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The Legume Manifesto: (Net)workers on *Fabaceae*, Unite!

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Summary: Legumes have been an important part of cropping systems since the dawn of agriculture. The shift in Europe from draught animals to meat animals coincided with the increasing availability of soybean meal from North and South America, and the Common Agricultural Policy of the European Union promoted the growing of cereals and oilseeds at the expense of other crops, so legumes fell out of favour with farmers and decision-makers. Continental concerns about food and feed security, high prices of oil and soybean meal, and advances in the application of fundamental molecular genetics to crop species, all mean that now is a good opportunity to promote the return of legumes to European cropping systems by enhancing the efficiency of research and development on this family. Hence we propose the establishment of a Legume Society that will promote information exchange and scientific productivity by uniting the various legume research communities.
Key words: food and feed security, Legume Society, modelling, networking, sustainability

Legumes, Past Tense: *Once Upon a Time There Were Legumes*

The *Fabaceae* is the third largest family of flowering plants, after *Orchidaceae* and *Asteraceae*, with over 650 genera and 20,000 species (Lewis et al. 2005). It is an extremely diverse family of worldwide distribution, encompassing everything from arctic alpine herbs, to annual xerophytes and equatorial forest trees. Members of the family are characterized by the distinct fruit, termed a *legume* or *pod*, which gives the family its name. Another peculiarity of legumes is their symbiosis with nitrogen-fixing bacteria that provides not only added value in agriculture, but also plays important role in natural ecosystems.

Legumes have always been a part of the everyday life of humans. Grain legumes such as pea (*Pisum sativum* L.), bitter vetch (*Vicia ervilia* (L.) Willd.), lentil (*Lens culinaris* Medik.), chickpea (*Cicer arietinum* L.), faba bean (*Vicia faba* L.) and grass pea (*Lathyrus sativus* L.) are commonly recognized as among the first domesticated plant species and the most ancient crops, contributing to the 'agricultural revolution' in the Fertile Crescent at the end of the last Ice Age (Bellwood 2005). Subsequently and independently, soybean (*Glycine max* (L.) Merr.) was domesticated in China, cowpea (*Vigna unguiculata* (L.) Walp.) in Africa, pigeon pea (*Cajanus cajan* (L.) Millsp.) in India and common bean (*Phaseolus vulgaris* L.) twice, in central and South America. Apart from these food legumes, forage legumes have been adapted from wild flora and used in managed grazing lands, and include lucerne (*Medicago sativa* L.), clovers (*Trifolium* spp.) and birdsfoot trefoil (*Lotus corniculatus* L.), providing animal husbandry with quality forage, although the history of domestication is much more obscure.

The most important and widely cultivated legume crops began to be studied first, such as pea, the key experimental organism for Mendel's pioneering genetic research (Ellis 2007), soybean, lucerne and white clover. They are followed progressively by the less widespread ones, now reaching vetchlings (*Lathyrus* spp.) and vetches (*Vicia* spp.), legumes with pharmaceutical properties including fenugreek (*Trigonella foenum-graecum* L.) and liquorice (*Glycyrrhiza glabra* L.), economically important tree legumes such as

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Robinia and *Pongamia*, and garden ornamentals such as sweet pea (*Lathyrus odoratus* L.). Certain legume crops have well-studied genetic systems. Yet, in many of these, comprehensive genetic analysis is limited due to the large size of their genomes. Thus in order to expedite and simplify genome analysis of crop legumes, model species with smaller genomes were selected, one being *Medicago truncatula* and *Lotus japonicus* another. Genomes of both species have been sequenced extensively by end of 2008, as has the genome of soybean in 2010, economically the most important legume crop.

Each segment of legume research began to develop its own network, maintained by diverse means, ranging from pure enthusiasm to specific financial support by projects, and improved through regular meetings. Some of the largest networks dealing with legumes such as European Grassland Federation (EGF) organize annual meetings, while by contrast the European Association for Plant Breeding Research (EUCARPIA), with its sections on fodder crops and amenity grasses, oil and protein crops, ornamental plants, and genetic resources, has irregular meetings where different aspects of legumes are covered by different groups. The European Association for Grain Legume Research (AEP) was established to support specifically grain legumes and, apart from its triennial conferences, actively participated in establishing various Framework Programme (FP) projects (Ellis et al. 2005, Schneider 2007) such as FP4 LINK, FP5 EU-Faba, FP5 GL-Pro, FP6 EUROCROP and FP6 Grain Legumes Integrated Project (GLIP) with its Grain Legumes Technology Transfer Platform (GL-TTP). Some global legume communities have existed mainly in the form of regular conferences such as the International Food Legume Research Conference (IFLRC), International Conference on Legume Genomics and Genetics (ICLGG) and European Nitrogen Fixation Conference. There are also long-term programmes such as the European Cooperative Programme for Plant Genetic Resources (ECPGR) with its working groups and narrowly specialized groups such as the *Pisum* Genetics Association (PGA) and EUCARPIA *Medicago* species group.

