Pak. J. Bot., 50(1): 161-167, 2018.

SUITABILITY OF VETCH (*VICIA SATIVA* L. AND *V. VILLOSA* ROTH) CULTIVARS FOR ORGANIC FARMING CONDITIONS

NATALIA GEORGIEVA

Institute of Forage Crops, Department of technology and ecology of forage crops, 5800 Pleven, Bulgaria
Corresponding author's email: imnatalia@abv.bg

Abstract

Cultivars suitable for organic agriculture are distinguished in many terms from ones cultivated in conventional agriculture. The suitability of vetch (*Vicia sativa*L. and *V. villosa* Roth)cultivars (Obrazets 666, Liya, Lorina, Vilena, Moldovskaya, Violeta, Viola) to organic farming conditions was determined on the basis of a complex of traits during a three-year experimental period (2012-2014). The block design method was used, at sowing rate of 220 seeds m^{-2}. The seeds were sown in the third decade of March after predecessor oat. The results revealed that cultivar Liya was appropriate for organic production of forage. The cultivar was characterized by high average daily growth rate, greater height, increased branching and amount of formed biomass (aboveground and root mass, by 55.0 and 36.9% over the averages of studied cultivars) - parameters which ensured a higher competitiveness against weeds, as well as uptake and use of nutrients. In addition, Liya was ecologically stable (bi=0.77) and despite the manifested susceptibility to rust (IT = 4, DS = 30.5%), it had high productiveness (4588.2 kg DM ha^{-1} or by 58% over the average productivity). Suitability for growing in organic farming on certain of the traits (biomass per plant, forage yield, rust resistance) showed and cultivar Moldovskaya, but it had low ecological stability. Violeta and Viola were low-productive cultivars, but with high quality of the biomass and increasing to the greatest extent the content of soil mineral nitrogen because of that they can be used to improve the soil fertility in organic production. Cultivar Obrazets 666 was suitable as a donor for immunity to rust (IT = 0). Cultivars characterized by increased lignin content of the cell walls demonstrated immunity or resistance to *Uromyces viciae-fabae.*

Key words: Cultivars, Organic farming, Suitability, Vetch.

Introduction

Organic agriculture often is defined as a natural farming system. Nowadays, organic farming is known for its disallowance of using of chemicals and its aim for environmental preservation. But organic agriculture is more than simply a substitution of chemicals with natural compounds (Anon., 2002). One of its general principles is a choice of species and cultivars, which are the most suitable in local environmental conditions and in which the applying of non-renewable resources is minimized (Kostadinova & Popov, 2012).

From annual legumes suitable for the conditions of organic production are vetches, especially common vetch (*Vicia sativa* L.) (Georgieva *et al*., 2016) and hairy vetch (*Vicia villosa*) (Ćupina *et al*., 2004; Mihailović *et al*., 2005). These species are habitually grown in southeastern Europe (Karagić *et al*., 2011a). In regard to climatic conditions and soils are not very demanding and exhibit great plasticity. Their high nutritional value is combined with good productivity and possibilities for multilateral use: green forage, hay, silage, haylage, forage meal, grazing, green manure (Abd El Moneim, 1993; Karagić *et al*., 2011b; Seven & Cerci, 2006; Mikić *et al*., 2006).

The cultivars which are suitable for organic production system differ in many aspects from those adopted in conventional farming (Konvalina *et al*., 2009). In this term, different crops were investigated (Lammerts van Bueren, *et al*., 2010): rye and triticale (Bozhanova *et al*., 2014), wheat (Konvalina *et al*., 2009), vegetables (Lammerts van Bueren *et al*., 2002), peas (Kalapchieva *et al*., 2010) etc. Based on these researches, the general criteria for cultivar characteristics, desired for the organic farming system could be summarized in four groups. Building on these researches, the basic requirements for cultivar characteristics proper for the organic farming system can be generalized in four categories.

Nutrient uptake and utilization efficiency: To be compensated lower nitrogen inputs in the system of organic production, the cultivars ought to have a good potential for nitrogen accumulation, i.e. the uptake and reserves of total nitrogen must be higher. In this connection, cultivars with more vegetative tissues and greater overall biomass are more appropriate (Ur *et al*., 2014). On the other hand, a high nutrient uptake is as much essential as the ability to interact with beneficial soil organisms, such as bacteria and fungi (Mäder *et al*., 2000). It is known that interactions between micro-organisms and plant roots (including between legumes and *Rhizobium* ssp.) are genetically determined (Jacobsen, 1984). The author reported for pea genotypes with increased nodulating ability and more intensive interaction with rhizobia.

