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CORRELATION DEPENDENCES OF QUANTITATIVE TRAITS IN WINTER PEA GENOTYPES

Ancuța BĂRBIERU

National Agricultural Research Development Institute Fundulea,
1 Nicolae Titulescu Street, Fundulea, Romania

Corresponding author email: cringasuancuta@yahoo.com

Abstract

*In the past, majority of the plant breeding programmes were focused mostly on developing the cultivars with high yields. Recently, stable, quality and reliable yields under various environmental conditions have consistently gained importance over solely increased yield. The experiment was conducted during the period 2019-2021 at the National Agriculture Research Development Institute Fundulea in order to establish the phenotypic and genotypic correlations between the main quantitative traits in eight winter pea genotypes. The highest positive correlation was found between plant height and grain yield (r = 0.99***), the number of pods per plant with number of grains per plant (r = 0.90***) and grain yield (r = 0.87***) and plant height (r = 0.80***), the grains weight per plant with earliness (r = 0.83***); the highest negative correlation was registred between earliness and plant height (r = -0.83***), grain yield and earliness (r = -0.82***). Pea breeding should be focused on traits with consistent heritability and a positive effect on seed yield when selecting high-yielding genotypes, and on allowing for more widespread use of pea in various agricultural production systems.*

Key words: *winter peas, seed yield, correlation, yield component.*

INTRODUCTION

Pea (*Pisum sativum* L.) is an important and wide spread legume crop. There is a great demand to develop high yielding cultivars in order to achieve future crop improvement of both, quantitative and qualitative traits (Kalapchieva et al, 2021; Singh et al., 2018).

Yield potential is the genetically determined ability of a crop to generate optimal yield in a given growth environment. Yield potential is thought to be partially determined by seed size, and numerous studies have tried to understand the relationship between seed size and yield in pea and other pulses with contradictory results (Biger, 2009; Gusmao, 2013; Smitchger et al., 2018). Grain yield is associated with harvest index, which is the ratio of grain yield to plant biomass. The source-sink relationship in peas is dependent on seed size, pod length, plant height, leaf size, stem width, stem wall thickness, leaf thickness, stipule size and other factors (Smitchger, J. & Weeden, F.N., 2018).

The fundamental goal of pea breeders is to increase seed yield to maximize plant productivity and allow for more widespread use of pea in various agricultural production systems. Seed yield is a complex trait that is quantitatively inherited, and its expression depends on genetic factors, environment and interaction (G x E) (Tan et al., 2012). Many studies have shown a significant influence of environment and genotype-by-environment interaction on seed yield and the yield components on their phenotypic performance (Bocianowski, 2019; Tiwari & Lavanya, 2012; Uhlarik et al., 2022). Otherwise, associations between yield components may be used as the best guide to achieve a yield increase through indirect selection. Phenotypic and genotypic correlation values provide a reliable information about the relationship between two or more rather than two independent variables. Highlighting the relation between the various traits and seed productivity would be of great assistance toward a successful selection and screening program. Correlations between yield and its components in different legumes have been reported. (Kamandi et al, 2015; Kour & Agarwal, 2016; Kumar & Lavania, 2014). The phenotypic correlation is conditioned by the relationship among individual characters and the influence of environmental factors. The genotypic correlation is a function of the pleiotropic action of the genes involved and their related inheritance. Linked genes have additive genes are of greatest value in breeding (Kosev & Georgieva, 2022). In this study, grain yield and some yield component, some physiological characters and correlation among these traits were investigated in eight winter pea genotypes.

