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# IMPROVEMENT GENOTYPES SELECTION AND ASSESSMENT METHODS FOR PEA BY THE COMPLEX OF ECONOMICALLY VALUABLE TRAITS

*Selected are recombinant and transgressive forms of Pisum sativum* L. *with a complex of signs important to breeding. Established was inheritance and variability of morphobiological and quantitative traits with futher usage the selected breeding material in hybridization process.*
***Keywords:*** *Pisum sativum* L.*; hybridization; selection; seed; variety*

**Introduction**. Pea production is constantly growing in the world due to the breeding progress resulting in its high-yield varieties. Modern technology for pea growing urges breeders to create varieties of certain morphotypes (leaf-free, short-stem, of determined growth type). Pea is one of the prominent crops among the legumes for its protein content, as well as essential amino acids and their uptake. The value of pea as fallow crop is that it can improve soil structure, restore its fertility by accumulation of nitrogen from the air. Pea is considered the best winter wheat predecessor. Due to climate changes the important thing is to breed new pea varieties, which will be technological, high productive and resistant to weather changes.

Today, the priority in breeding for adaptability pea plants is to create its leaf and leaf-free (tendrils) varieties with small and medium-sized but thick leaf plates, large stipules, 60 to 90 cm plant height and more than 18 mg/cm stem linear density, 10-13 nodules in vegetative part of the plant, and from three to five nodules in generative part. Varieties of physiologically limited /genetically determined type of growth have advantage [1, 2].

It is important to find out the inheritance and variability regularity of *Pisum sativum* L. Morphobiological and quantitative signs, and then use the selected breeding material in hybridization.

*The goal of the research* was to improve methods for creating high-productive and competitive pea varieties with complex of economic valuable and morphobiological signs for seed, forage and vegetable purposes with resistance to pests, diseases, lodging, seed shattering able to provide yield up to 6.0 t/ha.

**Materials and methods**. Experiments were performed at Uladiv-Liulynets EBS Institute of Bioenergy Crops and Sugar Beet NAAS during 2012-2013.

Pea collection at the station numbers more than 715 variety samples being a wide genetic diversity of the specie. In the breeding process involved were materials resistant to shattering of seeds with signs known as "tendril leaf type", with limited growth and apical bean placement.

Creation of original material was performed through complex and stepping sexual hybridization. Selection of hybridization components was done on the basis of ecological and geographical origin and long-term investigation using integrated sign combination (overall productivity, plasticity as well as contrast) under morphological and biological signs using complex convergent hybridization. It was also performed multiple individual selection of breeding material by "pedigree" method as well as line complex assessment of protein content and palatability. During the plant growing phenological observations, accounting and control of fissile hybrid populations (hibrydological analysis), calculation of the plant density as well as selection of analyzed sheaves was carried out.

Analyzed varieties were compared with standard varieties of Liulynetskyi Korotkosteblovyi, Intensyvnyi 92 and Ulus. Placement of standard and analyzed samples in testing was randomized.

Accounting area of the testing nursery plot was 15 $m^2$ wityh 27 cm of row space. Pea lines in breeding and control nurseries were seeded by triple repetition, the accounting area was 12.5 $m^2$. Placement of breeding and standard varieties in repetition was systemic.

Phenological observations of $F_1$, $F_2$, $F_3$ – $F_n$ pea hybrids and selection of the best hybrid combinations were made in breedingnursery, and undesirable genotypes were rejected.

The accounting area in the control nursery was 10 $m^2$ with triplicate repetition of numbers.

Complex field evaluation of breeding material in crop comparing categories included phenological observations over the plant development main phases, assessment of breeding lines growth and development compared to standard varieties, analysis of their resistance to disease, pests and climatic factors, as well as calculation of crop density and growing phases. Previous and small competitive variety testing was performed in fourfold repetition. Accounting area made up 25 $m^2$.

Mathematical processing of the research data was carried out according to statistical analysis methods [3, 4].

The accounting was performed on the following economically valuable signs: plant height, number of fertile and nonfertile nodes per a plant, plant weight, number of pods per plant, weight of pods, number of seeds from one plant, number of peas in a pod, bean weight, and weight of 1000 peas.

