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Original article

Assessment of Initial Material of Vetches in Productive and Adaptive Ability [1]

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Abstract

Eight winter vetch varieties (BGE004222, BGE001847, BGE000637, BGE001076, BGE000639, BGE000643, BGE001383 and Asko 1) were assessed by plant height, fresh leaf weight, fresh stem weight and nodule number per plant in field trial in the Institute of Forage Crops, Pleven, Bulgaria. The varieties are characterised by low general adaptive ability and average specific adaptive ability on the investigated signs. With the highest general adaptive ability by fresh leaf weight is distinguished BGE000643, by number of nodules per plant BGE004222 and BGE001383, and by plant height - BGE001847 and BGE000637, respectively. By the complex indicator selection value of the genotype, taking into account the general adaptive ability and stability, the signs fresh leaf weight and fresh stem weight the best was found BGE001383 variety. According to the number of nodules per plant and the indicators of adaptability and stability, the interest represents the variety BGE004222. Based on the aggregate assessment of the varieties, which is based on the average height of the plant and the parameters of adaptability, the most valuable were the varieties BGE001847 and BGE001076. A positive correlation was established between fresh leaf weight and: the specific adaptive ability (r = 0.568), the general adaptive ability (r = 0.099) and the indicator of the stability level of the variety (r = 0.544); and between the number of nodules with the coefficient of linear regression (r = 0.115) and with homeostaticity (r = 0.116).

Keywords: Genotype, Selection value, Stability, Vetch.

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INTRODUCTION

Vetch species are one of the most common annual forage crops. The winter vetch (*Vicia villosa* Roth.) has good productivity of the fresh biomass. The biology of culture enables it to be cultivated in a wide range of cultivation. It is suitable for sowing both, in pure crops and in mixtures with grass component (Debelyi et al., 2011, 2015).

Adaptive potential is the limit of the resistance of cultural plants to adverse factors such as harmful insects, diseases, drought, soil salinity, cold. One of the main directions of the adaptive selection is the increasing the adaptive potential, in which the task is only high productivity obtaining, but also assessing the resistance of plants to adverse climatic conditions and biotic stress (Korzun and Bruylo, 2011; Popovic et al., 2015).

The complex nature of environmental conditions sometimes leads to a strong variability in the productivity of the grown crops. In this regard, the problem of increasing the yield should be combined with elements of its stabilisation. In such a situation, the varieties do not fully realise their genetic potential. The main reason for this is the insufficient level of adaptability of regionated sortiment of varieties, which acts as a decisive factor for the realization of potential productivity in non-regulated environmental conditions (Sapega et al., 2012).

In this context, the breeding programmes should be oriented towards the creation of adaptive varieties characterised by stability with regard to the basic elements of production and output quality. There is an objective possibility of creating genotypes of high productive potential and resistance to adverse factors, as these properties are controlled by different genetic systems (Anokhina and Mazuka, 2006).

The examination of the varieties of productivity and adaptive ability in the dynamics of the years allows detecting the reserves for increasing the real yield, to reveal the role of the selection and to provide a justification for the further activity in this direction (Sapega, 2011).

The purpose of the study was a comprehensive assessment of the winter vetch varieties by productivity and parameters of adaptability.

Materials and Methods

The study was conducted in 2014-2016 in the experimental field of the Institute of Forage Crops, Pleven, Bulgaria. Sowing was carried out manually in optimal time according to the technology of cultivation of vetch. Plant material from aboveground and root mass of 8 winter vetch varieties originating from abroad, vs. BGE004222, BGE001847, BGE000637, BGE001076, BGE000639, BGE000643, BGE001383 and the Bulgarian variety Asko 1, used as a control. The following characteristics have been assessing in the beginning of flowering stage of the plants: plant height (cm), fresh leaf weight (g), fresh stem weight (g) and number of nodules per plant. Biometric measurements are made of 15 plants of each variety.

From the existing different methods for quantitative assessment of the plasticity and stability parameters, in this study the method of Kilchevsky and Khotyleva (1985a; 1985b), which is based on the testing of varieties in different environment was used. It allows determining the general adaptive ability (GAA), specific adaptive ability (SAA), relative stability of the genotypes (Sgi,%: indicator which for comparing different crops and varieties), variance of specific adaptability (σ2CACi), criterion for estimation of the genotype ability to enter into interaction with environment (σ(GxE)gi) and selection value of genotype (SVG: used for determining the variety which combines high-productiveness and stability). The stress resistance (Y) of varieties by Rossielle and Hamblin (1981) method was determined. Homeostaticity (Hom) was calculated by the method of Hangildin (1984), the variety stability (VS) by Nettevich (2001).

