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DYNAMICS OF FORAGE BIOMASS ACCUMULATION IN DECADES OF A NATURAL MEADOW OF *AGROSTIS CAPILLARIS-FESTUCA FALLAX* TYPE IN THE RHODOPE MOUNTAINS

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Abstract. The purpose of this study was to establish the changes in productivity and chemical composition of forage biomass in decades of vegetation period of a natural meadow *Agrostis capillaris-Festuca fallax* type in the Rhodope Mountains (Smolyan region, Southern Bulgaria). The productive potential of the grass stand was dependent on age of the grasses and the level of mineral fertilization. The greatest yields were obtained after fertilization - 3.92 t.ha^{-1} ($N_{160}P_{80}$) and 3.68 t.ha^{-1} ($N_{80}P_{80}$). Most crude protein (320-325 g.kg^{-1} dry matter) contained the forage at the beginning of grass vegetation, while in the same period the crude fiber were at least. It was observed an opposite dependence with advance of vegetation. With the same period, the crude fat content decreased significantly but this reduction was greater in unfertilized control. Nitrogen-free extract substances content increased with the age of grasses and decreased with increasing of mineral fertilization levels. This chemical indicator varied from 350 g.kg^{-1} dry matter after $N_{160}P_{80}$-fertilization to 370 g.kg^{-1} in control. The advance of vegetation had a negative effect on the crude ash content as at the end of vegetation period it decreased almost 3 times. The crude ash values varied in small limits - from 81 g.kg^{-1} dry matter ($N_{160}P_{80}$) to 90 g.kg^{-1} (in unfertilized control). The greatest values of the crude protein yields were reported between 71st–92nd day (from 91.9 to 97.0 t.ha^{-1}) after $N_{80}P_{80}$- and between 71st–102nd day (from 105.9 to 110.5 t.ha^{-1}) after $N_{160}P_{80}$-fertilization. Most feed units per 1 ha were obtained after fertilization with $N_{160}P_{80}$ - 2509.4 FU and with $N_{80}P_{80}$ - 2225.5 FU.

Key words: natural meadow, forage biomass, decade accumulation, indicators, the Rhodope Mountains (Southern Bulgaria).

Introduction

The natural meadows of *Agrostis capillaris-Festuca fallax* type in Smolyan region (the Middle Rhodope Mountains, Southern Bulgaria) reached 56.8% of the total area of natural meadows in the region, and annually give about 1.5-2.0 t.ha^{-1} good quality hay (in 100 kg hay containing 46 food units and 3.41 kg digestible protein). [CHESHMEDJIEV, 1976, YAKIMOVA *et al.,* 1977].

Due to irrational use and low levels of applied agricultural machines, the condition of natural meadows and pastures in the region is unsatisfactory. Furthermore, the main reasons for their low forage productivity are specific vegetation of grass stands and available natural and environmental characteristics that are typical of the region such as weak soil reserve with essential nutrients, high soil acidity, irregular rainfall distribution, a high rough of country, etc.

The conducted multiple studies in Bulgaria [TOTEV, 1984, PAVLOV, 1996, TOTEV et al., 1998] and abroad [KASPER, 1971, SUR, 1975, SUNG AND KIM, 1985, GRANDI et al., 1989, GIRALDEZ et al., 1993] show that apart from specific natural characteristics the quality and quantity of biomass obtained from natural grasslands has been also influenced to a great extent by the level of enforcement. Mineral fertilization and its ways of use are among the most important in farming practices.

The purpose of this study was to establish the changes in productivity and chemical composition of forage biomass in decades of vegetation period of a natural meadow *Agrostis capillaris-Festuca fallax* type in the Rhodope Mountains (Smolyan region, Southern Bulgaria).

Material and Methods

The field experiment was conducted during the 1993-1995 period, on natural meadow of *Agrostis capillaris-Festuca fallax* type in the Rhodope Mountains (Smolyan region, Southern Bulgaria) at 1100 m altitude. The soil in the area of experiment was a brown forest with light mechanical structure because the chemical composition was characterized by a middle reserve of humus and a low total nitrogen and phosphorus. Low values were established by water soluble forms of nitrogen, phosphorus and molybdenum and the reserve of water soluble forms of potassium and boron was optimum. The soil reaction was acidic.

