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PERSPECTIVES IN WINTER PEAS BREEDING PROGRAM

Ancuţa CRÎNGAŞU (BĂRBIERU)[1,2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
Faculty of Biotechnologies, 59 Mărăşti Blvd, 011464 Bucharest, Romania,
phone. 004-021-318.36.40, fax..004-021-318.25.88, e-mail: cringasuancuta@yahoo.com
[2]National Agricultural Research and Development Institute Fundulea, Street N. Titulescu, No.1,
Calarasi, Romania, phone. 021-3110722, fax. 021-3110722, e-mail: office@incda-fundulea.ro

Corresponding author email: cringasuancuta@yahoo.com

Abstract

Peas (Pisum sativum) are an excellent source of protein, carbohydrates and many essential micronutrients therefore is considered a nourishing flow throughout the body. Field pea is the main large-grain legume in Europe. According to the purpose, peas can be divided into grain and fodder peas. Grain pea cultivars are mostly spring crop, while the majority fodder pea cultivars are winter-forms. The field pea it is a main protein crop used for both, human and animal nutrition, being an alternative European plant species that will reduce imports of soybean from the United States, Argentina etc. In the last 20 years, in Romania, the grown area with field pea decreased considerable, the average cultivated being approximately 25.000 ha/year. The main reason of this aspect is the drastic reduction of number of animal big farms. However, winter peas can be an alternative to improve the area grown with peas in Romania. Preliminary data obtained at NARDI Fundulea shown that the yield of winter forms of peas was between 4267-4800 kg/ ha, over yield the spring type, sown in the spring with 191-215 %. Winter peas have some advantages over spring peas like: a better establishment and more efficient use of humidity during the winter season - which makes it less vulnerable to drought over the spring, frequently in Romania in the last years; winter peas can be sown in mixture with some cereal (barley, triticale) for obtaining high nutritive green forage; earlier harvest; has a longer vegetation period and get higher productivity and more stable yield than spring peas type. The winter peas breeding programs at international level have several objectives: frost is one of the main climatic stresses which have to be overcome by a winter pea crop; realized the winter pea varieties with better performance in no-till technology systems to obtain the green forage in mixture with some cereals. In Romania, the initiation of winter peas breeding program started at NARDI Fundulea in 2010, following acquisition of some winter peas germplasm from USA and Austria. The main goals of this program are related to: realized winter pea varieties adapted to specific climatic conditions from Romania, and initiation of the program for obtaining the green forage.

Key words: *winter pea, green forage, breeding.*

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important annual cool season legumes in the world today (Mihailovic and Mikic 2010). Producing pea (*Pisum sativum* L.) is one of the least expensive and at the same time most quality answers to a perennial demand for plant protein by animal husbandry (Maxted and Ambrose 2000). Pea also represents a valuable addition to or a complete replacement for soybean meal in the years with less favorable conditions for the cultivation of the latter (Mikic et al. 2003). Their total area in Europe may and should be increased due to many environmental, economic and social reasons. Recent agroeconomic research in contrasting regions of the European Union confirmed that pea and other grain legumes may profitably be included in diverse crop rotations every 3–6 years (Nemecek et al. 2008). Achieving this strategic goal requests the vivid and strengthened interactions between genetics, breeding, agroecology and agronomy.

Pea is considered rather well adapted to wide temperature ranges, with seedlings able to survive even -20°C (Shereena and Salim, 2006). From a physiological viewpoint, pea becomes tolerant to frost if first exposed to low non-freezing temperatures, causing the so-called cold acclimation, where regular light intensity improves the freezing tolerance and where a close relationship between the soluble sugar concentration of leaves just before the frost and the degree of freezing tolerance exists (Bourion et al. 2003). Pea plants are also able to modulate their photosynthetic rate during growth at low temperature and adjust it as needed for survival (Yordanov et al. 1996).

Delayed floral initiation helps some forage pea genotypes to escape the main winter freezing periods, as susceptibility to frost increases during the transition to the reproductive state (Lejeune-Henaut et al. 1999). Numerous studies describe the physiological and phenological effects of the main loci governing the transition to flowering in pea, such as *Lf* and *Hr*, known to delay floral initiation of autumn-sown peas until a longer day length is reached in the following spring (Lejeune-Henaut and Delbreil 2009). The oldest winter pea cultivars carry the dominant allele, *Hr*, although some bear *hr* (Bourion et al. 2002). They are generally characterized by prominent winter hardiness and a long growing season, from sowing in early October until either cutting for forage production in late May or harvesting seeds in mid-July. A study of one population of recombinant inbred lines (RILs) allowed detection of six quantitative trait loci (QTL) for frost tolerance, which is in agreement with an oligogenic determinism of frost tolerance in pea.