**Results**. To create a productive source material we used pair sexual hybridization involving male forms of various environmental groups with contrasting morphological signs. The research was aimed at creating new and improving existing source material of tendril leaf type and determined forms of various architectonic versions.

By sexual hybridization method without flower castration selected were 18 male forms to create source material of tendril leaf type and determined forms as well as these signs combination in vegetable pea varieties.

It was established that the highest percentage of hybrid pea ovary (91-95%) out of 34 F1 hybrid combinations featured 15% of plants. The same percentage was in selected group of hybrid progenies where ovary ranged from 34 to 70%. Ovary of remaining progenies framed 71-90%.

There were identified the dominance of signs and heterosis degree (high, present, absent) in $F_1$ pea hybrids as well as false hybrids and depressive plants were removed. Hybridological analysis of $F_1$ hybrid manifested splitting (in some combinations according to male forms contrast) of seed shape and color. We received 90802 beans in $F_1$ pea hybrids, of which 63388 were certified.

Diversity of split signs in $F_2$ hybrid combination and their new presence in single genotype indicates the hybrid material perspectives and subsequent allocation of valuable constant forms.

Hybridological analysis was performed in $F_2$ pea hybrid offspring. Complex evaluation, selection of valuable recombinant and transgressive genotypes as well as selection of promising breeding lines source material were performed.

Overall investigation of hybridization components and selection of male forms is fundamental for different source material and its involvement in the further breeding process. Required volume of breeding work is essential that increases the possibility of recombinant and transgressive genotypes allocation as well as it provides further breeding process [5, 6].

In the nursery we investigated the following constant pea types: 131 numbers of tendril leaf type, two of multiple odd-pinnate leaf type, one of tendril acacia leaf type, two of acacia leaf type and its offspring with typical leaf type, three of stamb determinants type, one of stamb type, 119 of yellow unshattering seed type, 83 of ordinary yellow type, 19 of ordinary green seed type, 10 of yellow “brain” type and one of green «brain» type.

The average yield at area plot was 2336 g varying from 779 to 4300 g. Yield for numbers and standards is shown in Fig. 1.

