

Suitability of *Vicia faba* L. genotypes for organic farming conditions

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Abstract

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Vicia faba is one of the best performing crops under global warming and climate change conditions, with opportunities to be grown in low-energy and organic production systems. The present study aimed to evaluate, based on a complex of characteristics (stability, productivity, tolerance to *Botrytis fabae* and feeding value), and to identify *Vicia faba* genotypes suitable for organic production conditions as well as for breeding purposes. The source collection included 12 genotypes. Suitability for organic growing showed Fb11, which is characterized by a fast average daily growth rate (0.88 cm day⁻¹), greater plant height (68.70 cm), and amount of biomass formed (56.10 g DM plant⁻¹ or 21.4% above the average for the studied accessions) – traits that ensure higher competitiveness against weeds. The same one demonstrated good stability (according to the values of the regression coefficient /bi/ and stability variance /σ²/), and received a high overall evaluation according to the main parameters of biochemical composition (CP, CF, NDF, ADF, ADL), *in vitro* digestibility, protein (PBD, PDIN, PDIE) and energy (FUM, FUG) feeding value of the forage. Fb11 was able to realize its productive potential despite showing sensitivity (S) to *Botrytis fabae*. From a breeding point of view, the following genotypes with the corresponding characteristics were of interest as parent forms: Fb 10 – most productive (58.31 g DM plant⁻¹), but unstable (bi = 1.91); Fb08 – showing moderate resistance (MR) to *Botrytis fabae*; Fb 05 – with the highest feeding value; Fb 12 – stable in all studied parameters (bi, θi, W², σ²), but less productive (by 4.5% below the average value for the group).

Keywords: *Vicia faba*; genotypes; organic farming; suitability; feeding value; *Botrytis fabae*

Introduction

Vicia faba L. is one of the earliest domesticated legumes, probably during the Late Neolithic period. The exact geographical origin is unknown, although Central Asia and the Mediterranean region are considered possible centers (Metayer, 2004). In the world, it is the third most important legume crop after soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) (Singh et al., 2013), and it is becoming increasingly important in order to meet the protein need globally (Kumar et al., 2018).

Due to its high protein content, *V. faba* is mainly used as a human food in developing and as animal feed in industri-

alized countries (Negash et al., 2015). O’Kiely et al. (2015) define it as forage with high palatability for ruminants. Its potential of fixing atmospheric nitrogen is high and reaches 300 kg N/ha, and therefore is a preferred predecessor in crop rotations (Singh et al., 2013). According to Singh et al. (2013), it is one of the best-performing crops under global warming and climate change due to its good adaptability to different climatic conditions and soil types. Broad bean is characterized by a comparative tolerance to biotic and abiotic stress, and can be grown in low-energy systems with minimal inputs (Singh and Bhatt, 2012a). The studies of Negash et al. (2015) show good opportunities and prospects for its growing also in organic farming conditions. However,

cultivars suitable for an organic production system differ in several aspects from those adapted to the conventional one (Wolfe, 2002; Kalapchieva et al., 2010). The environmental conditions in organic production are much more varied than in conventional farming. Therefore, the cultivars must be much more adaptable, and the stability of the yield is as significant as its magnitude (Bozhanova et al., 2014). Other important criteria in the evaluation of genotypes, which are suitable for organic farming, are increased weed competitiveness, pest tolerance and high quality, regardless of low input levels (Lammerts van Bueren et al., 2002; Lammerts van Bueren, 2010; Uhr et al., 2014).

The present study aimed to evaluate, based on a complex of characteristics (stability, productivity, tolerance to *Botrytis fabae* and feeding value), and to identify *Vicia faba* genotypes suitable for organic production conditions as well as for breeding purposes.

Material and Methods

The experimental activity was conducted at the Institute of forage crops (Pleven) in the period 2015-2016. Objects of the study were 12 genotypes of *Vicia faba* species. It was used a randomized block method (Barov, 1982). The sowing was done by hand, with a rate of 30 seeds per m², plot size of 4 m² and three replications. Plants were grown under organic farming conditions without the use of fertilizers and pesticides. Average daily growth rate (ADGR, cm day⁻¹), plant height (cm) and productivity (g DM plant⁻¹) were recorded during the vegetation period.

