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EVALUATION OF QUALITY–RELATED CHARACTERISTICS AND YIELD IN WINTER FORAGE PEA VARIETIES

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Abstract. In 2010–2011 r. the Second Experimental Field of the Institute of Forage Crops–Pleven, was carried out field trial with seven (Mir, Pleven 10, Fenn, Austrian winter pea, E.F.B.33, Uzbetskij 71 and *Chlumecka fialova*) winter pea (*Pisum sativum* L.) varieties from the pea collection. Variety Mir 4 was used as a standard. A biochemical assessment of the aboveground biomass of the varieties was made by the following characteristics: content of crude protein, crude fiber, calcium, phosphorus and water soluble sugars. The results of the study showed that, with the highest green mass yield and crude protein in phenological stage–full pod formation stage are varieties Pleven 10, E.F.B.33 and *Chlumecka fialova* and grain yield and crude protein Fenn and Austrian winter pea. At both phenological stages of the development of the plants *Chlumecka fialova* was characterized with high content of crude protein and low of crude fiber. The highest content of the water soluble sugars in aboveground biomass was established in variety Uzbetskij 71. At phenological stage the full pod formation were established correlational relationships–positive between crude protein and phosphorus (r = 0.653) and negative between crude protein and crude fiber (r = –0.589), phosphorus and crude fiber (r = –0.585).

Keyword: aboveground biomass, biochemical assessment, winter forage pea

Introduction

Pea is a long established and significant crop in Europe. The forage pea (*Pisum sativum* L.) is one of basic protein crops used in the production of forage.

It is good energy source for ruminants and addition to non-ruminants and significant degree can be used as alternative to soybean.

Relatively the high content of crude protein macro and micro elements, short vegetation period and possibility to be used as grain, senage, hay, or green forage in full pod formation stage make forage pea preferred culture by farmers [GUJSKA *et al.*, 1994; BEDNAR *et al.*, 2001; McPHEE 2003; KIRILOV 2005; KIRILOV and TRIFONOVA 2007; SRIVASTAVA *et al.*, 2009, BUTNARIU *et al.*, 2006, CAUNII *et al.*, 2015].

The biological characteristics of the pea give opportunity in Bulgaria it to be grown successfully as winter and spring crop. The winter type varieties use the winter–spring moisture, they avoid spring and summers dry, they heap up more biomass and ensure in the years steady and secure yields [ANGELOVA 1995; KERTIKOVA and KERTIKOV 2013].

As a nitrogen–fixing crop, pea is of great importance also to natural soil fertility. Its inclusion in the crop rotation schemes as a preceding crop for other crops decreases the nitrogen fertilizing to a great extent, which is particularly important in organic farming [ANGELOVA 2006, VASILEVA and ILIEVA 2012].

Despite that the yield being most important criterion in selection process, the traits related with the quality of the forage acquire increasingly meaning.

Between the separate varieties exist the determined difference in the content of the crude proteins and other chemical compounds, determining of the feed value of the forage.

Systematization of assessment information gathered from pea collection along with chemical characterization created possibilities for increasing the effectiveness of a breeder's programme [ADSULE *et al.*, 1989; BUXTON 1996; HYMPHREY and THEODOROU 2001; ANGELOVA and STOILOVA 2009].

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The purpose of this study was to make a comparative evaluation of genetic diversity of winter forage pea varieties on yield and biochemical content with a view to their use as parental components in the breeding programs.

Material and methods

In the period of 2010–2011 in the Second Experimental Field of the Institute of Forage Crops–Pleven, Bulgaria situated in the central part of the Danube hilly plain is carried out field trial with a size of experimental plot of 4 m^2.

Sowing was conducted on soil subtype slightly leached chernozem under without irrigation conditions at the optimal dates for the crop according to the adopted technology for growing spring pea in the Institute of Forage Crops–Pleven, at the sowing rate of 120 germinable seeds/m^2, with an inter–row spacing of 11 cm and a sowing depth of 5 cm.

Plant material from the aboveground biomass of seven (five of them are with normal type leaves) winter varieties of forage pea (*Pisum sativum* L.) was analyzed.

