AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 9, No 1, pp 19 - 25, 2017
DOI: 10.15547/ast.2017.01.004

Productivity and adaptability of new genotypes field pea (*Pisum sativum* L.) cultivated under environmental condition of Southern Romania

R. Sturzu*, A. M. Ene, Cr. Melucă, J. M. Cojocaru

Agricultural Research and Development Station Teleorman, Drăgănești Vlașca, 147135 Teleorman, Romania

(Manuscript received 11 October 2016; accepted for publication 19 January 2017)

Abstract. *The purpose of the paper was to identify new peas genotypes, created in Agricultural Research and Development Station, Teleorman, South Romania, with improved productivity and adaptability to the environmental conditions of that region. The study was carried out with 25 field pea varieties for a period of three years (2013-2015). The experiment was conducted in randomized complete blocks design in three replications. The results of variance analysis showed that there was significant difference among pea genotypes by grain yield. The average yield over three years showed that lines M 1357, M 1410, M 1418 and M 720 achieved higher yield levels compared with the control genotype Vedea and with the average yield of all tested genotypes. Yields stability was estimated by coefficient of variability. Correlation analysis showed that the strongest relations there are between productivity elements: number of pods and seeds per plant (r = 0.905), number of pods and seeds weight per plant (r = 0.655), number of seeds per plant and seeds weight (r = 0.815), plant height and first pod insertion height (r = 0.921). There are significant negative correlations between 1000 seeds weight and number of grains per plant (r = - 0.229), number of pods per plant and 1000 seeds weight (r = -0.346), the first pod insertion height and number of pods per plant (r = -0.530), and the number of grains per plant (r = -0.412). The results obtained in this study suggest that, the new field pea genotypes are suitable for spreading and cultivating in Southern Romania.*

Keywords: pea, genotypes, yield, variability coefficient, correlation

Introduction

Legumes occupy unique position in world agriculture due to their high protein content and the ability to fix atmospheric nitrogen. Peas are grown in many countries from all continents and occupy a total area of about 6.33 million ha (Cherinet and Tazebachew, 2015). This crop has significant economic and environmental benefits in the areas of crop production, particularly due to their role in enhancing soil fertility and crop rotations, which serves as a break crop suitable for crop rotation, minimizing the negative impacts of monoculture grain. Furthermore, peas provides valuable and inexpensive food for humans because it contains 27% protein, 42.6% carbohydrates, many vitamins, minerals, dietary fibers and antioxidant compounds (Siddika et al., 2013; Tofiq et al., 2015), and it is a good source of income for farmers. Although the average production worldwide is about 1.7 t/ha, while in Romania it stands at 2-2.5 t/ha, the productive potential of peas is high (4-5 t/ha), especially in Western European countries (Cherinet and Tazebachew, 2015; Roman et al., 2016), where expanded areas are planted (1 723 000 ha with 3 021 000 tons) and improved varieties of „aphila" type are used, very productive and adapted to biotic and abiotic stress.

Creating and identifying lines and varieties more valuable than those in the target crop is characteristic of modern agriculture, since variety directly contributes to increased production, more efficiently utilising the other technological measures applied. To increase the stability of yields from year to year, new varieties of peas must have an attitude superior both in terms of years of drought, and in the normal rainfall or surplus that combines a high potential for production with good adaptability to water and temperature stress.

Reviving the crop peas in Romania is conditional on the introduction of the crop of certain varieties of peas increasingly valuable and continuous improvement of the cultivation technology, it is strongly supported by its role as the basic raw material for the production of aggregated protein feed and satisfying the domestic production of vegetable protein as a goal. The purpose of the paper was to identify new peas genotypes, created in Agricultural Research and Development Station, Teleorman, South Romania, with improved productivity and adaptability to the environmental conditions of that region.

* e-mail: rodicasturzu@yahoo.com

Material and methods

During 2013 – 2015, in the Agricultural Research and Development Station (ARDS), Teleorman, Romania, complex ecological pea testing was organized to identify the most suitable and efficient genotypes, improving genetic vulnerability and environmental sizing of agro-ecosystems. The data presented in this paper refers to the behavior of 25 field pea genotypes (one variety witness and 24 new lines of type „aphila") in three years with different climatic conditions in terms of air temperature and rainfall. The meteorological parameters were recorded by the local meteorological station.

