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DYNAMICS OF FORAGE BIOMASS ACCUMULATION IN MAIN PHENOPHASES OF A NATURAL MEADOW OF *AGROSTIS CAPILLARIS-FESTUCA FALLAX* TYPE IN THE RHODOPE MOUNTAINS (BULGARIA)

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Abstract. The purpose of this study was to establish the changes in biomass productivity and forage chemical composition in main phenophases of vegetation period of a natural meadow *Agrostis capillaris-Festuca fallax* type in the Rhodope Mountains (Smolyan region, Southern Bulgaria). The greatest dry mass yields (2.91 and 2.68 $t.ha^{-1}$) were obtained after annually fertilization with $N_{160}P_{80}$ and $N_{80}P_{80}$. With advance of vegetation (from complete stalk shooting to complete flowering) was established a decreasing of the crude protein, crude fat and crude ash contents, while in the crude fiber and nitrogen-free extract substances (NFES) was reported an increasing. The most crude protein production was obtained after fertilization with $N_{160}P_{80}$ (0.89 $t.ha^{-1}$), and at least in the unfertilized control (only 0.33 $t.ha^{-1}$). The most feed units (FU) per 1 ha also were reported in fertilization-use $N_{160}P_{80}$ (2184.33 FU) and $N_{80}P_{80}$ (1892.00 FU).

Key words: natural meadow, phenophase, biomass accumulation, chemical indicators, the Rhodope Mountains.

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). [YAKIMOVA *et al.*, 1977; CHESHMEDJIEV, 1980].

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., 1997, 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.

Together with mineral fertilization of grass stand in farming practices are important also the ways of use (for hay, for pasture or combined), i.e. the phenophase for harvesting.

The purpose of this study was to establish the changes in productivity and chemical composition of forage biomass in main phenophases 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 levels of fertilization: 1. N_0P_0 (unfertilized variant) – as a control; 2. $N_{80}P_{80}$; 3. $N_{160}P_{80}$. 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 main phenophases of grass stand as variants: 1. Complete stalk shooting; 2. Complete ear formation; 3. Complete flowering.

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

Productive potential of dry mass.

The yields of dry matter were influenced from time at the beginning of corresponding phenophase, the development of the predominant species in grass stand (*Agrostis capillaris*) as well as mineral fertilization levels. *(Table 1)* The highest dry matter yields in all three levels of mineral fertilization was established in 1995, followed by yield in 1994 and the lowest was in 1993. The main trend of yields dynamics indicated in the table was their increasing from stalk shooting phenophase to flowering as well as from unfertilized control to fertilization variants. Thus, in 1993 maximum yield (2.26 $t.ha^{-1}$) in the control was obtained in complete flowering phenophase, while after fertilization use (var. 2 and 3) – respectively 2.61 and 3.02 $t.ha^{-1}$. The yields difference in this phenophase and stalk shooting amounted to 0.9 $t.ha^{-1}$ (N_0P_0), 1.1 $t.ha^{-1}$ ($N_{80}P_{80}$) and 1.41 $t.ha^{-1}$ ($N_{160}P_{80}$). In the same year average for the fertilization levels the greatest dry mass quantity (2.31 $t.ha^{-1}$) was reported after $N_{160}P_{80}$-fertilization and at least in the control – 1.76 $t.ha^{-1}$.

Table 1.

Dry matter yields in $t.ha^{-1}$ in main phenophases and fertilization levels by years and average for the 1993-1995 period.

Phenophase	1993			1994			1995			Average for the period		
	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$
1.Complete stalk shooting	1.36	1.51	1.61	1.51	1.99	2.09	1.68	2.00	2.16	1.52	1.83	1.95
2.Complete ear formation	1.65	2.10	2.32	1.91	2.91	3.08	2.11	2.99	3.16	1.89	2.67	2.85
3.Complete flowering	2.26	2.61	3.02	2.57	3.86	4.20	2.65	4.12	4.54	2.49	3.53	3.92
Average for the fertilization level	1.76	2.07	2.31	2.00	2.92	3.12	2.15	3.04	3.29	1.97	2.68	2.91

During the next year a maximum yield was obtained again after the same fertilization level – 3.12 $t.ha^{-1}$ and it exceeded the other variants (var. 1 and 2) with 1.12 and 0.2 $t.ha^{-1}$, respectively. On the other hand in the control variant the greatest yield value was reported in complete flowering – mostly with 1.06 and 0.66 $t.ha^{-1}$ in comparison with the other two phenophases. After fertilization use (var. 2 and 3) these yield differences between phenophases were respectively 1.87, 0.95 $t.ha^{-1}$ and 2.11, 1.12 $t.ha^{-1}$.

In the last studying year (1995) average maximum yields were obtained in fertilization variants and at least in the control – 3.29 and 3.04 $t.ha^{-1}$ as against 2.15 $t.ha^{-1}$. The yields exceeding in the flowering toward other phenophases varied between 0.97 and 0.54 $t.ha^{-1}$ (in control), 2.12 and 1.13 $t.ha^{-1}$ (after $N_{80}P_{80}$), 2.38 and 1.38 $t.ha^{-1}$ (after $N_{160}P_{80}$).