Varieties Mir (officially acknowledged by the State variety commission in Bulgaria as standard in winter pea varieties) and Pleven 10–from Bulgaria, Fenn (acacia type leaves) and Austrian winter pea (afila type)–from USA, E.F.B.33–from Germany, Uzbetskij 71–from Russia and *Chlumecka fialova*–from Czech republic.

The samples were taken at two phenological stages of plant development–full pod formation stage and full (technical) maturity.

A biochemical assessment of the varieties was made by the following characteristics: content of *crude protein* (CP)–by the method of Kjeldahl, *crude fiber* (CF)–by the Weende method, *calcium* and *phosphorus*–according to Sandev [SANDEV, 1979] and *water soluble sugars* (WSC)–according to Ermakov and collab. [ERMAKOV *et al.*, 1987].

Were studied grain yield (kg/ha), green mass yield (kg/ha) and crude protein yield (kg/ha).

The relationships between the characteristics were established by a correlation analysis [DIMOVA and MARINKOV 1999].

The statistical processing of the experimental data was performed by the programmes Excel of Microsoft Office 2002 and Statgraphics Plus 2.1 for Windows.

Results and discussion

In Table 1 are shown Biochemical assessment of the winter forage pea varieties (2010–2011).

Table 1.

Biochemical assessment of the winter forage pea varieties (2010–2011)

Variety	CP % DM	% toward ST.	CF % DM	% toward ST.	Ca % DM	% toward ST.	P % DM	% toward ST.	WSC % DM	% toward ST.
full pod formation stage										
Mir	17.11^{ab}	100.0	19.58^{a}	100.0	0.852^{a}	100.0	0.326^{ab}	100.0	13.70^{ab}	100.0
Pleven 10	19.70^{ab}	115.1	17.00^{a}	86.8	0.761^{a}	89.3	0.389^{b}	119.3	14.30^{b}	104.4
Fenn	20.23^{b}	118.2	16.54^{a}	84.5	0.727^{a}	85.3	0.352^{ab}	108.0	12.95^{ab}	94.5
E.F.B.33	19.78^{ab}	115.6	18.37^{a}	93.8	0.734^{a}	86.1	0.322^{ab}	98.8	13.50^{ab}	98.5
Uzbetskij 71	16.54^{a}	96.7	20.37^{a}	104.0	0.806^{a}	94.6	0.279^{a}	85.6	14.55^{b}	106.2
Chlumecka fialova	20.23^{b}	118.2	16.96^{a}	86.6	0.800^{a}	93.9	0.353^{ab}	108.3	11.75^{a}	85.8
Austrian winter pea	18.33^{ab}	107.1	18.59^{a}	94.9	0.838^{a}	98.3	0.350^{ab}	107.4	12.60^{ab}	92.0
LSD 0.05	3.527		5.386		0.261		0.108		2.404	
maturity										
Mir	15.86^{a}	100.0	24.01^{a}	100.0	0.843^{ab}	100.0	0.344^{a}	100.0	2.00^{ab}	100.0
Pleven 10	15.01^{a}	94.6	27.72^{a}	115.4	0.829^{ab}	98.3	0.362^{a}	105.2	1.35^{a}	67.5
Fenn	16.82^{a}	106.1	26.32^{a}	109.6	0.803^{a}	95.2	0.333^{a}	96.8	2.70^{ab}	135.0
E.F.B.33	16.88^{a}	106.4	28.31^{a}	117.9	0.962^{bc}	114.1	0.328^{a}	95.3	2.10^{ab}	105.0
Uzbetskij 71	15.56^{a}	98.1	25.34^{a}	105.5	1.028^{c}	121.0	0.288^{a}	83.7	2.95^{b}	147.5
Chlumecka fialova	18.20^{a}	114.8	22.65^{a}	94.3	0.955^{bc}	113.3	0.335^{a}	97.4	2.05^{ab}	102.5
Austrian winter pea	17.90^{a}	112.9	23.67^{a}	98.6	0.892^{abc}	105.8	0.357^{a}	103.8	2.45^{ab}	122.5
LSD 0.05	3.305		9.911		0.147		0.083		1.539	

a, b, c,–statistically proven differences in P=0.05; CP–Crude protein, CF–Crude fiber; Ca–calcium; P–phosphorus; WSC–water soluble carbohydrate; % DM–% of dry matter, ST–standard;

