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Original article

Study of Initial Material of Vetch

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Abstract

The study was conducted in the experimental field of the Institute of Forage Crops – Pleven, Bulgaria for a three-year period. Ten vetch specimens (varieties and populations) different originated were examined – Bulgarian population (*Vicia sativa*); Bulgarian population (*Vicia pannonica ssp. striata*; Detenicka Panonska (*Vicia pannonica*) and Asko 1; Kowatschite, K- 25 331, K- 29 800, K- 30 553, K- 30 574, K- 30 671 from *Vicia villosa*. The main quantitative characteristics were analyzed: plant height (cm), height of the first pod (cm), number of pods per plant, number of seeds per plant, number of seeds per pod, weight of seeds per plant (g) and indicators: beginning of flowering stage (days) and duration of the growing season (days). Two-way ANOVA and variance analysis were used for statistical data processing. High values of variation coefficient were found for seed weight (107.87%), number of seeds per plant (88.80%), height of first pod (30.78%), number of pods per plant (37.97%) and number of seeds per pod (27.45), and average variation for plant height (15.97%), respectively. The varieties of *Vicia pannonica* can be characterized as early ripening with a growing season duration of 244-246 days, the population of *Vicia sativa* as medium ripening (242-252 days), and from *Vicia villosa* (except K-29 800, Kowatschite and Asko 1) as late maturing (242-256 days). The varieties of the species *Vicia villosa* K-30 671, Asko and 1 K-25 331, which are well leafed and form long stems (142-151 cm), are suitable as parental components in the combinational selection in the direction for forage. The Bulgarian population of *Vicia sativa* was found to form the largest number of both, pods (87) and seeds (351). For other the numbers, the seeds per plant trait was between 116 (K-30 574) and 133 (K-30 553). In the direction of seed production the Bulgarian population of *Vicia sativa* can be emitted.

Keywords: *Productivity, Vetch, Vicia villosa, Vicia sativa*, seeds, breeding.

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INTRODUCTION

There are many subspecies and varieties known in the *Vicia* genus. Common vetch (*Vicia sativa ssp. sativa*) is an annual legume crop. It can be grown for animal feed and grain production and the seeds can be used for animal feed because of their high quality (Tenopala et al., 2012). In addition to grazing, it can be mowed and dried for hay or processed for silage (Aleksieva et al., 2016). Vetch is high in crude protein (16.5-26.5%), making it an excellent component in mixtures with some grasses, such as oats or triticale, as it significantly increases the crude protein content of them as well as the green mass productivity (Aquilar-Lopez et al., 2013).

Vetch is one of the valuable sources of vegetable protein, which, although less widely distributed than other legumes, is important for solving the protein problem (Kertikov and Kertikova, 2017). Despite its great economic importance, over the years the areas planted with vetch in the country either decrease significantly or increase slightly. Grain and green mass yields are low and one of the main reasons for this is early spring drought occurred (Kertikova et al., 2012).

In the selection for quality of legumes, it is important to study the variability under the effect of the genotype factor in a particular area and the mode of cultivation and use. Genetic variability in the tested genotypes and knowledge about it provide the basis for improvement and development of new varieties (Mikić et al., 2014; Churkova et al., 2016).

The purpose of the study was to investigate the productive capabilities of vetch samples for the region of Central North Bulgaria.

Materials and Methods

The study was conducted in 2016 - 2018 in the experimental field of the Institute of Forage Crops – Pleven, Bulgaria. The seeds of the individual specimens were sown in a row at a distance of 1 m between the rows and 20 cm m inside the row. The sowing was done manually at optimal times according to the technology of cultivation of the crop. Ten specimens of vetch, both varieties and populations different originated were studied, i.e. Bulgarian population (*Vicia sativa*); Bulgarian population (*Vicia pannonica ssp. striata*; Detenicka Panonska (*Vicia pannonica*) and Asko 1; Kowatschite, K- 25 331, K- 29 800, K- 30 553, K- 30 574, K- 30 671 from *Vicia villosa*.

