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It's wonderful to sail the Fabaceous Sea!

Legumes in the Mediterranean agricultures

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Front cover art
Navigare trans Mari Fabaceārum mirabilis est!
by Aleksandar Mikić

EDITORIAL

We are pleased to present this 10th issue devoted to the legumes in the Mediterranean agriculture. Legumes are important everywhere, but nowhere they are most introduced in the diet and culture than is Mediterranean countries. The current situation and challenges and perspectives for a range of legume crops in the area are presented and critically discussed by a number of authors from different countries. At the International Legume Society, we hope that the information provided here will be useful to the readers and further cooperative research and development on legume crops.

The importance of legumes in Mediterranean agriculture can be seen also from the fact two out the 10 projects granted by the FP7-ERANet ARIMNET (Coordination for Agricultural Research in the Mediterranean Area; http://www.arimnet.net) in its first call dealt with legumes. These were the now terminating MEDILEG (http://www.ias.csic.es/medileg/) and REFORMA (http://reforma.entecra.it) projects. Hope that these initiatives can follow up helping to bridge along the Mediterranean sides because a long term multinational and multidisciplinary cooperation is needed for the reinforcement of legume cultivations in the area.

Thanks to all the authors for their valuable contributions. Thanks to all that with their voluntary efforts are making possible this Legume Perspectives *journal and our growing Legume Society.*

Diego Rubiales
Managing Editor of
Legume Perspectives *Issue 10*

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Carte blanche to…

…Diego Rubiales

Legumes in the Mediterranean culture

Legumes are crops with extraordinary historical importance in the Mediterranean basin. They are protein-rich and integral part of the Mediterranean diet, already used since prehistory.

Grown in rotation with cereals, they improve significantly soil fertility and minimise the use of inorganic nitrogen fertilizers, contributing to a sustainable and environmentally friendly agriculture in the region. This was already noted by ancient Greek and Roman authors such as Theophrastus, Cato, Columella or Pliny.

Despite their importance, the production of food legumes is decreasing in most of the Mediterranean farming systems. A major cause for this is the low and irregular yield as a consequence of insufficient breeding efforts. Additionally, the recent socio-economic and political context discouraged farmers to grow these crops. Increasing importations is the general rule in the Mediterranean countries. In spite of this regressive pattern, producers, manufactures and consumers are demanding more food and feed legumes. Mediterranean consumers love their legumes, being a major component of many traditional dishes and an integral part of their culture. Therefore, is not that legumes are not demanded, but that they cannot be produced in sufficient quantity at the right price.

Returning legume crops to Mediterranean rotations can only be achieved through an integrative approach leading to the adjustment of cropping practises and breeding more adapted, attractive and productive cultivars.

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Chickpea production in Mediterranean Basin

by Eva MADRID[1]*, Mariem BOUHADIDA[2], F. Sara DOLAR[3], Mohamed KHARRAT[2], Chafika HOUASLI[4] and Josefa RUBIO[5]

Abstract: Chickpea has an especial significance in the agriculture of the Mediterranean Basin. Kabuli type is mainly cultivated and essentially used for human food. In this region, chickpea ranks first between grain legumes with 656,373 ha cultivated and a production of 692,448 t, but the progression in the last 30 years is decreasing. Nowadays, the countries dedicating more hectares to this crop are Turkey, followed by Syrian Arab Republic, Morocco, Spain, Algeria and Tunisia. In Mediterranean Basin, chickpea is traditionally sowed in spring causing a low yielding. The introduction of winter sowing using varieties resistant to Ascochyta blight has allowed significant increase in yield. In addition, Fusarium wilt and drought are the main constraints in the Mediterranean Basin.

Key words: chickpea, constraints, cultivated area, production, yield

General aspect of chickpea crop

Chickpea (*Cicer arietinum* L.) is one of the earliest grain legumes to be domesticated by man in the Old World. The Mediterranean origin of the crop imparts special significance to chickpea in the agriculture of the Mediterranean Basin, where it has multiple functions in the traditional farming system (Fig. 1). *C. arietinum* is divided into two main cultivar groups for breeding purposes, "desi" (purple flower with smaller, angular and dark-colored seeds) and "kabuli" (white flower with large and cream-colored seeds) types. The last one is mainly cultivated in the Mediterranean Basin and is essentially used for human food (*homusbet-hina*, *falafel*, *tadjines*, *karentika*, *cocido*, *lablabi*, *ghraiba*).

Nowadays, chickpea is grown all over the five continents in around 50 countries, with 90% of its cultivated area (around 13 10^6 ha) in developing countries. India ranks first in the world in respect of cultivated area (68.5%) followed by Pakistan (8.7%). In the Mediterranean Basin, in terms of cultivated area chickpea ranks first among grain legumes with 656,373 ha (4.8% of the global value), followed of lentil (*Lens culinaris* Medik.), with 514,381 ha, and dry peas (*Pisum sativum* L.), with 214,242 ha (3). Chickpea, together with soybean (*Glycine max* (L.) Merr.) and lentil in terms of production (691,748 t, 682,700 t and 620,329 t, respectively) are the most important grain legumes in this region (3). If the global and the Mediterranean Basin progression of both cultivated area and production is compared in the last 30 years, it is remarkable that both parameters are increasing in the world, but decreasing in the Mediterranean (Fig. 2).

At the present time, Turkey is the leading country growing 423,557 ha (64.5%) and its production was estimated to be 506,000 t (73%). Other production areas are Syrian Arab Republic (84,500 ha and 57,500 t), Morocco (57,019 ha and 25,003 t), Spain (35,000 ha and 22,000 t), Algeria (31,000 ha and 29,000 t) and Tunisia (8,050 ha and 7,700t) (Fig. 3). Chickpea production has increased worldwide over the past 30 years from 6.1 10^6 t to around 13 10^6 t and from 0.5 t to 0.7 t in the Mediterranean Basin (Fig. 2) (3). This increase can be explained by (i) the development of new high yielding varieties tolerant/resistant to main diseases, pests and abiotic stresses and (ii) a successful integrated crop management practices. The difference in yield between world and the Mediterranean Basin (968 kg ha^{-1} and 1,431 kg ha^{-1}, respectively) could be because in some countries the crop is mainly growing under irrigated conditions or the introduction of winter sowing in some countries. In fact the countries with the higher yield (Israel and Egypt) irrigate the crop (Fig. 3).

Figure 1. Kabuli chickpea in field

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One of the major limiting factor in the area affecting the yield is that chickpea is traditionally a spring crop (February - mid-April) and, consequently, plants develop poor biomass during their growing period. This showing date is due to the susceptibility of chickpea to blight (*Ascochyta rabiei* (Pass.) Labrousse, a destructive foliar disease that could cause total loss of the crop in the winter sowing (December). Experimental results suggest that shifting of chickpea acreage from traditional spring to winter season could give twice more yield (6). Other important disease is Fusarium wilt caused by the soil-borne fungus *Fusarium oxysporum* f. sp. *ciceris* Matuo & K. Satô, and widespread in almost all countries growing this legume. Both diseases, together with terminal drought and unfavorable distribution of the rainfall, are the main constraints affecting chickpea yields in the Mediterranean Basin.

Turkey

Turkey has 15,620,000 ha land of field crops in which food legumes with 800,000 ha share 5.2%. Chickpea is the predominant crop among pulse in Turkey, being the first major pulses in area and production. It is cultivated over an area of 423,557 ha with production of 506,000 t (3), accounting 44% of the food legumes production. According to the records of 2013, chickpea consumption per person is reported to be 5.5 kg year^{-1} (7).

Chickpea is grown almost in all regions in the country but the major chickpea production areas are in Central Anatolia, South East, Mediterranean and Aegean regions. In recent years, Uşak, İçel, Konya, Karaman and Antalya provinces are located in the upper row in chickpea production value (25,000 t). Over the period 2003 to 2013, the area under cultivation in Turkey gradually decreased from 630,000 ha to 423,557 ha and also production decreased about 100,000 t. Nevertheless, yield increased by 26% (from 960 kg ha^{-1} to 1,210 kg ha^{-1}) (7). Although Turkey is the fifth biggest chickpea producer in the world, the average yield of the crop is much lower than other producer countries in the world (Fig. 3). The main limiting factors for chickpea production are the lack of improved varieties for all ecological regions and cultivars with high resistance level to diseases, especially Ascochyta blight. There is a need to increase the yield to make chickpea price competitive in the international market.

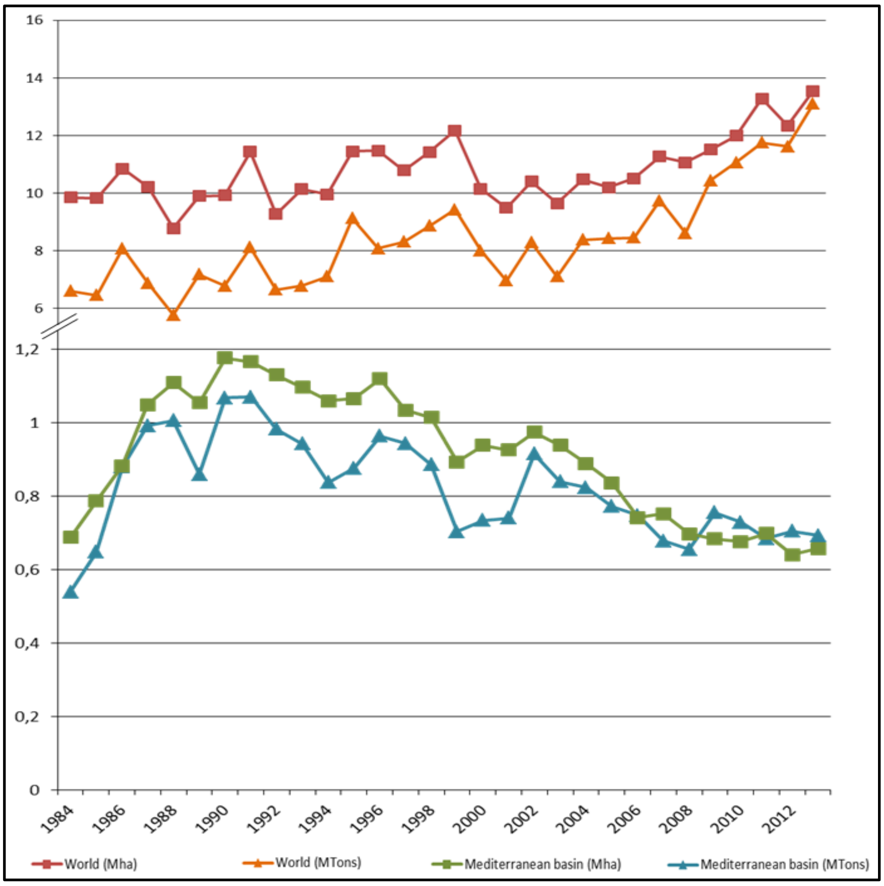

Figure 2. Comparison of the chickpea area (millions ha, Mha) and production (millions tons, MTons) evolution in the Mediterranean Basin (down) and world (up)

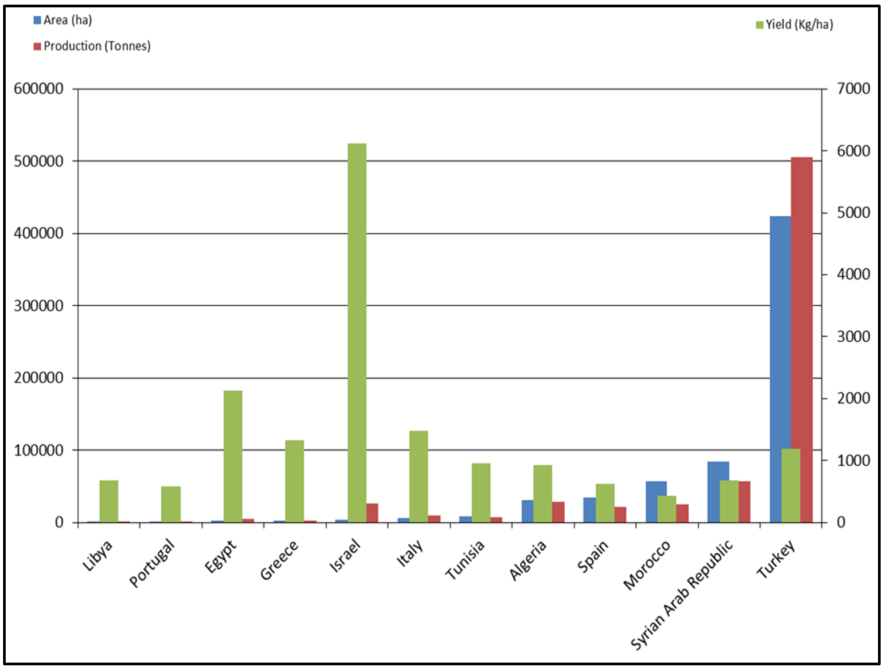

Figure 3. Chickpea cultivated area, production and yield in the Mediterranean Basin countries

Syrian Arab Republic

Syrian Arab Republic is the second most important country in terms of cultivated area (84,500 ha) and production (57,500 t). The patterns of variation in both, area and production, are remarkably similar to the countries in the Mediterranean Basin, with large fluctuations between different years. Although there has been a noticeable increase in area planted to chickpea, the trend in increased production is less notice able due to the downward in yield (680 kg ha^{-1}). With increasing pressure on land in Syria, profitability of spring chickpea is declining relative to other crops.