The block-method was used in four repetitions and the harvesting plot area of 10 m^2 with the following fertilizer rates in kg per 1 ha as variants: 1. N_0P_0 (unfertilized variant) – as a control; 2. Fertilization with $N_{80}P_{80}$; 3. Fertilization with $N_{160}P_{80}$. The fertilization was accomplished annually, in early spring and shortly before the beginning of active vegetation of grasses, with nitrogen (as ammonium nitrate), phosphorus (as superphosphate) and potassium (as potassium sulphate).

The trial plots were hay-making by hand in the following age of grass stand: on 01.05. (1^{st} day); on 10.05. (10^{th} day); on 20.05. (20^{th} day); on 31.05. (31^{st} day), on 10.06. (41^{st} day); on 20.06. (51^{st} day); on 30.06. (61^{st} day); on 10.07. (71^{st} day); on 20.07. (81^{st} day), on 31.07. (92^{nd} day); on 10.08. (102^{nd} day); on 20.08. (112^{th} day); on 31.08. (123^{rd} day), on 10.09. (133^{rd} day); on 20.09. (143^{rd} day); on 30.09. (153^{rd} day); on 10.10. (163^{rd} day); on 20.10. (173^{rd} day); on 31.10. (184^{th} day).

During the conduction of the field experiment information about the following indicators was collected:

1. Dry mass (DM) yields (in $t.ha^{-1}$) was established by drying in muffle oven to constant weight at 105^0C of 0.5 kg green mass samples, taken immediately after cutting each trial plot and repetition. It has been reported for years and average for the experimental period.

2. Chemical composition of the absolutely dry matter (in %) – of crude protein content, of crude fiber and of crude fat through infrared spectroscopy with apparatus lnfraAlyser-400. The nitrogen-free extract substances (NFES) were calculated as the amount difference among crude protein, crude fiber, crude fat and crude ash.

Results and Discussion

Dry matter yields.

The dynamics in the productive potential of the grass stand was dependent on age of the grass stand and the level of mineral fertilization. *(Table 1)* It is obvious that the yields increase passed four (for unfertilized control) and five periods (for fertilized variants) of the grass vegetation.

Thus, at the beginning of vegetation (the 1^{st} decade of May), the dry matter yields at different fertilization levels had comparatively allied values – 1,21 $t.ha^{-1}$ (control), 1.30 $t.ha^{-1}$ ($N_{80}P_{80}$) and 1.39 $t.ha^{-1}$ ($N_{160}P_{80}$), as the differences were not mathematically proven (-). The reason for these values was a relatively good soil stockpile with moisture and insufficiently influence of mineral fertilizers. In the 2^{nd} and 3^{rd} year the influence of mineral fertilizers was more tangible. From the same table it is obvious that with advance of the grass vegetation the dry matter yields increased continuously. In the unfertilized control the yields increased a slowly (only after 61^{st} - 92^{nd} day from vegetation) and in after $N_{80}P_{80}$- and $N_{160}P_{80}$-fertilization – quickly (as to 41^{st} - 51^{st} day). At that time the following yield values were reported – respectively from 2.01 to 2.82 $t.ha^{-1}$, 2.16-2.58 $t.ha^{-1}$ and 2.39-2.78 $t.ha^{-1}$. Next yields increase, but more gradually (from 102^{nd} to 153^{rd} day) was observed in control, and the obtained dry mass reached from 3.04 to 3.96 $t.ha^{-1}$ during 51 days. The mineral fertilization (var. 2 and 3) reduced the period of dry matter accumulation in comparison with the control. For the same period these variants were accumulated from 4.29 to 5.19 $t.ha^{-1}$ dry matter ($N_{80}P_{80}$) and from 4.54 to 5.56 $t.ha^{-1}$ dry matter ($N_{160}P_{80}$), respectively. From 163^{rd} to 184^{th} day (the end of vegetation) the dry matter accumulated at a slower and varied from 4.09 to 4.21 $t.ha^{-1}$ (in control), from 5.31 to 5.52 $t.ha^{-1}$ ($N_{80}P_{80}$) and from 5.67 to 5.87 $t.ha^{-1}$ ($N_{160}P_{80}$). For the experimental period the greatest yields were obtained in the fertilized variants (var. 3 and 2) – average 3.92 and 3.68 $t.ha^{-1}$ and exceeded the control (2.73 $t.ha^{-1}$) respectively with 43.59 and 34.80%. The obtained data of dry matter yields after 71^{st} day of vegetation had a very good proof (***).

Table 1.

Dry matter yields in $t.ha^{-1}$ average for the 1993-1995 period.

