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FORAGE QUALITY ANALYSIS AND EVALUATION OF PERENNIAL GRASSES IN THE VEGETATION

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Abstract

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The changes in protein and plant cell wall fiber components content, studied by classical chemical Weende and detergent systematic process of Goering and Van Soest for analysis of plant cell wall components content, assuring forage nutritive value estimation and *in vitro* enzymatic digestibility of original Bulgarian varieties of perennial grasses: orchardgrass (*Dactylis glomerata* L.), var. **"Dabrava"**; tall fescue (*Festuca arundinacea* Schreb.), var. **"Albena"**, smooth bromegrass (*Bromus inermis* Leyss.), var. **"Nika"** are presented. The study was carried out at the Institute of Forage Crops, Pleven as a part of its breeding program in the last decade. Comparative analysis in plant cell walls fiber components content was effectuated between three plant species. The mean day rate changes and degree of grass lignification were established. The possibility of rapid evaluation of changes in composition content and digestibility in the vegetation process was studied by scanning spectral analysis in near infrared region of the spectrum (NIRS - Near Infrared Reflectance Spectroscopy Analysis). The calibration models in NIRS with enlargement of the value region for each parameter in the vegetation process, in difference of the harvesting in definite vegetative stage, demonstrate increasing the prediction accuracy – Coefficients of determination over R 0.90. The three perennial grass species composition and digestibility was determined with high accuracy by linear regression models with plant age in days from the beginning of the vegetation as independent modified quantity.

Key words: Perennial grasses – Vegetation – *in vitro* digestibility – Plant cell walls fiber components – NIRS – Linear regressions

Резюме

Найденова Й., 2012. Анализ и оценка качеството на фураж от многогодишни житни треви през вегетацията. FCS 8(1):111-128

Представени са промените в състава на протеин и структурни влакнинни компоненти на клетъчните стени, проучени чрез класическия химичен Weende анализ, детергентен систематичен ход на Goering и Van Soest за анализ компонентите на клетъчните стени, осигуряващ оценката на енергийната хранителна стойност на фуража и in vitro ензимната смилаемост на сухото и органично вещество на фуража на оригинални български сортове многогодишни житни треви: ежова главица (Dactylis glomerata L.), сорт "Дъбрава", тръстиковидна власатка (Festuca arundinacea Schreb.), сорт "Албена", безосилеста овсига (Bromus inermis Leyss.), сорт "Ника". Проучванията са изведени в Института по фуражните култури, Плевен при реален селекционен процес през последното десетилетие. Направен е сравнителен анализ в съдържанието на влакнинните компоненти между трите растителни вида. Установен е среднодневният им темп на промяна и степента на лигнификация. Чрез Сканиращ спектрален анализ в близката инфрачервена област на спектъра (NIRS - Near Infrared Reflectance Spectroscopy Analysis) е проучена възможността за бърза оценка на промените в състава и смилаемостта през вегетацията. Калибрационните модели в NIRS с увеличаване обхвата на стойностите за всеки един показател по време на вегетацията за разлика от прибиране на растенията в определена фаза на развитие, показват увеличение точността на предвиждане – коефициенти на детерминация над 0,90. Съставът и смилаемостта при трите вида житни треви се определят с много добра точност с линейни регресионни уравнения чрез възрастта на растенията в дни от началото на вегетацията като независима променлива величина.

Ключови думи: Житни треви – Вегетация – in vitro смилаемост – Влакнинни компоненти на клетъчни стени – NIRS – Линейни регресии

INTRODUCTION

Perennial grasses: orchardgrass (*Dactylis glomerata* L.), tall fescue (*Festuca arundinacea* Schreb.) and smooth bromegrass (*Bromus inermis* Leyss.) are the most important forage grass crops in Bulgaria in development of stable forage base for ruminant farming in marketing conditions. They are the components of the grass-legume mixtures for grass production in grazing or as hay, silage, haylage (Tomov 1987; Peeters 2004). For each of the three perennial species were developed country varieties **"Dabrava", "Albena", "Nika"** (Tomov 1987; Katova 2007). Combining breeding process of vegetative reproducing themselves perennial grasses by phenotype established perennial grasses with breeding for forage quality – composition, digestibility and feeding value, the new initial material for breeding of new varieties with improved quality characteristics were created (Naydenova et al. 1998, 2001; Naydenova 2008, 2009). The changes leading to strong decreasing in nutritive effect of plant growing, in forage grass vegetation process, come on (Pavlov 1996). Theirs establishment is connected with applying of rapid, accurate and low cost laboratory methods and systems for evaluation of chemical composition, digestibility and feeding value. Plant cell walls fiber components and lignification are keys towards development and improvement of laboratory methods for forage quality evaluation (Brink et al. 2007; Fahey&Hussein 1999; Casler&Vogel 1999; Casler&Jung 2006; Casler et al. 2000).

Plant cell walls fiber components content determination as new parameters of forage quality is standardized in European Community and will be more significant (EN ISO13906 2008). Digestibility, determined *in vitro* by enzymes is rapid and promising method and it application in plant-growing, where small quantity of large number accessions of species, varieties, genotypes, cuts must be evaluated in breeding process or technological decisions (Buxton&Redfearn 1997; Casler et al. 2000).

The aim of the study is to establish the changes in plant cell walls fiber components content – polyosides and lignin and digestibility of principal for the country forage perennial grasses: orchardgrass (*Dactylis glomerata* L.), variety **"Dabrava"**, tall fescue (*Festuca arundinacea* Schreb.), variety **"Albena"** and smooth bromegrass (*Bromus inermis* Leyss.), variety **"Nika"** as forage crops and possibilities for their prediction by Near Infrared Reflectance Spectroscopy and regression analysis in point of view to develop of new varieties with improved forage quality.

MATERIAL AND METHODS

Plant material for forage quality evaluation in the vegetation is presented by following varieties from three perennial grass species, developed in the Institute of Forage Crops – Pleven, Bulgaria, asknowledged by State variety commission as standards in the country (*Dactylis glomerata* L.), variety **"Dabrava"**, tall fescue (*Festuca arundinacea* Schreb.), variety **"Albena"** and smooth bromegrass (*Bromus inermis* Leyss.), variety **"Nika"**, growing in the clone collection nurseries. All plant materials are part of breeding experiments of perennial grasses of the Institute of Forage Crops, Pleven*, lead off by Prof. Petar Tomov. In the vegetation process in a week periods, the changes in fiber components content, digestibility and feeding value are established at representative for the species (variety) perennial grasses, duplicate samples from collection nurseries for each from the three species (variety). For the beginning of the study is accepted conditional four-week plant age (pasture stage) after beginning of the active vegetation (Barton 1976). Eight-weekly periods in the first growth, and six in the second (aftergrass) are established. The plant development stages are defined (Table 1.)

Table 1. Dates and phonological stages in study of perennial grass composition and feeding value

Таблица 1. Дати и фази на развитие при проучване състава и хранителността на житни треви

Вид/Сорт Crop/Variety		Dactylis glomerata L., var. "Dabrava"	Festuca arundinacea Schreb., var. "Albena"	Bromus inermis Leyss., var. "Nika"
Week	Дата/Date	Фаза на развитие / Development stage		
Първи подраст / First growth				
4	18 April	Пасищна/ Pasturestage	Пасищна/Pasture stage	Пасищна/ Pasturestage
5	25 April	-"-	-"-	-"-
6	02 May	Early heading	-"-	-"-
7	09 May	-"-	-"-	Early heading
8	16 May	Изметляване/ Heading	Early heading	-"-
9	23 May	Цъфтеж/ Flowering	-"-	Изметляване/ Heading
10	29 May	-"-	Изметляване/Heading	Цъфтеж/Flowering
11	06 June	-"-	Цъфтеж/Flowering	-"-
Отава / Aftergrass				
6	27 June	Братене/ Tillering	Братене/ Tillering	Братене/ Tillering
7	04 July	-"-	-"-	-"-
8	11 July	-"-	-"-	-"-
9	18 July	-"-	-"-	-"-
10	25 July	-"-	-"-	-"-
11	01August	-"-	-"-	-"-

Plant sample preparation from the above ground part of the plants is effectuate by air ventilation at 65^0C till crumbly at previous fixing for 20 min at 105^0C and grinding till particle size 1,0 mm consecutively at laboratory mills QC 136 and QB 114, Labor Mim, Hungary and obligatory screen. Weende systematic analytic procedure (AOAC 2000) is applied and the parameters are established*: Dry matter; Crude ash (Mineral matter, MM); Crude protein (CP)* by Kjeldhal method at Autoanalyser, Tekator, Sweeden; *Crude fiber (CF)* - by Heneberg&Stoman method, adapted for Fibertec M analyser, Tekator, Sweeden.

