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Original article

Evaluation of Winter Vetch Varieties by Quality Indicators

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Abstract

Biochemical assessment of the aboveground biomass of 8 winter vetch (Vicia villosa) varieties was performed in two stages of plant development - beginning of flowering and technical maturity of seeds. Field trial was carried out in the Institute of Forage Crops, Pleven, Bulgaria (2014-2016). The variability in crude protein (CP) content (5.55 - 6.12%), calcium (8.17 - 9.87%) and phosphorus (5.34 - 6.74%) in both phenological stages was weak. The variation of crude fiber (CF) content (6.02 - 11.08%) and crude ash (CA) (7.42 - 10.88%) was found stronger. At the beginning of flowering with a higher crude protein content Asko 1 (21.78%) and BGE001076 (21.53%), phosphorus content BGE001076 (0.48%), BGE004222 and BGE000643 (0.47%) were distinguished. In the technical maturity stage with a high crude protein content BGE004222 (20.51%) and BGE001847 (20.07%) are characterized and with phosphorus BGE004222 (0.38%). Positive statistically significant relationship was found between the grain yield and crude protein content (r = 0.58).

Keywords: Vetch, Aboveground mass, Biochemical assessment.

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INTRODUCTION

Grain legumes among which the different types of vetch are one of the main sources of high-quality plant protein. For many areas of the world for the needs of livestock breeding, the most important source of protein and fat remains the legumes (Stoycheva, 2015; Stoycheva and Kirilov, 2019). As high-protein food crops at this stage, they play an important role in solving the protein problem (Vasyakin, 2002; Vasileva and Vasilev, 2012).

The high content of crude protein in the fresh biomass of vetch makes it a desirable component in mixtures with certain grasses as it significantly increases the total crude protein content in them, as well as the yield of green mass (Aquilar-Lopez et al., 2013; Aleksieva et al., 2016).

For the needs of agricultural production, the widest application is peas and vetch. Their biological properties and qualities allow them to be grown in various soil and climatic zones on large areas. As nitrogen-fixing crops they are also important for natural soil fertility. Their inclusion in crop rotation schemes as precursors of other crops largely reduces nitrogen fertilization, which is particularly important in organic farming (Chekalin, 2003; Kadermas, 2014). Temperate climate zones are characterized by a complex of conditions that make them a suitable agro ecological area for the development of different types of winter vetch. Vetch can provide spring grazing, green fodder and hay with excellent feed quality and can be grown on low-productivity soils in extensive farming (Naidenova et al., 2012).

In the characterization of varieties, specimens and genotypes, more and more attention is paid to quality indicators that determine the nutritional value of the forage. The determination of the chemical composition of the forages is necessary for the compilation of optimal feed rations for farm animals and their better absorption (Ilieva and Naidenova, 2016).

This study aimed to perform a comparative characterization of the introduced winter varieties of chemical composition and further selection of suitable genotypes for the needs of the combinatorial selection.

Materials and Methods

The study was conducted during three consecutive years (2014-2016) in the experimental field of the Institute of Forage Crops, Pleven, Bulgaria. (43.41ºN, 24.61ºE), situated in the central part of the Danube hilly plain. Plant material of aboveground biomass of 8 winter vetch (Vicia villosa Roth.) cultivars BGE004222, BGE001847, BGE000637, BGE001076, BGE000639, BGE000643, BGE001383 (from Spain) and Asko 1 (from Bulgaria) (used as a standard) was analyzed. Sowing was carried out manually in optimal time according to the technology of cultivation of vetch in 3 replications, between row spacing of 50 cm and depth of sowing of 5 cm.

