Evaluation of new green pea lines for freezing*

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Abstract. Five Bulgarian lines of wrinkle-seeded garden peas for freezing have been characterized. The experiment was carried out in the experimental field of the Maritsa Vegetable Crop Research Institute, Plovdiv, during 2011–2013. The vegetation period, productivity, biometric and technological characteristics have been determined. Panel test has been performed three and six months after the freezing. The aim of the study was to establish the biological, technological and quality characteristics of garden pea lines suitable for freezing with a view to their implementation into production or their use in breeding process as donors of valuable qualities. The results from the summarized evaluation show that line № 1159 belongs to a group of mid-early varieties and is suitable for freezing and short-term storage. It was given for testing in the Executive Agency for Variety Testing, Field Inspection and Seed Control, Sofia.

Key words: biological, technological and quality characteristics, freezing, *Pisum sativum*.

Introduction

Garden pea is one of the most plastic protein crops with a great diversity of forms and varieties registered both in the Official variety bulletin, issued by Executive Agency for Variety Testing, Approbation and seed Control – Sofia and in the Common catalogue of varieties of vegetable species, issued by the European Commission. The breeding studies have been focused mainly on the inheritance of morphological characteristics associated with the yield and disease resistance. The modern DNA-technology and biotechnological approaches have extended the genetic investigations to studies of the pea genome, including the physiological characteristics and metabolic ways (Leonforte & al. 2006; McMurray & al. 2010; Ohmido 2011). The biological characteristics of the pea provide an opportunity for successful growing as a winter and early spring crop and thus limiting the water and temperature stress during the reproductive period (Alcalde & al. 2006; Kosev & Sachanski 2012).

Global breeding priorities are focused on creating a resistance to biotic and abiotic stress, including resistance to herbicides (Dita & al. 2006; Clement & al. 2009), breeding of genotypes with higher adaptability, wide ecological plasticity as well as studies related to the quality of pea production (Lejeune-Henaut & al. 2008; Burstin & al. 2011; Materne & al. 2011; Atanasova & al. 2013).

Green seeds are used mainly for processing and this does not reflect strongly on their nutritional qualities, compared to the other vegetables. Vitamin C and vitamin B_2 are preserved 70 % and 97 %, respectively, in the frozen peas. In the sterilized cans this loss was significantly greater: Vitamin C was preserved 20 %, and vitamin B_2 – 66 %.

Minimal quality requirements for green seeds in the industrial processing are to maintain optimal colour, flavour and structural characteristics. Larger seeds are suitable for freezing and cold storage, while the fine-seed pea varieties are recommended for sterilization (Kalapchieva & al. 2002).

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The aim of this study was to evaluate the suitability for freezing of garden pea breeding lines and to determine a candidate-variety for testing of distinctness, uniformity and stability (DUS) in the Executive Agency for variety Testing, Field Inspection and Seed Control, Sofia.

Material and Methods

Five garden pea lines from the collection of the Maritsa Vegetable Crops Research Institute, Plovdiv, Bulgaria: №72_2, №72_9, №73_{10} (*Frimento* x *Debretseny*), № 95_4 (*Noytsuht 205* × *Vitalis*) and line №1159 from Institute for Plant Genetic Resources – Sadovo, Bulgaria were the object of this study. Variety *Skinado* of mid-early group was used as a control.

The experiment was performed in the experimental plot of the Maritsa Vegetable Crop Research Institute-Plovdiv, Bulgaria during the period 2011–2013 set by a block method with 4 replications, in a 6.4 m^2 working plot, on a high flat bed by scheme 80+20+40+20/4–5 cm. The trial was carried out by adopted technology for green pea field production.

Studied characteristics:

- Phenological observations and duration of interphase periods /in days/ sowing-emergence, emergence-flowering, flowering-technological maturity as well as vegetation /in days/ from emergence to technological maturity.
- Morphological characteristics and biometrical measurements of average sample, containing 10 plants: plant height (cm) and height to first pod (cm), node number per plant and node number to the first pod, inter-node length (cm), length of pod (cm), pod number per productive node, number of seeds per pod.
- Productivity – green pods and green seeds yield (kg/da).
- Technological analysis – dry matter content (%), average output (%), distribution of seeds by fractions (%).
- Sensory analysis of frozen pea immediately after freezing and no later than 3- and 6-month storage – colour, condition of the seed skin, aroma, tenderness, sweetness, starch taste, texture and overall taste. A five-point hedonic scale from 1 to 5 with 0.25 step was applied.