Morocco

Chickpea is the second most important food legume crop in Morocco, after faba bean (*Vicia faba* L.). The chickpea cultivated area during the past two decades is around 67,854 ha and annual production is 37,883 t (2). In 1994, Morocco produced 70,000 t, however, in 2013 the production has gone down to 25,000 t. This decline of around 65% has been due to biotic and abiotic stresses, and low investment in production techniques (improved varieties, certified seeds, weed management, mechanization...). Most of the chickpea cultivated land is located in the north and west regions of the country which includes the provinces of Taza-Alhoucima-Taounate (27%), Meknes-Tafilalet (16%), Fes-Boulemane (12%) and Gharb-Chrarda-Benihssen (24%). Nearly 80% of the total chickpea production comes from these regions.

The chickpea breeding program at INRA Morocco aims to develop and release varieties that are well adapted to different agro-ecological areas, processing high yield potential, resistant to Ascochyta blight and other diseases and pests prevalent in the target areas. Tolerance to drought and making the new varieties suitable for mechanized harvesting are also other important objectives. Other traits related to seed quality, such as large size, cooking time and high nutritional value, are also being introduced in the breeding program. Since 1994, seven winter chickpea varieties were released and registered by the breeding program. Those new high yielding varieties are resistant to blight. However, seed increase and commercialization is still needed to make those varieties available to farmers.

Spain

Chickpea has been a traditional crop in Spain for centuries. Today, traditional landraces, susceptible to blight and wilt, are still the most cultivated. Currently, it ranks fourth in harvested area (36,830 ha, 9.72% in 2014) after other legumes like pea, vetches (*Vicia* spp.) and bitter vetch (*V. ervilia* (L.) Willd.) (5). In the last 30 years, Spain has suffered great fluctuation in both cultivated area and production, with around 64% each (3). The occurrence of Ascochyta blight coupled with imports of cheap chickpea from Mexico adversely affected chickpea cultivation in Spain. Fortunately in 2014 the cultivated area has increased to 12,100 ha, explained partly by the European Union Common Agricultural Policy and the high market prices for first-quality seeds.

Spain is the major producer (42.8% of the total European production) and consumer of chickpea in Europe (around 76,051 t), therefore needs to import approximately double than its chickpea production, in 2010 around 53,800 t, being the fifth country in terms of world imports.

Seed size is a key quality determinant in the Spanish market. In the Andalusia region (southern Spain) the farmers prefer chickpea „Blanco Lechoso" type with big seed (around 0.6 g) because it fetches three times higher prices than other chickpea cultivars (around 1.5 EUR kg^{-1} „Blanco Lechoso" and 0.50 EUR kg^{-1} median or small seeds type). Today, the development of resistant lines to both diseases (Fusarium and Ascochyta blight) and big seeds size is the main objective of chickpea breeding in Spain.

Algeria

The implementation of the program for decreasing fallow areas and intensifying food legume production during 1983 to 1988 in Algeria caused an increase in the cultivated area (more than 50,000 ha) (3, 4). Nowadays, the area under cultivation of chickpea is around 31,000 ha, ranking the fifth most important country in the Mediterranean Basin (Fig. 3). The main reason for decrease in area under cultivation is that it has to compete with wheat (*Triticum aestivum* L.), which, yield is about five times that of chickpea. Although the chickpea production suffered fluctuations in the last 30 years, it has been increasing since 2010, with 29,000 t in 2013. During the last 30 years, yield increased from 262 kg ha^{-1} to 936 kg ha^{-1}. As mentioned before, the yield is too low to compete with other crops like wheat and its domestic production, as well as with imported chickpea. Algeria imports more than 200% of its production (66,000 t).

Tunisia

Food legumes in Tunisia represent only 5% of the harvested areas of field crops or around 90,000 ha (1). Chickpea is the third legume in terms of cultivated areas after faba bean and pea. It is grown on about 8,050 ha with a yield of 956 kg ha^{-1} and a production of roughly 7,700 t (3). Until the early 1980s, chickpea crop covered more than 35,000 ha, mainly as a spring crop. In the last 10 years the area under cultivation has decreased for 78%. This tremendous decrease is due to several socio-economic and technical constraints. Successive spring droughts occurring in 1990s were also responsible for the decline in the spring chickpea area, especially in semi-arid zones. The introduction of winter chickpea technologies and new varieties resulted in improving grain yield; however, those varieties were not extensively adopted due to their small seed size and preference of the market for large seed. Furthermore, during the last seasons, growing winter chickpea in humid and sub-humid regions was abandoned due to heavy damage caused by root rot diseases. Actually, the winter variety „Beja1" is adopted by a large number of farmers in Tunisia and contributed in the last decade in the increase of the chickpea yields. Tunisian consumers prefer the large spring-type seeds (around 0.5 g). Therefore, the chickpea improvement program is now focusing on developing high yielding winter varieties with large seed size and better disease resistance.

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Grass pea prospective at the Mediterranean Basin

by Letice GONÇALVES[1], Diego RUBIALES[2] and M. Carlota VAZ PATTO[1]*

Abstract: Although with a high potential for harsh environments, grass pea cultivation in the Mediterranean region is in regression. Due to an increased knowledge accumulation on locally adapted grass pea germplasm, with high agronomic potential for modern low input/integrated production systems and the development of molecular tools to support breeding programs, this reality is slowly changing. With the present work we reviewed grass pea actual importance and perspectives within Mediterranean countries.

Key words: feed and food legume, grass pea, landraces, *Lathyrus sativus*, Mediterranean region

Grass pea (*Lathyrus sativus* L.) is an annual legume crop, originated in southwest and central Asia, subsequently spreading into the eastern Mediterranean (8). Today it is grown in large areas of South Asia and Sub-Saharan Africa, but its formerly frequent cultivation has drastically decreased in Mediterranean countries. At worldwide level, grass pea is presently regarded as a promising crop for drought-prone and marginal areas, being superior in yield, protein content, nitrogen fixation and tolerance to drought and salinity, when compared to other legume crops (19).

Grass pea is highly suitable for human consumption, being rich in polyunsaturated fatty acids. It is also interesting as functional food thanks to its antioxidant activity, higher than that of chickpea (*Cicer arietinum* L.), lupin (*Lupinus* spp.) or soybean (*Glycine max* (L.) Merr.) seeds (11). Unfortunately grass pea suffers from a reputation of being toxic, as its overconsumption, under certain circumstances, has caused neurolathyrism, a neurotoxic disease related to its content on a non-protein amino acid, β-ODAP. However, there is an agreement today that grass pea is harmless to humans and animals when consumed as part of a balanced diet (10). Also, as a result of large breeding efforts a number of cultivars with low β-ODAP content are now available (9).

Mediterranean accessions tend to have white and large seeds, in contrast with the predominantly blue-flowered and small dark seeds typical from Asia and Ethiopia. Preference for larger seeds in the Mediterranean area is common to other grain legumes such as lentil (*Lens culinaris* Medik.), chickpea and faba bean (*Vicia faba* L.), and is a product of human selection. Mediterranean accessions tend also to have higher yields, later phenology and lower β-ODAP content (7).

Regardless of a customary cultivation of grass pea in Mediterranean countries and high gastronomic appreciation by local consumers, the sad fact is that today, and in this region, grass pea is a neglected crop, even in risk of genetic erosion (16). There are no available registered cultivars in most Mediterranean countries, what is common more or less to all Europe. For instances, the European Common List of Commercial and Protected Varieties Catalogue does not include a single grass pea cultivar, as clear indication of the little attention paid to this species, in spite of its great potential value for dryer areas.

Fortunately, significant germplasm collections are preserved in a number of Mediterranean genebanks (see Table 2 in 16) and grass pea research activities are maintained in some of these countries. These are focused mainly on germplasm genetic, agronomic and quality characterization (1, 4, 5, 6, 14), with some genetic resistance studies and cross breeding schemes initiated (17, 18).

In the absence of proper statistics on grass pea cultivation or consumption and based on the few references available, we tried to elucidate the crop actual importance and perspectives in the Mediterranean region, using four different countries as examples. Mediterranean countries experienced in common a severe decrease in grass pea cultivation during the last 50 years, and presently grass pea is mainly grown by small farmers, for own or local consumption, with little or negligible trade. However, farmers of all these countries also share an appreciation for grass pea food products and an interest in the crop cultivation, provided that better adapted cultivars are made available.

In Portugal, present grass pea production is very small and mainly used for self consumption, rather than for commercial purposes (15). However, there is an increasing interest on this crop, especially in the central mountainous regions of Serra do Sicó, where grass pea has been used for a long time as a traditional crop. Grass pea is also cultivated in the southern region of Algarve (Caldeirão Mountains) and in Serra de Sintra, near Lisbon, being all these areas characterized by limestone soils. As an example, in Alvaiázere region (Serra de Sicó), farmers integrate grass pea in crop rotations, mainly alternating with cereals; in intercropping systems with olive (*Oliva europaea* L.), chickpea or faba bean; or as sole crop for grain production. Based on the information collected locally, grass pea yield is around 1 t ha^{-1}. Thanks to the active enrollment of local authorities in supporting and organizing grass pea gastronomic annual festivities (“Festival do chícharo”, “O chícharo da Serra”), this crop has become

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progressively more well-known in the country, with an increasing number of growers and cultivated area, mainly as a delicatessen market oriented production. Recent reports indicate that there are individual farmers sowing up to 6 ha of grass pea, what is quite impressive for the region average farm size. No registered variety exists yet in Portugal, so farmers cultivate traditional landraces selected over centuries of cultivation, but with reduced yields.

Spain follows a similar trend. There are historic records of grass pea cultivation since Pré-historic period, with seeds found in Cueva del Toro (Málaga), dated from Neolitic and in El Acequión (Albacete), from Bronze Age (12). Grass pea was frequently cultivated until the sixties (55,000 ha in 1950), but markedly decreased since then, being today almost abandoned (15 ha in 2007) (4). It was used both for animal feed and human food. Presently this crop is still cultivated in Castilla-La-Mancha and Castilla-León regions, mainly in small areas and only in familiar agricultural systems, where is mainly consumed in traditional dishes, being "gachas" the most popular. Indeed, some traditional folk celebrations retain a grass pea stew as the main dish, showing its importance in the Spanish cultural heritage (3).

The situation is similar in Italy, where grass pea was a crop typically used in a number of traditional dishes, being the hay used for animal feed (14). Presently, grass pea is still cultivated, but only in small farms, mainly for home consumption (14). However, a renewed interest on this crop in growing, justified by its high adaptability to organic farming and sustainable systems, used as alternative, in crop rotation, in areas overexploited by cereal cultivation and as a source of protein for animal feeding (13).

Grass pea was highly cultivated in Turkey in the past. However its cultivation has decreased dramatically from the 1960s. Presently, mainly due to the government support to forage production, grass pea area reached 35,000 ha (28,000 ha for forage and 7,000 ha for seed production) (2). Therefore grass pea production is mainly used for feed and rarely for human consumption (1). There are presently three registered varieties of grass pea in Turkey, two of them only since 2013, and so until now almost all seed cultivated was of a landrace type (2).

We may conclude that the highly resilient diverse Mediterranean adapted grass pea germplasm, once neglected, may presently play a crucial role on the immense agricultural challenges faced by this region and predicted based on the exponential increase on global demand for food.

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Lentil (*Lens culinaris* Medik.)

by Marcelino PÉREZ DE LA VEGA* and Richard FRATINI

Abstract: Lentils (*Lens culinaris* Medik.) have been cultivated and consumed around the Mediterranean since their domestication and initial spread, and they are nowadays still a traditional food all-around of the basin. The total production over the past 50 years has doubled to approximately 600,000 t with yield having nearly doubled. The main factors still limiting lentil production throughout of the Mediterranean Basin consist likely in the small-scale farming practiced as well as the cultivation under rainfed in harsh semi-arid regions.
Key words: breeding, culture, domestication, production, stresses

Lentil (*Lens culinaris* subs. c*ulinaris* Medik.) was domesticated among the first set of crops, such as einkorn (*Triticum monococcum* L.), emmer (*T. turgidum* subsp. *dicoccon* (Schrank. (Thell.)), barley (*Hordeum vulgare* L.) and pea (*Pisum sativum* L.), during the agriculture origin in the Fertile Crescent. According to archaeological data, the distribution of wild species and the existence of remains of both wild and cultivated lentils in the same region, the Fertile Crescent is the most obvious candidate with regard to the domestication place. Available data point to the region of southern Turkey–northern Syria as the most likely place of lentil domestication and where some populations of *L. orientalis* (Boiss.) Hand.-Mazz. were unconsciously subjected to automatic selection leading up to *L. culinaris* arising as a new crop. The expansion of the cultivated lentil occurred most likely simultaneously with that of the other in the Fertile Crescent first domesticated crops as agriculture expanded around the Mediterranean Sea and to other parts of the Old World. The expansion of the lentil crop was relatively rapid; lentil archaeological remains exist in the most occidental part of the Mediterranean basin, the Iberian Peninsula, already since the early Neolithic. Remains of several crops, such as einkorn and emmer wheat, barley, pea, grass pea (*Lathyrus sativus* L.), lentil and faba bean (*Vicia faba* L.) comprising a typical Near East crop complex, have been dated by ^{14}C to 7,540 ± 140 BP (5).