The next characteristics were analyzed: plant height (cm), height of the first pod (cm), number of pods per plant, number of seeds per plant, number of seeds per pod, weight of seeds per plant (g). Information on the main characteristics of the specimens is presented in Tables 2 and 3. The characterization of the phenological traits was done: beginning of flowering stage (days) and duration of the growing season (days). Biometric measurements were taken on 10 plants from each sample.

The data obtained were processed by a two-way ANOVA and variance analysis of the variant for each trait to determine the effect of genotype and environmental (year) factors. The degree of maturity was determined according to Kuzmova (2002). The maturity date was adopted as the criteria for evaluating the degree of maturity, using the coefficient of maturity for quantitative evaluation. For the ultra-early varieties, the value of this coefficient is from 1.00 to 1.17, for the early varieties from 1.17 to 1.33, for the middle-early from 1.34 to 1.66, and for the late varieties, it is greater than 1.66. The coefficient of variation (CV,%) is determined by the formula of Dimova and Marinkov (1999). MS Excel (2003) and GENES 2009.7.0 for Windows XP (Cruz, 2009) software were used to process the experimental data.

Results

Dispersion Analysis

The two-factor analysis of the variance for genotypes (samples) and years (environments) presented in Table 1 shows that there are no significant differences between the samples by almost all characteristics (height of the first pod, number of pods per plant, number of seeds per plant, number of seeds per pod and seed weight per plant) except for plant height. The second factor - years, has a significant influence on the manifestation of plant height, number of pods and plant seeds and weight of plant seeds. All this indicates that long-term studies are needed to more accurately evaluate the vetch samples on these traits.

Table 1. Variance analysis of genotypes (samples) tested and years

Source of variation	DF	Middle square					
		Plant height (cm)	Height of the first pod (cm)	Number of pods per plant	Number of seeds per plant	Number of seeds in pod	Seeds weight per plant (g)
Years	2	29685.9**	908.033 ns	32598.3**	349857.4**	2.421ns	634.432*
Samples	9	1393.5148*	352.0148ns	255.3185ns	19210.0778ns	0.5877ns	72.2393ns
Residue	18	403.0481	160.2926	797.9296	23172.77	0.7325	79.0764
CV(%)		15.97	30.78	37.97	88.80	27.45	107.87

* / **- significance at P=5%/1%; ns – no significance

On average, over the three years of the study, the highest variability (Table 1), determined on the basis of the variation coefficients, was found for seed weight (107.87%) and number of seeds per plant (88.80%). The height of first pod (30.78%), number of pods per plant (37.97%) and number of seeds per pod (27.45%) varied also with high values. The vetch genotypes analyzed showed average variation only by plant height (15.97%).

Meteorological characteristics

The agro meteorological conditions for the study period are represented by the sum of precipitation, air humidity and average daily air temperature (Fig. 1). The rainfall fallen in the autumn and in the winter months determines the realization of the biological potential of the vetch varieties and populations. The average rainfall is characterized by a maximum in May (155.90 mm) for 2017 and June (155.2 mm) for 2018 and a minimum in July (7.8 mm) and December (14.40 mm) for 2016, and April (19.6 mm) and September (15.4 mm) for 2018. The lowest average monthly air temperature for 2016 was recorded in December (-0.5 °C) and January (8.7 °C) and the highest for July (24.6 °C). Meteorological factors mean daily air temperature and rainfall during the months of active vegetation show an unfavorable combination with each other, which has had a negative impact on plant growth and development. The average daily temperature for 2017 in the months of April, May and June is in the range 12.2 ° C to 23 ° C. The lowest monthly average air temperature was recorded in January (-4.40 ° C) and December (1.10 ° C) and highest in July (23 ° C). The temperature stress did not have the extreme character of the area.