The interdependence between the traits and the parameters of stability and adaptability were determined by correlation analysis (Dimova and Marinkov, 1999). The analysis of adaptability were performed according to the methods proposed by Nascimento et al. (2009), stability parameter Finlay and Wilkinson (1963) and Francis and Kannenberg (1978).

All experimental data were processed statistically with using the computer software GENES 2009.7.0 and Excel for Windows XP (Cruz, 2009).

Results

The data obtained on the adaptability and stability of the varieties by parameters tested are given in Table 1. The assessment allows defining prospective genotypes for inclusion in the breeding process according to the individual indicators.

The coefficient of regression (bi) explains the adaptiveness of the tested genotypes over the evaluated environments. BGE000637 and BGE000643 form significant leaf biomass and are characterised by bi-value larger than 1 indicating that these varieties can perform better productivity in favorable environments. The only variety Asko 1 according to the regression coefficient (bi = 0.927) approximates the ideal genotype of this attribute. As stable can be defined low productive varieties BGE000639 (bi=0.17) and BGE001383 (bi=0.127).

By fresh leaf weight, the varieties studied are characterised by relatively low general adaptive ability (GAA). Highest general adaptive ability was established in the BGE000643 (2.89) and in BGE000637 (1.22). It can be seen from the data submitted that all high-level varieties of general adaptive ability are relatively high in relation to this attribute. This corresponds to the theoretical situation that the high-value varieties of general adaptive ability are capable of providing maximum average yield under different environmental conditions.

The selection of specific adaptive ability (SAA) is appropriate in case of predictability of the environmental conditions. Since specific adaptive ability is an element of stability, its assessment allows the different level of stability of the varieties studied to be disclosed.

The results of the studies show that the varieties are characterised by an intermediate level of a specific adaptive ability. Highest specific adaptive ability (SAA) and therefore the highest stability was recorded in the BGE000637 (6.88) and BGE000639 (5.97) varieties. It should be noted that the selected varieties of specific adaptive ability are also characterised by the highest fresh leaf weight BGE000637 (11.156 g) BGE000639 (12.817 g) in the tested specimen group (Table 3).

The relative stability of the genotype makes it possible to compare the results of experiments conducted even with a different set of cultures, genotypes, and environment of a given attribute. According to data from the studies carried out, the relative stability of the genotype was found average for the varieties BGE001383 and Asko 1. The analysis showed that with the highest instability according to this parameter were the varieties BGE000643 and BGE000637 (Sgi,%46.60% and 61.67%). For a simultaneous selection of forms by general adaptive ability and stability of the genotype, the value of selection value of genotypes (SVG) parameter is used. According to the results of the study, the best indicators of SVG were obtained in varieties BGE001383 (8.15) and Asko 1 (7.15). The lowest value of this parameter, combined with a good general adaptive ability (GAA) was established in BGE000637.

In the selected set of samples are also included varieties with maximum values of the general adaptive ability by fresh stem weight per plant. Therefore, in spite of the possible lack of a close relationship between the attribute and its stability, varieties with comparatively higher weights of stems and good resistance to adverse environmental factors can be chosen. This was the case with the BGE001383 variety (19.527 g, 4.91%).

The varieties BGE001847, BGE000637, BGE001076 and BGE000643 have the highest values of fresh leaf weight and a regression coefficient, statistically significantly higher than 1 (bi >1.0). They were sensitive to the environmental changes and were well adapted to favourable environments. Two of the varieties BGE001383 and Asko 1 possessed bi<1.0 and have relatively heavy stems suggesting that these genotypes were better adapted to poor environments and insensitive to changing environments. These genotypes could be better for cultivation only in unfavourable conditions.

Based on the data obtained on the value of the attribute fresh stem weight and the parameters of adaptability, the varieties BGE001847 (SAA=12.98), BGE000637(SAA=12.94) and BGE001383 (SAA=18.65) can be assessed as the most valuable.

