State, Problems and Prospects in Genetic Improvement of Annual Leguminous Fodder Crops in Bulgaria

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Summary

Annual grain legumes continue to be important crops worldwide, both for food and feed and as rotational crops with other cultures. In grain legumes breeding programs, the selection is based mainly on yields and yield components. Grain yield of these crops is a quantitative trait which is influenced by many genetic and environmental factors. Availability of genetically diverse grain legume germ plasm allows the breeders to overcome many production limits. Preliminary genetic studies and understanding in legumes and plant genetics as a whole will open opportunities for crop improvement of these cultures.

Key words: Annual grain legumes; Accessions; Genetic improvement; Breeding

Introduction

The role of the starting material for enhancing the effectiveness of the breeding-improved work in all crops is well known. The high effectiveness and success in the breeding are based on the use of rich genetic diversity with various valuable qualities. They serve as donors in crossing and recombination of the hereditary factors. A limited starting material and its genetic uniformity can slow down the selection process and lead to unsatisfactory results Mihov et al. [1].

Annual legumes as peas, vetch, chickling vetch and lupine are preferred in rotations with positive impact on the subsequent crops Medvedev & Smetannikova [2]; Ryabtseva [3]. An important additional source of nitrogen is the accumulated biological nitrogen in the soil resulting from the activity of nitrogen-fixing bacteria which utilize molecular nitrogen from the air. Thereby, during their growing period, the cultures in symbiosis with nodule bacteria enrich the soil with nitrogen Sidorov [4]; Tyutyunnikov, Fadeev, [5].

Peas (Pisum ssp.) are main legume crops that are rich in protein and with ample opportunities for use as a proper meal in humans and animals. In Bulgaria peas compared to the grain of other legume crops are most often used in feeding ruminants and monogastric animals. Peas are considered as a possible substitute for soybean meal. It is becoming an increasingly important crop in Bulgaria hardly at the beginning of XX century. Of all legumes crops it occupies the largest areas and from it are obtained higher yields of 410 kg/da against 286 kg/da for soybeans, 59 for beans kg/da and 37 kg/da for lens. Mainly grown are white-flowering varieties with spring type of development and low tannin content. Its contribution to organic nitrogen in the system of organic farming is indisputable and is going to increase Mihov et al. [6]; Mehandjiev et al. [7]; Krachunov et al. [8].

Soil-climatic conditions in Bulgaria enable the peas to be grown as main and intermediate crops in spring, summer and autumn. Due to its multifaceted use and large differences in soil and climatic conditions in the country, some breeding directions have been imposed – wintering varieties for grain and green mass and spring varieties for grain and green mass Kuzmova [9].
White lupine is the oldest culture of lupine species. It has the greatest importance for green fertilization as in this regard exceeds all other legumes. It is also drought-resistant, tolerates acid soils which are unsuitable for growing other legumes and may fix to 162 kg N/ha Putnam, et al. [10]; Sparrow, et al. [11]; Kurlovich, et al. [12]. Globally, there is an interest in the cultivation of white non-alkaloid lupine. In the countries of the European Union, total areas with protein crops have increased since 2004 firstly with sweet lupine which is preferred for use as fodder in the farms (LMC International, 2009). In Institute of vegetation and genetic resources (Sadovo, Bulgaria) are tested and introduced two French non-alkaloid varieties - Ljuki and Ljubljana.

Chickling vetch (Lathyrus sativus L.) is also a good nitrogen-fixing crop. It can be successfully grown in the warmer and drier southern areas of the country as it is a drought-resistant crop. Except for fodder-grain and hay, chickling vetch is a good melliferous plant Sidorova, et al. [13]. Of significance is the fact that on acidic soils which has poor fertility or are quite eroded (especially in mountain and foothill regions) can be grown crops as white lupine and chickling vetch Angelova [14]. Winter vetch also shows tolerance to the acidic, alkaline and poor drained soils which defines part of its significance and value as a fodder crop McLeod [1982]; Hughes & Metcalfe [1972]. Despite the advantages in the cultivation of these crops, there are no registered Bulgarian varieties of lupine and chickling vetch in the National Catalogue of varieties. Until now has been created one variety of winter vetch (Asko 1) and two varieties of spring vetch (Obrazets 666 and Tempo).

