UDK 633.31:631.523

Portion of Alfalfa Leaves in Yield Depending on Genotypes and Developmental Stages

- Original scientific paper -

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Abstract: Portion of leaves in alfalfa dry matter yield at different stages of the growth has been examined in the second and the third year of plant the development. The study was conducted in the Rimski Šančevi experiment field of the Institute of Fields and Vegetable Crops in Novi Sad using standard cultivation practices. The study included three alfalfa varieties, NS Banat ZMS II, Orca, Du Puits, and two genotypes, Syn II and Syn III. The genotypes had been developed at the Institute of Fields and Vegetable Crops within a programme on cultivars improvement. Portions of leaves were measured in five growth stages: early vegetative, mid-vegetative, late vegetative, early bud and late bud-early flower. Furthermore, a portion of leaves in yield was evaluated from the first growth to the fifth regrowth in 1997 and from the second to the fifth regrowth in 1998. It was found that the portion of leaves in dry matter yield depended significantly on the cultivar. NS Banat ZMS II had the lowest portions of leaves from the early vegetative stage to the beginning of flowering. The portion of leaves in dry matter yield was the highest in the early vegetative stage, gradually becoming lower until the stage of flowering. Fastest changes in the portion of leaves occurred from the late vegetative stage to the bud stage. The portions of leaves in dry matter yield were the lowest in the second and the third regrowth, and a somewhat higher in the fourth and the fifth regrowth. Significant differences in the portion of leaves in green forage and dry matter yield existed between the early vegetative stage and the early bud stage. Higher values were obtained by measuring the portion of leaves in dry matter. There were no significant differences in the portions of leaves in green forage and in dry matter between bud and flowering stage.

Key words: Alfalfa, genotype, growth, portion of leaves, stages of growth.

Introduction

As the alfalfa plant grows and develops, the portion of leaves in green forage yield decreases and the portion of stems increases. At the beginning of flowering, the portion of leaves makes a half of the green forage yield, ***Hill et al.,*** 1988. ***Čobić et al***., 1989, reported that six alfalfa cultivars had the portion of leaves in green forage yield ranging from 37.5% to 45.2% in the first growth, 36.9% to 45.9% in the second regrowth, 39.3% to 45.9% in the third regrowth, 46.1% to 53.1% in the fourth regrowth and from 54.1% to 70.0% in the fifth regrowth. In dry matter yield, however, portion of leaves was 41.5% and the portion of stems 58.5%, ***Jiakai*** and ***Wenshu***, 1988, with insignificant differences among cultivars. There are no significant differences in the portions of leaves and stems in different years of alfalfa growing, ***Ivanov***, 1980. The lamina size and form do have an influence on the proportion of leaves and stems, ***Ivanov***, 1980, ***Fick et al***., 1988. In the first growth, the portion of leaves in the total yield is small, ***Mijatović***, 1960, ***Ivanov***, 1980, ***Čobić et al***., 1989. During the first growth, shoots come from crown buds; in later regrowths, most shoots arise from axillary basal buds, ***Mijatović***, 1960, ***Nelson*** and ***Smith***, 1968. A poor leaves to stems ratio in the first growth is also due to daylength, ***Massengale et al***., 1971, differences between day and night temperatures, ***Greenfield*** and ***Smith***, 1973, or a moisture shortage in the summer period, ***Onstad*** and ***Fick***, 1983.

Leaves are more digestible and better quality than stems because of higher contents of proteins and vitamins, ***Buxton et al***., 1985, ***Kalu*** and ***Fick***, 1981. Digestibility and the nutritional value increase in proportion with the increase in the portion of leaves in yield, ***Rowe***, 1988, ***Rotili et al***., 2001. As the plant matures, the portion of stems increases and the portion of leaves decreases, which is important for alfalfa quality, ***Onstad*** and ***Fick***, 1983. Leaves contain more crude proteins, vitamins, fats and some mineral elements than stems, ***Ivanov***, 1980. An increase in the air temperature from 15-20ºC to 25-30ºC results in the reduced leaf area, thickness, weight and intercellular space in the leaf, ***Bula***, 1972, ***Pearson*** and ***Hunt***, 1972, ***Wolf*** and ***Blaser***, 1971. As the air temperature increases, leaf form changes from generally obovate to generally oblandceolate, and the length to width ratio of the lamina is reduced, ***Fick et al***., 1988. The leaf area increases in the proportion with the rate of the reduction of light intensity, ***Cooper***, 1967. However, the relationship between the leaf area and the photosynthetic activity is not linear, but rather complex, ***Wilfong et al***., 1967.