Thus, lentils have been a traditional food around the Mediterranean since the beginning of agriculture taking active part in the culinary culture. Numerous references to lentils exist in the classical Hellenistic and Roman periods and in the Middle Age on lentil cropping and consumption (2). Nowadays, lentil is still a traditional food around the Mediterranean, cooked in different forms since each region and location hold their own traditions, from the traditional mujjadara, mudardara or mjadra in the Middle East to all of the European soups and stews. For instance, in Spain they are part of an everyday main meal and are eaten, as a soup or as a stew, at home or at work dinners. After all, lentils are considered as the easiest and friendliest to digest among all of the dry seed legumes. Thus lentils are currently devoted to human consumption, with an almost negligible use dedicated to livestock feed (exceptionally straw and damaged seeds are directly used by farmers). The main consumption entails dry seeds, although in some countries a minor part of the production is derived into the canned food industry.

Lentils are mainly grown worldwide under rainfed systems, and the Mediterranean region is not an exception, although in Egypt they are mainly irrigated likewise a minor part of the surface in other countries is devoted to irrigated lentil cropping. According to the available data from FAOSTAT (unfortunately no data is available for several Mediterranean countries), the current production and consumption is rather heterogeneous (4). The Mediterranean countries represent 13% of the world lentil production with a mean yield similar to the world average (Table 1). The production and yield analysis during the approximately 50 years covered by the statistics manifests that while the area harvested has increased by one third the production and yield have doubled, nonetheless, the limited lentil cropping area expansion is most likely the result of a small scale and low-input farming practiced in most of the Mediterranean countries. During the last decade, Turkey has been the third world producer, behind of India and Canada, while Egypt and Croatia are second and third in yield after New Zealand. Since lentils are part of the traditional foods throughout of the Mediterranean basin, the relative low production in many countries is supplemented by large imports, mainly from Canada and the USA but also from other Mediterranean countries such as Turkey. This country was the second world exporter (212,596 t) subsequent to Canada in the year 2011, although it also appeared in the same year as the first world importer with 309,561 tones. Spain is an example of an importing country to cover the internal consumption demand. Lentils, as other dry legumes, are part of the traditional diet and widely consumed, yet lentil production in Spain, whilst being the largest lentil producer within of the EU, only roughly covers one quarter of the national demand. However, it is difficult to establish each country's real food supply needs given that statistics only reflect trade. For instance, no record in the FAOSTAT statistics accounts for the production of lentils in Portugal, nevertheless this country appeared as a lentil exporter (3,537 t) in the year 2011.

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Table 1. Lentil cropping area, production and yield of Mediterranean countries (five year averages) together with basin Total/Average figures followed by World data for comparison (4)

	Area harvested (ha)		Production (t)		Yield (kg ha^{-1})	
Country	1961-1965	2009-2013	1961-1965	2009-2013	1961-1965	2009-2013
Algeria	12,854	3,544	4,622	3,872	370	1,078
Croatia	-	34	-	57	-	1,780
Egypt	32,669	836	50,274	1,495	1,526	1,882
France	11,616	13,034	9,540	20,848	814	1,588
Greece	15,602	2,327	8,850	2,990	576	1,286
Israel	472	106	160	36	344	344
Italy	20,076	2,171	13,724	1,622	685	754
Lebanon	2,082	1,105	2,150	2,011	987	1,830
Morocco	24,600	47,111	12,000	32,413	483	682
Spain	46,284	35,484	25,599	23,633	616	657
Syria	79,356	126,696	63,563	109,498	787	872
Tunisia	2,525	2,609	524	1,374	275	503
Turkey	102,780	235,634	93,600	402,107	910	1,446
Total/average	350,916	470,690	284,606	601,956	698	1,131
World	1,672,165	4,180,706	940,259	4,547,314	562	1,087

Factors seriously affecting lentil production and yield in the Mediterranean comprise biotic as well as abiotic stresses. In view of the fact that most of the lentil production is attained in the Mediterranean basin under rainfed conditions, drought is probably the most common abiotic stress; in particular drought during the flowering up to the seed filling periods. In elevated areas, such as the central part of the Iberian or of the Anatolian Peninsulas, another major threat consists of frost injury, winter frost in the case of early sowing alongside spring frost for late sowing. In relation to biotic stresses, Ascochyta blight is probably the most common disease; nevertheless, the weedy root parasite broomrape (*Orobanche crenata* Forssk.) is also a considerable limiting factor to lentil production, almost preventing growth and development of lentil plants in heavily infected broomrape areas. Moreover, lentils are damaged by many types of insects together with other pests. Among insects, the major field pests consist of aphids (*Aphis craccivora* C. L. Koch, *Acyrthosiphon pisum* Harris), leaf weevil (*Sitona* spp.), lygus bugs (*Lygus* spp.) and the cutworm (*Agrotis ipsilon* Hufnagel). Seed insect species constitute yet another major pest problem causing great seed loss: *Bruchus ervi* Frölich and *B. lentis* Frölich with *Callosobruchus chinensis* L. and *C. maculatus* Fabricius (6). Little progress in breeding for insect resistance has so far been achieved in comparison with breeding for diseases, nowadays the situation remains similar. No sources of resistance to *Sitona* were detected in ICARDA materials which only showed effectiveness against the adult insect whilst not to larvae (6). Nonetheless, resistance to *S. crinitus* Herbst has been described in wild materials (3). In addition, viruses constitute also a source of yield reduction, although in general the information regarding these infectious agents which limit crop harvests is less abundant within of the literature.

The accumulating information obtained from "omic" data together with that retrieved from the genome sequencing project in development (1) will clearly speed up the application of the new technologies to complement the classical lentil breeding allowing for the identification of the main genes involved in the responses to the different challenging and limiting stress factors. Knowledge of the genome of both the cultivated lentil and its wild relatives is critical in order to accelerate the pace of breeding via marker-assisted selection, also for the mining of useful genetic variation derived from the more exotic germplasm via marker-assisted background selection or introgression. Sequencing information will thus add considerable resources to the breeder's toolbox for lentil genetic improvement, in view of the global climate changes and an increasing human population growth with an ever rising demand for lentils as part of their staple food.

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White lupin improvement for countries of the Mediterranean Basin

by Paolo ANNICCHIARICO[1]* and Imane THAMI-ALAMI[2]

Abstract: There is raising interest in white lupin for feed and food, but modest yields and narrow adaptation that arise from the paucity of breeding efforts jeopardize the expansion of lupin cultivation. Recent selection programs started in Italy and Morocco using segregating material developed in France have showed progress for specific environments. Wider and more focused exploitation of landrace genetic resources is a primary avenue for improving the crop yields and adaptation to Mediterranean environments, with proper support from low-cost molecular breeding tools under development. Grain quality traits, such as increased γ-conglutin or oil content, may become important breeding targets for specific crop uses.

Key words: adaptation, breeding gain, drought tolerance, grain quality, landrace, *Lupinus albus*

Current and perspective cultivation

White lupin (*Lupinus albus* L.) was seemingly domesticated in Ancient Greece from the locally-occurring wild type var. *graecus* (Boiss. & Spruner) Gladst. (6). It was important in Ancient Rome, being a staple food for the Roman Army that conquered western Europe. Its grain, after boiling and alkaloid removal through prolonged soaking in water, is still consumed as a traditional snack in several countries of the Mediterranean basin. However, lupin cultivation in this region is modest according to available statistics (mainly from FAO), extending over about 6500 ha in Spain, 5000 ha in France, 4000 ha in Italy and Morocco, nearly 3000 ha in Egypt, and less than 1000 ha elsewhere.

There is raising interest in white lupin grain for feed and food. As a feed, its high protein content (36% - 44%) makes it the most valuable alternative to imported soybean (*Glycine max* (L.) Merr.) in Mediterranean-climate regions, where soybean cropping is hindered by water required throughout its spring-summer cycle. Lupin can replace completely the soybean meal even in diets for high-producing lactating cows (11). It is an excellent ingredient for vegetarian food, owing to a combination of nutritional, technological and sensory characteristics (as highlighted by European projects such as HealthyProFood, Lupicarp, HealthyLupin, PlantsProFood, and LikeMeat). There is growing evidence that lupin-based diets can contribute to prevent and treat a number of diseases, including type-2 diabetes mellitus (T2DM), hypertension, cardio-vascular diseases, and metabolic syndrome. Finally, lupin grain contains a moderate amount (10-15%) of oil featuring a particularly high ω3/ω6 ratio (5). Compared with narrow-leafed lupin (*L. angustifolius* L.), which is mainly grown in Australia and some regions of northern Europe, white lupin tends to be higher yielding in different south-European environments (1), and has higher protein and oil contents (11). Compared with other cool-season feed grain legumes such as pea (*Pisum sativum* L.) or faba bean (*Vicia faba* L.), white lupin showed higher protein yield per unit area (although not higher grain yield) (1), and has the advantage of being tolerant to broomrape (*Orobanche* spp.).

Genetic improvement

White lupin breeding has been very modest in Europe and elsewhere. It got impulse by research work and germplasm development performed at INRA of Lusignan (France), which improved the crop yield and climatic adaptation to temperate regions through varieties with greater cold tolerance and novel plant architectures (7). Breeding programs in Mediterranean countries are present in France at Jouffray-Drillaud, Italy at CREA, and a few other countries such as Spain and Morocco. White lupin genetic resources are limited to the primary gene pool and include essentially landrace germplasm, because of effective genetic barriers to interspecific hybridization and the limited distribution of var. *graecus* (6).

The main environmental factor that can constrain lupin cultivation is its poor adaptation to soils that are even just moderately calcareous, i.e., those whose soluble fraction of calcium carbonate according to Drouineau's method exceeds 1% (11). Material displaying moderate tolerance to calcareous soil has been located within landrace germplasm from Egypt (8) and Italy (2). Raising yields by autumn sowing in cold-prone regions requires improved winter-hardiness, whose contributing traits are well-defined (late flowering via greater vernalization requirement; intrinsic tolerance; large seedling root, associated with large seed) (7). The multi-environment evaluation of a global collection of landrace germplasm has provided indications on most useful country gene pools for breeding programs as a function of the target climatic adaptation (4). However, drought tolerance variation and associated mechanisms have been poorly investigated. Anthracnose (*Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc.) is considered the main abiotic stress globally (7), but seems to be less threatening in Mediterranean regions.

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Grain yield has undoubtedly been the main breeding target. Breeding progress has been manifest (although still insufficient for widespread cultivation) in France, where lupin is not a traditional crop, particularly by means of innovative plant architectures (semi-dwarf and/or semi-determinate types) and increased winter hardiness (11). Smaller selection programs that started recently in Italy and Morocco using segregating material developed in France have showed progress for specific environments relative to reference cultivars, such as Multitalia in Italy, or Multolupa in Morocco (where this cultivar was introduced and multiplied for about 30 years). In Morocco, some elite breeding lines clearly out-yielded Multilupa in a highly-favourable cropping environment (where their greater tolerance to lodging proved important), while showing little progress in a less favourable site (Table 1). Less favourable cropping conditions arose from a combination of late autumn sowing and lower rainfall amount, which impacted negatively on breeding lines indiscriminately later-flowering than Multolupa (Table 1). In Italy, yield gains over Multitalia across autumn-sown, climatically-contrasting environments proved possible only through new lines specifically adapted either to mild-winter Mediterranean areas (such as Sardinia) or cold-prone regions (such as the Po Valley) (Fig. 1). However, wide climatic adaptation would be preferable for new varieties in Italy, given the large extent of areas with intermediate climatic characteristics and the limited market size of the crop.

Breeding perspectives

The outstanding value showed by specific sets of landraces over commercial varieties in terms of grain yield in different agro-climatic regions or tolerance to moderate lime soil (Table 2) suggests that the primary strategy for future breeding success is represented by wider and more focused exploitation of the available genetic resources, whose potential is largely untapped. The evaluation of global germplasm collections, such as that in (3), for tolerance to specific abiotic and biotic stresses is commendable. The future development of low-cost, high-throughput genotyping techniques such as Genotyping-by-Sequencing (under study at CREA), combined with data from selection or germplasm evaluation experiments, could allow for implementing genomic models for selecting advanced lines within a reference breeding population or for locating useful

Table 1. Grain yield, onset of flowering and lodging susceptibility of 10 elite selected lines and the control cultivar Multolupa in a moderately-favourable (Merchouch) and a highly-favourable (Larache) cropping site of Morocco; source: Thami-Alami, unpublished data

Line	Grain yield (t ha^{-1}) Merchouch	Larache	Mean	Flowering (dd from Jan. 1)	Susceptibility to lodging[a]
MO40	5.00	8.35	6.68	99	M
MO93	5.49	7.83	6.66	96	HH
20	5.83	7.32	6.57	100	L
MO92	5.83	6.94	6.38	100	HH
21	5.70	6.65	6.17	106	M
MO41	5.66	6.45	6.05	99	L
MO65	5.87	6.24	6.05	97	HH
17	5.50	6.39	5.95	105	M
MO45	5.46	6.41	5.93	96	L
3	5.39	6.37	5.88	102	L
Multolupa	5.51	5.09	5.30	93	HH
LSD ($P < 0.05$)	0.81	2.47	1.16	2	-

[a] L = low (< 10%), M = medium (10% - 30%), H = high (30% - 50%), HH = very high (> 50%)