Competitiveness in terms of weeds: Weeds are considered as the most important problem in organic systems. The interrelation between cultured plants and weeds has always been determined as negatory. However, this relationship could contribute to the formation of a stable agroecosystem (Lammerts van Bueren, 2002).It was found that the competitiveness of a cultivar to weeds due to a combination of traits: greater height and leaf area of the plants, rapid growth, accumulating more biomass (aboveground and underground), presence of allelopathic potential – all these signs correlate negatively with the formation of weed biomass (Ur *et al*., 2014).

Resistance to pests: The good phytosanitary state of plants is determined primarily on the preventives, which mean the establishment of favorable conditions for development and bearing in mind the natural tolerance to pests-diseases and insects (Tamis & Van den Brink, 1999). The resistance to diseases has an important meaning in organic farming. Because an organic farmer has hardly any curative means, he will have to give more priority to varietal resistance, even if this is accompanied by a lower productivity. The focus is not merely on absolute resistance; in many cases tolerant or field-resistant cultivars can be sufficient (Lammerts van Bueren *et al*., 2002).

Yield stability and product quality: According to Mader *et al*. (2002) and Lammerts van Bueren *et al*. (2002), the organic yields in the best organic farms are about 20-30 % lower than the conventional. The quality and stability of the yield are the main priorities for organic farming, which does not lay accent on the quantity of production. An advantage is given to cultivars which are reliable and can tolerate the potential variations in the weather and the press of diseases.The target cultivar can provide a lower, but stable yield. The suitability of the conventional cultivars should be tested in the organic farming conditions where relatively stable cultivars providing a high yield can be selected (Konvalina *et al*., 2009).

The aim of this study was to evaluate vetch cultivars on a complex of traits and determination of suitable cultivars for conditions of organic farming.

Materials and Methods

Study area and experimental design: The study was carried out in the Second experimental field of the Institute of Forage Crops (Pleven) during the 2012-2014 period. The soil type was slightly leached chernozem with the following properties: pH ($_{H20}$) – 6.54, content of hydrolysable nitrogen – 0.225 mg/1000 g soil, phosphorus– 4.29 mg/100 g soil and potassium – 31.10 mg/100 g soil. According to these values, the soil was poorly supplied with nitrogen and phosphorus and well-supplied with potassium. Daily average temperature and total precipitation during the growing season (March-July) of the three experimental years were on average 17.3°C and 266 mm, respectively. The precipitation distribution was uneven, as the majority of them were in May. An object of the study were seven vetch cultivars: Obrazets 666, Liya, Lorina, Vilena, Moldovskaya (belonging to *Vicia sativa* L.), Violeta, Viola (belonging to *Vicia villosa* Roth), grown in conditions of organic production (without the use of fertilizers and pesticides). Except the Bulgarian cultivar Obrazets 666, all the others were newly bred cultivars originating in Moldova which were characterized by an increased productiveness. The block design method was used, at sowing rate of 220 seeds m^{-2} and 3 replications. The seeds (organically grown) were sown in the third decade of March, by hand, after predecessor oat.

Data collection: During the vegetation period by making several measurements of the plant heights was recorded the average daily growth rate (ADGR, cm day^{-1}) (Thomas *et al*., 2003). As a criterion for assessing the degree of early-ripeness is accepted the date of the beginning of flowering as for quantitative assessment is used a coefficient of early-ripeness (Kuzmova, 2002). The value of this coefficient for ultra-early-ripening cultivars is up to 1.17; for early-ripening ones – from 1.17 to 1.33; for mid-ripening ones – from 1.34 to 1.66, and for late-ripening cultivars – more than 1.66. The vetch plants were harvested at stage 60 according to the BBCH scale (Anon., 2013) and forage yield, some related quality features – nitrogen and ash content (Anon., 1990), acid detergent lignin (ADL) (Goering & Van Soest, 1970) and relative water content (RWC) in leaves (method of Barrs & Wetherly, 1962) were determined. At the same phenological stage, from all plots were taken soil monoliths (20/30/40 cm) and the following parameters were reported: nodule numbers per plant, dry root and aboveground mass per plant.

The ecological stability of vetch cultivars was estimated through the application of regression analysis (according to Eberhart & Russell, 1966), in which the regression coefficient (bi) and the variance of the deviations from regression (Si^2) were calculated. The impact of environmental conditions on the formation of yield is expressed with the coefficient of regression bi.It characterizes the cultivar reaction to the environmental changes and shows its stability. The parameter Si^2 reveals in what degree matches the empirical and theoretical meanings of the trait, located on the regression line.