Average for the 1993-1995 period regardless of the three fertilization levels the most dry matter yields were reported during the complete flowering phenophase – respectively exceeding the other phases (stalk shooting and ear formation) with 1.97 and 1.07 $t.ha^{-1}$ (after $N_{160}P_{80}$), 1.70 and 0.86 $t.ha^{-1}$ (after $N_{80}P_{80}$) as against 0.97 and 0.60 in the unfertilized control.

It is obvious that the different fertilization levels not only increased dry matter yields but also reduced the negative effect of the grasses age. Average for the three fertilization levels in fertilization variants were obtained 2.91 and 2.68 $t.ha^{-1}$ dry mass as against 1.97 $t.ha^{-1}$ in the control.

Chemical composition of the grass biomass.

Under the influence of grass stand age, respectively by turns of phenophase, occurred different changes in the chemical composition of the forage biomass. *(Table 2)* With advance of vegetation (from complete stalk shooting to complete flowering) was reported a decreasing of the crude protein, crude fat and crude ash contents, while in the crude fiber and nitrogen-free extract substances (NFES) was established an increasing. Thus, the most crude protein was accumulated in stalk shooting phase after $N_{160}P_{80}$-fertilization - 352 $g.kg^{-1}$ a dry matter. At least protein in forage was reported in complete flowering without fertilization (control) – 117 $g.kg^{-1}$ a dry matter. The fertilization with $N_{80}P_{80}$ and $N_{160}P_{80}$ reduced the adverse influence of the grasses age and increased the accumulation of crude protein. So, average for the fertilization levels the crude protein increased from 182.00 $g.kg^{-1}$ a dry matter in unfertilized control to 294.67 $g.kg^{-1}$ a dry matter ($N_{80}P_{80}$) and 313.33 $g.kg^{-1}$ a dry matter ($N_{160}P_{80}$).

Table 2.

Chemical composition of the grass biomass ($g.kg^{-1}$ a dry matter) in main phenophases and fertilization levels average for the 1993-1995 period.

Phenophase	Crude protein			Crude fiber			Crude fat		
	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$
1.Complete stalk shooting	262	337	352	217	184	170	54	55	58
2.Complete ear formation	167	284	307	322	243	211	52	54	56
3.Complete flowering	117	263	281	373	260	237	48	50	52
Average for the fertilization level	182.00	294.67	313.33	304.00	229.00	206.00	51.33	53.00	55.33

Continuation of Table 2.

Phenophase	NFES			Crude ash		
	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$
1.Complete stalk shooting	325	320	307	142	104	113
2.Complete ear formation	355	344	336	104	75	90
3.Complete flowering	377	354	349	85	73	81
Average for the fertilization level	352.33	339.33	330.67	110.33	84.00	94.67

And vice versa, the increasing of nitrogen fertilization level reduced the crude fiber content in different phenophases. So, in stalk shooting phase the decreasing of fiber was with 33 $g.kg^{-1}$ a dry matter ($N_{80}P_{80}$) and reached to 47 $g.kg^{-1}$ a dry matter ($N_{160}P_{80}$) in comparison with unfertilized control (217 $g.kg^{-1}$ a dry matter). During the next phenophases these differences were even greater: in ear formation - 79 $g.kg^{-1}$ a dry matter after $N_{80}P_{80}$-fertilization and 111 $g.kg^{-1}$ a dry matter after $N_{160}P_{80}$; in flowering - 113 $g.kg^{-1}$ a dry matter after $N_{80}P_{80}$ and 136 $g.kg^{-1}$ a dry matter after $N_{160}P_{80}$.

With advance of vegetation the crude fat content decreased as from 54 $g.kg^{-1}$ a dry matter (in stalk shooting) reduced to 48 $g.kg^{-1}$ a dry matter (in flowering) without

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fertilization, but after $N_{80}P_{80}$ and $N_{160}P_{80}$ reached to 50 and 52 $g.kg^{-1}$ a dry matter, respectively. Thus, average for the fertilization levels the crude fat had comparatively allied values – from 51.33 $g.kg^{-1}$ a dry matter (N_0P_0) to 55.33 $g.kg^{-1}$ a dry matter ($N_{160}P_{80}$). It is obvious that the fertilization during the corresponding phenophase increased the crude fat content.

With advance of vegetation the nitrogen-free extract substances (NFES) increased the quantity, but with application of mineral fertilization was reduced their content in grass biomass. Average for the three main phenophases the NFES content from 352.33 $g.kg^{-1}$ a dry matter (N_0P_0) reduced to 330.67 $g.kg^{-1}$ a dry matter ($N_{160}P_{80}$). The introducing of mineral fertilizers ($N_{80}P_{80}$ and $N_{160}P_{80}$) reduced in some degree the NFES values in all phenophases – from 325 $g.kg^{-1}$ a dry matter (in stalk shooting) to 320 and 307 $g.kg^{-1}$ a dry matter; from 355 $g.kg^{-1}$ a dry matter (in ear formation) to 344 and 336 $g.kg^{-1}$ a dry matter and from 377 $g.kg^{-1}$ a dry matter (in flowering) to 354 and 349 $g.kg^{-1}$ a dry matter.

