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MODULAR ORGANIZATION OF QUANTITATIVE SIGNS IN VETCH (*VICIA VILLOSA* ROTH) GENOTYPES

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Abstract

The above-ground plant material and root mass of eight winter vetch genotypes (*Vicia villosa* Roth) varieties were studied. As a method of study and evaluation, the ecological and genetic models for the organization of the quantitative trait and the method of orthogonal regressions were applied. The study was conducted in 2014-2016 in the experimental field of the Institute of Forage Crops, Pleven, Bulgaria. The highest and most stable seed yield was obtained at BGE001847 (87.69 kg /da), followed by BGE000643 (77.51 kg/da) and BGE004222 (72.42 kg/da). BGE000639 and Asko 1 were characterized by high variability and low seed yield (28.30 kg/da, 54.28 kg/da). The highest yielding and most stable in relation to green mass were varieties BGE000643 (3736.32 kg/da) and BGE001847 (3206.33 kg/da). Strong genes of physiological systems attraction and adaptability by fresh aboveground and root mass weight have been identified as BGE000637, and varieties BGE000639, BGE000643, BGE001383, Asko 1 and BGE004222 had good adaptation by seeds weight per plant and root mass weight. Due to the high productive capacity of seed and green mass, as well as the high root mass weight, these patterns represent a particular interest for the needs of combinatorial breeding.

Key words: Module, Resultant traits, Genotype, Phenotype, Component trait.

Introduction

Increasing plant potential in terms of productivity has always been and remains the foundation of selection programs. However, modern varieties, in addition to high yielding have also be resistant to adverse environmental factors, i.e. to have high homeostatistics. Only the high adaptability of the variety can provide stability under different environmental conditions (Potanin *et al*., 2014).

The ecological-genetic basis of the adaptive potential of crop plants determines the priority directions in their adaptive selection, variety testing, and seed production. The absence of a systemic approach to living organisms often leads to significant cases in genetics, such as the current trend in determining the main genes that determine quantitative signs (Zhuchenko, 2009).

The development of high-quality and environmentally sustainable agrocenoses should be based on the widest use of the species and variety of crop plants. Particular attention should be paid to legumes due to the activation of their biological characteristics in the improvement of the environment. These crops can be included in crop rotation to avoid the accumulation of harmful substances in the soil from excessive use of pesticides (Tihonovich & Provorov, 2009; Kazydub *et al*., 2015).

The analysis of the efficiency of the selection work in vetch requires the search for other possibilities and methods of analytical selection in the creation of new varieties. The complex tasks of breeding this crop and the problems associated with it require the accumulation of deeper knowledge about the biological nature of the signs and the ways in which they combine in the genotype (Kosolapov *et al*., 2009; Tyurin *et al*., 2013).

For a given quantitative trait under different conditions a decisive meaning had absolutely different genes, such as genes for resistance to abiotic or biotic environmental factors (Zhuchenko, 2001; Korzun & Bruylo, 2011).

The success of the breeding largely depends on the correct selection of perspective forms at the various stages of the selection process. It is important to know at what stage and on what signs to make a selection. In addition, it is important to use methods for the identification of genotypes by phenotype without requiring knowledge of how to inherit the trait using different methods of genetic analysis (Dragavtcev, 1994).

In order to identify the genotype by phenotype, it was proposed to use the genetic and physiological systems - adaptability, attraction, and micro-distribution rather than quantitative signs. With these systems, breeders empirically improve the variety of complex quantitative signs that characterize productivity. Parameters of these systems make it very likely to choose the selectively valuable forms (Petrova & Kardis, 2010).

The purpose of the study was to assess the productive capabilities of winter vetch varieties by applying the ecological-genetic model for the organization of the quantitative trait.

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 at an optimal time according to the technology of cultivation of vetch. Plant material from aboveground and root mass of 8 winter vetch (*Vicia villosa* Roth) varieties originating in the country and abroad, i.e, BGE004222, BGE001847, BGE000637, BGE001076, BGE000639, BGE000643, BGE001383 and Asko 1 were analyzed.

The following characteristics have been assessed: i) in the beginning of flowering stage: leaf fresh weight per plant (g), stem fresh weight per plant (g), aboveground mass fresh weight per plant (g), nodule number per plant, weight of one nodule (g), nodule weight per plant (g), supply of root mass of one plant in nodules (g nodules/g roots), root mass weight (g) and green mass yield (kg/da); ii) in the technical maturity of seeds stage: number of seeds per plant, weight of one seed (g), seed weight per plant (g), number of pods per plant, number of seeds in one pod and seed yield (kg/da). Biometric measurements were made on 10 plants of each variety.