The vetchcultivars were evaluated for resistance to rust (caused by*Uromyces viciae-fabae* (Pers.) J. Schrot.) under conditions of natural field infestation. The infection type (IT) and the disease severity (DS), as percentages of the symptomatic surface of the whole plant, were estimated before harvesting. The IT scale of Stackman *et al*. (1962)was used, where IT 0 = without symptoms, IT; = necrotic spots, IT 1 = minute pustules barely sporulating; IT 2 = necrotic halo around small pustules, IT 3 = chlorotic halo and IT 4 = well-formed pustules without associated chlorosis and necrosis. The cultivars were considered as immune (when they did not show any symptoms, IT = 0), resistant (IT from; to 2) and susceptible (IT ≥ 3).

Soil samples from each plot were taken randomly at a depth of 0-30 cm one month after harvesting (Minta & Tsige, 2014). These samples were analyzed for mineral nitrogen (Cornfield, 1966), phosphorus (by the Egner-Riehm method, 1960) and organic carbon (Laktionov, 1985).

Mathematical data processing was done by the Software Statgraphics Plus (1995) for Windows Ver.2.1 and two-way ANOVA at LSD 0.05%.

Results and Discussion

The early ripeness in vetch is defined by some authors (Kicheva & Angelova, 2005) as an extremely valuable trait, especially in recent years under conditions of changing climate and global drought. Based on the calculated coefficient of early-ripeness, the studied cultivars were defined as follows: mid-ripening – Liya, Lorina, Vilena and Moldovskaya, late-ripening – Violeta and Viola, ultra-early-ripening – Obrazets 666 (Table 1). Full flowering stage in the different vetch cultivars occurred on average after 74 days when the average accumulated amountof active temperatures was 1385.0°C and rainfalls - 185 mm. Significant differences were established between the cultivars belonging to *V. sativa* and those belonging to *V. villosa*. At the first group, the plants were formed for 69 days, after the accumulation of temperature sum and precipitation from 1278°C and 162.8 mm, while for cultivars of the second group were necessary 86 days, 1652.9°C and 239.8 mm, respectively.

The growth rate is an important feature, providing competitiveness of the plant, which is crucial to the terms of organic production (Bozhanova *et al*., 2014). According to Köpke (2005) the competitiveness depends on the speed of growth, capacity of the upper biomass and the tallness in the DC 31-75 stage.). A large part of the cultivars which demonstrate a high productive potential in organic conditions is characterized by a faster growth or greater root mass (Bozhanova *et al*., 2014). During the vegetation period significantly higher ADGR was realized by cultivars Villena, Liya, Viola and Violeta (an average of 0.17 cm day-1), as the same ones at harvesting had a greater height as well (average by 31.5%) (Table 2).

Substantial differences between the cultivars were established in relation to the amount of formed biomass (g plant^{-1}). Cultivar Liya demonstrated significantly higher weight of aboveground biomass (55.0% above the average value of tested cultivars), followed by Moldovskaya and Vilena (18.5 and 14.9%, respectively). To the positive traits of Liya and Moldovskaya could be referred also their ability to form a larger number of branches, which is essential for the establishment of a dense stand suppressing the weed development. The relative water content as an indicator of the water status of plants and determinant to some extent their drought resistance showed little variations among the cultivars. Significantly higher values of RWC were observed in cultivars Moldovskaya, Liya, Lorina, Vilena and Violeta.

In soils with a lower concentration of accessible nitrogen, the roots growth is more important than the growth of upper phytomass. A well-developed root system, responsive to the interaction with the soil edaphone, is an important aspect for the efficient absorption of nutrients (Lammerts van Bueren *et al*., 2002). The dependence in the cultivars in this experiment regarding the root weight followed the trend in the aboveground weight. The cultivar, whose weight of root mass differed significantly from the weight of the rest cultivars, was Liya (excess of 36.9%), followed by Moldovskaya and Vilena (excess of 10.1 and 6.9%, respectively). In organic farming systems plants have to form and maintain not only a larger, but also more active root system, with increased interaction with beneficial soil micro-organisms that promote nutrient uptake (Lammerts van Bueren *et al*., 2002). For potential possibilities of family Fabaceae to absorb and fix nitrogen indirectly can be judged by the quantity formed nodules (Zachariassen & Power, 1991). Increased nodulation showed cultivar Violeta, Viola and Liya, which exceeded the average number of nodules for all tested cultivars with 43.9, 29.7 and 4.1% respectively.

Table 1. Coefficient of early-ripeness, active temperatures and precipitations accumulated during the period germination-full flowering in vetch cultivars, 2012-2014.

Cultivars	Period germination-full flowering			Coefficient of early-ripeness
	days	sum of active temperatures, °C	sum of precipitations, mm	
Liya	68	1272.5	156.5	1.53
Lorina	68	1272.5	156.5	1.53
Vilena	69	1276.0	167.2	1.53
Moldovskaya	71	1299.8	167.2	1.53
Obrazets 666	69	1268.6	166.5	1.03
Violeta	86	1652.9	239.8	2.03
Viola	86	1652.9	239.8	2.03
LSD $_{(0.05)}$	3.64	120.22	36.93	

Table 2. Parameters of aboveground and root mass in vetch cultivars in organic farming conditions, 2012-2014.