For stability evaluation, the following parameters were used: mean variance component θ_i (Plaisted and Peterson, 1959), ecovalence W^2 (Wricke, 1962); regression coefficient b_i (Finlay and Wilkinson, 1963) and stability variance σ^2 (Shukla, 1972) by using the GENES software product (Cruz, 2009).

The response of the genotypes to *Botrytis fabae* was expressed as the MDI (mass disease index) values according to Ding et al. (1993). Six resistance levels were used: HR (highly resistant), MDI ranging between 0 and 2.0; R (resistant), MDI = 2.1–15.0; MR (moderately resistant), MDI = 15.1–40.0; MS (moderately susceptible), MDI = 40.1–60.0; S (susceptible), MDI = 60.1–80.0; HS (highly susceptible), MDI = 80.1–100.

The general chemical composition of broad bean herbage (stage BBCH 71-72) was determined as crude protein (CP) by Kjeldal method and crude fiber (CF) by Weende system (AOAC, 2010). The plant cell walls components content in energy feeding value were determined as Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent

lignin (ADL) in percent of dry matter by systematic detergent analysis of Goering and Van Soest (1970). Polyoses hemicellulose and cellulose as cell walls components, contained in fiber fraction were represented empirically: Hemicellulose = NDF – ADF; Cellulose = ADF – ADL. The degree of lignification was presented as relation of ADL and NDF/100. Enzymatic *in vitro* digestibility of dry matter (IVDMD, %) and organic matter (IVDMD, %) were performed by two stage pepsin-cellulase method of Aufrere (Todorov et al., 2010). The energy feeding value was determined according French system (UFL-UFV) (INRA, 1988) and Bulgarian system (FUM-FUG, Feed units for milk, Feed units for growth). The protein feeding value was estimated by French system (INRA, 1988) through following parameters: TDP – Total Digestible Protein and a really digestible protein in ruminant small intestine – PDIN (Protein digestible in intestine depending on nitrogen, PDIN = PDIA + PDIMN) and PDIE (Protein digestible in intestine depending on energy, PDIE = PDIA + PDIMN) in g kg⁻¹ dry matter.

Results and Discussion

Meteorological conditions during the active vegetation period (March-May) in both experimental years differed substantially. The first year was characterized by an average daily air temperature of 12.6 °C, relative air humidity of 64%, extremely insufficient (143 mm) and uneven distribution of precipitation. The conditions in the second year can be defined as very favorable for the growth and development of broad bean. The precipitation amount was 58% higher compared to the previous year, and the relative air humidity and average daily temperature were 6% and 0.8 °C higher, respectively.

Morphological traits, controlling plant competitiveness against weeds, which is particularly important in organic production conditions, include a faster growth rate and early biomass accumulation (Uhr et al., 2014). The average daily growth rate (ADGR) of the studied genotypes varied from 0.69 to 0.88 cm/day (Table 1). The faster growth rate corresponded to a greater plant height, and a strong correlation dependence was established between them ($r = 0.894$). In terms of plant height and ADGR with statistically significant values, above the average for the group, were distinguished three genotypes: Fb09, Fb06, and Fb11. The exceedence was 6.1, 14.3, and 19.3%, and 6.6, 8.8, and 13.7%, respectively, for plant height and ADGR. Data regarding biomass accumulation as one of the factors determining competitive ability showed a strong variation between genotypes, from 34.71 to 58.31 g DM/plant. In two of them, the biomass amount exceeded the average value for the group by 26.2 and 21.4%,

respectively, in Fb10 and Fb11. In our previous study, a comparative evaluation of five pea cultivars under organic farming conditions was carried out. The results showed that the Bulgarian variety *Pleven 4* was distinguished by greater height, total biomass (aboveground and root), leaf area and average daily growth rate (27.8, 17.3, 22.9 and 32.5% on average) compared to the other four introduced varieties (*Glyans*, *Svit*, *Kamerton*, *Modus*). These parameters provided higher competitiveness against weeds and nutrient uptake (Georgieva, 2017). In a similar experiment with vetch varieties (*Vicia stauva*, *Vicia villosa*), it was found that *Liya* cultivar showed a complex of characteristics that define it as the most suitable for organic fodder production. It was characterized by a high ADGR (1.04 cm day⁻¹), greater height (70.4 cm), increased stem formation and biomass (aboveground and root, with 55.0 and 36.9% above the average for the varieties studied) (Georgieva, 2018).