Legumes, Present Tense: *How Can We Rescue the Disappearing Legume Community?*

Legumes are established as one of the most important crop groups with extraordinarily diverse uses. They are recognized as a quality source of protein for human consumption and in animal feed, their starch has the nutritional advantage of being slowly digestible, while others such as soybean are rich in oil (Đorđević 2009). Their impact on soil and its properties is positive for all succeeding crops, since they live in symbiotic community with nitrogen-fixing bacteria and both renew and enrich the ecosystem fertility (Stoddard et al. 2009). They are also a source of various bioactive compounds that are used in pharmaceutical industries. Perennial and tree legumes may represent a valuable biofuel and ornamental legumes contribute to the beauty of living.

Despite all these and many other benefits for all of society, legume cropping has been in decline throughout Europe. Legumes are often considered not sufficiently profitable in comparison to other major crops such as cereals or oilseed brassicas, in a context where crop profitability is largely determined by subsidies set by decision-makers. The decrease in the legume cultivation area causes a decrease in the support for legume research. In the end, this badly affects the legume research communities and their networks, until the European legume research community may be likened to galaxies following the cosmological Big Bang (Fig. 1).

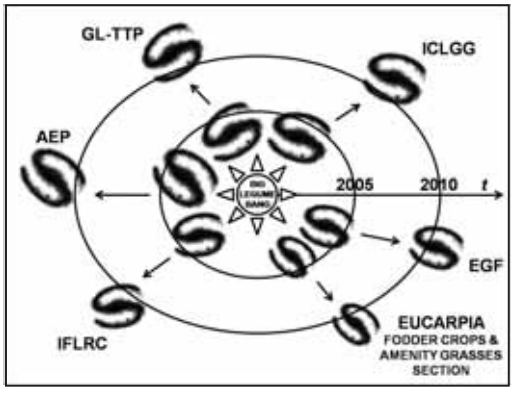

Fig. 1. Current situation in the European legume research community as compared to the Big Bang model in cosmology: with the flow of time and in ever-expanding space, each community behaves like a galaxy and becomes more and more remote from the others and with continuously weakened mutual bonds

Slika 1. Trenutne okolnosti u evropskoj istraživačkoj zajednici mahunarki u poređenju sa modelom Velikog praska u kosmologiji: tokom vremena i u svemiru koji se večno širi, svaka zajednica se ponaša poput galaksije i sve se više udaljava od ostalih uz postojano slabljenje međusobnih veza

Legume research in the USA, Australia and Canada, unlike that in Europe, demonstrates how a feasible and sustainable link between basic science, applied research and end-users may be established and maintained (Warkentin et al. 2008). Organizations such as Pulse Australia and Pulse Canada thrive much better than their counterparts in Europe, in spite of the latter being the home to many of the finest discoveries in legume research, especially its basic science. This is the reason why legumes occupied less than 2% of European arable area in 2007-2009, in contrast to 6% in Australia and 10% in Canada, and why the EU imports over 70% of its plant-derived protein, including 21-32 Mt soy meal annually from 2000 to 2007.

Perhaps the EU FP6 project GLIP was the final mover in the European legume research community. Its support to the networks such as AEP and GL-TTP was essential and since it ended, both are in serious financial trouble and unable to carry out their mission of enhancing legume research and even to maintain their membership. With the exception of FP7 project Legume Futures and some multilateral projects, there is currently little EU investment in legumes. Opportunities for synergy and interaction are therefore progressively harder to find and develop.

Many legume scientists therefore became concerned during 2009 and 2010: How could the disintegration of the existing legume research communities and their networks in Europe be reversed?