Date/Day	N_0P_0	Proof	$N_{80}P_{80}$	Proof	$N_{160}P_{80}$	Proof
01.05. (1st day)	1.06	-	1.15	-	1.25	-
10.05. (10th day)	1.21	-	1.30	-	1.39	-
20.05. (20th day)	1.33	-	1.58	-	1.73	-
31.05. (31st day)	1.47	-	1.76	-	1.87	-
10.06. (41st day)	1.66	*	2.16	*	2.39	*
20.06. (51st day)	1.83	*	2.58	**	2.78	**
30.06. (61st day)	2.01	**	3.05	***	3.22	***
10.07. (71st day)	2.24	***	3.49	***	3.74	***
20.07. (81st day)	2.56	***	3.82	***	4.04	***
31.07. (92nd day)	2.82	***	4.11	***	4.25	***
10.08.(102nd day)	3.04	***	4.29	***	4.54	***
20.08. (112th day)	3.27	***	4.52	***	4.76	***
31.08. (123rd day)	3.49	***	4.74	***	5.06	***
10.09. (133rd day)	3.61	***	4.95	***	5.23	***
20.09. (143rd day)	3.81	***	5.07	***	5.41	***
30.09. (153rd day	3.96	***	5.19	***	5.56	***
10.10. (163rd day)	4.09	***	5.31	***	5.67	***
20.10. (173rd day)	4.16	***	5.43	***	5.76	***
31.10. (184th day)	4.21	***	5.52	***	5.87	***
Average	2.73		3.68		3.92	

$P<0.05^{*}$; $P<0.01^{**}$; $P<0.001^{***}$

P<0.05	59.8	76.3	95.8
P<0.01	90.1	112.4	138.4
P<0.001	110.7	143.2	158.7

Chemical composition of grass biomass.

The age of the grass stand and level of mineral fertilization had a direct effect on the chemical composition of grass biomass *(Table 2)*. Thus, the beginning of vegetation was characterized by high and comparatively allied values of crude protein – from 320 $g.kg^{-1}$ dry matter in control to 325 $g.kg^{-1}$ in fertilized variants (var. 2 and 3). In the same period (to 2nd decade of May) as an opposite of crude protein the crude fiber content was less, but the values of crude fat (56-57 $g.kg^{-1}$ dry matter) and crude ash (123-128 $g.kg^{-1}$ dry matter) were comparatively high. With advance of vegetation and mineral fertilizers application occurred significant differences in the values of these chemical indicators. For example, right after 2nd decade of May the crude protein in forage reduced continuously but faster in control and gradually in fertilized variants. It is obvious that the fertilization not only increased the crude protein content, but retains its level considerably longer. Thus, 100 days after the beginning of the vegetation of crude protein in grass biomass was 1.9 times greater at $N_{80}P_{80}$-fertilization and 2.5 times greater at $N_{160}P_{80}$-fertilization. At the end of vegetation the crude protein content was lower and only fertilization variants had higher values. Average for three years of the study the crude protein content was 150 $g.kg^{-1}$ dry matter (in N_0P_0), 217 $g.kg^{-1}$ (in $N_{80}P_{80}$) and 238 $g.kg^{-1}$ (in $N_{160}P_{80}$).

Regarding the crude fiber content had been exactly the opposite trend. Their values increased with advance of vegetation and decreased after fertilization with $N_{80}P_{80}$ and $N_{160}P_{80}$. The fiber reached most high values in the end of vegetation period (on 184th day) and the greatest amount was in $N_{160}P_{80}$-fertilization (438 $g.kg^{-1}$ dry matter) and in the control variant (419 $g.kg^{-1}$ dry matter).

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Table 2.

Chemical composition of grass biomass (in g.kg^{-1} dry matter) average for the 1993-1995 period.