The experiment was conducted in the field after the randomized blocks design in three replications with compartment harvested 10 m^2, wheat as a predecessor plant, irrigated, fertilized with 150 kg/ha complex fertilizers (N20:P20:K0) to prepare the soil. The sowing was carried in a mechanized way, crop density of 55 germinated grains/m^2 and a depth of 4-5 cm.

In the three years of study, genotypes were analyzed both in terms of production capacity (yield/ha) and some morphological characters - height plant, height insertion of first pod, number of pods and number of seeds per plant, seeds weight per plant and

1000 grains weight. The plant analysis included biometric measurements and determining the weight of the productive parameters.

All data obtained were statistically processed and interpreted by variance analysis method (Ceapoiu, 1968) and coefficients of variation and correlation.

Results and discussion

Climatic conditions during 2013 – 2015 were different from year to year with marked effects on key elements of pea productivity of different studied pea genotypes. During the pea crop vegetation in 2013 the average temperatures in March, April, May and June were higher compared to the annual average temperature with deviations of + 0.4°C, +1.4°C, + 1.2°C and +2.3°C, respectively. The rainfalls in this period exceeded the annual average quality by 6.7 mm in March, by 25.1 mm in May and by 71.8 mm in June. Monthly rainfall distribution was uneven in most months of the vegetation period. During the first 20 days of April it was only 6.8 mm, and in May - 11.6 mm, all in the first two decades of the month, which led to poor vegetative growth of the plants, the (phenophases) periods of flowering, fruiting and ripening were even faster (shorter). As a result, grain yields of the majority of genotypes obtained were very low (Figures 1 and 2).

2014 was characterized by moderate average temperatures in April, May and June (deviations by months were -0.3°C, +0.5°C and +1.2°C), but with higher rainfall than the monthly average rainfall with relatively even distribution (+45.4 mm, +16.9 mm and +55.0 mm). Plants developed very well, with lush growth and yields were very high, but harvesting has been difficult because plants fell due to torrential rains accompanied by storms.