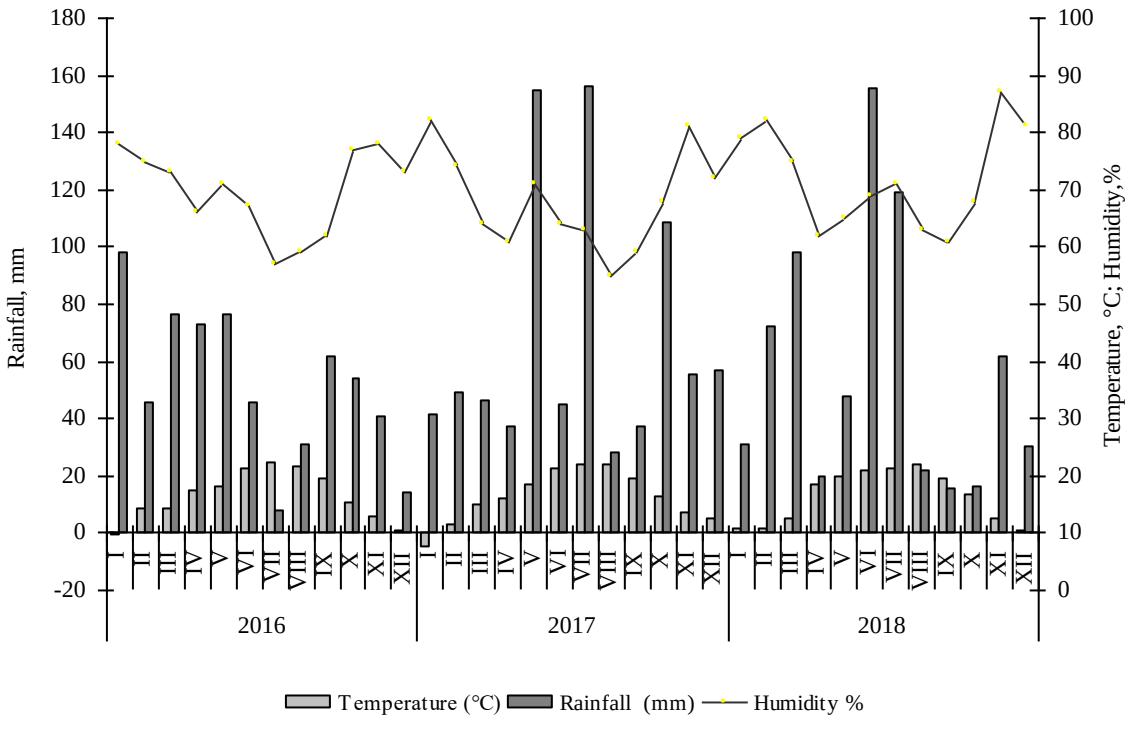

Figure 1. Climate diagram for the period 2016-2018

The vegetation period 2016 - 2017 had a favorable effect on the growth and development of the vetch specimens. Meteorological conditions allowed the normal wintering of plants and hence the realization of their productive capabilities. Due to the sufficient moisture accumulated in the soil, the

plants in all three species tested emerged and developed well. In the third year (2018) of the study, plants start their development under favorable temperature and water conditions. The whole month of October 2017 is characterized by significant rainfall (108.9 mm). Monthly average daily air temperatures are also relatively higher. In February and March rainfall exceeds the norm for months. April and May are extremely dry. Insufficient moisture and high temperature during these months are a serious prerequisite for poor seed germination. In May, high temperatures are combined with insufficient and uneven rainfall (20.2-47.7 mm). Many rainfalls at the end of the growing season (June and July) did not affect the productivity and structural elements of the crop.

The beginning of flowering stage occurs earlier at Detenicka Panonska of the species *Vicia pannonica* (07-09.05). The phenological evolution of the population of *Vicia pannonica ssp. striata* is similar. Representatives of *Vicia villosa* enter into this phenological stage at the latest. Of this species, K-25 331 and K-29 800 may be noted, which have a more rapid beginning of flowering, beginning to flower from 4 to 18 days earlier than other varieties. The Bulgarian population of *Vicia sativa* occupies an intermediate position, and data for the Asko 1 standard indicate that the beginning of flowering stage came relatively late and could be characterized as a late ripening variety.

The vegetation period is important for overcoming abiotic and biotic stress - early spring drought, low atmospheric humidity, the appearance of various diseases and pests (Mehandjiev et al., 2006).