Cultivars	Aboveground mass					Root mass	
	ADGR cm day^{-1}	Height cm	Branches number plant^{-1}	Weight g plant^{-1}	RWC %	Weight g plant^{-1}	Nodulation number plant^{-1}
Liya	1.04d	70.4b	5.4d	6.478d	84.2c	0.189d	19.0d
Lorina	0.87b	59.5a	3.8b	3.657b	83.8c	0.129bc	16.3c
Vilena	1.06d	71.8b	4.3bc	4.803c	83.9c	0.147bc	14.2b
Moldovskaya	0.87b	61.0a	5.9de	4.951c	84.6c	0.152c	16.9c
Obrazets 666	0.82a	56.6a	2.8a	2.868a	76.8a	0.097a	11.5a
Violeta	0.97c	82.2c	6.1e	2.802a	83.7c	0.120ab	23.7e
Viola	1.01cd	86.0c	4.5c	3.699b	80.6b	0.131bc	26.3f
Average	**0.95**	**69.6**	**4.7**	**4.180**	**82.5**	**0.138**	**18.3**
LSD $_{(0.05)}$	0.05	4.44	0.67	0.579	2.65	0.030	1.67

Legend: ADGR - average daily growth rate, RWC - relative water content, a–f - values in each column followed by the same letters are not significantly different

Table 3. Response of vetch cultivars to *U. viciae-fabae* and ADL content (g kg^{-1} DM) of the studied cultivars.

Cultivars	*U. viciae-fabae*		ADL*
	IT	DS	
Liya	4	30.5e	51.7a
Lorina	3	15.9bc	60.7b
Vilena	3	15.3b	59.9b
Moldovskaya	1	25.3d	74.1d
Obrazets 666	0	0.0a	93.3f
Violeta	1	19.1c	70.6c
Viola	1	14.6b	77.4e

Legend: IT = Infection type; DS = Disease severity, ADL = Acid-detergent lignin, a–f - Values in each column followed by the same letters are not significantly different at p<0.05

*The determination of ADL content was conducted by Prof. Y. Naydenova (IFC, Pleven)

Rust is one of the major fungal diseases of vetches. *Uromyces viciae-fabae* (Pers.) J. Schrot. is the causal agent of the vetch rust (Stancheva, 2002). *U. viciae-fabae* infects species of the genera *Vicia*, *Pisum*, *Lathyrus* and *Lens* (Conner & Bernier 1982; Stancheva, 2002; Kushwaha *et al*., 2006). The disease generally exhibits in the middle of spring when the plants are at flowering or podding stage. The activity of the rust usually results in a break of biochemical and physiological processes in the crop (Anon., 2009). When the environmental conditions in the year are favorable, the leaves (with symptoms) dry up and fall from the plant so that the seeds stay small, undeveloped and thus the yield losses may reach 50 and more percentages (Anon., 2009; Rai *et al*., 2011). Different methods of rust control have been developed, but the use of resistance cultivars is a more desirable and efficient strategy for the rust control (Sillero *et al*., 2010). Under conditions of the present experiment, the tested cultivars displayed different reactions (from IT 0 to IT 4) to *U. viciae-fabae*, with DS ranging from 0 to 30.5% (Table 3). Liya, Lorina and Vilena showed susceptibility to the pathogen (IT ≥ 3). In contrast, a reaction of resistance was observed in three cultivars – Viola, Violeta and Moldovskaya (IT = 1) as the symptomatic area percentage was the lowest in Viola. Obrazets 666 was determined as immune, as it did not show any symptoms of the disease (IT = 0).According to Lammerts van Bueren *et al*. (2002) an important criterion in the evaluation of cultivars suitable for cultivation in the system of organic farming can be not only the level of resistance but also the ability ofindividual cultivar to ensure high yield despite the pressure of infectious diseases.As an example of such can be pointed Liya.