The modular organization of the quantitative trait is presented in the model of Dragavtcev (1995). According to this model, the genetic formula of the attribute consists of a multitude of discreetly displayed, functionally coherent components of a unified system. Due to the integrity of the elements of the genetic system within the whole organism the phenotype can be presented as the realization of two hierarchies - structural and temporary. The module as an elementary unit describes the organization of the quantitative trait, which (or trait that) consists of three interrelated attributes - one resultant and two components. The module reflects all stages of realization of genetic formulas depending on the level of ecological factors during ontogenesis. In the modular organization of the quantitative trait, the resultant can be considered as a component in the next module.

The orthogonal regression method was described by Kramer (Dragavtcev, 1995, 2002). The essence of the phenomenon becomes clear when considering the divergence in a two-dimensional coordinate system with two attributes: breeding (BA) and background (BA). Orthogonal regression differs from the commonly used in applied regression analysis, which is always two variables: A x B and B x A. Orthogonal regression always has one major axis, which is the major axis of the scatter ellipse, or the geometric point of the points (straight line) the sum of squares of distances from which empirically the scattering point is minimal. The co-ordination system BA-BA (Breeding - Background) allows one to identify the genotype of an individual organism by phenotype.In this respect, the relative part of the influence of genotype and environment is quantified on a scale of factual measurements of the trait.

All experimental data were processed statistically using the computer software STATGRAPHICS Plus for Windows Version 2.1 and MS Excel (2003) for Windows XP.

Results

The study period covers three consecutive years differing in climatic terms. (Table 1) presents the data on average monthly temperatures and the amount of precipitated rainfall by months during vegetation. The vegetation 2014 is the most favorable for the study period with average monthly air temperatures (April 12.3°C, May 16.7°C, June 20.6°C) and rainfall 139.8 l m^{-2}, 83.0 l m^{-2} and 54.3 l m^{-2}, respectively. As a result of the balanced combination of air temperature and optimum rainfall, it has been favorable for plant development. The second year (2015) has relatively higher temperatures in May of 18.8°C and uneven precipitation distribution, characterized by a certain drought in April (43.6 l/m^2) and May (30.6 l/m^2), and a larger quantity in June (95.7 l/m^2). The third year (2016) occupies an intermediate position over the other two years with temperatures in the months of April and May, close to normal (15.3-16.4°C) and rainfall between 73.1 and 76.5 l/m^2.

Modular organization of the quantitative trait and rank analyses: The ecological-genetic approach implies that instead of performing genetic analysis of the signs to study the genetic and physiological systems of the organism through which genotypes appropriate to the research goal can be improved. This approach is not intended to model the dynamics of the vast number of genetic spectra, but to evaluate the effect of these systems on the status of the initial module (trait).

Seed weight per plant: Seed weight per plant (seed productivity) is a complex trait defined by the ratio of many components. Significant influence on the value of this trait is the number and the weight of seeds. (The number and weight of seeds have a significant influence on the value of this trait). The analysis of seed productivity elements (Module I, Table 2) shows that they vary by year and by mean values of component signs. The number of seeds formed from one plant in 2014 and 2015 in all varieties was found to be greater than in 2016. Exceptions were BGE000639 and BGE001383 the plants of which succeed to form 63 and 96 number of seeds per plant in 2016. For the study period, the highest ranges (2 and 3) were obtained for the varieties BGE001847 and BGE000643, with BGE001847 being highly productive over the three years of study (Table 3). Third position by rank and fourth by seed productivity occupies BGE004222. The remaining varieties (excluding BGE000639, which is the least productive) exhibit a certain instability of the trait (rank 5-6) and seed productivity above the average for the group of varieties studied.

Table 1. Climatic characterization of the experimental period.