For the period of investigation varieties Pleven 10, E.F.B.33 and *Chlumecka fialova* exceed standard (Mir) in green mass yield (59000 kg/ha, 56500 kg/ha and 56000 kg/ha respectively) and crude protein (11623 kg/ha, 11427 kg/ha and 11074 kg/ha) (Figure 1).

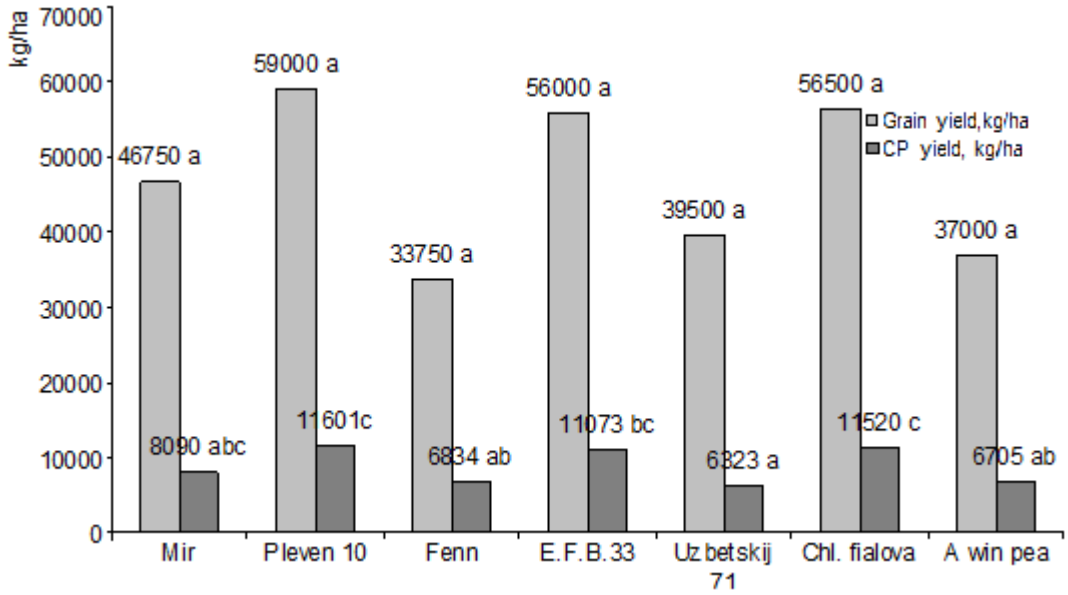

Figure 1. Green mass yield and crude protein yield (kg/ha) in full pod formation stage
a, b, c,–statistically proven differences in P=0.05

The highest grain yield and crude protein from seeds was realized from Fenn (2757 kg/ha and 464 kg/ha respectively) and Austrian winter pea (2030 kg/ha and 363 kg/ha) (Figure 2).

