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Original scientific article

CORRELATION DEPENDENCES ON QUANTITIVE SIGNS IN GRASS PEA (*Lathyrus sativus* L.) ACCESSIONS

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To assess the phenotypic and genotypic relationships among basic quantitative indicators in grass pea the field experiment was performed in the Institute of Forage Crops, Pleven, Bulgaria during the period of 2014-2016. Correlation (r) and regression (R) analysis were applied. Six grass pea accessions were used. For the most of the indicators, phenotypic relationships were found slightly lower than the values of the coefficients of their genetic correlations. The next phenotypic and genotypic correlation coefficients were distinguished with significant medium to strong relationships: fresh plant weight with: number of leaves (r=0.99; r=0.86; r=0.88), fresh leaves weight (r=0.98, r=0.96, r=0.99) and fresh stems weight (r=0.85; r=0.97; r=0.91); fresh leaves weight with: number of branches (r=0.66; r=0.69; r=0.58) and number of pods (r=0.48; r=0.12; r=0.48); number of branches with: fresh plant weight (r=0.52, r=0.69; r=0.62), number of leaves (r=0.54, r=0.53; r=0.49) and fresh leaves weight (r=0.66, r=0.69; r=0.58). Most significant effect for the formation of seed productivity under the different conditions of the years of study have the signs of fresh root weight (R=4.829; R=2.449; R=0.01), dry stems weight (R=0.369; R=0.507; R=0.387), fresh leaves weight (R=0.297; R=0.101; R=0.097), fresh stems weight (R=0.059; R=2.027; R=0.95) and number of pods (R=0.184; R=0.095; R=0.052), but negatively exert a fresh plant weight (R= - 0.044; R= - 1.882; R= - 1.017) and nodule number (R= - 0.04; R= - 0.03; R= - 0.034). In the selection work the seed productivity can be increased by paying attention to these signs.

Key words: grass pea, nodules, productivity, regression, root mass

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INTRODUCTION

Grass pea or chickling pea (*Lathyrus sativus* L.) is a diploid (2n=14), self-pollinated annual with branched, straggling, or climbing habit, blue (sometimes violet or white) flowers and characteristic smooth seed with pressed sides (POLIGNANO *et al.,* 2005)

The genus Lathyrusis large with 187 species and sub-species being recognized, out of which, four species viz. Lathyrussativus, Lathyrusodoratus, Lathyrusochyrous and Lathyrusaphaca are found in India. However, only *Lathyrus sativus* L. is the most commonly used for nutritional purposes (HILLOCKS and MARUTHI, 2012; SINGH *et al*., 2017).

The interest in the species from genus Lathyrus is a result of their usage as a forage, honey, medicine and decorative plants. According to these valuable features some of the species are cultivated and others are important components of the pasture vegetation (TOSHEVA *et al*., 2014; ABATE *et al*., 2018).

In the selection process, before the breeder stands the difficult task to characterize the signs of plants that are significantly dependent on environmental conditions. These changes can cause variability not only of the signs, but also of the dependencies between them. In this connection, the task arises to seek and establish the regularities of the variability of the signs when environmental conditions change, as well as the nature of correlations in the specific experimental conditions for a specific year (BULGAKOVA and SYAKOV, 2015; KOUR and AGARWAL, 2016).

Knowledge of the interlinkages between important indicators makes it possible to improve a greater number of signs simultaneously, especially for those parameters with low genetic variability, in which the success of the selection is achieved by indirect methods (TUCAK *et al*., 2008; PARIHAR *et al*., 2015).

The establishment of correlation relationships between the signs of variation lines consisting of a variety of genotypes kept under the same conditions is the basis for establishing objective criteria for the conduct of the selection (VALCHEVA and VALCHEV, 2012).

The purpose of the study was to establish correlation and regression dependencies between quantitative indications of 6 grass pea (*Lathyrus sativus* L.) accessions.

MATERIAL AND METHODS

The experiment was performed on the experimental field of the Institute of Forage Crops, Pleven, Bulgaria during the period of 2014-2016. Sowing was carried out manually in optimal time, according to the technology of cultivation of grass pea. Aboveground and root biomass plant material of 6 grass pea varieties, originating in Spain, vz BGE027129, BGE015741, BGE025277, and Portugal, vz LAT4362, LA5108, LAT5038 was analysed. The following characteristics have been assessed: in the beginning of flowering stage - fresh plant weight (g) (X1); number of leaves (X2), fresh leaves weight (g) (X3), fresh stems weight (g) (X4), root length (cm) (X5), fresh root weight (g) (X6), dry root weight (g) (X7), number of nodules (X8), nodule weight (g) (X9), specific nodulating ability (X10); in the technical maturity – plant height (cm) (X11), dry stems weight (g) (X12), number of branches (X13), number of pods per plant (X14), number of seeds per plant (X15), dry root weight (g) (X16) and weight of seeds per plant (g) (Y). Biometric measurements were made to 10 plants of each variety. Correlation (r) and regression (R) analysis were applied to clarify the dependencies among seed productivity and other quantitative indications of grass pea samples (DIMOVA and MARINKOV, 1999). In the processing of experimental data, MS Excel (2003) and GENES 2009.7.0 (CRUZ, 2009) software were used.