Legumes, Future Tense: *And They Grew Legumes Happily Ever After*

The critical time for action has come and the next five years must be a turning point for legume research networking (Mikić & Smýkal 2010). A society to assemble all legume researchers in Europe will be established, provisionally named the Legume Society (LS), and its network will assist in healing the wounds in the European legume research community.

The purposes of such pan-European, all-legume, interactive, multifunctional and sustainable society and its network are three-fold: scientific, economic and social.

1. Scientific benefits.

- The national, bilateral and multilateral projects, funded by national and international bodies, will be linked together in an efficient, useful and productive way;

- The results and the databases will be more accessible, available and applicable and the general flow of information will be eased;

- Improved coordination will lead to a more sustainable actions and better use of existing financial resources on national and EU levels;

- The network will interact with non-European legume science networks, exchanging ideas and best practices.

2. Economic benefits.

- The network will include food, feed and non-food industry, extension services, farmers, stake-holders and all other end-users (Smýkal et al. 2010);

- The network will lobby European decision-makers for more favourable solutions for legumes, such as an end to the anti-legume weighting of the Common Agricultural Policy, which would allow replacement of at least 50% of imported soybean meal by a 4-fold increase in European grain legume areas;

- The network will promote legumes as the crops that:

symbiotically fix nitrogen and do not require synthetic N fertilizers, resulting in cost savings and reductions in energy inputs, greenhouse gas emission and water pollution;

when handled correctly, are competitive with weeds and are highly effective in mixed cropping, particularly of annual legumes either with annual cereals or, at the establishment phase, with perennial forage legumes, resulting in reduced costs and pollution together with higher forage and feed yields;

often have allelopathic properties that destroy or suppress parasites such as broomrape, some nematodes and certain pathogenic fungi, allowing a reduction in the use of agrochemicals in integrated systems;

and are multi-functional crops providing food, feed, fibre and fuel, with benefits to the following crop, thus enhancing the diversity of farm income streams, farm economic viability, and sustainability, and providing a broader range of raw materials to processing industries.

Social benefits.

- The network will promote the benefit to the whole system, encompassing ecological and social aspects of legumes as crops that:

improve mechanical and chemical soil properties;

have beneficial effects by their root exudates upon soil microorganisms;

are the best choice to remediate soils contaminated by mines or power plants;

reduce cereal crop diseases;

renew soil fertility;

reduce the negative impacts of agriculture on climate and help mitigate negative climatic changes;

enrich agroecosystems and landscapes, contribute to regional biodiversity and support pollinating bee and other useful insect populations;

assist in the conservation of the traditional ways of living, improve the viability of rural communities, and renew the interest of younger generations in agricultural production and its benefits;

provide the food and feed sector with healthy, safe and rich source of plant protein, the pharmaceutical sector with raw materials and the energy sector with sustainable biofuels;

and contribute to the overall health and thus to the good of society.

The structure of LS should be light and efficient, comprising both managing roles, in the form of Executive Committee headed by President, and scientific counselling, represented by Scientific Committee with several sections following the legume research topics as the most natural links between the individual legume crop groups.

Among the innovative aspects of the idea about ILS and its network there are:

- The fact that all legumes are to be covered by one society and managed by one network;

- The transfer of information from the model legumes to the cultivated species will be made easier;

- Novel uses will no longer risk falling into the gaps between specialties, for example when a grain legume is assessed for use as a forage or green manure;

- Facilitation of re-introduction of neglected and underutilized crops such as grass pea and cowpea in southern Europe, or faba bean and lentil in the Balkans;

- Facilitation of introduction of novel crops, such as alkaline soil-tolerant white lupin or photoperiod-neutral pigeon pea in temperate Europe for forage and grain production;

- Use of legumes as bioherbicides, bioinsecticides, biofumigants and other biopesticides, such as fenugreek against broomrape in faba bean, pea against weeds in perennial forage legume establishment (Ćupina et al. 2010);

- Use of legumes as cover crops, catch crops, mulch and biofuel;

- Use of legumes in soil remediation and erosion prevention;

- Innovations in genomics and other omic basic sciences;

- Innovations in legume quality, chemical composition and biofortification;

- Innovations in place, role and potential in various cropping systems.

The rough agenda of the LS development during the years to come comprises three major steps (Fig. 2).

