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ECOLOGO-GENETICAL MODEL FOR CONTROL OF THE QUANTITATIVE TRAITS IN WHITE LUPIN

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An attempt a transition from a selection based on the concepts of "gene-character" to selection of genetic-physiological systems was done suggesting an ecologo-genetical model for control of the quantitative traits in white lupin. Plant material of the aboveground and root mass of 7 varieties of white lupin different originated was analyzed: PI457923 (Greece), PI368911 (Czech Republic), PI533704 (Spain), PI457938 (Morocco), KALI (Poland), Zuter (France) and Lucky801 (France). The study was performed on the experimental field of the Institute of Forage Crops, Pleven, Bulgaria during three subsequent years (2014-2016). The ecologo-genetical models for organization of the quantitative traits and method of the orthogonal regressions were applied as methods for assessment. The highest average seed yield was found at Lucky801 (208.67 kg/da) and PI533704 (151.92 kg/da). PI368911, PI457938 and KALI were characterized by high variability and seed yields (90.00 kg/da, 80.08 kg/da, 83.25 kg/da) below the average ones for the tested group of varieties. PI533704 and PI457938 varieties showed the highest fresh aboveground mass yields (485.12 and 597.98 kg/da). Plants of PI457938 formed high fresh aboveground and root mass weight and exhibit a good combination of adaptability and attraction genes. Lucky801 and PI533704 varieties showed strong genes of the physiological systems attractiveness and adaptability by seed weight and root mass weight per plant, but PI457923 and Zuter were well adapted. These varieties were of greatest interest and may be included in future hybridization schemes to obtain hybrids combining in one genotype high seed and root mass weight.

Keywords: ecologo-genetical models, genotype, productivity, regression, white lupin

INTRODUCTION

White lupin (*Lupinus albus* L.) (2n=50), a member of the Leguminosae family, is an annual grain-legume crop widely grown in Australia and other parts of the world (GANCHEV, *et al*., 2008).

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. Lupin is important grain legume crop and component of the sustainable farming system of the Mediterranean climate region. Low yield and lack of stability of currently registered varieties make white lupin acreage is small (RAMAN, *et al*., 2008; HEFNY, 2013). Lupin production in Europe declined steadily during the second half of the 20th century, mainly because of low productivity driven by seasonal variability the low price of grain (CERNAY *et al*., 2015; PREISSEL *et al*., 2015).

Lupins form root nodules in which biological nitrogen fixation takes place in symbiosis with compatible soil bacteria of the genus *Bradyrhizobium*. Biological nitrogen fixation is strongly related to the physiological state of the host plant, so that environmental stresses not only have a detrimental effect on metabolism, growth and development of the plant, but also affect symbiosis. Rhizobial strain and lupin genotype interactions influence nodulation score, nitrogen fixation and plant growth. (FERNÁNDEZ-PASCUAL *et al*., 2007).

The genetics of the quantitative traits of white lupin at the present moment have been given partial attention. This is largely related to the difficulty in studying the complexity of the quantitative trait although these traits determinea plant productivity.

In most cases, quantitative traits are formed and altered over a period of time in the ontogenesis process, depending on the duration, strength and nature of the limiting factors. Quantitative traits as the main target of selection can be improved by obtaining transgression segregates (in self-pollinating species) or through heterozygous (in cross-pollinating species) as well as by transferring a genotype into a new ecological niche (the effect of genotype-environment interaction) (DRAGAVTCEV and AVERIANOVA, 1983).

From the point of view of the ecologo-genetical model, any quantitative feature related to plant productivity was not only a product of the action of certain genes or chromosomes but also of the interaction of environmental limiting factors with systems of gene complexes, i.e. quantitative traits under different conditions were determined by a labile spectrum of genes. These signs are emerald inherent to each plant in a specific environment. However, due to the fact that environmental conditions are constantly changing, it is difficult or almost impossible to study them using the classical methods developed to study the genetics of qualitative traits (DRAGAVTCEV, 1983; KOCHERINA and DRAGAVTCEV, 2008; KOCHERINA, 2009).

Identifying germplasm with tolerance to a range of abiotic stresses may allow lupin cultivation to expand into a wider range of agroclimatic conditions across Europe. In areas subjected to frequent or occasional frosts, high vernalization requirement along with intrinsic cold tolerance is required, as sudden winter frost may lead to high mortality even in regions with relatively mild winters (ANNICCHIARICO and IANNUCCI, 2007).