RESULTS

The main climatic parameters amount of rainfall and temperature during the period of the study were characterized by a strong fluctuation and uneven distribution over the phenological phases of the plant development. The study period covered three consecutive years differing in climatic terms. Figure 1 presented the data on average monthly temperatures and the amount of precipitated rainfall by months during vegetation. The vegetation 2014 was the most favorable with average monthly air temperatures for April 12.3 °C, May 16.7 °C and June 20.6 °C, and rainfall 139.8 mm, 83.0 mm and 54.3 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) had 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) occupied 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 mm.

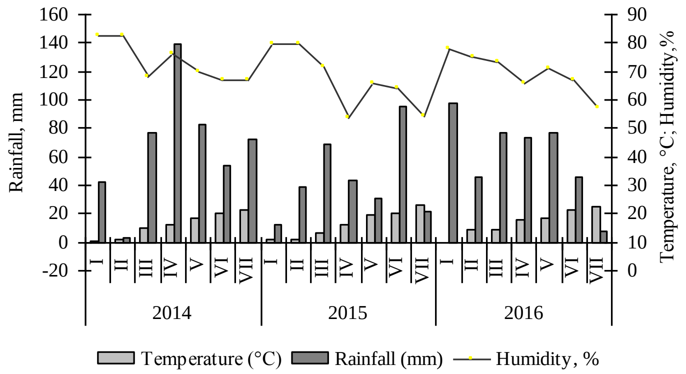


Figure 1. Climatic characterization of the experimental period

The choice of the appropriate selection material was based on certain criteria that illustrate the suitability of a given genotype for a specific selection program. In most cases, the breeder's attention was attracted by the quantitative characteristics that determine the productivity of the initial selection material. The yield was complex indicator, depending on the manifestation of other signs. Correlation and regression analyses gave an opportunity for more complete estimation of the signs studied under the different conditions of the year.

Correlation analysis

The analysis of the dependencies between the investigated signs for 2014 showed that the coefficients of phenotypic dependencies were slightly lower than the values of the genetic correlations (Table 1).

Table 1. Phenotypic (above the diagonal) and genotypic (under the diagonal) correlation coefficients, 2014

	X1	X2	X3	X4	X5	X6	X7 (f)	X8	X9	X10	X11	X12	X13	X14	X15	X16	Y
X1		0.99	0.98	0.83	0.66	0.72	0.64	0.33	0.80	0.74	0.26	0.67	0.52	0.31	0.08	0.43	0.65
X2	0.99		0.96	0.83	0.69	0.71	0.69	0.40	0.77	0.71	0.32	0.67	0.54	0.32	0.02	0.37	0.63
X3	0.98	0.97		0.70	0.65	0.60	0.59	0.37	0.90	0.85	0.33	0.78	0.66	0.48	0.22	0.51	0.72
X4	0.85	0.86	0.73		0.55	0.86	0.62	0.17	0.36	0.26	0.02	0.20	0.02	-0.23	-0.30	0.11	0.29
X5	0.66	0.68	0.64	0.57		0.59	0.86	0.89	0.38	0.31	0.49	0.50	0.62	0.19	-0.19	-0.30	0.25
X6	0.72	0.71	0.62	0.86	0.59		0.81	0.29	0.35	0.24	0.42	0.37	0.01	-0.35	-0.60	-0.04	0.50
X7	0.64	0.69	0.60	0.63	0.88	0.81		0.78	0.36	0.27	0.73	0.55	0.43	-0.03	-0.56	-0.31	0.45
X8	0.34	0.40	0.37	0.18	0.92	0.29	0.79		0.20	0.17	0.64	0.47	0.69	0.29	-0.21	-0.49	0.13
X9	0.81	0.79	0.90	0.39	0.37	0.38	0.37	0.21		0.99	0.43	0.91	0.72	0.69	0.40	0.73	0.88
X10	0.75	0.73	0.85	0.29	0.31	0.26	0.29	0.18	0.99		0.39	0.90	0.75	0.76	0.49	0.77	0.85
X11	0.29	0.34	0.34	0.09	0.53	0.48	0.78	0.68	0.43	0.39		0.75	0.54	0.25	-0.41	-0.14	0.66
X12	0.67	0.68	0.78	0.23	0.50	0.39	0.56	0.47	0.92	0.91	0.75		0.82	0.68	0.18	0.46	0.90
X13	0.51	0.54	0.65	0.01	0.62	0.01	0.43	0.70	0.72	0.75	0.56	0.83		0.87	0.43	0.24	0.50
X14	0.30	0.32	0.47	-0.26	0.17	-0.36	-0.02	0.29	0.69	0.77	0.25	0.68	0.87		0.74	0.53	0.42
X15	0.07	0.01	0.21	-0.36	-0.21	-0.63	-0.58	-0.23	0.41	0.50	-0.41	0.18	0.43	0.75		0.64	0.03
X16	0.45	0.37	0.53	0.14	-0.32	-0.05	-0.32	-0.53	0.77	0.80	-0.14	0.48	0.24	0.55	0.70		0.64
Y	0.65	0.64	0.72	0.33	0.25	0.53	0.47	0.14	0.88	0.85	0.67	0.91	0.51	0.42	0.03	0.61	