To assess the genotype-environment interaction and importance of different factors in yield formation, a two-factor analysis of variance was performed (Table 2). The share of

Table 1. Average daily growth rate, plant height and productivity in *Vicia faba* genotypes in organic production conditions

Genotypes	Average daily growth rate, cm day ⁻¹		Plant height, cm		Productivity, g DM plant ⁻¹	
Fb01	0.81	f	62.39	e	51.46	e
Fb02	0.76	d	58.60	cd	41.80	bc
Fb03	0.73	c	55.46	ab	41.45	bc
Fb04	0.71	b	53.84	a	38.65	ab
Fb05	0.74	c	56.38	b	44.60	cd
Fb06	0.84	g	71.74	g	34.71	a
Fb07	0.69	a	55.69	ab	45.31	cd
Fb08	0.78	e	59.53	d	47.92	de
Fb09	0.82	f	63.77	e	50.13	e
Fb10	0.73	c	56.67	bc	58.31	f
Fb11	0.88	h	68.70	f	56.10	f
Fb12	0.70	ab	58.58	cd	44.14	cd
Average	0.77		60.11		46.22	

Source: Authors' own elaboration

Table 2. Analysis of variance regarding dry mass productivity in *Vicia faba* genotypes

Source of variation	DF	Sum Squares	Mean Squares	F value	Pr (>F)	% of total variation
Environment (E)	2	22783.6	11391.8	5 637.36	1.505e-10 ***	73.8
Replication/R	6	12.1	2.0	0.18	0.979	
Genotype (G)	11	4760.5	432.8	2.84	0.017 *	15.4
G × E	22	3349.2	152.2	14.09	<2.2e-16 ***	10.8
Residuals	66	713.0	10.8			

Significance: (***) 0.001, (**) 0.01, (*) 0.05

Source: Authors' own elaboration

factor „environment“ (year) was considerable and represented 73.8% of the total trait variation. The genotype factor had a significant influence on the trait manifestation, but the hereditary characteristics of broad bean were not determinative (15.4%). The genotype × environment interaction had also a significant influence on productivity, but its importance was the least (10.8%).

According to Kumar et al. (2018), the main challenges in broad bean cultivation are yield instability and low productivity. For more objective evaluation of the ecological stability of studied genotypes, four stability parameters were calculated: mean variance component θ_i (Plaisted and Peterson, 1959), ecovalence W^2 (Wricke, 1962); regression coefficient b_i (Finlay and Wilkinson, 1963) and stability variance σ^2 (Shukla, 1972). The coefficient of linear regression characterized genotypes Fb02, Fb03, Fb06 and Fb11 as stable, with values of $b_i < 1$ (Table 3). They can be defined as extensive type genotypes, of which only Fb11 was highly productive. Fb07 and Fb10 had the highest “ b_i ” values and therefore, can be referred to the unstable genotypes. The closest to the so-called “ideal” genotypes were Fb12, Fb09, Fb04, and Fb01. From this group of interest was Fb01, occupying the third position in terms of productivity.

The values of stability variance (σ^2) (Shukla, 1972) in some of the investigated genotypes had negative values. That suggests a non-linear genotype response and influence of other factors, which is difficult to comment on. According to this parameter, Fb03 (2.99) and Fb011 (6.00) can be defined as the most stable.

According to the mean variance component (θ_i) (Plaisted and Peterson, 1959) and ecovalence (W^2) (Wricke, 1962), cultivars that show lower absolute values are defined as exhibiting stability. In our research, these were Fb12 (0.06; 27.66) and Fb05 (0.53; 27.79), but they were low-productive. A similar dependence was found when determining the stability with the parameters σ^2 and W^2 in varieties of broad bean (Temesgen, 2015) and lentils (Karimizadeh et al., 2012). The authors reported that low-yielding cultivars were more stable than high-yielding ones.