Samples for biochemical analysis were taken over two phenological stages of plant development - beginning of flowering and technological maturity of the seeds. They were dried at 60 °C to constant weight. All dried samples were milled to pass through a 1 mm screen and analysed. Crude protein content (CP) as percentage of absolute dry matter (%, DM) was determined according to Kjeldahl method (CP = N × 6.25), crude fibre (CF) (%, DM) and crude ash (Ash) (%, DM) by Weende methods (AOAC, 1990), macro elements calcium (Ca) (%, DM) - complexometrically and phosphorus (P) (%, DM) by hydroquinone (AOAC, 1990), Ca:P ratio was calculated.

The dependencies between the indicators were determined by correlation analysis and the variability by the coefficient of variation (CV, %) (Dimova and Marinkov, 1999). Statistical processing (dispersion analysis) of experimental data was performed through the Microsoft Excel 2002 and Statgraphics Plus 2.1 for Windows Excel programs.

Results

Variance analysis

Table 1 shows the results of a two-factor dispersion analysis of crude protein, crude fiber, crude ash, calcium, phosphorus data and Ca:P ratio, which show that in the beginning of flowering stage the factor environment (the year of cultivation) plays a stronger effect on the phenotypic change of all indicators. The influence of the other factor genotype (variety) on the manifestation of the studied parameters is significantly weaker, which implies a stronger change of these signs under the influence of the environment, despite their genetic determinants. No statistically significant differences were found between the genotypes by crude fiber content, calcium, Ca:P and crude ash. The year factor also had no influence on the calcium content.

Table 1. Analysis of variance (ANOVA) of the quality parameters of vetch varieties

Source	**df**	**CP**	**CF**	**Ca**	**P**	**Ash**	**Ca:P**
		beginning of flowering					
Year	2	23.3723**	58.948*	0.0204^{ns}	0.0143**	10.1813**	1.3158**
Genotype	7	8.1176**	4.584^{ns}	0.0302^{ns}	0.0027**	1.2724^{ns}	0.2502^{ns}
CV (%)		6.12	11.08	9.87	5.34	7.42	11.69
		technical maturity					
Year	2	37.3270**	407.7654**	0.5971**	0.1064**	100.6213**	56.3542**
Genotype	7	2.6494^{ns}	16.0145**	0.0355^{ns}	0.0015*	10.4208*	1.0383^{ns}
CV (%)		5.55	6.02	8.17	6.74	10.88	11.93
Error	14						

CP - Crude protein, CF - Crude fiber, CV (%) - coefficient of variation, *; ** significant at $P < 0.05$; $P < 0.01$

In the technical maturity stage the genotypic differences in crude protein, calcium content and Ca:P are insignificant and statistically unproven. The influence of the year factor as well as in the previous phenological stage is stronger than the other major factor genotype (variety).

Variation coefficient

The content of phosphorus (5.34%), crude protein (6.12%), crude ash (7.42%) and calcium (9.87%) in the beginning of flowering stage slightly varied for the period of study (Table 1). With regard to crude fiber content in fresh biomass, variation can be determined as an average (11.08%).

In the technical maturity stage the low values of coefficients calculated of crude protein (5.55%), crude fibers (6.02%), phosphorus (6.74%) and calcium (8.17%) defined them as relatively stable. The crude ash content (10.88%) in the straw of the studied winter vetches was broader, indicating that the phenotypic expression of the trait was more influenced by the factors of the environment. For the crude protein, calcium and phosphorus parameters, the difference between the values of the coefficient of variation determined in the two phenological stages is negligible. Greater variation is obtained by the content of crude fiber.

According to the chemical analysis of parameters in beginning of flowering stage (Table 2), the crude protein content is in the range of 16.58% (BGE000639) to 21.78% (Asko 1). High crude protein content in green biomass was also reported for BGE001076 (21.53%). Among the sample group tested, none of the introduced vetch varieties exceeded this Asko 1.

With the highest crude fiber content, the plants of BGE001383 (29.34%) and BGE000637 (28.65%) are distinguished, although their superiority to other samples, including the control variety Asko 1 (27.40%) is not statistically significant. The lowest crude fiber content was found at BGE000639 (25.56%) and BGE001076 (26.05%).