According to ***Ivanov***, 1980, cultivars of blue and hybrid alfalfa and some natural populations have round, oval, obovate or wedge-shaped laminas. Laminas of yellow alfalfa are smaller, often light green in colour and elongated. According to this author, the variability in the portion of leaves is higher in blue alfalfa than in hybrid alfalfa, and the highest variability being in French cultivars.

The aim of this study was to determine the portion of leaves in alfalfa yield in different growth stages for five alfalfa cultivars. The results should improve our knowledge of the biology of vegetative and generative development of this plant species. Also, information about changes in quality of dry matter in alfalfa genotypes during their growth and development will be obtained.

Material and Methods

A field trial was established in 1996 in slightly calcareous carbonate chernozem at the Rimski Šančevi experiment field of the Institute of Field and Vegetable Crops in Novi Sad, applying standard cultivation practices. Experiments were conducted according to randomised block design with five replicates. The elementary plot size was $5m^2$ and the seeding rate was 15 kg ha^{-1}. Leaves were separated from stems and the portion of leaves measured in green bulk and in dry matter. Sample size was 100-150 g. The samples were dried at 65°C for 72 hours.

The trial included fivd alfalfa cultivars (factor A). NS Banat ZMS II has a high yield of dry matter, Orca is resistant to lodging and viral infections and Du Puits is of high quality. The genotypes Syn I and Syn II had been developed at the Institute of Field and Vegetable Crops within the programme on cultivars improvement.

The portion of leaves in five stages of growth was determined by the method of ***Kalu*** and ***Fick***, 1981, (factor B):

0 - early vegetative - stems 15 cm long, no buds, flower or seed pods
1 - mid-vegetative - stems 16-30 cm long, no buds, flower or seed pods
2 - late vegetative - stems 30 cm long, no buds, flower or seed pods
3 - early bud, one or two nodes with visible buds, or one nod with an open flower
4-5 - late bud, early flower - three nodes with buds, or one nod with open flower

The portions of leaves in yield were evaluated from the first to the fifth growth in 1997 and from second to fifth growth in 1998 (factor C).

Samples were taken at five-day intervals from the stage of the vegetative regrowth (10 days after cutting) until the stage of early flower. In the first growth in 1997, samples were taken at ten-day intervals starting 15 days after solstice.

The obtained data were processed by the three-factorial analysis of variance. Differences among treatments were examined by the LSD test.

Results and Discussion

The portion of leaves in dry matter yield was found to significantly depend on cultivars and the growth stage in both years (Tables 1 and 2).

NS Banat ZMS II had significantly lower portions of leaves from the early vegetative stage (71.1% and 67.8%) to early flower (46.0% and 45.3%) than other cultivars in both years. Differences among the other cultivars were not significant. The results indicate that it is possible to obtain important information on the portion of leaves in yield and quality of dry matter from the early vegetative to the early flower stage. Such information may be useful in alfalfa breeding for high quality.

The highest portions of leaves in yield found for all cultivars in the earliest vegetative stage (74.1% and 70.9%), were significantly reduced by the stage of early flower to 48.8% and 47.7% in 1997 and 1998, respectively. The fastest reduction in

Table 1. Portion of Leaves in Dry Matter Yield at Ddifferent Growth Stages of Alfalfa in 1997
Udeo listova u prinosu suve materije u različitim fazama rasta lucerke u 1997.