Table 3. Parameters of stability in broad bean genotypes regarding dry mass productivity

Genotypes	bi (Finlay and Wilkinson, 1963)	θ_i (Plaisted and Peterson, 1959)	W ² (Wricke (1965))	σ^2 Shukla (1972)
Fb01	1.08	28.76	4.12	-2.56
Fb02	0.47	74.13	170.44	97.24
Fb03	0.85	31.28	13.36	2.99
Fb04	1.03	27.80	0.57	-4.68
Fb05	0.97	27.79	0.53	-4.71
Fb06	0.37	93.46	241.32	139.77
Fb07	1.49	67.94	147.76	83.63
Fb08	0.95	28.05	1.51	-4.12
Fb09	1.03	27.84	0.75	-4.58
Fb10	1.91	165.88	506.86	299.09
Fb11	0.83	32.65	18.37	6.00
Fb12	1.01	27.66	0.06	-4.99

bi – regression coefficient (Finlay and Wilkinson, 1963), θ_i – mean variance component (Plaisted and Peterson, 1959), W² – ecovariance (Wricke, 1962), σ^2 – stability variance (Shukla, 1972)

Source: Authors' own elaboration

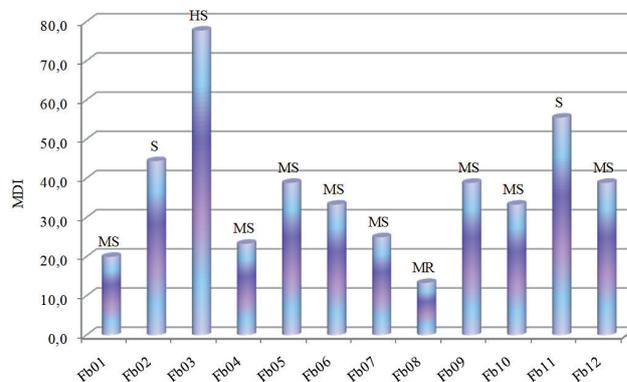
The differences in stability assessment for individual parameters, are due to the fact that different assessment methods are based on different concepts of stability.

Broad bean is attacked by many diseases, including fusarium (*Fusarium spp.*), bacteriosis (*Xanthomonas sp.*), downy mildew (*Peronospora fabae* Jacz.), rust (*Uromyces fabae* (Persson) de Bary), ascochyta (*Ascochyta fabae* Spegazzini) etc. (Stancheva, 2002). In the present experimental conditions, symptoms of chocolate spot (caused by *Botrytis fabae* Sard) were established. The disease develops in moderately warm weather (optimal temperature 15-18 °C) and high relative humidity (over 90%) during several consecutive days. On both sides of the leaf plant surface, characteristic chocolate, rounded, slightly sunken spots are formed. Similar spots, but with elliptical shape, appear on the stems and pods. According to Rhaïem et al. (2002), epidemics of this disease can cause severe yield losses (up to 100%), especially under favorable conditions. Chemical control combined with preventive measures has proved impractical, mainly because of widespread fungicide resistance to the causative agent of the chocolate spot. Currently, using resistant varieties remains the main means of reducing yield losses (Rhaïem et al., 2002, El-Komy, 2014).

Under the experimental conditions, MDI showed susceptibility (S) to *Botrytis fabae* in two of the studied genotypes (Fb02, Fb11), highly susceptibility (HS) in one (Fb03), and moderately susceptibility (MS) in eight of them (Fb01, Fb04, Fb05, Fb06, Fb07, Fb09, Fb10, Fb12) (Figure 1). Only one

of the genotypes (Fb08) exhibited moderate resistance (MR). It is evident that the high-productive Fb10 and Fb11 were susceptible to *B. fabae*, but nevertheless, they were able to realize their productive potential. In this sense, Lammerts van Bueren et al. (2002) reported that the main criterion for selection in organic production can be not only a high level of resistance, but also the ability of a given variety to maintain a certain level of yield and quality despite the pressure of infectious diseases. A similar conclusion was made by Konvalina et al. (2009) in evaluating wheat cultivars in organic production system. In studying nine broad bean varieties under organic farming, Negash et al. (2015) found that the latest ripening cultivar *Hachalu* was characterized by the highest tolerance (3.4) to the causative agent of the chocolate spot. The same was distinguished by the greatest height and grain productivity, and was defined by the authors as suitable for agroecological cultivation. The response of 67 *Vicia faba* genotypes to the virulent isolate "IBf24" of *B. fabae* was tested by Rhaïem et al. (2002) under field conditions. Five of these genotypes (LPF39, LPF113, LPF44, LPF237 and LPF05) were moderately resistant to chocolate spot, ten lines were moderately susceptible, and fifteen lines were susceptible according to their values of MDI and AUDPC (area under disease progress curve). In another study, Beyene et al. (2014) tested 50 local populations and 10 broad bean cultivars. The authors found essential differences in their response to *B. fabae*. The highest level of resistance was established in ILB-4726, ILB-938 and BPL-710. The authors also indicated that, in general, resistance was highly heritable, suggesting that phenotypic selection could be used to improve resistance to chocolate spot in broad bean cultivars.