The aim of the study was to try a transition from a selection based on the concepts of a "gene-character" to a selection of genetic-physiological systems be done.

MATERIALS AND METHODS

The study was conducted in 2014-2016 on the experimental field of the Institute of Forage Crops, Pleven, Bulgaria. Sowing of white lupin was done manually in optimal terms, according to crop cultivation technology. Plant material of the aboveground and root mass of 7 varieties of white lupin of different origins was analyzed as follows: PI457923 (Greece), PI368911 (Czech Republic), PI533704 (Spain), PI457938 (Morocco), KALI (Poland), Zuter (France) and Lucky801 (France).

The following traits and indicators were recorded: i) in the beginning of flowering stage in fresh state of the plants - weight of plant leaves (g), weight of plant stems (g), weight of aboveground mass (g), number of nodules per plant, weight of one nodule (g), weight of plant nodules per plant (g), supply of root mass of one plant in nodules, weight of root mass (g); ii). in technical maturity of seeds stage - number of pods per plant, number of seeds per plant, number of seeds in one pod, weight of seed (g) of one plant, weight of one grain (g), grain yield (kg/da) and fresh aboveground mass 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 displaying, functionally, inter-orderly components of one system. Due to the integrity of the elements of the genetic system within the whole organism, the phenotype can be represented as the realization of two hierarchies - structural and temporary. The module as a elementary unit describes the organization of the quantitative trait, which consists of three interrelated attributes - one resultant and two component. 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 trait can be considered as a component in another next module. For example: component trait 1 x component trait 2 = resultant trait.

The orthogonal regression was described by Kramer (DRAGAVTCEV, 1995; DRAGAVTCEV, 2002): If **φ** is the angle of orthogonal regression, then Xi is an individual (or mean) value the character xi, x is a mean value of all the individuals within the variety (or the mean of the average values of the varieties when calculating the genotypic regression).

$$tg\,2\varphi = \frac{2\mu_{11}}{\mu_{20} - \mu_{02}}$$

$$\mu_{20} = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

$$\mu_{02} = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2$$

$$\mu_{11} = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

The parameters of axes of the orthogonal regression are given by:

$$y - \bar{y} = \frac{2\mu_{11}}{(\mu_{20} - \mu_{02}) \pm \sqrt{(\mu_{20} - \mu_{02})^2 + \mu_{11}}}(x - \bar{x})$$

Where the sign "-" corresponds to the longer axis of the ellipse of dispersion.

$$a = \frac{c}{\frac{1}{2}(\frac{1}{\mu_{20}} + \frac{1}{\mu_{02}}) \pm \sqrt{\frac{1}{4}(-\frac{1}{\mu_{20}} - \frac{1}{\mu_{02}})^2} - \frac{1-r^2}{\mu_{20}\mu_{02}}}$$

Where r- the coefficient of correlation, cthe constant (c=2 with P= 5%), a- the initial ordinate.

It should be emphasized that in the graph presented in Figure 2, so-called orthogonal regressions are used, from where the method bears the name of the orthogonal regression method. These regressions are different from those commonly used in the applied regression analysis, which are always 2-A x B and B x A. Orthogonal regression is always only one - this is the major axis of the scatter ellipse or the geometric place of the points (straight line), the sum of squares of distances from which empirical scattering points are minimal.

The statistical processing of experimental data, including regression, dispersion and rank analysis, used MS Excel (2003) and STATGRAPHICS Plus for Windows Version 2.1 software.

RESULTS

The study period covers three consecutive years differing in climatic terms. Figure 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 139.00 mm, 83.00 mm and 54.30 mm, 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 mm) and May (30.6 mm), and a larger quantity in June (95.7 mm). 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 (15-16°C) and rainfall between 73 and 76 mm.