The linear regression of the nodule number per plant of a single genotype on the average trait of all genotypes in each environment generated the regression coefficients (bi), which ranged from 0.307 for BGE001076 to 1.968 for BGE001383. This wide range of regression coefficients indicates that the

8 genotypes had different responses to environmental changes. With regard to the trait studied, the varieties of BGE000637 and BGE001847 are characterised by the highest averages (106.26-108.53), but with not very good responsiveness to the changing environment. According to the criteria selection value of the genotype BGE001847 occupies a third position, retreating to BGE004222 and BGE001383.

Maximum values of the general adaptive ability are noted in BGE004222 (13.48) and BGE001383 (10.21), varieties which form a number of nodules around the average for the sample. By the specific adaptive ability defined as a deviation of the general adaptive ability in a particular environment and showing the ability of the genotype to react to the effects of specific (abiotic and biotic) environmental factors are distinguished BGE004222 and BGE001383. BGE001383 forms a relatively large number of nodules per plant (99.10) and has the most pronounced responsiveness and reaction to the changes of the environment (GxEgi=229.88). A certain drawback of all varieties is the relatively low stability on this attribute, expressed by the values of the Sgi,% parameter, which range from 44.98% (BGE001076) to 139.86% (BGE000643).

The height of the plant varieties BGE004222 and BGE001383 are characterised by the highest value of the attribute, respectively 29.73 cm and 26.46 cm. For the years of study they have demonstrated one of the lowest values for adaptability and stability, particularly BGE004222. Insignificant environmental variability was established only in BGE001076 (7.85%). The regression coefficient of the BGE000639 and BGE001383 varieties is statistically significant and is close to the 1 (bi=1.153 and bi=1.196), indicating that these genotypes have good general adaptivity. In the mathematical processing of the data with high value of the genotype have distinguished BGE001076 (SVG=74.11) and BGE001847 (SVG=73.74), the plants of which are relatively lower. Among the tested samples positive values of the general adaptive ability parameter showed only BGE001847 (10.43), BGE000637 (8.16) and BGE001383 (0.99).

The applied nonparametric analysis (Table 3) based on the methodologies of centroid (Nascimento et al., 2009), confirms the existence of differences between the individual genotypes.

A difference was found in the evaluation of this method and on the analysis of the previous methods in the classification of genotypes. For example, by the plant height, BGE001847 can be characterised as a high phenotypic stability genotype in the “bi” parameter, as well as a general adaptive ability (GAA=10.43) and according to the method centroid is defined as unstable, belonging to rank IV.

By the sign of fresh leaf weight the stability of the genotypes BGE004222, BGE001076, BGE001847 and Asko 1 was classified as adaptability overall average (rank V). With specific adaptability to adverse environments was evaluated BGE000639 rank III, which shows great adaptability to a variety of growing environments.

In a significant part of the varieties, the adaptability by the characteristic fresh stem weight per plant to the environment is classified as average (rank V). The BGE000643, variety, which has a maximum value of the attribute, occupies the self-ranking VI, defining it as the genotype with specific adaptability to favorable conditions.

BGE000639 was classified as genotype with minimal adaptability and reduced phenotypic stability, because based on centroid method the probability of belonging to rank IV was the highest.

The same rank (IV) characterizes the BGE001847 and BGE001076 by the height of the plant. Among the studied group of varieties with the highest plant and the highest general adaptability is distinguished BGE004222 (rank I). Three of the varieties have an average degree of adaptability (rank V). The BGE001383 variety exhibits specific adaptability to the improved growing conditions. Asko 1 was rated with rank III, showing specific adaptability to adverse environments.

By number of nodules per plant with maximum adaptability to the environment was estimated variety BGE001847 (rank I). The control variety Asko 1 retains its rank (rank III) from the previous attribute, i.e. it is well adapted to the changes in local conditions for growing. With rank V are ranked varieties BGE001076, BGE000639, BGE000643 and BGE001383, characterized by an average degree of adaptability.

Several other authors (Vasconcelos et al., 2008; 2011) also found excellent groupings using the Centroid method for adaptability analysis.

Homeostatistics and stress resistance

The homeostasis in plants is associated with the ability of their genetic mechanisms to minimize the effects of the adverse external conditions. In practical terms, interest are those varieties which combine in themselves a high level of productive abilities with high indicators of homeostaticity. An analysis of the variability of the values of the individual traits of the plants shows that the limiting factors on their expression appear to be not so much the potential biological option as the persistence of the genotype to the adverse conditions of the external environment, i.e. homeostaticity. The main value of the new varieties should be determined by the magnitude homeostaticity and the quality of the plant production for a particular region.