As a whole, the larger part of the investigated cultivars showed a resistant response to *U. viciae-fabae*which was in agreement with the findings of other researchers (Sillero & Rubiales, 2014; Matic *et al*., 2015). Sillero & Rubiales (2014) noted that high resistance to *U. viciae-fabae* was usually observed in cultivars of the *Vicia* species, particularly in those which belong to *V. villosa*. As cultivars with resistance to rust Matic *et al*. (2015) pointed out Morava, Rasina, Volga, Timok (belonging to *V. sativa*) and Haymaker, Capello, RM4 (belonging to *V. villosa*). According to Barilli *et al*. (2014), the resistance was characterized by reduced infection frequency due to different mechanisms: decreases in stomatal penetration, the growth of infection hyphae and haustorium formation; changes in chitinase, phenylalanine ammonia-lyase, and peroxidase activities, and in total phenolic content. It has been established that phenolic compounds play an important role in the disease resistance because they limit fungal germ tube development, as well as the lignins which helping to the cell walls strengthening (Prats *et al*., 2002). The data in this study showed that cultivars with a higher ADL content (Obrazets 666, Viola, Violeta, Moldovskaya) had an immune or resistant response to the rust. The resistance in Violeta and Viola can be determined also by the increased content of phenolic compounds and the greater "hairiness" which characterize *V. villosa* cultivars (Kostov & Pavlov, 2004). When leaf hairs are denser, they form a mat over the abaxial surfaces on which water droplets stay without making contact with the leaf epidermis. In this way, on hairy leaves, the rust germ tubes are unable to contact with the leaf epidermis (Von Alten, 1983). Shaik & Steadman (1988) first reported negative correlations between leaf pubescence and low intensity of rust pustules.

In organic farming, the environmental conditions are more varied than in conventional farming, so that the species and genotypes should be much more adaptable, and the yield stability is as important as its amount (Bozhanova *et al.,* 2014).For the three-year experimental period in conditions of organic production, highest productive (58% above the average productivity of the tested cultivars) and significantly different from the other cultivars was Liya (Table 4).With a coefficient of linear regression less than 1, Liya was defined as ecologically stable. Cultivars Moldavskaya and Villena also formed higher yields, exceeding the average productivity with 17.8 and 11.0%, respectively but they manifested themselves as unstable. Such cultivars are responsive to improving the environmental conditions and under intensive technology from them can be received high yields. Obrazets 666 (bi=0.22), Violeta (bi=0.27) and Viola (bi=0.77) were ecologically stable but low-productive. Moll & Stuber (1974) have found that cultivars with high stability show mostly lower and middle yields. In addition to the above-mentioned were the values of parameter Si2, which showed a greater stability in Violeta, Obrazets 666 and Liya.

The nitrogen content is determinative for the quality of forage crops (Kirilov, 2009). Nitrogen content accumulated in the plant roots is also important, which then undergoes mineralization and increases soil fertility (Pachev, 2016). The nitrogen quantity in the aboveground and root mass of studied cultivars was averagely 30.86 and 25.06 g kg dry matter^{-1}, respectively. More substantial differences compared to the averages were established in Viola and Violetta with exceedance of 8.4 (for above ground mass) and 6.5% (for root mass). In the other five cultivars, the nitrogen in biomass was lower or close to the indicated averages. Regarding ash content, the differences among cultivars were less pronounced as significantly higher mineral content in aboveground mass showed Moldavskaya, and in root mass - Liya, Villena and Obrazets 666.

Table 4. Forage yield, ecological stability and quality parameters in vetch cultivars under organic farming conditions, 2012-2014.

Cultivars	Forage yield kg ha^{-1}	Stability parameters		Aboveground mass g kg dry matter^{-1}		Root mass g kg dry matter^{-1}	
		bi	Si^2	Nitrogen g kg DM^{-1}	Ash g kg DM^{-1}	Nitrogen g kg DM^{-1}	Ash g kg DM^{-1}
Liya	4588.2f	0.77	280.42*	30.31c	18.46b	25.47e	12.89c
Lorina	2517.5b	1.11	3655.16*	30.06b	19.23c	23.60b	11.36ab
Vilena	3204.3c	2.53	8257.50*	30.91d	19.44cd	24.67c	12.41bc
Moldovskaya	3401.2d	1.33	449.27*	30.33c	20.82e	24.99d	10.62a
Obrazets 666	2027.4a	0.22	180.21*	27.50a	19.95d	23.30a	12.28bc
Violeta	1988.0a	0.27	20.68*	32.92e	18.32ab	26.55f	10.84a
Viola	2484.9b	0.77	9091.78*	34.01f	17.84a	26.84g	10.11a
LSD $_{(0.05)}$	92.70			0.225	0.559	0.140	1.440

Means in each column followed by same letters are not significantly different (p>0.05)
*Significance at *p< 0.05