In this population, the most explanatory QTL was found to localize with the Hr locus (Lejeune-Henaut et al. 2008). Further studies in the same genetic background gave an insight in the genetic determinism of physiological traits potentially involved in cold acclimation, showing for example the colocalization of QTLs for raffinose concentration or RuBisCO activity with QTLs for frost tolerance on linkage groups 5 and 6 (Dumont et al. 2009).

Breeding winter forage pea emphasizes the development of the lines with satisfying tolerance to low temperatures and more prominent earliness, with great potential for both forage and grain yields.

Breeding and the cultivation of fall-sown pea confirm that it could be one of the least expensive and most efficient ways to decrease the unpredictable and destroying effects of spring droughts and other manifestations of climatic changes on protein-rich crops such as pea. They also establish a solid basis for the anticipation that the existence of high-yielding, early and winter hardy fall-sown dry pea cultivars will increase the total area under grain legumes, especially in Europe, and thus contribute to a significant increase of the protein needed for ever demanding animal husbandry.

The paper presented the preliminary results obtained in the winter pea breeding program NARDI Fundulea.

MATERIALS AND METHODS

The winter peas breeding program started at NARDI Fundulea in 2010, using a germplasm originated from USA (Specter and Windham) and from Austria, (Checo). Beside this winter type germplasm was added several spring Romanian genotypes with some tolerance to winter hardiness after autumn planted test.

During the 2012 and 2013 has been tested yield performance and winter hardiness level of resistance at three winter genotypes and eight spring genotypes in one trial, in three reps planted in autumn. Also in 2013, in head rows are tested, for the first time 940 F3 lines selected from winter /winter or winter/spring crosses pea genotypes for winter hardiness, plant height and earliness. Among this in the paper are presented only 20 F3 lines selected from the crosses Specter/Checo.

The level of resistance to winter hardiness was estimated in the field, early in the spring, in a scale 1to 9, where score 1 is very resistance and 9 very susceptible. Plant height was measure in cm, total length of plant from the ground till the top to the end of flower time. The earliness was appreciated like number of days from 1st January till the end of flowering time.

The statistical analyses of data have been evaluated by ANOVA and calculation of linear regressions between traits.

RESULTS AND DISCUSSIONS

The yield performances and the winter hardiness of winter and spring pea genotypes planted in autumn in two years are presented in the table 1. It is notice that the all three winter varieties out yielded significantly, in average, in the both years, the spring pea genotypes. In some case the level of yield of the winter varieties has been almost double against the spring control variety Aurora. Of course the differences between the winter form and the spring form can be higher in the years with a severe winter.

In the tested years, 2012 and 2013, as can see the score data of level winter hardiness in the spring forms, the winter in both years was too mild.

Table 1. Yield and winter hardiness of several winter and spring pea genotypes sown in autumn.

Genotype	Yield kg/ha (2012)	Yield kg/ha (2013)	Yield mean		Winter hardiness
			kg/ha	%	
Checo (W)	2800	3840	**3320**	145	1,5
Windham (W)	4267	3180	**3990**	174	1
Specter (W)	4800	2544	**3672**	160	1,5
Aurora (S)	1866	2714	2290	100	3
Dorica (S)	1533	1969	1751	76	3
Marina (S)	1700	1856	1778	78	3
Nicoleta (S)	1433	1444	1439	63	4
F05-2039 (S)	1800	2235	2018	88	4
F98-492 (S)	1600	1552	1576	69	5
F98-603(S)	1400	2267	1834	80	2
F95-927 (S)	1167	1495	1331	58	3
LSD 5%	705	626	666	29	-

Yield advantage of winter pea varieties against spring varieties remained also when was compared the yield of winter forms planted in autumn with the spring forms planted in spring (Table 2). This can be explain that the winter pea varieties used much better the water accumulated during the winter time and are much lower affected by the drought period in the early spring.

Table 2. Comparison between yields of spring pea varieties planted in spring with those of winter pea type planted in autumn

No	Genotypes	Growth habit	Time of planting	Yield (2012/2013)		
				Kg/ha	Diff.	%
1.	Nicoleta (control)	spring	spring	2360	0	100
2.	Rodil			1766	-594	74
3.	Aurora			1846	-514	78
4.	Specter	winter	winter	3672	1312	155
5.	Windham			3724	1364	157
6.	Checo			3320	960	140

Among the winter germplasm used in the NARDI-Fundulea breeding program there are genotypes with long vegetation period, like Specter and Windham form USA, and earliness European type (Checo from Austria) both with good level of resistance to winter hardiness (fig.1).

