Research Article

Interrelations of quantitative signs with the yield in genotypes *Pisum sativum* L. with non-distributed pods

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ABSTRACT

Aim: The beans without a parchment layer in the sections based on donors with recessive allele's p and v were used as the selective feature in the selection Pisum sativum L. This led to the restructuring of crop element structure, their variability and interrelationships among new genotypes. **Materials and Method:** The grades of beans without a parchment differ in response to environmental condition changes. The genotypes with a moustache type of leaf implement a high-yield potential in the conditions with an insufficient moisture. **Results:** They isolated the sample KT-6489 with a high resistance to the humidification mode fluctuations. They determined stable correlations of signs: The number of beans, seeds, and productive nodes on a plant, the weight of seeds on a plant and the weight of 1000 seeds, and the number of beans, seeds, and a productive node weight, equally directed irrespective of environmental conditions. They offer the signs of 1000 seeds weight and the number of seeds per productive unit, which have a direct positive contribution to the yield, as the main features during the selection of the non-parchment form of pea seed. **Conclusion:** The obtained data on the variability and the conjugation of quantitative traits can be used in selection work during the selection and the development of selection process technology.

KEY WORDS: Beans without a parchment, Correlation coefficient, Genotype, Path analysis, Pea seed, Yield

INTRODUCTION

During the solution of *Pisum sativum* L. cultivation problem associated with the biological characteristics of culture (the tendency to plant fall and the loss of seeds), morphological mutations are used as a selection feature. The introduction of only one mutation into the genotype leads to a structural rearrangement of the plant as a whole and to the variability of response rate to environmental conditions. In this regard, the phenotypic manifestation of mutations of economic value requires a detailed and careful study.[1] The knowledge of the interrelationships between quantitative traits in a certain ecological niche will allow to reveal the value of each feature for yield selection, the plasticity of varieties and to make changes in the practice of selection process technology. To achieve further progress, it is of great importance to identify signs that have a direct or an indirect effect on yield, or their optimal combination if these influences are differently directed.[2]

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Researchers express ambiguous opinions about the influence of individual characteristics on yield. The length of plants is among the important signs that determine the productivity of pea plants.[3,4] Often, there is a high-positive correlation of productivity with the number of beans and seeds per plant with the weight of 1000 seeds.[3-6] The studies conducted by Tamene[7] determined a positive effect of seed quantity in a bean and a negative mass of 1000 seeds on the productivity of the plant. The detection of a high-positive correlation of the seed weight from a plant with the biomass, the number of seeds from a plant, and the number of seeds in a bean at the genotype level makes it possible to use the listed characteristics in the selection of highly productive forms.[8] The results of correlation studies between crop elements indicate a low homeostasis of the production process among determinant pea forms with mustached and heterophilic leaves.[9]

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Most scientists point to a high-positive correlation of pea productivity with the number of beans and seeds per plant, with the weight of 1000 seeds.[3-6,10] Path analysis established a positive direct effect on the harvest of seeds of harvest index and biomass yield at the genotypic level.[11,12]

In our studies, at a comparative study of pea genotypes, they revealed genotypic correlations of quantitative traits, which are manifested stably or multidirectionally in groups, depending on bean type and environmental conditions.[13] In the Tatar NIISH, they created new genotypes of pea with a high stability of beans to opening. The non-parchment type of bean is used as a selection feature, the endocarp of which has no lignified cells.[14] It is known that the presence or the absence of a parchment layer is controlled by two genes (p and v). In the dominant state, they cause a strong development of the endocarp lignin layer. Recessive mutations p and v, which disrupt the formation of the parchment layer in a bean, are widely used in the selection of vegetable varieties *P. sativum* L.[15,16]

The plants with non-parchment beans in the conditions of moderate moisture demonstrate a direct effect on the productivity of the number of seeds on a plant, in a bean and on the productive site. A significantly high contribution to the crop is made by the mass of seeds, the biomass of plants, and the length of plants under conditions of moderate moistening. They indicate the advantage in yields of tall genotypes under these conditions.[17] To improve the model of a pea plant with a new feature, an in-depth study of the crop dependence and its constituent elements of productivity is necessary. In this paper, we analyzed the path coefficients, which allow us to isolate the direct effect of one characteristic and the indirect effects of others.[18]