Most of the specimens of the species *Vicia villosa* reach technical maturity between 8 and 18.07 or a vegetation period of 242-256 days. The exceptions are the K-29 800, Kowatschite and Asko 1, which have a longest growing period of 257 days. Pannonian vetches (the Bulgarian population and the variety Detenicka Panonska) have completed their growing season for 244-246 days. The Bulgarian population representative of *Vicia sativa* is maturing over the same period. According to the climatic conditions and their genetic characteristics, the vetch specimens can be grouped in the following maturity groups: the Bulgarian population of *Vicia pannonica ssp. striata* - ultra-early (1.17), the Detenicka Panonska variety of *Vicia pannonica* (1.33) - the early mature, the Bulgarian population from *Vicia sativa* (1.59) and K-25 331 from *Vicia villosa* (1.64) - medium early, Asko 1 (1.70), Kowatschite (1.67), K-30 574 (1.74), K-30 553 and K-30 671 (1.77) and K-29 800 (1.79) - late varieties (Fig. 2).

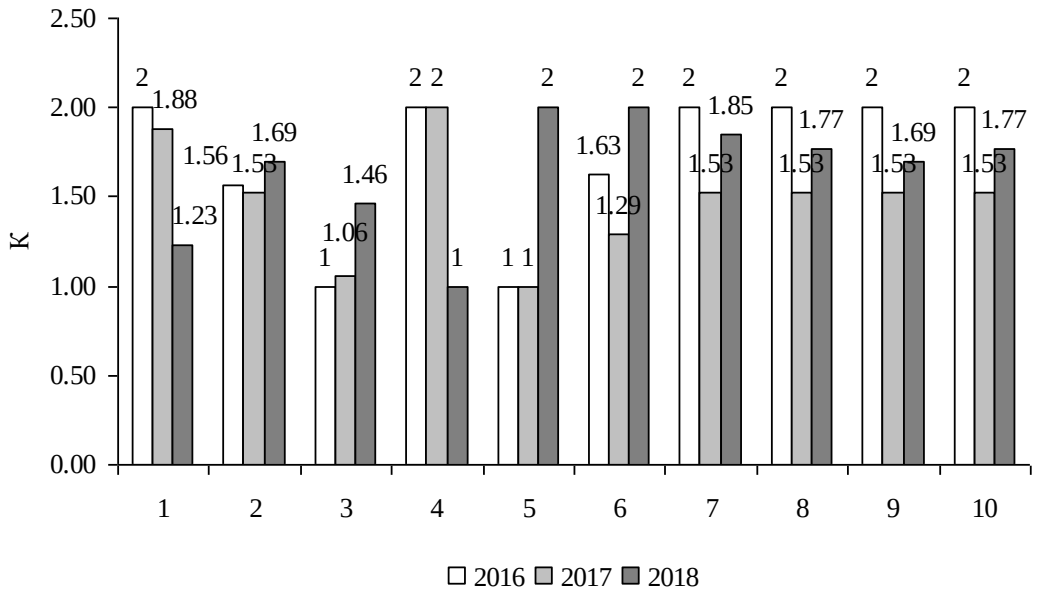

Figure 2. Maturity coefficient (K) of vetch specimens

1, *Vicia villosa* Asko 1; 2, *Vicia sativa* (Bulgarian population); 3, *Vicia pannonica ssp. striata* (Bulgarian population); 4, *Vicia villosa* (Kowatschite); 5, *Vicia pannonica* (Detenicka Panonska); 6, *Vicia villosa* (K- 25 331); 7, *Vicia villosa* (K- 29 800); 8, *Vicia villosa* (K- 30 553); 9, *Vicia villosa* (K- 30 574); 10, *Vicia villosa* (K- 30 671).