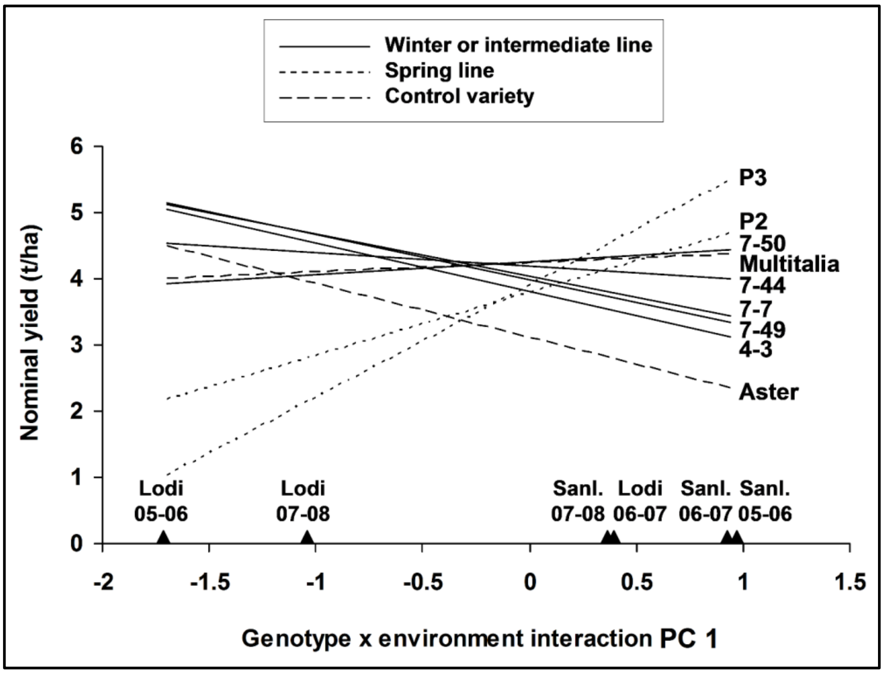

Figure 1. Nominal grain yield of seven lines selected for wide or specific climatic adaptation and two control varieties of white lupin as a function of the environment score on the first genotype × environment interaction principal component (PC) in an Additive Main effects and Multiplicative Interaction (AMMI) analysis; environments are combinations of two Italian locations (Lodi, Po Valley, subcontinental climate; Sanluri, Sardinia, Mediterranean climate) by three cropping years (2005-2006, 2006-2007 and 2007-2008)

Table 2. Best-performing white lupin landrace vs. variety germplasm for grain yield (t ha^{-1}) in three European agro-climatic environments (Lodi, Po Valley, and Sanluri, Sardinia, under autumn sowing; St. Sauvant, western France, under spring sowing), and lime tolerance expressed as dry aerial biomass ratio between moderate-lime (ML) and low-lime (LL) soil

Material	Yield in Lodi [a]	Yield in Sanluri [a]	Yield in St. Sauvant [a]	ML/LL ratio [b]
Best landraces	6.99	4.96	2.40	0.78
Best variety	5.41	3.96	2.07	0.47

[a] Landraces: top 10% (11 entries out of 113); best variety: Adam in Lodi, Energy in Sanluri and St. Sauvant (3)
[b] Average of two experiments: landraces, top 13% (2 entries out of 15); variety: Adam (2)

landrace accessions for specific traits in germplasm collections. Another important research issue for yield improvement is verifying whether the semi-dwarf, semi-determinate plant architecture that proved useful for temperate environments (7) confirms its value also for Mediterranean, drought-prone environments.

White lupin cultivation as a feed crop would be boosted not only by higher yields and wider soil and climate adaptation, but also by the dual-purpose crop for protein and oil, if oil content in its grain could be raised enough to justify its extraction and marketing (likely up to 18% - 19%, whereas current most-suitable material hardly reaches 15%) (11). Higher grain content in γ-conglutin could be a specific breeding objective for varieties used to produce nutraceuticals that control glycaemia (10). Molecular (9) and possible NIR-based procedures for rapid and precise determination of alkaloids content in the seed (which should not exceed 0.200 mg g^{-1}) have great practical importance for selection programs.

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Alfalfa improvement in the Mediterranean basin

by Paolo ANNICCHIARICO

Abstract: Alfalfa is an important crop in the Mediterranean basin. Its improvement is challenged by the need for varieties with increased drought tolerance, salt tolerance and, limitedly to non-dormant germplasm, cold tolerance, highlighting the strategic interest of international co-operation between regional breeding programs that share similar objectives. Selection of specific varieties for environments featuring different prominent stresses is a promising strategy, especially when seconded by the exploitation of elite, well-characterized landrace germplasm. Further support could derive from genomic selection models for specific environments based on genotyping-by-sequencing SNP markers. A regional breeding strategy including all of these elements is assessed within the FP7-ArimNet project REFORMA.

Key words: drought tolerance, genomic selection, *Medicago sativa*, plant adaptation, salt tolerance

Table 1. Alfalfa pure stand cultivated area, alfalfa percent of arable land, mean alfalfa dry matter yield, and most-grown perennial forage legume, in countries of the Mediterranean Basin

Country	Cultivated area (ha) [a]	Percent of arable land [a]	Mean yield (t DM ha^{-1}) [a]	Main legume [b]
Albania	150,000	24.3	9.7	Alfalfa
Algeria	2,300	0.01	3.2	Alfalfa
Bosnia and Herzegovina	19,750	2.0	9.4	Red clover
Bulgaria	64,600	2.0	7.1	Alfalfa
Croatia	26,050	2.9	10.6	Alfalfa
Cyprus	750	0.9	3.7	Alfalfa
France	329,100	1.6	14.8	Alfalfa / white clover
Greece	129,300	5.2	3.7	Alfalfa
Italy	716,400	10.1	10.5	Alfalfa
Lebanon	750	0.6	20.5	-
Montenegro	3,000	1.7	6.0	Alfalfa
Morocco	100,000	1.1	15.0	Alfalfa
Romania	332,650	3.7	6.0	Alfalfa
Slovenia	2,600	1.5	2.4	Alfalfa / red clover
Spain	248,500	2.0	15.8	Alfalfa
Syria	2,550	0.01	9.6	-
Tunisia	12,400	0.4	-	Alfalfa
Turkey	554,250	2.6	6.5	Alfalfa

[a] Source: average of 2008-2011 according to FAOSTAT, except for Greece (2007), based on EU Stat, and Morocco, Tunisia and partly France, based on national sources; no data available for Egypt, Israel and Lybia; [b] (3)

Figure 1. Alfalfa in flower

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Alfalfa (alias lucerne, *Medicago sativa* L., Fig. 1) has historically been the main forage crop in the Mediterranean basin already during the Roman Empire, the Moors kingdoms and the Renaissance (8). It keeps being the most-grown perennial forage legume in nearly all countries of the region (Table 1). Statistical data relative to pure stand cultivation indicate the special importance of alfalfa in Italy and Albania (where it exceeds 10% of the arable land), Greece, and Romania (Table 1). These data underestimate the actual cropping area in countries, such as France, where alfalfa is largely grown in mixture with grasses. The importance of alfalfa in several drought-prone countries is better appreciated when considering the share of irrigated land devoted to its cultivation, e.g., over 5% in Spain, and nearly 10% in Morocco. These countries, Lebanon (where alfalfa is irrigated) and France show the highest crop mean yield (Table 1). Over 50% of cropping area in Spain, 20% in France, and 10% in Italy, is used to produce alfalfa dehydrated bales or high-protein (from 17% to 22%) pellets. Alfalfa dry forage (hay; silage; dehydrated bale) or fresh forage is usually fed to ruminants. Pellets are also fed to monogastrics (up to 10% - 20% on a diet dry-matter basis depending on species and production level), for which they offer the advantage of higher levels of omega-3, carotene and minerals compared with other high-protein feedstuff.

Drought, which is the main stress affecting alfalfa at the global level (3), constrains severely alfalfa production in rainfed, low-rainfall Mediterranean environments. Its impact is expected to rise, owing to the combination of higher evapotranspiration and lower and/or less regular rainfall caused by climate change (4). Breeding new cultivars with increased drought tolerance will be needed not only for rainfed environments but also for environments currently using large irrigation amounts (mostly in Spain and north-African countries), where the decreasing availability of irrigation water will push for the adoption of limited or suspended summer irrigation. Also, the expected increased adoption of poor-quality, saline irrigation water will emphasize the need for highly salt tolerant varieties. Climate change also offers opportunities, such as the introduction of varieties with low or about nil autumn dormancy in inland areas of southern Europe, but higher yields by this avenue could be achieved only through varieties that are concurrently improved for tolerance to winter low temperatures and erratic, early or late frosts.

A dual-purpose crop providing feed protein from leaves and energy from stems could increase the alfalfa cultivation and profitability. Equipment for the separate harvest of leaves and stems has been developed in USA, with optimal energy chain production, crop management and variety type for this utilization also defined (5).

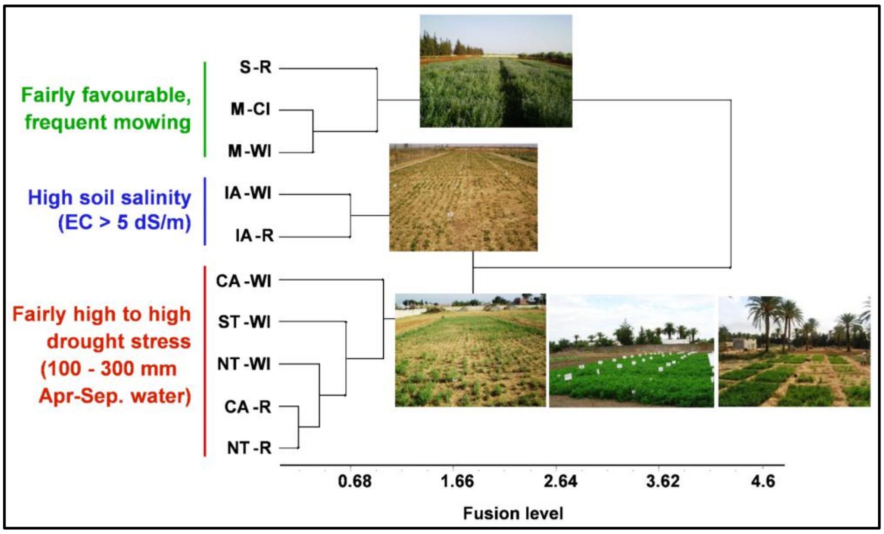

Figure 2. Classification by pattern analysis of 10 north-African or south-European coded environments, based on their similarity for three-year dry matter yield genotype × environment interaction responses of 12 alfalfa cultivars (2)

Genetic improvement

Despite its importance, alfalfa has been a minor target of genetic improvement in the Mediterranean basin and several other cropping regions, owing to several reasons (such as lower seed market value, greater genetic complexity, less favourable reproductive system, more difficult farmer's assessment of variety value, and greater exposure to seed fraud, relative to other major crops). Long-term private breeding programs are present in just a few countries of southern Europe, and public breeding or pre-breeding has been pivotal in nearly any country hosting breeding work. In Italy, a number of registered varieties derived from mass-selected (or even non-selected) farm landraces. Research work aimed to improve alfalfa drought tolerance has been remarkably modest worldwide (3). International co-operation between breeding programs in the Mediterranean basin that share similar objectives could be particularly important, given the challenge of breeding new stress-tolerant varieties, the modest opportunities for economic return of private seed companies, and the budget constraints imposed on public programs.

Mediterranean landraces and recent varieties from Europe, USA and Australia that were evaluated across many rainfed and irrigated environments of the western Mediterranean basin revealed the large extent of specific-adaptation responses in relation to drought stress and soil salinity (2), supporting the development of varieties adapted to specific cropping conditions. The classification of test environments according to cultivar adaptive responses indicated three main trans-national target environments for regional breeding (relatively moisture-favourable; saline; severely drought-prone: Fig. 2). Selecting varieties specifically adapted to rainfed or irrigated cropping resulted in greater crop yields even over an area, such as northern Italy, where rainfed cropping implies just moderate drought stress (1). Landrace germplasm can be particularly valuable as a donor of adaptive genes not only for stress conditions but also for favourable ones (1, 2).

Recent progress in marker development, particularly genotyping-by-sequencing (GBS), has the potential for cutting genotyping costs dramatically, opening the way to genomic selection for alfalfa production traits (3, 6). To be really successful, genomic selection should be carefully integrated into selection schemes in an ecological prospect capable of exploiting germplasm resilience and specific adaptation (3). Germplasm phenotyping and/or selection in managed environments (1) or controlled conditions (7) that can reproduce well-defined target environments is another key issue to explore, to facilitate the implementation of genomic selection and/or to allow for more cost-efficient phenotypic selection.

REFORMA: a trans-national improvement project

REFORMA (Resilient, water- and energy-efficient forage and feed crops for Mediterranean agricultural systems) is an FP7-ArimNet project joining nine research institutions from Italy, France, Algeria, Morocco, Tunisia and USA.

The work on alfalfa within REFORMA aims to develop: a) varieties with enhanced stress tolerance; b) cost-efficient marker-assisted selection (with emphasis on genomic selection for forage yield in drought-prone, saline, and favourable conditions); c) ecological breeding strategies, and use of managed selection environments; d) optimal forage crops in relation to alfalfa and grass plant types, site drought stress, acceptability by farmers in participatory assessments, and target forage quality and utilization.