Determining the nutritional value of forage based on chemical composition and enzymatic *in vitro* digestibility, is a suitable method for comparative assessment of its quality.

**Fig. 1. Response of *Vicia faba* genotypes to *Botrytis fabae***

Source: Authors' own elaboration

The data presented in Table 4 show the main biochemical composition, fiber component content, and digestibility of broad bean genotypes. The content of CP, CF, and ash was in the limits of 171.7 – 212.5 g/kg DM, 139.0 – 169.9 g/kg DM, and 100.2 – 127.5 g/kg DM, with variation coefficients (VC) of 14.0, 9.7 and 8.2, respectively. Fb 05 was characterized by the most favorable main biochemical composition, in which the CP content exceeded the average value for the group by 10.1%, and the CF content was 11.8% lower. A number of researchers reported a considerable variation in the crude protein content of different broad bean cultivars: Wegi et al. (2018), Mayer et al. (2021), and others. The average protein content under the present study conditions was 196.3 g/kg DM, which is similar to the values reported by Borreani et al. (2009) and Fraser et al. (2001).

According to Fahey and Hussein (1999), breeding programs aimed at developing high-quality varieties are associated not only with increased protein content, but also with a decreased fibrous component of cell walls. Data regarding the fractions of structural fibrous components of cell walls in the present experiment, and in particular for NDF, ADF and ADL, were unidirectional, reaching minima in four genotypes – Fb 11 (277.3, 261.4 and 49.6 g/kg DM), Fb 09 (292.2, 268.3 and 50.7 g/kg DM), Fb 07 (303.7, 249.5 and 45.9 g/kg DM) and Fb 05 (296.4, 259.5 and 49.0 g/kg DM). The decrease in mentioned accessions (compared to the average for the group) was expressed to a greater extent in ADL (on average by 7.2%), and to a lesser extent – in ADF and NDF by 5.7 and 5.1%. The fraction of fibrous components

in cell walls is an indicator of forage intake by ruminants, and reducing the content of this fraction results in improved forage intake.

As is known, NDF include four main chemical components – cellulose, hemicellulose, lignin and cutin. Cellulose and hemicellulose are potentially digestible, but because of their complex chemical structures, they resist the attack of digesting microorganisms in the animal rumen. Lignin and cutin are practically indigestible in both the rumen and the intestine. A well-balanced composition in terms of cellulose and hemicellulose was demonstrated by Fb 07, 203.6 and 54.2 g/kg DM, respectively. The degree of lignification was the indicator that showed the least variation between genotypes (VC = 1.0%), from 15.3 to 18.7, with values below the group mean were found in Fb 04, Fb 07 and Fb 11.

In vitro digestibility of dry and organic matter of the broad bean genotypes was high: 68.5 – 70.0% and 69.4 – 73.6%, respectively. Of interest were five genotypes (Fb 01, Fb 04, Fb 07, Fb 09 and Fb 11), in which the indicated parameters exceeded the respective mean values for the group. In a similar study, Gebremeskel et al. (2011) reported values for IVDMD and NDF in tested broad bean accessions from 65.0 to 73.8% and from 33.1 to 51.5%, respectively. It should be specified that, on the one hand, according to Meissner et al. (2000), *in vitro* digestibility values above 65% indicate a good nutritional value of the forage, and values below this level lead to reduced intake due to decreased digestibility. On the other hand, regarding the content of NDF, Shirley (1986) determined the critical level of 55–60%. This level

Table 4. Main chemical composition (g kg⁻¹ DM), cell walls components and *in vitro* digestibility (%) in *V. faba* genotypes (stage BBCH 71-72)