The age of the grass stand depends on the crude ash content in dry matter. Thus, in the younger age of the grasses, the obtained fodder had high ash content, and with advancing age decreased. In phase stalk shooting and in control variant it was 142 $g.kg^{-1}$ crude ash in a dry matter and decreased to 85 $g.kg^{-1}$ in the flowering. The mineral fertilization use also reduced the ash content in grass biomass. Thus, in $N_{80}P_{80}$ - fertilization and in stalk shooting phase it decreased from 104 $g.kg^{-1}$ of 73 $g.kg^{-1}$ and in fertilization with $N_{160}P_{80}$ - from 113 $g.kg^{-1}$ reduced to 81 $g.kg^{-1}$ a dry matter in flowering phase. As it seen, with the beginning of next phenophases the non-use of mineral fertilizers as well as a fertilization reduced the amount of crude ash content in the forage. Average for the fertilization levels the greatest crude ash content (110.33 $g.kg^{-1}$ a dry matter) was reported in the control, following by $N_{160}P_{80}$ (94.67 $g.kg^{-1}$) and $N_{80}P_{80}$ (84.00 $g.kg^{-1}$).

Productive potential of crude protein and feed units.

The data of crude protein yields *(Table 3)* showed that with advance of vegetation (from complete stalk shooting to complete flowering phases), the amount of this indicator was reduced but only in the unfertilized variant - from 0.40 to 0.29 $t.ha^{-1}$. In variants with fertilization was established opposite trend as follows: with $N_{80}P_{80}$ - from 0.62 $t.ha^{-1}$ reached 0.93 $t.ha^{-1}$ and with a $N_{160}P_{80}$ - from 0.69 $t.ha^{-1}$ increased to 1.10 $t.ha^{-1}$. Average for the studying fertilization levels, most protein was obtained after fertilization with $N_{160}P_{80}$ - 0.89 $t.ha^{-1}$, and at least in the control - only 0.33 $t.ha^{-1}$.

Table 3.

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

Phenophase	Crude protein yields, $t.ha^{-1}$			Feed units per 1 ha		
	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$	N_0P_0	$N_{80}P_{80}$	$N_{160}P_{80}$
1. Complete stalk shooting	0.40	0.62	0.69	864	1101	1210
2. Complete ear formation	0.31	0.76	0.87	1305	1893	2167
3. Complete flowering	0.29	0.93	1.10	1844	2682	3176
Average for the fertilization level	0.33	0.77	0.89	1337.67	1892.00	2184.33

From the same table shows that the obtained feed units (FU) per 1 ha increased from complete stalk shooting to complete flowering phenophases as well as control and fertilization variants. The increasing of the FU yields with together increasing of the grasses age, due to the continuous growth of forage dry mass in vegetation. For example, in unfertilized variant in complete stalk shooting phase the FU yield was 864 $FU.ha^{-1}$ and reached 1844 $FU.ha^{-1}$ in complete flowering (average 1337.67 $FU.ha^{-1}$). In comparison with control the mineral fertilization significantly increased the obtained FU. Thus, in stalk shooting phase the yield increased from 1101 FU.ha^{-1} in fertilization with $N_{80}P_{80}$ to 1210 FU.ha^{-1} in $N_{160}P_{80}$ - fertilization, and in complete flowering from 2682 FU.ha^{-1} to 3176 FU.ha^{-1}. The average values of this forage quality indicator amounted to 1892.00 and 2184.33 FU.ha^{-1} for the relevant fertilization level.

Conclusions

The experiment with a natural meadow of *Agrostis capillaris-Festuca fallax* type in Rhodope Mountains (Smolyan region, Southern Bulgaria) shows that according to main phenophases there were changes in quantitative and qualitative productivity and dynamics of the most important chemical indicators of the forage.

The greatest dry mass yields (2.91 and 2.68 t.ha^{-1}) were obtained after annually fertilization with $N_{160}P_{80}$ and $N_{80}P_{80}$.

With advance of vegetation (from complete stalk shooting to complete flowering) was established a decreasing of the crude protein, crude fat and crude ash contents, while in the crude fiber and nitrogen-free extract substances (NFES) was reported an increasing.

The most crude protein production was obtained after fertilization with $N_{160}P_{80}$ (0.89 t.ha^{-1}), and at least in the unfertilized control (only 0.33 t.ha^{-1}). The most feed units (FU) per 1 ha also were reported in fertilization-use $N_{160}P_{80}$ (2184.33 FU) and $N_{80}P_{80}$ (1892.00 FU).

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