Detergent analysis of Goering&Van Soest (1970) was performed as a standard systematic chemical analysis of plant cell walls fiber components. The following fiber fractions: *Неутрално-детергентни влакнини / Neutral-detergent fiber (НДВ/NDF)*; *Киселинно-детергентни влакнини/Acid-detergent fiber (КДВ/ADF)*, *Киселинно-детергентен лигнин / Acid-detergent lignin (КДЛ/ADL) are determined*. Polyosides hemicellulose and cellulose as a cell walls components, contained in fiber fraction are presented emperically: *Hemicellulose = NDF – ADF; Cellulose = ADF – ADL. The degree of lignification* is presented as relation of ADL and NDF/100 (Akin&Chesson 1989). Enzyme *in vitro* digestibility of dry (СмСВ/IVDMD) and organic (СмОВ /IVOMD) matter is determined by two stage pepsin-cellulase enzyme method of Aufrere (Найденова 2010). First step – previous attack with *pepsin* /200 FIB-U g^{-1}/, Merck 7190, Germany in *1 N* Hydrohloric acid for 24 hours. Second step – attack with cellulase *“Onozuka R-10”,* isolated from *Trichoderma viride* /Endo-1,4-β-glucanase; 1,4-(1,3:1,4)-β-D glucan - 4-glucanhydrolase/ with enzyme activity 1,2 $U.g^{-1}$, M 52 000, EC 3.2.1.4., Serva 16419, 1g l^{-1} in 0,05 M acetate buffer pH 4,6 for 24 hours at 40^0C.

The feeding value estimation – energy and protein is performed as: 1. Evaluation of feeding value on the basis of fiber components – *Relative feeding value* RFV; *potential intake* of digestible dry matter (Linn&Martin 1991; Ensminger 1993; Todorov at al. 1995). The Digestible Dry Matter (DDM% = 88,9-(0,779xADF%); Dry Matter Intake (DMI /% body weight/ = 120/NDF%) and Relative feeding value (RFV=DDMxDMI/1,29) are estimated. 2. The Energy feeding value* is calculated by French system: UFL-UFV (INRA, 1988), recalculated in Bulgarian by coefficients, followed by Todorov (1997). The followed parameters are estimated: Metabolic energy /ME/ on the basis of equations according to *experimental values of CP, CF and IVOMD.* The coefficient of digestibility of organic matter dMO_{invivo} (Andrieu&Demarquilly 1987) is received by relationship on the basis of *in vitro organic matter digestibility, determined experimentally by Aufrere (1982).* Net energy is determined according French (UFL-UFV), Bulgarian – Feed units for milk and Feed units for growth (KEM-KEP/FUM-FUG) and Dutch (VEM-VEVI) systems. The Protein feeding value** is performed French system (INRA 1988) as a really digestible protein in ruminant small intestines. The values of

PDIN = PDIA + PDIMN and PDIE = PDIA + PDIME in g kg^{-1} dry matter are estimated.

*,** Investigations and feeding value estimation are consulted by Dr Ph. Lecomte and Dr P. Dardenne, CRA-Gembloux; SHB-Libramont, Belgium.

Spectral data bases for NIRS (Near Infrared Reflectance Spectroscopy) are obtained from all plant materials by scanning twice and the spectra are collected as a Log 1/R in the NIR region 1100-2500 nm, 2 nm step on a monochromator model 6500 NIRSystems Inc., Silver Spring, MD, USA in SHB-Libramont, Belgium. The spectral and mathematical treatments of data are performed using the ISI NIRS 3, ver.4 Software (Infrasoft International, Port Matilda, PA, USA). After averaging the duplicates the spectral boundaries of sample population are determined by PCA (Principal Component Analysis) method. It is applied also for evaluation of spectral distances between three perennial grasses /varieties/ (Shenk and Westerhause, 1995). The spectra are stored according to their Mahalanobis distance (H statistics). The screening and improving representation of each plant sample are performed by calculation of Mahalanobis distance (H statistics) of each sample in relation to all others (Dardenne 1990). Calibration models are developed with a pretreatment of the spectral data by scatter correction NSVD (Normal Standard Variate and Detrend) and a first and second derivative by segment-gape method (Shenk and Westerhaus, 1995). The calibration models are obtained by using a *Modified Partial Least Squares /MPLS/* as a regression method and tested in cross-validation at maximum number of regression factors (terms). The accuracy of calibration models and cross-validation results for each parameter are evaluated on the base of theirs lowest standard errors (Standard Error of Calibration SEC and Standard Error of Cross-Validation SECV), respectively highest coefficients of determination (R2 and R2CV) and highest ratio of the standard deviation of the original data by the SECV (SD/SECV) which are independent of the measurement units and allows a comparison of different calibration models.

The Linear regression equations are developed for prediction of each parameter of chemical composition, digestibility and feeding value by days of the vegetation as independent variable of a type y=ax ± b, where y is evaluated parameter; x –days from the beginning of the vegetation; a, b – the regression coefficients, specific for each predictive parameter.

RESULTS AND DISCUSSION

Changes in composition and digestibility in the vegetation

When establishing the efficiency and forage value of grasses it is of great importance to determine the content of principal chemical substances having relation to assimilation of grass biomass and the changes that occur in their concentration with the change of plant age. The protein and structural fiber components are the main substances exerting substantial influence on plant quality and their nutritive value having in mind that fat quantity in grasses is in small quantity (approximately 2%) and nitrogen free extracts are computable character. When estimating the different species and particularly when proving the differences in the quality in different genotypes (clones) of one plant species or even variety, the content of the individual structural plant cell wall fiber components has a substantial importance. They are directly related to plant morphological structure and cell walls composition and exert considerable influence on perennial grass digestibility and feeding value.

In the first vegetative growth in growing process of the perennial grasses with the increase of their height parameters the *crude protein content decrease* (Tables 2, 4 and 6). In early vegetation stage the protein content for all three perennial grass species: orchardgrass, tall fescue and smooth bromegrass is equal – 28% of dry matter. According to Skoblin (1983) orchardgrass can accumulate up ton 32% protein in dry matter at early vegetation stage. The protein content is particularly high in pasture stage, when according to Wiering (1978) the protein cannot be utilized completely. Because of carbohydrate shortage the forage does not stay enough time in the rumen, so the digestion is incorrect and the utilization incomplete. The differences are observed in the degree of decreasing of the protein content. The protein content of orchardgrass decrease more rapidly and in the heading stage it is less (15,13%) as compared to the other two plant species (17-20%). At this vegetative stage the protein content is higher in smooth bromegrass (19,89%). Higher protein content in smooth bromegrass as compared to orchardgrass is also reported by Andreev et al. (1982), Sanderson et al. (1989) and with the nitrogen fertilizing the protein values increase and reach up to 20-22% of dry matter. *The average daily degree of decreasing of protein content* for the period studied in first growth is: orchardgrass – 0,38%, tall fescue – 0,34%, smooth bromegrass – 0,28%. Since all three perennial grass species (varieties) after first growth form no generative stems, but the regrowth is only represented by the vegetative stems and leaves in aftergrass, the protein content almost does not change – it is equal for all three grass species (14-15%). In the growing process in first growth the *crude fiber content is increased*. The increase is over twice – from 16 to 34% for orchardgrass, from 17 to 34% for tall fescue and from 18 to 34% for smooth bromegrass. In the first growth the three perennial grass species do not differ in crude fiber content (on average 26,17-27,42%). *The average daily degree of crude fiber content increase* for the period studied in the first growth is: orchardgrass – 0,30%, tall fescue – 0,32%, smooth bromegrass – 0,31%, i.e. there are no substantial differences

Table 2. Principal composition, plant cell walls fiber components content and digestibility of orchardgrass
Таблица 2. Основен състав, структурни влакнинни компоненти и смилаемост на ежова главица