Genotypes	Ash	CP	CF	NDF	ADF	ADL	HC	C	DL	IVDMD	IVOMD
Fb 01	107.2	212.5	169.9	309.5	279.5	53.3	30.0	226.2	17.1	71.8	72.6
Fb 02	100.4	180.9	168.4	313.3	278.6	53.0	34.7	225.7	16.8	70.8	71.5
Fb 03	103.9	204.4	155.3	300.6	278.4	51.2	22.1	227.2	16.9	70.2	71.5
Fb 04	100.2	189.4	155.9	298.8	267.6	47.4	31.2	220.2	15.7	72.1	73.2
Fb 05	113.0	216.3	139.0	296.4	259.5	49.0	36.9	210.5	16.7	70.6	71.5
Fb 06	112.6	199.6	165.8	324.9	299.7	58.0	25.3	241.7	17.8	68.6	69.4
Fb 07	101.8	196.8	146.9	303.7	249.5	45.9	54.2	203.6	15.0	73.0	73.1
Fb 08	108.6	198.8	164.2	352.0	298.0	66.2	34.1	232.1	18.7	68.7	70.3
Fb 09	110.1	176.7	160.9	292.2	268.3	50.7	23.9	217.6	17.1	71.9	73.6
Fb 10	100.7	171.7	163.6	331.8	286.6	55.5	45.0	231.3	16.7	68.5	70.0
Fb 11	117.4	204.1	155.7	277.3	261.4	49.6	15.3	221.9	15.3	72.4	73.3
Fb 12	127.5	205.0	146.1	298.5	269.1	51.2	29.4	217.9	17.3	69.7	71.0
Average	108.6	196.3	157.6	308.2	275.5	52.6	31.8	223.0	16.7	70.7	71.7
VC	8.2	14.0	9.7	20.0	15.2	5.4	10.4	10.2	1.0	1.6	1.4

CP – Crude protein, CF – Crude fiber, NDF – Neutral-detergent fiber, ADF – Acid-detergent fiber, ADL – Acid-detergent lignin, HC – Hemicellulose, C – Cellulose, DL – Degree of lignification (coefficient, ADL/NDFx100), IVDMD – *In vitro* dry matter digestibility, IVOMD – *In vitro* organic matter digestibility

Source: Authors' own elaboration

reduces voluntary feed intake and feed conversion efficiency due to longer rumination time. The values obtained in the present study for IVDMD and NDF were, respectively, higher and lower than the above-mentioned critical levels, which defines the tested genotypes as high-quality ones (Singh and Oosting, 1992).

The feed quality evaluation regarding *in vitro* digestibility fully corresponded to this one of the energy feeding value (Table 5). Genotypes Fb 01, Fb 04, Fb 07, Fb 09 and Fb 11 had the highest energy nutritional value, assessed according to the French (UFL-UFV: 0.828-0.811; 0.736-0.714) and

Bulgarian (FUM: 0.687-0.674; FUG: 0.601-0.583, respectively) systems, as Fb 04 took the first position. The protein feeding value determined on the basis of total digestible protein (PBD) and protein digestible in the small intestine dependent on nitrogen (PDIN) and energy (PDIE) showed a slightly different estimate. Fb 01, Fb 03, Fb 05, Fb 11 and Fb 12 were distinguished by the highest protein nutritional value, as the first position was occupied by Fb 05 (PBD 172; PDIN 136; PDIE 106 g/kg DM). Determination of protein, digestible in the rumen and small intestine of ruminants, is important for predicting the nutritional value of forages. In

Table 5. Energy and protein feeding value of *Vicia faba* genotypes

Genotypes	RFV	UFL	UFV	FUM	FUG	PBD	PDIN	PDIE
Fb 01	203.5	0.813	0.716	0.674	0.585	168	134	106
Fb 02	202.5	0.808	0.713	0.670	0.583	138	114	99
Fb 03	210.9	0.808	0.710	0.670	0.579	160	128	103
Fb 04	216.4	0.828	0.736	0.687	0.601	146	119	102
Fb 05	217.0	0.800	0.701	0.664	0.573	172	136	106
Fb 06	188.8	0.774	0.677	0.642	0.551	156	125	101
Fb 07	214.5	0.826	0.732	0.685	0.599	153	123	103
Fb 08	174.1	0.789	0.690	0.654	0.564	155	125	102
Fb 09	218.9	0.821	0.729	0.681	0.595	134	111	99
Fb 10	186.5	0.793	0.697	0.658	0.569	129	108	96
Fb 11	227.3	0.811	0.714	0.672	0.583	161	128	104
Fb 12	212.0	0.780	0.679	0.646	0.555	162	129	103
Average	206.00	0.804	0.708	0.667	0.578	153	123	102
VC	15.7	0.02	0.02	0.01	0.02	13.5	8.8	2.9