X1- fresh plant weight; X2 – number of leaves; X3 – fresh leaves weight; X4 – fresh stems weight; X5 – root length; X6 – fresh root weight; X7 – dry root weight; X8 – number of nodules; X9 – nodule weight; X10 – specific nodulating ability; X11 – plant height; X12 – dry stems weight; X13 – number of branches; X14 – pods number; X15 – number of seeds; X16 – dry root weight; Y – seeds weight per plant
Underline significant at 5%; bold significant 1% level of probability

Strong positive phenotypic correlation dependencies were found between the fresh plant weight and number of leaves (r=0.99), fresh leaves weight (r=0.98), fresh stems weight (r=0.83), nodule weight (r=0.80), specific nodulating ability (r=0.74) and root length (r=0.66). The number of leaves very well interacts with the fresh leaves weight (r=0.96), fresh stems weight (r=0.83), root length (r=0.69), fresh root weight (r=0.71) and dry root weight (r=0.69). The other characteristic of the leaves – fresh weight has a very pronounced positive correlation with the nodule weight (r= 0.90), specific nodulating ability (r=0.85) and dry stems weight (r=0.78). Positive and statistically significant were the coefficients of the phenotypic correlation of fresh stems weight with fresh root weight (r=0.86) and dry root weight (r=0.62).

Of the signs characterizing the root system of plants, the impression is made by the high values of the correlation coefficients of the nodule weight with the specific nodulating ability (r=0.99) and dry root weight (r=0.81). The nodule weight and specific nodulating ability are distinguished by the fact that they correlates very strongly with the dry stem weight (r=0.91; r=0.90), number of branches (r=0.72; r=0.75) and number of pods (r=0.69; r=0.76).

Negative, but statistically insignificant correlations were found between the signs number of seeds per plant and dry root weight and roots length, fresh root weight, dry root weight and nodule number. Correlation between the number of seeds per plant and the fresh stems weight (r=-0.30) was found weak, negative and significant. A strong positive genotypic correlation with good significance has been found between seeds weight and dry stems weight (r=0.90), nodule weight (r=0.88), specific nodulating ability (r=0.85), fresh leaves weight (r=0.72) and plant height (r=0.66) and average positive genotypic correlationwith the number of pods (r=0.42).

The agrometeorological conditions in 2015 had an adverse effect on the growth and development of the plants. In relation to the previous year, there was a change in the interaction between the signs, some of them changing only the strength of the relationship, for example, the nodule weight correlated with fresh root weight slightly weaker, but significant (r=0.29).

The correlation of fresh plant weight with the number of leaves (r=0.86), fresh leaves weight (r=0.96), fresh stems weight (r=0.97) and number of pods (r=0.15) have not changed the direction of their action, i.e. they are positive, and only marginally reduced the strength of their interaction (Table 2). Compared to 2014 a stronger correlation relationships were noted for the signs of number of seeds per plant (r=0.73); fresh leaves weight with the number of seeds per plant (r=0.81); dry root weight with the nodule number (r=0.88); number of branches with number of seeds per plant (r=0.85).

Table 2. Phenotypic (above the diagonal) and genotypic (under the diagonal) correlation coefficients, 2015

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	Y
X1		0.86	0.96	0.97	0.26	0.93	0.89	0.77	0.26	-0.59	0.26	0.43	0.69	0.15	0.73	-0.34	0.96
X2	0.86		0.96	0.72	0.08	0.76	0.77	0.62	0.49	-0.37	0.21	0.51	0.53	-0.10	0.79	-0.01	0.88
X3	0.96	0.96		0.87	0.13	0.89	0.9	0.78	0.46	-0.43	0.16	0.56	0.69	0.12	0.81	-0.16	0.95
X4	0.97	0.72	0.86		0.37	0.92	0.82	0.71	0.07	-0.68	0.34	0.28	0.64	0.18	0.6	-0.47	0.90
X5	0.27	0.08	0.13	0.38		0.36	0.21	-0.14	-0.66	-0.89	0.82	-0.14	0.23	-0.27	0.32	-0.75	0.40
X6	0.95	0.77	0.9	0.93	0.38		0.94	0.74	0.29	-0.55	0.16	0.57	0.82	0.36	0.76	-0.31	0.96
X7	0.90	0.78	0.91	0.83	0.22	0.95		0.88	0.50	-0.38	-0.01	0.78	0.93	0.47	0.88	-0.27	0.93
X8	0.79	0.63	0.8	0.73	-0.13	0.75	0.88		0.60	-0.11	-0.25	0.73	0.84	0.60	0.71	-0.22	0.70
X9	0.28	0.55	0.5	0.06	-0.77	0.31	0.56	0.66		0.57	-0.73	0.81	0.47	0.50	0.45	0.600	0.28
X10	-0.63	-0.38	-0.47	-0.74	-0.99	-0.6	-0.41	-0.14	0.51		-0.88	0.17	-0.28	0.32	-0.40	0.80	-0.62
X11	0.28	0.20	0.17	0.35	0.83	0.18	0	-0.26	-0.88	-0.88		-0.45	-0.13	-0.70	0.17	-0.68	0.31
X12	0.47	0.57	0.62	0.3	-0.19	0.63	0.88	0.81	0.76	0.04	-0.59		0.86	0.63	0.79	0.12	0.55
X13	0.68	0.53	0.69	0.63	0.23	0.84	0.95	0.87	0.53	-0.29	-0.14	0.96		0.65	0.85	-0.34	0.77
X14	0.12	-0.11	0.09	0.15	-0.29	0.36	0.48	0.63	0.51	0.33	-0.75	0.67	0.65		0.19	0.04	0.14
X15	0.75	0.85	0.86	0.61	0.35	0.83	0.97	0.83	0.61	-0.39	0.21	0.78	0.88	0.14		-0.31	0.86
X16	-0.34	0	-0.16	-0.47	-0.77	-0.31	-0.28	-0.24	0.67	0.85	-0.69	0.15	-0.33	0.06	-0.30		-0.33
Y	0.15	0.97	0.37	0.97	0.43	0.38	1.03	0.78	0.17	-0.83	0.29	0.47	0.83	0.10	0.88	-0.34	