Cultivar Genotip	Cutting Otkos	Stage - Faza					$\bar{x}$
		0	1	2	3	4 - 5	
Banat	I	69.6	67.5	55.8	44.0	39.2	55.2
	II	72.6	61.8	53.6	52.2	50.4	58.1
	III	73.1	64.5	53.9	42.7	39.2	54.7
	IV	76.6	70.3	63.3	55.6	46.9	62.5
	V	63.6	60.5	54.3	55.1	56.4	58.0
	$\bar{x}$	71.1	65.0	56.7	45.0	46.0	57.7
Syn. II	I	73.9	72.0	53.7	41.1	47.2	57.6
	II	71.7	66.1	59.5	55.7	52.3	61.1
	III	78.6	74.3	55.3	50.0	54.1	62.5
	IV	81.6	74.3	64.5	59.5	51.5	66.3
	V	69.4	61.8	66.9	59.1	55.0	62.4
	$\bar{x}$	75.0	69.7	56.0	53.1	52.0	62.0
Syn. III	I	72.9	70.9	55.8	43.2	43.2	57.2
	II	71.6	65.8	61.6	57.2	52.0	61.6
	III	83.0	66.5	60.6	42.4	45.3	59.6
	IV	78.0	76.9	68.3	64.4	49.5	67.4
	V	68.9	66.4	62.0	58.6	55.4	62.3
	$\bar{x}$	74.9	69.3	61.7	53.2	49.1	61.6
Du Puits	I	75.5	66.8	54.8	43.9	43.9	57.0
	II	71.7	69.6	58.0	56.4	53.6	61.9
	III	78.2	70.1	53.1	43.2	48.1	58.5
	IV	81.9	73.7	72.7	62.1	52.7	68.6
	V	68.1	58.6	59.5	58.6	55.4	60.0
	Mean	75.1	67.8	59.6	52.8	50.7	61.2
Orca	I	72.4	73.4	58.5	43.7	39.3	57.5
	II	70.6	68.1	61.7	54.9	47.1	60.5
	III	78.5	72.0	52.9	42.2	36.5	56.4
	IV	80.4	73.2	71.1	60.5	51.8	67.4
	V	71.1	65.8	61.8	56.0	56.3	62.2
	$\bar{x}$	74.6	70.5	61.2	51.0	46.2	60.8
$\bar{x}$		74.1	68.5	59.0	51.1	48.8	60.7

		cv. genotip	cutting oktos	stage faza	cv. x cutting genotip x otkos	cv. x stage genotip x faza	cutting x stage otkos x faza
LSD	0.05	1.07	1.07	1.20	2.41	2.69	2.41
	0.01	1.44	1.44	1.59	3.18	3.56	3.1

in the leaf portion occurred from the mid-vegetative stage (68.5% and 62.9%) to the stage of bud formation (51.1% and 48.9%). According to ***Marten et al***., 1988, the reduction of leaf is fastest until the middle of budding. Before budding, the portion of leaves is higher than the portion of stems. The ratio is 48.9% vs. 51.1% at the

Table 2. Portion of Leaves in Dry Matter Yield at Ddifferent Growth Stages of Alfalfa in 1998
Udeo listova u prinosu suve materije u različitim fazama rasta lucerke u 1998.

