QUALITY OF THE *Dichanthium ischaemum* (L.) Roberty SPECIES ON HARVESTING PHENOPHASES

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Abstract

The forage value of the species is strongly influenced by their growth stage when they are harvested or grazed. The forage value is the highest during the vegetative growth and the lowest during the seed formation stage. Therefore, when forage species are cultivated for the purpose of feeding cattle, they must be harvested or grazed in the early stages of maturity. As the forage plants reach maturity crude protein content decreases, ADF, NDF content increases and feed digestibility is reduced. The objectives of this study were to determine the influence of harvesting phenophases and of the organo-mineral fertilization on the quality of the *Dichanthium ischaemum* (L.) Roberty species. The experimental factors were represented by the harvesting phenophase, with three graduations: a_1 - harvesting at plants height of 15-18 cm, a_2 - harvesting at the ear formation (control), a_3 - harvesting to full flowering and fertilization with seven graduations: b_1 - unfertilized (control), b_2 - $N_{50}P_{50}$ kg·ha^{-1} annually, b_3 - $N_{75}P_{75}$ kg·ha^{-1} annually, b_4 - $N_{100}P_{100}$ kg·ha^{-1} annually, b_5 - 10 Mg·ha^{-1} sheep manure annually, b_6 - 20 Mg·ha^{-1} annually and b_7 - 30 Mg·ha^{-1} annually sheep manure applied at two years. The obtained results showed that the developmental stage is an essential factor that determines important changes in the quality of the analyzed species, the chemical composition of the species obtained being influenced by the harvesting phenophase, as well as the type of fertilizer and the applied doses. The relative qualitative value of the forage was found to be highest during the vegetative growth, so as the species advances the vegetation the crude protein content decreases, the content in ADF, NDF increases and its digestibility decreases.

Key words: old world bluestem (OWB), organic and mineral fertilization, CP, NDF, ADF, RFQ

Ionel A. *et al*., 2003; Vîntu V. *et al*, 2004, mention that the species *Dichanthium ischaemum* L. is common on eroded, dry steppe and forest steppe grasslands, with low feed value (1), while in Asia it is considered an alternative to *Eragrostis curvula* and *Cynodon dactylon* species (Coleman SW and Forbes TDA, 1998). The percentage of crude protein is between 7 - 10% in the leaves and around 5% in the stems, and the phosphorus is only 0.08% (Coleman S.W. *et al*., 2004).

Berg W.A., 1993, mentions that in terms of economic importance, the *Dichanthium ischaemum* L., species is considered to be a forage species consumed only in the early stages of vegetation. Allen V.G. and Brown P., 2005, show that the quality of *Dichanthium ischaemum* L. is high in the first half of the growing season (May-July), with crude protein concentrations averaging 9-12% during the growing period active (May-July). Redfearn D.D., 2003, shows that the highest crude protein content of *Dichanthium ischaemum* species is in the active growth period (May-July), when the vegetative mass is in full formation. After mid-July, the quality of the forage had a rapid decline. As the species progresses in vegetation, there is a decrease in the crude protein content and an increase of the cell wall components (NDF, ADF, hemicellulose and cellulose) (Carvallo T.D., 2008; Mahyuddin P. şi Purwantari N.D., 2009**;** Burns J.C. and Fisher D.S., 2010; Burns J.C. and Fisher D.S., 2012). The quality of the forage is influenced by many factors, including the harvesting stage, growing conditions, as well as soil fertility (Dabo S.M. *et al*., 1988; Bumb I. *et al*., 2016). The composition and nutritional value of the feed changes during the growing period, with a decreasing tendency during the vegetation period (Basurto R. *et al*., 2000). The stage of plant maturity or developmental phenophase at harvest time is the main factor responsible for decreasing the nutritional value of the forage (Bumb I. et al., 2016). Thus, the present study aims to recommend optimal harvesting phenophase of the dominant species *Dichanthium ischaemum* L., from a permanent grassland of *Dichanthium ischaemum* (L.) Roberty from Moldavian Forest Steppe with

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different variants of organic and mineral fertilization on the quality of the species.