Weeks	CP	CF	NDF	ADF	ADL	HEMI	CELLU	LIGNIF	IVDMD	IVOMD
Първи подраст / First growth Dactylis glomerata L., var. "Dabrava"										
4	27,85	15,78	28,00	18,33	1,57	9,67	16,76	6,17	89,90	80,45
5	25,02	20,15	32,05	25,12	2,71	6,93	22,41	8,45	81,17	80,32
6	22,74	23,32	49,73	28,66	2,82	21,07	25,84	5,67	75,88	73,39
7	18,98	27,89	56,88	32,71	3,21	24,17	29,50	5,64	70,27	69,37
8	15,13	30,26	58,62	36,78	3,52	21,84	33,26	6,00	64,18	60,24
9	13,77	31,29	61,50	38,74	4,37	22,56	34,57	7,10	59,32	57,24
10	9,32	34,05	62,11	39,44	5,94	22,67	33,50	9,56	54,20	52,14
11	9,26	34,40	62,23	40,72	6,53	21,51	34,19	10,49	47,06	45,70
Mean	**17,76**	**27,14**	**51,40**	**32,60**	**3,80**	**18,80**	**28,75**	**7,38**	**67,75**	**64,86**
SD	*7,05*	*6,77*	*13,84*	*7,98*	*1,70*	*6,58*	*6,54*	*1,89*	*14,34*	*13,00*
Отава / Aftergrass										
6	15,70	30,05	57,84	34,24	3,86	23,60	30,38	6,67	75,56	72,85
7	15,12	30,52	57,84	34,49	3,93	23,35	30,56	6,79	69,80	67,74
8	14,95	30,57	57,82	34,63	4,17	23,19	30,46	7,09	68,48	65,74
9	14,86	30,51	59,40	35,31	4,40	24,09	30,91	7,41	66,06	63,55
10	14,70	30,60	59,88	36,18	4,95	23,70	31,23	8,27	63,64	61,36
11	16,71	29,88	61,19	35,93	5,25	25,26	30,68	8,58	75,34	72,94
Mean	**15,36**	**30,35**	**59,00**	**35,13**	**4,43**	**23,86**	**30,70**	**7,47**	**69,80**	**67,36**
SD	*7,43*	*0,31*	*1,40*	*0,80*	*0,56*	*0,75*	*3,18*	*0,79*	*4,85*	*4,80*
Mean										
Mean	**16,56**	**28,74**	**55,20**	**33,86**	**4,12**	**21,23**	**29,72**	**7,42**	**68,78**	**66,00**
SD	*7,14*	*3,54*	*7,62*	*1,13*	*1,13*	*3,66*	*4,86*	*1,34*	*9,60*	*8,90*

CP - Crude protein, CF - Crude fibre, NDF - Neutral detergent fibre, ADF - Acid detergent fibre, ADL - Acid detergent lignin, HEMI - Hemicellulose; CELLU – Cellulose, in % dry matter; LIGNIF=ADL/NDF x100, coeff., IVD(O)MD - In vitro dry (organic) matter digestibility, %

Table 3. Feeding value calculated by different systems for estimation of orchardgrass in the vegetation
Таблица 3. Хранителна стойност на ежова главица, оценена по различни системи

Weeks	DDM	DMI	RFV	ME	UFL	UFV	FUM	FUG	VEM	VEVI
Първи подраст / First growth Dactylis glomerata L., var. "Dabrava"										
4	75	6,6	379	12,38	0,99	0,92	0,82	0,75	1077	1152
5	69	4,8	257	12,24	0,98	0,91	0,81	0,74	1048	1116
6	67	4,2	216	11,59	0,91	0,83	0,76	0,68	1012	1061
7	63	3,7	180	11,11	0,87	0,79	0,72	0,66	955	987
8	60	3,3	152	9,97	0,77	0,67	0,64	0,55	855	860
9	59	3,1	140	8,81	0,75	0,65	0,62	0,53	848	847
10	58	3,0	137	9,05	0,69	0,58	0,57	0,48	775	758
11	57	2,0	131	8,39	0,63	0,52	0,51	0,43	729	700
Mean	**64**	**3,8**	**200**	**10,56**	**0,82**	**0,73**	**0,68**	**0,60**	**912**	**934**
SD	*6,2*	*1,4*	*85*	*0,80*	*0,13*	*0,15*	*0,11*	*0,12*	*129*	*167*
Отава / Aftergrass										
6	62	3,5	169	11,22	0,89	0,81	0,73	0,66	952	990
7	62	3,5	167	10,73	0,84	0,75	0,70	0,61	914	939
8	62	3,5	166	10,52	0,82	0,73	0,68	0,60	898	918
9	61	3,4	162	10,25	0,80	0,70	0,66	0,57	880	893
10	61	3,3	156	10,00	0,77	0,67	0,64	0,55	860	869
11	61	3,3	158	11,24	0,89	0,81	0,74	0,66	958	996
Mean	**61**	**3,4**	**163**	**10,65**	**0,84**	**0,74**	**0,69**	**0,61**	**910**	**934**
SD	*0,62*	*0,07*	*5,2*	*0,27*	*0,04*	*0,06*	*0,04*	*0,04*	*39*	*51*
Mean										
Mean	**63**	**3,6**	**182**	**10,60**	**0,83**	**0,74**	**0,69**	**0,61**	**911**	**934**
SD	*3,4*	*0,72*	*45*	*0,54*	*0,08*	*0,10*	*0,08*	*0,08*	*84*	*104*

Table 4. Principal composition, plant cell walls fiber components content and digestibility of tall fescue
Таблица 4 Основен състав, структурни влакнинни компоненти и смилаемост на тръстиков власатка

Weeks	CP	CF	NDF	ADF	ADL	HEMI	CELLU	LIGNIF	IVDMD	IVOMD
	Първи подраст / First growth				Festuca arundinacea Schreb., var. "Albena"					
4	28,92	17,58	31,22	19,96	1,24	11,26	18,72	3,97	86,44	85,88
5	26,87	19,33	37,75	23,84	1,27	13,91	22,57	3,36	77,22	76,16
6	25,47	22,67	43,28	27,14	1,62	16,14	25,52	3,74	71,94	69,66
7	21,61	26,95	49,20	30,77	2,02	18,43	28,75	4,10	68,49	67,05
8	17,67	28,60	52,50	32,73	2,58	19,77	30,15	4,91	63,75	62,58
9	16,51	30,05	57,79	37,80	3,19	19,99	34,61	5,52	63,06	61,55
10	14,66	30,75	61,84	37,93	5,69	23,91	32,24	9,20	60,69	58,92
11	12,45	33,45	65,59	40,54	6,16	25,05	34,38	9,40	48,03	46,00
Mean	**20,52**	**26,17**	**49,77**	**31,73**	**2,97**	**18,56**	**28,36**	**5,52**	**67,45**	**65,98**
SD	*6,10*	*5,71*	*11,85*	*7,48*	*1,94*	*4,70*	*5,71*	*2,42*	*11,54*	*11,92*
	Отава / Aftergrass									
6	14,86	32,56	63,88	35,74	2,00	28,14	33,74	3,13	61,32	58,76
7	14,80	32,06	59,07	34,46	2,06	24,61	32,40	3,49	58,31	57,03
8	14,04	31,91	58,37	33,93	2,49	24,44	31,44	4,26	58,76	56,76
9	13,68	31,38	59,97	34,80	2,96	25,17	32,00	4,94	57,75	54,92
10	13,40	31,33	61,49	35,60	3,40	25,89	32,20	5,53	56,74	53,08
11	13,22	31,19	62,70	34,00	3,83	28,70	30,17	6,11	57,95	54,82
Mean	**14,00**	**31,73**	**60,90**	**34,76**	**2,79**	**26,26**	**32,00**	**4,58**	**58,48**	**55,90**
SD	*0,70*	*0,53*	*2,15*	*0,77*	*0,74*	*1,83*	*1,17*	*1,16*	*1,55*	*7,85*
	Mean									
Mean	**17,26**	**28,95**	**55,34**	**33,24**	**2,88**	**22,36**	**30,18**	**5,05**	**62,96**	**60,94**
SD	*3,40*	*3,12*	*7,00*	*4,13*	*1,34*	*3,26*	*3,44*	*1,79*	*6,54*	*9,88*

CP - Crude protein, CF - Crude fibre, NDF - Neutral detergent fibre, ADF - Acid detergent fibre, ADL - Acid detergent lignin, HEMI - Hemicellulose; CELLU – Cellulose, in % dry matter; LIGNIF=ADL/NDF x100, coeff.; IVD(O)MD - In vitro dry (organic) matter digestibility, %

Table 5. Feeding value calculated by different systems for estimation of tall fescue in the vegetation
Таблица 5. Хранителна стойност на тръстиковидна власатка, оценена по различни системи