X1- fresh plant weight; X2 – number of leaves; X3 – fresh leaves weight; X4 – fresh stems weight; X5 – root length; X6 – fresh root weight; X7 – dry root weight; X8 – number of nodules; X9 – nodule weight; X10 – specific nodulating ability; X11 – plant height; X12 – dry stems weight; X13 – number of branches; X14 – pods number; X15 – number of seeds; X16 – dry root weight; Y – seeds weight per plant

Underline significant at 5%; bold significant 1% level of probability

Some of the correlation coefficients significantly change their value from positive to negative and vice versa under the influence of environmental conditions, and in 2015 the dependencies among the fresh stems weight with a number of seeds per plant was average positive and significant (r=0.60), and the plant height with the dry stems weight (r= - 0.45) and the specific nodulating ability with the seeds weight per plant (r= - 0.62) was found medium to very negative.

Low to medium but significant were found the correlation dependencies between the seeds weight and dry stems weight (r=0.55), plant height (r=0.31), nodule weight (r=0.28) and number of pods (r=0.14). Specific nodulating ability in unfavourable conditions has a strong negative impact on seed productivity.

Phenotypic manifestations of quantitative indications are differently expressed depending on the variety characteristics of the accessions tested and the environment. Climatic conditions in 2016 had an intermediate position compared to the other two years of the study period. The correlation coefficient values are an expression of this effect.

In 2016, similar in intensity and direction correlations between the fresh plant weight and the number of leaves, the fresh leaves weight, the fresh stems weight, the number of branches and the number of seeds per plant were found. High significant correlation values were recorded in the case of fresh leaves weight with nodule weight (r= 0.95) and dry stems weight (r=0.85); in the case of fresh stems weight with the fresh roots weight (r=0.74), dry root weight (r=0.90) and dry stems weight (r=0.91); root length with number of branches (r=0.71); fresh roots weight (r=0.84), nodule number (r=0.80) and dry stems weight (r=0.74); number of branches with number of pods (r=0.83) (Table 3).

Table 3. Phenotypic (above the diagonal) and genotypic (under the diagonal) correlation coefficients, 2016

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	Y
X1		0.88	0.99	0.91	0.75	0.73	0.90	0.68	0.96	0.33	-0.03	0.90	0.62	0.52	0.23	-0.22	0.81
X2	0.88		0.83	0.90	0.44	0.84	0.77	0.54	0.83	-0.03	-0.28	0.99	0.49	0.47	0.26	0.20	0.99
X3	0.91	0.93		0.98	0.77	0.69	0.89	0.69	0.95	0.38	0.03	0.85	0.58	0.48	0.19	-0.29	0.75
X4	0.91	0.91	0.93		0.74	0.74	0.90	0.67	0.96	0.31	-0.06	0.91	0.63	0.53	0.25	-0.18	0.83
X5	0.77	0.44	0.91	0.76		0.47	0.80	0.79	0.86	0.58	0.34	0.43	0.71	0.35	-0.11	-0.67	0.37
X6	0.75	0.86	0.86	0.75	0.47		0.84	0.80	0.80	-0.29	0.11	0.74	0.29	0.02	-0.29	-0.01	0.90
X7	0.91	0.78	0.87	0.91	0.82	0.84		0.83	0.94	0.08	0.35	0.73	0.43	0.14	-0.15	-0.44	0.75
X8	0.71	0.55	0.85	0.70	0.80	0.81	0.84		0.84	0.14	0.40	0.44	0.46	0.00	-0.52	-0.46	0.56
X9	0.92	0.93	0.95	0.94	0.95	0.92	0.91	0.92		0.31	0.09	0.81	0.67	0.42	0.00	-0.31	0.79
X10	0.44	-0.08	0.17	0.56	0.86	-0.38	0.12	0.20	-0.04		-0.17	0.07	0.69	0.68	0.39	-0.36	-0.16
X11	-0.02	-0.27	-0.03	-0.02	0.38	0.15	0.38	0.43	0.06	-0.39		-0.36	-0.38	-0.72	-0.73	-0.85	-0.27
X12	0.93	0.96	0.85	0.93	0.44	0.75	0.73	0.45	0.91	0.15	-0.36		0.52	0.58	0.41	0.21	0.94
X13	0.62	0.49	0.62	0.65	0.72	0.29	0.43	0.46	0.72	0.66	-0.40	0.53		0.83	0.33	-0.04	0.44
X14	0.53	0.48	0.56	0.55	0.36	0.03	0.14	0.00	0.46	0.65	-0.76	0.58	0.84		0.78	0.28	0.38
X15	0.22	0.26	0.19	0.25	-0.12	-0.29	-0.15	-0.53	-0.02	0.56	-0.76	0.42	0.32	0.78		0.42	0.15
X16	-0.23	0.21	-0.38	-0.18	-0.69	0.01	-0.45	-0.47	-0.40	-0.69	-0.89	0.21	-0.05	0.28	0.42		0.27
Y	0.83	0.52	0.87	0.85	0.37	0.91	0.75	0.58	0.87	-0.29	-0.29	0.95	0.44	0.38	0.15	0.27	