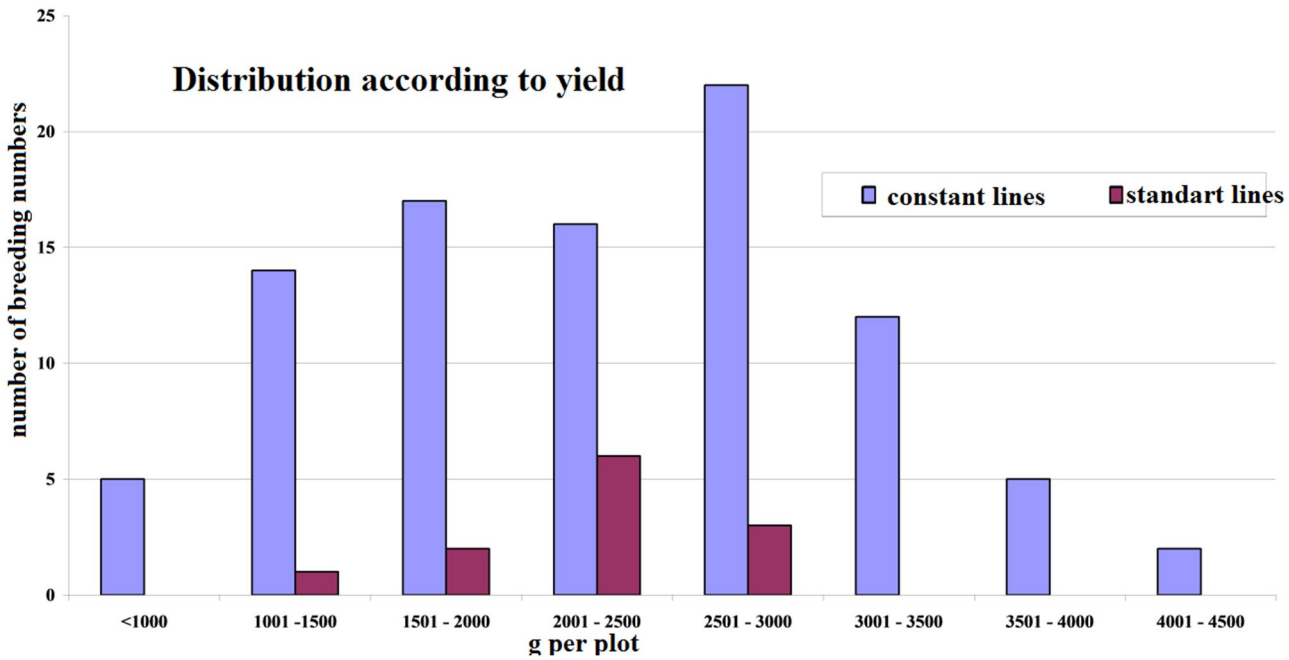


**Fig. 1. Distribution of lines and standards for yield (2011-2013)**

Out of 39 lines of tendril leaf type selected were 12 lines, which yield is much higher than group standard yield (2325 g/plot), and the maximum yield of leaf-free lines was 3500 g/plot. There were 19 tendril leaf type lines, which appeared very resistant to lodging, as well as were selected six lines that combine signs of tendril leaf type, green seed type and uncrumble type.

Among the constant lines we determined three vegetable samples of 2700 g/plot yield, four samples with modified architectonics (stamb, stamb determinants, multiple offspring, tendril acacia), which level of yield was substantially higher than the standard. Offsprings were selected according to growth speed, resistance to lodging, fertility, resistance to root rot. Botanical and varietal weeding was performed also.

The average yield of breeding lines was 2504 g/plot with a maximum of 4320 g/plot (Table 1). Among leaf-free types there were identified 45 lines, which yield was significantly higher than in standard (2688 g/plot). Maximum yield of leaf-free type lines was 4140 g/plot.

*Table 1*

**Yield of progeny and pea standard varieties (2011-2013)**

| Breeding numbers | Distribution for yield, g/plot, % | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 501 - 1000 | 1001-1500 | 1501-2000 | 2001-2500 | 2501-3000 | 3001-3500 | 3501-4000 | 4001 - 4500 |
| Constant lines | 0.9 | 6,7 | 16.3 | 28.0 | 28.4 | 16.3 | 2.9 | 0.5 |
| incl. tendril leaf | - | 6,6 | 14.4 | 27.9 | 35.6 | 12.5 | 2.8 | - |
| Intensive 92 | - | - | - | 16.7 | 33.3 | 33.3 | 16.7 | - |
| Liulynetskyi Korotkosteblovyi | - | - | 33.3 | 33.3 | 33.4 | - | - | - |
| Ulus | - | - | - | 16.7 | 33.3 | 50.0 | - | - |

Breeding pea numbers were estimated on their average yield and plasticity (bi) was defined, which reflects variety regression for environmental conditions and stability (sd2) of this reaction.

Among 90 investigated numbers there were identified 16 such as exceed group standard. Yield level of breeding samples is shown in Table 2.

*Table 2*

**Yield of investigsted pea breeding numbers, (2011-2013)**

| Type of investigated samples | | Yield, t/ha |
|---|---|---|
| Average under investigation | | 3.25 |
| Breeding samples | Group standard | 3.12 |
| | Best number | 3.80 |
| $LSD_{0.05}$ t/ha | | 0.12 |

It was identified in leaf-free type the resistance to lodging as well as it was selected a number of high yield lines: 1409-41/1488-51 10/10 and 1410-127/08, exceeding group standard at 0.26-0.42 t/ha. Yield in the best lines 1455-5/09 and 1479-142/09 exceeded 0.54-0.73 t/ha at $LSD_{05}$ of 0.49 t/ha.

As a result of research we created pea plants with the following signs: reduced branching 0.7 - 1.2 times, stem length to 69 cm, leaf number of productive and unproductive nodules to 4.7, 4.3, 3 pieces, length of internoduls and petioles to 3.5 and 1.7 cm. Thickness and linear density of stem increased up to 30% and leaves up to 20%. Generative pea part appeared compact that improved lighting of leaves. Combination of tendrils and short stem signs in a single genotype lets increase the resistance to lodging.

