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PRELIMINARY RESULTS OF THE WINTER PEAS BREEDING PROGRAM

Ancuţa CRÎNGAŞU (BĂRBIERU)[1,2]

[1]University of Agronomic Sciences and Veterinary Medicine – 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, 1 N. Titulescu Street, Calarasi, Romania, phone. 004-021-311.07.22, fax. 004-021-3110722, e-mail: office@incda-fundulea.ro

Corresponding author email: cringasuancuta@yahoo.com

Abstract

The development of the winter pea crop represent a major challenge to expand plant protein production in temperate areas. Breeding winter cultivars requires the combination of freezing tolerance as well as high seed productivity and quality.
Winter peas have some advantages over spring peas like: 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, grasses) 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.
In this paper we present data obtained from the first F3 lines of winter peas obtained in the NARDI-Fundulea program with the germplasm of winter peas from USA and Austria. A number of 176 lines, selected from winter/winter and winter/spring crosses pea genotypes, have been tested in preliminary trials in 2015. Data for yield showed a large variation, but some lines over yield significantly the winter control (Specter, Checo and Windham).
The conclusion of this preliminary study is that will be possible to realize the genetic progress in breeding in winter peas, to select the new varieties with good enough winter hardiness and being with high yield, different earliness or plant height.
Of course, the breeding program just started, from a short time, and it is needed to improve the genetic bases of the germplasm use for all traits, but mainly for winter hardiness.

Key words: *winter pea, breeding, witer hardiness, yield.*

INTRODUCTION

Field pea (*Pisum sativum* L.) is an economically important grain legume crop cultivated worldwide. Its agricultural benefits include improved soil nitrogen, better weed management and reduced disease for other crops with which it is grown in rotation. It is high in protein and is extensively used for animal feed and is increasingly used for the production of food products. The growing market for this crop demands adapted varieties with high grain yield and potential to tolerate the stresses prevalent in a range of production environments (Shafiq et al. 2012)
Mechanisms of resistance or tolerance to freezing temperatures in cool season of grain legumes have already been reviewed. The plants can avoid or resist ice crystal formation in the cells. They can also escape freezing stress by delaying sensitive phonological stages, particularly floral initiation and flowering, until after winter freezing periods have passed.
Forage peas have been used in all winter pea breeding programs in Europe. Winter peas have a good level of frost resistance, and are also characterized by a large foliage development in spring which favors lodging and fungal diseases in humid conditions (Lejeune-Heaut et al., 1999).
Development of winter pea cultivars should be a way to improve yield potential and stability through a longer life cycle and hence increase crop competitiveness. Autumn sowing allows for a higher biomass production as well as the

avoidance of drought and heat stresses of late spring (Stoddard et al., 2006).

Winter hardiness is a complex quantitative trait conditioned by the plant genotype and the environment in which is grown. Current varieties grown in world are considered as cold tolerant. Winter hardiness has been sought by North American and French scientists and although some level tolerance to cold has been obtained it remains a challenge (Murray and Swensen, 1991).

Most winter pea breeding programs have used the wild winter *Pisum fulvum* pea because it has good resistance to freezing: such genotypes can survive temperatures of -6°C (no damage to leaves; 100% survival). Although several genetic studies have been conducted, there is not a general consensus on the gene action controlling the expression of cold hardiness in pea. Genetic studies on winter hardiness in pea have rivaled that it is quantitative in nature and governed by intermediate dominance and additive genes (Ercan, 2006).

Quantitative trait loci (QTL) for frost tolerance were detected on linkage groups III, V and VI. A major QTL of pea frost tolerance on LGIII was located in vicinity of the Hr locus (Weller et al., 2012).

Lejeune-Henaut et al. (1999; 2008) proposed that reproductive frost damage might be avoided by developing winter varieties with the Hr (gene) flowering phenotype, in which floral initiation is delayed under short days. In European production environments, Hr plants may be able to escape frost stress by delaying flowering until after freezing periods have passed.

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 (Crîngaşu, 2015).

The aim of this work was to appreciate the yield performance and other traits and mainly the winter hardiness of several winter pea genotypes in the climatic conditions from 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 Austria, (Checo). Beside this winter type germplasm was added several spring Romanian genotypes with some tolerance to winter hardiness after autumn planted test. All the experiments were performed on experimental fields at NARDI Fundulea.