The data were processed by Duncan's multiple range test and two-way analysis of variance (SPSS statistic programme).

Results and Discussion

The results of this study have demonstrated that there were no proved differences in the duration of vegetation period and phenophases of garden pea lines (Fig. 1). It was established that the vegetation period of Line 95_4 was with an average of five days longer compared to the period of standard *Skinado* (65 days). The studied accessions may be referred to the group of mid-early varieties of garden pea.

Plants of the five lines had mid-high stems varying from 61 to 78 cm (Table 1). The height of lines №1159 and №95_4 depended not on the length of internodes (5 cm per №1159 and 4.6 cm per №95-4) but mainly on their greater number (21) per plant. Fertile part of the plant height was suitable for mechanized harvesting – 32.9 cm – 56.8 cm. The investigated breeding lines did not differ in their formed pods per plant, except for №1159, being in a separate group, according to the analysis made. Line №73_{10} had the lowest percentage of the two pods per peduncles while for other lines

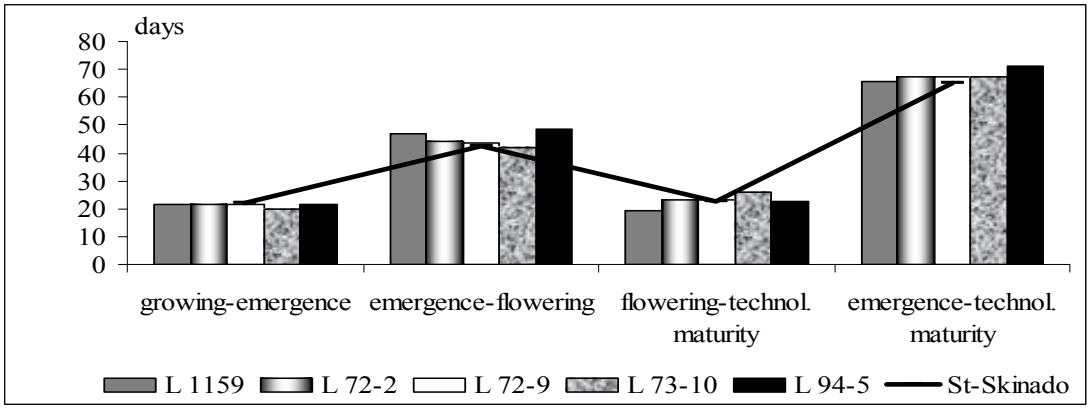

Fig. 1. Duration of the vegetation period, in days.

Table 1. Morphological analysis.

Variety, lines	Plant height, cm	Height to first pod, cm	Internode length, cm	Unproductive nodes, number	Nodes per plant, number	Pods per plant, number	Pods per productive node, %			Pod length, cm	Weight of green seeds /plant (g)	Seeds per plant, %		Average seed number per pod
							by 1	by 2	by 3			Plump	Non-plump	
Line 1159	78.0a	56.8a	5.0bc	16.4a	21.5a	8.9c	16.5cd	83.5a	0.0b	10.0a	23.8n.s.	90.3n.s.	9.7n.s.	7.2a
Line 72_2	65.6bc	45.2c	4.8bc	14.4b	19.8b	12.7b	22.1bc	77.9a	0.0b	7.8c	22.1n.s	89.3n.s.	10.7n.s.	6.2bc
Line 72_9	61.3c	37.9d	5.0bc	13.8b	20.0b	17.0a	25.5ab	74.5ab	0.0b	7.2d	28.7n.s.	91.5n.s.	8.5n.s.	5.7c
Line 73_{10}	64.0c	32.9e	6.3a	10.4d	17.8c	16.5ab	33.1a	66.9bc	0.0b	8.2b	25.6n.s.	89.6n.s.	10.4n.s.	5.7c
Line 95_4	69.0b	49.3b	4.6c	15.7a	21.1a	14.7ab	18.8bcd	81.2a	0.0b	7.8bc	27.4n.s.	88.6n.s.	11.4n.s.	6.3b
St-*Skinado*	68.0b	48.2bc	5.4b	13.1c	19.1b	14.4ab	12.8d	60.7c	26.5a	7.7c	26.3n.s.	90.5n.s.	9.5n.s.	6.7b

a,b… Duncan's multiple range test (p<0,05)

this percentage was over 75 % and variety *Skinado* only formed three pods per peduncles. Line № 1159 was characterized by larger length of the pods and a greater number of seeds in the pods. There were no differences for the individual productivity and the percentage of plump seeds per pod in the studied genotypes.