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 Andrieşeni locality, Iaşi 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. The aim of the study was to analyze the influence of the harvesting phenophase and of the organic and mineral fertilization at different doses on the quality of the species *Dichanthium ischaemum* (L.) Roberty, and the objectives were the determination quality indicators: plant crude protein (CP), NDF (neutral detergent fiber), ADF (acid detergent fiber) and calculate forage quality relative (RFQ).

The experimental factors were represented by the harvesting phenophase, with three graduations: a_1 - harvesting at plants height of 15-18 cm, a_2 -harvesting at the ear formation (control) and a_3 - harvesting to full flowering and fertilization with seven graduations: b_1 - unfertilized (control), b_2 - $N_{50}P_{50}$ kg·ha^{-1} annually, b_3 - $N_{75}P_{75}$ kg·ha^{-1} annually, b_4 - $N_{100}P_{100}$ kg·ha^{-1} annually, b_5 - 10 Mg·ha^{-1} sheep manure applied annually, b_6 - 20 Mg·ha^{-1} sheep manure applied annually and b_7 - 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 ($N_{20}P_{20}$). The manure and mineral fertilizers were manually applied every year in the spring, at the beginning of plant growth.

Nitrogen content was determined by Kjeldahl method, and NDF and ADF content were determined by Van Soest method (Van Soest P., 1963). RFQ (Relative Forage Quality) was calculated using the Equation 1 (Ward R, Ondarza M.B., 2008; Linn J.G.,Martin N.P., 2012).

The results were statisticaly 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, harvesting pheophase and the species analyzed content in CP and RFQ.

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

Equation 1. Relative Forage Quality

RESULTS AND DISCUSSIONS

The strategy of harvesting on a certain meadow in different phenophases represents a good alternative for optimizing green mass production, choosing the optimal harvesting time having a favorable impact on the quantity and nutritional value of the forage.

The chemical composition of *Dichanthium ischaemum* varies throughout the vegetation period. Protein values are high at the beginning of the vegetation period to a grazing height of 35-40 cm, having a decreasing tendency towards the end of the vegetation period (Teague W.R. *et al*., 1998; Allen V.G. and Brown P., 2005).

Analyzing the influence of the studied factors on the crude protein content of the *Dichanhium ischaemum* species (*table 1*), it is found that the values of the content of the species in CP, are different, depending on the fertilization variants used, and at the same doses, depending on the harvesting phenophase. Harvesting at plants height of 15-18 cm had the effect of distinct and very significant increases of the crude protein content in relation to the unfertilized variant, the highest values of the crude protein content, of 11.37 g·100 g^{-1} DM and 10.24 g·100 g^{-1} DM respectively were registered in mineral fertilized variants with $N_{100}P_{100}$ kg·ha-^{1} annually and $N_{75}P_{75}$ kg·ha^{-1} annually, with increases of 54.7% and 39.35% respectively (*table 1*). The data obtained (*table 1*), show that in this early phenophase the species has a high content of crude protein in all experimental variants compared to the unfertilized variant, with distinct and very significant differences compared to the control variant, the high values obtained being due to the level to intensify the meadow, but especially the young stage of the plants.

As can be seen in *table 1*, mineral as well as organic fertilization significantly influenced the crude protein content, causing substantial increases compared to the unfertilized variant taken as a control.

At the ear formation (control) phenophase of the species *Dichanhium ischaemum* taken as a control, the crude protein content of the analyzed species registered a slight decrease, with 45.3% for the fertilized variant with $N_{100}P_{100}$ kg·ha-^{1} annually and 31.7% for the fertilized variant with $N_{75}P_{75}$ kg·ha-^{1} annually compared to the first phenophase, the obtained values being 8.04 g·100 g^{-1} DM and 7.91 g·100 g^{-1} DM respectively, with insignificant differences compared to the control (*table 1*).