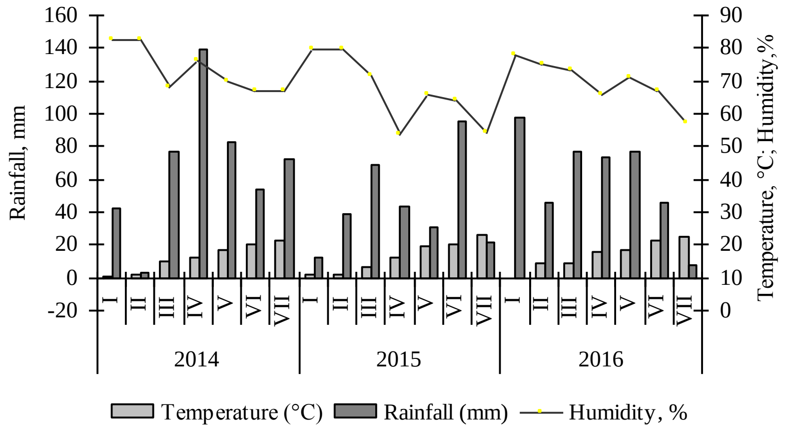

Figure 1. Climatic characterization of the experimental period

Modular organization of quantitative trait and rank analysis

The realization of the potential of variety largely depends on the biological possibilities of the genotype. In the development of a modern system for sustainable and environmentally friendly agriculture, an important requirement is the new varieties to be high-yielding but at the same time environmentally stable. The re-determination of the genetic formula of the attribute as a result of the interaction between genotype and the environment raises the question of revealing new models of complex quantitative traits.

The ecologo-genetical analysis is based on the fact that different genotypes have different genetic formulas defining the expression of each trait. The phenomenon is known as redefinition of the genetic formula of the trait under changing environment conditions (DRAGAVTCEV and AVERYANOVA, 1983). In the present study, the limiting factor of the environment is the year. Analysis of the elements of productivity (Table 1) showed significant variations in years and averages of traits tested.

Table 1. Impact of environmental conditions on the modules seed productivity per plant and number of seeds per plant in white lupin varieties (at book value)

Variety	Year								
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Module I: Seed productivity per plant									
	Component trait 1			Component trait 2			Resultant trait		
Module I: Seed productivity per plant									
	Seeds per plant			Grain weight (g)			Seed weight per plant, g		
PI457923	20.0	16.0	13.8	0.282	0.248	0.282	5.63	3.97	3.89
PI368911	12.9	1.2	24.9	0.234	1.650	0.233	3.02	1.98	5.80
PI533704	24.0	26.0	28.8	0.239	0.215	0.240	5.73	5.60	6.90
PI457938	18.6	7.0	13.9	0.251	0.211	0.250	4.66	1.48	3.47
KALI	15.2	4.0	24.4	0.239	0.120	0.241	3.64	0.48	5.87
Zuter	17.4	22.0	25.2	0.305	0.205	0.305	5.30	4.51	7.68
Lucky801	20.3	40.0	29.2	0.306	0.248	0.306	6.21	9.90	8.93
Module II: Number of seeds per plant									
	Pods per plant			Seeds per pod			Seeds per plant		
PI457923	5.7	5.0	5.5	3.51	3.20	2.51	20.0	16.0	13.8
PI368911	3.9	7.0	10.0	3.31	2.31	2.49	12.9	16.2	24.9
PI533704	7.2	10.0	11.5	3.33	2.60	2.50	24.0	26.0	28.8
PI457938	5.0	5.0	5.6	3.72	1.40	2.48	18.6	7.0	13.9
KALI	5.6	2.0	12.0	2.71	2.00	2.03	15.2	4.0	24.4
Zuter	4.6	12.0	10.1	3.78	1.83	2.50	17.4	22.0	25.2
Lucky801	4.7	14.0	11.7	4.32	2.86	2.50	20.3	40.0	29.2

Table 1 continuited: Impact of environmental conditions on the modules seed productivity per plant and number of seeds per plant in white lupin varieties (at book value)