Table 2. Biochemical assessment of vetch varieties

Varieties	**CP**	**CF**	**Ca**	**P**	**Ash**	**Ca:P**
	Beginning of flowering					
BGE004222	19.31	27.81	1.38	0.47	12.01	2.99
BGE001847	20.43	27.49	1.32	0.41	10.37	3.25
BGE000637	20.38	28.65	1.31	0.40	11.06	3.43
BGE001076	21.53	26.05	1.23	0.48	10.90	2.61
BGE000639	16.58	25.56	1.16	0.43	11.97	2.67
BGE000643	19.60	27.52	1.39	0.47	11.19	2.98
BGE001383	18.97	29.34	1.20	0.42	10.70	2.92
Asko 1	21.78	27.40	1.44	0.44	10.29	3.26
LSD 0.05	2.124			0.078		1.177
LSD 0.01	6.004			0.116		1.743
LSD 0.001	9.279			0.18		2.693
	Technical maturity					
BGE004222	20.51	29.27	1.51	0.38	12.86	4.48
BGE001847	20.07	30.41	1.60	0.32	14.85	5.56
BGE000637	19.26	27.90	1.51	0.32	17.26	6.48
BGE001076	19.41	30.90	1.37	0.33	14.06	5.35
BGE000639	18.16	26.24	1.47	0.34	16.30	4.96
BGE000643	18.23	32.96	1.26	0.33	13.33	4.87
BGE001383	18.19	30.94	1.45	0.34	17.36	5.22
Asko 1	18.25	32.81	1.34	0.31	13.06	5.18
LSD 0.05		6.076	0.898	0.075	5.414	
LSD 0.01		8.992	0.392	0.111	8.012	
LSD 0.001		13.895	0.581	0.172	12.382	

CP - Crude protein, CF - Crude fiber

The content of calcium and phosphorus in plants affects the nutritional value of the forage and the state of health of the animals. With the content of calcium in the fresh biomass, winter vetch samples show very close relative values - from 1.16% (BGE000639) to 1.44% (Asko 1). Minor differences suggest the absence of genetic diversity in this indicator. The phosphorus content of the above-mentioned biomass samples ranged from 0.47% - 0.48% for BGE001076, BGE004222 and BGE000643 to 0.40% - 0.41% for BGE001847 and BGE000637. Asko 1 ranked on average with 0.44% phosphorus.

BGE004222 variety is also characterized by a higher crude ash content (12.01%), which in this case exceeds all other specimens in the group. BGE000639 can be ranked second with a crude ash content of 11.97%, and the last two places were for BGE001847 (10.37%) and Asko 1 (10.29%).

As vegetation progresses from the beginning of flowering to the technical maturity stage there is a change in the content of the studied parameters between the individual specimens due to their specific biological features (Table 2).

On average for the study years, the crude protein content of BGE004222 and BGE001847 was higher than 20.00%. In the other specimens, the crude protein content ranges from 18.16% (BGE000639) to 19.41% (BGE001076).

BGE000643 (32.96%) and Asko 1 (32.81%) have a higher crude fiber content than other varieties but the difference is statistically proven only against BGE000639 (26.24%).

The values obtained for the calcium content vary insignificantly and do not differ significantly from the control variety Asko 1. The content of this indicator varies from 1.26% (BGE000643) to 1.60% (BGE001847). The phosphorus content of straw BGE004222 is 0.38%, and in all others it varied from 0.31% (Asko 1) to 0.34% (BGE000639 and BGE001383), but only for Asko 1 variety the difference is significant.

The crude ash content of BGE001383 variety straw was 17.26%, BGE000637 - 17.36%, and low at BGE004222 (12.86%), Asko 1 and BGE000643 (13.33%).