In the unfertilized variant in this phenophase, was registered a crude protein content of 7.35 g·100 g^{-1} DM.

When harvesting in full flowering phenophase, in contrast to the other two harvesting phenophases, in all the fertilized variants there were insignificant decreases in the crude protein content compared to the unfertilized variant, the

highest protein content, of 7.61 g·100 g^{-1} DM being registered in the variant fertilized with 30 Mg·ha^{-1} sheep manure applied at two years. In this phenophase in the variant fertilized with $N_{100}P_{100}$ kg·ha^{-1} annually, the crude protein content decreased by 53.8% compared to the first phenophase and by 8.5% compared to the ear formation phenophase taken as a control. Also, the same aspect can be observed in the case of the fertilized variant with $N_{75}P_{75}$ kg·ha^{-1} annually where the decrease of the crude protein content was 38.6% compared to the first phenophase and 6.8% compared to the ear formation phenophase taken as a control (*table 1*).

The values of the regression coefficient (R^2), in the case of the crude protein content of *Dichanthium ischaemum* species, were positively insignificant and significant in the case of mineral fertilization with NP (*figure 1*) and positively insignificant in the case of fertilization with sheep manure (*figure 2*), which shows that the value of the analyzed indicator correlated with the type and doses of fertilizer applied.

Table 1

The influence of the interaction between harvesting phenophase and fertilization on the quality of the species *Dichanthium ischaemum*

Variant		Quality parameters			
		CP (g·100 g^{-1} DM)	NDF (g·100 g^{-1} DM)	ADF (g·100 g^{-1} DM)	RFQ
a_1 - harvesting at plants height of 15-18 cm	b_1-unfertilized	8.55**	70.74	41.11ooo	78.00*
	b_2- $N_{50}P_{50}$	8.95***	69.83	41.04ooo	79.11*
	b_3- $N_{75}P_{75}$	10.24***	69.08o	40.27ooo	81.18*
	b_4- $N_{100}P_{100}$	11.37***	68.04oo	39.11ooo	84.29***
	b_5-10 Mg·ha^{-1} sheep manure applied annually	8.61**	71.15	41.19ooo	77.42
	b_6-20 Mg·ha^{-1} sheep manure applied annually	8.84***	70.02	40.37ooo	79.95**
	b_7-30 Mg·ha^{-1} sheep manure applied at 2 years	8.99***	69.07o	38.94ooo	83.29***
a_2 - harvesting at the ear formation (C)	b_1-unfertilized (C)	7.35(C)	71.11(C)	44.89(C)	71.82(C)
	b_2- $N_{50}P_{50}$	7.58	70.38	44.47	73.21
	b_3- $N_{75}P_{75}$	7.91	69.48	43.66	75.42
	b_4- $N_{100}P_{100}$	8.04	68.29oo	42.38ooo	78.77*
	b_5-10 Mg·ha^{-1} sheep manure applied annually	7.69	70.96	44.46	72.62
	b_6-20 Mg·ha^{-1} sheep manure applied annually	7.91	69.26	43.50	75.91
	b_7-30 Mg·ha^{-1} sheep manure applied at 2 years	8.14	68.33oo	42.33ooo	78.80*
a_3 - harvesting to full flowering	b_1-unfertilized	7.07	74.89***	49.33***	61.75ooo
	b_2- $N_{50}P_{50}$	7.12	73.77*	48.16***	64.41o
	b_3- $N_{75}P_{75}$	7.41	71.99	47.06**	67.67
	b_4- $N_{100}P_{100}$	7.42	71.02	45.73	70.62
	b_5-10 Mg·ha^{-1} sheep manure applied annually	7.17	74.55**	48.50***	63.24oo
	b_6-20 Mg·ha^{-1} sheep manure applied annually	7.52	73.55*	47.49***	65.58o
	b_7-30 Mg·ha^{-1} sheep manure applied at 2 years	7.61	72.42	46.77**	67.69
	LSD 0.01	1.41	3.56	2.49	9.99
	LSD 0.1	1.07	2.70	1.88	7.57
	LSD 0.5	0.80	2.02	1.41	5.65