In terms of stress resistance most of the varieties are similar in fresh leaf weight per plant. The exception is Asko 1, which has very high variability (Y =-296.78) and the lowest homeostaticity (Hom = 0.13) on this attribute, although the indicator of the level of stability of the variety (VS) occupies a second position after the BGE001383 variety. BGE001383 is distinguished by the highest homeostaticity (Hom = 10.85) and stress resistance (Y =-4.45).

Significant differences in homeostasis are also found by fresh stem weight per plant. The varieties BGE004222 and BGE001383 tolerate best with minimal effects the adverse environmental impact of this sign (Y=-2.66, Hom=10.19; Y=-9.74, Hom=7.64). As seen from Table 2, BGE000643 although inferior to the remaining varieties on these indicators, prevails in relation to the high value of the attribute, which is of great interest to the selection in the production pathway of fresh aboveground mass.

The results of Table 2 show that in all samples of winter vetch by the nodule number per plant the homeostasis is very low and varies in narrow range from 0.26 (BGE000639) to 1.42 (BGE001847). The BGE001847 and BGE001076 varieties are found to be most resistant to stress factors (Y=-14.63; Y=-10.24).

In terms of plant geight the varieties Asko 1 and BGE004222 exhibit the lowest variability (high homeostaticity), respectively Hom = 184.67 and Hom = 151.42. According to the indicator of the stability level of the variety they retreated to BGE001847 (962.376) and BGE001076 (953.667).

In the process of adaptation to sharper and longer-lasting changes in the external environment, the homeostasis may be insufficient and as a result the transition from one steady state to another would be less appropriate for the organism.

Francis and Kannenberg (1978) reported that the coefficients of variation (CV%) estimated from the variances over environments of the genotypes grown in different environments are used as the stability parameter. In this study, the coefficient of variation for fresh leaf weight varied from 21.69% (BGE001383) to 63.01%. From a selection point of view interest are the varieties BGE001383, Asko 1 and BGE001847, which fall within the quadrant, limited by higher values of the attribute and the lower of the coefficient of variation.

The coefficient of variation (CV) of each genotype as a measure of stability. A high yielding genotype with a low coefficient of variation is considered stable (Francis and Kannenberg, 1978). Given the data presented in Figure 1, it is noted that BGE001383 has the lowest CV (26.25%) among the tested genotypes. So, it is more stable variety. The plants of variety BGE000643 have the heaviest stems, but are characterized with the greatest variability. The varieties BGE001847 and BGE000637 are very close to the abscissa axis of the coordinate system. They combine relatively good stability and high value of the attribute.

According to the height of the plant, there is a complete match between the distributions of Francis and Kannenberg (1978) and the linear regression coefficient (bi). As ecologically stable can be determined BGE001847, BGE001076 and BGE000643. However, they refer to the low productive genotypes group. From the varieties with long stems and medium level of stability can be chosen only BGE001383.

On average for the period of study with the lowest coefficient of variation by number of nodules per plant are distinguished BGE001076, BGE000639 and standard variety Asko 1, but in terms of the attribute are low productive, fail to form many nodules per plant. Of all the varieties, BGE004222, which is of average productivity combines high no stability of the attribute. For the needs of combinatorial selection a promising is the variety BGE000637.

Correlation analysis

In the process of the study correlation analysis was conducted (Table 4) between the number of nodules per plant and the fresh leaf weight and the indicators of adaptability and stability. The results showed a weak positive, but very well significant dependency (r=0.099) between fresh leaf weight and general adaptive ability (GAA) and a weak negative correlation (r=-0.025) with responsiveness to change in environmental conditions (GxEgi). High correlation coefficient is established between the linear regression coefficient (bi) and the fresh aboveground mass weight of the plant (r=0.682), as well a positive mean dependence with the specific adaptive ability (SAA) (r=0.568) and the level of varietal stability (VS) (r=0.544). The positive dependence on the fresh leaf weight and the general adaptive ability implies that the creation and introduction of varieties in production adapted for cultivation to a wide range of environmental conditions will contribute to an increase the average level of the attribute.

A positive strong significant relationship between the stress resistance parameters with the regression coefficient (bi) (r = 0.721), SAA (r = 0.830), Sgi,% (r = 0.817) and variety stability (VS) (r = 0.855) has also been established. With the same sign is the dependence between Sgi,% with bi (r = 0.866) and with SAA (r = 0.993). A negative and significant was the correlation of the selection value of genotype with specific adaptive ability (r =-0.955), with Sgi,% (r =-0.983), with variety stability (VS) (r =-0.739) and with stress resistance (Y) (r =-0.786).