Weeks	DDM	DMI	RFV	ME	UFL	UFV	FUM	FUG	VEM	VEVI
	Първи подраст /	First growth			***Festuca arundinacea* Schreb., var. "Albena"**					
4	73	6,0	342	12,94	1,05	0,98	0,87	0,80	1109	1196
5	70	5,0	274	11,78	0,93	0,84	0,77	0,69	1041	1102
6	68	4,4	232	11,06	0,86	0,77	0,72	0,63	983	1024
7	65	3,9	196	10,69	0,83	0,74	0,69	0,60	937	966
8	61	3,4	159	10,30	0,80	0,70	0,66	0,57	894	907
9	59	3,2	146	10,16	0,79	0,69	0,65	0,56	879	890
10	59	3,2	145	10,00	0,77	0,67	0,64	0,55	860	863
11	57	3,0	131	8,48	0,64	0,52	0,53	0,43	748	721
Mean	**64**	**4,0**	**203**	**10,67**	**0,83**	**0,74**	**0,69**	**0,60**	**931**	**959**
SD	*5,82*	*1,08*	*74*	*0,72*	*0,12*	*0,13*	*0,10*	*0,10*	*113*	*148*
	Отава / Aftergrass									
6	61	3,4	159	9,68	0,74	0,64	0,62	0,52	837	839
7	62	3,5	167	9,37	0,71	0,61	0,59	0,50	818	816
8	62	3,5	171	9,36	0,71	0,61	0,59	0,50	819	817
9	62	3,5	165	9,18	0,70	0,59	0,58	0,48	800	793
10	61	3,4	160	8,98	0,68	0,57	0,56	0,47	736	775
11	62	3,5	171	9,13	0,69	0,58	0,57	0,48	798	793
Mean	**62**	**3,45**	**166**	**9,29**	**0,70**	**0,60**	**0,58**	**0,49**	**810**	**806**
SD	*6,05*	*0,07*	*5,2*	*0,13*	*0,02*	*0,02*	*0,02*	*0,02*	*18*	*23*
	Mean									
Mean	**63**	**3,7**	**185**	**9,97**	**0,76**	**0,67**	**0,64**	**0,54**	**870**	**882**
SD	*5,94*	*0,58*	*40*	*0,42*	*0,07*	*0,07*	*0,06*	*0,06*	*66*	*85*

Table 6. Principal composition, plant cell walls fiber components content and digestibility of bromegrass
Таблица 6. Основен състав, структурни влакнинни компоненти и смилаемост на безосилеста овсига

Weeks	CP	CF	NDF	ADF	ADL	HEMI	CELLU	LIGNIF	IVDMD	IVOMD
Първи подраст / First growth						***Bromus inermis* Leyss., var. "Nika"**				
4	27,93	18,56	44,96	23,27	1,76	21,69	21,51	3,91	86,89	85,30
5	26,08	23,18	52,36	27,53	1,85	24,83	25,68	3,53	82,83	81,46
6	20,65	27,24	57,66	30,85	2,08	26,81	28,77	3,60	72,51	71,14
7	20,29	27,83	59,44	33,45	2,71	26,00	30,74	4,55	70,38	68,65
8	19,89	28,06	62,50	37,50	3,84	25,00	33,66	6,14	69,00	67,50
9	16,55	30,04	64,12	41,62	5,85	22,50	35,77	9,12	58,04	54,17
10	15,23	30,90	66,00	42,50	6,29	23,50	36,21	9,53	49,68	47,3
11	14,11	33,97	67,37	43,54	7,06	23,83	36,48	10,48	44,44	41,66
Mean	**20,09**	**27,42**	**59,30**	**35,03**	**3,93**	**24,27**	**31,10**	**6,36**	**66,72**	**64,65**
SD	*4,92*	*4,69*	*7,56*	*7,48*	*2,17*	*1,72*	*5,48*	*2,92*	*15,03*	*15,64*
Отава / Aftergrass										
6	15,76	28,34	59,44	34,83	4,44	24,61	30,39	7,47	67,66	66,30
7	16,33	26,88	55,75	30,55	3,80	25,24	26,75	6,81	68,46	66,18
8	15,97	27,06	55,70	31,22	3,50	24,48	27,72	6,28	72,64	70,92
9	15,32	27,24	55,76	31,92	3,16	23,84	28,76	5,76	72,55	67,84
10	14,37	27,85	55,56	33,69	4,06	21,87	29,63	7,31	72,40	64,76
11	14,46	27,34	53,77	33,84	3,94	19,93	29,90	7,33	72,24	70,21
Mean	**15,37**	**27,45**	**56,00**	**32,67**	**3,82**	**23,33**	**28,86**	**6,83**	**71,00**	**67,70**
SD	*0,81*	*0,54*	*1,85*	*1,70*	*0,45*	*2,03*	*1,40*	*0,68*	*2,28*	*2,43*
Mean										
Mean	**17,73**	**27,44**	**57,65**	**33,85**	**3,88**	**23,80**	**29,98**	**6,60**	**68,86**	**66,18**
SD	*2,86*	*2,62*	*4,70*	*4,60*	*1,31*	*1,88*	*3,44*	*1,80*	*8,66*	*9,04*

CP - Crude protein, CF - Crude fibre, NDF - Neutral detergent fibre, ADF - Acid detergent fibre, ADL - Acid detergent lignin, HEMI - Hemicellulose; CELLU – Cellulose, in% dry matter; LIGNIF=ADL/NDF x100, coeff., IVD(O)MD - *In vitro* dry (organic) matter digestibility, %

Table 7. Feeding value calculated by different systems for estimation of bromegrass in the vegetation
Таблица 7. Хранителна стойност на безосилеста овсига, оценена по различни системи

Weeks	DDM	DMI	RFV	ME	UFL	UFV	FUM	FUG	VEM	VEVI
Първи подраст / First growth						***Bromus inermis* Leyss., var. "Nika"**				
4	72	5,4	299	13,03	1,05	0,99	0,87	0,81	1126	1213
5	67	4,4	228	12,45	1,00	0,93	0,83	0,76	1080	1151
6	65	3,9	196	11,26	0,89	0,80	0,73	0,66	972	1009
7	63	3,5	172	11,04	0,87	0,79	0,72	0,64	956	985
8	62	3,5	168	11,00	0,86	0,78	0,71	0,63	953	984
9	57	3,0	132	10,45	0,72	0,62	0,60	0,50	824	917
10	56	2,9	126	8,72	0,66	0,54	0,54	0,44	780	759
11	56	2,8	122	7,96	0,59	0,48	0,49	0,39	703	666
Mean	**62**	**3,7**	**180**	**10,74**	**0,83**	**0,74**	**0,68**	**0,63**	**924**	**960**
SD	*5,60*	*0,87*	*60,4*	*0,93*	*0,16*	*0,18*	*0,13*	*0,13*	*145*	*182*
Отава / Aftergrass										
6	62	3,4	165	10,45	0,81	0,72	0,67	0,59	897	919
7	65	3,9	198	10,60	0,83	0,74	0,69	0,60	908	932
8	65	3,8	192	11,13	0,88	0,80	0,72	0,64	944	979
9	64	3,8	187	10,67	0,83	0,75	0,69	0,61	910	936
10	63	3,6	173	10,76	0,79	0,69	0,68	0,59	872	890
11	63	3,6	172	10,18	0,84	0,76	0,70	0,62	913	945
Mean	**63**	**3,7**	**181**	**10,64**	**0,83**	**0,74**	**0,69**	**0,61**	**907**	**934**
SD	*1,31*	*0,18*	*13*	*0,17*	*0,03*	*0,03*	*0,02*	*0,02*	*23*	*29*
Mean										
Mean	**63**	**3,7**	**180**	**10,69**	**0,83**	**0,74**	**0,69**	**0,62**	**916**	**947**
SD	*5,94*	*0,58*	*40*	*0,42*	*0,07*	*0,07*	*0,06*	*0,06*	*66*	*85*

in the changes for the three perennial grass species. The trends of change in the content of crude fiber are presented in Fig.1. With the increase of plant age at the flowering stage the protein decrease down to 8-10% and the fiber increases and reaches up to 30-34%. The differences are observed in the next growths. The aftergrass of smooth bromegrass has less fiber as compared to orchardgrass and tall fescue.

