Asian Journal of Crop Science

ISSN 1994-7879

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Asian Journal of Crop Science 7 (3): 207-213, 2015
ISSN 1994-7879 / DOI: 10.3923/ajcs.2015.207.213

Assessment of Chemical Composition of Grain Crops Depending on Vegetative Stage for Feeding

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ABSTRACT

The following grass: *Bromus inermis*, *Elytrígia bluish*, *Agropyron pectiniforme* that are widely used in diets of ruminants were gathered and assessed for contents of Dry Matter (DM), Crude Protein (CP), ash, crude fat, Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), lignin, hemicellulose, Crude Fiber (CF), nitrogen-free substances. Samples of grain crops were assessed. The samples were taken within earing phase, flowering period, seeding in intact plant and in separate vegetative parts (n = 10). Dry matter regularly increases with developing vegetation phases. This index of smooth brome and wheatgrass has better balance in vegetative parts in earing and flowering phases during the assessment of their feed value. Mass weight of crude protein was in leaves and reproductive organs during all periods of plants development. At earing phase the highest content of it was registered. Higher content of crude fiber was registered in culm and leaves of smooth brome during earing phase. It was higher by 3.4-8.5%. The tendency for more intensive accumulation of crude fiber is observed rather well within seeding phase. Fiber content in culm of smooth brome was by 2.1-2.4% higher. Culm and leaves of wheatgrass in its turn have the highest content of nitrogen-free substances. With growth and development of crop neutral detergent fiber increases from 49.4% (in earing phase) up to 64.1% (in seeding phase) acid detergent fiber increased by 8.2-11.4% and hemicellulose and cellulose - by 0.7-4.4%. Concentration of metabolizable energy in 1 kg dry matter decreases by 17.3-19.7% in the process of physiological maturation of grain crops for feeding. Maximum content of structural carbohydrates was observed in culm part of grain crops, minimum content-in leaves and generative parts of plants had intermediate position. Thus, type of feed crop, phase of its development determine mainly chemical composition and content of carbohydrate fractions not only in whole grain crops but also in vegetative parts. It can further influence on preparation technology and fodder quality.

Key words: Grain crops, vegetative phase, chemical composition, neutral detergent fibre, acid detergent fibre

INTRODUCTION

The improvement of quality of crops used for feeding animals is one of contemporary issues. Among them there are influence of heat stress on protein quality and breeding drought tolerant varieties of plants (Thomas, 2015), efficient use of cultures under dryland conditions (Robles *et al*., 2008; Boufennara *et al*., 2012), increasing the bioavailability of minerals from grain crops (Gupta *et al*., 2015). More efficient use of perennial crops that require less protection chemicals and energy are marked (Schendel *et al*., 2015). Moreover, indices of crop quality assume significance: relationship between soluble carbohydrates and gas production (Coblentz *et al*., 2013), fiber and chemical composition (Jancik *et al*., 2008), influence of maturity on fiber quality (Palmonari *et al*., 2014). Eventually, chemical composition of plants influences on nutrition of animals: digestibility of nutrients taking into account fiber from fodder (Sousa *et al*., 2014), influence of dietary fiber on health (Gidenne, 2015), on ruminal digestion (Brooks *et al*., 2014). The objective of this work is assessment of chemical composition grain crops taking into account vegetative phases under conditions of steppe are of the South Urals.

MATERIALS AND METHODS

Study area: Study was performed in Orenburg region of Orenburg oblast (51.678°N. 55.202°E). The climate is sharply continental, temperatures range from -40.1-+38°C. Annual amount of precipitation is 350-450 mm.

Research object: Such grain crops as smooth brome (*Bromus inermis*), quackgrass (*Elytrígia bluish*) and wheat grass (*Agropyron pectiniforme*). Chemical assessment of grain crops was carried out in samples taken in phases of earing, flowering, seeding in the whole plant and in some vegetative parts (n = 10).

Studies were performed in the test center of All-Russian Research Institute of Beef Cattle Breeding, state certificate #ROSS RU 0001.21 PF 59).

Chemical analysis of plant: Dry Matter (DM) was determined by drying samples to constant weight at 105°C (GOST 31640-2012, 2012). Crude Protein (CP) was determined by method of Kjeldahl and estimating crude protein content (nitrogen*6.25), GOST 32044.1-2012 (2014) (ISO 5983-1:2005). Crude Fiber (CF) was determined by express method with addition of more acid and alkali (GOST 31675-2012, 2013). Crude fat was found using Soxhlet extraction (GOST 13496.15-97, 2011), Crude Ash (CA) by burning the trial sample and subsequent calcination of the ash (GOST 26226-95, 2003). Nitrogen-free substance was estimated as the difference between the total amount of dry matter and crude fat, ash, fiber and protein. Neutral (NDF) и Acid Detergent Fiber (ADF) was determined by method described by Van Soest *et al*. (1991) using neutral and acid detergent. Cellulose fraction in sample was almost removed after subsequent treatment with ADF (72% H_2SO_4), lignin remained in residue. Hemicellulose was calculated according to difference between NDF and ADF and cellulose is estimated by the difference between ADF and lignin. Simple linear correlation coefficients were calculated to evaluate the linear relationships between analyzed components.