Correlations

Correlative relationships between the parameters studied were established. In the beginning of flowering (Table 3) the following dependencies are strongly expressed and statistically proven: strong positive correlation between the content of phosphorus and crude ash (r = 0.722), between calcium content and Ca:P (r = 0.711); average correlation between Ca:P and crude fiber content (r = 0.555), between Ca:P and green biomass yield (r = 0.508).

The yield of green biomass correlates poorly with crude protein, crude fiber and calcium but the dependencies are not significant. Negative correlations were observed between crude ash and crude protein content (r = - 0.663) as well as between the crude ash and crude fiber content (r = - 0.602) and crude ash content and Ca:P (r = - 0.661).

Table 3. Correlations between the investigated parameters in the beginning of flowering stage

	CP	**CF**	**Ca**	**P**	**Ash**	**Ca:P**
CF	0.182					
Ca	0.390	0.166				
P	-0.384	-0.651**	-0.177			
Ash	-0.663**	-0.602*	-0.287	0.722**		
Ca:P	0.494	0.555*	0.711**	-.080**	-0.661**	
Green mass yield	0.115	0.444	0.384	-0.215	-0.386	0.508*

CP - Crude protein, CF - Crude fiber, * p≤ 0.05; ** p≤ 0.01

At the technical maturity stage (Table 4) the correlation coefficients obtained were statistically significant. There is a certain analogy with the dependencies between the indicators in the beginning of flowering stage. The phosphorus content correlates strongly with all other parameters.

Table 4. Correlations between the investigated parameters in maturity stage

	CP	**CF**	**Ca**	**P**	**Ash**
CF	0.786**				
Ca	0.872**	0.759**			
P	-0.735**	-0.913**	-0.826**		
Ash	0.689**	0.669**	0.834**	-0.813**	
Ca:P	0.769**	0.869**	0.890**	-0.974**	0.877**

CP - Crude protein, CF - Crude fiber, * p≤ 0.05; ** p≤ 0.01

Highest positive correlation coefficients are obtained between calcium and Ca:P (r = 0.890), between calcium and crude protein (r = 0.872) and between calcium and crude ash content (r = 0.834), as well as between the crude fiber content and Ca:P (r = 0.869) and between the crude protein content and Ca:P (r = 0.769).

Between grain yield and crude protein, crude fiber, calcium, phosphorus content and Ca:P dependence is found positive, the highest is between grain yields and calcium content (r = 0.84), but statistically significant only between grain yields with crude protein content (r = 0.58) (Fig. 1). Between grain yields and crude ash content a negative (r = - 0.30) correlation was found.

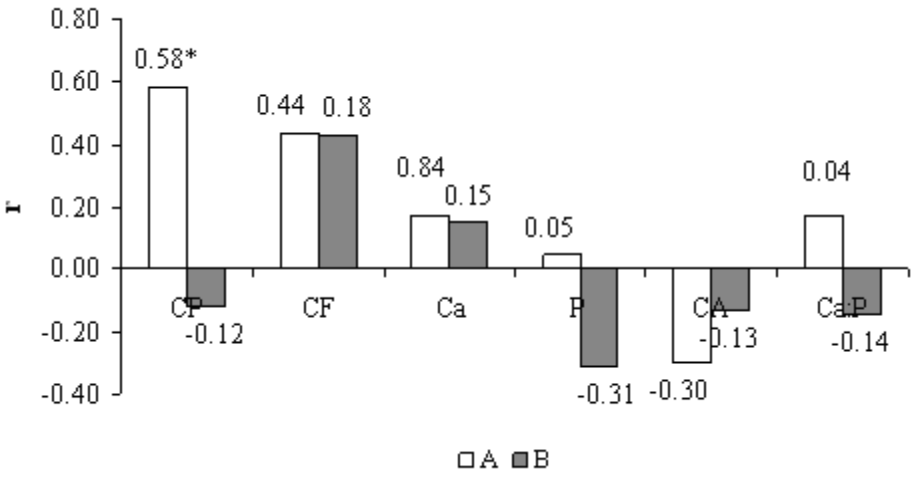

Figure 1. Correlations of the studied parameters with the grain yield and duration of the vegetation period