Importantly, especially in the breeding process, there is information obtained on the dependence of the number of nodules per plant with the parameters of adaptability. Our results show that the relationship of this attribute to the plants of the studied group of varieties and their variability is characterized by negative but statistically insignificant relationship with GxEgi (r=-0.150), SVG (r=-0.088), GAA (r=-0.024), VS (r=-0.024) and stress resistance (Y) (r=-0.070). Between the number of nodules per plant and the specific adaptive ability (SAA) and stability (Sgi,%) a positive no significant dependence (r = 0.059, r = 0.099) was found which implies the possibility of increasing the number of nodules by selection and creating varieties with increased ecological stability. In relation to this attribute very strong correlations between the parameters SAA and Sgi (r=0.908); SAA and VS (r=0.893); the coefficient of linear regression bi and SAA (r = 0.852) were established.

Discussion

Ashiev (2014) reports that the assessment of the varieties studied by certain quantitative signs is correct only for the particular growing conditions. Improvement or deterioration of the environmental conditions, or their individual factors relative to baseline, results in a change in the rank of the specimens studied. This is due to the specifics of the potential productivity and the rate of response of the genotype to the environmental conditions. The determination of the real value of varieties is therefore usually carried out for a multiannual period of study.

According to Kurkova et al. (2015) in the process of adapting the organism to sharper and longer-lasting changes in the external environment, the homeostasis may be insufficient, as a result of which a steady state passes into another, possibly less appropriate for the organism.

According to Sapega (2011), currently in agricultural production are introduced varieties of intensive type, the potential possibilities of which are difficult to realise anywhere in production conditions. They can be successfully grown on farms with high farming culture. At the same time, varieties with an average level of productivity and ecologically sustainable are not less valuable.

According to Kilchevsky and Khotyleva (1989) the main feature of adaptive selection is control of environmental stability in the breeding process. Its necessity is based on the fact that the average value of the attribute and the sensitivity to environmental conditions are found under self-genetic control and are relatively independent.

In his studies Hangildin (1984) reported that the variety as a genetic system reacted specifically to external environmental factors. According to the author, the distinctive feature of each variety is the totality of properties that determine its suitability for a given range of distribution, so the right choice of variety is of paramount importance for the cultivation of the cultural plants.

Sarviro (2008) establishes a close correlation between productivity and common combinative ability, general adaptive ability and the selection value of the genotype; high correlation between the general adaptive ability and the selection value of the genotype and the regression coefficient (bi), and a negative correlation between the common combinative ability and the relative stability of the genotype.

Nikiforova (2015) does not establish a reliable linear relationship between the average grain productivity and the relative stability of the genotype in a set of samples which it has studied. According to the author, this shows that in the group of varieties there are relatively stable both, high and low-yielding genotypes.

Zharkova (2009) points out that the determination of correlations allows to establish the direct and indirect relationships between the different parameters. This kind of information is of interest to the selection of adaptability and allows for the implementation of selection by indirect signs.

Conclusions

In general, the varieties are characterised by low general adaptive ability and average specific adaptive ability on the investigated signs. With the highest general adaptive ability by fresh leaf weight is distinguished BGE000643 variety, by number of nodules per plant BGE004222 and BGE001383 varieties, and by plant height BGE001847 and BGE000637.

By the complex indicator selection value of the genotype, taking into account the general adaptive ability and stability, by the signs fresh leaf weight and fresh stem weight the best was the variety BGE001383. According to the number of nodules per plant and the indicators of adaptability and stability, the interest represents the variety BGE004222.

Based on the aggregate assessment of the varieties, which is based on the average height of the plant and the parameters of adaptability, the most valuable were the varieties BGE001847 and BGE001076.

A positive correlation was established between the fresh leaf weight and: the specific adaptive ability (r = 0.568), the general adaptive ability (r = 0.099) and the indicator of the stability level of the variety (r = 0.544), and between the number of nodules with the coefficient of linear regression (r = 0.115) and with homeostaticity (r = 0.116).