Statistical analysis: Data was recorded and classified using Microsoft Office Excel 2007. The significance of differences between indices was determined using criteria of nonparametric statistics ($p<0.05$) and were calculated using Statistica (2001).

RESULTS AND DISCUSSION

As a result of studies it was shown that dynamics of chemical composition in the compared crops was not the same and it concerned the DM content (Fig. 1a-c). The DM of the whole plant increased in wheatgrass by 20.8% in smooth brome by 11.8 and quackgrass by 14.8% in the period from earing phase to the beginning of seeding. Accumulation of DM was faster in leaves of

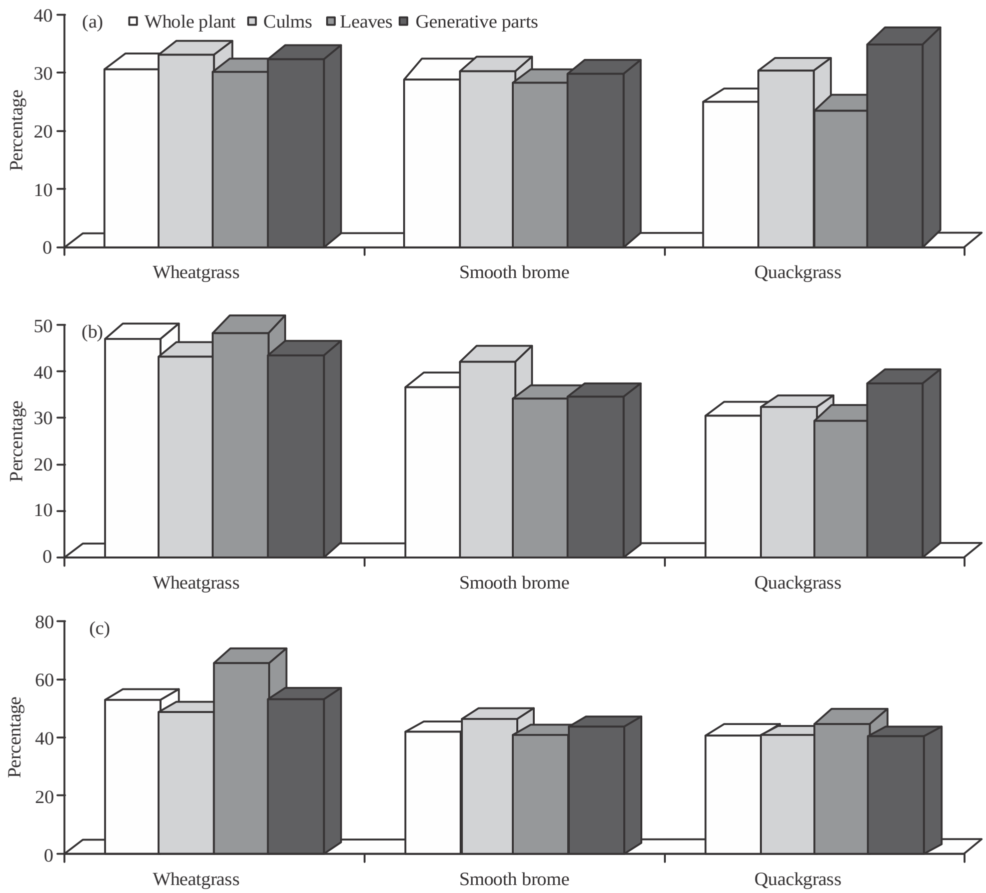

Fig. 1(a-c): Dry matter content in crops at (a) Earing phase (b) Flowering phase and (c) Seeding phase

wheatgrass. Content of DM was up to 30.0% at earing phase. At the beginning of seeding this index increased 2.2 times. Increase in culm was 10.6 and 14.6% in the period from earing to seeding and in reproductive organs it was 11.4 and 19.7%. DM did not accumulate in smooth brome so fast, so, leaves roughened by 6.0% within the period from earing to flowering, by 10.6% up to seeding phase, culm by 12.3, 15.2% and reproductive organs by 5.0; 13.1%, respectively. Leaves of quackgrass had the least content of DM (23.5-28.3%) within earing and flowering phase. This index increased up to 45.4% at seeding phase. With age DM content grew up to 39.0% in culm and reproductive parts.