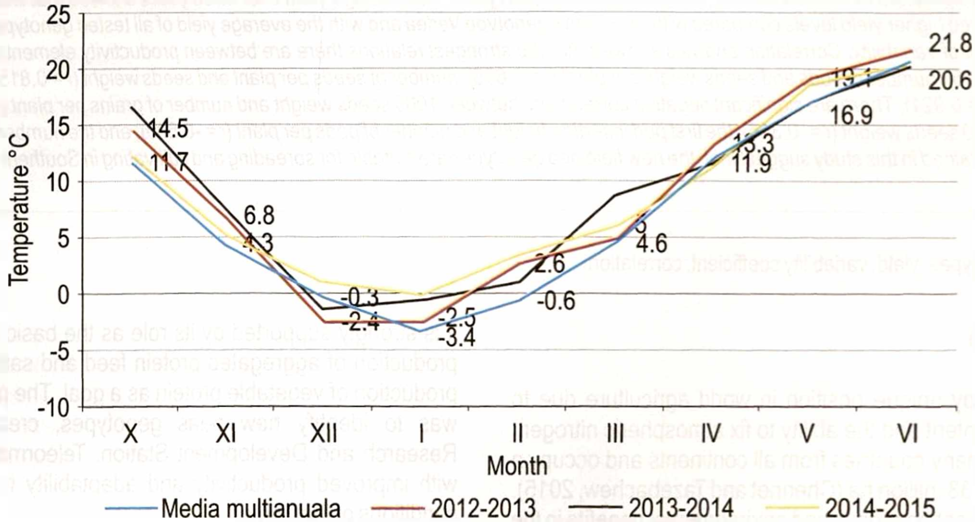

Figure 1. Monthly temperatures (°C) registered during 2013 - 2015

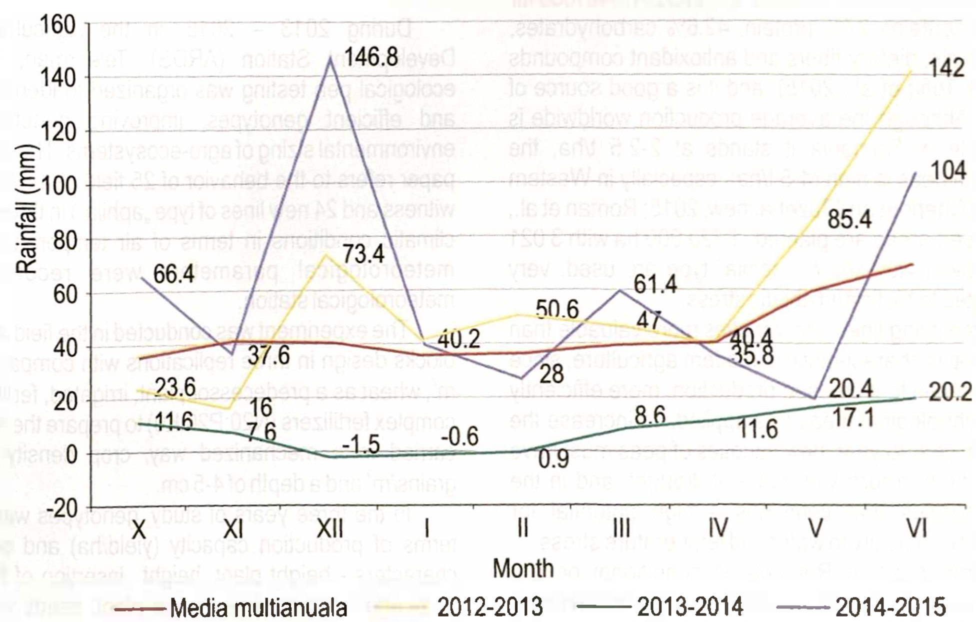

Figure 2. Monthly rainfall (mm) registered during 2013 - 2015

In 2015, the average monthly temperatures in March, May, June and July exceeded the annual average temperature by +1.4°C, +1.7°C, +0.3°C and +3.0°C, respectively. Amid a precipitation surplus in March (20.4 mm) and April (30.4 mm in the first and second decade), there was delayed soil preparation and sowing was carried out with a delay of about 30 days. May was with rainfall deficit of 39.9 mm, which had the effect of rising and relatively uneven growth of pea plants. In June the recorded rainfall (104.0 mm) exceeded the annual average rainfall by 33.0 mm, which led to a relatively normal growth and development of pea plants, and in July there were 9.8 mm rainfall, of which 8.0 mm in the first decade, which was not been used by peas that were in the mature stage and were harvested.

Yields obtained during the three years (2013 – 2015) of the investigation showed that there is great variability from year to year, from 1830 kg/ha (line M 1504, 2013) to 5027 kg/ha (line M 1327, 2014). The production increases statistically significant compared with the average values of all tested pea genotypes in lines M 1327 (2013, 2014, 2015), M 1418 (2013, 2014, 2015), M 1421 (2013, 2014, 2015), I 225 (2014, 2015), M 1011 (2014, 2015), and M 720 (2013, 2015) (Table 1). The lowest yields were obtained in 2013, dry year with rainfall unevenly distributed on vegetation stages of pea (highest rainfalls were recorded in the period of formation of productivity elements). The highest yields were obtained in 2014, characterized as normal in terms of temperature and water soil supply was relatively uniform, distributed rainfalls throughout the pea growing season.

Table 1. Average yields obtained by pea genotypes tested during 2013-2015

Genotype	2013		2014		2015	
	kg/ha	significance	kg/ha	significance	kg/ha	significance
Vedea (control)	3050	***	3327		3230	
M1	3000	***	3605		3550	
M2	2300		3370		3365	
M9	2150		3507		3185	
M 720	2850	*	4103		3843	**
I 1011	2050		4383	***	3983	***
I 225	1900		4450	***	4157	***
I 242	1850		4100		3448	
I 995	2330		3950		3127	
I 121	2700		4183	*	3143	
M 155	2450		3650		3547	
M 759	2150		3483		3130	
M 170	2983	***	3750		3357	
M 879	2700		4053		3423	
M 1504	1830		3257		2950	
M 1441	2650		3480		3390	
M 1431	3000	***	3487		3340	
M 1424	1950		3775		3193	
M 1421	2840	*	4363	***	3890	***
M 1418	3000	***	4330	**	3747	*
M 1399	1850		4297	**	3607	
M 1390	1900		3975		3613	
M 1327	3450	***	5027	***	3970	***
M 1290	2300		4783	***	3600	
M 1263	2960	**	3700		3607	
Mean	2488		3936		3496	
LSD 5%	2.83		2.43		2.23	
LSD 1%	3.78		3.24		2.97	
LSD 0.1%	4.92		4.22		3.87	