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		
PI457923	13.128	5.282	1.89	12.86	10.989	2.27	25.987	16.271	4.16
PI368911	17.959	3.942	2.33	22.57	5.382	1.98	40.529	9.324	4.31
PI533704	13.068	12.600	11.00	12.78	5.046	3.72	25.848	17.646	14.72
PI457938	15.279	7.101	3.44	29.23	11.138	3.41	44.509	18.239	6.85
KALI	13.335	6.368	3.00	17.36	9.832	3.13	30.695	16.200	6.12
Zuter	15.543	2.570	2.55	18.50	3.031	3.16	34.043	5.601	5.71
Lucky801	12.87	2.788	4.57	23.77	3.270	5.71	36.64	6.058	10.28
Module IV: Nodule weight per plant									
	Number of nodules per plant			Weight of one nodule			Weight of nodules per plant		
PI457923	3.6	16.0	11.0	0.147	0.026	0.022	0.53	0.412	0.240
PI368911	3.8	11.6	8.6	0.087	0.016	0.020	0.33	0.186	0.170
PI533704	1.6	3.0	11.0	0.094	0.053	0.015	0.15	0.160	0.167
PI457938	4.2	7.8	12.0	0.171	0.036	0.023	0.72	0.277	0.272
KALI	1.2	2.2	6.8	0.075	0.028	0.024	0.09	0.062	0.160
Zuter	1.8	8.6	10.0	0.354	0.030	0.030	0.62	0.261	0.298
Lucky801	8.4	6.6	32.8	0.038	0.022	0.018	0.32	0.146	0.582
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		
PI457923	5.587	4.760	3.438	0.53	0.412	0.240	2.961	1.961	0.825
PI368911	13.867	4.220	4.224	0.33	0.186	0.170	4.576	0.785	0.718
PI533704	17.947	4.656	8.030	0.15	0.160	0.167	2.692	0.745	1.341
PI457938	4.822	5.617	3.246	0.72	0.277	0.272	3.472	1.556	0.883
KALI	16.589	16.081	5.475	0.09	0.062	0.160	1.493	0.997	0.876
Zuter	3.692	3.287	2.520	0.62	0.261	0.298	2.289	0.858	0.751
Lucky801	12.581	6.342	2.945	0.32	0.146	0.582	4.026	0.926	1.714

With respect to the number of plant seeds, variety variations have been identified, both on component and resultant traits. The number of plant seeds in 2014 and 2016 was higher than in 2015. Lucky801 was an exception and the plants succeeded in 2014 to produce 40 seeds per plant. On average the highest ranks (1 and 2) (Table 2) and corresponding mean values were obtained for the varieties PI533704 and Lucky801. Zuter occupies a third position with a rank of 4. KALI variety forms a small number of pods and seeds in pods, so with the resultant number of plant seeds occupied the last place with a rank of 6.

The specific biological capabilities of white lupin varieties were also shown in the plant productivity module. There is some analogy with the previous module. This is because the number of plant seeds participated in module one, already as a component rather than a resultant trait. The lower values of this attribute also negatively affect the total weight of seeds, although a compensatory response by the plant organism is possible through the second component trait.

This is the case of PI457923, which in rank occupied 5 position by weight of seeds, and by weight of grain of plant – third position, together with Zuter. Seed productivity was best represented by Lucky801, PI533704 and Zuter ranked 1, 2 and 3 respectively.

Table 2. Impact of environmental conditions on the modules seed productivity per plant and number of seeds per plant in white lupin varieties (by rank)

Variety	Year											
	2014	2015	2016	av	2014	2015	2016	av	2014	2015	2016	av
	Module seed productivity per plant											
	Component trait 1				Component trait 2				Resultant trait			
	Module I: Seed productivity per plant											
	Seeds per plant				Grain weight (g)				Seed weight per plant, g			
PI457923	3	4	7	5	3	2	3	3	3	4	6	4
PI368911	7	7	4	6	7	1	7	5	7	5	5	6
PI533704	1	2	2	2	5	4	6	5	2	2	3	2
PI457938	4	5	6	5	4	5	4	4	5	6	7	6
KALI	6	6	5	6	5	7	5	6	6	7	4	6
Zuter	5	3	3	4	2	6	2	3	4	3	2	3
Lucky801	2	1	1	1	1	2	1	1	1	1	1	1
	Module II: Number of seeds per plant											
	Pods per plant				Seeds per pod				Seeds per plant			
PI457923	2	5	7	5	4	1	1	2	3	5	7	5
PI368911	7	4	5	5	6	4	5	5	7	4	4	5
PI533704	1	3	3	2	5	3	2	3	1	2	2	2
PI457938	4	5	6	5	3	7	6	5	4	6	6	5
KALI	3	7	1	4	7	5	7	6	6	7	5	6
Zuter	6	2	4	4	2	6	2	3	5	3	3	4
Lucky801	5	1	2	3	1	2	2	2	2	1	1	1
	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			
PI457923	5	4	7	5	6	2	6	5	6	3	7	5
PI368911	1	5	6	4	3	4	7	5	2	5	6	4
PI533704	6	1	1	3	7	5	2	5	7	2	1	3
PI457938	3	2	3	3	1	1	3	2	1	1	3	2
KALI	4	3	4	4	5	3	5	4	5	4	4	4
Zuter	2	7	5	5	4	7	4	5	4	7	5	5
Lucky801	7	6	2	5	2	6	1	3	3	6	2	4