X1- fresh plant weight; X2 – number of leaves; X3 – fresh leaves weight; X4 – fresh stems weight; X5 – root length; X6 – fresh root weight; X7 – dry root weight; X8 – number of nodules; X9 – nodule weight; X10 – specific nodulating ability; X11 – plant height; X12 – dry stems weight; X13 – number of branches; X14 – pods number; X15 – number of seeds; X16 – dry root weight; Y – seeds weight per plant
Underline significant at 5%; bold significant 1% level of probability

The dry roots weight is characterized by the fact that it is present in a state of negative dependence with most of the signs studied, and in a weak to medium positive correlation with the rest. The correlation coefficients are statistically significant only between the dry roots weight with the nodule weight (r= - 0.31) and specific nodulating ability (r= - 0.36).

From the correlation analysis of the aboveground and root mass and the plant productivity, high and medium significant positive correlations were found between the seeds weight per plant and the number of leaves (r=0.99), fresh plant weight (r=0.81), fresh leaves weight (r=0.75), fresh stems weight (r=0.83), nodule weight (r=0.79) and number of branches (r=0.44).

For the study period relatively constant with a positive sign were the dependencies (both, phenotypic and genotypic) of fresh plant weight with the number of leaves, fresh leaves weight and fresh stems weight; of fresh leaves weight with number of branches and number of pods; of the nodule number with number of pods; of the number of branches with the fresh plant weight, number of leaves and fresh leaves weight. The mutual influence of the specific nodulating ability with the nodule weight, number of pods with the fresh plant weight and fresh leaves weight as well as the fresh plant weight with the number of seeds per plant is also retained, but varies in broader limits.

These slightly higher values of the coefficients of genetic correlations for the majority of the signs compared to the coefficients of phenotypic dependencies may be considered as an indication that the environment had significant effect on the manifestations of the strong hereditary relationships. The presence of strong and medium positive genetic dependencies between some of the indicators shows that there are good opportunities for successful selection at the same time on several signs. In this aspect, selection interest also represents some of the negative genetic correlations fount, the simultaneous selection of which would contribute to improve and increase the selection value of genotypes.

Regression analysis

From the multiple regression analysis performed, equations of the performance patterns (the seeds weight) have been compiled for each of the years of study. The results showed that the analysis was statistically significant (Table 4). The type of model of the regression equations [(1), (2), (3)] are as follows:

for 2014

(1) Y = 0.495 - 0.044*X1 - 0.103*X2 + 0.297*X3 + 0.059*X4 - 0.239*X5 + 4.829* X6 + 6.105* X7 - 0.04* X8 + 0.01* X9 + 0.01* X10 + 0.079* X11 + 0.369* X12 - 0.925* X13 + 0.184* X14 + 0.001* X15 + 0.01* X16;

for 2015

(2) Y = -1.281 - 1.882* X1 + 0.101* X2 + 1.481* X3 + 2.027* X4 - 0.317* X5 + 2.449* X6 + 0.010* X7 - 0.030* X8 + 0.010* X9 - 0.706* X10 + 0.051* X11 + 0.507* X12 - 0.550* X13 + 0.095* X14 -010* X15 - 3.279* X16;

for 2016

(3) Y = 0.110 - 1.017* X1 + 0.097* X2 + 0.954* X3 + 0.950* X4 + 0.061* X5 + 0.010* X6 - 8.456* X7 - 0.034* X8 + 1.931* X9 - 0.068* X10 + 0.057* X11 + 0.387* X12 + 0.142* X13 + 0.052* X14 -0.161* X15 + 0.010* X16;

where, Y is seed productivity; X1 is fresh plant weight; X2 is number of leaves; X3 is fresh leaves weight; X4 is fresh stems weight; X5 is root length; X6 is fresh roots weight; X7 is dry roots weight; X8 is nodule number; X9 is nodule weight; X10 is specific nodulating ability; X11 is plant weight; X12 is dry stems weight; X13 is number of branches; X14 is number of pods; X15 is number of seeds per plant; X16 is dry root weight.

