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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.

Keywords: 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 legume collection (Table 1). Annually, in this Gene bank when evaluating plant resources of peas fodder are examined 60 indicators (according to the classifier IBPGR).

Table 1: Composition of the Bulgarian grain legume collections in Institute of Plant Genetic Resources (IPGR) - Sadovo Angelova [2015].

Genus	Total	Long Term Conservation	Medium Term Conservation	Working Collection
Pisum	2540	810	1150	1120
Lupinus	308	70	208	14
Lathyrus	344	270	100	57
Vicia sp	1880	777	1151	158
Vicia faba	702	467	220	35

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In the pea breeding, preferred varieties for grain are springs, white-blossoming, medium early, with a lower habitués 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
Pisum sativum var. triver	1
Pisum sativum var.hiemale	5
Pisim sativum var. melanocarpum	1
Total	200
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 синя	1
Lupinus червена	1
Total	44
Lathyrus Sativus	
Lathyrus sativus	16
Vicia Faba	
Vicia faba	20

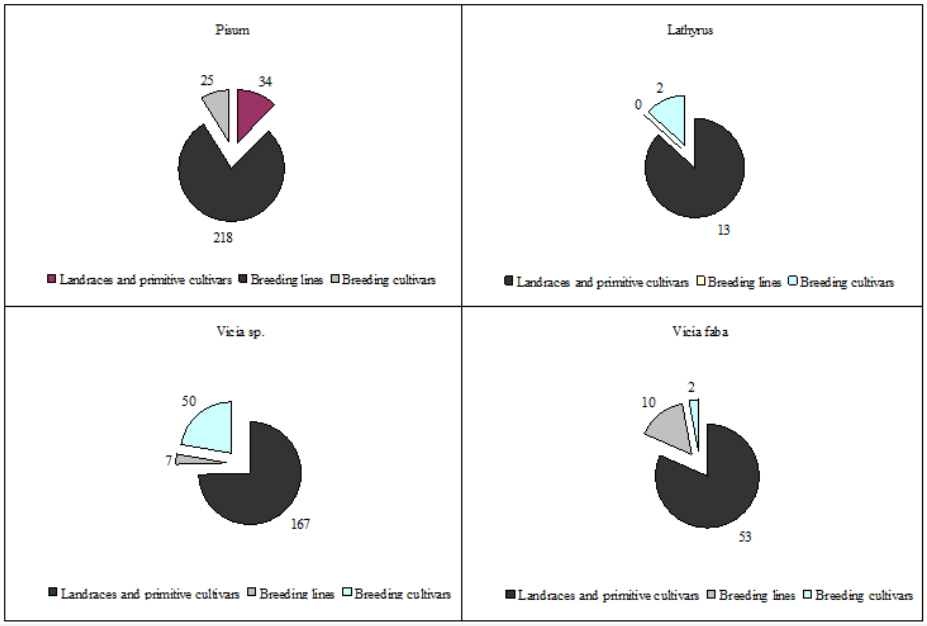

Figure 1: Inventory of grain legume collection with bulgarian origin Angelova, [2015].

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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 №	Variety Maintainer Code №
Pisum Sativum L. - Spring				
Bohatyr	1995	BG 38	c-BG 38	BG 38
Amitie	2004	BG 2	c-BG 2	BG 2
Vokil	2009	38		38
Drujba	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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