The significant differences among the species (varieties) are observed in individual plant cell walls fiber components content. Smooth bromegrass contains considerably more *neutral-detergent fiber (NDF)*(59,30%) in first growth as compared to orchardgrass (51,40%) and tall fescue (49,77%). The smooth bromegrass accumulate less NDF in aftergrass – 56% as compared to 59% for orchardgrass and 60,9% for tall fescue. This tendency in aftergrass is identical to the lower content of fiber components in smooth bromegrass as compared to the other two grass species. According to Saiga et al. (1992) some orchardgrass varieties accumulate less and slower cell walls. *The average daily degree of NDF content increase* in the first growth is: orchardgrass – 0,70%, tall fescue – 0,69%, smooth bromegrass – 0,45%, i.e. increase for the first two grass species is considerably greater. For the *aid-detergent fiber (ADF)* it is observed similar tendency in the first growth, where smooth bromegrass accumulates more acid-detergent fiber. In second growth it also contains less acid-detergent fiber than orchardgrass and tall fescue. *The average daily degree of ADF content increase* in the first growth is: orchardgrass – 0,46, tall fescue – 0,42%, smooth bromegrass – 0,45%, i.e. the increase is of equal order. As compared to the other fiber components the *acid-detergent lignin (ADL)* has least relative proportion (1,76-7,06%). With the plant growth in the vegetation process in first growth the lignin content increases and the extent of increase being considerably greater – five times as compared to the other fiber components. That is probably due to relatively greater leaf participation. Sheehan (1985) finds a higher lignin content in leaves. There is no substantial difference in lignin content among the three grass species. *The average daily degree of ADL content increase* in the first growth is: orchardgrass – 0,10, tall fescue – 0,10, smooth bromegrass – 0,11, i.e. the increase is of equal order. The *hemicellulose* content in the first growth increase over twice. Smooth bromegrass in this growth contains more hemicellulose than tall fescue and orchardgrass. In the aftergrass there are no substantial differences among the species. According to Weding et al. (1986) orchardgrass contains more xylose and less galactose in the hemicellulose as compared to lucerne; xylose-glucose ratio is higher for orchardgrass and manose digestibility is higher. *The average daily degree of hemicellulose content increase* in the first growth is: orchardgrass – 0,22%, tall fescue – 0,28%, smooth bromegrass – 0,04%, i.e. increase is of equal order for the two species and for smooth bromegrass the hemicellulose content increases very little. Smooth bromegrass accumulates more *cellulose* in first growth as compared to orchardgrass and tall fescue. Like the other fiber components in the aftergrass the cellulose content for smooth brome is lower as compared to the other two plant species. The lower total content of fiber components exerts an influence for smooth bromegrass. *The average daily degree of cellulose content increase* in the first growth is: orchardgrass – 0,36%, tall fescue – 0,32%, smooth bromegrass – 0,30%, i.e. the increase is of close order corresponding by ratio among the grass species as for acid-detergent fiber. Pavlov (1996) finds from early vegetation to the flowering stage an increase of all fiber fractions for orchardgrass the extent of increase being different: NDF increase from 46,8 to 63,08%, i.e. the increase is 1,3 times; ADF and cellulose also increase 1,3 times; the acid-detergent lignin changes most, from 2,77% it increase to 4,73% at the flowering stage the increase is 1,7 times. According to it the extent of lignin increase is not equal during the different stages. Till early heading the lignin increases a little. The increase is greater between the heading and flowering stage because of the considerably greater increase of acid detergent lignin content as compared to the other fiber components, with plant growth in the vegetation the degree of lignification also increases (3,91-10,49%). Both in first growth and aftergrass tall fescue has a little less pronounced lignification degree as compared to smooth bromegrass and orchardgrass.

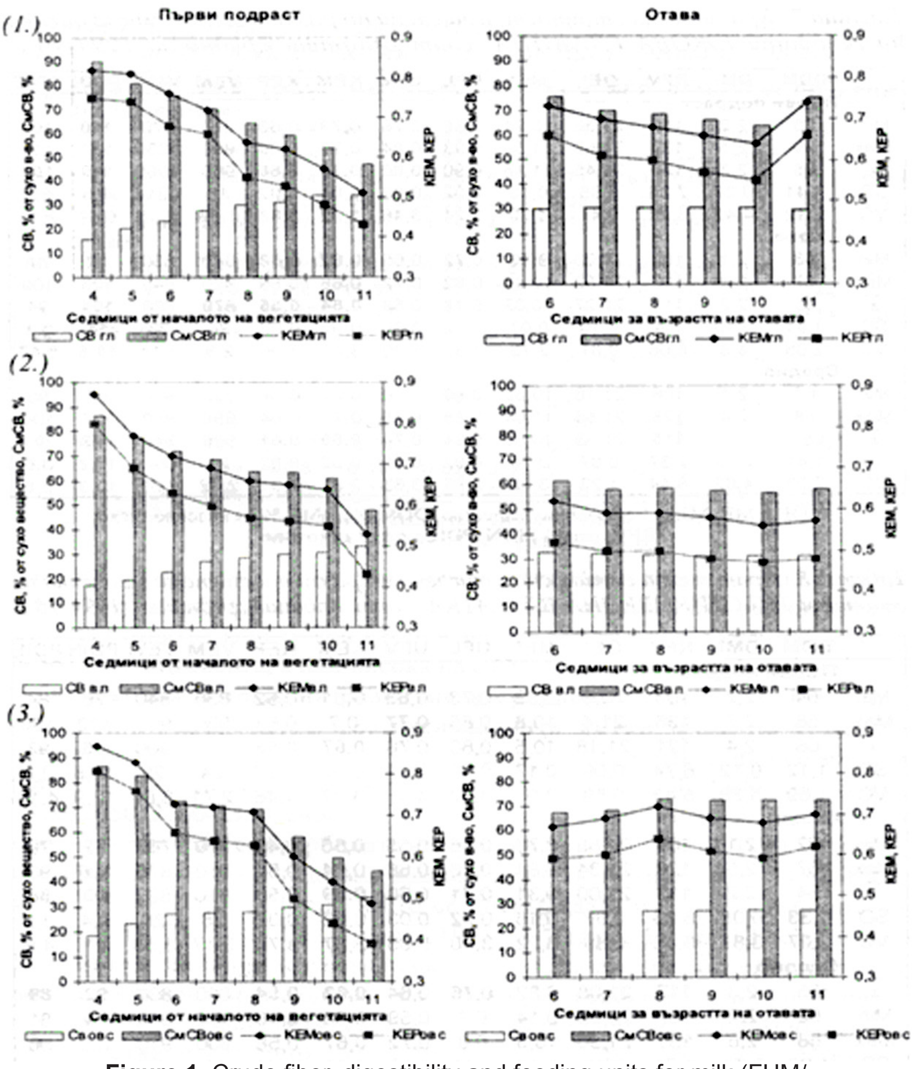

Figure 1. Crude fiber, digestibility and feeding units for milk (FUM/KEM), feeding units for growth (FUG/KEP) of orchardgrass (1), tall fescue (2), smooth bromegrass (3) in the vegetation

Фигура 1. Промени в съдържанието на сурови влакнини, смилаемост и нето енергийни единици КЕМ, КЕР на ежова главица (1.), тръстиковидна власатка (2.), безосилеста овсига (3.) през вегетацията

Because of increase of fiber components content with plant growth the digestibility of dry and organic matter decreases (Table 2, 4 and 6). The extent of decrease of *in vitro* digestibility is almost twice. The dry matter digestibility is higher than that of organic matter. In first growth there is no difference in the digestibility of both dry and organic matter for the three species (varieties) of perennial grasses. However there are differences in the next growths. In the aftergrass *in vitro* digestibility of dry and organic matter is a little lower as compared to that for orchardgrass and smooth bromegrass. Furthermore for tall fescue its average value in the aftergrass is lower than the average value for first growth, while for orchardgrass and smooth bromegrass the trend is opposite. For them the digestibility in the aftergrass is higher than in the first growth. The lower digestibility of dry and organic matter of aftergrass for tall fescue is due to the higher content of indigestible fiber components as lignin and cellulose. The trend of digestibility decrease in the vegetation process is presented at Fig.1.

Changes in feeding value of perennial grass species in the vegetation

In the first vegetative growth in growing process with increasing of plant age the digestible dry matter content, potential intake and relative feeding value, energy feeding value decrease (Tables 3, 5 and 7). In the second and consequent growths these parameters are no changed, because of that the generative stems are not formed. The three perennial species does not differ significant in dry matter intake *(DMI).* In the first growth the intake value decrease two fold. While for orchardgrass and smooth bromegrass in the first growth and aftergrass the intake value is almost equal, for tall fescue the aftergrass intake is less with comparison of those in first growth. This probably is due to higher content of plant cell walls components content in aftergrass in this crop and lower digestibility. The *relative feeding value (RFV)* for smooth bromegrass has lower value in first growth as compared to those of orchardgrass and tall fescue. The higher content of NDF, ADF, hemicellulose and cellulose exert influence. *Metabolic (ME) energy feeding value* for the three perennial grass species is equal. In the first growth it value is decreased. For orchardgrass and smooth bromegrass the Feed units for milk (FUM) and Feed units for growth (FUG) values are closed (Fig.1). The tall fescue feeding value is lower. The difference is higher in aftergrass. Influence occur higher plant cell wall fiber components content that decrease feeding value. The grasses orchardgrass and smooth bromegrass have equal feeding units value. The difference among plant species is greater in feeding units for growth (FUG) value. Higher fiber components content in tall fescue aftergrass leads to more strong decrease in feeding units for milk (FUM) in lacting ruminants. This trend establish also for the net energy feeding values UFL, UFV; VEM and VEVI.