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Table 1. Parameters of adaptability and stability in vetch varieties

Variety	Parameters					
	bi	**GxEgi**	**SAA**	**Sgi, %**	**SVG**	**GAA**
	Fresh leaf weight (g)					
BGE004222	1.666	0.92	3.71	39.69	4.43	-0.57
BGE001847	1.366	5.07	3.82	35.80	5.60	0.73
BGE000637	2.281**	27.51	6.88	61.67	2.04	1.22
BGE001076	1.381	1.61	3.36	39.33	4.09	-1.39
BGE000639	0.170**	29.79	3.09	43.88	2.95	-2.88
BGE000643	2.578**	12.51	5.97	46.60	4.90	2.89
BGE001383	0.127**	19.42	1.75	16.73	8.15	0.54
Asko 1	0.927	-1.67	1.70	18.05	7.15	-0.53
	Fresh stem weight (g)					
BGE004222	1.156*	0.14	11.69	62.89	7.85	-4.61
BGE001847	1.656**	24.35	16.35	58.36	12.98	4.81
BGE000637	1.487**	19.01	15.03	56.18	12.94	3.55
BGE001076	1.328**	-9.97	12.77	66.07	7.59	-3.87
BGE000639	0.147**	278.61	5.58	35.86	10.43	-7.65
BGE000643	2.987**	421.91	30.80	89.66	6.04	11.14
BGE001383	0.220**	63.79	0.96	4.91	18.65	-3.68
Asko 1	0.186**	356.49	14.39	61.24	10.27	0.30
	Nodule number per plant					
BGE004222	1.817**	164.09	29.09	97.84	14.20	13.48
BGE001847	0.435**	73.72	6.15	49.86	9.06	-3.92
BGE000637	1.230**	11.78	19.73	131.63	4.45	-1.27
BGE001076	0.307**	116.13	3.72	44.98	6.29	-7.98
BGE000639	0.798**	13.57	12.89	89.10	7.58	-1.79
BGE000643	0.964	-9.32	15.15	139.86	2.74	-5.42
BGE001383	1.968**	229.88	31.47	118.92	9.66	10.21
Asko 1	0.482**	110.40	9.94	76.84	7.63	-3.32
	Plant height (cm)					
BGE004222	1.916**	469.15	31.90	33.08	5.59	-1.68
BGE001847	0.948	-22.04	12.22	11.26	73.74	10.43
BGE000637	1.319**	29.75	18.59	17.50	53.33	8.16
BGE001076	0.613**	15.47	7.49	7.85	74.11	-2.68
BGE000639	1.153**	13.59	16.27	17.61	46.06	-5.71
BGE000643	1.429**	84.98	21.07	21.56	37.71	-0.41
BGE001383	1.196**	108.53	19.40	19.58	43.85	0.99
Asko 1	0.174**	536.79	10.71	12.04	58.49	-9.11

bi: Regression coefficient Finlay and Wilkinson's regression model; σ(GxE)gi: criterion for estimation of the genotype ability to enter into interaction with environment; SAA: specific adaptive ability; Sgi,%: relative stability of the genotypes; σ2CACi: variance of specific adaptability; SVG: selection value of genotype; GAA: general adaptive ability.

*; **: Significant at 0.05; 0.01 probability levels, respectively.

Table 2. Parameters of homeostaticity (Hom) of vetch varieties

Varieties	**Parameters**				
	VS	**X_{opt}**	**X_{lim}**	**Stress resistance (Y)**	**Hom**
	Fresh leaf weight (g)				
BGE004222	2.056	11.88	4.76	-7.12	3.10
BGE001847	2.969	14.88	6.73	-8.15	3.42
BGE000637	1.975	18.94	5.28	-13.66	1.30
BGE001076	1.702	11.88	4.63	-7.25	2.75
BGE000639	1.026	10.65	3.86	-6.79	2.14
BGE000643	3.426	16.49	5.72	-10.77	2.48
BGE001383	5.052	12.96	8.51	-4.45	10.85
Asko 1	3.729	307.67	10.89	-296.78	0.13
	Fresh stem weight (g)				
BGE004222	5.049	12.8378	10.173	-2.66	10.19
BGE001847	12.851	47.2960	14.6614	-32.63	1.41
BGE000637	12.085	42.6032	10.892	-31.71	1.42
BGE001076	5.264	34.8540	14.370	-20.48	1.33
BGE000639	5.009	23.8442	9.1844	-14.66	2.20
BGE000643	12.988	70.1488	19.990	-50.16	0.75
BGE001383	14.526	23.4666	13.730	-9.74	7.64
Asko 1	8.514	40.97	12.8378	-28.13	1.29
	Nodule number per plant				
BGE004222	8.954	62.0	4.6	-57.40	0.52
BGE001847	2.571	19.625	5	-14.63	1.42
BGE000637	1.674	38.167	2	-36.17	0.31
BGE001076	1.046	14.444	4.2	-10.24	1.23
BGE000639	2.246	30.0	5.8	-24.20	0.64
BGE000643	0.807	28.8	0.1	-28.70	0.26
BGE001383	5.845	62.0	1	-61.00	0.36
Asko 1	2.026	19.625	0.6	-19.03	0.82
	Plant height (cm)				
BGE004222	277.511	62.0	60.1	-1.90	151.42
BGE001847	962.376	119.6	93.8	-25.80	34.37
BGE000637	621.839	127.0	88.8	-38.20	15.31
BGE001076	953.667	100.8	84.9	-15.90	62.79
BGE000639	461.750	111.0	77.4	-33.60	14.87
BGE000643	429.774	121.8	79.7	-42.10	10.45
BGE001383	484.500	122.2	85.7	-36.50	13.39
Asko 1	592.003	97.6	94.0	-3.60	184.67