- Firstly, enhanced contact among legume scientists belonging to different crop communities should result in enriched exchanges of ideas and scientific outcomes;

- Gradually, the expected synergy between soybean, grain, forage and tree legume research will develop (Rubiales 2009);

- Legume scientists from the EU and its converging regions will be brought together so the network covers the whole Enlarged European Research Area, filling the geographical gaps that have existed for decades and caused delays in progress;

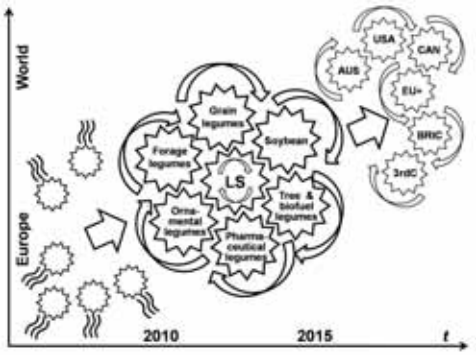

Fig. 2. A provisional LS agenda: existing contacts between various legume communities, as initiated especially by AEP and GL-TTP, serve as a condensation centre that delivers the LS, during the next five years and at least on a European level, as the main gear that would give power to diverse legume research communities and that later would bind together the legume research on a global level, integrating legume research in Europe as a whole (EU+) with that in USA, Canada (CAN), Australia (AUS), Brazil, Russia, India and China (BRIC) and third countries (3rd C)

Slika 2. Okvirni rokovnik Društva za mahunarke (LS): postojeće veze između različitih zajednica mahunarki, začete posebno od strane AEP i GL-TTP, služe kao središte zgušnjavanja koje rađa LS, tokom narednih pet godina i najmanje u evropskoj ravni, kao glavni zupčanik koji pokreće razne istraživačke zajednice mahunarki i kasnije objedinjava istraživanje mahunarki u svetskoj ravni, integrišući istraživanje Evrope u celini (EU+) sa onim u SAD (USA), Kanadi (CAN), Australiji (AUS), Brazilu, Rusiji, Indiji i Kini (BRIC) i zemljama Trećeg sveta (3rd C)

- The LS will welcome participants from non-European legume communities, from: (1) large producers, such as USA, Canada, Australia, Brazil, Russia, India and China, with the main goal of exchange of knowledge and joint enhancement of the global legume production and use; (2) third countries, such as those in Asia, Africa and South America, for technology transfer from the core countries, know-how improvement in target regions, and unbiased information exchange, with essential help from the CGIAR centres such as ICARDA, ICRISAT and IITA and with the aim of increasing food, feed, fibre and fuel supplies as well as the quality of life in all countries.

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Establishment of the LS requires little more than enthusiasm, good will, and members' time. Its maintenance will require the continuing efforts of the current legume research network in Europe to provide it with the necessary token financial support and, at times, a little volunteer labour. We expect that this support will be returned many times over in the improved success rate of research grant applications and research outcomes. Perhaps the greatest opportunity to fulfil this task lies in the form of a COST action, where the proposal on a European legume research network has been submitted and is being processed at the time of writing. In fact, LS and its network already exist in an embryonic form, demonstrating that the goals of this manifesto are feasible and already half-achieved.

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Legumistički manifest: (Net)proleteri svih *Fabaceae*, ujedinite se!

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Izvod: Mahunarke su bile važan deo sistema ratarenja od osvita poljoprivrede. Pomak sa ispaše na stajaću stoku u Evropi odigrao se istovremeno sa povećanjem raspoloživih količina sojine sačme iz Severne i Južne Amerike, dok je Zajednička poljoprivredna politika Evropske Unije promovisala gajenje žitarica i kupusnjača na račun ostalih useva, te su mahunarke izgubile ugled kod proizvođača i struktura vlasti. Pažnja koju Evropa ukazuje bezbednosti ljudske i stočne hrane, visoke cene uljane i sojine sačme i dostignuća u primeni osnovne molekularne genetike kod gajenih vrsta ukazuju da je u ovom trenutku dobra prilika za promociju povratka mahunarki u evropske sisteme ratarenja putem povećanja efikasnosti istraživanja i razvoja na ovoj familiji. Stoga predlažemo osnivanje Društva za mahunarke koje će promovisati razmenu informacija i naučnog stvaralaštva ujedinjenjem različitih istraživačkih zajednica mahunarki.
Ključne reči: bezbedna ljudska i stočna hrana, Društvo za mahunarke, modeliranje, netvorking, održivost