Near Infrared Reflectance Spectroscopy analysis. Possibilities for a rapid estimation of changes in compositon and feeding value

It is of particular importance at every moment in the vegetation of the perennial grasses to determine forage chemical composition and feeding value in contrast to plant harvesting for forage at the definite vegetative stage when the nutrients are in optimum concentration on proportions. Namely for that reason calibration models are developed for evaluation and prediction of composition and feeding value of the three perennial grass species (varieties) in the vegetation process in first and second derivative of the spectrum. The ranges of variation, mean values and statistical parameters for evaluation of calibration models for each parameter of composition, digestibility and feeding value are presented in Table 8. The prediction accuracy in second derivative of the spectrum slightly increases in the most cases. For instance for neutral detergent fiber R2CV in first derivative 0,962 and in second 0,984;*in vitro d*ry matter digestibility 0,947 in first derivative and 0,968 in second. When comparing the calibration models at the same mathematical processing SNVD in second derivative of the spectra, usually with the decrease of the number of PLS factors in regression, the coefficient of determination increases and is always high R2CV - over 0,90 for all parameters studied. The standard errors of verification SECV in second derivative of the spectrum as compared to those in global calibration models (Fig.2) (Naydenova 2008) are lower or close to them. The same also applies to the parameters of feeding value as compared to those in global calibraton models. For the parameter of organic matter digestibility the coefficient of determination in the calibration model describing the vegetation process dynamics is 0,96, while that in the global calibration models is 0,84, i.e. the prediction accuracy is higher. The same also applies to the parameters of fiber components content in cell walls where the coefficient of determination R2CV is always over 0,90 (hemicellulose 0,86). With respect to complex characteristics determined on the basis of the fiber components content, the coefficient of determination R2CV is also very high for DMI and RFV – 0,97 and for DDM – 0,98. The SD/SECV ratio in the calibration models for estimation of parameters dynamics in vegetation process as compared to those in the global calibration models is considerably higher – 4,65 and 4,94 for dry and organic matter digestibility, repectively as compared to 2,5 for the two parameters in the global calibration models.

Table 8. Characteristics of referent values and NIRS calibration models in MPLS Regression for prediction of composition, digestibility and feeding value of perennial grass species

Таблица 8. Характеристика на референтните стойности и NIRS калибрационните модели чрез MPLS регресия за предвиждане състава, смилаемостта и хранителната стойност на видове житни треви

Показател Parameter	N	Mean	Min	Max	SD	T	R2C	SEC	SECV	R2CV	SD/ SECV	Scatter	Math
NDF	78	56,38	31,22	66,00	8,27	8	0,99	0,78	1,03	0,98	8,0	NSVD	2.5.5
ADF	78	33,36	18,33	42,50	5,63	8	0,99	0,52	0,68	0,99	8,3	NSVD	1.5.5
ADL	74	3,35	1,24	6,53	1,32	7	0,95	0,29	0,38	0,92	3,5	NSVD	2.5.5
HEMI	83	22,38	6,93	28,70	4,41	8	0,92	1,23	1,62	0,87	2,7	NSVD	2.5.5
CELLU	77	29,70	16,76	36,65	4,69	7	0,98	0,52	0,69	0,90	6,8	NSVD	2.5.5
LIGNIF	69	6,22	3,49	11,14	1,90	9	0,97	0,32	0,44	0,95	4,3	NSVD	1.5..5
IVDMD	79	67,39	47,06	89,90	10,33	8	0,97	1,82	2,22	0,95	4,7	NSVD	1.5.5
IVOMD	80	64,57	41,66	85,88	10,67	8	0,97	1,82	2,16	0,96	4,9	NSVD	1.5.5
DDM	78	62,91	55,79	74,62	4,38	8	0,99	0,41	0,53	0,98	8,2	NSVD	1.5.5
DMI	83	3,72	2,82	6,55	0,80	7	0,98	0,12	0,15	0,99	5,5	NSVD	1.5.5
RFV	84	184	122	378	55	7	0,98	7,02	9,34	0,97	5,8	NSVD	2.5.5
ME	78	5,70	4,33	7,08	0,65	8	0,98	0,093	0,115	0,97	5,6	NSVD	1.5.5
UFL	84	0,812	0,59	1,05	0,11	7	0,96	0,023	0.029	0,93	3,7	NSVD	2.5.5
UFV	80	0,715	0,48	0,99	0,13	8	0,98	0,019	0,026	0,96	5,0	NSVD	2.5.5
FUM	82	0,672	0,49	0,87	0,093	7	0,97	0,017	0,023	0,90	6,8	NSVD	2.5.5
FUG	78	0,587	0,39	0,81	0,102	8	0,98	0,140	0,020	0,94	4,0	NSVD	2.5..5
VEM	84	67,39	47,06	89,90	10,33	8	0,97	1,82	2,22	0,96	5,1	NSVD	2.5.5
VEVI	80	64,57	41,66	85,88	10,67	8	0,97	1,82	2,16	0,96	4,9	NSVD	2.5.5
PDIN	81	110,0	58,15	181,6	32,45	7	0,99	1,22	1,50	0,99	21,6	NSVD	1.5.5
PDIE	79	97,1	67,11	131,9	16,88	7	0,99	1,29	1,70	0,99	9,95	NSVD	1.5.5

NDF, ADF, ADL, HEMI, CELLU - %DM; LIGNIF- coeff.; IVD(O)MD, DDM-%; DMI-%of bw; RFV-relative%
ME - (MJ.kg^{-1}); UFL, UFV, FUM, FUG (kg^{-1} DM); PDIN, PDIE (g.kg^{-1})

Determination of composition, digestibility and feeding value by linear regression equations

The *crude protein* content correlate very well and is determined with high accuracy by linear equations by days from the beginning of the active vegetation as independent variable. The coefficient of determination is higher for orchardgrass 0,982 and lowest for smooth bromegrass 0,940 (Tabl. 9). The determination accuracy is highest for tall fescue, where the error is small 0,88. Because orchardgrass, tall fescue and smooth bromegrass are closed in point of view of morphological structure and the rate of growing, the protein content may be determined and by common regression equation. The precision of common equation is lower as compared to specific equations. Common *crude fiber* content also correlate very well by plant age and may be determined very well by regression equations by days from the beginning of active vegetation. The coefficient of determination vary from 0,900 to 0,960. The coefficient of determination is lowest for smooth bromegrass and highest for tall fescue. Common equation for determination of CF may by apply with good precision. For *neutral - detergent fiber* the coefficient of determination vary from 0,809 to 0,991. The precission is highest for tall fescue and lowest for orchardgrass, where the error is highest. Common equation has very lower accuracy. The coefficient of determination 0,738 is very lower as compared to coefficients of specific equations. *Acid-detergent fibers* are determined with higher accuracy as compared to NDF. For the three crops the standard error is lower – below 1,0, but the coefficient of determination is higher and uniformly – 0,926; 0,978; 0,972. The accuracy of determination is also higher for tall fescue – 1,15 towards 1,35 for smooth bromegrass and 2,35 for orchardgrass. *Acid-detergent lignin* is determined with lower accuracy for tall fescue – coefficient of determination 0,861; error 0,78. For orchardgrass and tall fescue the lignin is determined with good accuracy – correlation coefficients 0,932; 0,927 respectively. The *hemicellulose* content is changed no uniformly for the three grass crops in the vegetation. Only for tall fescue there are very good correlation between hemicellulose content and plant age and linear equation may be used. The coefficient of dermination is sufficient high – 0,908; the error is low 1,86 at high statistical significance p<0,001. For orchardgrass and smooth bromegrass the coefficient of determination is low and equations are no reliable. Common equation is also no reliable.