METHODS

Experimental data were obtained on the materials of competitive testing of peas in the Tatar Scientific and Research Institute of Agriculture. Four genotypes with non-parchment beans are included in the study: The varieties of Kaban, Fregat, Veles, and a prospective sample KT-6489. Except for the species Caban (leafy), new specimens have a mustachio-type leaf. During the development of genotypes with a new sign, the donors were used obtained from the N.I. Vavilov All-Russian Institute of Plant Genetic Resources.

The morphometric analysis of plants was carried out on the basis of plant length, the number of productive nodes on a plant, the number of beans and seeds, the weight of seeds on a plant and on a productive site, the number of seeds in a bean, and the weight of 1000 seeds. The yield is converted to a standard moisture content of 14%.

The studies were conducted in 2016–2017, characterized by contrast meteorological conditions. The amount of precipitation (62 mm) and the hydrothermal coefficient HTC,[19] equal to 0.52, characterize 2016 as a very dry during the vegetative period. The greatest stress was observed during the flowering phase of plants (HTC 0.08). In 2017, 178.2 mm of precipitation fell during the vegetative period of peas, which indicates an excessive moistening. Particularly, abundant showers passed in the phase of linear growth of plants and flowering. In general, during the growing season, the hydrothermal coefficient was 1.43, during the flowering period its value reached 2.83.

The statistical analysis of the experimental material was carried out using the program Microsoft Excel XP, the package of statistical and biometric genetic analysis in plant growing and selection AGROS 2.13.

RESULTS AND DISCUSSION

The analysis of the competitive test results showed that the new varieties are not inferior to the Vatan standard with soft beans by average yields [Figure 1]. These graphs show that the varieties demonstrated a high response to changing environmental conditions. A number of genotypes are able to implement a high potential within the conditions of insufficient moisture (2016). A significant excess of yield over the standard was obtained from the varieties Fregat, Veles, and KT-6489. An excessive hydration had a multidirectional effect on genotypes. The resistance to this factor was noted among KT-6489, the yield of which reached 4.46 t/ha. The yield of the Fregat variety decreased due to the crop thinning under the influence of a high infectious load.

The morphometric analysis of plants showed genotypic differences of new trend varieties in terms of quantitative characteristics and their manifestation depending on year conditions. The values of productivity structure elements indicate a fairly

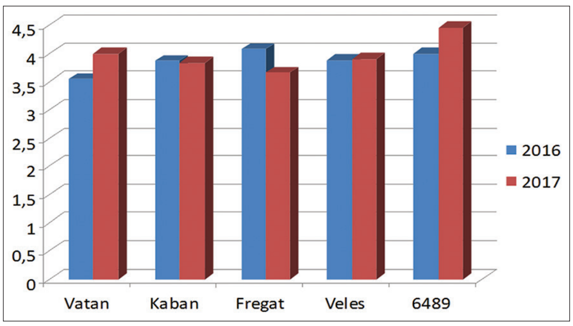

Figure 1: Yield of pea varieties by years, t/ha

balanced ratio. The selection was aimed at productive node number increase, the completion of a bean, and the reduction of 1000 seeds weight.

The correlation analysis established a significant direct effect on the productivity of bean number at the production site (r = 0.53*), noted under the conditions of excessive moisture. Stable correlations of signs were revealed: The number of beans, seeds, and productive nodes on a plant, the weight of seeds on a plant and the weight of 1000 seeds, and the number of beans, seeds, and the weight of a productive node, equally directed in different media, most of which manifested itself in a high degree [Table 1]. The weight of seeds from plants is the resultant indicator in yield development. It correlated positively with the number of beans (r = 0.68**... 0.74**) and seeds on the plant (r = 0.80**... 0.91**). Similar relationships were established in our previous studies[18] on many grounds in the group of genotypes with non-parchment beans, which allow us to adjust the selection work to increase the productivity of plants, depending on vegetation conditions.