Harvesting in different phenophases, as well as the administration of organic and mineral fertilizers, produced significant changes in the content of cell walls (ADF and NDF) in the species *Dichanhium ischaemum* (*table 1*). Analyzing the influence of the studied factors on the content of NDF in the species *Dichanhium ischaemum* (*table 1*), we observe that harvesting at plants height of 15-18 cm caused a decrease of the NDF values in most experimental variants, the negative differences between the unfertilized variant and the fertilized variants being insignificant and distinctly significant.

This decrease is mainly due to the phenophase in which the plants contain less cellulose and lignin, results confirmed by other similar studies. In this phenophase we observe a decrease of the species content in the NDF with the increase of the doses of NP, but also a slight increase in the variants organically fertilized with sheep manure in different doses, this fact being due to the poor assimilation by the plants of the fertilizers under unfavorable climate conditions, aspect observed also in the ADF content of the

feed (*table 1*). The NDF values for the species analyzed in the first phenophase were between 68.04 g·100 g^{-1} DM and 71.15 g·100 g^{-1} DM.

The results obtained in the other two phenophases studied (harvesting at the ear formation and harvesting to full flowering), also highlighthed the decrease of the NDF plant content in the fertilized variants compared to the unfertilized variant, but also an increase in the NDF values due to the development stage which the plant accumulates in the cells more cellulose (*table 1*).

The results regarding the content of the *Dichanhium ischaemum* species in ADF, show us that in the phenophase in which the harvesting was made at the plants height of 15-18 cm different fertilization variants, a decrease of the values of this parameter is observed in all fertilized variants compared to the control variant, the differences being very significant negative (*table 1*).

Thus, the values in this phenophase were between 32.75 g·100 g^{-1} DM and 35.39 g·100 g^{-1} DM depending on the fertilization variant.

With the advancement of the species in vegetation, there is a tendency to increase the content values in ADF as a result of the accumulation of cell walls (lignin and cellulose), from 35.49 g·100 g^{-1} DM to 41.0 g·100 g^{-1} DM in the case of unfertilized variants. There is also a decrease in ADF values in the other two harvesting phenophases as a result of mineral or organic fertilization (*table 1*).