CP – Crude protein, CF – Crude fiber; A – grain yield (kg/da), B – vegetation period (days) * p≤ 0.05

We observed a slight negative correlation between the duration of the vegetation period and the parameters crude protein (r = - 0.12), phosphorus (r = - 0.31), crude ash (r = - 0.13) and Ca:P (r = - 0.14), and positive correlation between the duration of the vegetation period with crude fiber content (r = 0.18) and the calcium content (r = 0.15).

Discussion

Desalegn and Hassen (2015) in making a comparative assessment of green mass yield and the quality of different vetches, found that *Vicia dasycarpa* plants were more promising for growing in the forage direction than the other three species they studied (*Vicia atropurpurea*, *Vicia villosa* and *Vicia sativa*) due to the higher crude protein content in the fresh biomass. According to Goncharova et al. (2013) the complexity of selecting appropriate genotypes is determined by the multifaceted nature of their use, especially if they are for both green mass and grain yields due to the negative correlation between these indicators.

Barbashov (2012) in a similar one-year legume crop (bean) found a negative correlation between grain yield and crude protein content in the grain. Popovic et al. (2016) reported similar results in soybean. Linear correlation coefficients between agro-morphological and qualitative indices in varieties of *Vicia narbonensis* and *Vicia sativa* in the Kebede et al. (2013) studies have shown that the crude protein content is in positive correlation with the duration of the sowing period to the harvesting of the green biomass and the crude protein content in the grain is negatively correlated with the grain yield. Similar models were studied by Nakova and Christova in maize.

In his studies Alemu et al. (2007) report that the dry matter content increases with retarded harvest due to reduced moisture content in the leaves as the plants age and lignify.

Conclusions

The results of the study show that the variability in crude protein content (6.12-5.55%) and macro elements Ca (9.87-8.17%) and P (5.34-6.74%) is weak in both phenological stages of plant development. The variation of crude fiber content (11.08-6.02%) and crude ash (7.42-10.88%) is stronger. At the beginning of flowering with a higher crude protein content, Asko 1 (21.78%) and BGE001076 (21.53%), crude fiber BGE001383 (29.34%) and BGE000637 (28.65%), phosphorus content BGE001076 (0.48%), BGE004222 and BGE000643 (0.47%) were distinguished.

In the technical maturity stage with a high crude protein content BGE004222 (20.51%) and BGE001847 (20.07%) are characterized, with high crude fiber content BGE000643 (32.96%) and Asko 1 (32.81%), with phosphorus BGE004222 (0.38%), with ash BGE001383 (17.26%) and BGE000637 (17.36%).

At the beginning of flowering stage strong positive relationships between phosphorus content and crude ash content (r = 0.722), between calcium content and Ca:P (r = 0.711) were found; average correlation between Ca:P and crude fiber content (r = 0.555).

At the technological maturity stage, the highest positive correlations were obtained between calcium content and Ca:P (r = 0.890) and between calcium content and crude protein content (r = 0.872); between crude fiber content and Ca:P (r = 0.869), between crude protein content and Ca:P (r = 0.769). Positive statistically significant relationship was found between the grain yield and crude protein content (r = 0.58).

Additional Declaration

Research and publication ethics principles were comply with in this study. Authors contributed equally to the study.

REFERENCES

Aleksieva, A., T. Bozhanska and Y. Naydenova (2016). Biochemical evaluation of breed lines of common vetch (*Vicia sativa* L. *ssp.sativa*) and opportunities to use them as green forage. J. Mount. Agric. Balk., 19 (3), 99-113.