Date/ Day	Crude protein N_0P_0	Crude protein $N_{80}P_{80}$	Crude protein $N_{160}P_{80}$	Crude fiber N_0P_0	Crude fiber $N_{80}P_{80}$	Crude fiber $N_{160}P_{80}$	Crude fat N_0P_0	Crude fat $N_{80}P_{80}$	Crude fat $N_{160}P_{80}$
01.05. -1st day	320	325	325	160	165	170	56	56	57
10.05. -10thday	296	330	335	180	163	170	56	55	56
20.05. -20thday	270	335	341	219	169	172	54	55	57
31.05. -31stday	258	325	332	224	173	178	55	55	58
10.06. -41stday	205	308	312	280	188	191	54	54	56
20.06. -51stday	196	298	324	298	207	190	54	55	56
30.06. -61stday	154	265	305	336	236	205	53	54	57
10.07. -71stday	137	270	283	353	231	227	54	55	58
20.07. -81stday	122	254	275	368	251	242	47	50	55
31.07. -92ndday	105	224	260	388	284	260	42	47	47
10.08. -102ndday	97	187	241	396	319	281	38	40	43
20.08. -112thday	94	165	202	404	343	317	36	38	40
31.08. -123rdday	87	151	186	407	349	328	34	36	38
10.09. -133rdday	95	136	171	415	390	364	35	35	36
20.09. -143rdday	90	120	154	418	397	374	30	31	33
30.09.-153rd day	87	111	136	439	425	406	28	30	30
10.10. -163rdday	85	116	121	436	409	408	25	28	30
20.10. -173rdday	80	107	110	441	418	419	22	25	28
31.10. -184thday	82	104	108	438	420	419	20	24	28
Average	150	217	238	347	291	280	42	43	45

Continuation of Table 2.

Date/Day	NFES N_0P_0	NFES $N_{80}P_{80}$	NFES $N_{160}P_{80}$	Crude ash N_0P_0	Crude ash $N_{80}P_{80}$	Crude ash $N_{160}P_{80}$
01.05. -1st day	336	330	325	128	124	123
10.05. -10thday	340	328	327	128	124	112
20.05. -20thday	341	330	322	116	111	108
31.05. -31stday	338	334	325	125	113	107
10.06. -41stday	342	336	332	119	114	109
20.06. -51stday	355	342	340	97	98	90
30.06. -61stday	360	351	344	97	94	89
10.07. -71stday	358	347	341	98	97	91
20.07. -81stday	360	353	343	103	92	85
31.07. -92ndday	365	358	350	100	87	83
10.08. -102ndday	371	366	354	98	88	81
20.08. -112thday	380	371	362	86	83	79
31.08. -123rdday	388	380	369	84	84	79
10.09. -133rdday	377	370	363	78	69	66
20.09. -143rdday	390	386	380	72	66	59
30.09. -153rd day	401	392	388	45	42	40
10.10. -163rdday	411	406	401	43	41	40
20.10. -173rdday	415	410	403	42	40	40
31.10. -184thday	418	412	407	42	40	38
Average	370	363	350	90	86	81

With the advance of the grass vegetation, the crude fat content also decreased significantly but this reduction was greater in unfertilized control. Regardless of fertilization or non-fertilization of the grass stand their content varied to 71st day in very low limits. After that the crude fat decreased constantly and to 184th day reached 20, 24 and 28 g.kg^{-1} dry matter, respectively.

Nitrogen-free extract substances (NFES) content increased with the age of grasses and decreased with increasing of mineral fertilization levels. Thus, to 41st day after start of vegetation the NFES content had allied values in three fertilization levels. After that their values begin to increase and this trend was more expressed in control in comparison with fertilized variants. Average

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for the 1993-1995 period NFES content reached respectively 370 $g.kg^{-1}$ dry matter in unfertilized control as against 363 and 350 $g.kg^{-1}$ dry matter.

The advance of vegetation had a negative effect on the crude ash content as at the end of vegetation period it decreased almost 3 times. Average for three studying years the crude ash values varied from 81 $g.kg^{-1}$ dry matter ($N_{160}P_{80}$) to 90 $g.kg^{-1}$ (in unfertilized variant).

Crude protein yields and feed units.

The data in *Table 3* show that the crude protein yields are mainly influenced by the fertilization level and age of the grass stand. Thus, the data of unfertilized variant show that during the vegetation period had not considerable differences as regards to crude protein yields. The reason for that was the fact that a part of dry mass remained and always shared in yields formation, regardless of crude protein decreasing in forage. The yields in control variant were from 29.4 $t.ha^{-1}$ on 102nd day of vegetation to 35.9 $t.ha^{-1}$ on 51st day.

The application of mineral fertilization increased significantly the crude protein yields. The greatest values were reported between 71st–92nd day (91.9-97.0 $t.ha^{-1}$) after $N_{80}P_{80}$- and between 71st–102nd day (105.9-110.5 $t.ha^{-1}$) after $N_{160}P_{80}$-fertilization. Average for the studying period maximum crude protein yields was established in fertilization variants (var. 2 and 3) – 67.7 and 81.0 $t.ha^{-1}$, while in control was obtained barely 33.2 $t.ha^{-1}$, i.e. with 2.04 and 2.44 times a less.