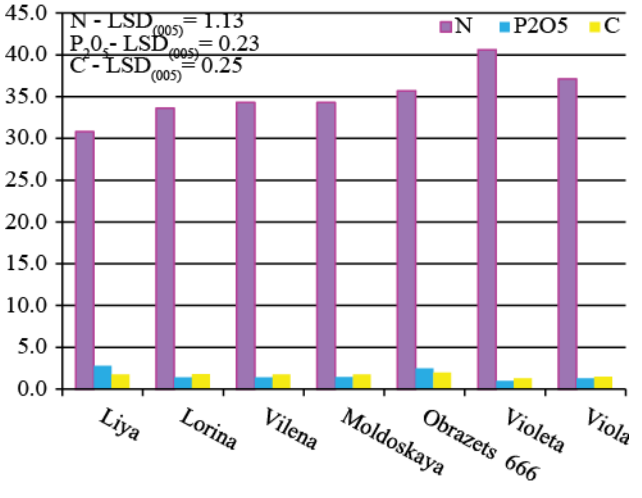

Fig. 1. Soil chemical properties after harvesting of vetch cultivars in organic farming – mineral N (mg/1000 g soil), P_2O_5 (mg/100 g soil), C (%).

In organic production systems and a ban on the use of synthetic fertilizers, the question of maintaining and enhancing soil fertility is especially important. Vetch is determined by Al Chami *et al*. (2012) as soil fertility-building crop which reduces inputs, improves soil fertility and yield in subsequent crop. Soil characteristics, however, may vary greatly after cultivation of different vetch cultivars (Ingels, 1998). After harvesting the hairy vetches (Violeta and Viola), the mineral nitrogen amount in soil was significantly greater (by 20.3 and 6.8%, respectively) compared to the average values in the common vetches (Fig. 1). Regarding the content of soil organic carbon and phosphorus was observed the reverse trend: the common vetches Liya, Lorina, Villena, Moldovskaya and Obrazerts 666 increased the carbon and phosphorus to a greater extent than hairy vetches. The exceedance had the highest values in cultivars Liya and Obrazets 666.

Conclusions

Based on the three-year experiment conducted and evaluation of seven vetch cultivars can be concluded that cultivar Liya possesses a complex of traits that defined it as suitable for organic production of forage. The cultivar was characterized by high average daily growth rate (1.04 cm day^{-1}), greater height (70.4 cm), increased branching (5.4 number plant^{-1}) and amount of formed biomass (aboveground and root mass, by 55.0 and 36.9% over the averages of studied cultivars) - parameters which ensured a higher competitiveness against weeds, as well as uptake and use of nutrients. In addition, Liya was ecologically stable (bi=0.77) and despite the manifested susceptibility to rust (IT = 4, DS = 30.5%), it had high productiveness (458.82 kg da^{-1} or by 58% over the average productivity of the studied cultivars). After its harvesting, the soil had an increased carbon and phosphorus content.

Suitability for growing in organic farming conditions on certain of the traits (biomass per plant, forage yield, rust resistance) showed and cultivar Moldovskaya, but it had low ecological stability. Violeta and Viola were low-productive cultivars, but with a high quality of the biomass and contributed to increase to the greatest extent the content of soil mineral nitrogen because of that they can be used to improve the soil fertility in organic production.Cultivar Obrazets 666 was suitable as a donor for rust immunity (IT = 0). Cultivars with higher lignin content of the cell walls exhibited immunity or resistance to the pathogen *Uromyces viciae-fabae*.

References

Abd El Moneim, A.M. 1993. Agronomic potential of three vetches (*Vicia* spp.) under rainfed conditions. *J. Agron. Crop Sci.*, 170(2): 113-120.

Al Chami, Z., L. Al Bitar, N. Amer, D. Baysal and U. Aksoy. 2012. Evaluation of pre-crops and organic fertilization program on soil chemical properties and on the subsequent crop under Mediterranean conditions: case of South of Italy. In: (Eds.): Mourão I. and U. Aksoy. *Acta Hort*., 933.

Anonymous. 1990. *Official Methods of Analysis*. (15th Ed) Association of Official Analytical Chemists, Arlington, Virginia.

Anonymous. 2002. *Basic standarts for organic production and processing*. International Federation of Organic Agricultural Movements (IFOAM). Tholey-Theley, Germany.

Anonymous. 2009. Standards Pea. Available at http://archives. eppo.org/EPPOStandards/PP2_GPP/pp2-14-e.doc.

Anonymous. 2013. Union for Protection of New Varieties of Plants. *Guidelines for the conduct of tests for distinctness, homogeneity and stability. Vicia sativa*. TG/32/7. http://www.upov.int/

Barilli, E., J.C. Sillero, E. Prats and D. Rubiales. 2014. Resistance to rusts (*Uromyces pisi* and *U. viciae-fabae*) in pea. *Czech J. Genet. Plant Breed*., 50(2): 135-143.

Barrs, H.D. and P. E. Weatherley. 1962. A re-examination of the relative turgidity technique for estimating water deficit in leaves. *Aust. J. Biol. Sci*., 15(3): 413-428.