Thus, regular increase of DM is observed in all considered perennial crops with the development of vegetative phases. However, dry matter of smooth brome and wheatgrass had better balance in the vegetative parts in phases of earing and flowering, when their feed value was assessed. Thus, all considered perennial grasses can be traced regularity DM increase with the development of the vegetative phase, however, the figure in the rump and wheatgrass in the phase of earing and flowering has better balance in the vegetative parts, assessing their stern dignity. The explanation for this can be given to the influence of abiotic factors on the development of plants and individual characteristics (Maiti and Satya, 2014; Halford *et al*., 2014). This is especially true of wheatgrass, as the difference in accumulation of dry matter in culm and leaves was 6.8 and 3.5% at phase of earing and blooming, respectively.

Nutrients in dry matter of perennial crops changed and were characterized not only by the dynamics of individual nutrients but also their redistribution between vegetative parts of plants. Crude protein within all periods of crop development was found in leaves and reproductive parts. The highest content was registered at earing (from 18.0-20.7 and 15.7-17.4%).

In particular, wheatgrass and quackgrass, on average, exceeded smooth brome by 2.7% according to the content of crude protein in leaves. Quackgrass had higher content of crude protein (1.3-2.0%) in culm. Crude protein was less by 1.8 and 2.0% in reproductive organs of wheatgrass and smooth brome, respectively.

Higher content of CF was registered in culms and leaves of smooth brome at earing phase. So, CF content in wheatgrass was less by 3.4 and quackgrass by 8.6-8.4; 8.5% than its content in smooth brome.

At the same time, NFS accumulated in culms of quackgrass by 3.5% more than in wheatgrass and by 3.0% - in smooth brome. The NFS in leaves of wheatgrass and quackgrass had the same content, smooth brome accumulated less NFS (by 5.7%). At flowering and seeding phases CF content increased; NFS content also increased in aerial parts of crops, crude fat and crude protein simultaneously decreased. At the same time it should be noted that quackgrass had the highest level of CF in all vegetative parts at flowering phase, wheatgrass by 0.6, 1.1 and 1.7%, smooth brome by 3.4, 4.8 and 7.7%, respectively. The NFS level in culm of smooth brome increased from 50.0 up to 57.0%, in wheatgrass from 49.0-53.0% and NFS decreased almost by 3.0% in quackgrass. Leaves of quackgrass had up to 60.0% of NFS at that time or higher by 17.6-14.0% than in wheatgrass and smooth brome. By seeding phase there was a rather clear tendency to more intensive accumulation of CF, its content in culms of smooth brome was by 2.1% higher than that of wheatgrass and by 4.2% higher than in quackgrass. In leaves of smooth brome, in contrast, it was less by 8.0% than in wheatgrass and quackgrass, this difference was not significant. In its turn, culms and leaves of quackgrass had higher content of NFS than wheatgrass (by 1.4, 3.2%) and smooth brome by 3.7 and 3.8%, respectively. Vegetation phase has a great influence on the chemical composition of crops (Rosser *et al*., 2013).

The performed studies have shown that structural carbohydrates from different feed significantly differ in composition from each other (Table 1). With growth and development of plants their quantity increases. So, NDF content in smooth brome increases from 49.4% (at earing phase) to 61.8% (in seeding phase) with growth and development. The NDF in wheatgrass increases

Table 1: Content of structural carbohydrates by vegetation phases (whole crop), (%)

Crops	NDF	ADF	Lignin	Cellulose	Hemicellulose
Earing					
Smooth brome	49.4±2.3	34.8±3.5	4.5±4.6	30.30±2.9	14.6±3.0
Quackgrass	51.0±4.1	36.0±4.3	4.2±3.3	31.80±3.1	15.0±3.8
Wheatgrass	51.9±2.2	38.2±1.2	6.0±2.1	32.20±4.2	13.8±2.7
Flowering					
Smooth brome	56.0±2.2	39.1±4.4	7.4±1.9	31.70±2.4	16.8±2.5
Quackgrass	56.9±3.1	41.0±3.9	8.2±3.6*	32.80±3.5	15.9±3.7
Wheatgrass	59.3±2.4	43.0±2.8	8.9±4.2*	34.01±1.8	16.3±4.6
Seeding					
Smooth brome	62.0±2.1**	43.0±3.5	10.1±3.4**	32.90±2.7	18.8±4.7
Quackgrass	62.2±2.6**	45.4±3.1**	11.5±2.3**	33.90±3.4	16.8±2.1
Wheatgrass	64.1±3.8**	49.6±1.9**	13.1±4.1**	36.50±3.0	14.5±3.8

Significant difference (p<0.05) between development phases of smooth brome, quackgrass, wheatgrass, *: Between earing and flowering phases, **: Earing and seeding phase, NDF: Neutral detergent fiber, ADF: Acid detergent fiber