Table 4. Regression analysis (ANOVA) of seed yield from a plant in terms of quantitative indicators for each of the years of study

			2014		
	Sum of Square	Df	Mean Square	F	Significance F
Regression	16	101.0512	6.315702	1.81306E+31	4.4E-109
Residual	9	3.58E-30	3.98E-31		
Total	25	101.0512			
			2015		
	df	SS	MS	F	Significance F
Regression	16	25.8504	1.615650019	2.1E+29	6.79E-88
Residual	9	8.5E-29	9.4487E-30		
Total	25	25.8504			
			2016		
	df	SS	MS	F	Significance F
Regression	16	30.44571	1.902857	2.82E+30	2.82E-91
Residual	9	7.47E-30	8.31E-31		
Total	25	30.44571			

Figure 2 presents the performance dependencies (expressed by seeds weight) with the signs of the aboveground mass and the indicators characterizing the root system of grass peas for each of the years of the study.

The data obtained from the regression analysis support the results of the correlation analysis.

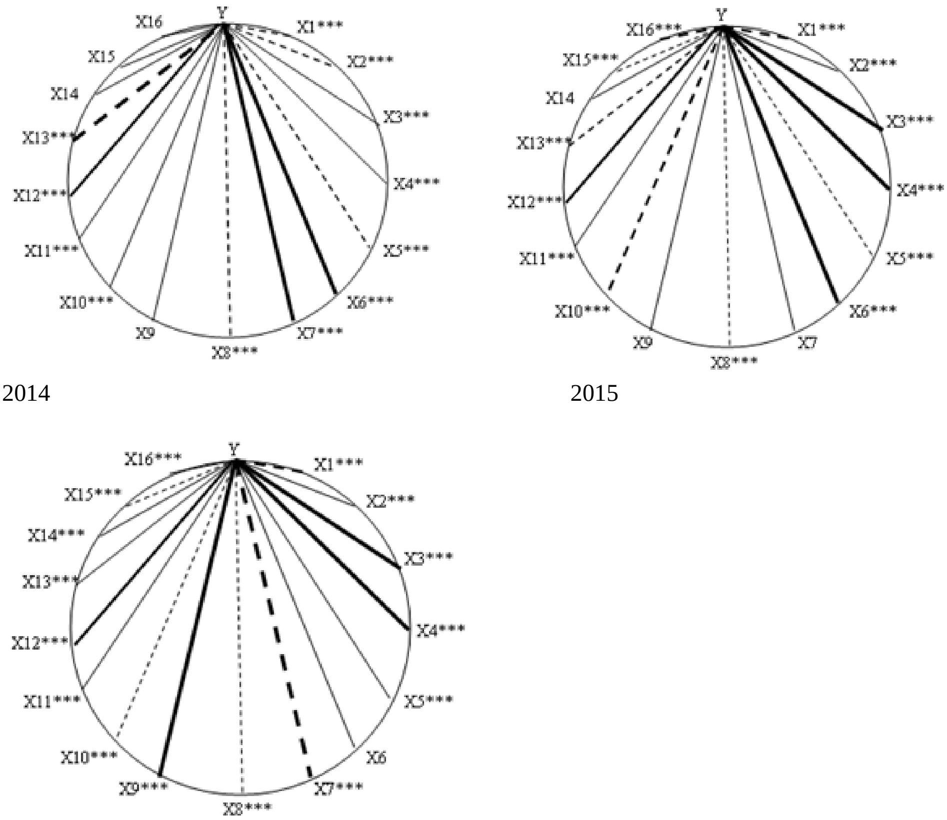
Based on the values of the regression coefficient (R) it appears that the greatest direct effect on the formation of the seeds weight per plant for 2014 is dry roots weight (R=6.11), fresh roots weight (R=4.83), followed by dry stems weight (R=0.793), fresh leaves weight (R=0.30) and number of pods (R=0.842) at very good significance.

High regression coefficient for 2015 demonstrated fresh roots weight (R=2.145), fresh leaves weight (R=1.48) and dry stems weight (R=0.51), as well as fresh stems weight (R=2.03). Also positive, but much weaker is the impact on the productivity of the number of pods (R=0.10) and plant height (R=0.05).

The dependencies obtained in 2016 between the seeds weight per plant and other indicators showed that the strongest effect on productivity had the nodule weight (R=1.93), fresh leaves weight (R=0.95) and fresh stems weight (R=0.95), followed by the dry stems weight (R=0.38) and number of branches (R=0.14).

According to the values of the regression coefficients (R), the environment affects the manifestation of the signs included in the study. More variable were found the fresh leaves weight, fresh stems weight, fresh roots weight, dry roots weight and nodule weight.

The values of the regression coefficients for the number of leaves, the number of nodules and the plant height during the period of study indicate that these signs do not play an essential role for the yield formation.



2016

Figure 2. Regression dependencies (R) on the weight of plant seeds with other signs

X1- fresh plant weight; X2 – number of leaves; X3 – fresh leaves weight; X4 – fresh stems weight; X5 – root length; X6 – fresh root weight; X7 – dry root weight; X8 – number of nodules; X9 – nodule weight; X10 – specific nodulating ability; X11 – plant height; X12 – dry stems weight; X13 – number of branches; X14 – pods number; X15 – number of seeds; X16 – dry root weight; Y – seeds weight per plant

strong positive ▬▬ ; medium ▬▬ ; weak ――― ;
strong negative _ _ _ ; weak _ _ _ _ _ _ ;

*; **, ***, significant at 5%, 1% and 0.1% level of probability

Having in a mind the negative regression coefficients of the fresh plant weight and the number of nodules in the three years of the study, it is clear that the increase in their values adversely affects the productivity of seeds. In such a situation are the root length and the number of branches, which during the first two years of the study have a well-expressed negative effect, and in the third year their effect is positive, but very poorly expressed.