Bozhanova, V., V. Koteva, T. Savova, M. Marcheva, G. Panayotova, S. Nedyalkova, G. Rachovska, K. Kostov and G. Mihova. 2014. Choice of appropriate cereals varieties and seed production for the needs of organic farming in Bulgaria - problems and answers. National Conference "Biological plant science, animal science and foods", 27-28 November, 2014, Troyan, pp. 68-77.

Conner, R.L. and C.C. Bernier. 1982. Host range of *Uromyces viciae-fabae*. *Phytopathol*., 72: 687-689.

Cornfield, A.H. 1966. A qualitative method of assessing the available nitrogen, potassium and phosphorus in the soil. *J. Sci. Food Agr*., 17: 321-323.

Ćupina, B., P. Erić, V. Mihailović and A. Mikić. 2004. The importance and role of cover crops in sustainable agriculture. *Zbornik Radova*, 4: 419-430.

Eberhart, S.A. and W.A. Russel. 1966. Stability parameters for comparing varieties. *Crop Sci*., 6: 36-40.

Egner, H., H. Riehm and W.R. Domingo. 1960. Investigations of the chemical soil analysis as a basis for the evaluation of nutrient status in soil. II. Chemical extraction methods for phosphorus and potassium determination. *Kung Lantbr Høgsk Ann*., 26: 199-215.

Georgieva,N., I. Nikolova,Y. Naydenova and D. Pavlov. 2016. Productivity, chemical composition and energy efficiency in organic vetch cultivation. *Russian Agri. Sci.*, 42(1): 50-57.

Goering, H.K. and P.J. Van Soest. 1970. *Forage fiber analysis*. USDA Agric. Handbook No. 379. USDA-ARS, Washington, DC.

Ingels, Ch. 1998. *Cover cropping in vineyards: A grower's handbook*. UCANR Publications, Jackson, CA.

Jacobsen, E. 1984. Modification of symbiotic interaction of pea (*Pisum sativum* L.) and *Rhizobium leguminosarum* by induced mutations. *Plant Soil*, 82(3): 427-438.

Kalapchieva, S., S. Masheva and V. Yankova. 2010. Characterizing of the agrobiological response of pea in organic production. *Scientific Works*, LV(1): 87-92.

Karagić, Đ., S.Vasiljević, S. Katić, A. Mikić, D. Milić, B. Milošević and N. Dušanić. 2011a. Yield and quality of winter common vetch (*Vicia sativa* L.) haylage depending on sowing method. *Biotech. Anim. Husbandry*, 27(4): 1585-1594.

Karagić, Đ., V. Mihailović, S. Katić, A. Mikić, D. Milić, S. Vasiljević and B. Milošević. 2011b. Effect of row spacing on seed yield of hairy, common and hungarian vetches. *Rom. Agric. Let.*, 28: 143-150.

Kicheva, P. and S. Angelova. 2005. Comparative study of promising accessions of common vetch. *Plant Sci.*, 42: 173-177.

Kirilov, A. 2009. Variation in some qualitative characteristics of fresh and preserved forages. Dr. Sci. thesis, Pleven, BG.

Konvalina, P., Z. Stehno and J. Moudry. 2009. The critical point of conventionally bread soft wheat varieties in organic farming systems. *Agron. Res*., 7(2): 801-810.

Köpke, U. 2005. Crop ideotypes for organic cropping systems. In: (Eds.): Lammerts van Bueren, E.T., I. Goldringer and H. Ostergard *Organic plant breeding strategies and the useof molecular markers*. ECO PB, Driebergen, pp.13-16.

Kostadinova, P. and V. Popov. 2012. Basic principles and methods of organic farming. *New Knowledge*, 3: 55-63.

Kostov, K. and D. Pavlov. 2004. *Forage production*. (4th Ed) Academic Press of Agrarian University, Plovdiv.

Kushwaha, C., R. Chand and C. Srivastava. 2006. Role of aeciospores in outbreaks of pea (*Pisum sativum*) rust (*Uromyces fabae*). *European J. Plant Pathol.*, 115(3): 323-330.

Kuzmova, K. 2002. Quantitative assessment of winter and spring varieties under degree of early-ripeness. Jubilee Conference "120 years agricultural science in Sadovo", pp. 109-112.

Laktionov, N.I. 1985. *Guidance for the characterization of the humus state of soils in their agricultural use*. Harkov University Press, Harkov.

Lammerts van Bueren, E.T. 2010. Ethics of plant breeding: The IFOAM basic principles as a guide for the evolution of organic plant breeding. *Ecol. & Farm.*, 2: 7-10.

Lammerts van Bueren, T., C. Struik and E. Jacobsen. 2002. Ecological aspects in organic farming and its consequences for an organic crop ideotype. *Neth. J. Agric. Sci*., 50: 1-26.