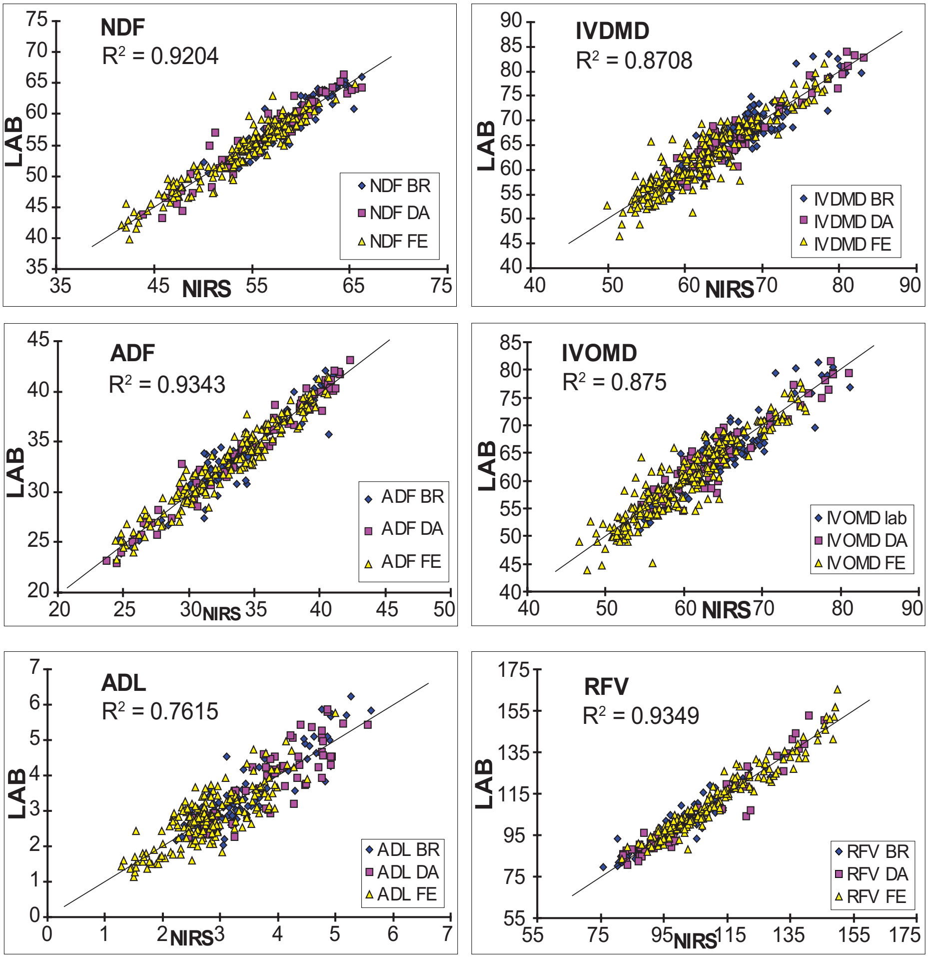

Figure 2. NIRS predicted vs reference values for cell wall composition, digestibility and feeding value in global clone population for orchardgrass, tall fescue and smooth bromegrass

Table 9. Equations for determination of composition content and digestibility of grasses in the vegetation
Таблица 9. Уравнения за определяне състава и смилаемостта на житни треви през вегетацията

Показател / Parameter	Уравнения / Equations	R^2	SEE	F	P
Суров протеин/ CP -%					
Ежова главица DA	У=39.139-0.407 Д	**0.982**	1.00	340.6	***
Тръстиковидна власатка FE	У=38.902-0.35 Д	0.981	**0.88**	319	***
Безосилеста овсига BR	У=34.706-0.278 Д	**0.940**	1.30	94.1	***
Общо Common	У=37.618-0.345 Д	**0.901**	**1.82**	221.2	***
Сурови влакнини/ CF - %					
Ежова главица DA	У=6.953+0.384 Д	0.949	1.64	113.2	***
Тръстиковидна власатка FE	У=9.033+0.326 Д	**0.960**	1.22	146.6	***
Безосилеста овсига BR	У=13.624+0.263 Д	**0.900**	1.62	54.5	***
Общо Common	У=9.937+0.324 Д	**0.911**	**1.68**	227.7	***
Неутрално детергентни влакнини/ NDF - %					
Ежова главица DA	У=13.268+0.727 Д	0.809	**6.53**	25.4	***
Тръстиковидна власатка FE	У=13.479+0.613 Д	**0.991**	**1.18**	706.8	***
Безосилеста овсига BR	У=37.202+0.420 Д	0.911	2.42	61.9	***
Общо Common	У=21.316+0.613 Д	**0.738**	6.11	62.0	***
Киселинно детергентни влакнини/ ADF - %					
Ежова главица DA	У=9.113+0.447 Д	**0.926**	2.32	766.0	***
Тръстиковидна власатка FE	У=9.155+0.422 Д	**0.978**	**1.15**	274.7	***
Безосилеста овсига BR	У=12.436+0.403 Д	**0.972**	1.35	208.7	***
Общо Common	У=10.234+0.433 Д	0.914	2.22	234.5	***
Киселинно детергентен лигнин/ ADL - %					
Ежова главица DA	У=-1.151+0.0949 Д	**0.932**	0.47	82.9	***
Тръстиковидна власатка FE	У=-2.547+0.105 Д	**0.861**	**0.779**	37.4	***
Безосилеста овсига BR	У=-2.47+0.121 Д	**0.927**	0.63	77.0	***
Общо Common	У=-2.0633+0.107 Д	0.849	0.758	124.2	***
Хемицелулоза/ Hemicellulose - %					
Ежова главица DA	У=4.184+0.278 Д	0.524	4.90	6.6	
Тръстиковидна власатка FE	У=11.703+0.317 Д	**0.908**	**1.865**	59.6	***
Безосилеста овсига BR	У=24.77-0.00952 Д	0.008	1.85	0.05	
Общо Common	У=11.092+0.180 Д	0.309	4.50	9.8	
Целулоза/ Cellulose - %					
Ежова главица DA	У=10.235+0.353 Д	0.855	2.68	35.5	***
Тръстиковидна власатка FE	У=11.703+0.317 Д	0.908	1.865	59.6	***
Безосилеста овсига BR	У=14.909+0.308 Д	**0.931**	1.55	80.7	**
Общо Common	У=12.282+0.326 Д	0.849	2.296	124.5	***
Коефициент за степен на лигнификация/ Coefficient for degree of lignification					
Ежова главица DA	У=3.793+0.068 Д	0.388	1.587	3.8	
Тръстиковидна власатка FE	У=-1.025+0.124 Д	**0.777**	1.23	20.9	**
Безосилеста овсига BR	У=-2.047+0.160 Д	**0.885**	1.06	46.2	***
Общо Common	У=0.233+0.117 Д	0.614	1.564	35.0	***
Смилаемост на сухото вещество/ Digestibility of dry matter - %					
Ежова главица DA	У=111.539-0.834 Д	**0.995**	1.04	1908.2	***
Тръстиковидна власатка FE	У=101.631-0.651 Д	**0.935**	3.175	86.4	***
Безосилеста овсига BR	У=112.147-0.864 Д	**0.970**	2.80	195.7	***
Общо Common	У=108.41-0.782 Д	0.956	2.798	483.3	***
Смилаемост на органичното вещество/ Digestibility of organic matter - %					
Ежова главица DA	У=104.296-0.751 Д	**0.981**	1.915	316.5	***
Тръстиковидна власатка FE	У=101.170-0.670 Д	**0.929**	3.401	79.5	***
Безосилеста овсига BR	У=111.811-0.898 Д	**0.969**	2.97	188.0	***
Общо Common	У=105.755-0.773 Д	0.946	3.075	390.2	***

Д - дни от началото на вегетацията, Days from the beginning of the vegetation

* Достоверност на уравнението при $P<0.05$; Significance $P<0.05$; **Significance $P<0.01$;*** $P<0.001$

Достоверност на уравнението при $P<0.01$; * Достоверност на уравнението при $P<0.001$

DA – orchardgrass; FE – Tall fescue, BR – smooth bromegrass

The *cellulose* content is determined by linear equations with high accuracy. The coefficient of determination vary from 0,855 to 0,931. The variability in *degree of lignification* is high and correlation for different crops is different. For orchardgrass the linear equation may not be used for the parameter degree of lignification. For smooth bromegrass the coefficient of determination 0,885 is higher in comparison with those for tall fescue – 0,777. The coefficient of determination is lower as compared to these for fiber components in different grass species (varieties) as well as at common equation. The *digestibility of dry and organic matter* correlates very well in the vegetation with plant age and may be predicted by linear equations. The coefficient of dermination vary from 0,929 to 995. For the three perennial grass species the *digestibility of organic matter* is determined with higher accuracy as compared to those for determination of digestibility of dry matter. The accuracy of determination of both parameters is higher for orchardgrass – coefficient of determination 0,995 and 0,981, respectively and error – 1,04 and 1,91 respectively. The accuracy is lower for tall fescue. All equations for two parameters for different perennial grass species (varieties) as well as common for them have high statistical reliability $p<0,001$. The quantity of digestible dry matter (DDM) is determined with high accuracy. The coefficient of determination vary from 0,919 to 0, 964 (Table 10). The precision is higher for tall fescue – the coefficient of determination 0,964, error 1,2; $p<0,001$. The coefficient of determination in dry matter intake (DMI) is lower in comparison with those for DDM. It vary from 0,881 to 0,886 equally for the three perennial grasses. It is lower for orchardgrass for the parameter relative feeding value (RFV) 0,790. *Gross and metabolic energy* are determined with high accuracy. The coefficient of determination is high 0,912–0,952 and vary slowly. The feeding unit values correlate very well with plant age and are determined with high accuracy by days for plant age. All linear regression equations for composition, digestibility and feeding value, these for different perennial grass species (varieties) as well as common for them have high statistical reliability $p<0,001$.