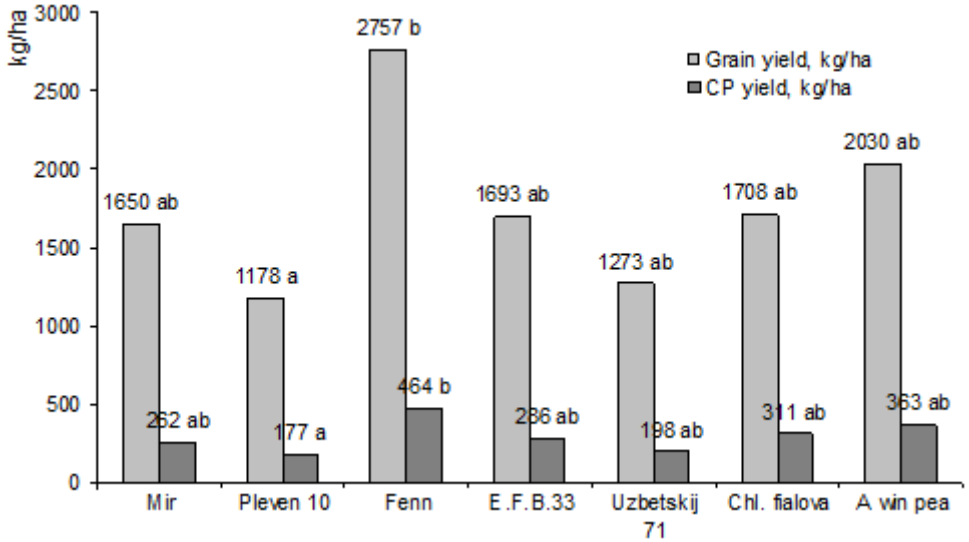

Figure 2. Grain yield and crude protein yield (kg/ha) in maturity
a, b, c,–statistically proven differences in P=0.05

The average data for years of the investigation (Table 1) showed that at the stage full pod formation the content of crude protein in the aboveground mass of the studied varieties of winter forage pea varied from 16.54 % (Uzbetskij 71) to 20.23 % (Fenn and *Chlumecka fialova*).

All varieties except to Uzbetskij 71 exceeding over the standard Mir (17.11 %) with 7.1–18.2 %.

The content of crude fiber varied within wide limits–from 16.54 % to 20.37 %. In comparison with the standard (19.58 %), the lowest content of crude fiber was recorded in varieties Fenn

(16.54%), *Chlumecka fialova* (16.96%) and Pleven 10 (17.00%) with statistically significant differences at P = 0.05.

The content of crude fiber in Uzbetskij 71–20.37% was the highest than all other varieties. Rodrigues and collab. and De Blas and collab. also reported for comparatively low values of crude fiber in investigated from them genotypes forage pea [RODRIGUES *et al.*, 2012, De BLAS *et al.*, 2009, BUTNARIU *et al.*, 2005].

The content of calcium and phosphorus in the plants had an influence on the nutritive value of forage, and hence on the productivity and health status of animals.

The data show that, the content of calcium in the aboveground biomass of the studied varieties is found lower than Mir (0.862%).

The decrease is from 1.7 % to 14.7 %. Only in Austrian winter pea the content is on level of standard.

The lowest content of calcium is found in Fenn–0.727 %.

The results for content of phosphorus in the aboveground mass showed that varieties Pleven 10, Fenn, *Chlumecka fialova*, E.F.B.33 and Austrian winter pea exceeded the standard Mir with 7.4 %–19.3 %.

The content of phosphorus in Uzbetskij 71 is found lower than Mir with 14.4 %.

For feeding the animals the content of water soluble sugars in the forage has decisive meaning as basic source of energy for metabolism on accepted plant protein.

In the our study the content of water soluble sugars varied from 11.75 % in variety *Chlumecka fialova* to 14.55 % in Uzbetskij 71. In this index only Pleven 10 and Uzbetskij 71 exceeded standard (13.70 %) with 4.4 % and 6.2 % respectively; in all other varieties it is lower than Mir.

The results statistical analysis showed that the differences between varieties and standard were statistically nonsignificant (in P= 0.05).

With advance of the vegetation from full pod formation stage to full maturity, the content of crude protein in the aboveground biomass in these winter pea varieties decreased, and that of crude fiber increased.

In full maturity stage the content of crude protein varied from 15.01% (Pleven 10) to 18.20% (*Chlumecka fialova*).

Varieties Fenn, E.F.B.33, *Chlumecka fialova* and Austrian winter pea exceeded standard variety in the content of crude protein with 6.1%–14.8%, and in Pleven 10 and Uzbetskij 71 it was lower content of crude fiber than Mir.

Only in *Chlumecka fialova* the content of crude fiber is lower than Mir.

The decrease is with 5.7 unity percents. Pleven 10, Fenn, E.F.B.33 and Uzbetskij 71 exceeded standard with 5.5–17.9%.