Prior cultivar testing in Mediterranean environments (2) has been exploited to develop a widely-based reference genetic base of nearly non-dormant germplasm for regional breeding (by repeated intercrossing among one drought-tolerant Italian landrace, one salt-tolerant Moroccan landrace and one widely-adapted Australian variety). On-going phenotyping of about 140 parents is based on responses of their half-sib progenies, a scheme which offers considerable advantages relative to other schemes (e.g., cloned parents) (3). It contemplates forage yield and persistence assessments under: a) severe drought, in agricultural environments of Algeria and Tunisia and large artificial environments of Italy; b) saline conditions, in Tunisia; c) under moisture-favourable conditions, in Italy. Additional phenotyping under severe drought in Argentina and low winter temperatures in Serbia is under way on the same material, using national funds. Genomic selection models based on SNP markers (issued by a GBS procedure developed at the Samuel Roberts Noble Foundation) will be developed for environments featuring different prominent stresses (drought; salinity; low-temperature) and non-stress conditions, for use in predicting parent breeding values as a function of the target environment. Preliminary results, which are relative to prediction of parent breeding value for yield under favourable conditions, suggest greater gain per unit time than ordinary phenotypic selection.

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RESEARCH

The role of sainfoin in Mediterranean region

by Svetlana VUJIĆ*, Branko ĆUPINA, Pero ERIĆ and Đorđe KRSTIĆ

Abstract: Sainfoin (*Onobrychis viciifolia* Scop.) is a perennial legume well adapted to drought conditions and calcareous soils. It is a high protein tanniferous legume with non-bloating effect on ruminants, but however areas under this crop decreased in the last thirty years. Recently, is getting more attention in Mediterranean countries as a quality source of forage for organic livestock production particularly in the winter period. Sainfoin can also serve as land cover between trees in plantations or can be intercropped with cereals or grasses for forage production. Its significant constraint like persistence and seed yield production should be the main issues of the breeding programs in the future.

Key words: forage crop, organic farming, sainfoin

Figure 1. A wild population of sainfoin in the southern FYR Macedonia

Sainfoin is a perennial forage legume well adapted to the temperate zones of Europe, North America and the Middle East (11). It is also well adapted to drought and calcareous soils, but it's sensitive to acidic soils and saline conditions (Fig. 1). Areas under this species have declined because of its low persistency and because of development and higher use of other perennial legumes such as alfalfa (*Medicago sativa* L.) and red clover (*Trifolium pratense* L.). Another important reason for this reduction is low seed yields and high amounts of seeding rate that are required for good establishment of sainfoin stand. It has been reported that the cultivation area in semiarid environments of Italy has decreased from 160000 to 9000 ha in the last three decades (7). In the Mediterranean region, except in Italy today sainfoin is still being cropped in Spain, Turkey and Iran (3). In 1998 in Turkey this species was grown on about 93000 ha. Recently, sainfoin is getting more attention since this is a high protein tanniferous legume with non-bloating effect on ruminants. Rising interest for this species is also in correlation with growth of organic livestock production in Mediterranean countries supported by EU. The major constraint with organic production is lack of high forage quality, particularly in the winter period (8). Alternative forage crops like sainfoin and French honeysuckle (*Hedysarum coronarium* L.) can respond to this request. The meadows with this species are most utilized in Mediterranean environments where they are mainly used for grazing from October to April (9). Studies have shown that sainfoin have similar and even better nutritional values when cultivate organically in comparison with a conventional management (8) (Table 1). And more it's a crop that can face the climate change impacts in Mediterranean, such as lack of water and irregular rainfall (6).

Table 1. Nutritional values of sainfoin and alfalfa from organic production according to farms in Catalonia (Spain) and from conventional production (8), with *n* being the number of sampled sites of organic farming and the number of references from conventional farming (1, 4, 5)

	Organic farming		Conventional farming	
	Sainfoin *n* = 5	Alfalfa *n* = 3	Sainfoin *n* = 4*	Alfalfa *n* = 3**
Ash	8.0-11.6	8.9-12.4	10.4-11.5	10.2-11.1
CP	17.8-26.1	14.8-26.4	13.1-17.5	16.8-22.4
DP	10.9-18.9	9.0-17.6	8.1-10.6	12.2-18.8
NDF	30.8-47.7	25.0-54.5	45.1-53.6	46.4-52.5
ADF	21.1-35.4	16.8-35.4	27.6-36.3	29.4-34.4
Lignin	4.3-7.9	4.0-6.4	-	-
Starch	3.4	1.0-5.6	-	-
EE	1.5-2.4	1.9-2.0	-	-
NEL	1.3-1.7	1.3-1.9	1.3-1.6	1.2-1.3
OMD	55.0-72.0	55.7-80.8	67.0-76.0	60-66

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Sainfoin has a good effect on erosion control either of wind or water (12) and on soil fertility particularly in vineyards and orchards (10). In Mediterranean conditions sainfoin and alfalfa are common species in plantations in which they are planted as fodder intercrops. In such systems legumes compete with trees for water during the summer, but unlike the grasses which are also often sown between tree rows, they do not compete for nitrogen (2).

In northern part of Serbia in temperate climate zone there are research on growing sainfoin in intercropping with field pea (*Pisum sativum* L.) and oat (*Avena sativa* L.) (Fig. 2 and 3). Field pea was chosen to provide more proteins to the first cut and to prevent weeds development and oat was used as a traditional way of sowing perennial legumes (mostly alfalfa) with cereals. Pure stand of sainfoin had the lowest dry matter yield in the first cut (2.1 t ha^{-1}), while the highest obtained sainfoin with oat (6.5 t ha^{-1}). Yield of sainfoin and field pea ranged from 4.2 t ha^{-1} to 6.3 t ha^{-1} depends on number of pea plants and pea variety. Re-growth of sainfoin in subsequent crops and obtained yield was similar in pure stand and in intercrops with pea. This way of cultivation can also be applied in Mediterranean, but with some corrections. Namely, sainfoin can be intercropped with oat or some other cereal or grass but with a reduction of plant number of other component in order to enable sainfoin to have a good establishment and re-growth after the first cut.

Sainfoin can improve forage production and to enlarge the very limited number of perennial legumes for cultivation in rain-fed conditions of Mediterranean environments. Since this is a high nutritional and palatable crop and have positive effect on environment, it can provide enough feed and to be included in organic livestock production. However, the major constraint of its stability like persistence and seed yield production should be the main issues of the breeding programs in the future.

Acknowledgements

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Figure 2. Intercropping sainfoin with pea (left) and oat (right) for forage production in a field trial in northern Serbia

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Around the world in two centuries or why French serradella (*Ornithopus sativus*) should return to its Mediterranean homeland

by Aleksandar MIKIĆ

Abstract: French serradella (*Ornithopus sativus*) is an underutilised annual legume crop, used mostly for forage and grazing. It is grown sporadically in Europe and mostly in the coastal areas of Australia and South America with Mediterranean climates. The advanced cultivars of French serradella have been developed in Australia from the germplasm introduced from Europe, producing up to 4.2 t ha^{-1} of forage dry matter and more than 1400 kg ha^{-1} of seed. This crop is highly tolerant to various stresses and thus may be grown on the soils of a poorer quality or infested with pathogens and weeds the other legumes are less resistant to. A reintroduction of French serradella in the agriculture of the Mediterranean basin is necessary and highly desirable.

Key words: forage, French serradella, Mediterranean climate, *Ornithopus sativus*, underutilised legume crops

Introduction

French serradella (*Ornithopus sativus* Brot.) is the only economically important species in the genus *Ornithopus* L., also including *O. compressus* L., *O. micranthus* (Benth.) Arechav., *O. perpusillus* L., *O. pinnatus* (Mill.) Druce and *O. uncinatus* Maire & Sam. and belonging to the tribe *Loteae* DC. (7). This crop is a little known annual legume, used mostly for forage production and grazing. It is grown sporadically throughout Europe, mostly in the Mediterranean and its adjacent regions, as well as in the coastal areas of Australia with the Mediterranean climate to where it was relatively recently introduced (9).

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Origin and biodiversity

Similarly to botanically and phylogenetically close taxa, French serradella has $2n = 14$ chromosomes. Since the richness of its wild populations, it is generally considered that French serradella originated in the region roughly comprises northwest Portugal, northern Spain and southwest France, from where it spread as a cultivated plant in other parts of Europe and the Mediterranean in 19th century (16).

The current knowledge on the biodiversity of French serradella is extremely limited. Despite the fact that its local landraces are numerous and easily accessible, especially in its centre of origin, they have never been thoroughly studied. One of the rare analysis using molecular techniques, such as ITS1 and ITS2 DNA sequences from a large number of wild populations of French serradella, revealed narrow population diversity within the local landraces of this species (13).

Figure 1. A stand of the French serradella cultivar Cadiz in full flower

Breeding

So far, there has not been any significant achievement in enhancing French serradella in the majority of the countries of South Europe, North Africa and West Asia. As a rule, there are no data on its cultivation area, yield or production. The wild populations and local landraces seem to satisfy the regional needs and remain within their natural bounds for centuries. On the other hand, French serradella also accompanied numerous human migrations during past few centuries and found its new homes. There, it became a promising pasture annual legume, with much better agronomic performance in comparison to other indigenous crops. The best example of a country offering such new opportunities for French serradella is Australia, where the advanced cultivars are developed from the germplasm introduced from Europe. One such widely cultivated cultivar of French serradella is Cadiz (Fig. 1), with a potential for high seed production and pods not requiring additional processing other than cleaning, since their specific morphology, with prominent segments with a seed in each (Fig. 2). Such ideotype of a French serradella cultivar ensures easy removal of weed seeds, low seed price and sowing at high density, not requiring specific machinery (2).

An existence of seed hardiness in the local landraces of French serradella has been raised as one of the important tasks for breeders (3). There is a possibility of the interspecific hybridisation between French serradella and *O. compressus*. The aim of such schemes is to develop such genotypes that would retain the seed hullability of French serradella with more increased drought and pathogen tolerance in *O. compressus* and that would also lose a prostrate habit and a high percentage of hard seeds that confer greater persistency on *O. compressus* (15).

Figure 2. The pods of French serradella in the stage of grain filling and with a typical morphology for the species of the tribe *Loteae*

Potential

In one of the relatively rare documented field trials, carried on a sandy soil type, both diploid and tetraploid serradella cultivars had a forage dry matter yield 25% higher than *O. compressus*and *O. pinnatus* (14). In the dry regions with a Mediterranean climate in Chile, the introduced French serradella cultivars from Australia demonstrated a potential to produce up to 4.2 t ha^{-1} of forage dry matter and more than 1400 kg ha^{-1} of seed (10).

In addition, French serradella in various cropping systems may produce abundant aboveground biomass and thus be used as forage or for grazing (4) and as green manure, especially in many regions with moderately temperate climates, such as Portugal (11).

Abiotic and biotic stress

The literary resources on biotic stress in French serradella are scarce in comparison to the other legume crops, but emphasize its high tolerance to various forms of stress.

French serradella has a certain degree of winter hardiness and may be suitable for sowing in late autumn in the climates with mild winters, such as New Zealand (6).

In the test comprising various legume species, the local landraces of French serradella showed a rather high tolerance to a root disease caused by *Phytophthora clandestina* Taylor, Pascoe and Greenhalgh (8).

Using French serradella as a break crop in wheat-based cropping systems, in the environments with Mediterranean climate such as Western Australia, may contribute to ecological services by significantly reducing weeds and thus decreasing the need for applying herbicides (5).

An analysis with amplified fragment-length polymorphism (AFLP) markers, used to elucidate the existing genetic relationship between populations and to suggest a potential origin for the recently detected vetch-infecting population by fetid broomrape (*Orobanche foetida* Poir.), revealed that the most genetic divergent population by cluster analysis was the population collected on French serradella (12).

When cut in the stage of full flower and ploughed in the soil, the local landraces of French serradella may also have an additional beneficial effect on reducing the pests such as nematodes (1).

There is a solid basis for the French serradella crop improvement, with enhancing the contemporary cultivars less tolerant to stresses by intraspecific crossing with a much more tolerant local landraces and by growing this crop on the soils of a poorer quality or infested with pathogens and weeds the other legumes are less resistant to.

Conclusions

During past few centuries, French serradella has passed a long voyage from its native home in West Mediterranean to other parts of Europe and distant regions with similar climates, such as Australia. In a way, it is somewhat ironic that the greatest improvement of this crop has been made in those new habitats, while the old wild populations became endangered in the homeland of French serradella. It is to be anticipated that these facts may send a strong stimulus that would initiate reintroduction of French serradella in the agriculture of the Mediterranean basin.

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Common bean cultivation in the Mediterranean Basin

by Lucia LIOI and Angela Rosa PIERGIOVANNI*

Abstract: The worldwide common bean production has significantly increased in the past three decades, except in Europe where it is dropped. Nowadays, about half of beans consumed in Europe is imported. In the Mediterranean basin, the major common bean productions and consumptions are recorded in Spain, Italy and Greece, where a myriad of landraces survive on-farm. Actions to safeguard this germplasm cannot be disregarded, since Europe is considered a secondary centre of diversification of this species. Moreover, there is the need to increase the plant tolerance to drought, in view of expansion of water-stressed lands in the Mediterranean basin. Rapid progress in breeding for resistances has strongly reduced the effects of pests and diseases.