The relationships obtained between the seeds weight and fresh roots weight, the dry stems weight, the fresh leaves weight, the fresh stems weight and the number of pods were found positive and significant, although their values varied. All this indicates that when changing the environment it is possible to change the behavior of the signs studied.

DISCUSSION

According to the opinion of LIHACHEVA *et al*. (2016) for breeding-genetic studies, it is necessary to apply different methods of integrated assessment of the breeding material, since the characteristic of the new lines and hybrids are not only in their individual but and the dependencies between them. The authors recommend including methods of correlation, regression and PATH analysis in the evaluation of the material.

NEYKOV (2018) considered that analyses related to the determination of dependencies between plant signs are one of the most effective methods in the selection process, which help to increase accuracy in the selection of criteria for a selection.

In the present study, most of the genotypic correlations were higher than the phenotypic for the same signs, indicating that the influence of the environment on these characteristics was not significant. These results correspond to those obtained by ALMEIDA *et al*. (2010) and NOGUEIRA *et al*. (2012) in soybeans and GONÇALVES *et al*. (2017) in beans.

DAVODI *et al*. (2011) and MARINOVA and PETKOVA (2013) in studies with other leguminous crops (alfalfa accessions) found that the yield of the forage positively correlates with the plant height, the stems number, the number of nodes, etc.

The current study of the dependences on some of the quantitative signs of grass pea is consistent with the studies of TALUKDAR (2009) and JEBERSON *et al.* (2018). In the same crops the authors found that the seed productivity positively and significant correlated with the plant height and pods number, but the 1000 seeds weight correlated slightly negatively and statistically not significantly with certain signs.

Productivity is not a single characteristic of the plant, but rather the cumulative function of many mutually dependent signs with the weight of the seeds. The results obtained confirm the studies of BEEBE *et al*. (2013) and ASFAW *et al.* (2017) in beans, where the authors observe similar dependencies. The extension of the genetic basis of the existing assortment included in the production and evaluation of the tested new selection material is a continuous process. The constant accumulation and systematization of the information received makes it possible to increase the efficiency of the selection work.

The strong positive associations obtained from the regression analysis of some of the signs with the seeds productivity may be useful information in the selection of grass pea.

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REFERENCES

ABATE, A., F., MEKBIB, A., FIKRE, S., AHMED (2018): Genetic variability and heritability in Ethiopian grasspea (*Lathyrus sativus* l.) accessions. Ethiopian J. Crop Sci., *6, 2*: 79-94.

ALMEIDA, R.D., J.M., PELUZIO, F.S., AFFERRI (2010): Phenotypic, genotypic and environmental correlations in soybean cultivated under an irrigated meadow in south of Tocantins state. BioScience J., *26, 1*: 95-99.

ASFAW, A., D., AMBACHEW, T., SHAH, M.W., BLAIR (2017): Trait associations in diversity panels of the two common bean (*Phaseolus vulgaris* L.) gene pools grown under well-watered and water-stress conditions. Frontiers in Plant Sci., *8*: 1-15.

BEEBE, S.E., I.M., RAO, M.W., BLAIR, J.A., ACOSTA-GALLEGOS (2013): Phenotyping common beans for adaptation to drought. Frontiers in Physiology, *4*: 35.

BULGAKOVA, A.A., V.V., SYUKOV (2015): Relationship of the aboveground biomass with quantitative signs of cenoses. Young Scientist, *22.2 (102.2)*, 24-25.

CRUZ, C.D. (2009): Programa Genes: Biometria. version 7.0. University of Federal Viçosa, Viçosa, Brazil.

DAVODI, M., A.A., JAFARI, G., ASSADIAN, A., ARIAPOUR (2011): Assessment of relationships among yield and quality traits in alfalfa (*Medicago sativa* L.) under dryland farming system. Hamadan, Iran. Journal of Rangeland Science, *1, 2*: 247-254.

DIMOVA, D., E., MARINKOV (1999): Experimental work and biometrics. HAI-Plovdiv 263 (in Bulgarian).

GONÇALVES, D.L., M.A.A., BARELLI, T.C., OLIVEIRA, P.R.J., SANTOS, C.R., SILVA, J.P., POLETINE, L.G., NEVES (2017): Genetic correlation and path analysis of common bean collected from Caceres Mato Grosso State, Brazil. Cienc Rural Santa Maria, *47, 8*: 1-7.

HILLOCKS, R.J., M.N., MARUTHI (2012): Grass pea (*Lathyrus sativus*): Is there a case for further crop improvement? Euphytica *186*, 647-654.

JEBERSON, M.S., R., GONMEI, M., KUMAR, K.S., SHASHIDHAR, N.B., SINGH, P.H.R., SHARMA (2018): Genetic variability, heritability, correlation coefficient and path analysis in *Lathyrus* for yield and its related contributes under NEH condition. Journal of Pharmacognosy and Phytochemistry, *7, 6*: 1806-1809.