Retrospection

After France (1835), England (1843), Sweden (1847) and Germany (1852), Bulgaria is the fifth country in the world that initiates the beginning of agricultural researches with the creation of the First experimental field (1882) and the First Agricultural Experimental Station (1902). In 1939 in Bulgaria have been planted 10,000 acres of peas imported from Romania and in 1965 - 4, 98,000 acres of introduced and Bulgarian varieties. The following years are sown significantly less areas, despite the increase in the needs of protein-rich fodder. Until 1964 the method of target selection was used in creating of pea varieties for green mass. During this period were selected winter varieties №5 and Pleven 2 but they did not find practical application due to their low propagation coefficient. Since 1964 as major methods are used the gender hybridization (through which are created wintering varieties Pleven 10 and Mir) and experimental mutagenesis Sachanski [15].

Lupines have not been bred in Bulgaria yet, which explains why accessions in different research collections are mainly of foreign origin. Interest in this crop is limited. Enriched and preserved collections have been stored since 1966 and serve mainly for educational and theoretical investigation purposes related to biochemical composition and changes in alkaloid content Angelova & Stoilova [16]. Nowadays in the gene bank of the Institute for Plant Genetic Resources (Sadovo) are registered 238 crop species of Bulgarian origin. With the largest share are fodder crops - 43, technical crops - 41, grain legumes - 34, cereals - 33, vegetables - 29, permanent crops - 39 and decorative crops - 19. The grain legume cultures, are really good predecessor; in consequence of biological nitrogen fixation which realize with them the soil bacterium, Rhizobium leguminosarum, which has the capability of fixing atmospheric nitrogen into plant-available forms and reduces the need to apply synthetic nitrogen fertilizer.

But until 2006 they are grown in small areas by reasons of due to the limited needs of livestock breeding - bean for grain (36 765 da), lentils, (19 182 da), garden pea (10 865 da), forage pea for grain (5 700 da), chickpea (5 190 da), soybean (899 da), and broad bean (117 da) or everything leguminous 78 718 da. Despite this, in Institute of International Plant Genetic Resources is maintain composition of large grain 78, 718 da. Since 1964 as major methods are used the gender hybridization (through which are created wintering varieties Pleven 10 and Mir) and experimental mutagenesis Sachanski [15].

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In the pea breeding, preferred varieties for grain are springs, white-blossoming, medium early, with a lower habitus and light-colored seeds, and for green mass - varieties with purple colors, higher stems and colorful seeds Angelova [17]. The expansion of areas planted with peas and the use of diverse variety composition from farmers is only possible in an efficient and well-organized seed production. Varieties from European as well as from Bulgarian Variety Catalogue are used Angelova [18].

The problem with effectiveness of the selection work is a complex and has different aspects. It is associated with greater involvement and rational use of various genetically source material with shortening the time for obtaining new varieties and increasing the efficiency of the team in hybrid generations Mihov, et al. [19]. Until now there have been made various examinations which aimed clarification of some questions related to the genetics and the selection of peas. A rich collection is mobilized (Table 2) and a large genetic diversity of varieties and forms is created in different research centers. Intensive breeding work in fodder peas in Bulgaria is conducted in the selection centers in Sadovo, Pleven and General Toshevo (Figure 1).