Table 2 continuited. Impact of environmental conditions on the modules seed productivity per plant and number of seeds per plant in white lupin varieties (by rank)

Module IV: Nodule weight per plant												
	Number of nodules per plant				Weight of one nodule				Weight of nodules per plant			
PI457923	4	1	3	3	3	5	4	4	3	1	4	3
PI368911	3	2	6	4	5	7	5	6	4	4	5	4
PI533704	6	6	3	5	4	1	7	4	6	5	6	6
PI457938	2	4	2	3	2	2	3	2	1	2	3	2
KALI	7	7	7	7	6	4	2	4	7	7	7	7
Zuter	5	3	5	4	1	3	1	2	2	3	2	2
Lucky801	1	5	1	2	7	6	6	6	5	6	1	4
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			
PI457923	5	4	4	4	3	1	4	3	4	1	5	3
PI368911	3	6	3	4	4	4	5	4	1	6	7	5
PI533704	1	5	1	2	6	5	6	6	5	7	2	5
PI457938	6	3	5	5	1	2	3	2	3	2	3	3
KALI	2	1	2	2	7	7	7	7	7	3	4	5
Zuter	7	7	7	7	2	3	2	2	6	5	6	6
Lucky801	4	2	6	4	5	6	1	4	2	4	1	2

Two component traits - weight of leaves and weight of stems were used in the formation of the fresh aboveground mass productivity module. Highest aboveground mass for 2014 formed PI368911 (17.959 g/plant), and in 2015-2016 - PI533704 (12.60-11.00 g/plant). PI533704 exhibits the lowest variance of the attribute placed in different limits of the environment. For all other varieties under more unfavorable conditions, the value of fresh aboveground mass, expressed by the weight of leaves sharply dropped. Under the second component, variations in the varieties and the conditions of growing were also established. The highest weight of leaves was found in PI457938, 29.23 g/plant, 11.138 g/plant and 3.41 g/plant for 2014, 2015 and 2016. The applied rank analysis ranked this variety in the first position with a rank of 2, followed by PI533704 with a rank 3.

The module weight of nodules per plant directly depends on the weight of one nodule and the number of nodules of plant. For the first trait, an interest for breeders were Lucky801 and PI457923 varieties, although they do not retain their productive capacity in changing the growing conditions, as well as PI457938, which is characterized by an average but also good stability of the traits. The average nodule weight per plant was 0.138 g for 2014, 0.030 g for 2015 and 0.022 g for 2016. In most of the varieties studied the increased number of nodules was at the expense of their weight. A good combination of number and weight of nodules was found in PI457938, which has the highest complex rating (rank 2). The same rank was Zuter, while KALI has a rank of 7, testifying to the more limited possibilities of this variety to form more nodules with higher weight. The module root mass weight was the result of the multiplicative inheritance of the two component traits - supply of root mass with nodules and the weight of nodules per plant, multiplication of which was the resultant trait. The varieties PI368911 and Lucky801 are ranked in rank 4 on both attributes, PI457923 was ranked 4-3, and the others significantly alter their position. Those with a strong position on the first trait occupied the last places under the second trait.

The influence of the environmental conditions on grain yield and aboveground mass is presented in Table 3. The change of limiting environmental factors in critical phases of organogenesis leads to a change in the spectrum of locus which determines the quantitative trait in plants. In these cases, there is a change in the genetic formula of the quantitative trait.