Table 2. Phenological development of the studied samples of vetch

Phenological stages/Variety (population)	Data of sowing	Beginning of flowering	Technical maturity	Vegetation period, days
V. villosa (Asko 1)	04.11.2015	25.05.2016	18.07.2016	256
	01.11.2016	23.05. 2017	17.07.2016	252
	02.11.2017	17.05.2018	13.07.2018	264
V. sativa (Bulgarian population)	04.11.2015	18.05.2016	07.07.2016	245
	01.11.2016	17.05. 2017	07.07.2016	242
	02.11.2017	11.05.2018	05.07.2018	252
V. pannonica ssp. striata (Bulgarian population)	04.11.2015	09.05.2016	04.07.2016	242
	01.11.2016	09.05. 2017	03.07.2017	238
	02.11.2017	14.05.2018	05.07.2018	252
V. villosa (Kowatschite)	04.11.2015	25.05.2016	18.07.2016	256
	01.11.2016	25.05. 2017	17.07.2016	252
	02.11.2017	20.05.2018	13.07.2018	264
V. pannonica (Detenicka Panonska)	04.11.2015	09.05.2016	04.07.2016	242
	01.11.2016	08.05. 2017	03.07.2017	242
	02.11.2017	07.05.2018	03.07.2018	255
V. villosa (K- 25 331)	04.11.2015	19.05.2016	07.07.2016	245
	01.11.2016	13.05.2017	11.07.2017	246
	02.11.2017	07.05.2018	08.07.2018	255
V. villosa (K- 29 800)	04.11.2015	09.05.2016	04.07.2016	242
	01.11.2016	17.05.2017	11.07.2017	246
	02.11.2017	09.05.2018	10.07.2018	257
V. villosa (K- 30 553)	04.11.2015	25.05.2016	18.07.2016	256
	01.11.2016	17.05.2017	11.07.2017	246
	02.11.2017	10.05.2018	08.07.2018	255
V. villosa (K- 30 574)	04.11.2015	25.05.2016	18.07.2016	256
	01.11.2016	17.05.2017	11.07.2017	246
	02.11.2017	11.05.2018	11.07.2018	258
V. villosa (K- 30 671)	04.11.2015	25.05.2016	18.07.2016	256
	01.11.2016	17.05.2017	11.07.2017	246
	02.11.2017	10.05.2018	08.07.2018	255

Table 3 presents data for some elements of the productivity of specimens over the three years of the survey. The variation of the values of the traits between the individual samples indicates the presence of genetic diversity in the studied plant assortment. Representatives of the species *Vicia villosa* K-30 671 and Asko 1 are characterized by the highest plants (150-151 cm), followed by K-25 331 (142 cm). The height of the plants is the lowest in the Bulgarian population of species of *Vicia pannonica ssp. striata* (90 cm). Plants of the common vetch *Vicia sativa* (113 cm) occupy an intermediate position.

The sign of height of the first pod also varies within a relatively wide range of 26 cm for *Vicia pannonica ssp. striata* up to 62 cm in variety K-29 800 from *Vicia villosa*. Plants of *Vicia sativa* form their first pod at a height of 41 cm. Detenicka Panonska is among the samples occupying one of the last positions (31 cm). It is noteworthy that many well-leafed specimens, especially those of *Vicia villosa*, do not form their first pod in proportion to the length of the stem. Asko 1 is ranked third with balanced values on these traits.

Table 3. Morphological characteristics of the vetch specimens investigated

Variety, population	Plant height (cm)	Height of the first pod (cm)	Number of pods per plant	Number of seeds per plant	Number of seeds in pod	Seeds weight per plant (g)
V. villosa (Asko1)	150e	49bc	82a	267a	3ab	10ab
V. sativa (Bulgarian population)	113abcd	41abc	87a	351a	4b	21b
V. pannonica ssp. striata (Bulg. popul.)	90a	26a	78a	187a	2a	8ab
V. villosa (Kowatschite)	100ab	30ab	68a	92a	3ab	3a
V. pannonica (Detenicka Panonska)	106abc	31ab	76a	137a	3ab	6ab
V. villosa (K- 25 331)	142de	36ab	83a	125a	3ab	5a
V. villosa (K- 29 800)	137cde	62c	74a	177a	3ab	5ab
V. villosa (K- 30 553)	136cde	49bc	64a	133a	3ab	9ab
V. villosa (K- 30 574)	131cbde	45abc	57a	116a	3ab	10ab
V. villosa (K- 30 671)	151e	42abc	76a	130a	3ab	5a

a, b, c, d, e – significance at P=0.05

The largest number of pods succeeded in forming the Bulgarian population of *Vicia sativa* (87), as well as K-25 331 (83) and Asko 1 (82) of *Vicia villosa*, and with the smallest number of pods the K-30 574 varieties emerged (57) and K-30 553 (64), which are of the same type.