Key words: European policy, legume, landrace, *Phaseolus vulgaris,* yield

Legumes represent an important component of human diet in several areas of the world, contributing to about 33% of the dietary protein nitrogen. In Europe, the higher legume consumption is observed in the Mediterranean countries, with a daily intake from 8 g capita^{-1} to 23 g capita^{-1} (4). In 1961, legume crops for human consumption dominated grain legume cropping in Europe with 67% of the area. This dropped to 22% by 2010, so of the legumes consumed in Europe, only 57% are produced within the EU. A major underlying driver behind the reduction of grain legumes is the increased advantage in the production of starch-rich cereals. Moreover, the attractiveness of legume cultivation is negatively affected by farmer switch to more specialised and intensive productions, the reduced demand, and the indirect subsidises to crops for biodiesel production (2). However, pulse cultivation is more sustainable than cereals, due to the nitrogen-fixing capacity of bacteria associated to legume roots that significantly reduces the need for synthetic fertilisers. Nowadays, legume cultivation in the Common Agricultural Policy (CAP) is supported by voluntary and short-term measures only in some EU states. The European Commission proposals for the CAP 2014-2020 are unlikely to reverse the trend towards decreasing areas under protein crops (2).

Among grain legumes, the common bean (*Phaseolus vulgaris* L.) is of great agronomic and nutritional interest worldwide, and represents about 50% of grain legumes for direct human consumption. Among major food crops, it has one of the highest levels of variation in growth habit, environmental adaptation, seed traits (size, shape, and colour), and classes of consumption (leaves, green pods, immature seeds, dry seeds). Latin America is the leading common bean producer and consumer; in Africa, it is cultivated mainly for subsistence, while in Asia is less important than other legumes. The world production is increased constantly during the past three decades, but the higher increase occurred from 2000 to 2010. Americas, Africa, and Asia have significantly incremented the production (49%, 145% and 36%, respectively), while Europe saw a decrease of about 35% (2).The production areas of the Mediterranean European countries are reported in Table 1, and the main producers are shown in Fig. 1.

Table 1. Production area of common bean in Mediterranean EU member states in 2011 (2)

Country	Production area (ha)	Percentage of arable land (%)
Cyprus	200	0.24
France	3216	0.02
Greece	9062	0.36
Italy	6320	0.09
Malta	132	1.47
Portugal	3365	0.31
Slovenia	289	0.17
Spain	9875	0.08

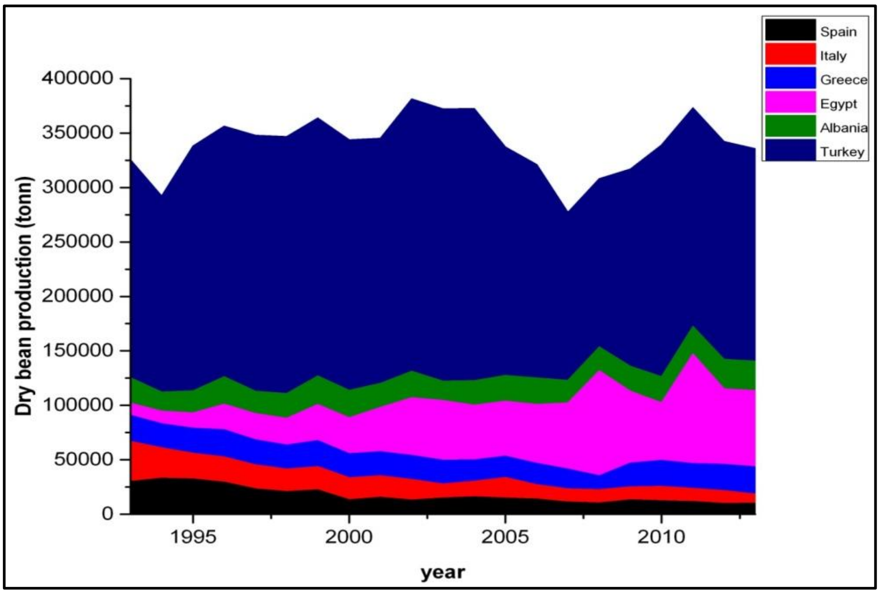

Figure 1. Variation of common bean production inmain Mediterranean producers. Data are relative to the period 1993-2013; data source: http://faostat3.fao.org/browse/Q/QC/E

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Common bean cultivation in the Mediterranean Basin

Common bean has been introduced into Europe in the early decades of 16th century. Materials from both domestication centres, the Mesoamerican and the Andean one, were introduced firstly in Iberian Peninsula and spread in short time through the Mediterranean European countries, and successively into the neighbouring countries (6). Outside of Americas, the common bean populations were free to pass through new evolutionary pathways that were not possible in the American centres of domestication. As a consequence of new pedoclimatic conditions, farmer selection, breeding or accident, the common bean has developed in Europe into a myriad of landraces grouped into different classes (i.e.: French beans, kidney beans, haricot beans, salad beans, snap beans and string beans). Investigations carried out by using DNA-based markers have evidenced a very high variation within the European germplasm. Based on these evidences, Angioi *et al.* (1) suggested that the whole continent and not some countries therein, could be regarded as a secondary centre of diversification. Common bean is superior in terms of genetic diversity still surviving on-farm, compared with the major cereals and maize. The Mediterranean basin is particularly rich of landraces, variable populations lacking of a formal crop improvement, with specific adaptation and tolerances (7). Often they possess a local name and are closely associated with uses, dish preparations, or celebrations of the people that continue to grow them. Groups of landraces are traditionally cultivated in well-defined sub-regional areas and generally can be hardly cultivated with success outside them. This means that, despite the lack of coordinated efforts, farmers have *de facto* practiced the on farm maintenance of this germplasm. Interesting examples are the Ganxet bean (Spain), Fagiolo del Purgatorio (Italy), the Prespon Florinas and Kastorias beans (Greece) (6). Strategies of landraces on-farm conservation should be further developed and promoted, because this germplasm can be useful source of genetic diversity for disease and pest resistance, and tolerance to abiotic and biotic stresses.

Table 2. Common bean production (t) in minor Mediterranean producers; data are relative to the period 1993-2013; data source: http://faostat3.fao.org/browse/Q/QC/E

Country / Year	Algeria	Cyprus	France	Lebanon	Libya	Morocco	Tunisia
1993	586	965	11244	4700	700	5879	1800
1994	344	800	9668	4726	800	5200	370
1995	308	860	9880	5000	900	8020	720
1996	561	570	9693	5124	940	8000	1575
1997	646	400	10389	1400	965	6213	540
1998	1079	180	9867	400	970	11000	502
1999	939	190	10229	500	980	12902	589
2000	419	180	8860	100	1000	11750	550
2001	734	190	8635	100	930	12000	375
2002	864	190	8693	736	814	10502	104
2003	1096	200	9222	300	713	11900	200
2004	581	186	7648	400	975	15700	100
2005	666	215	8974	200	1000	12000	100
2006	915	206	8055	200	1000	12075	100
2007	917	192	6539	200	1000		170
2008	544	208	6142	400	1000		100
2009	1159	218	5513	200	1030		95
2010	845	193	7521	750	1100	not available	140
2011	953	231	6884	831	1220		100
2012	1024	187	7395	950	700		160
2013	1000	187	7545	1000	700		150

Common bean cultivation is relevant only in some Mediterranean countries (Fig. 1). Among them, Turkey is the main producer, with a wide variation in cultivated types; dry beans are cultivated in every Turkish province, while green bean production is concentrated near Black sea (10). Expansion in bean cultivation, mainly green bean, has exhibited impressive growth during the past years in Egypt, so that about 3.5% of total world production comes from this country. Bean cultivation is not of major importance in the countries listed in Table 2, where the import exceeds the production. Medium-size white beans are preferred in the North African area, but cultivation is often limited to a few cultivars, for example "Cocoblanc" in Tunisia and "Giza" in Egypt.

Constraints cultivation and future perspectives

Grain legume cultivation is subjected to several constraints limiting the production (8). Water and phosphorous (P) deficiencies are major environmental constraints in arid and semi-arid Mediterranean regions. As concerns common bean, there is a crucial need to increase drought tolerance, in view of the expected expansion of water-stressed areas in the Iberian plains, the coastal regions of Italy, Greece, and Turkey, all areas where the production is significant (9). Low P availability in Mediterranean soils is an important limiting factor for nitrogen fixation and, in turn, for protein storage. Diseases and pests are also major constraints

(3), but their impact on yield is more relevant in the tropics and subtropics. Moreover, a rapid progress in disease resistance breeding has been made in beans (5, 6). Preference for specific colour or seed type, long soaking or cooking times, hard shell, loss of nutrients during preparation, affect the market value of cultivars and landraces and consequently their attractiveness for farmers.

Dry beans have outstanding importance for human nutrition. Seeds contain from 18 to 28 % of proteins, being rich in lysine, complement the nutritional profile of cereals and tubers. The recent inclusion of the Mediterranean diet, that emphasizes the pulse consumption, in the UNESCO list of the "Intangible Cultural Heritage of Humanity" is producing a renewed interest towards common bean. Moreover, common bean has been recently proposed as a nutraceutical food due to the presence of phenolic compounds exhibiting antimutagenic, anticarcinogenic and antioxidant activities.

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Pea in Mediterranean agriculture

by Diego RUBIALES

Abstract: Pea is a cool season legume most cultivated in Europe, second most in the world. Its cultivation is however less popular in Mediterranean Basin although with a clear increasing trend that contracts with the decreasing one experienced both at European and world level. There is huge potential for pea revalorization in Mediterranean agriculture, both for dry pea in rainfed farming systems and green pea under irrigation. However, further efforts are needed in breeding for Mediterranean targets that have been neglected in modern breeding programs that targetted mainly temperate northern environments.

Key words: ascochyta, broomrape, fusarium, mildew, pea, rust

Table 1. Trend for dry and green pea acreage (1 kha = 1000 ha) per Mediterranean regions in the period 1963-2013 compared to trend at world and European level (1)

Dry pea	Acreage (kha)					
	1963	1973	1983	1993	2003	2013
Southern Europe	64	35	25	36	132	141
Northern Africa	60	110	69	60	58	82
Western Asia	4	4	4	6	8	15
World total	13382	8295	8311	7393	6149	6380
Europe total	8302	4553	5415	4372	2043	1723
Green pea	**Acreage (kha)**					
	1963	1973	1983	1993	2003	2013
Southern Europe	71	74	69	52	40	45
Northern Africa	8	15	26	44	74	80
Western Asia	7	9	10	14	16	23
World total	698	806	795	982	1758	2266
Europe total	298	350	385	249	204	208

Pea (*Pisum sativum* L.) is a cool season legume crop produced worldwide, mainly in temperate regions whose seeds can be used to feed livestock or for human food. It is a cool season legume most cultivated in Europe, second most in the world. However, pea has not been so popular legume in Mediterranean countries in recent years. This is somehow surprizing as the primary centre of diversity for pea is in the eastern Mediterranean and the western Asia where wild forms of P. *fulvum* Sm. and P. *sativum* subsp. *elatius* (M. Bieb.) Asch. & Graebn. can still be found growing today (2, 5). An explanation might be in the poor adaptation to Mediterranean environments as modern breeding programs have concentrated their efforts to other environments, not having targeted regions of the Mediterranean Basin (4).

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Pea world production in 2012 amounted to 10.5 Mt grown over 6.7 Mha for dry pea and 18.5 Mt grown over 2.3 Mha for green pea (1). This agreage was lower only than chickpea (*Cicer arietinum* L., 12.1 Mha) within the cool season legumes, althought markedly lower than some warm season legumes such as soybean (*Glycine max* (L.) Merr., 107 Mha), dry bean (*Phaseolus vulgaris* L., 28.8 Mha) or groundnuts (*Arachis hypogaea* L., 24.6 Mha) (1, 2). As experienced by most cool season legumes, dry pea cultivation has followed a general decreasing trend at world level, from 13.4 Mha in 1963 to 6.4 Mha in 2013. However, dry pea crop area has significantly increased in Canada, from 0.02 Mha in 1993 to 1.3 Mha in 2013, making this country the world leading producer and exporter of dry pea with over 3.8 Mt, followed by Russian Federation and China with 1.3 Mt each, and by further distance by USA with 0.7 Mt, India 0.6 Mt, France 0.5 Mt, Ethiopia 0.4 Mt, Australia 0.2 Mt, Spain 0.18 Mt and Germany 0.13 Mt. This rapid increase in production in Canada was prompted by the rotational advantages of pea and the availability of cultivars adapted to the dry land conditions of the northern Great Plains.

In contrast, dry pea area has decreased significantly in Europe during the same period (from 8.3 Mha to 1.7 Mha) although it is still the most cultivated temperate grain legume, followed at great distance by faba bean (*Vicia faba* L., 0.24 Mha), lupins (*Lupinus* spp., 0.15 Mha), lentil (*Lens culinaris* Medik., 0.08 Mha) and chickpea (0.07Mha).

Conversely, to this 2x fold reduction and world level and 5x fold reduction at European one, dry pea cultivation is increasing in the Mediterranean basin, with a 2.2x, 1.4x and 3.7x fold increase in southern Europe (from 64 kha to 141 kha), northern Africa (from 60 kha to 82 kha) and western Asia (from 4 kha to 15 kha), respectively (Table 1). The larger producer of dry pea today in the Mediterranean basin is Spain (164 kha), followed at distance by Morocco (52 kha) and Tunisia (14 kha) (Table 2). This production is extensive, under rainfed conditions with low inputs, reaching low average yields in the range of 600 kg ha^{-1} - 2500 kg ha^{-1}, depending with the country. Yield averages in southern Europe are a bit higher (1043 kg ha^{-1}) than in northern Africa (753 kg ha^{-1}), but still markedly slightly lower than the European (1714 kg ha^{-1}) and world (1537 kg ha^{-1}) averages, reiforcing the need of development of more adapted cultivars.