Table 2: Composition of the grain legume collections in Research Institute of Forage Crops (RIFC) - Pleven.

| Genus          | RIFC |
|----------------|------|
| Pisum Sativum  |      |
| ssp. arvense   | 141  |
| ssp. sativum   | 52   |
| Vicia sp.      |      |
| Vicia pannonica| 21   |
| Vicia villosa  | 70   |
| Vicia striata  | 2    |
| Vicia incisa   | 1    |
| Vicia sativa   | 3    |
| Total          | 97   |
| Lupinus sp.    |      |
| Lupinus albus  | 40   |
| Lupinus luteus | 2    |
| Lupinus sinea | 1    |
| Lupinus червена| 1    |
| Total          | 44   |
| Lathyrus Sativus|    |
| Lathyrus sativus| 16   |
| Vicia Faba     |      |
| Vicia faba     | 20   |

Figure 1: Inventory of grain legume collection with bulgarian origin Angelova, [2015].
Almost all breeding directions are developed and new technologies are applied. The selection is aimed primarily at early ripening, winter resistance and drought tolerance. Due to the climatic conditions of the country, only early-ripening and mid-ripening varieties can fully realize their productive potential. The diversity of varieties and forms of forage peas (Table 3) includes old local varieties, populations, new varieties and lines as prevailing are selection materials Mihov, et al. [6]; Angelova [20,21].

Table 3: Bulgarian official catalogue of forage varieties of *Pisum sativum* (Ministry of Agriculture and Food, Executive Agency for Variety Testing, Field Inspection and Seed Control) - 2016 year.

| Varieties       | Year of Recognition | Applicant Code No | Certificate Owner Code No | Variety Maintainer Code No |
|-----------------|---------------------|-------------------|---------------------------|---------------------------|
| *Pisum Sativum L. - Spring*                     |                     |                   |                           |                           |
| Bohatyр         | 1995                | BG 38             | c-BG 38                   | BG 38                     |
| Amitie          | 2004                | BG 2              | c-BG 2                    | BG 2                      |
| Vokil           | 2009                | 38                |                           | 38                        |
| Druja           | 2006                | BG 38             | c-BG 38                   | BG 38                     |
| Kerpo           | 2009                | 7                 | c7                        | 7                         |
| Kristal         | 2004                | BG 1              | c1                        | BG 1                      |
| Mishel          | 2009                | 1                 | c1                        | 1                         |
| Pickardi        | 2004                | BG 2              | c-BG 2                    | BG 2                      |
| Pleven 4        | 2008                | BG 7              | c-BG 7                    | BG 7                      |
| Ruse 1          | 2009                | 4                 | c4                        | 4                         |
| Tedi            | 2008                | 2                 | c2                        | 2                         |
| Yatrus          | 2012                | 38                |                           | 38                        |
| *Pisum Sativum L. Winter*                       |                     |                   |                           |                           |
| Vesela 23E      | 2003                | BG 2              | c-BG 22                   | BG 2                      |
| Mir             | 2000                | BG 17             | c-BG17                    | BG2, 7, 38                |
| *Vicia Sativa L. - Spring*                      |                     |                   |                           |                           |
| Obrazets 666    | 2014                | 38                |                           | 38                        |
| Tempo           | 2011                | 7                 | c7                        | 7                         |

The necessary genetic diversity and its use in the creation of new genotypes is implemented in different soil and climatic conditions by applying the most appropriate methods of team in hybrid and mutant populations. The method of intervarietal hybridization is associated with some difficulties due to low cross-fertilization and high labour-consumption of this process. The greatest efficiency is obtained by combining the bulk method in the early generations, after that, the following procedures are applied pedigree, single seed method and their modifications, as well as combining hybrid variability with mutational variability Mihov [1988] LMC International [22].

To improve the efficiency of the selection process in fodder peas is required to be known sufficiently the combining ability of the varieties used in combinative selection and the degree of expansion of the formative process in the hybrid variability. In this connection, there is an increasing need of studying constantly renewing starting selection material Ryabtseva NY [3], Mehandjiev, et al. [7], Koeva, et al. [23].

Conclusion

Annual grain legumes continue to be important crops worldwide, both for food and feed and as a rotational crop with other cultures. The selection is based on yield and yield components in grain legumes breeding programs. Grain yield of these crops is a quantitative character which is affected by many genetic and environmental factors. The availability on genetically diverse grain legume germplasm allows the breeders overcome many production constraints. The advance genetic study and understanding of legumes and plant genetics as a whole will open opportunities for crop improvement of these cultures.

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