VS - variety stability, X_{opt} - the average value on the sign with an optimal background on the growing, X_{lim}- the average value on the sign at limiting conditions of growing, Y- Stress resistance, Hom - homeostaticity

Table 3. Estimation of parameters of adaptability of vetch hybrid lines for yield's components, based on the methodologies of centroid (Nascimento et al., 2009)

Genotypes	**Fresh leaf weight (g)**	**Rank**	**Fresh stem weight (g)**	**Rank**
BGE004222	9.359b	V	18.594b	V
BGE001847	10.662cd	V	28.012f	V
BGE000637	11.156d	II	26.759e	V
BGE001076	8.537b	V	19.333bc	V
BGE000639	7.049a	III	15.556a	IV
BGE000643	12.817e	II	34.349d	VI
BGE001383	10.468c	VII	19.527b	V
Asko 1	9.403b	V	23.503d	III
Genotypes	Plant height (cm)	Rank	Nodule number per plant	Rank
BGE004222	29.733f	I	96.433d	II
BGE001847	12.342c	IV	108.533g	I
BGE000637	14.989d	V	106.267h	VII
BGE001076	8.281a	IV	95.433c	V
BGE000639	14.467d	V	92.400b	V
BGE000643	10.800b	V	97.700e	V
BGE001383	26.467e	VI	99.100f	V
Asko 1	12.942c	III	89.000a	III

Rank I: high general adaptability; Rank II: specific adaptability to favorable environments; Rank III: Specific adaptability to adverse environments; RankIV: Partially adapted; RankV: Adaptability overall average; RankVI: specific adaptability to favorable environments; RankVII: Adaptability specific to unfavorable environments.

a, b, c…h, - statistically proven differences in P=0.05

Table 4. Correlation coefficient of number of nodules (above diagonal bold) and fresh leaf weight (below the diagonal) with stability parameters

	bi	**GxEgi**	**SAA**	**Sgi,%**	**SVG**	**OACi**	**VS**	**Y**	**Hom**	**Fresh leaf weight**
bi		**-0.08**	**0.903****	**0.866****	**-0.781***	**0.339**	**0.577**	**0.721***	**-0.558**	**0.682**
GxEgi	-0.171		**0.341**	**0.406**	**-0.501**	**-0.565**	**0.495**	**0.269**	**-0.163**	**-0.025**
SAA	0.852**	0.346		**0.993****	**-0.955****	**0.074**	**0.749***	**0.830***	**-0.659**	**0.568**
Sgi, %	0.659	0.447	0.908**		**-0.983****	**-0.044**	**0.758***	**0.817***	**-0.659**	**0.174**
SVG	-0.430	-0.435	-0.705	-0.934**		**0.226**	**-0.739***	**-0.786***	**0.678**	**0.184**
GAA	0.682	-0.026	0.567	0.174	0.184		**-0.024**	**0.085**	**0.116**	**0.099****
VS	-0.165	-0.191	-0.355	-0.698	0.893**	0.544		**0.855****	**-0.231**	**0.544**
Y	0.153	0.435	0.436	0.517	-0.428	0.108	-0.298		**-0.64**	**0.107**
Hom	-0.470	0.193	-0.377	-0.478	0.564	0.132	0.609	0.409		**0.131**
Nodule number	0.115	-0.150	0.059	0.099	-0.088	-0.024	-0.024	-0.070	0.116	

b_i - Regression coefficient Finlay and Wilkinson's regression model; σ(GxE)gi - criterion for estimation of the genotype ability to enter into interaction with environment; SAA - specific adaptive ability; Sgi% - relative stability of the genotypes; SVG - selection value of genotype; GAA - general adaptive ability; VS - variety stability, Y- Stress resistance, Hom - homeostaticity