Table 2. Dry and green pea acreage (kha), yield (kg ha^{-1}) and production (1 kt = 1000 t) per major Mediterranean producing countries in 2012, compared with world and Europe (1)

Country	Dry pea			Green pea		
	kha	kg ha^{-1}	kt	kha	kg ha^{-1}	kt
Algeria	9.9	928	9.2	34.1	4122	140.6
Egypt	0.1	1823	0.2	20.1	8969	180.6
Greece	0.5	1400	0.7	3.0	7333	22.0
Italy	7.1	2514	17.9	15.2	5274	80.2
Libya	2.8	2321	6.5	1.1	5435	6.2
Morocco	51.8	567	29.4	21.1	6208	131.3
Spain	163.8	835	136.8	10.6	6972	73.9
Syria	4.0	1650	6.6	1.9	6180	11.6
Tunisia	13.8	1000	13.8	3.6	3194	11.5
Turkey	1.3	2174	3.2	15.0	6826	102.4
World total	6769	1537	10401	2266	8159	18491
Europe total	1968	1714	3374	208	6857	1424

Table 3. Major importers of dry pea at world level during the period 2000-2011 (1)

Country	Dry pea imports (kt)					
	2000	2001	2002	2003	2004	2005
China	89	154	111	56	69	241
India	137	849	870	700	643	810
Italy	141	104	100	88	139	174
Spain	625	523	215	190	724	1031
Country	Dry pea imports (kt)					
	2006	2007	2008	2009	2010	2011
China	330	262	203	373	553	730
India	1389	1738	1216	1656	1335	1867
Italy	174	63	60	106	118	83
Spain	663	67	-	81	110	123

In contrast to the general decreasing trend of dry pea, green pea cultivation is increasing at world level (from 0.7 Mha in 1963 to 2.3 Mha in 2013) and is rather stable in Europe at around 0.2 Mha - 0.3 Mha. Green pea has also increased markedly in northern Africa (from 8 kha to 80 kha) and in western Asia (from 6.6 kha to 23.5 kha) although it reduced slightly in southern Europe (from 71.4 kha to 44.7 kha). The larger producers of green pea today in the Mediterranean Basin are Egypt with 0.18 Mt, followed by Algeria, Morocco and Spain (Table 2).

This production is intensive, reaching average yields in the range of 3000 kg ha^{-1} - 9000 kg ha^{-1}, depending with the country. Regional yield averages are 5058 kg ha^{-1} in southern Europe, 5866 kg ha^{-1} in northern Africa and 6239 kg ha^{-1} in western Asia, which are slightly lower than European (6857 kg ha^{-1}) and world (8159 kg ha^{-1}) averages. Therefore there is still room for yield improvement by refinement of agronomic practices and deployment of adapted cultivars.

Mediterranean countries are not behind Europe in the insufficiency of concentrate feed, especially for high-protein feedstuff. For example, soybean cake is currently the first imported agricultural commodity in France with 3.4 Mt, being the third in southern Europe with 6.1 Mt. Unfortunately, northern Africa and western Asia are not far behind in this external dependence, with 2.8 Mt each of imported soybean cake, imports that increased markedly from the just 0.1 Mt - 0.2 Mt imported in 1980. This external dependence relates also to pea, being Spain and Italy among the four historically major dry pea importers at world level (Table 3). There is therefore, perspectives for pea increase in the Mediterranean basin althought higher efforts are needed in refining agronomic practices and developing cultivars specifically adapted to Mediterranean constraints (4). Such increase in pea production could contribute to alliviate the inability of local forage and feed production to keep pace with the increasing demand, leading to alarming levels of feed imports.

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Berseem clover (*Trifolium alexandrinum* L.) in the Mediterranean Basin

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Abstract: This review provides basic insight into the current status and production of berseem clover (*Trifolium alexandrinum* L.) in Mediterranean basin countries. From the rainfed crop farming of the Aegean Island to rice based cropping of salt affected soils of Nile Delta, berseem clover has an exceptional role in the sustainable crop-livestock farming systems of the Mediterranean basin. It is generally sown in pure stands or in mixtures with annual graminaceous species for grazing during the winter period, for haying or ensiling in spring. It is adapted to mild climates and neutral to alkaline soils and has the constraints of being prone to frost and to acidic, salty and hydromorphic soils.

Key words: annual forage legume, berseem clover, constraints, cultivation, Mediterranean Basin, potential

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Berseem or Egyptian clover (*Trifolilum alexandrinum* L.) is an annual forage legume species native to western Asia. The origin of berseem clover is not well known but it is considered to be originated from Asia Minor, later migrating southward to Syria, Palestine and Egypt (8). It appears that domestication and genetic improvement of the crop occurred in Egypt and that the varieties that were developed were later distributed worldwide (4). Today, berseem clover is extensively cultivated in the Mediterranean Basin (Table 1), the Indian sub-continent and the southern USA in irrigated and rainfed farming conditions due to its excellent feeding value, high growth rate and good regrowth potential after cutting or grazing. Berseem clover is generally used as a winter annual crop in rotation with summer crops such as rice (*Oryza sativa* L.), maize (*Zea mays* L.), sesame (*Sesamum indicum* L.), sorghum (*Sorghum bicolour* (L.) Moench) and cotton (*Gossypium* spp.) and well suited to no-till system especially when direct drilled in standing rice. It is generally seeded in October and can be harvested a few times as forage before it is incorporated into soil as a green manure. Berseem clover is used in mixture with oat (*Avena sativa* L.), triticale (× *Triticosecale* Wittm. ex A. Camus.) and rye (*Secale cereale* L.) as winter annual forage/green manure crop and shown to be effective N supplier for the summer crops (15). Mixtures of berseem clover and forage cereals outyielded pure berseem stands and may provide forage with more balanced nutritional quality for ruminants. Depending on the cultivar, region and number of cuts in a season, dry matter production of berseem clover ranged from 6 t ha^{-1} to 30 t ha^{-1} in multi-cut systems in the Mediterranean region (Table 1).

Table 1. Berseem clover in northern and southern Mediterranean countries

Country	Cultivated area (1000 ha)	Average DM production (t DM ha^{-1})	Cropping system and way of use	Reference
Algeria	5-15.6*	8-0	Rainfed or irrigated, in a mixture with *Lolium* or barley	(1)
Egypt	1175	11-21	Irrigated, in rotation with rice and cotton	(6)
Greece	5	12-30	Pure stands or in mixtures with annual graminaceous species	(14)
Italy	25		Rainfed or irrigated, in mixture with cereal or forage grass	(13)
Morocco	50	8-10	Irrigated or rainfed, in rotation with maize	(1)
Tunisia	4.6-6.6	6-8	Irrigated or rainfed, pure or in a mixture with ryegrass, in rotation with cereals	(3, 5, 12)
Turkey	< 2	12-17	In rotation with maize and cotton	(16)

*berseem clover + alfalfa

Berseem in southern Mediterranean

Berseem clover is well-suited to non-mechanized small farms in the southern Mediterranean and has been widely grown for centuries for fodder and soil fertility maintenance. In Egypt, berseem clover has achieved the distinction of being designated "king of forages" and has been the base of Egyptian crop-livestock farming. It has sustained livestock and crop production for centuries in situations where natural pasture and feed resources are scarce (6). Berseem is a key component of the sustainable cropping system in particular rice and cotton based crop production of the Nile Valley and Delta. It is the main winter forage crop occupying about a third of the total cultivated area in winter but it is currently facing a competition with wheat cropping due to increasing food security concern. Berseem clover is a major seed export crop in Egypt with annual seed exports exceeding 12 thousand tons in 2004 (6). In some Maghreb countries, berseem clover is the main forage legume used as green fodder mainly in cattle farming where the seeds are largely self-produced by farmers. In Algeria, it constitutes excellent forage for dairy due to its easy establishment, production potential and high feeding value (1). In Morocco, berseem is grown in rotation with maize mainly in the irrigated systems but is also grown under rainfed conditions in the north. The current 50,000 ha of land dedicated to berseem clover cultivation in Morocco has an increasing trend (20% increases in the last decade). Average production reaches 8 t DM ha^{-1} to 10 t DM ha^{-1}, well below the potential yield of 16 t DM ha^{-1} (2). The area under berseem clover production in Tunisia varied between 4600 ha and 6600 ha during the last decade (5) representing 7% of the total winter forage cultivation area (12). An average of 350 kg ha^{-1} of seeds is produced each year on less than 60 ha. Research activities on berseem clover in Tunisia included inventory of cultivars and evaluation, parasitism with *Orobanche crenata* Forssk., feeding value for dairy cows, physiology and agronomic and fertilizer management aspects (7). Intercropping with berseem clover reduced infection by *O. crenata* in food legumes (7).

Berseem in northern Mediterranean

In Greece, forage production is mainly based on alfalfa (*Medicago sativa* L.), common vetch (*Vicia sativa* L.) and berseem clover (14). Itis usually grown in central and southern Greece and the Aegean islands, being used for forage production mainly in fields that cannot be irrigated during summer. With three to six cuttings, fodder yield of berseem clover ranges from 12 t DM ha^{-1} to 30 t DM ha^{-1}. Despite the demand, which reaches a modest 400 t year^{-1} - 600 t year^{-1}, its value as fodder crop and soil improving properties, berseem clover is a poor competitor of alfalfa which offers higher income to Greek farmers. Researches in Greece showed that some varieties of berseem clover (cvs. Lito, Kastalia and Pinias) have some frost tolerance, down to -7°C (9). In Turkey, Berseem is widely underutilized despite the region is the origin and the antiquity of its cultivation. Cropping of berseem clover is limited to only less than 2,000 ha. Dry matter production ranges from 1.5 t ha^{-1} to 9 t ha^{-1} in single cut system and from 12.4 t ha^{-1} to 16.4 t ha^{-1} in multi-cut system in Mediterranean region of Turkey. In Italy, berseem clover was introduced as a forage crop in the early 1900s and today, it is the best adapted and most cultivated clover in large areas of central, southern and insular regions of the country (13). It is grown in pure stand on about 25,000 ha, mostly in the central and southern regions, but it is also widely used in mixtures with grasses or other legumes. It is the fourth forage species in Italy in terms of amount of produced certified seed. In recent years, several varieties have been released, but only nine of them contributed to 80% of the certified seed in 2010.

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Annual clovers in Mediterranean area

by Branko ĆUPINA[1]*, Svetlana VUJIĆ[1], Sanja VASILJEVIĆ[2] and Aleksandar MIKIĆ[2]

Abstract: Among many clover (*Trifolium* spp.) species that are present in this region, several of them are of the particular importance: crimson clover (*T. incarnatum* L.), berseem or Egyptian clover (*T. alexandrinum* L.), Persian clover (*T. resupinatum* L.) and subterranean clover (*T. subterraneum* L.). Annual clovers are getting more importance in present low-input agriculture. They are significant as animal feed as forage crops, N supplement, soil organic matter improver and for soil erosion prevention. The integration of annual clovers in crop production is a measure which has been taken to increase environmental protection and for better use of natural resources often during the off-season period.
Key words: annual clovers, forage, low-input agriculture

Introduction

Annual clovers belong to the genus *Trifolium* and are well adapted to the climate of Mediterranean basin with mild, rainy winters and hot, dry summers. However, In Mediterranean part of Europe those clovers are mostly present on permanent grasslands. The literature contains limited data on areas and forage yield. In 80's in central and southern part of Italy berseem clover (*T. alexandrinum* L.) was grown in pure stand on cca 35000 ha (9), while in the last ten years in Egypt this clover covered 1.3 million ha and 50000 ha were under irrigation in Morocco (7). Cultivation, use and seed production are much more developed in southern part of Australia, parts of the USA (i.e. California) and New Zealand. From their introduction into Australia, and significantly its south parts which have a Mediterranean-type of climate, clover-based pastures have increased livestock production and improved soil fertility. Today, most of the cultivars and research are being created and improved in those countries. In addition in the climatic conditions of Mediterranean environments, seed yield is often reduced by high temperatures and water stress that occur during the reproductive period.

Annual clovers are used for grazing, hay, silage, as cover crops and green manure for soil organic matter improvement. In Mediterranean area annual clovers can serve as living mulch in orchards, vine yards as well as in vegetable production (Fig. 1). Their importance is emphasized in low-input agriculture, particularly where livestock production is based on grazing (9). Recently it has been noticed that annual legumes are very important for preventing soil erosion and as fire protection, which become often activity of open natural grasslands in the last decade. This role of annual clovers derives not only because of their resistance to Mediterranean climate, but also because of the possibility of the reseeding. They can be sown as sole crops or in a mixture with grasses and cereals, mostly barley (*Hordeum vulgare* L.) and oat (*Avena sativa* L.), but often seed production is not sufficient for this application and requires extra costs (6). Thus extensive use in rain fed conditions is the most common. However with irrigation annual clovers can achieve much higher forage yield (Table 1).

Figure 1. *Trifolium incarnatum* as living mulch in orchards

Several annual clovers have a significant role in the Mediterranean such as crimson (*T. incarnatum* L.), berseem or Egyptian, Persian (*T. resupinatum* L.) and subterranean (*T. subterraneum* L.) clovers (Fig. 2, 3 and 4).