Months	2014			2015			2016		
	t	Rainfall	Humidity	t	Rainfall	Humidity	t	Rainfall	Humidity
	°C	l m^{-2}	%	°C	l/m2	%	°C	l/m2	%
I	0.8	41.8	82.0	1.9	12.4	80.0	-0.5	98.0	78.0
II	2.3	3.4	82.0	2.3	39.2	80.0	8.7	46.0	75.0
III	9.7	76.9	68.0	6.7	68.4	71.0	8.5	76.6	73.0
IV	12.3	139.8	76.0	12.2	43.6	54.0	15.3	73.1	66.0
V	16.7	83.0	70.0	18.8	30.6	66.0	16.4	76.5	71.0
VI	20.6	54.3	67.0	20.7	95.7	64.0	23.0	45.8	67.0
VII	23.1	71.8	67.0	25.8	21.5	54.0	24.6	7.8	57.0

Table 2. Impact of environmental conditions on the modules seed productivity per plant and number of seeds per plant in vetch varieties (at book value).

Variety	Year								
	2014	2015	2016	2014	2015	2016	2014	2015	2016
	Component trait 1			Component trait 2			Resultant trait		
	Module I. Seed productivity per plant								
	Seeds per plant			Weight of one seed (g)			Seed weight per plant (g)		
BGE004222	94.27	126.8	41.2	0.007	0.016	0.004	0.610	1.971	0.168
BGE001847	334.21	222.8	74.2	0.006	0.019	0.003	1.863	4.225	0.242
BGE000637	91.21	98.4	46.4	0.006	0.024	0.004	0.558	2.385	0.162
BGE001076	133.40	154.0	35.0	0.004	0.017	0.002	0.568	2.683	0.085
BGE000639	43.27	35.25	63.4	0.005	0.007	0.004	0.234	0.257	0.272
BGE000643	93.85	109.0	92.2	0.007	0.015	0.004	0.632	1.586	0.406
BGE001383	71.57	33.25	96.8	0.006	0.033	0.004	0.456	1.085	0.341
Asko 1	64.86	50.6	50.2	0.006	0.037	0.003	0.391	1.892	0.164
	Module II. Number of seeds per plant								
	Pods per plant			Seeds per pod			Seeds per plant		
BGE004222	34.78	70.6	15.2	2.71	1.80	2.71	94.27	126.8	41.2
BGE001847	88.28	105.6	19.6	3.79	2.11	3.79	334.21	222.8	74.2
BGE000637	49.14	57.0	25.0	1.86	1.73	1.86	91.21	98.4	46.4
BGE001076	70.89	84.0	18.6	1.88	1.83	1.88	133.40	154.0	35.0
BGE000639	17.34	16.25	25.4	2.50	2.17	2.50	43.27	35.25	63.4
BGE000643	31.76	36.5	31.2	2.95	2.99	2.96	93.85	109.0	92.2
BGE001383	20.56	9.75	27.8	3.48	3.41	3.48	71.57	33.25	96.8
Asko 1	21.19	22.0	16.4	3.06	2.30	3.06	64.86	50.6	50.2
	Module III. Productivity of fresh aboveground mass per plant								
	Fresh weight of leaves per plant (g)			Fresh weight of stems per plant (g)			Weight of fresh mass per plant (g)		
BGE004222	11.435	11.878	4.763	10.173	33.241	12.368	11.657	21.707	17.13
BGE001847	10.383	14.876	6.726	22.08	47.296	14.661	12.629	34.688	21.39
BGE000637	18.944	9.243	5.280	26.782	42.603	10.892	14.094	34.693	16.17
BGE001076	9.104	11.877	4.631	14.37	34.854	8.775	10.490	24.612	13.41
BGE000639	6.633	3.862	10.653	13.64	9.184	23.844	5.247	11.412	34.50
BGE000643	16.234	16.494	5.722	19.99	70.149	12.908	16.364	45.070	18.63
BGE001383	8.509	9.937	12.958	13.73	23.467	21.385	9.223	18.599	34.34
Asko 1	10.476	10.894	6.839	40.97	16.702	12.838	10.685	28.836	19.68
	Module IV. Nodule weight per plant								
	Number of nodules per plant			Weight of one nodule (g)			Weight of nodules per plant (g)		
BGE004222	62.000	4.60	22.6	0.008	0.022	0.009	0.491	0.100	0.203
BGE001847	19.625	5.00	12.4	0.013	0.028	0.010	0.252	0.142	0.121
BGE000637	38.167	2.00	4.8	0.009	0.016	0.009	0.324	0.032	0.043
BGE001076	14.444	6.20	4.2	0.010	0.009	0.009	0.140	0.058	0.036
BGE000639	30.000	7.60	5.8	0.003	0.006	0.009	0.219	0.043	0.052
BGE000643	28.800	3.86	3.6	0.046	0.016	0.009	1.311	0.062	0.032
BGE001383	62.000	1.00	16.4	0.008	0.016	0.009	0.491	0.016	0.148
Asko 1	19.625	0.60	18.6	0.013	0.016	0.008	0.252	0.010	0.144
	Module V. Weight of root mass per plant								
	Supply of root mass of one plant in nodules			Weight of nodules per plant (g)			Weight of root mass (g)		
BGE004222	1.776	10.300	4.394	0.491	0.100	0.203	0.872	1.030	0.892
BGE001847	4.762	5.500	6.395	0.252	0.142	0.121	1.200	0.781	0.774
BGE000637	9.130	37.313	12.558	0.324	0.032	0.043	2.958	1.194	0.540
BGE001076	6.664	13.397	9.361	0.140	0.058	0.036	0.933	0.777	0.337
BGE000639	3.858	9.977	22.754	0.219	0.043	0.052	0.845	0.429	1.183
BGE000643	1.070	25.065	8.344	1.311	0.062	0.032	1.403	1.554	0.267
BGE001383	2.540	48.938	1.284	0.491	0.016	0.148	1.247	0.783	0.190
Asko 1	11.421	49.800	1.882	0.252	0.010	0.144	2.878	0.498	0.271