* p< 0.05; ** p<0.01; *** p<0.001

Regarding the yields achieved by the tested lines, averaged over the experimental period (2013-2015), higher production than the average of all genotypes tested (3308 kg/ha) were recorded in lines M 1327 (4149 kg/ha), M 1421 (3698 kg/ha) M 1418 (3692 kg/ha), M 720 (3599 kg/ha) M 1290 (3561 kg/ha), I 225 (3502 kg/ha) M 1011 (3472 kg/ha) and M 1263 (3422 kg/ha). The yields of those lines were statistically higher (between 140 and 841 kg/ha) compared to the mean yield of all tested genotypes (Tables 1 and 2). Compared with control variety Vedea which achieved an average production of 3302 kg/ha, the genotypes tested have achieved significant production increases of 140-947 kg/ha. Pea genotypes with the worst record production were M 1504, M 759, M 9 and M 1424.

Analysis of the variation coefficients values of each tested genotypes shows that lines M 1327, M 1421, M 1418, M 720, M 1290, I 225 and I 1011 were the slightest during these years (C_v = from 7.39 to 8.96%), which demonstrates that these lines are very productive, with high adaptability to climatic conditions of the area. Pea lines M 1424, M 9, M 759 and M 1504 were with the biggest changes in yields (C_v = from 10.30 to 11.44%). They achieved low average yields, including the lowest one (below 3000 kg/ha), which shows that these genotypes productivity and production stability reacted weakly even in good years (Table 2), (Figure 3).

Table 2. Average 3 years yield of tested pea lines - difference, significance error and coefficient of variation

Genotype	Yield (kg/ha)	%		Difference (kg/ha)		Significance error		Coeff. of var. (Cv),%
		to control	to mean lines	to control	to mean lines	control	mean lines	
Vedea (control)	3202	100.0	96.8	0	-106			9.57
M1	3385	105.7	102.3	183	77	**		9.06
M2	3012	94.0	91.0	-191	-296			10.18
M9	2947	92.0	89.1	-255	-361			10.40
M 720	3599	112.4	108.8	397	291	***	***	8.52
I 1011	3472	108.4	105.0	270	164	***	**	8.83
I 225	3502	109.4	105.9	300	194	***	**	8.75
I 242	3133	97.8	94.7	-69	-175			9.78
I 995	3136	97.9	94.8	-67	-172			9.77
I 121	3342	104.4	101.0	140	34	*		9.17
M 155	3216	100.4	97.2	13	-92			9.53
M 759	2921	91.2	88.3	-281	-387			10.49
M 170	3403	106.3	102.9	201	95	**		9.01
M 879	3392	105.9	102.5	190	84	**		9.04
M 1504	2679	83.7	81.0	-523	-629			11.44
M 1441	3173	99.1	95.9	-29	-135			9.66
M 1431	3276	102.3	99.0	73	-32			9.36
M 1424	2973	92.8	89.9	-229	-335			10.31
M 1421	3698	115.5	111.8	496	390	***	***	8.29
M 1418	3692	115.3	111.6	490	384	***	***	8.30
M 1399	3251	101.5	98.3	49	-57			9.43
M 1390	3163	98.8	95.6	-39	-45			9.69
M 1327	4149	129.6	125.4	947	841	***	***	7.39
M 1290	3561	111.2	107.7	359	253	***	***	8.61
M 1263	3422	106.9	103.5	220	114	***		8.96
Mean	3308	-	100.0	-	0	-	-	9.57
	LSD 5% = 119 kg/ha							
	LSD 1% = 157 kg/ha							
	LSD 0.1% = 202 kg/ha							

* $p< 0.05$ ** $p<0.01$ *** $p<0.001$

The results of analysis of production variance in genotypes tested for 3 years and interaction variants x years are presented in Table 3. The F sample experimental value shows very significant effects of both variants, and the interaction variants x years reveals that genotypes had different behavior from one year to another.