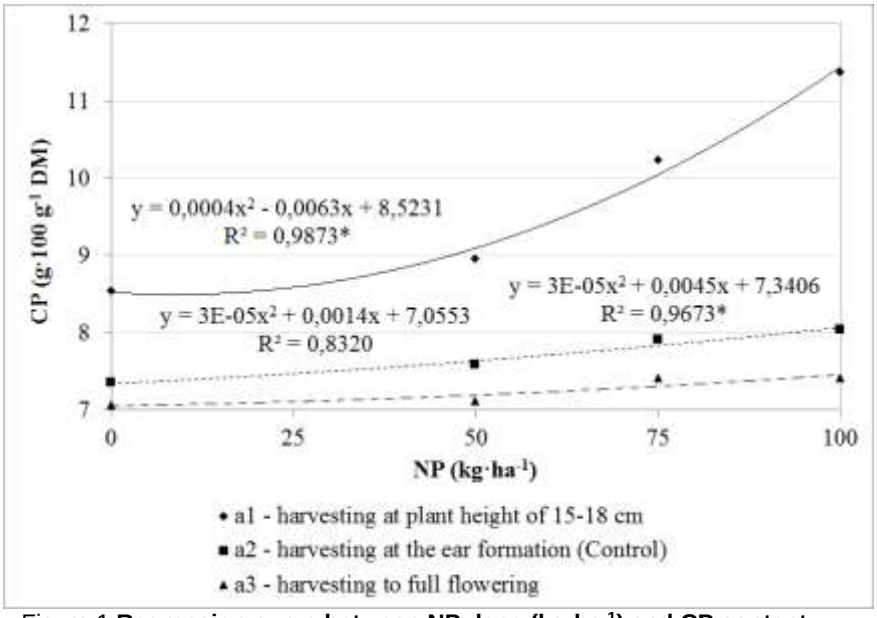

Figure 1 **Regression curve between NP dose (kg·ha^{-1}) and CP content**

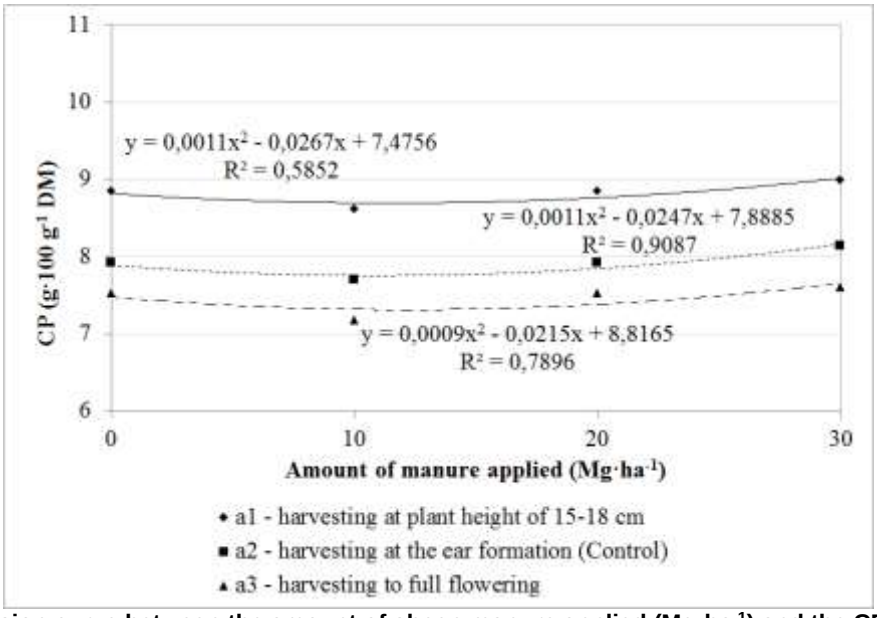

Figure 2 **Regression curve between the amount of sheep manure applied (Mg·ha^{-1}) and the CP content**

The results regarding the relative qualitative value of the species *Dichanhium ischaemum* (RFQ) (*table 1*), show us that the obtained RFQ values were influenced by the applied mineral and organic fertilization, but especially by the harvesting phenophase, with statistically assured differences in relation to the variant control.

The highest value of RFQ, of 84.29 was obtained in the variant harvested at the plants height of 15-18 cm in the variant fertilized with $N_{100}P_{100}$ kg·ha-^{1} annually, with an increase compared to the unfertilized variant taken as a control of 17.4%. Higher values of the RFQ in the first harvesting phenophase at the plants height the analyzed species of 15-18 cm were recorded in most experimental variants, with insignificant, significant, distinct and very significant differences from the control (*table 1*).

According to the results obtained, it is noted that the *Dichanhium ischaemum* species has a poor quality in the first phenophase in which the harvesting was made at the height of the plants of 15-18 cm depending on the applied fertilization, the quality of the species being correlated with its content in crude protein, as well as in cell walls (ADF and NDF).

Also, the obtained results confirm that with the advance of the species in vegetation (full flowering) the relative qualitative value of the species analyzed is reduced, by decreasing the crude protein content and accumulation of cell walls, so that the species acquires a very poor quality (*table 1*).

The relative qualitative feed value (RFQ) of the *Dichanthium ischaemum* species showed a general growth tendency with the increase of the applied NP doses, correlating significantly with these values (*figure 3*).

In the case of manure due to the unfavorable climatic conditions that negatively influenced the use of manure by plants, the relative qualitative value of the species (RFQ) correlated positively insignificantly with the studied phenophases (*figure 4*).