RFV-relative feeding value; UFL (Fr), FUM (Bg) – Feed units for milk; UFV (Fr), FUG (Bg), – Feed units for growth

TDP/PBD – Total Digestible Protein/Protein Brute Digestible, PDIN – Protein digestible in intestine depending on nitrogen, PDIE – Protein digestible in intestine depending on energy

Source: Authors' own elaboration

Table 6. Ranks of the parameters of chemical composition, digestibility and feeding value of vetch cultivars *Vicia faba* genotypes

Genotypes	CP	CF	NDF	ADF	ADL	IVDMD	FUM	FUG	PBD	PDIN	PDIE	ARS	Ranks
Fb 01	2	12	8	9	8	5	5	4	2	2	1	58	5
Fb 02	10	11	9	8	7	6	6	5	10	8	6	86	8
Fb 03	4	4	6	7	6	8	6	6	5	4	3	59	6
Fb 04	9	6	5	4	2	3	1	1	9	7	4	51	4
Fb 05	1	1	3	2	3	7	7	7	1	1	1	34	1
Fb 06	6	10	10	12	10	11	11	11	6	5	5	97	10
Fb 07	8	3	7	1	1	1	2	2	8	6	3	42	3
Fb 08	7	9	12	11	11	10	9	9	7	5	4	94	9
Fb 09	11	7	2	4	5	4	3	3	11	9	6	65	7
Fb 10	12	8	11	10	9	12	8	8	12	10	7	107	11
Fb 11	5	5	1	3	4	2	4	5	4	4	2	39	2
Fb 12	3	2	4	5	6	9	10	10	3	3	3	58	5

CP – Crude protein, CF – Crude fiber, NDF – Neutral-detergent fiber, ADF – Acid-detergent fiber, ADL – Acid-detergent lignin, IVDMD – *In vitro* dry matter digestibility, FUM FUG (Bg) – Feed units for milk and growth, PDIN – Protein digestible in intestine depending on nitrogen, PDIE – Protein digestible in intestine depending on energy, ARS –Arithmetical rank sum, Lowest R – Highest forage quality

Source: Authors' own elaboration

conclusion, the overall evaluation by ranging main parameters of biochemical composition, *in vitro* digestibility, protein (PBD, PDIN, PDIE) and energy feeding value (FUM, FUG) determined rank 1 for Fb 05, and ranks 2 and 3 – for Fb 11 and Fb 07 (Table 6).

Conclusions

Based on the complex evaluation of 12 *Vicia faba* genotypes according to traits and parameters characteristic of varieties under organic production conditions, the following more important conclusions can be made:

Suitability for organic growing showed Fb 11, which is characterized by a fast average daily growth rate (0.88 cm day⁻¹), greater plant height (68.70 cm), and amount of biomass formed (56.10 g DM plant⁻¹ or 21.4% above the average for the studied accessions) – traits that ensure higher competitiveness against weeds. The same one demonstrated good stability (according to the values of the regression coefficient /*b*/ and stability variance / σ^2 /), and received a high overall evaluation according to the main parameters of biochemical composition (CP, CF, NDF, ADF, ADL), *in vitro* digestibility, protein (PBD, PDIN, PDIE), and energy (FUM, FUG) feeding value of the forage. Fb11 was able to realize its productive potential despite showing sensitivity (S) to *Botrytis fabae*.

From a breeding point of view, the following genotypes with the corresponding characteristics were of interest as parent forms: Fb 10 – most productive (58.31 g DM plant⁻¹), but unstable (*b*_i = 1.91); Fb08 – showing moderate resistance (MR) to *Botrytis fabae*; Fb 05 – with the highest feeding value; Fb 12 – stable in all studied parameters (*b*_i, θ _i, *W*², σ^2), but less productive (by 4.5% below the average value for the group).

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