Cultivar Genotip	Cutting Otkos	Stage - Faza					$\bar{x}$
		0	1	2	3	4 - 5	
Banat	I	-	-	-	-	-	-
	II	650	0.629	0.525	0.381	0.365	0.510
	III	0.755	0.551	0.490	0.430	0.378	0.521
	IV	0.615	0.489	0.507	0.449	0.449	0.502
	V	0.690	0.707	0.651	0.587	0.620	0.651
	$\bar{x}$	0.678	0.594	0.543	0.462	0.453	0.546
Syn. II	I	-	-	-	-	-	-
	II	0.707	0.648	0.586	0.451	0.451	0.569
	III	0.797	0.581	0.515	0.418	0.401	0.542
	IV	0.650	0.593	0.537	0.502	0.485	0.553
	V	0.723	0.676	0.655	0.638	0.633	0.665
	$\bar{x}$	0.719	0.625	0.573	0.502	0.493	0.582
Syn. III	I	-	-	-	-	-	-
	II	0.748	0.692	0.571	0.426	0.400	0.567
	III	0.826	0.610	0.475	0.387	0.389	0.530
	IV	0.561	0.590	0.541	0.464	0.458	0.523
	V	0.706	0.755	0.668	0.659	0.611	0.680
	$\bar{x}$	0.710	0.662	0.564	0.484	0.465	0.577
Du Puits	I	-	-	-	-	-	-
	II	0.764	0.622	0.573	0.408	0.408	0.555
	III	0.855	0.594	0.505	0.423	0.378	0.551
	IV	0.625	0.564	0.579	0.516	0.516	0.560
	V	0.696	0.756	0.674	0.629	0.637	0.678
	Mean	0.735	0.634	0.583	0.494	0.485	0.586
Orca	I	-	-	-	-	-	-
	II	0.729	0.670	0.566	0.439	0.439	0.569
	III	0.826	0.618	0.454	0.429	0.378	0.541
	IV	0.648	0.546	0.585	0.525	0.491	0.559
	V	0.609	0.692	0.674	0.620	0.640	0.647
	$\bar{x}$	0.703	0.632	0.570	0.503	0.487	0.579
$\bar{x}$		70.9	62.9	56.7	48.9	47.7	57.4

		cv. genotip	cutting oktos	stage faza	cv. x cutting genotip x otkos	cv. x stage genotip x faza	cutting x stage otkos x faza
LSD	0.05	1.23	1.10	1.23	2.46	2.69	1.74
	0.01	1.63	1.45	1.63	3.25	3.64	2.30

beginning of budding, after which period the portion of leaves steadily decreases. Significant differences in the portion of leaves in dry matter yield were registered among the growths (Table 3).

The lowest portions of leaves and the fastest reduction were observed in

Table 3. Portion of Leaves in Yields of Green Forage (G) and Dry Matter (D) in Five Alfalfa Cultivars
Udeo listova u prinosu zelene krme (G) i suve materije (D) kod pet genotipova lucerke

Growth stage Faza rasta		1997				1998				$\bar{x}$
		II	III	IV	V	II	III	IV	V	
0	G	58.1	74.8	72.1	57.5	62.3	73.9	52.6	61.7	64.1
	D	69.3	78.3	79.7	68.2	72.0	81.2	62.0	68.5	72.4
1	G	55.9	59.6	62.6	54.2	52.9	50.2	48.4	65.6	56.2
	D	63.3	68.9	66.7	61.6	65.2	59.1	56.4	71.7	64.1
2	G	49.1	45.8	56.6	53.3	49.1	47.7	50.6	63.7	52.8
	D	57.7	54.4	68.0	60.3	56.4	48.7	53.8	66.4	58.2
3	G	46.1	-	51.0	55.8	-	44.8	-	66.9	52.9
	D	55.3	-	60.4	52.8	-	41.7	-	62.7	54.6
4	G	42.3	41.3	46.4	51.7	39.9	40.1	49.8	63.6	46.9
	D	45.5	43.9	51.7	51.9	42.1	38.5	49.1	62.8	48.2
$\bar{x}$	G	55.2	60.4	62.6	57.3	56.8	54.2	53.4	65.6	54.4
	D	53.8	56.0	60.3	56.6	53.9	50.2	52.9	65.8	56.2

		growth rast	growth stage faza rasta	G or D G ili D
LSD	005	4.24	4.74	3.00
	001	5.64	6.31	3.99

regrowth stages II (53.8% and 55.2%) and III (56.0% and 60.4%) in 1997 and in stages II (53.9% and 56.8%), III (50.2% and 54.2%) and IV (52.9% and 53.45) in 1998. These regrowth stages coincided with the warmest and driest periods in both years, with the longest photoperiod and sun-hours. ***Bula***, 1972, reported that a temperature increase from 15-20ºC to 25-30ºC - decreased the portion of leaves in the yield. Increased portions of leaves in stage IV (62.6% and 60.35) in 1997 and the stage V (65.6% and 65.8%) in 1998 were due to lower temperatures, less sun-hours and increased soil moisture during these periods, ***Evans*** and ***Peaden***, 1984.