Table 3. Impact of environmental conditions on the modules productivity per plant and number of seeds per plant in vetch varieties (by rank).

Variety	Year											
	2014	2015	2016	av	2014	2015	2016	av	2014	2015	2016	av
	Component trait 1				Component trait 2				Resultant trait			
	Module I. Seed productivity per plant											
	Seeds per plant				Weight of one seed				Seed weight per plant			
BGE004222	3	3	7	4	2	6	3	4	3	4	5	4
BGE001847	1	1	3	2	6	4	6	5	1	1	4	2
BGE000637	5	5	6	5	4	3	4	4	5	3	7	5
BGE001076	2	2	8	4	8	5	8	7	4	2	8	5
BGE000639	8	7	4	6	7	8	2	6	8	8	3	6
BGE000643	4	4	2	3	1	7	1	3	2	6	1	3
BGE001383	6	8	1	5	3	2	4	3	6	7	2	5
Asko 1	7	6	5	6	5	1	6	4	7	5	6	6
	Module II. Number of seeds per plant											
	Pods per plant				Seeds per pod				Seeds per plant			
BGE004222	4	3	8	5	5	7	5	6	3	3	7	4
BGE001847	1	1	5	2	1	5	1	2	1	1	3	2
BGE000637	3	4	4	4	8	8	8	8	5	5	6	5
BGE001076	2	2	6	3	7	6	7	7	2	2	8	4
BGE000639	8	7	3	6	6	4	6	5	8	7	4	6
BGE000643	5	5	1	4	4	2	4	3	4	4	2	3
BGE001383	7	8	2	6	2	1	2	2	6	8	1	5
Asko 1	6	6	7	6	3	3	3	3	7	6	5	6
	Module III. Productivity of fresh aboveground mass per plant											
	Fresh weight of leaves per plant				Fresh weight of stems per plant				Weight of fresh mass per plant			
BGE004222	3	3	7	4	8	5	6	6	4	6	6	5
BGE001847	5	2	4	4	3	2	3	3	3	3	3	3
BGE000637	1	7	6	5	2	3	7	4	2	2	7	4
BGE001076	6	4	8	6	5	4	8	6	6	5	8	6
BGE000639	8	8	2	6	7	8	1	5	8	8	1	6
BGE000643	2	1	5	3	4	1	4	3	1	1	5	2
BGE001383	7	6	1	5	6	6	2	5	7	7	2	5
Asko 1	4	5	3	4	1	7	5	4	5	4	4	4
	Module IV. Nodule weight per plant											
	Number of nodules per plant				Weight of one nodule				Weight of nodules per plant			
BGE004222	1	4	1	4	6	2	2	3	2	2	1	2
BGE001847	6	3	4	3	2	1	1	1	5	1	4	3
BGE000637	3	6	6	5	5	3	2	3	4	6	6	5
BGE001076	8	2	7	7	4	7	7	6	8	4	7	6
BGE000639	4	1	5	5	8	8	2	6	7	5	5	6
BGE000643	5	5	8	5	1	3	6	3	1	3	8	4
BGE001383	1	7	3	4	6	3	2	4	2	7	2	4
Asko 1	6	8	2	3	2	3	8	4	5	8	3	5
	Module V. Weight of root mass per plant											
	Supply of root mass of one plant in nodules				Weight of nodules per plant				Weight of root mass			
BGE004222	7	6	6	6	2	2	1	2	7	3	2	4
BGE001847	4	8	5	6	5	1	4	3	5	5	3	4
BGE000637	2	3	2	2	4	6	6	5	1	2	4	2
BGE001076	3	5	3	4	8	4	7	6	6	6	5	6
BGE000639	5	7	1	4	7	5	5	6	8	8	1	6
BGE000643	8	4	4	5	1	3	8	4	3	1	7	4
BGE001383	6	2	8	5	2	7	2	4	4	4	8	5
Asko 1	1	1	7	3	5	8	3	5	2	7	6	5