MATERIALS AND METHODS

The study was conducted in the experimental fields of the National Agriculture Research Development Institute Fundulea, during the period 2019-2021. Eight genotypes of winter peas, Enduro, James, Lavinia F, Ghittia F, 13008MT28-1, 12004MT2, 12034MT1-2, 12038MT2 were tested. The experiment was performed by randomized complete block design, three repetitions with a working plot area of 6 $m^{2.}$ The sowing was done out at 11.10.2019, 21.10.2020. The pea was grown according to the technology adopted for the culture. The main morphological (biometric) characteristics of the aboveground biomass were measured at the technological maturity of plants. For this, 5 plants were used from the three replications of the trial. Plant height (cm), the total number of pods per plant, number of grains per plant, the grains weight per plant (g), earliness, winter hardiness and grain yield were measured. The results obtained were statistically evaluated using ANOVA and correlation analysis.

Regarding meteorological conditions, NARDI Fundulea area is characterized by a continental temperate climate, with uneven distribution of rainfall by months. The data regarding temperature and rainfall registered during the years of testing, delivered by the Weather station of NARDI Fundulea, are presented in Table 1. Weather conditions over two years during winter peas vegetation period and especially during the grain filling period, were very different.

Table 1. Rainfall distribution and average temperatures during winter peas vegetation at NARDI Fundulea (2019-2021)

Month	2019/2020		2020/2021	
	Temperature (°C, mean values)	Rainfall (mm)	Temperature (°C, mean values)	Rainfall (mm)
October 2019/2020	12.8	38.2	14.7	28.6
November 2019/2020	6.2	33.2	6.1	20
December 2019/2020	4	12.8	3.9	77.6
January 2020/2021	0.9	2.0	1.6	77
February 2020/2021	5.2	16.0	3.2	16.2
March 2020/2021	8.3	16.6	5.1	59
April 2020/2021	12.3	29.8	9.7	31
May 2020/2021	16.8	14.0	17.2	56
June 2020/2021	21.7	57.8	21.1	135
Total rainfall		**219.8**	-	**500.4**

Source: The weather station NARDI Fundulea

As shown in Table 1, rainfall was higher and unevenly distributed during the vegetation period of 2021, in contrast to 2020 characterized by less rainfall. Overall monthly temperatures were positive on average, not allowing a good selection of genotypes according to their frost tolerance.

RESULTS AND DISCUSSIONS

Application of the two-way analysis of variance (Table 2) on the characteristics of the pea genotypes showed statistically significant effects of the environments (years) and genotypes in all investigated parameters excepting the both, number of seed per plant and grain yield. Genotypic influence on the expression of the height of the plant and the number of pods and seeds per plant was prevalent.

Table 2. Analysis of variance for stability for yield components in winter pea genotypes - NARDI Fundulea (2019-2021)

		Plant heigth		Number of pods per plant		Number of grains per plant		The grains weigh per plant (g)		Earliness		Grain yield	
Source of variation	df	F	P-value	F	P-value	F	P-value	F	P-Value	F	P-value	F	P-value
Genotypes	7	100.7**	0.000	2.52**	0.12	1.01	0.49	1.36	0.035	23**	0.0002	1.63	0.27
Years	2	289.5**	0.000	18.7**	0.003	20.8**	0.002	176.5**	0.000	25.2**	0.0015	105.2**	0.000
Interaction	7	-	-	-	-	-	-	-	-	-	-	-	-
Total	15	-	-	-	-	-	-	-	-	-	-	-	-

In Table 3 the correlation indexes between these characters over all genotypes are presented.
The values of the genotypic correlation coefficients with a positive sign were slightly higher than the phenotypic ones, that suggests a less pronounced effect on the manifestation of the studied traits.
Significant positive genotypic relations were evidential with respect to plant height and grain yield (r = 0.99***), number of pods per plant with number of grains per plant (r = 0.90***) and grain yield (r = 0.87***) and plant height (r = 0.80***), the grains weigh per plant with earliness (r = 0.83***). The number of grains per plant was significant positively correlated with grain yield (r = 0.69**) and plant height (r = 0.64*). The value of r = 0.68* indicates the significant and positively relation between winter hardiness and earliness. Our results suggest that these traits would contribute to increasing grain production and should be taken into account in the selection of genotypes. There was a strong negative correlation between earliness and plant height (r = -0.83***), grain yield and earliness (r = -0.82***), the grains weight per plant with grain yield (r = -0.66*) and plant height (r = -0.62*). Timmerman-Vaughn et al. (2005) indicated that grain weight is negatively correlated with seed yield. The results obtained in our study support the conclusions made by Adetiloye et al. (2017) in cowpea.