Two-way analysis of variance of morphological characteristics of garden pea lines showed the presence of significant differences between the tested genotypes, the years and interaction "genotype x year" for greater part of the studied characteristics (Table 2).

The factor Genotype has had the greatest influence on the variability of the unproductive node numbers, pods length and height to the first pod. Conditions of the year had an impact on plant height and weight of green seeds per plant, while the interaction "genotype x years" – on the internode length.

The technological analysis showed that the breeding lines were distributed in three groups according to the average size of seeds: line № 72-9 was in the same group with the standard. Lines № 72-2, 73-10 and № 95-4 were in another group and individually with the highest average size of seeds is line № 1159 (Table 3). There were no significant differences between investigated lines regarding the average output which varied within the range of 34.7 % to 39.5 %. The seeds of four lines were distributed in the two fractions (8–9 and 9–10 mm), whereas predominant per-

Table 2. Influence to the factors of variation on the morphological characteristics of the garden pea genotypes, in %.

Sources of variation	Plant height	Height to first pod	Internode length	Unproductive nodes	Nodes per plant	Pods per plant	Pods per productive node			Pod length	Weight of green seeds / plant	Seeds per plant		Average seed number per pod
							by 1	by 2	by 3			Plump	Non-plump	
Genotype (A)	16.3 ***	47.8 ***	13.3 ***	58.4 ***	21.8 ***	8.2 ***	13.2 ***	14.7 ***	41.5 ***	52.8 ***	n.s.	n.s.	n.s.	20.4 ***
Year (B)	40.4 ***	19.2 ***	16.5 ***	2.5 **	34.6 ***	30.1 ***	10.4 ***	8.8 ***	n.s.	15.6 ***	37.3 ***	2.8 *	3.0 *	4.2 **
(A) x (B)	9.7 ***	10.0 ***	31.4 ***	5.5 **	n.s.	10.5 ***	n.s.	n.s.	n.s.	4.5 **	8.7 **	n.s.	n.s.	8.5 *

*** P ≤ 0.001, ** – P ≤ 0.01, * – P ≤ 0.05, ns – not significant

Table 3. Technological analysis.

Variety, lines	Dry matter, %	Seed size, mm	Average output , %	Fractions, %					
				waste	6–7 mm	7–8 mm	8–9 mm	9–10 mm	над 10 mm
Line 1159	24.8 bc	9.1 a	39.2 n.s.	0.9 bc	1.6 c	9.1 c	31.1 c	42.3 a	15.1 a
Line 72_2	16.1 ab	8.5 b	39.5 n.s.	0.7 c	7.3 b	19.4 b	43.1 a	24.1 b	5.5 b
Line 72_9	24.3 bc	8.2 c	34.7 n.s.	1.5 a	11.6 a	28.8 a	39.0 b	16.3 c	2.9 c
Line 73_{10}	27.8 a	8.4 b	36.1 n.s.	1.1 abc	6.4 b	21.3 b	45.2 a	21.6 bc	4.4 bc
Line 95_4	23.3 c	8.5 b	35.1 n.s.	1.2 ab	5.2 b	19.8 b	44.2 b	25.1 b	4.5 bc
St-*Skinado*	25.3 b	8.2 c	37.9 n.s.	1.2 ab	10.8 a	30.4 a	38 5 b	16.2 c	2.9 c

a,b…Duncan's multiple range test (p<0,05)

centage of the seeds for the standard and line № 72-9 were in fractions 7–8 mm and 8–9 mm.

New line № 1159 has performed higher productivity than the standard *Skinado* and the other lines except for line № 95_4 (Table 4). The average yield of green seeds ranged from 252.8 kg/da to 389.4 kg/da.

Table 4. Productivity.

Variety, lines	Number of harvesting plants	Yield of green pods, kg		Yield of green seeds, kg	
		per 6.4 m^2	per 1 da	per 6.4 m^2	per 1 da
Line 1159	284.3 ab	5.69	997.3 a	2.29	389.4 a
Line 72_2	279.2 abc	3.19	777.8 bc	1.16	308.3 bc
Line 72_9	251.3 bc	3.66	724.3 c	1.3.8	252.8 c
Line 73_{10}	323.8 a	4.07	782.5 bc	1.50	272.8 c
Line 95_4	263.9 bc	4.85	889.2 ab	1.97	340.6 ab
St-*Skinado*	230.2 c	4.40	758.3. bc	1.74	288.1 bc

a,b… Duncan's multiple range test ($p<0.05$)

The studied genotypes have shown good value in the sensory evaluation after three- and six-month frozen storage (Fig. 2).