There were significant differences among the portions of leaves in alfalfa yield expressed per both, green forage and dry matter (Table 3). In the early stages, from early vegetative to early budding, the portion of leaves was higher when measured in dry matter. During these stages, alfalfa leaves had a higher percentage of dry matter than stems, ***Katić et al***., 1998, which was more evident in dried samples than in green forage. There was no significant differences among the portions of leaves in green forage or dry matter in the late bud stage because the leaves and stems had practically identical contents of dry matter from the early bud to early flower, ***Katić et al***., 1998. From the early flower to the early pod stage, there was a steady increase in the portion of stems. After the early flower stage, the portion of leaves was higher if measured in green forage than in dry matter.

Conclusions

The portion of leaves in dry matter yield at different stages of alfalfa regrowth depends significantly on cultivar. NS Banat ZMS II had the lowest portions of leaves from early vegetative to the early flower. The portions of leaves in dry matter yield were highest in the early vegetative stages, getting lower in later stages. The fastest reduction in the portion of leaves occurred from the late vegetative stage to the bud stage. The lowest portions of leaves in dry matter yield were registered in regrowth stages II and III, which proceeded in the warmest and driest periods, with the longest photoperiod and sun-hours. The higher portion of leaves in regrowth stages IV and V were due to lower temperatures, shorter days, less sun-hours and reduced soil moisture during that period. From the early vegetable stage to the and early bud stage, significant differences were obtained in the portion of leaves in dependence on a measurement method - in green forage or in dry matter. Higher values were obtained with the latter method. The measurement method was of no importance from the bud to the early flower stage.

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Received: 26/04/2003
Accepted: 14/07/2002

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UDK 633.31:631.523

Udeo listova u prinosu lucerke zavisno od genotipa i faze razvića

- Originalni naučni rad -

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R e z i m e

U drugoj i trećoj godini života biljka utvrđivan je udeo listova u prinosu suve materije lucerke u različitim fazama porasta i razvića na oglednom polju Instituta za ratarstvo i povrtarstvo u Rimskim Šančevima uz standardne agrotehničke mere.

U ispitivanja je su uključene tri sorte lucerke, NS Banat ZMS II, Orca, Du Puits, i dva genotipa, Syn II i Syn III, stvoreni u Institutu u cilju dobijanja sorti boljeg kvaliteta. Određen je udeo lišća za pet faza razvića: rana vegetativna, srednje vegetativna, kasna vegetativna faza, zatim početak butonizacije i puna faza butonizacije - početak cvetanja. Udeo listova u prinosu je ocenjen od prvog do petog porasta 1997. godine, i od drugog do petog porasta u 1998.

Udeo lišća u prinosu suve materije u različitim fazama porasta i razvića lucerke značajno zavisi od genotipa. Najmanji udeo lišća u prinosu suve materije imala je sorta NS Banat ZMS II od rane vegetativne do faze početka cvetanja.

Najveći udeo listova u prinosu suve materije bio je u ranoj vegetativnoj fazi i značajno se smanjivao do faze početka cvetanja. Najbrže se smanjuje udeo listova od kasne vegetativne do faze butonizacije. Najmanji udeo listova u prinosu suve materije lucerke bio je u II i III, a veći IV i V otkosu. Merenje udela listova u zelenoj krmi ili suvoj materiji se značajno razlikuje od rane vegetativne do faze početka butonizacije. Dobijen je veći udeo lista merenjem u suvoj materiji. U fazama butonizacije i početka cvetanja razlike dobijene određivanjem udela listova u zelenoj krmi ili suvoj materiji nisu značajne.

Primljeno: 26.01.2002.
Odobreno: 16.07.2002.

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