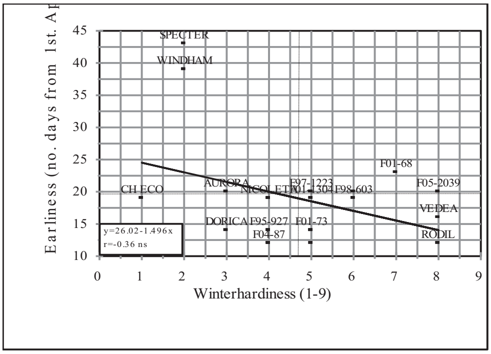

Fig.1 The relationship between earliness and winter hardiness of 25 winter and spring pea genotypes planted in autumn.

The relationships between earliness and winter hardiness had shown that different genetic mechanisms for winter hardiness are involved in the winter pea germplasm from USA and Austria one.

The preliminary data presented in this paper has been like aims to demonstrate if it is possible to recombine the plant height and high biomass from American variety Specter with earliness and high level of winter hardiness from the Austrian variety Checo.

The correlation between winter hardiness and earliness of the F3 lines selected from the cross Specter/Checo suggested that it is easier to identify the genotypes which combine earliness and with high winter hardiness (fig. 2).

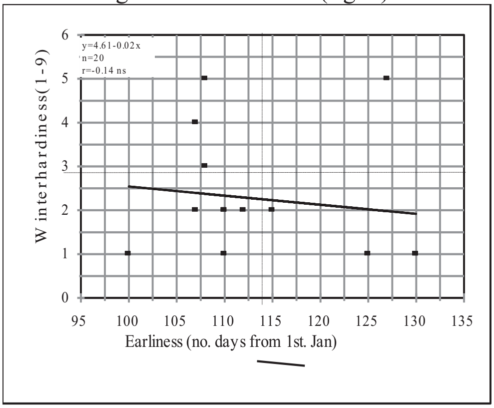

Fig. 2 *Relationships between earliness and winterhardiness of F3 lines selected from the cross Specter/Checo (winter peas/winter peas)*

Also, the data shown that there are no problems to recombine plant height and winter hardiness, correlation between those traits, of the lines F3 from the same cross, was no significantly (fig.3).

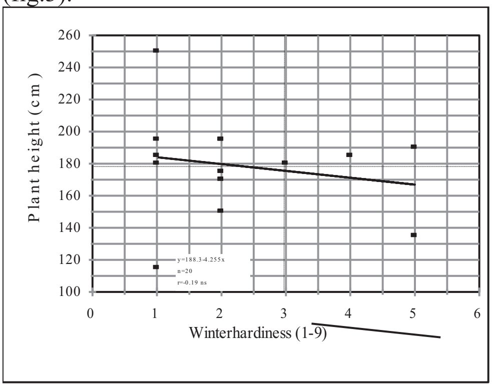

Fig. 3 *Relationship between plant height and winterhardiness of F3 lines selected from the cross Specter/Checo (winter peas/winter peas)*

More interesting it is the no significantly of correlations between earliness and plant height (fig. 4). That suggests the possibility to improve the biomass of the very early winter pea genotypes.

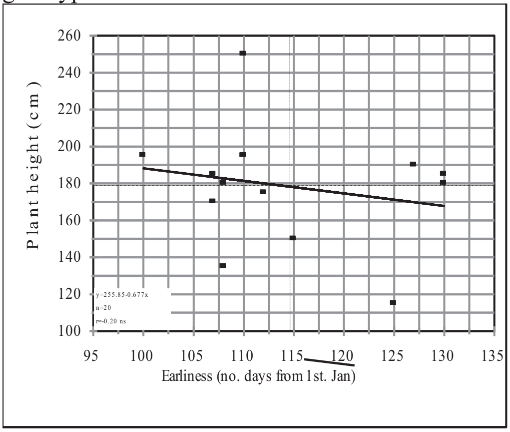

Fig. 4 *Relationship between plant height and earliness of F3 lines selected from the cross Specter/Checo (winter peas/winter peas)*

Of course, the researches which will develop in the next future will be emphasized to select the winter pea cultivars that must combine earliness, with high biomass, high yield, and lodging resistance and improve winter hardiness.

For that it is needed to developed better method to screen the breeding material, as early as possible for winter hardiness, in artificial (growth chamber) or field conditions and even using marker assistant selection for the QTL's well known involve in winter hardiness.

CONCLUSIONS

The preliminary data obtained suggested that the winter pea forms out yielded the spring pea type either in the planted in the autumn even when was compare with the yield of the spring type planted in the spring;

Our data shown the possibility to combine earliness, with high biomass, high yield and improve winter hardiness.

For that it is needed to developed better method to screen the breeding material, as early as possible for winter hardiness, in artificial (growth chamber) or field conditions and even using marker assistant selection for the QTL's well known involve in winter hardiness.

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