Number of seeds per plant: The number of seeds per plant is one of the most important signs in the yield structure. This trait is a derived value determined by the number of pods formed on the fertile nodules and the number of seeds in a pod. The varietal variations in the number of seeds per plant were significant. The varieties BGE001847, BGE001076 and BGE000637 form a larger number of pods (71, 57, 43, respectively), while BGE000639, BGE001383 and Asko 1 count no more than 20 pods per plant. The average number of seeds in a pod is very narrow range (between 2 and 3). Very low values of one of the component signs - number of pods per plant or number of seeds per pod determined the varieties BGE000639 and Asko 1 as the least represented by the resulting trait number of seeds per plant (47, 55) and were rated at rank 6 according to the rank analysis. In view of these signs, the variety of interest is the BGE001847 variety, with high values of the investigated signs and rank 2, followed by BGE000643, characterized by a smaller number of pods per plant and number of seeds per pod, but with relatively low variability.

Green mass weight per plant: The productivity of green mass per plant is a result of the combined influence of the fresh weight of leaves and stems. Climate conditions during the study period, used as environmental limits, have influenced the manifestation of both component signs. Most of the varieties tested in 2016 failed to fully realize their productive capacities in terms of leaf fresh weight. The exceptions were BGE000639 and BGE001383. As environmentally stable on both components, BGE000643 with rank 3, followed by BGE001847 with rank 3-4, can be considered. The varieties BGE001076 and BGE000639 exhibit the highest lability, both by leaf and stem weight, and are therefore assessed with a rank of 6. The remaining varieties, including Asko 1 occupy 4-5 positions in rank.

Nodule weight per plant: The module nodule weight per plant is determined by the structural elements number of nodules per plant and the weight of one nodule. Each of the component traits is characterized by varying variability in individual varieties. The varieties BGE004222 and BGE001383 form an average of 2 to 3 times more nodules (29, 26, respectively) than other varieties and are rated at rank 3 and 4. Asko 1 also has a medium rank of 3, but it exhibits very high variability and fails to form more than 12-13 nodules per plant. Variety BGE001076 has the lowest value and the highest variability of the trait (rank 7). With regard to the second component trait with the best rank rating (1) BGE001847 is distinguished, occupying the second position by weight of one nodule after BGE000643, which forms fewer nodules but with a higher weight. A good combination of these traits is characterized by variety BGE000643, with rank 2, followed by BGE004222 and BGE001383 with rank 3.

Root mass weight per plant: This module is the result of the multiplicative inheritance of the supply of root mass of one plant in nodules and the nodule weight per plant. The two component signs are best combined with BGE000637, BGE000643 and Asko 1 varieties. According to the results of the rank analysis, BGE000637 is ranked with a rank of 2 by root mass weight, BGE000643 with a rank of 4, and Asko 1 with a rank of 5. Varieties BGE004222 and BGE001847 have a lower root mass weight than the standard Asko 1 variety, but exhibit higher stability of the sign (rank 4). In the studied group of vetch patterns, it was found that varieties changed their position, with those with a lower rank at the first sign occupying more rear positions (higher variability) under the second sign.

Green mass and seed yield: The environmental conditions during the period of study had a different impact on yields of both, green mass and seeds (Table 4). The change of the limits of the environment (in the case of the years) through the individual stages of the plant’s development leads to a change in the spectrum of locus in the plant, determining the respective characteristic.