There were significant differences between the lines in the dry matter, the average seed size and the predominant factions as well as differences in the yield of green pods and green seeds between the years of the study (Table 5).

The relative part of genotypes in the general variation was 42 % for dry matter, 68 % for the average size of the seed and more than 50 % for most of the fractions (Table 5). Therefore, the characteristics were strongly genetically determined and the choice of genotypes would be more successful in these characteristics. The conditions of years had the strongest influence on the variability of yields of green pods (67.9 %) and of green seed (59.1 %), which is particularly valuable for breeding because of their unpredictability. The interaction "genotype x years" (as a factor) had the weakest effect on variation in the studied characteristics – a maximum of 25.6 % for the output.

Conclusion

Lines № 1159 and № 95-4 are perspective garden pea lines for freezing. We offer line № 1159 for official variety testing as a new variety in the Executive agency for variety testing, field inspection and seed control, Sofia in order to conduct tests for distinctness, uni-

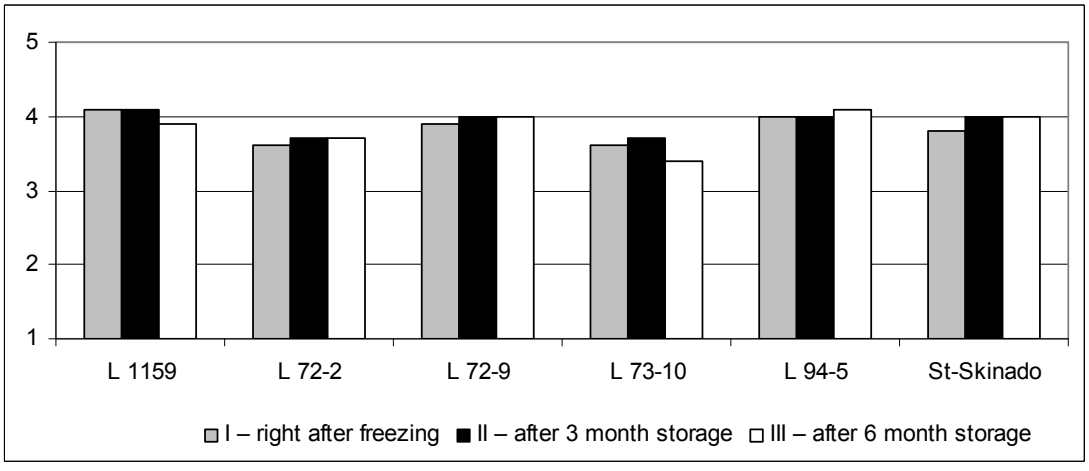

Fig. 2. Sensory evaluation of the frozen pea.

Table 5. Influence of the factors of variation on the yield and technological characteristics, in %.

Sources of variation	Number of harvesting plants	Yield of green pods	Yield of green seeds	Dry matter	Seed size	Average output	Fractions					
							waste	6–7	7–8	8–9	9–10	>10
Genotype (A)	7.0 *	5.3 *	8.1 **	42.0 ***	68.0 ***	n.s.	16.5 **	54.3 ***	57.8 ***	38.2 ***	54.5 ***	67.8 ***
Year (B)	56.6 ***	67.9 ***	59.1 ***	10.5 **	n.s.	5.8 *	18.1 ***	n.s.	n.s.	13.8 ***	n.s.	3.6 *
(A) x (B)	9.1 *	7.8 *	11.0 **	n.s.	n.s.	25.6 *	n.s.	n.s.	15.6 **	n.s.	12.2 *	7.7 *

*** $P \le 0.001$, ** – $P \le 0.01$, * – $P \le 0.05$, ns – not significant

formity and stability and consequently to accept this line as a new variety listed in the Official Variety List of the country.

The vegetation period from germination to technological maturity of this line is 65–66 days. The stem is a simple type, glabrous, high 74–78 cm. The flowers are white, 83.5 % are two and more rarely one per fertile node. The first pods are located on the 16^{th}-17^{th} node. The pods are with very weak curvature, with a pointed shape of the distal part, 10–11 cm long and with 8–9 well shaped dark green seeds.

In average dry matter 24.1 % the line has an average output of 40.0 % and an average seed size of 9 mm. The seeds are more than 73 % in the next two fractions – 8–9 mm and 9–10 mm.

The average yield of green seeds for the studied period is 389.4 kg/da. After three- and six-month storage the sensory characteristics are good enough and this is the main reason to determine this line as suitable for freezing.

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