Yield performance and winter hardiness level were studied in a trial with 25 entries, involved three winter genotypes (Checo, Windham, Specter) and twenty-two spring genotypes (Table 1), in three replications, planted in autumn during the 2014 and 2015.

Also in 2015, in eight trials, in one replicate, were tested, for the first time, 176 F3 lines, selected from winter/winter or winter/spring crosses pea genotypes, for yield, winter hardiness, plant height and earliness. The area of harvest plot was four m².

The level of resistance to winter hardiness was estimated in the field, early in the spring, in a scale 1 to 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 flowering time. The earliness was appreciated like number of days from 1st January till the end of flowering time and yield as kg/ha.

The statistic analyses of data have been evaluated by ANOVA, correlations and linear regressions between study 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 (Checo, Windham, Specter) out yielded significantly, in average, in the both years, the spring pea genotypes. The yield level of the winter varieties has been almost double against the spring control variety Nicoleta. 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, 2014 and 2015, as can see the score data, the differences in winter hardiness between the winter and spring forms in both years was not too high, because winters were milder than normal. However, differences in yield, between those three winter varieties and the spring control Nicoleta, range from 1161 till 1876 kg/ha.

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

Genotype	Yield kg/ha (2014)	Yield kg/ha (2015)	Yield mean			Winter hardiness
			kg/ha	Dif. kg/ha	%	1-9
Checo (W)	3300	2800	**3050**	1646	217	1
Windham (W)	1830	3300	**2565**	1161	183	1
Specter (W)	3031	3530	**3280**	1876	234	2
Aurora (S)	850	1455	1153	-251	82	5
Dorica (S)	910	880	895	-509	64	5
Marina (S)	1113	726	920	-484	66	5
Nicoleta (S)	1180	1627	1404	0	100	4
F01-1304 (S)	1380	760	1070	-334	76	5
F09-641 (S)	1903	938	1421	17	101	5
F04-87 (S)	990	1316	1153	-251	82	4
F01-73 (S)	710	1540	1125	-279	80	5
F98-492 (S)	930	1346	1138	-266	81	4
F97-1422 (S)	970	1241	1106	-298	79	4
F99-701 (S)	1060	850	955	-449	68	5
F09-641 (S)	1703	405	1054	-350	75	6
Mona (S)	1200	270	735	-669	52	5
Vedea (S)	870	400	635	-769	45	6
Rodil (S)	560	170	365	-1039	26	6
Eiffel (S)	970	450	710	-694	51	7
Zekon (S)	893	190	542	-862	39	8
F04-148 (S)	750	570	660	-744	47	5
Turbo (S)	1230	610	920	-484	66	5
F00-78 (S)	670	370	520	-884	37	6
F11-1189 (S)	1130	720	925	-479	66	6
LSD 5%	631	672	651	-	46	-

The preliminary data presented in this paper of the 176 F3 lines selected from the winter/winter and winter/spring crosses, demonstrated that it is possible to obtain genotypes which recombined good enough level of winter hardiness with high yield, earliness and different level of plant height. The yield distribution of 176 F3 lines (Figure 1) suggested the selection of genotypes with significant high yield than winter genitor used in the crosses (Specter, Checo and Windham).

The correlation between yield and winter hardiness had (Figure 2) shown a very strong negative relationship among those traits (r=-0.54***). However, the distribution of the lines along regression line, demonstrated the possibility to select the new lines with the same level of winter hardiness like winter parents but with high level of yield than these.

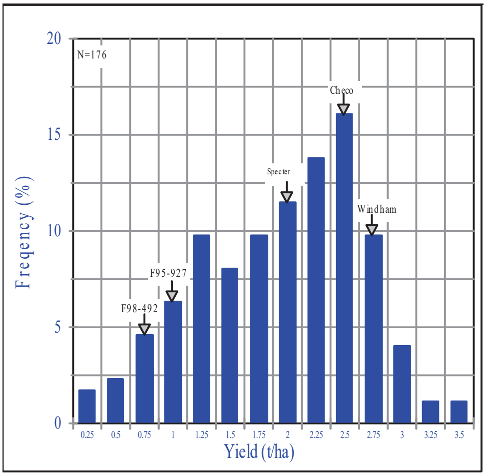

Figure 1. Distribution of 176 F3 winter pea lines after their yield (t/ha)