The highest average seed yield was obtained at BGE001847 (87.69 kg/da), followed by BGE000643 (77.51 kg/da) and BGE004222 (72.42 kg/da). The same varieties are also characterized as the most stable in seed yield and are rated at ranks 2 and 3. From the pattern collection, the lowest seed yield was recorded at BGE000639 (28.30 kg/da) and Asko 1 (54.28 kg/da) and, together with variety BGE001076 they are highly variable occupying the last position (6) by rank.

Regarding the green mass yield between the vetch samples, no statistically significant differences were found. The highest yielding and most stable (rank 2-3) for this trait were BGE000643 (3736.32 kg/da) and BGE001847 (3206.33 kg/da). Due to the high productive capabilities for seed formation and green mass, these samples represent a particular interest for the needs of combinatorial selection as parental components.

It is an obvious fact that there is a strong correlation between the level of development of quantitative signs from the external environment and the change in the rank of productivity of genotypes from one environment to another. This makes it difficult to apply the slim logic of Mendelism to the genetics of the quantitative trait and creates certain problems in using the actual methods of genetic analysis.

Orthogonal regression method. Identification of genotype by phenotype: There is currently a traditional principle of identifying the genotype of an individual organism according to its phenotype, being tested for its offspring in succeeding generations. The frequency of occurrence of unique genotypes in plant populations is so low because the populations themselves are so voluminous that the breeder is forced into the early selection units to scrap the phenotype of 80-90% of the individuals in the disintegrating population.

The phenomenon of redefinition of the genetic organization of the quantitative trait fundamentally alters old ideas about their genetic organization. Based on the phenomenon found there is a purposeful development, an essential role in which the functional organization of the ecological and genetic system of the quantitative trait plays.

Table 4. Impact of environmental conditions on the modules seed yield and green mass yield in vetch varieties (at book value and rank).

Variety	Limit (years)			Yield (kg/da)	Ranks			
	2014	2015	2016	2014-2016	2014	2015	2016	Average
	Module seed yield							
BGE004222	85.34	108.39	23.52	72.42[b]	3	2	5	3
BGE001847	102.45	126.74	33.88	87.69[b]	1	1	4	2
BGE000637	78.13	107.33	22.68	69.38[b]	5	3	7	5
BGE001076	79.58	80.50	11.90	57.33[ab]	4	6	8	6
BGE000639	32.70	14.12	38.08	28.30[a]	8	8	3	6
BGE000643	88.44	87.24	56.84	77.51[b]	2	4	1	2
BGE001383	63.85	59.69	47.74	57.09[ab]	6	7	2	5
Asko 1	54.71	85.16	22.96	54.28[ab]	7	5	6	6
	Module green mass yield							
BGE004222	1631.98	3038.98	2398.20	2356.39a	4	6	6	5
BGE001847	1768.06	4856.32	2994.60	3206.33a	3	3	3	3
BGE000637	1973.16	4857.02	2263.80	3031.33a	2	2	7	4
BGE001076	1468.60	3445.68	1877.40	2263.89a	6	5	8	6
BGE000639	734.58	1597.68	4830.00	2387.42a	8	8	1	6
BGE000643	2290.96	6309.80	2608.20	3736.32a	1	1	5	2
BGE001383	1291.22	2603.86	4807.60	2900.89a	7	7	2	5
Asko 1	1495.90	4037.04	2755.20	2762.71a	5	4	4	4

a, b, - Statistically proven differences in P = 0.05

As a criterion for the selection of parent parenting forms (varieties)-carriers of polygene in the genetic-physiological systems and valuable samples in the regard of selection, the direction and magnitude of displacement of the genotypes according to the coordinate system on the studied signs at the change of the limits of the environment are used.

In the two-dimensional system of indicative coordinates (Fig. 1) "green mass weight" and "root mass weight" in the phenological stage of flowering with the average values of the characteristics of the studied varieties, the polymorphism of the adaptive genes extends to the positive regression and polymorphism on the genes for attraction to the negative.

Under favorable conditions (in 2014) the most valuable is BGE000637 which is located in the quadrant, limited by the positive parts of attractiveness and adaptability. It exhibits a good combination of adaptive and attractive genes. The plants of this variety form an aboveground and root mass of high weight. In case of deterioration in the environment (2015) it slightly changes his position, remaining in the same quadrant.