A number of correlations are characteristic only of certain environmental conditions. Under the conditions of insufficient moisture (2016), they noted a positive effect of the seed weight on the productive site, on the number of plant seeds (r = 0.66**), on the number of productive nodes (r = 0.67**), and bean seeds (r = 0.76**). The weight of 1000 seeds is related with the number of seeds in a bean at the productive site (r = −0.61* and 0.50*) by the inverse relationship.

In the conditions of excessive moistening, they observed a direct correlation of seed weight from the plant with the number of seeds in a bean and on the productive site (r = −0.56* and 0.73**). The correlation coefficients indicate the correlation between the number of beans, seeds, and the productive node weight (r = −0.58*, 0.70**, and 0.53*). The weight of seeds on the productive node (r = 0.72**) and the negative number of productive nodes (r = -0.53*) made a positive influence on the weight of 1000 seeds.

Table 1: Reliable genotypic correlations of quantitative characters of peas at genotypes with no parchment layer pods

Associated characters	2016 year	2017 year
Number of pods/plant		
Number of seeds/plant	0.60*	0.85**
Weight of seeds/plant	0.74**	0.68**
Number of productive knots	0.92**	0.86**
Number of seeds/plant		
Weight of seeds/plant	0.91**	0.80**
Number of seeds/pod	0.69**	0.73**
Number of productive knots	0.56*	0.80**
Number of seeds	0.70**	0.68**
Weight of seeds/plant		
Weight of seeds/productive knots	0.64**	0.70**
Number of seeds/pod		
Number of seeds/productive knots	0.93**	0.80**
Number of seeds/productive knots		
Weight of seeds/productive knots	0.90**	0.69**

* t ($P \leq 0.01$), ** t ($P \leq 0.05$)

The revealed correlations make it possible to correct the selection work to increase the productivity of plants by structure element redistribution, to conduct plant selection in different years according to certain criteria.

The results of the path coefficient analysis in our studies show that during the years of testing, a high-positive direct effect in the seed yield is achieved by the weight of 1000 seeds (r = 3.69–6.26) and the number of seeds per productive site (r = 4.81–8.13) [Table 2]. In 2016, along with these features, a high-positive direct contribution of the following characteristics was noted: The number of beans per plant (r = 15.97) and the number of seeds in a bean (r = 3.88).

A negative direct contribution to the yield of seeds over the years of research was made by the weight of seeds from a plant (r = −5.35–10.42). Its indirect positive effect on the yield was manifested through the number of seeds per productive unit. In 2016, in addition to this trait, a positive indirect contribution was reflected through the number of beans on a plant, in 2017 - through the number of productive nodes.

The direct contribution of a number of characteristics to yields depended on environmental conditions. In the conditions of excessive moistening, the contribution of the sign “the number of productive nodes” was characterized by a positive effect (r = 7.36), a negative effect of this index (r = −8.00) was manifested with the lack of moistening.

In 2016, a direct negative effect of the sign “the number of beans on the productive node” was implemented in combination with positive indirect contributions of productive node number, plant bean number, and the number of seeds in a productive node. In 2017, there was a positive direct contribution of the trait to the yield through a positive indirect effect of the following signs: The number of seeds per productive node and the weight of 1000 seeds.

The presence of a residual effect indicates the effect of unaccounted factors in the studied system of cause-effect relationships. During the years of research, this indicator had close values, 0.885 and 0.815, respectively. The negative values of indirect effect sum (−7.88 and −12.93) indicate that the studied varieties during the years of research failed to implement the full potential for the development of crop structure individual elements.