Mader, P., D. Fliessbach, D. Dubois, L. Gunst, P. Fried and U. Niggli. 2002. Soil fertility and biodiversity in organic farming. *Science*, 296(5573): 1694-1697.

Mäder, P., S. Edenhofer, T. Boller, A. Wiemken and U. Niggli. 2000. Arbuscular mycorrhizae in a long-term field trial comparing low-input (organic, biological) and high-input (conventional) farming systems in a crop rotation. *Biol. Fertil. Soils*, 31(2): 150-156.

Matic, R., S. Nagel and G. Kirby. 2015. Vetch variety sowing guide 2015. SARDI National Vetch Breeding Program , 23-25. http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/237910/vetch.pdf.

Mihailović, V., A. Mikić, B. Ćupina, S. Vasiljević and D. Milić. 2005. Agronomic characteristics of Novi Sad winter vetch cultivars. In: (Eds.): O'Mara, F.P. *et al*. *Proceedings of XX International Grassland Congress*, Wageningen Academic Pub, pp.130-133.

Mikić, A., B.; Ćupina, S. Katić and Đ. Karagić. 2006. Importance of annualforage legumes in supplying plant proteins. *A Period. of Sci. Res. On Field & Veg. Crops*, 42(1): 91-103.

Minta, M. and A. Tsige. 2014. Effect of *Rhizobium* inoculation on herbage yield, quality and nitrogen fixation of annual forage legumes on nitisols in Central Highlands of Ethiopia. *Acta Adv. Agric. Sci.*, 2(10): 29-48.

Moll, R.H. and C.W. Stuber. 1974. Quantitative genetics-empirical results relevant to plant breeding. *Adv.Agron.*, 26: 277-313.

Pachev, I. 2016. *Soils - genetic nature, characteristics, use and meaning*. (1st Ed) Academic Publishing, Agrarian University, Plovdiv.

Prats, E., D. Rubiales and J. Jorrín. 2002. Acibenzolar-*S*-methyl-induced resistance to sunflower rust (*Puccinia helianthi*) is associated with an enhancement of coumarins on foliar surface. *Physiol. Mol. Plant Path*., 60(3): 155-162.

Rai, R., A.K. Singh, B.D. Singh, A.K. Joshi, R. Ch and, C.P. Srivastava. 2011. Molecular mapping for resistance to pea rust caused by *Uromyces fabae* (Pers.) de Bary. *Theor. Appl. Genet*., 123(5): 803-813.

Seven, P.T. and I.H. Cerci. 2006. The effects on nutrient digestibility of hay and silage made in different conditions in lambs. *Veterinarski arhiv*, 76(2): 111-117.

Shaik, M. and J.R. Steadman. 1988. Nonspecific resistance to bean rust and its association with leaf pubescence. *Ann. Rpt. Bean Improvement Coop*, 31: 62-63.

Sillero, J.C. and D. Rubiales. 2014. Response of *Vicia* species to *Ascochyta fabae* and *Uromyces viciae-fabae*. *Czech J. Genet. Plant Breed*., 50(2): 109-115.

Sillero, J.C., A.M. Villegas-Fernandez, J. Thomas, M.M. Rojas-Molina, A.A. Emeran, M. Fernandez-Aparicio and D. Rubiales. 2010. Faba bean breeding for disease resistance. *Field Crop Res*., 115: 297-307.

Stackman, E.C., D.M. Stewart and W.Q. Loegering. 1962. *Identification of physiologic races of Puccinia graminis* var. *tritici*. Agricultural Research Service. USDA, Washington.

Stancheva, Y. 2002. *Atlas of diseases in agricultural crops*. (1stEd) Pensoft Publisher, Sofia.

Statgraphics, 1995. *Software Statgraphics Plus for Windows*. Version 2.1. Rockville (MD): Manugistics.

Tamis, W.L.M. and M.J. Van den Brink. 1999. Conventional, intrgrated and organic winter wheat production in the Netherlands in the period 1993-1997. *Agric. Ecosyst. Environ*., 76: 47-59.

Thomas, B., D. J. Murphy and D. Murray. 2003. *Encyclopaedia of applied plant sciences*. Academic Press, London.

Ur, Z., G. Ivanov and G. Rachovska. 2014. Suitability of wheat varieties for organic farming system. *Agri. Sci.*, 4: 1-14.

Von Alten, H. 1983. The effect of temperature, light and leaf age on the frequency of appressoria formation and infection with *Uromycesphaseoli* (Pers.) *Wint. Phytopathol. Z.,* 107:327-335.

Zachariassen, J.A. and J.F. Power. 1991. Growth rate and water use by legume species at three soil temperatures. *Agron. J*., 83(2): 408-413.

(Received for publication 6 January 2017)