KOUR, J., N., AGARWAL (2016): Correlation and Path Coefficient Analysis of Yield Components in Advanced Lines of Grasspea (*Lathyrus sativus* L.). International Journal of Stress Management, *7*: 682-686.

LIHACHEVA, L.I., V.S., GIMALETDINOVA, E.G., KOZIONOVA (2016): The conjugation of quantitative traits varieties of peas in the conditions of middle Urals. Scientific-Production Journal "Grain legumes and cereal crops" *3, 19*: 45-48

MARINOVA, D., D., PETKOVA (2013): Correlations of some important alfalfa traits (*Medicago sativa* L.), In: Proceedings of the Fourth International Conference „Research people and actual task on multidisciplinary science", 12-16 June, Lozenec, Bulgaria, pp. 189-191.

NEYKOV, N. (2018): Correlational relationships between yield and productivity elements in spring barley accessions from African genetic center. Bulgarian J. Crop Sci., *55, 1*: 33-37.

NOGUEIRA, A.P.O., T., SEDIYAMA, L.B., SOUSA, O.T., HAMAWAKI, *et al*. (2012): Path analysis and correlations among traits in soybean grown in two dates sowing. BioScience Journal, *28, 6*: 877-888.

PARIHAR, A.K., G.P., DIXIT, D., SINGH (2015). Genetic variability analysis for quantitative traits in a germplasm set of grasspea (*Lathyrus* spp.). Legume Research, *38, 4*: 461-464.

POLIGNANO, G.B., P., UGGENTI, G., OLITA, V., BISIGNANO, V., ALBA, P., PERRINO (2005): Characterization of grass pea (*Lathyrus sativus* L.) entries by means of agronomically useful traits. Lathyrus Lathyrism Newsletter *4*: 10-14.

SINGH, P. K., R., SADHUKHAN, A., KUMAR (2017): Correlation Studied on Several Quantitative Traits in Induced Mutagenic Population of Grasspea (*Lathyrus sativus* L.). Int. J. Curr. Microbiology App. Sci., *6, 10*: 612-619.

TALUKDART, D. (2009): Association of seed yield components along with seed neurotoxin content in different varieties and induced mutant lines of grass pea (*Lathyrus sativus* L.). Int. J. Plant Sci., *4, 2*: 378-380.
TOSHEVA, A., K., PACHEDJIEVA, B., SIDJIMOVA (2014): Contribution to the chorology of genus Lathyrus (Fabaceae) in Bulgaria. Biotech. Biotech. Eq., 67-71.
TUCAK, M., S., POPOVIC, S., GRLJUSIC, T., CUPIC, V., KOZUMPLIK, B., SIMIC (2008): Variability and relationships of important alfalfa germplasm agronomic traits. Periodicum Biologorum, *110, 4*: 311-315
VALCHEVA, D., D., VALCHEV (2012): Correlation between yield and quality of grain varieties and lines malting barley. In: Scientific papers, Institute of Agriculture - Karnobat *1*, 43-52 (Bg)

KORELACIONE ZAVISNOSTI KVANTITATIVNIH PARAMETARA U SASTRICI (*Lathirus sativus* L.)

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Izvod

Da bi se procenili fenotipski i genotipski odnosi među osnovnim kvantitativnim parametrima u sastrici, poljski eksperiment je izveden u Institutu za krmno bilje, Pleven, Bugarska, u periodu 2014-2016. Primenjene su korelacione (r) i regresione (r) analize. Korišćeno je šest genotipova sastrice. Za većinu pokazatelja, fenotipski odnosi su pronađeni nešto niže od vrednosti koeficijenata njihovih genetskih korelacija. Sledeći fenotipski i genotipski koeficijent korelacije razlikovani su sa značajnim srednjim do jakim odnosima: težina sveže biljke sa: brojem listova (r = 0,99; r = 0,86; r = 0,88), masa svežeg lišća (r = 0,98, r = 0,96, r = 0,99) i težina svežih stabljika (r = 0,85; r = 0,97; r = 0,91); težina svežeg lišća sa: brojem grana (r = 0,66; r = 0,69; r = 0,58) i brojem mahuna (r = 0,48; r = 0,12; r = 0,48); broj grana sa: težinom sveže biljke (r = 0,52, r = 0,69; r = 0,62), brojem listova (r = 0,54, r = 0,53; r = 0,49) i težinom svežeg lišća (r = 0,66, r = 0,69 ; r = 0,58). Najvažniji efekat na formiranje produktivnosti semena u različitim uslovima godina proučavanja imaju pokazatelji mase svežeg korena (r = 4,829; r = 2,449; r = 0,01), težine suvih stabljika (r = 0,369; r = 0,507 ; r = 0,387), masa svežeg lišća (r = 0,297; r = 0,101; r = 0,097), masa svežih stabljika (r = 0,059; r = 2,027; r = 0,95) i broj mahuna (r = 0,184; r = 0,095; r = 0,052), ali negativno deluju na težinu sveže biljke (r = - 0,044; r = - 1,882; r = - 1,017) i broj čvorova (r = - 0,04; r = - 0,03; r = - 0,034). U selekcijskim radovima produktivnost semena može se povećati obraćajući pažnju na ove parameter.

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