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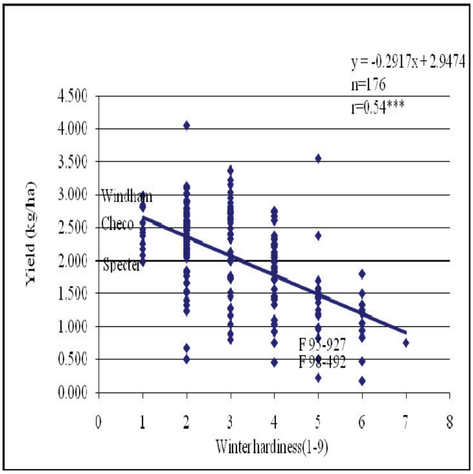

Figure 2. Correlation between winter hardiness and yield data of 176 F3

The data obtained till now form the study of relationship between winter hardiness and plant height indicated the possibility of recombination of both traits of interest (plant height and winter hardiness) (Figure 3) suggesting that, in functions of the end use the production, for forage need to be a tall variety, for high biomass production or mid tall variety for grain type.

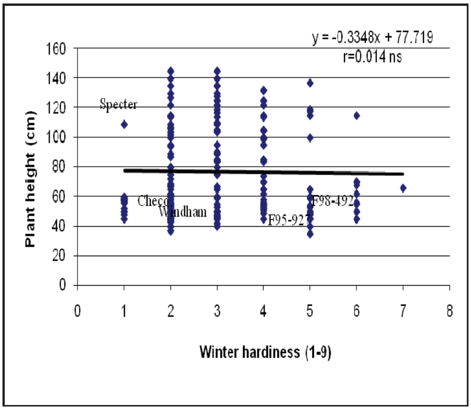

Figure 3. Relationship between winter hardiness and plant height data of 176 F3

No relationship has been found between winter hardiness and earliness data of those 176 lines analyzed (Figure 4).

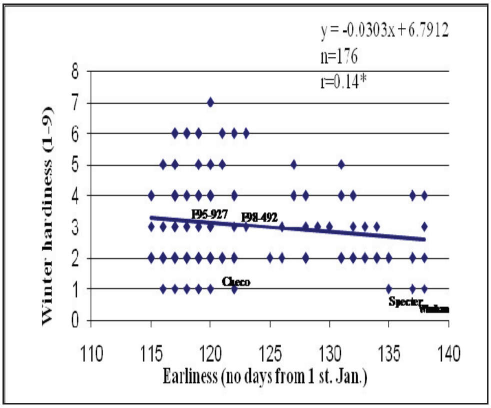

Figure 4. Relationship between winter hardiness and earliness of F3 data of 176 F3

However, high enough correlation between winter hardiness of F4 generation lines and F3 generation lines was observed, demonstrating that trait it is too high inherit and make it easy to be improved.

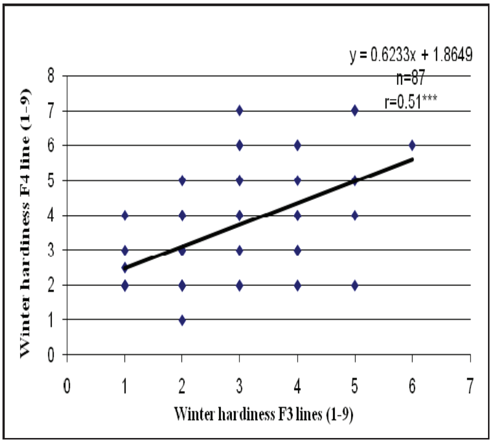

Figure 5. Relationship between winter hardiness F4 and of F3 data of 176 F3

CONCLUSIONS

The conclusion of this study is that will be possible to realize the genetic progress in breeding in winter peas, to select the new varieties with good winter hardiness and being with high yield, different earliness or plant height.

The yield data had shown high yield performances of winter pea's type than spring type sown in autumn, even in the mild winter condition.

The breeding program just started, from a short time, and it is needed to improve the genetic bases of the germplasm use for all traits, but mainly for winter hardiness.

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