Table 3.

Crude protein yields (in $t.ha^{-1}$) and feed units per 1 ha average for the 1993-1995 period.

Date/Day	Crude protein, $t.ha^{-1}$			Feed units per 1 ha		
	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$
01.05. (1st day)	33.9	37.3	40.5	530	585	674
10.05. (10th day)	35.7	43.0	46.4	628	704	791
20.05. (20th day)	35.8	53.0	59.0	730	918	1039
31.05. (31st day)	38.0	57.2	61.9	854	1074	1176
10.06. (41st day)	34.0	66.4	74.6	1029	1402	1602
20.06. (51st day)	35.9	76.7	90.0	1192	1830	2083
30.06. (61st day)	31.0	80.7	98.1	1409	2224	2543
10.07. (71st day)	30.7	94.3	105.9	1683	2755	3144
20.07. (81st day)	31.1	97.0	110.0	1815	2979	3230
31.07. (92nd day)	29.6	91.9	110.5	1976	3039	3274
10.08. (102nd day)	29.4	80.2	109.4	2036	3048	3361
20.08. (112th day)	30.7	74.6	96.1	2063	3029	3333
31.08. (123rd day)	30.3	71.5	94.1	2092	2939	3341
10.09. (133rd day)	34.3	67.3	89.3	2059	2971	3241
20.09. (143rd day)	34.2	60.8	83.2	2132	2890	3244
30.09. (153rd day	34.4	57.6	75.5	2058	2804	3717
10.10. (163rd day)	34.7	61.5	68.5	1921	2601	2890
20.10. (173rd day)	33.2	58.0	63.3	1662	2286	2533
31.10. (184th day)	34.5	57.3	63.3	1601	2206	2463
Average	33.2	67.7	81.0	1551.0	2225.5	2509.4

From the same table it is obvious that in all studying variants with an advance of vegetation the obtained feed units (FU) increased continuously. After that the obtained FU in all variants decreased progressive to the end of grasses vegetation. Nevertheless, their values were significantly more than in the beginning of vegetation period because a dry mass availability. The dynamic of FU accumulation was most intensive after $N_{160}P_{80}$-fertilization, while in unfertilized variant the values were lower and changed slowly during vegetation. Thus, maximum values were obtained as following: 2132 FU to 143rd day in the control, 3048 FU after $N_{80}P_{80}$-fertilization and 3361 FU after $N_{160}P_{80}$-fertilization to 102nd day. Average for the vegetation period maximum yields per 1 ha were reported in $N_{160}P_{80}$-fertilization – 2509.4 FU, following in $N_{80}P_{80}$-fertilization –

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2225.5 FU and the control – 1551.0 FU.

Conclusions

The study of a natural meadow of *Agrostis capillaris-Festuca fallax* type in the Rhodope Mountains showed that the productive potential of the grass stand was dependent on age of the grasses and the level of mineral fertilization. The greatest yields were obtained after fertilization - 3.92 t.ha^{-1} ($N_{160}P_{80}$) and 3.68 t.ha^{-1} ($N_{80}P_{80}$).

Most crude protein (320-325 g.kg^{-1} dry matter) contained the forage at the beginning of grass vegetation, while in the same period the crude fiber were at least. It was observed an opposite dependence with advance of vegetation. With the same period, the crude fat content decreased significantly but this reduction was greater in unfertilized control. Nitrogen-free extract substances content increased with the age of grasses and decreased with increasing of mineral fertilization levels. This chemical indicator varied from 350 g.kg^{-1} dry matter after $N_{160}P_{80}$-fertilization to 370 g.kg^{-1} in control. The advance of vegetation had a negative effect on the crude ash content as at the end of vegetation period it decreased almost 3 times. The crude ash values varied in small limits - from 81 g.kg^{-1} dry matter ($N_{160}P_{80}$)to 90 g.kg^{-1} (in unfertilized control).

The greatest values of the crude protein yields were reported between 71st–92nd day (from 91.9 to 97.0 t.ha^{-1}) after $N_{80}P_{80}$- and between 71st–102nd day (from 105.9 to 110.5 t.ha^{-1}) after $N_{160}P_{80}$-fertilization. Most feed units per 1 ha were obtained after fertilization with $N_{160}P_{80}$ - 2509.4 FU and with $N_{80}P_{80}$ - 2225.5 FU.

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