The data presented in Table 3 show that the number of seeds per plant shows the same pattern - varieties and specimens with more pods per plant form more seeds. The first two positions in this respect are occupied by the Bulgarian population *Vicia sativa* (351) and the variety Asko 1 (267). For most varieties of *Vicia villosa* (except K-29 800), the number of plant seeds is between 116 (K-30 574) and 133 (K-30 553). Close to them as biological potential in this respect is Detenicka Panonska (137).

No significant differences were found between the samples on the number of seeds per pod. The highest number of seeds in pods (4) distinguishes the Bulgarian population from *Vicia sativa*. The other

Bulgarian population of *Vicia pannonica ssp. striata* produces the fewest seeds in beans (2) and this is statistically significant. The pods of *Vicia villosa* plants can feed an average of 3 seeds.

Following the weight of the seeds per plant, it was found that the Bulgarian population of *Vicia sativa* (21 g), followed by Asko 1 and K-30 574, with a seed weight of 10 g, has a good seed productivity, which is statistically significant. The lowest values for this indicator (3-5 g) are characterized by Kowatschite K-25 331; K-29 800 and K-30 671.

Discussion

In this study, no statistically significant differences were found between genotypes by number of pods and number of seeds per plant. Similar results were obtained by Milenković et al. (2017). The authors report that in the varieties and populations they studied, some quantitative parameters such as number of pods per plant, number of seeds per pod, and weight per 1000 seeds varied between genotypes, but there were no statistically significant differences. The interaction of genotype x enviroment was fpund provenin studies with winter common wheat lines (Uhr, 2015).

Mihailović and Mikić (2004) and Mikić et al. (2010) consider the number of pods to be one of the important productivity components for many of the legumes, including vetch. In their studies, this indicator averages 27-28 pods per plant - significantly less than the results of our studies. The authors report that for this reason the vetch is superior to some other legumes such as peas (5-11) and grass pea (11-18) grown under the same agro-ecological conditions.

In a multi-year study conducted with different types of vetch, Karagić et al. (2011) obtained results showing that plants of common vetch manage to feed a considerable number of seeds whose weight per plant exceeds other types of vetch. This finding is supported by current research also.

Similar are the results of other researchers (Taser et al. 2005; Mikić et al. 2013), who tested vetch genotypes similar to our agro-meteorological conditions, with the weight of 1000 seeds again having the common vetch. The authors are of the opinion that the larger seeds of the common vetch have a positive effect on the germinating energy of the seeds, and thus may be one of the goals in the selection of vetch to create varieties with larger and heavier seeds.

According to Mikic et al. (2011) plants of different vetch species compared to other annual legumes, which form significant aboveground biomass such as forage peas and grass pea, have a similar harvest index of fresh mass.

Ćupina et al. (2011) propose a solution to the problem of strong lodging and the loss of many seeds, recommending that the seed varieties be sown together with another legume component that is not lodging, such as white lupin.

Winter vetch grown in northern Bulgaria is characterized by very good winter survival, early flowering, and relatively good lodging resistance (Naydenova et al., 2012; Ilieva and Naidenova, 2016). It is less productive than the sandy vetch, but has other important characteristics - dryness, better morphological and phenological compatibility with modern wheat and barley varieties, which are grown in winter-spring mixtures for green forage, as well as the impermeability of pods.

Conclusions

The environmental conditions determined the variation of the traits studied in the vetch collection. On average for the period of study high values of the variation coefficient were found for the seed weight (107.87%), number of seeds per plant (88.80%), height of first pod (30.78%), number of pods per plant (37.97%) and number of seeds per pod (27.45), and average variation for plant height (15.97%), respectively. The varieties of *Vicia pannonica* can be characterized as early ripening with a growing season duration of 244-246 days, the population of *Vicia sativa* as medium ripening (242-252 days), and from *Vicia villosa* (except K-29 800, Kowatschite and Asko 1) as late maturing (242-256 days). The varieties of the species *Vicia villosa* K-30 671, Asko and 1 K-25 331, which are well leafed and form long stems (142-151 cm), are suitable as parental components in the combinational selection in the direction for forage. The largest number of both, pods (87) and seeds (351) formed the Bulgarian population of *Vicia sativa*. For other the number of seeds per plant was between 116 (K-30 574) and 133 (K-30 553). In the direction of seed production the Bulgarian population of *Vicia sativa* can be emitted.

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

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