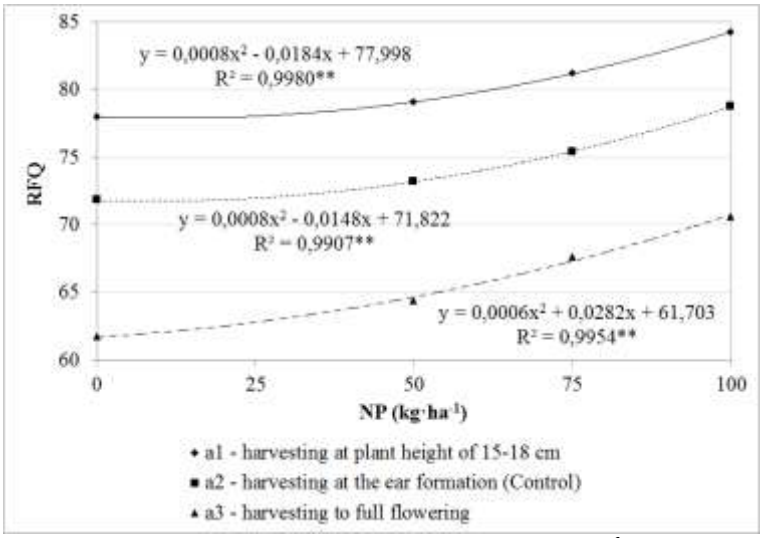

Figure 3 **Regression curve between NP dose (kg·ha^{-1}) and RFQ**

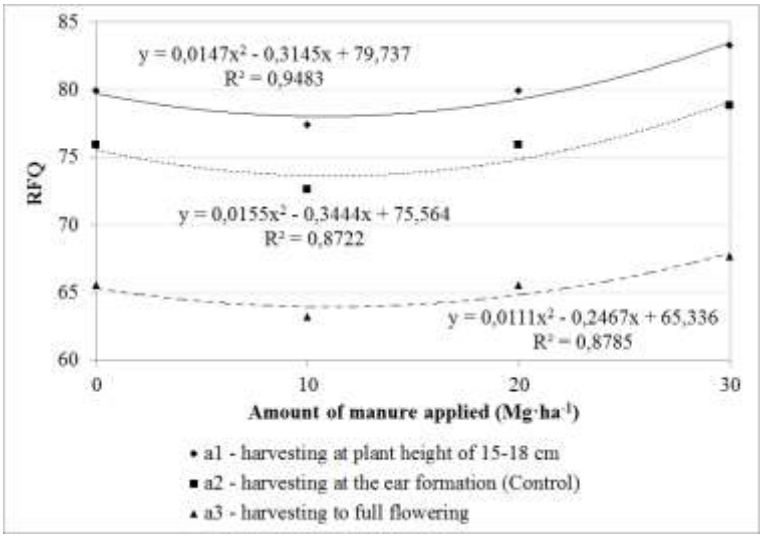

Figure 4 **Regression curve between the amount of sheep manure applied (Mg·ha^{-1}) and RFQ**

CONCLUSIONS

The obtained results show that the developmental stage is an essential factor that determines changes in the quality of the studied species *Dichanthium ischaemum*, the chemical composition being influenced by the harvesting phenophase, as well as the type of fertilizer and the applied doses.

The major factor that determines the composition and nutritional value of the species is the vegetation (development) phase of the plants at harvest.

Thus, according to the study, the relative qualitative feed value of the *Dichanthium ischaemum* species proved to be the highest during the vegetative growth, when the harvest was done at the plants height of 15-18 cm, the plants having a high protein content and a low cell wall.

Also, the results of the study highlight that as the plants age, the proportion of protein decreases, increasing the proportion of cellulose, hemicellulose and lignin (ADF and NDF), thus reducing the digestibility of the species. Both organic and mineral fertilizers influenced the quality of the species, the crude protein content increasing significantly compared to the unfertilized variant.

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