Forage and dry pea *(Pisum sativum)* breeding in Serbia

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Pea in Serbia

Annual legumes have a long tradition of cultivation in Serbia. Today the most important grain legume is soya bean *(Glycine max* (L.) Merr.) with numerous different uses in the animal feeding and industry (1). The most widespread pulse is *Phaseolus* beans that has almost completely replaced other pulses during the last two centuries, with the exception of vegetable pea, and become one of the most frequent components in the human diets in both Serbia and other Balkan countries (2). The other traditional annual legumes, such as faba bean *(Viciafaba* L.), lentil *(Lens culinaris* Medik.) or grass pea *(Lathyrus sativus* L.), have become neglected and extremely underutilized, but their revival and successful reintroduction are increasingly possible in Serbian agriculture as multipurpose crops (3). Pea *(Pisum sativum* L.) remains one the most important traditional annual legumes in Serbia and all over the Balkan Peninsula. It is estimated that all agronomic types of pea, including forage, feed and vegetable pea, are grown on about 35,000 ha in Serbia today. Like many other annual legume species, pea is a typical multi-purpose crop and may be used in human consumption, animal feeding and various non-food uses and ecological services (4). Pea may be used as green forage, hay, forage meal, silage, haylage, immature pods with undeveloped grains, immature grain, mature grain and straw (5) and as a cover crop and green manure in organic farming and sustainable agriculture (6).

Originally, pea in Serbia and other Balkan countries, as well as other Slavic nations, was well-known from time immemorial (7) with *P.s.* var. *sativum* used mainly as a garden crop, while *P.s.* var. *arvense,* together with vetches *(Vicia* spp.), played an essential role in forage production. On the other hand, the pea agronomic type, known as *feed* or *dry* pea, has been completely unknown in Serbia until twenty years ago. With the introduction of cultivars from Canada, such as 'Tara' and 'Century', and from Czechoslovakia, such as 'Bohatyr' and 'Tyrkys', dry pea began to be considered an excellent supplement and sometimes a complete substitution for soybean meal in dry seasons. under the influence of the terms used in the French language, dry pea immediately became better known under the name of *protein pea* (8).

Achievements in Novi Sad

So far, the Institute of Field and Vegetable Crops in Novi Sad has remained the only institution in Serbia involved in breeding forage and dry pea. The forage pea breeding program was the first one, while the dry pea breeding program came somewhat later and on the basis of the good results achieved by the foreign cultivars (9). Both forage and dry pea breeding programs are based upon the sustainable utilization of the *Pisum* collection within the Annual Forage Legumes Collection (AFLCNS), maintained in the Forage Crops Department of the institute (10).

The forage and dry pea breeding programs in the Institute of Field and Vegetable Crops in Novi Sad have resulted in the development and registration of 16 cultivars in Serbia (Table 1). The cultivars Jezero and Javor are registered in the Ukraine, while the cultivar Pionir is registered in the EU. It is estimated that the Novi Sad forage and dry pea cultivars account for about 95% of the harvested area in Serbia.

Breeding vegetable pea in Serbia is carried out in the Vegetable Crops Department of the Institute of Field and Vegetable Crops in Novi Sad and in the Institute for Vegetable Crops in Smederevska Palanka.

Time of sowing and purpose	*Name*	*Year of registration*
Winter forage pea	*NS-Dunav*	*1977*
	NS-Pionir	*1977*
	Pionir	*2006*
	Kosmaj	*2006*
	Pester	*2007*
Winter dual-purpose pea	*Cer*	*2006*
Spring forage pea	*NS-Lim*	*1992*
	Trezor	*2008*
Spring dual-purpose pea	*NS-Junior*	*1992*
	Jantar	*2009*
Spring dry pea	*Moravac*	*1994*
	Jezero	*1995*
	Javor	*2002*
	Partner	*2007*
	Kristal	*2007*
	Dukat	*2007*

Table 1. Forage and dry pea cultivars developed in Novi Sad and registered in Serbia

Breeding for forage yield and quality

One of the two major breeding programs in Novi Sad is aimed at the development of both winter and spring forage cultivars that may be suitable for utilization as green manure too. Such cultivars should produce high yields of forage, meaning more than 45 t ha^{-1} of green forage and 9 t ha^{-1} of hay, with a content of crude protein in the forage dry matter of about 200 g kg^{-1}. Variation in forage yields between years should not exceed 20 %, and the production of reliable yields of seed is also highly desirable.

The new forage pea cultivars should have increased plant height, not exceeding 120 cm, in order to avoid excessive lodging in market seed production, a moderate number of stems and a high proportion of leaves, either by producing a large number of internodes or by introducing genes for the acacia leaf type *(tl),* in which all tendrils are transformed into leaflets (11).

The most frequently used methods in breeding for yield of forage are individual selection in wild populations and local landraces and pedigree and bulk methods in hybrid populations.

Breeding for grain yield and quality

The goal of the second major breeding program is the development of spring and winter cultivars of pea with high yields (greater than 4500 kg ha^{-1}) of grain with a crude protein content in grain dry matter of about 250 g kg^{-1}.

The thousand grain weight of such cultivars should range between 150 g and 200 g, directly leading to a decreased cost of the sowing and thus being always preferred by farmers. At the same time, the introgression of a prominent earliness, ending the growing period of a cultivar before the harvest of winter wheat, may enable farmers to grow both crops at the same time and harvest them one after another with no overlap in the organization of harvest.

There are two ways to increase grain yield and these can be combined with each other. one way is to improve at least one of the yield components and bring all of them into an optimal relationship, together with determinate growth *(det)* of the stem to ensure uniform maturity. Another way is to introduce genes for morphological traits that save the produced yield, such as short internodes *(le),* stem fasciation *(fa, fas),* afila leaf type *(af)* and strong funiculus development *(def).*

Breeding for tolerance to abiotic and biotic stress

The development of winter cultivars is closely linked to tolerance of low temperatures, while breeding for drought tolerance is an integral part of the programs aimed at development of spring cultivars. A long-term evaluation of the tolerance to low temperatures brings enough hope that the development of the first Serbian winter dry pea cultivars could significantly increase harvested area in Serbia (12), especially due to the fact that the majority of farmers are not able to harvest pea and cereals, such as barley or wheat, at the same time and would always choose the latter. The most promising winter dry pea line is L-574, currently included in the official trials, with afila leaf type, full maturity in late May and a potential for average grain yields of more than 5 t ha^{-1} in preliminary trials from 2007 to 2009.

Since the pea weevil *(Bruchus pisorum* L.) is the most important pest in pea, breeding for improved tolerance to its attack in dry pea is based upon hybridization between the common pea and the red-yellow pea *(Pisum fulvum* Sm.), with *P. fulvum* as the pollen donor (13). The goal is the development of either resistant or tolerant lines from hybrid populations, serving for further improvement of the susceptible cultivars with great potential for increasing grain yield.

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