There were created pea materials, which combine def gene (seed unshattering), af gene (leaf free) and det gene (determinant growth kind). Under det gene influence two fertile nodes appeared on the plant, the last node produced two peduncles and then the plant fully completed its growth. There were investigated 41 $F_3 - F_n$ hybrid combinations, from which selected were hybrid offspring with apical bean placement. Fertility increasing in determinant forms is one of the conditions for creating high-yield genotypes both with tendril and ordinary type of leaves (Fig. 2, 3).

**Fig. 2. Policarpic determinant of leaf type (2013)**

**Fig. 3. Policarpic determinant of tendril leaf type (2013)**

Breeding process was directed to increase peas quantity. There were selected constant forms with 6-7 peas of medularum variety and 7-8 beans of *vulgare* variety, which were involved into creation of new breeding material. Selected was policarpic line 1434-117/09 of 4000 g (Fig. 4).

One genotype combined technological signs such as tendril leaf type and apical peas placement. However, resistance to lodging of such genotype requires additional donor of this sign and subsequent selection (Figure 5). There are more than 20 genes that control the length and number of plant internodes; they are used in breeding to create pea varieties with short and sturdy stem, resistant to lodging [6]. Four of them, le, na, ls and lh, control the formation of dwarf and micro-dwarf phenotypes [7]. Thus, le gene (bravi-internodium) shortens the stem and used in breeding for short-stem intensive pea varieties. Combination of tendril leaf short-stem signs in a single genotype allowed increasing resistance to lodging (Liulynetskyi Korotkosteblovyi) [8].

**Fig. 4. Increased bean quantity line of vegetable usage (2013)**

**Fig. 5. Stamb determinant of whisked type (2013)**

Among $F_3$ – $F_n$ hybrids selected was source material with various leaf type, namely multiple non-pair-cirrous, "chameleon", tendril acacia, leaf free, lupinoid and their genetic modifications (Fig. 6, 7).

Among stamb determined hybrids selected was "lupine" pea form (Fig. 7). Its distinguishing feature is apical peduncle of up to 11 alternately arranged flowers. By means of genetic analysis was revealed that two recessive genes det (determinant stem growth type) and fa (stem fasciation) effected this sign formation. Two productive nods were formed on the plant under the effect of det gene. Fascination is manifested when approaching some upper nodes [1, 8]. Combination of "lupine", short stem and tendril leaf type signs support their simultaneous maturation and provide new technologies using in their cultivation.

**Fig. 6. "Chameleon" morphotype pea form (2013)**

**Fig. 7. "Lupine" morphotype pea form (2013)**

**Conclusions**. Pair sexual hybridization involving male forms of different environmental groups with contrasting morphological signs and further selection made it possible to create new morphological pea types, namely leaf free, determinant growth kind, recombinant and transgressive forms with complex selection important signs that ensure the use of new technologies in their growing. Established was the regularity of inheritance and variability of pea morphobiological and quantitative signs. The best breeding materials were used in hybridization with promising breeding materials 1455-5/09 and 1479-142/09 were selected, the yield of which is higher than group standard by 0.54-0.73 t/ha.

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***Анотація***

***Орлов С.Д., Калюжна Е.А., Українець В.В.***

***Удосконалення способів добору та оцінки генотипів гороху за комплексом господарсько-цінних ознак***

*Виділено рекомбінантні і трансгресивні форми гороху посівного з комплексом селекційно важливих ознак. З'ясовано успадковування та мінливість морфобіологічних та кількісних ознак гороху посівного з подальшим використанням виділених селекційних матеріалів в гібридизації.*

***Ключові слова:*** *горох посівний, гібридизація, добір, насіння, сорт*

***Аннотация***

***Орлов С.Д., Калюжна Е.А., Украинец В.В.***

***Усовершенствование способов отбора и оценки генотипов гороха с компексом хозяйственно-ценных признаков***

*Выделено рекомбинантные и трансгрессивные формы гороха посевного с комплексом селекционно-ценных признаков. Установлено наследование и изменчивость морфобиологических и количественных признаков гороха посевного с последующим использованием выделенных селекционных материалов в гибридизации.*

***Ключевые слова:*** *горох посевной, гибридизация, отбор, семена, сорт*