁰⁰	
	b ₆ -20 Mg·ha ⁻¹ sheep manure applied annually	10.63***	70.22***	42.33 ⁰⁰⁰	76.68 ⁰⁰⁰	
	b ₇ -30 Mg·ha ⁻¹ sheep manure applied at 2 years	10.61***	67.04***	40.29 ⁰⁰⁰	83.63 ⁰⁰⁰	
a ₃ - harvested to full flowering	b ₁ -unfertilized	7.14	66.48***	40.54 ⁰⁰⁰	83.91 ⁰⁰⁰	
	b ₂ - N ₅₀ P ₅₀	8.11	65.09***	39.37 [*]	87.67 ^o	
	b ₃ - N ₇₅ P ₇₅	8.08	63.93 [*]	39.02	89.86	
	b ₄ - N ₁₀₀ P ₁₀₀	8.90	63.96 [*]	38.83	90.13	
	b ₅ -10 Mg·ha ⁻¹ sheep manure applied annually	8.01	72.29 [*]	43.77***	72.33 ⁰⁰⁰	
	b ₆ -20 Mg·ha ⁻¹ sheep manure applied annually	8.56	69.54***	42.13***	77.75 ⁰⁰⁰	
	b ₇ -30 Mg·ha ⁻¹ sheep manure applied at 2 years	9.45 [*]	67.65***	41.10***	81.57 ⁰⁰⁰	
		LSD 5%	1.06	0.97	0.75	4.63
		LSD 1%	1.42	1.30	1.00	6.18
		LSD 0.1%	1.87	1.70	1.31	8.13

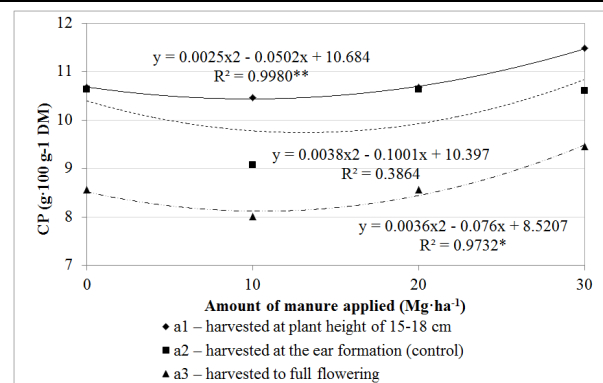
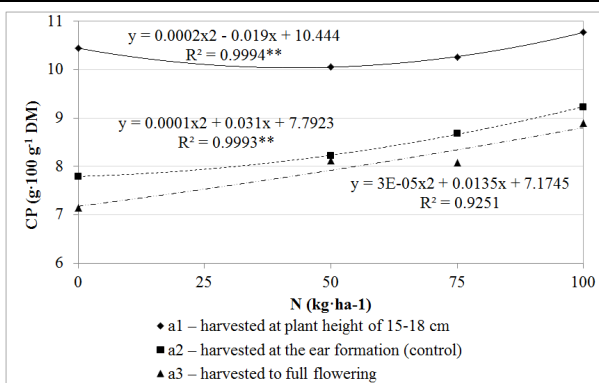


Figure 2 Correlations between the amount of fertilizer applied and the crude protein content of the forage obtained from the *Dichanthium ischaemum* (L.) Roberty grassland

CONCLUSIONS

From the results obtained during the experimentation on the *Dichanthium ischaemum* meadow it was found that their productivity is very low and can be substantially increased if the necessary measures for improvement and use are applied.

The level of the obtained productions was differentiated, depending on the applied doses, by the harvesting phenophase of the dominant species, as well as due to the climatic conditions during the experimentation period.

The harvesting phenophase and the applied fertilization had a marked influence on the quality of the forage obtained from the studied meadow, materialized by changes in the chemical composition with implications on the use value.

During the studied period, a poor quality of the forage resulted, and through improvement a medium quality can be reached, especially in the phenophase in which the harvesting was carried out at the height of the plants of the dominant species of 15-18 cm.

As the plants of the dominant species advance in the vegetation (the phenophase of ear formation and full flowering), there was a tendency to decrease the relative qualitative value of the forage obtained from the *Dichanthium ischaemum* meadow, due to the accumulation of cell walls (ADF and NDF) determined of the development stage.

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