E.F.B.33 is with the highest content of crude fiber–28.31%.

With advance of the vegetation the content of calcium increased and phosphorus varied slightly.

In comparison with Mir the content of calcium in E.F.B.33, Uzbetskij 71, *Chlumecka fialova* and Austrian winter pea is higher with 5.8–21.0%, and in Pleven 10 and Fenn, is lower with 1.7–4.8%.

The content of phosphorus is higher than standard only in Pleven 10 and Austrian winter pea. In full maturity stage content of water soluble sugars vastly decrease in comparison with full pod formation stage.

Considerable decrease in highest degree is observed in Pleven 10–from 14.30 % full pod formation stage to 1.35 % in full maturity.

All investigated varieties except Pleven 10, exceeded Mir in the content of water soluble sugars with 2.5–47.5 %.

In full maturity stage statistical analysis of the data show that, at comparison with standard did not establish statistically nonsignificant (at P= 0.05) for indices.

An important forage indicator is the correlation between calcium and phosphorus, as the most favourable ratio was considered to be 1:1.5–1:2.5 [BUXTON and FALES 1994, BUTU *et al.*, 2014, BUTNARIU *et al.*, 2014].

In this study, the most favourable proportion close to above–mentioned was found in Pleven 10 (1.96; 2.29) and Fenn (2.07; 2.41).

The correlational relationships between the studied parameters were established.

At the full pod formation stage (Table 2) the following relationships were well expressed and statistically significant at P = 0.05: positive between crude protein and phosphorus (r = 0.653) and negative between crude protein and crude fiber (r = –0.589), phosphorus and crude fiber (r = –0.585).

At the full maturity stage the obtained relationships were statistically no significant (Table 2).

Table 2.

Correlations between the investigated parameters

	1	2	1	2	1	2	1	2	1	2
	CP		CF		Ca		P		WSC	
CF	–0.589*	–0.459								
Ca	–0.139	–0.010	–0.343	–0.049						
P	0.653*	0.184	–0.585*	–0.027	0.173	–0.077				
WSC	–0.356	0.383	0.033	–0.092	0.188	0.193	–0.001	0.135		
Yield	0.148	0.438	–0.237	–0.294	0.092	–0.088	0.371	0.142	–0.006	0.287

*significant at the 0.05; **significant at the 0.01. 1–full pod formation stage; 2–maturity stage; CP–Crude protein, CF–Crude fiber; Ca–calcium; P–phosphorus; WSC–water soluble carbohydrate; Yield–Green mass yield (1) and grain yield (2)

The results for crude protein and calcium are consistent with the finding of Harmankaya and collab. [HARMANKAYA *et al.*, 2010] who investigated pea varieties in maturity reported for negative relationships between them and positive between crude protein and phosphorus.

Similarly, correlations between protein content and yield have been reported to be often negative, but also sometimes nonsignificant and sometimes positive [COBER and VOLDENG 2000; LAWN and REBETZKE 2006; BURSTIN *et al.*, 2007; FRIMPONG *et al.*, 2009] and selection for high protein content has often but not always led to reduced yield [BURSTIN *et al.*, 2011, BUTNARIU and BOSTAN, 2011].

Saxena and collab. reported for negative correlations between seed size and protein content in pigeon pea [SAXENA *et al.*, 2002, BUTNARIU *et al.*, 2012] also they have been obtained some lines with high protein content and large seed size.

Conclusions

The results of the study showed that, with the highest green mass yield and crude protein in phenological stage–full pod formation stage are varieties Pleven 10, E.F.B.33 and Chlumecka fialova and grain yield and crude protein Fenn and Austrian winter pea.

At both phenological stages of the development of the plants *Chlumecka fialova* was characterized with high content of crude protein and low of crude fiber.

The highest content of the water soluble sugars in aboveground biomass was established in variety Uzbetskij 71.

At phenological stage the full pod formation were established correlational relationships–positive between crude protein and phosphorus (r = 0.653) and negative between crude protein and crude fiber (r = –0.589), phosphorus and crude fiber (r = –0.585).

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