The BGE001076 and BGE000643 varieties are the least adaptable and have a place on the chart in the negative part of the adaptation line over the three years (at the three limit of the environment). They do not react positively when placed in a favorable growing environment.

From the location of the varieties of coordinate systems, it is clear that they do not have "strong" genes at the attractiveness of the fresh mass weight, and in 2016, all samples are negatively attractive. The varieties BGE001847, BGE000637 and BGE000643 in 2014 and 2015 show a positive, though not very high attraction.

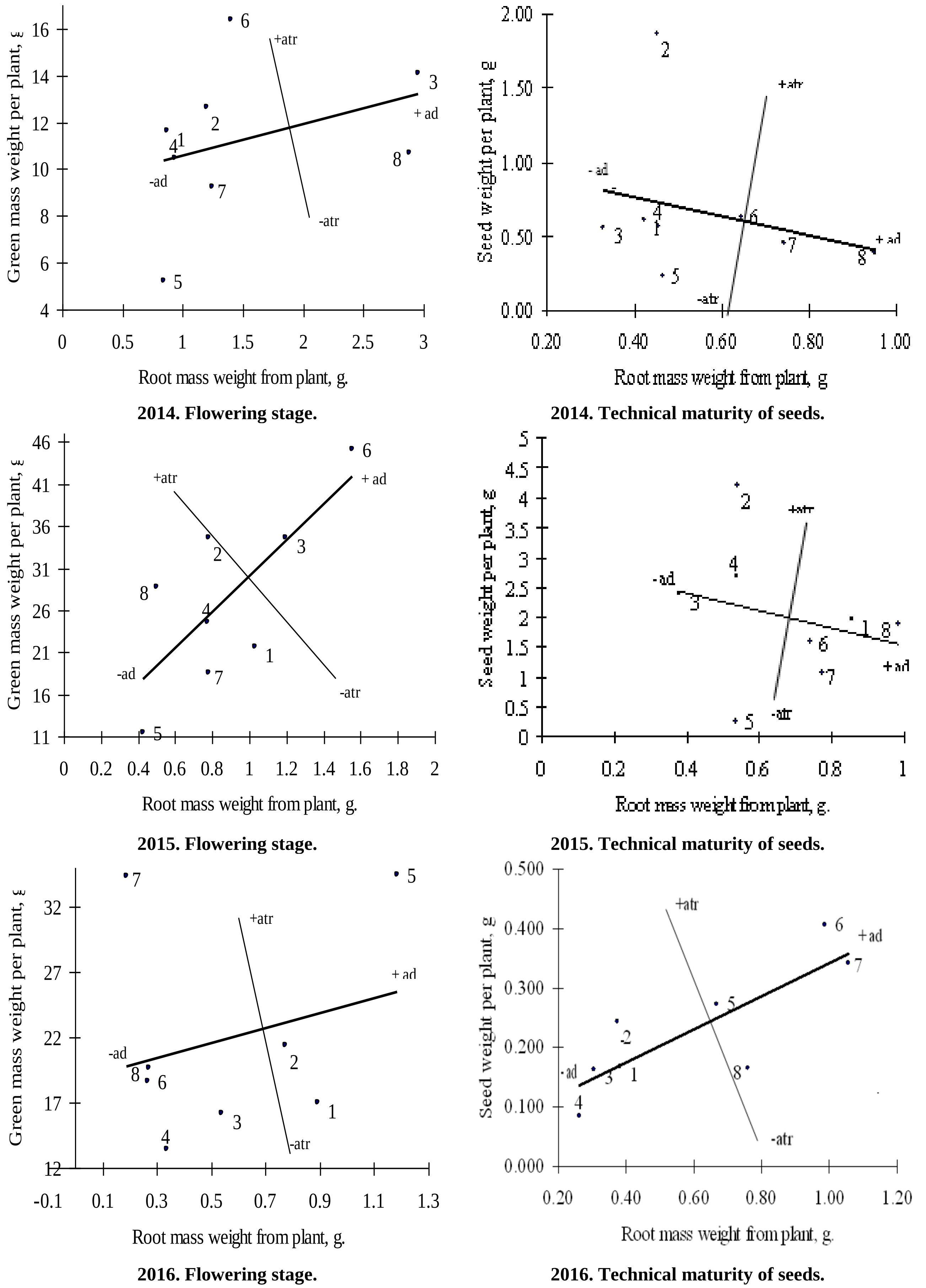
If there is no genetic diversity in the genes for attraction, then all points will fall directly on the positive part of the regression line. If such a variety is found by attraction genes but not by adaptive genes, all points of the average genotype values will fall on the negative fraction of the regression line.