Table 3. Impact of environmental conditions on the modules seeds yield and fresh aboveground mass yield in white lupin varieties (at book value and rank)

Variety	Limit (years)			Yield (kg/da)	Ranks			
	2014	2015	2016	2014-2016	2014	2015	2016	Average
				Module seeds yield				
PI457923	140.75	99.25	97.25	112.42[ab]	3	4	6	4
PI368911	75.50	49.50	145.00	90.00[ab]	7	5	5	6
PI533704	143.25	140.00	172.50	151.92[bc]	2	2	3	2
PI457938	116.50	37.00	86.75	80.08[a]	5	6	7	6
KALI	91.00	12.00	146.75	83.25[a]	6	7	4	6
Zuter	132.50	112.75	192.00	145.75[abc]	4	3	2	3
Lucky801	155.25	247.50	223.25	208.67[c]	1	1	1	1
				Module fresh aboveground mass yield				
PI457923	649.68	406.78	104.00	386.82[a]	6	3	7	5
PI368911	1013.23	233.10	107.75	451.36[a]	2	5	6	4
PI533704	646.20	441.15	368.00	485.12[a]	7	2	1	3
PI457938	1112.73	455.98	171.25	579.98[a]	1	1	3	2
KALI	767.38	405.00	153.00	441.79[a]	5	4	4	4
Zuter	851.08	140.03	142.75	377.95[a]	4	7	5	5
Lucky801	916.00	151.45	257.00	441.48[a]	3	6	2	4

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

The final selection was awarded the highest average rankings. From the selected sample collection, the highest seed yield was recorded at Lucky801 (155.25 kg/da, 247.50 kg/da, 223.25 kg/da) and PI533704 (143.25 kg/da, 140.00 kg/da, 172.50 kg/da) over the three years of study. These varieties occupied the stable first and second positions according to the rank analysis. PI368911, PI457938 and KALI are characterized by high variability and grain yields below the average (90.00 kg/da, 80.08 kg/da and 83.25 kg/da) for the test group of varieties. Therefore, the rank analysis gives them the last 6 position.

The varieties PI457938 and PI533704 showed the highest fresh aboveground mass yield an average yielded over the period 597.98 - 485.12 kg/da. PI533704 was very impressive - it was also relatively high in grain yield and it was highly variable in the yield of fresh aboveground mass, ranking in 2014 at the last place with a rank of 7. Fresh aboveground mass yield of PI368911 (451.36 kg/da), KALI (441.79 kg/da) and Lucky801 (441.48 kg/da) was close to average yield of fresh aboveground mass.

Orthogonal regression method

Unlike methods for genetic analysis of traits, the method of orthogonal regression offers the study of 7 genetic-physiological systems. The use of this method in the selection evaluation allows optimization of the prospective material breeding process for the different directions of use as well as potential parental forms for the needs of the combined selection.

The co-ordination system SP-BP (Selection-Background) allows identifying the genotype of the individual organism by phenotype. Moreover, the relative share of the influence of genotype and environment is quantified in a scale from the actual measurements of the trait. Unlike methods for genetic analysis of traits, it is proposed to undertake a study of 7 gene-physiological systems.

The method of orthogonal analysis suggests the identification of genotypes (varieties, hybrids) by "displacement" of the genetic - physiological systems of the organism (attr), micro distribution (mic) of photosynthesis products, adaptability (ad), polygenic immunity, reaction to limiting soil nutrition factors, tolerance to seed compaction, genetic variability in the ontogenesis phase duration.

PI457938 exhibits a good combination of adaptability and attraction genes (rapid passage of plastic substances under conditions of deterioration). The plants of this variety form an aboveground and root mass with high weight (Figure 2). The varieties PI533704, KALI and Zuter, presented on the graph in the negative part were the least adaptable. They do not react positively, placed in a favorable growing environment. PI368911, as shown in the chart in 2014, had the highest adaptability, although it was located close to the regression line. In the case of deterioration of the growing conditions (2015), it moves to the negative part of the adaptability line and occupies an almost final position, indicating that the genetic control of adaptability in terms of the weight of fresh aboveground mass and root mass weight was redefined negatively at these limits of the environment.