Studying the correlations between the main morphoproductive characters shows that the most relevant (positive and very significant) are the correlations between productivity elements: number of pods and number of seeds per plant (r = 0.905***), number of pods and seeds weight per plant (r = 0.655**), number of seeds per plant and seeds weight (r = 0.815***), but also between plant height and first pod insertion height (r = 0.921***), (Figures 4, 5 and 6). Similar results were obtained by Avci and Ceyhan (2006), Esposito et al. (2009), Yucel (2013), Anwar et al. (2014) and Tofiq et al. (2015) for the number of pods and seed weight/pl. The results

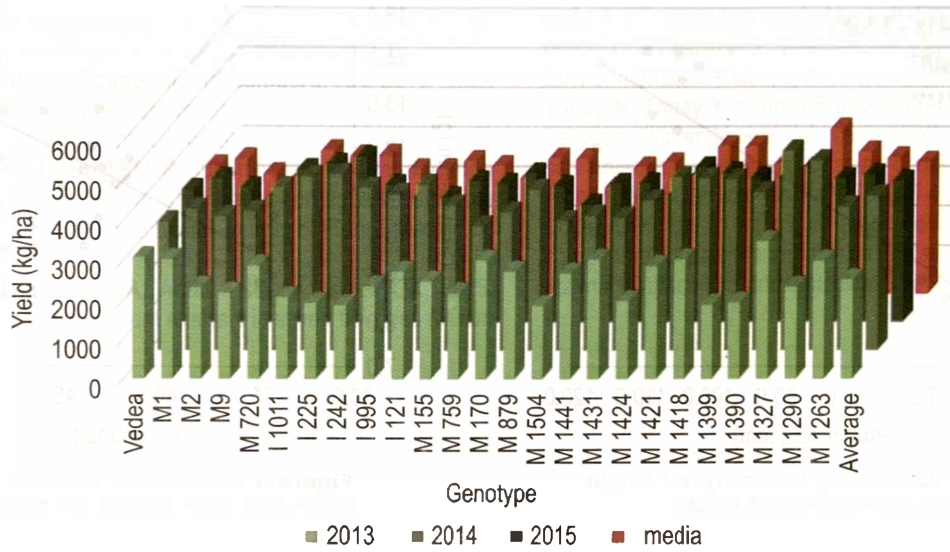

Figure 3. Yields of pea genotypes tested during 2013-2015

Table 3. ANOVA for yield over three years

Source of variation	SS	FD	SS/FD	F to E	F to s^2 V x Y
Blocks	2.23	6			
Years	11845444.70	1			
Variants	2030.28	23	88.27	55.16***	0.93^{NS} (2.00-2.70)
Var. x years	2174.75	23	94.55	59.09***	
Error	230.47	144	1.60		
Total	11849882.43	197			

*** p<0.001
NS - non significant

Table 4. Correlation coefficients between the main characters of tested morphoproductive pea genotypes

Character	First pod insertion	No. pods per plant	No. seeds per plant	Seed weight per plant	1000 grain weight
Plant height	+0.921***	+0.494**	+0.330*	-0.128	-0.317°
First pod insertion	x	-0.530°°	-0.412°°	-0.217	-0.069
No. pods per plant		x	+0.905***	+0.655**	-0.346°°
No. seeds per plant			x	+0.815***	-0.229
Seed weight per plant				x	+0.372**
1000 grain weight					x

*) and °) positive and negative correlation coefficients significant at p<0.05 level
**) and °°) positive and negative correlation coefficients significant at p<0.01 level
***) and °°°) positive and negative correlation coefficients significant at p<0.001 level

indicate that these characters are the main elements of peas productivity and links between them can be taken as the criteria for selection to increase productivity in the breeding program for this species.

A significant negative correlation between the first pod insertion height and number of pods per plant (r = -0.530°°), and the number of grains per plant (r = -0.412°°) shows that the number of grains and pods on plant height negatively decrease with increasing insertion (Table 4). Both plant height and first pod insertion height link negatively with grain size (r = -0.317° and r = -0.069), respectively. Close values of correlation coefficients were found by Togay et al. (2008) and Siddika et al. (2013), while Yucel (2013) reported significant positive correlation coefficients or none.