Comparison predictive accuracy for composition and feeding value by linear regression equations and NIR spectral calibration models for evaluation dynamics of the vegetation process

In comparison of commons linear regression equations for composition, digestibility and feeding value by global NIR spectral calibration models for three perennial grass species (varieties) it is observed close prediction accuracy. Ordinary, the accuracy of NIR spectral calibration models is higher. In some cases commons linear equations have higher accuracy. For instance for IVDMD the error of prediction by linear equations (SEE 2,80) is higher in comparison with those by NIR calibration model in the vegetation (SECV 2,22), but for digestibility of dry matter (IVDMD) SEE 3,07 and SECV 2,16 respectively. The same is related to net energy feeding value, determined as feed units for milk FUM 0,027, SECV 0,019. When it is no possibility for prediction by scanning NIR spectral analysis, the determination and prediction of composition, digestibility and feeding value may be performed with sufficient accuracy for practical purposes by linear regression equations by plant age in days as independent variable.

In the vegetation process at the first growth for the period studied *the average daily degree of decreasing of protein content* for the period studied in first growth is: orchardgrass – 0,38%, tall fescue – 0,34%, smooth bromegrass – 0,28%. *The average daily degree of crude fiber content increase* for the period studied in the first growth is: orchardgrass – 0,30%, tall fescue – 0,32%, smooth bromegrass – 0,31%, i.e. there are no substantial differences for the three perennial grass species. *The average daily degree of NDF content increase* in the first growth is: orchardgrass – 0,70%, tall fescue – 0,69%, smooth bromegrass – 0,45%, i.e. increase for the first two grass species is considerably greater. *The average daily degree of ADF content increase* in the first growth is: orchardgrass – 0,46, tall fescue – 0,42%, smooth bromegrass – 0,45%, i.e. the increase is of equal order. *The average daily degree of ADL content increase* in the first growth is: orchardgrass – 0,10, tall fescue – 0,10, smooth bromegrass – 0,11, i.e. the increase is of equal order. The decreasing of energy feeding value is: for FUM and FUG for orchardgrass – 0,310 and 0,320; for tall fescue – 0,340 and 0,370; for smooth bromegrass – 0,380 and 0,420.

Table 10. Equations for estimation of perennial grass feeding value in the vegetation

Таблица 10. Уравнения за определяне на хранителната стойност на житни треви през вегетацията

Показател / Parameter	Уравнения / Equations	R2	SEE	F	P
Смилаемо сухо вещество/ Digestible dry matter - %					
Ежова главица DA	У=82.071-0.354 Д	0.919	1.935	68.7	***
Тръстиковидна власатка FE	У=81.678-0.337 Д	0.964	1.200	162.0	***
Безосилеста овсига BR	У=79.392-0.326 Д	0.947	1.41	109.0	***
Общо Common	У=81.047-0.339 Д	0.925	1.609	274.0	***
Поемане на сухото вещество/ - %bw					
Ежова главица DA	У=7.846-0.0763 Д	0.881	0.519	44.5	***
Тръстиковидна власатка FE	У=7.057-0.057 Д	0.886	0.384	46.8	***
Безосилеста овсига BR	У=6.21-0.0482 Д	0.883	0.325	45.4	***
Общо Common	У=7.043-0.060 Д	0.838	0.448	113.9	***
Относителна хранителна стойност / Relative feeding value- отн. %					
Ежова главица DA	У=430.428-4.408 Д	0.790	41.99	22.6	*
Тръстиковидна власатка FE	У=418.928-4.110 Д	0.891	25.49	49.5	***
Безосилеста овсига BR	У=354-3.3308 Д	0.882	22.33	45.1	***
Общо Common	У=401.13-3.942 Д	0.817	31.24	98.3	***
Обща енергия, MJ.kg-1 органично вещество					
Ежова главица DA	У=23.113-0.0336 Д	0.931	0.169	81.7	***
Тръстиковидна власатка FE	У=23.206-0.0309 Д	0.977	0.086	265.0	***
Безосилеста овсига BR	У=22.927-0.027 Д	0.946	0.121	106.0	***
Общо Common	У=23.081-0.0307 Д	0.910	0.161	224.7	***
Метаболитна енергия/ Metabolic energy MJ.kg-1 органично вещество/ organic matter					
Ежова главица DA	У=15.206-0.0907 Д	0.952	0.373	121.2	***
Тръстиковидна власатка FE	У=14.534-0.0734 Д	0.912	0.421	62.5	***
Безосилеста овсига BR	У=15.793-0.0962 Д	0.931	0.485	80.9	***
Общо Common	У=15.178-0.0868 Д	0.915	0.441	238.9	***
UFL, kg сухо вещество/ dry matter					
Ежова главица DA	У=1.230-0.00774 Д	0.982	0.018	342.5	***
Тръстиковидна власатка FE	У=1.182-0.00665 Д	0.897	0.041	52.5	***
Безосилеста овсига BR	У=1.316-0.00925 Д	0.968	0.031	180.7	***
Общо Common	У=1.243-0.00788 Д	0.937	0.034	326.5	***
UFV, kg сухо вещество/ dry matter					
Ежова главица DA	У=1.19-0.00869 Д	0.980	0.022	295.2	***
Тръстиковидна власатка FE	У=1.127-0.00739 Д	0.895	0.047	50.9	***
Безосилеста овсига BR	У=1.281-0.0102 Д	0.961	0.038	148.2	***
Общо Common	У=1.200-0.0088 Д	0.932	0.039	305.4	***
КЕМ,kg сухо вещество/ dry matter					
Ежова главица DA	У=1.026-0.006598 Д	0.983	0.016	347.	***
Тръстиковидна власатка FE	У=0.983-0.00556 Д	0.905	0.033	57.5	***
Безосилеста овсига BR	У=1.088-0.00767 Д	0.965	0.026	168.3	***
Общо Common	У=1.033-0.00659 Д	0.940	0.027	348.8	***
КЕР -kg сухо вещество/ dry matter					
Ежова главица DA	У=0.968-0.00697 Д	0.974	0.021	223.1	***
Тръстиковидна власатка FE	У=0.918-0.006 Д	0.895	0.037	91.6	**
Безосилеста овсига BR	У=1.052-0.00855 Д	0.969	0.028	188.7	***
Общо Common	У=0.987-0.00732 Д	0.939	0.031	338.1	***
VEM, kg сухо вещество/ dry matter					
Ежова главица DA	У=1304.607-7.471 Д	0.980	19.579	299.6	***
Тръстиковидна власатка FE	У=126699.5-6.444 Д	0.958	25.03	136.2	***
Безосилеста овсига BR	У=1362.464-8.347 Д	0.963	30.281	136.3	***
Общо Common	У=1312.19-7.420 Д	0.952	27.621	445.4	***
VEVI, kg сухо вещество/ dry matter					
Ежова главица DA	У=1446.107-9.733 Д	0.983	23.79	344.4	***
Тръстиковидна власатка FE	У=1403.357-8.471 Д	0.957	33.00	35.6	***
Безосилеста овсига BR	У=1502.107-10.316 Д	0.940	47.87	95.5	***
Общо Common	У=1450.523-9.507 Д	0.948	37.26	401.9	***

The calibration models in near infrared region (NIR) at different mathematical treatment and differentiation of the spectrum studied demonstrate high degree of accuracy at determination of plant cell walls composition, digestibility and feeding value – energy and protein. With enlargement of the region of values for each parameter of composition, digestibility and feeding value in the vegetation process, in contrast of the plant harvesting in definite growing stage, demonstrate increasing of predictive accuracy – coefficients of determination over 0,90.

In the first vegetative growth in growing process of the perennial grasses with the increase of their height parameters and age, the content of protein and plant cell walls fiber components for three perennial grass species is changed regularly. The composition, digestibility and energy and protein feeding value for orchardgrass, tall fescue and smooth bromegrass are determined with very good accuracy for the practice by *linear regression equations by plant age in days from the beginning of the vegetation* as independent variable. All equations for each parameter of each species (variety) and commons for the three perennial grass species (varieties) demonstrate high statistical reliability.

In *comparison of commons linear regression equations* for composition, digestibility and feeding value by *global NIR spectral calibration models* for three perennial grass species (varieties) it is established closed prediction accuracy. The predictive accuracy of NIR spectral calibration models is higher. When it is no possibility for prediction by scanning NIR spectral analysis the determination and prediction of composition, digestibility and feeding value may be performed with sufficient accuracy for practical purposes by linear regression equations by plant age in days as independent variable.

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