At the seed technological maturity phase, Lucky801 was characterized by positive manifestations of the adaptivity and attraction. The larger distance to the adaptive line in 2015 compared to 2014 showed that this variety has strong attraction genes. PI533704 was in the same quadrant (limited by the positive part of the adaptability and attraction lines), but occupies an extreme right-hand position at both the limits of the environment, which is determined by the fact that it possesses stronger adaptive genes (exhibiting good ecological stability). The positive displacement of these two varieties in the physiological attraction systems (Lucky801) and adaptability (PI533704) identified them as the most interesting in the selection work as parents for the production of hybrids combining favorable seed weight genes from a plant and weight of the root mass. The varieties PI457923 and Zuter were also of interest in the combined selection, which were also well adapted to changes in the environment. They were characterized by negative attractiveness but were very close to the line of adaptability.

The co-ordination system SP-BP (Selection-Background) allows identifying the genotype of the individual organism by phenotype. Moreover, the relative share of the influence of genotype and environment is quantified in a scale from the actual measurements of the trait.

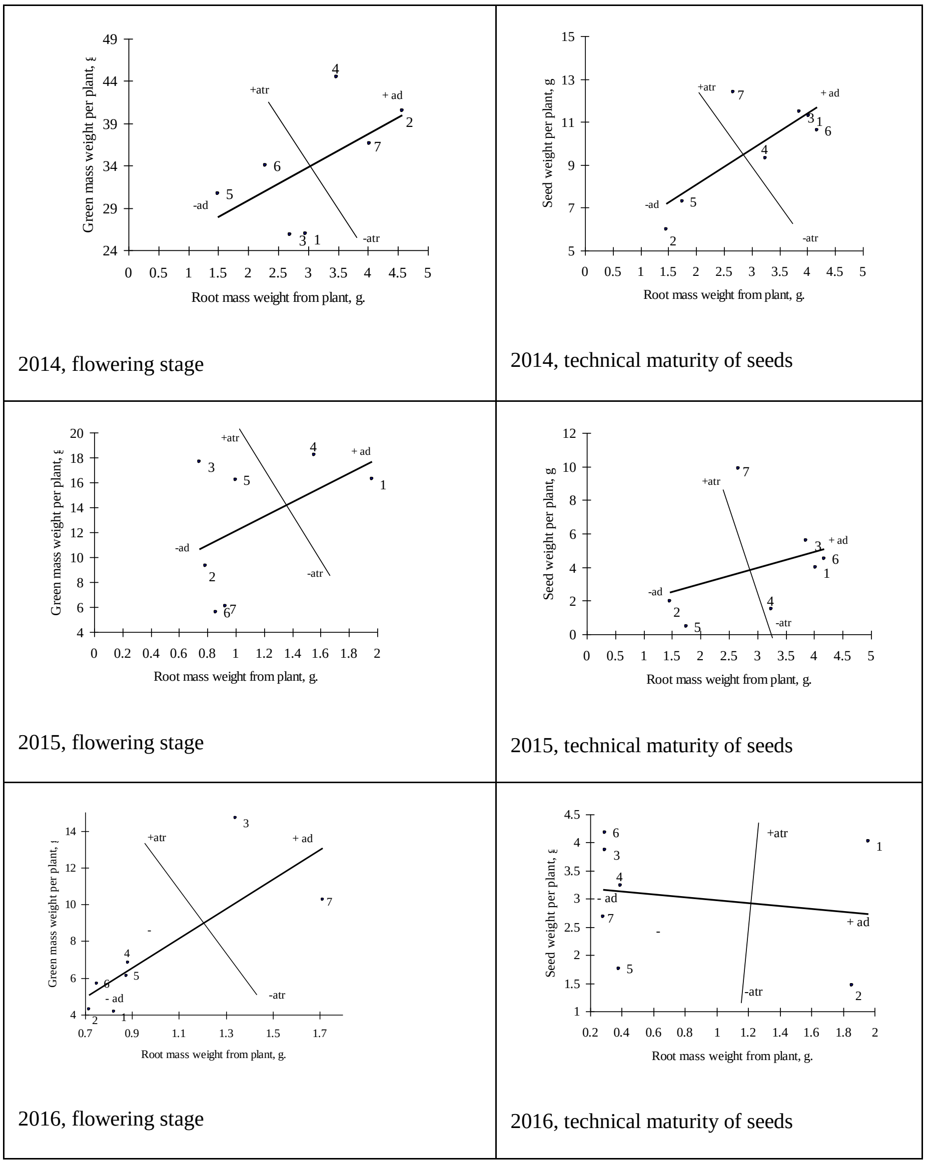

Figure 2. Distribution of mean values of varieties from white lupin
1-PI457923; 2-PI368911; 3-PI533704; 4-PI457938; 5-KALI, 6-Zuter; 7-Lucky801

DISCUSSION

According to DRAGAVTCEV (1995), in the current level of genetics of the quantitative trait in plants, quantitative traits such as grain yield or biomass should be studied taking into account the modular organization of the quantitative trait and the pyramid of modules that predetermine their phenotypic event. The author shares the need to study the inheritance of the modules related to the forming of yield and consider that the traditional approaches in genetics using polygene-based methods should be expanded and complementing the ecological approaches.