There are significant negative correlations between 1000 seeds weight and number of grains per plant (r = - 0.229), (Table 4). A significant inverse relation was found between the number of pods per plant and 1000 seeds weight (r = -0.346°°), which shows that 1000 seeds weight decreases with increasing the number of

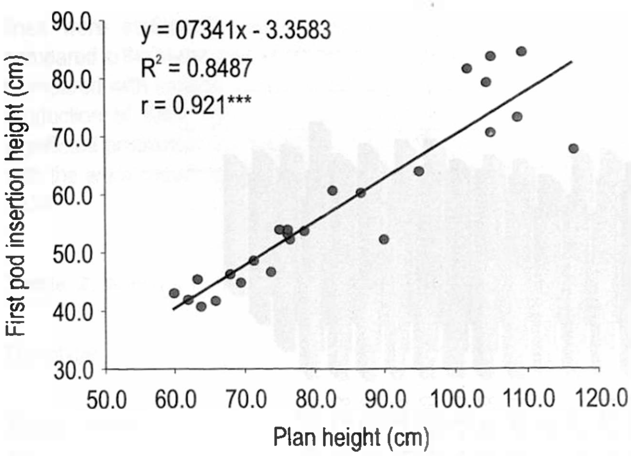

Figure 4. Relationship between plant height and first pod insertion height to pea

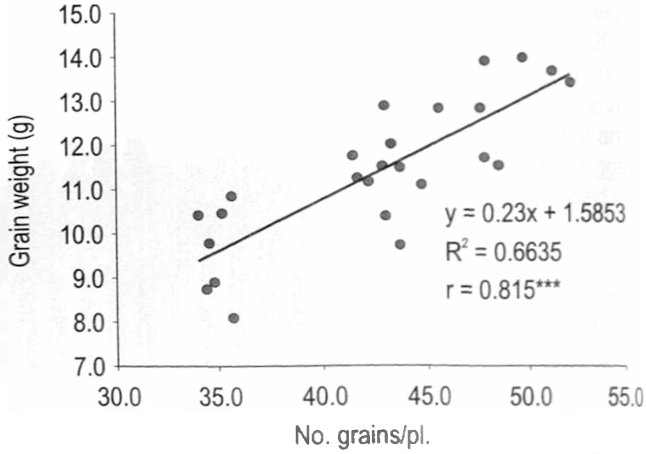

Figure 5. Relationship between the number of grains and grain weight per plant to pea

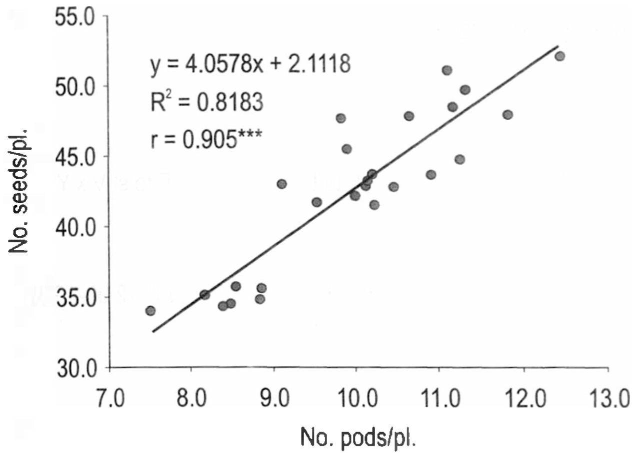

Figure 6. Relationship between number of pods and number of seeds per plant to pea

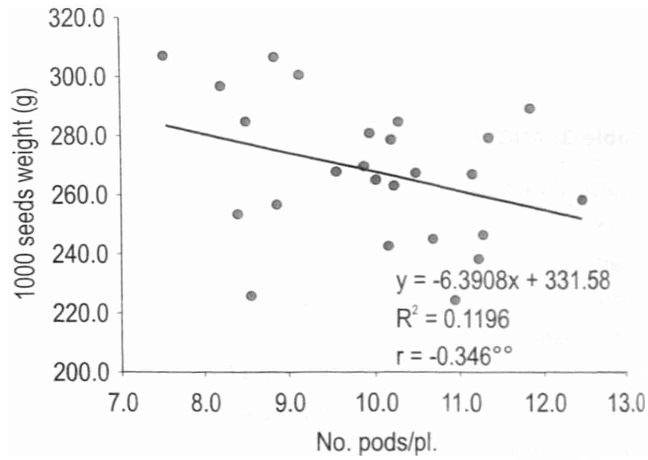

Figure 7. Relationship between number of pods per plant and 1000 seeds weight to pea