Alemu, B., S. Melaku and N. K. Prasad (2007). Effects of varying seed proportions and harvesting stages on biological compatibility and forage yield of oats (*Avena sativa* L.) and vetch (*Vicia villosa* R.) mixtures. Livest. Res. Rural Develop., 19 (1), 1-9.

AOAC (1990). Offical methods of analysis. Association of the official analytical chemists. (15th edition) Arlington, USA.

Aquilar-Lopez, E. Y., J. L. Boroques, I. A. Dominquez, A. Morales-Osorio and M. De Guadalupe Gutierrez-Martinez (2013). Forage yield, Chemical composition and *In-vitro* Gas Production of *Triticale* (x*Triticose* Wittmack) and Barley (*Hordeum vulgare*) associated with Common vetch (*Vicia sativa*) Preserved as Hay or Silage: 227-238.

Barbashov, M. V. (2012). Evaluation of the initial material of common beans (*Phaseolus vulgaris* L) for the creation of highly effective plant-microbial systems. The dissertation author's abstract on competition of a scientific degree of the candidate of agricultural sciences. The Eagle.

Chekalin, N. M. (2003). Genetic bases of selection of leguminous crops for resistance to pathogens. Poltava: *Intergraph*, p.186

Desalegnp, K. and W. Hassen (2015). Evaluation of Biomass Yield and Nutritional Value of Different Species of Vetch (*Vicia*). Acad. J. Nutr., 4 (3), 99-105.

Dimova, D. and E. Marinkov (1999). Experimental work and biometrics. HAI-Plovdiv 263 (in Bulgarian).

Goncharova, A. V., P. L. Goncharov, E. E. Andrusovich, T. V. Ryttel (2013). Integrated research in the selection of fodder crops. Genfond and plant breeding, 1, 118-124

Ilieva, A. and G. Naidenova (2016). Phenotypic evaluation of variability in quality traits of Hungarian vetch (*Vicia pannonica ssp. pannonica* Crantz) accessions. Rastenievadni nauki (Bulgarian Journal of Crop Science), 53 (4), 63-67.

Kadermas, I. G. (2014). Formation of photosynthetic and symbiotic apparatuses of plants and their contribution to the increase in the productivity of pea sowing agrocenoses (*Pisum sativum* L.). PhD thesis, Omsk, 147 p.

Kebede, G., G. Assefa, A. Mengistu and H. Mohammed (2013). Evaluation of vetch species and their accessions for agronomic performance and nutritive value in the Central Highlands of Ethiopia. Ethiop. J. Agric. Sci., 24, 99-121.

Naidenova, G., A. Ilieva and A. Aleksieva (2012). Investigation of winter vetch accessions as initial material for breeding in grass-feed direction. J. Mount. Agric. Balk., 15 (6), 1388-1404.

Nakova, R. and S. Christova (2012). Contemporary investigations on competitive relations between maize (*Zea mays* L.) and weeds. Rastenievadni nauki (Bulgarian Journal of Crop Science), 59 (4), 73-77.

Popovic, V., M. Tatić, V. Sikora, J. Ikanovic, G. Drazic, V. Djukic, B. Mihailovic, V. Filipovic, G. Dozet, L. Jovanovic and P. Stevanovic (2016). Variability of yield and chemical composition in soybean genotypes grown under different agroecological conditions of Serbia. Rom. Agric. Res., 33, 29-39.

Stoycheva, I. (2015). Influence of grazing and preserved forage on milk production of sheep. PhD Thesis, Pleven, 2015.

Stoycheva, I. and A. Kirilov (2019). Feeding female lambs with peas and soybeans as protein sources. Arch. Zootech., 21 (1), 57-63.

Vasileva, V. and E. Vasilev (2012). Study on Productivity of some Legume Crops in Pure Cultivation and Mixtures. Agric. Conspec. Sci., 77 (2), 91-94.

Vasyakin, N. I. (2002). Leguminous crops in western Siberia. Omsk, 2002. 234 pp.