In the technology, maturity of seeds stage under pronounced limiting conditions of the environment (2015), the varieties BGE004222 and Asko 1 are distinguished by positive manifestations of adaptability and attraction genes, and for BG16000639 and BGE000639 varieties for 2016. The characteristic of the four varieties, considering their very close location to the regression line, is that they have more pronounced adaptability than attractiveness. The varieties BGE000643, BGE001383 and Asko 1 have had stronger adaptability genes in the three years of study, which can be used in future breeding work in selecting genotypes with good ecological stability.

Discussion

Kocherina & Dragavtcev (2007, 2008) consider that in the absence of reliable methods for identifying genotypes by their phenotype, most of the valuable forms are irretrievably lost, which can not be compensated for by more accurate estimates of offspring in the next stages of the selection process. According to the authors, the results of traditional selection methods are difficult, and costly, requiring long-term testing for offspring, and their overall reliability is low.

Dragavtsev & Diacov (1982) have shown that in fact, in the phenotype of each individual plant unit, a distinction can be made between the genotypic features of the organism, combined with the environmental impact, and the phenotypic manifestation of a trait. This is done by means of two-dimensional coordinate systems (Background-Breeding) and the effect of the environment moves the trait on a positive regression line and the contribution of the genotype to the negative, i.e. it is orthogonal to the effect of the environment, which makes it possible to quickly distinguish between these contributions in a simple two-dimensional system of trait coordinates.



1. BGE004222; 2. BGE001847; 3. BGE000637; 4. BGE001076; 5. BGE000639; 6. BGE000643; 7. BGE001383; 8. Asko 1.
Fig. 1. Distribution of mean values of vetch varieties.

In these coordinate systems, the action of the genetic systems is directed differently, and this phenomenon is used for the correct selection of parent pairs in combinatorial selection. Based on the diversity of the genetic and environmental contributions of the trait, a system for the identification of individuals carrying valuable polygeny is created.

This theory is confirmed by Dragavtcev (2005) who thoroughly analyzes it and reveals that if a component is formed on a provocative background of drought (for example, the number of seeds per plant) and another - on the background of cold (as the weight of one seed), it is not possible to describe the genetic nature of the resulting trait (seed weight per plant) either in the language of classical Mendelian genetics or in the language of modern molecular genetics.

Only the language of the ecological-genetic theory of the quantitative trait is capable of adequately describing the complex ecological-genetic 'device' of the given trait due in part to the polymorphism of polygene for resistance to drought and partly to polygene for cold resistance.

Zolotarev *et al*., (2008), Tyurin & Zolotarev (2013) also support the thesis that the environment can be used as an effective selective background, allowing the reproduction process of the breeding material (hybrid populations) to exclude those genotypes that are negatively affected by unfavorable environmental factors.

The results of the Tyurin (2014) studies in vetch show that the creation of high-yielding varieties in the green mass direction can be achieved by forming a larger number of leaflets on the complex leaf prior to the first fertile node, and the seed productivity may increase by the higher number of seeds in pod, the number of pods per plant and the 1000 seed weight.

Davletov (2006) concluded that the number of seeds per plant and 1000 seed weight as component signs had a negative effect on the resulting trait seed weight per plant in the breeding activity with peas in the seed direction.

The author believes that in the formation of the yield, their role is not one-sided and depends on the genetic features of the genotype.

Conclusions

The highest and stable seed yield was obtained at BGE001847 (87.69 kg/da), followed by BGE000643 (77.51 kg/da) and BGE004222 (72.42 kg/da) varieties. BGE000639 and Asko 1 are characterized by high variability and low seed yield (28.30 kg/da, 54.28 kg/da). The highest yielding and most stable in relation to green mass were varieties BGE000643 (3736.32 kg/da) and BGE001847 (3206.33 kg/da).

Strong genes of physiological systems attraction and adaptability by fresh aboveground and root mass weight has BGE000637, and varieties BGE000639, BGE000643, BGE001383, Asko 1 and BGE004222 had good adaptation by seed weight per plant and root mass weight. Due to the high productive capacity of seeds and green mass, as well as the high root mass weight, these patterns represent a particular interest for the needs of combinatorial breeding.

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