Table 3. Correlation coefficients between winter pea yield component

	Number of pods per plant	Number of seeds per plant	The grains weight per plant (g)	Plant heigth	Earliness	Grain yield	Winter hardi ness
Number of pods per plant	X						
Number of seeds per plant	0.90***	X					
The grains weight per plant (g)	-0.45	-0.07	X				
Plant heigth	0.80***	0.64*	-0.62*	X			
Earliness	-0.48	-0.24	0.83***	-0.83 ***	X		
Grain yield	0.87***	0.69**	-0.66*	0.99 ***	-0.82 ***	X	
Winter hardiness	0.42	0.34	-0.52*	0.47	0.68*	0.51*	X

The authors established significant positive genotypic correlations between productivity and pods number, pod length and seeds number per plant. The carried out assessment on the dependencies in white lupine accessions was in line with the studies of Machado et al. (2017) in soybean genotypes correlations concerning the pods number and seed production per plant. Similar finding have been reported by other researchers (Tiwari & Lavanya, 2012; Govardhan et al. 2013 and Kosev & Georgieva, 2022).
According to the results of experiments at NARDI Fundulea, extensive phenotypic variation was observed in the analyzed pea genotypes. Means value of plant height, number of pods per plant, number of seeds per plant, seed weight per plant and grain yield were lower, which is likely to be the consequence of drought in the flowering period in May 2020 (Table 1). For all characteristics, statistically significant differences were observed for mean value between two season, except for earliness and winter hardiness (Table 4). The results obtained in our study partially support the conclusions made by Uhlarik et al. (2022). The highest coefficients of variation (CV) were observed for grain yield (102% by James), grain weight per plant (82% by 12034MT1-2), plant height (53 % by James), number of seeds per plant (51% by 12034MT1-2), number of pods

per plant (37 % by James). The lowest CV was observed for winter hardiness and earliness.

The results of this study should contribute to a better knowledge of variability and seed yield stability of winter pea genotypes. These phenotypic results could improve pea breeding by developing new cultivar scarring favorable traits to attain more sustainable production and higher yields. Last but not least, such work should promote the broader use of pea as a grain legume within diverse agricultural systems to provide multiple beneficial economic advantages, in line with the principles of sustainability within diverse national agricultural systems.