Table 2: Path coefficient analysis of elements of structure of harvest with the productivity

Characters	Path coefficient										Correlation coefficient with harvest rg
	A	B	C	D	E	F	G	H	I	J	
2016											
A	−0.4	1.8	−3.2	0.0	2.7	−0.6	3.4	−2.3	−0.1	−1.6	−0.3
B	0.1	−8.0	14.7	0.0	−0.5	1.2	−1.0	−7.0	0.0	0.4	−0.1
C	0.1	−7.4	16.0	0.0	−0.6	−0.6	−0.3	−7.7	−0.0	0.6	0.1
D	−0.2	−4.5	9.6	0.1	2.7	−0.4	3.4	−9.5	0.0	−1.3	−0.1
E	−0.3	1.1	−2.4	0.0	3.9	0.0	4.5	−4.7	−0.1	−2.3	−0.2
F	−0.1	2.1	2.1	0.0	−0.0	−4.6	1.6	−1.0	−0.1	0.4	0.4
G	−0.3	1.6	−1.1	0.0	3.6	−1.5	4.8	−5.2	−0.2	−1.8	−0.0
H	−0.1	−5.4	11.8	0.0	1.7	−0.5	2.4	−10.4	−0.1	0.2	−0.2
I	−0.2	1.0	0.8	−0.0	3.0	−2.0	4.3	−6.7	−0.2	−0.3	−0.2
J	0.2	−0.9	2.5	−0.0	−2.4	−0.6	−2.4	−0.5	0.0	3.7	−0.3
Unrecorded factors Po=0.858											
2017											
A	−0.3	0.1	0.1	0.2		0.5	−0.2	−2.8	−2.8	−0.3	−0.3
B	−0.0	7.4	−1.8	−0.9		−0.6	−0.5	0.9	0.9	−3.3	−0.3
C	0.0	6.3	−2.1	−1.0		−0.5	0.3	2.9	−0.1	−2.2	0.0
D	0.1	5.9	−1.8	−1.2		−1.2	0.1	5.5	−0.9	−2.4	0.1
E	0.1	2.6	−0.6	−0.9		−1.6	0.1	6.5	−1.4	−1.9	−0.1
F	0.0	−2.4	−0.4	−1.1		−0.1	1.4	4.7	−3.0	2.4	0.5
G	0.1	0.8	−0.8	−0.8		−1.3	0.8	8.1	−2.9	0.0	0.2
H	0.1	3.6	−1.4	−0.9		−0.9	0.6	5.9	−3.0	1.5	0.1
I	0.1	−2.1	−0.1	−0.3		−0.5	1.0	5.6	−4.2	4.5	0.3
J	0.0	−3.9	0.7	0.5		0.5	0.5	0.00	−3.0	6.3	0.3

Unrecorded factors Po=0.815. Bold path coefficient, indicating a direct effect. A - length of plants, B - number of productive knots, C - number of pods/plant, D - number of seeds/plant, E - number of seeds/pod, F - number of pods/productive knot, G - number of seeds/productive knot, H - weight of seeds/plant, I - weight of seeds/productive knot, J -1000 seeds weight

SUMMARY

1. New grades with non-parchment beans differ in response to environmental condition changes. The genotypes with a moustache type of leaf implement a high-yield potential in the conditions with insufficient moisture. They isolated the sample KT-6489 with a high resistance to fluctuations in the humidification regime. Negative values of indirect effect sum indicate that during the years of research the studied varieties could not fully implement the potential for the manifestation of crop structure individual elements.
2. The correlations have been revealed that allow us to correct model features to increase the productivity of plants by structural element redistribution, to conduct selection according to certain characteristics, depending on vegetation weather conditions.
3. The signs of "1000 seeds weight" and "the number of seeds per productive unit" showed a direct positive effect regardless of weather conditions. The selection according to these characteristics is the most expedient for non-parchment bean genotype yield increase.

CONCLUSIONS

Thus, the obtained data on the variability and the contingency of quantitative characteristics can be used in selection work during the selection and the development of selection technology process. The limiting elements of the crop in the group of the genotypes with non-parchment beans were represented by the following signs: The weight of 1000 seeds and the number of seeds per productive unit, which showed a direct positive effect regardless of year conditions. Therefore, the selection according to these characteristics is the most reliable one.

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