fructifications being a proxy on selection for productivity (Figure 7). Similar values of the correlation coefficient between the two characters were reported by Yucel (2013), Siddika et al. (2013) and Tofiq et al. (2015), while Avci et al. (2006) and Togay et al. (2008) found significant positive correlations or none.

Conclusion

The investigation period (2013 – 2015) was characterized by different air temperature and rainfall. The main factor influencing the level and stability of pea production is the amount and distribution of rainfall during the crop growing season. Average yields of over 3500 kg/ha were obtained from new lines of pea M 1327 (4149 kg/ha), M 1421 (3698 kg/ha), M 1418 (3692 kg/ha) M 720 (3599 kg/ha) M 1290 (3561 kg/ha) and I 225 (3502 kg/ha). The production of these genotypes increases compared to the control genotype Vedea between 140 and 947 kg/ha and compared to the average yields of tested pea genotypes by 164 to 841 kg/ha. The strongest correlation relations are between productivity elements: number of pods and seeds per plant (r = 0.905), number of pods and seeds weight per plant (r = 0.655), number of seeds per plant and seeds weight (r = 0.815), plant height and first pod insertion height (r = 0.921). The highest yields were obtained in 2014, a year characterized as favorable (normal) both in terms of heat and rainfall, and the lowest yields were obtained in 2013, a year characterized as dry. The climatic conditions in the Southern Romania are suitable for cultivation of the new pea genotypes as they are with good productivity and versatility to the biotic and abiotic stress features of the environment.

References

Anwar RA, Jalal OA and Sarkawt AA, 2014. Study five genotypes of pea (*Pisum sativum* L.) in terms of yield components under conditions Sulaymanyah-Bakrajo. International Journal of Engineering and Technical Research, 2, 18-22.

Avci MA and Ceyhan E, 2006. Correlations and genetic analysis of pod characteristics in pea (*Pisum sativum* L.). Asian Journal of Plant Sciences, 5, 1-4.

Ceapoiu N, 1968. Metode statistice aplicate în experiențele agricole și biologice. Ed. Agro-Silvică, București (Ro).

Cherinet A and Tazebachew A, 2015. Adaptability of fields pea (*Pisum sativum* L.) varieties under irrigation, Western Amhara Region, Ethiopia. International Journal of Plant Breeding and Genetics, 9, 28-31.

Espósito MA, Martin EA, Cravero VP, Liberatti D, López AFS and

Cointry EL, 2009. Relationships among agronomic traits and seed yield in pea. Journal of Basic and Applied Genetics, 20, 1-8.
Roman GV, Epure LI, Toader M and Lombardi AR, 2016. Grain legumes – main source of vegetal proteins for European consumption. AgroLife Scientific Journal, 5, 178-183.
Siddika A, Aminul Islam AKM, Rasul MG, Mian MAK and Ahmed JU, 2013. Genetic variability in advanced generations of vegetable pea (*Pisum sativum* L.). International Journal of Plant Breeding, 7, 124-128.
Tofiq SE, Abdulkhaleq DA, Amin TNH and Azez OK, 2015. Correlation and path coefficient analysis in seven field pea (*Pisum sativum* L.) genotypes created by half diallel analysis in Sulaimani region for F2 generation. International Journal of Plant, Animal and Environmental Sciences, 5, 93-97.
Togay N, Togay Y, Yldirim B and Dogan Y, 2008. Relationships between yield and some yield components in Pea (*Pisum sativum* ssp. *arvense* L.) genotypes by using correlation and path analysis. African Journal of Biotechnology, 7, 4285-4287.
Yucel DO, 2013. Impact of plant density on yield and yield components of pea (*Pisum sativum* ssp. *sativum* L.) cultivars. ARPN Journal of Agricultural and Biological Science, 8, 169-174.