Table 2: Content of structural carbohydrates by vegetation phases in vegetative parts of crops (%)

Parts of crops	NDF	ADF	Lignin	Hemicellulose	Cellulose
Earing					
Brome					
Leaves	43.5	28.6	1.4	27.2	15.0
Culms	48.3	31.2	3.0	28.2	17.0
Heads	45.0	29.9	2.0	28.0	15.0
Quackgrass					
Leaves	46.1	30.4	1.0	29.4	15.7
Culms	49.9	32.9	8.8	29.1	17.0
Heads	48.0	31.1	1.5	29.6	16.8
Wheatgrass					
Leaves	47.1	32.0	3.0	29.0	15.0
Culms	52.1	33.8	4.8	29.0	18.2
Heads	50.9	33.0	3.3	29.7	18.0
Flowering					
Brome					
Leaves	46.0	33.1	6.0	27.1	12.9
Culms	52.5	40.1	8.0	32.1	12.4
Heads	50.3	35.9	7.0	28.2	14.4
Quackgrass					
Leaves	50.9	37.5	6.3	31.3	13.4
Culms	55.0	40.0	7.3	32.6	15.0
Heads	53.1	39.0	7.0	32.0	14.1
Wheatgrass					
Leaves	52.8	39.0	7.3	31.7	13.8
Culms	58.9	42.9	9.0	33.8	16.0
Heads	57.1	41.3	8.0	33.3	15.9
Seeding					
Brome					
Leaves	53.6	40.7	9.0	31.8	12.9
Culms	59.9	46.0	11.5	34.5	13.9
Heads	53.0	40.1	9.3	30.8	12.8
Quackgrass					
Leaves	57.0	44.8	10.0	34.8	12.2
Culms	62.8	48.0	12.2	35.8	14.8
Heads	56.9	43.7	10.8	32.9	13.1
Wheatgrass					
Leaves	58.6	45.4	10.0	35.4	13.2
Culms	63.0	49.3	12.8	36.4	13.7
Heads	59.1	46.0	11.3	34.7	13.1

NDF: Neutral detergent fiber, ADF: Acid detergent fiber

from 51.9-64.1%. Based on the performed studies it was found that the amount of NDF characterizes the degree of plants ripening as grass, harvested at later vegetative phases, have higher percentage of NDF.

ADF level of analyzed grasses increased by 8.2-11.4% with the change of phenological phases of vegetation and levels of hemicellulose and cellulose by 0.7-4.4 and 2.6-4.3%. As the plants ripe, cell wall thickens and increasing the number of fractions associated with lignin. The amount of lignin increased by 5.6-7.1% with change of phenological phases. Concentration of Metabolizable Energy (ME) decreased by 17.3-19.7% during physiological maturation of crops. The content of structural carbohydrates was determined not only for the whole plants but also for the vegetative parts (Table 2). As phenological phases shift, maximum content of structural carbohydrates (NDF, ADF, lignin, cellulose, hemicellulose) was observed in culm of crops, minimum content in leaves and generative parts of crops had the mid position. At earing phase NDF content in culm of crops was higher by 4.7-5.0% than in leaves and in generative parts by 1.2-3.3%.

The NDF quantity in culms increased by 4.4-6.2% as compared with leaves and in generative parts by 3.9-6.9%. Significant changes were found in the content of ADF. Its content in culms increased by 3.8-5.3% in comparison with leaves and in generative parts by 3.3-5.9%. It should be noted that each phase of vegetation was characterized with different lignin content in vegetative parts (Burton and Fincher, 2014).

So, within earing phase lignin content in leaves was 1.0-3.0% in culms 3.0-4.9% and in generative parts 1.5-3.3%. Within seeding phase lignin content in leaves was 8.9-10.0%, in culms 11.5-12.8% and in generative parts 9.4-11.3%. Data analysis has shown that lignin accumulates in culms much faster by 2.6-2.8% than in leaves of plants and in generative parts by 1.5-2.2%. The content of cellulose at earing phase was approximately the same in all vegetative parts (28.2-29.7%) and at flowering phase the amount of cellulose in culms was 32.1-33.8%, in leaves 27.1-31.7%, in generative parts 28.8-33.3%. At seeding phase cellulose content increased in culms by 3.5-3.7%, in generative parts by 0.9-1.4%. With growth and development of crops, hemicellulose content decreased in culms by 3.2-4.5, 1.9-3.5% in leaves and in generative parts by 2.2-4.8%.

CONCLUSION

Type of feed culture, phase of its development largely determines the chemical composition including certain fractions of carbohydrates not only in whole plants but also in their vegetative parts. Development phase of the plants shall be taken into account for the efficient use and conservation of nutrients from crops used for feeding purposes. It seems necessary in order to choose best available technology for fodder preparation.

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