Table 4. Descriptive measures of winter peas genotypes at NARDI Fundulea

No.	Genotype	X_{av}	X_{opt}	X_{lim}	Stress tolerance	Std.	C.V.%
Plant height							
1.	JAMES	46.,5	64	29	-35	24.7	53
2.	ENDURO	50.5	63	38	-25	17.7	35
3.	LAVINIA F	51.5	66	37	-29	20.5	40
4.	GHITTIA F	58	79	37	-42	29.7	51
5.	13008MT28-1	54	70	38	-32	22.6	42
6.	12004MT2	56.5	73	40	-33	23.3	41
7.	12034MT1-2	128.5	147	110	-37	26.2	20
8.	12038MT2	49	63	35	-28	19.8	40
Number of pods per plant							
1.	JAMES	13.25	16.7	9.8	-6.9	4.9	37
2.	ENDURO	14	14.2	14	-0.2	0.14	0
3.	LAVINIA	12.25	14.5	10	-4.5	3.2	26
4.	GHITTIA F	12.15	13	11.3	-1.7	1.2	10
5.	13008MT28-1	13.8	15.3	12.3	-3	2.1	15
6.	12004MT2	11.1	13.5	8.7	-4.8	3.4	31
7.	12034MT1-2	17	20	14	-6	4.2	25
8.	12038MT2	11.45	12.4	10.5	-1.9	1.3	12
Number of seeds per plant							
1.	JAMES	48	63	33	-30	21.2	44
2.	ENDURO	59	66	52	-14	9.9	17
3.	LAVINIA	51	65	37	-28	19.8	39
4.	GHITTIA F	48.5	49	48	-1	0.7	1.4
5.	13008MT28-1	52	64	40	-24	17	33
6.	12004MT2	41.5	48	35	-13	9.2	22
7.	12034MT1-2	62.5	85	40	-45	31.8	51
8.	12038MT2	47.5	56	39	-17	12	25
The grains weigh per plant (g)							
1.	JAMES	8.3	13	3.6	-9.4	6.6	81
2.	ENDURO	10.35	14	6.7	-7.3	5.2	50
3.	LAVINIA	10.3	15	5.6	-9.40	6.6	65
4.	GHITTIA F	9.75	12	7.5	-4.5	3.2	33
5.	13008MT28-1	9	13	5	-8	5.7	63
6.	12004MT2	8.75	12	5.5	-6.5	4.6	53
7.	12034MT1-2	7.6	12	3.2	-8.8	6.2	82
8.	12038MT2	9	13	5	-8	5.7	63
Earlines							
1.	JAMES	118	121	115	-6	4.2	4
2.	ENDURO	118	122	114	-8	5.7	5
3.	LAVINIA	117.5	119	116	-3	2.1	2
4.	GHITTIA F	118	121	115	-6	4.2	4

No.	Genotype	X_{av}	X_{opt}	X_{lim}	Stress tolerance	Std.	C.V.%
5.	13008MT28-1	119.5	122	117	-5	3.5	3
6.	12004MT2	118	121	115	-6	4.2	4
7.	12034MT1-2	136.5	137	136	-1	0.7	1
8.	12038MT2	117	120	114	-6	4.2	4
Grain yield							
1.	JAMES	3413.5	5875	952	-4923	3481	102
2.	ENDURO	4171.5	6667	1676	-4991	3529	85
3.	LAVINIA	3567.5	6083	1052	-5031	3557.5	100
4.	GHITTIA F	3498	5208	1788	-3420	2418	70
5.	13008MT28-1	3270.5	4875	1666	-3209	2269	70
6.	12004MT2	3104.5	5208	1001	-4207	2975	96
7.	12034MT1-2	1808	2917	699	-2218	156.4	87
8.	12038MT2	2883.5	4375	1392	2983	2109.3	73
Winter hardiness							
1.	JAMES	1.5	1.5	1	-0.5	0.4	3
2.	ENDURO	1.5	2	1	-1	0.7	6
3.	LAVINIA	1.5	2	1.5	-0.5	0.4	3
4.	GHITTIA F	1.5	1.5	1.5	0	0	0
5.	13008MT28-1	2	2	1.5	-0.5	0.4	3
6.	12004MT2	1.5	2	1	-1	0.7	6
7.	12034MT1-2	2	3	1.5	-1.5	1	7
8.	12038MT2	2	3	1.5	-1.5	1	7

X_{av} - average value of trait (2019-2021), X_{opt} - maximal value of trait (in optimal conditions), X_{lim} - minimal value of trait (in limit conditions), Std.- standard deviation, C.V. - coefficient of variation (%).

CONCLUSIONS

- Investigated of eight winter pea genotypes for yield and physiological parameters under field condition in Fundulea region, Romania revealed that yield and yield components in pea is a complex character largely depending on genotypes, environmental, agronomical and physiological characters.
- Grain yield and some yield components, some physiological characters and correlation among these traits varied in winter pea genotypes analysed.
- The genotypic correlation was higher than the phenotypic one for all the traits that indicates a minor role of environment on the expression of the genes involved.
- Pea is a sustainable crop with multiple economic advantages.

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