*,;**, Correlation is significant at the 0.05; 0.01 level

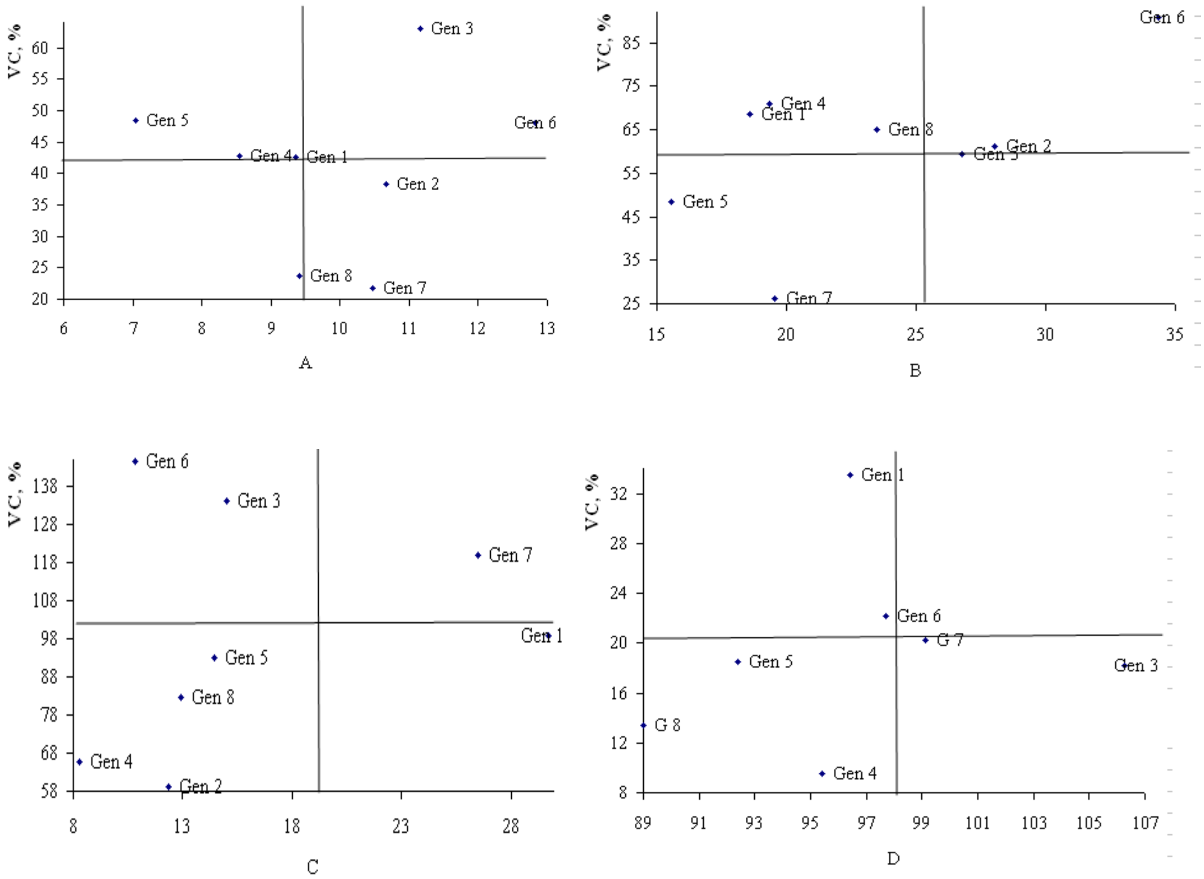

Figure 1. Stability and distribution of varieties by the parameters studied in vetch (according to Francis and Kannenberg, 1978)

A - Fresh leaf weight (g), B - Fresh stem weight (g), C - Plant height (cm); D - Nodule number per plant

Gen 1 - BGE004222, Gen 2 - BGE001847; Gen 3 - BGE000637; Gen 4 - BGE001076; Gen 5 - GE000639, Gen 6 - BGE000643, Gen 7 - BGE001383, Gen 8 - Asko 1.