TIURIN (2014) determines the adaptability of the plant to exogenous factors in the agrophytocenosis as the most important criterion for the commercial value of the variety, which largely determines the level and stability of yields in different climatic years.

According to CHESNOKOV *et al*. (2008) and DRAGAVTCEV *et al*. (2012), selective genetic research will increasingly focus on the ecological and genetic organization of quantitative traits. The genotype includes many genes that interact with each other as a complete system. The phenotypic manifestation of any trait is the result of these interactions.

In the genotype studies of maize HRISTOV *et al*. (2002) conclude that the discovery of DRAGAVTCEV and DIAKOV (1982), according to which variations in the quantitative trait when changing the limits of the environment are divergent, is of great practical interest. The authors point out the possibility of measuring the phenotypic and genotypic dispersions in a two-dimensional system of signaling coordinates without changing the generation (F1 with F2, etc.).

Although the very possibility of developing rapid assessment methods (without generation testing) of individual genotypes on their phenotype of quantitative traits was explicitly denied by a number of researchers based on their scientific and practical research. KOCHERINA (2007) considers that the use of the orthogonal regression method reveals significant prospects for the selection of crop plants.

CONCLUSIONS

It should be noted that it is necessary to continue the application of the traditional Mendel analysis and the Hayden, Griffing dialectical analysis methods, which are based on the Mendelistic base and derive from the polygene theory. These studies should be combined with the study of the environmental model for organizing the quantitative trait, which reveals new opportunities for plant selection. The development of research in this direction will undoubtedly lead to a change of the known models of plant selection pattern.

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EKOLOŠKO-GENETIČKI MODEL ZA KONTROLU KVANTITATIVNIH OSOBINA BELE LUPINE

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Izvod

Urađen je pokušaj prelaska iz selekcije zasnovane na konceptu "gen-svojstvo" ka selekciji na osnovu genetika-fiziološki sistem, koji sugerišu ekološko-genetički model za kontrolu kvantitativnih osobina bele lupine. Analiziran je biljni materijal nadzemne i korenove mase 7 varijeteta bele lupine različitog porekla: PI457923 (Grčka), PI368911 (Češka Republika), PI533704 (Španija), PI457938 (Maroko), KALI (Poljska), Zuter (Francuska) i Lucky801 (Francuska): izučavanje je izvedeno na eksperimentalnom polju Instituta za krmno bilje, Pleven, Bugarska tokom tri uzastopne godine (2014-2016). Ekološko-genetički modeli za organizaciju kvantitativnih osobina i metod ortogonalnih regresija primenjeni su kao metode procene.Najviši prosečan prinos zrna utvrđen je za varijetete Lucky801 (208.67 kg/da) i PI533704 (151.92 kg/da). PI368911, PI457938 i KALI su se karakterisali visokom varijabilnošću i prinosom zrna (90.00 kg/da, 80.08 kg/da, 83.25 kg/da) ispod proseka za testiranu grupu varijeteta. PI533704 i PI457938 su postigli najviši prinos sveže nadzemne mase (485.12 i 597.98 kg/da). Biljke PI457938 formirale su visoku svežu nadzemnu masu i masu korena i pokazale su dobru kombinaciju gena prilagodljivosti i privlačnosti. Lucki801 i PI533704 sorte pokazali su jake gene fizioloških sistema atraktivnost i prilagodljivosti za težinu semena i težinom korena po biljci, ali su PI457923 i Zuter bili dobro prilagođeni. Ove sorte su bile od najvećeg interesa i mogu se uključiti u buduće šeme hibridizacije kako bi se dobili hibridi koji kombinuju u jednom genotipu veliku težinu semena i masu korena.

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