Table 1. Four-year forage yield of annual clovers grown in irrigated (I) and non-irrigated (NI) conditions in southern Italy (5)

Clover	Year									
	1992		1993		1994		1995		Mean	
	I	NI	I	NI	I	NI	I	NI	I	NI
Berseem clover	6.48	3.69	4.56	2.87	4.75	3.21	4.04	2.52	4.81	3.10
Crimson clover	2.33	1.53	3.63	1.59	4.32	3.63	1.54	0.95	2.96	1.68
Persian clover	4.39	2.03	3.10	2.48	4.93	4.77	2.88	2.25	3.92	2.88
Squarrosum clover	9.36	2.74	4.94	2.91	6.19	3.43	2.81	1.94	5.83	2.76
Average	5.64	2.49	4.07	2.64	4.90	3.76	2.82	1.92	4.36	2.61

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Annual clovers as cover crops

The integration of annual clovers as cover crops in crop production is a measure which has been taken to increase environmental protection and for better use of natural resources often during the off-season period. They are usually sown in winter time and they help in retaining soil and thus prevent erosion. Clovers incorporate nitrogen in the soil and reduce fertilizer costs. Due to their fast initial growing they are an excellent competitive with weeds and reduce the need for herbicides and other pesticides (8), they conserve soil moisture, improve concentration of soil organic matter etc (1). Thus, in annual cropping systems, annual clovers are often included to maximize benefits like biomass and nitrogen production (2). There are several harvest possibilities with clovers, especially when they are use between two cash crops, such as forage, grazing or as green manure that are grown and plough under to add nutrients and improve the soil.

In Mediterranean, drought-tolerant species such as annual clovers that require minimal management are preferred. In these conditions, cultivation of annual clovers or cereals during the winter is important in order to provide forage production (4). After winter period by earlier harvest time drought in spring season can be avoided (5).

Figure 2. A Turkish variety of *Trifolium alexandrinum*

Figure 3. *Trifolium resupinatum* in Vojvodina, northern Serbia

Forage management of some annual clovers

Crimson clover is an excellent pasture and hay winter crop especially at leafy growth stage because it provides protein rich forage. Because of its fast recover after winter this annual clover provides early grazing in the spring, in some countries even a month before perennial legumes. It is recommended that close grazing should be avoided in winter so as not to affect spring growth or seed production adversely. Since crimson clover can be used early in the spring it is a valuable green manure crop in crop rotations, leaving enough time for cash crop production and enriching the soil with nitrogen. In mixtures, crimson clover is usually combined with various grasses such as perennial ryegrass but also wheat and rye; a good companion legume species is red clover (3). Early maturity makes it highly suitable for no-tillage rotations. Berseem or Egyptian clover is native in the Middle-East but it is widespread through Mediterranean region where represent important forage crop. By its high nutritive value it is very similar to alfalfa except that doesn't cause bloat in ruminants. It is mainly used as green forage crop, as green manure crop or for silage, since the stems and leaves do not dry easily, thus hay production is difficult. Persian clover, compared to other mentioned species, can grow in wide range of soil acidity from pH 5 to pH 9, except that is more productive on acidic soils. Also it's more tolerant on salinity and drought. Persian clover is present on natural grasslands, fallows, besides the roads in abandoned areas and the main use is for grazing as pasture crop or hay production. Compared to berseem clover, fresh forage of Persian clover can cause the bloat in ruminants which can be reduced by sowing this clover in mixture with grasses or cereals. Subterranean clover is exploited for forage as a pasture crop. The main precaution with this species is that some cultivars may cause reproductive disorders in sheep due to high phytoestrogenic activity. Since grazing is more often way of exploitation, this should be taken with significant awareness.

Species such as *T. squarossum* and *T. hirtum* are also native of the Mediterranean basin, but they are less cultivated than previously described species.

Figure 4. *Trifolium subrterraneum,* the Italian variety Compeda

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Trends and perspectives for faba bean production in the Mediterranean Basin

by Ángel M. VILLEGAS-FERNÁNDEZ* and Diego RUBIALES

Abstract: The Mediterranean Basin is still one of the main producers of faba bean worldwide in spite of the decline of the area devoted to this crop in the last decades. Acreage significantly decreased in southern Europe from 0.8 Mha in 1960s till the actual less than 0.1 Mha, whereas it remained rather stable around circa 0.4 Mha in northern Africa. Globally, faba bean acreage has remained rather stable in the last decade around 0.6Mha. The major producers in the area are Egypt, Morocco, Italy and Tunisia, followed by Algeria, Spain, Syria and Turkey. Yield has increased notably in the last fifty years, being highest in Egypt and lowest in Morocco. Considering the potential demand and the technical efforts being made, there is a chance for an increase of the production of faba bean in the future.

Key words: breeding, legumes, yield, *Vicia faba*

Faba bean (*Vicia faba* L.) has been a well-known crop in the Mediterranean Basin since time immemorial (1). Nowadays it is still a relevant crop both for human consumption and animal feed, though its importance may vary from one country to another. Cultivation of most temperate legumes has suffered a general decline worldwide in the last decades, and faba bean has been no exception. Our aim in this article is to depict a general view of the state of faba bean production in this area, and to suggest some indications of future perspectives for this crop. We will focus on dry faba bean, which is the most produced and for which most data are available.

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Faba bean cultivation has declined in the Mediterranean Basin, from 1.2 Mha in 1961 to 0.46 Mha in 2013 (3). This decline, however, has not been homogenous all over the region. It has mainly taken place in southern European countries, where the acreage has markedly fallen from 0.8 Mha to 0.09 Mha. On the contrary, cultivation in northern Africa has remained rather constant at around 0.4 Mha. In the Near East, Turkey moved in the range of 30 kha - 40 kha till 1990, when it started to decrease till the actual 7kha.

The larger faba bean producer in the world is China with 1.62 Mt. The Mediterranean Basin ranks second with an average in the last five years of 0.67 Mt, followed closely by Ethiopia with 0.62 Mt and at a further distance by France and Australia with 0.30 Mt - 0.35 Mt (Fig. 1). It is important to clarify that the major faba bean production in France is not in the south but in central-north France, and therefore are not included here as "Mediterranean". But considering the Mediterranean Basin as a whole hides the fact that there is a high diversity among countries from this region in the production of faba bean (Table 1). The larger producer in the Mediterranean Basin is Egypt, with 0.2 Mt. Actually, Egypt was the fifth top world producer until it was overtaken by Australia in 2010. The second Mediterranean producer is Morocco with more than 0.15 Mt, followed at distance by Italy with 0.09 Mt and Tunisia with 0.07 Mt. It is remarkable that Morocco needs a lot of more acreage than Egypt to attain its high production. This takes us to the issue of yield, which is not homogenous across the Mediterranean Basin either, reflecting the differences in efficiency in the cultivation of this crop among the various countries. The range in which the yield of most of the producers is found (Table 1) is between 1000 kg ha^{-1} and 2000 kg ha^{-1}. Egypt outstand for its highest yield (3281 kg ha^{-1}) while Morocco shows the lowest (803 kg ha^{-1}).

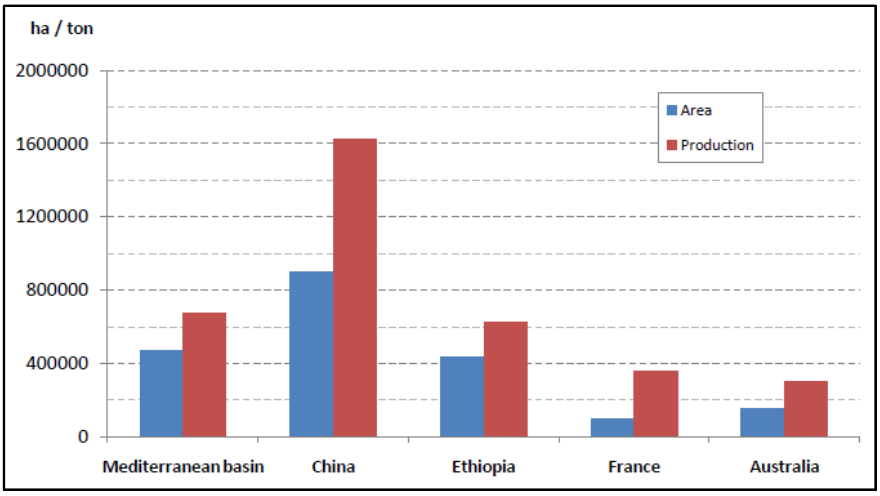

Figure 1. Production (t, in blue) and area harvested (ha, in red) of faba bean in the Mediterranean Basin and in the four top world producers; average for 2009-2013)

Table 1. Area harvested, production, yield, imports, exports and the proportion of imports related to total production of faba bean in major Mediterranean producers; average for 2009-2013, except for imports and exports, average for 2009-2011

Country	Area (ha)	Production (t)	Yield (kg ha^{-1})	Imports (t)	Exports (t)	% Imports / Production
Algeria	35,483	38,722	1,091	1,524	0	4
Egypt	61,238	200,897	3,281	302,906	12,050	150
Greece	1,592	2,856	1,794	1,746	64	61
Italy	45,884	90,192	1,966	44,444	1,891	49
Libya	950	1,551	1,632	2,076	0	134
Morocco	193,798	155,527	803	8,151	1,711	5
Portugal	22,896	21,870	955	1,908	32	9
Spain	22,866	32,211	1,409	21,643	3,087	67
Syria	15,440	31,100	2,014	581	244	2
Tunisia	55,793	66,828	1,198	103	623	0.1
Turkey	8,145	19,392	2,381	483	867	2.5

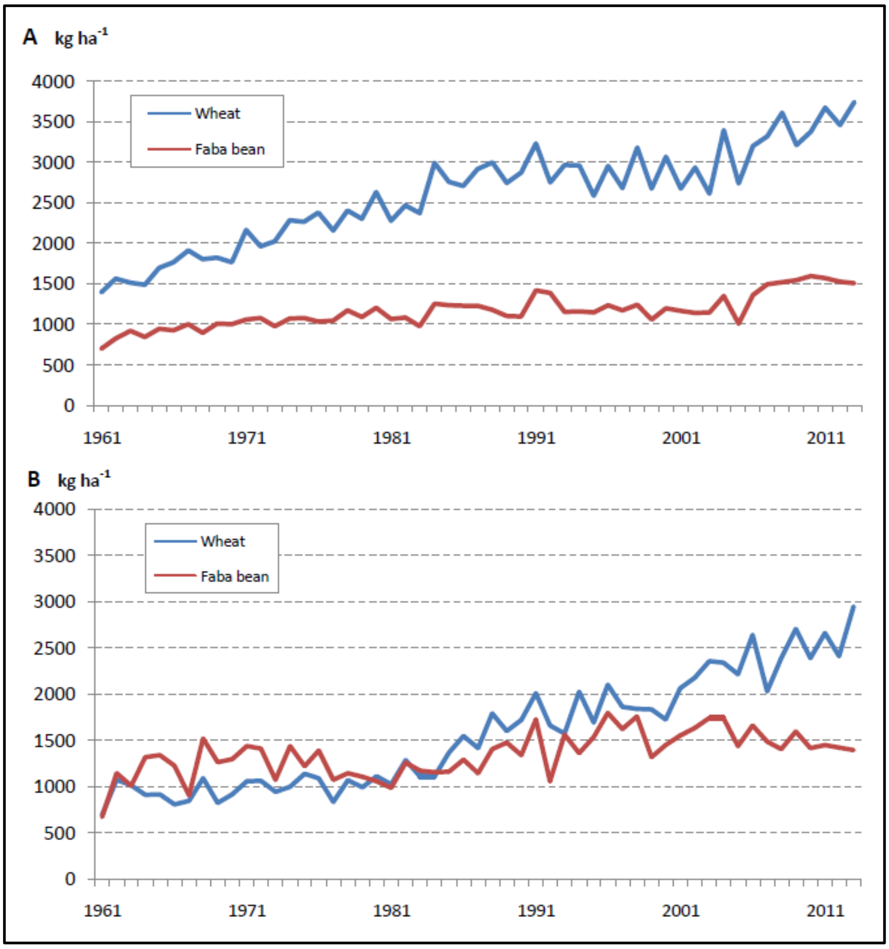

Figure 2. Yields (kg ha^{-1}) of wheat and faba bean since 1961 till 2013 in South Europe (A) and North Africa (B)

Increasing and stabilising yield has been for long the subject of efforts to improve faba bean cultivation. Yield instability is said to be famous in faba bean (2), so breeders have focused on reducing those unwanted variations of production in time and space. Though faba bean is not one of the top crops at a global level, if we compare with rice (*Oryza sativa* L.) or wheat (*Triticum aestivum* L.) for instance, it has nevertheless benefitted from the modernisation of agriculture that has taken place in the last decades. In Fig. 2 we compare the evolution of yield of faba bean and wheat since the middle of the last century for the two main regions of production of faba bean in the Mediterranean Basin: the South of Europe and the North of Africa. In both regions the yield of faba bean has increased from less than 700 kg ha^{-1} to around 1500 kg ha^{-1}. The yield of wheat is higher and has increased at a faster pace than that of faba bean (in the case of Northern Africa this is so from 1980 on). However, the variations in yield from year to year are more marked in the case of wheat, especially in Southern Europe, presenting often a zig-zag pattern that reveals not-so-stable yields. Therefore, in contrast with the general opinion, the yield stability of faba bean appears to be higher (or at least comparable) than that of wheat.

As for trade, it is remarkable that the main producer of faba bean in the Mediterranean Basin is the main importer too: Egypt imports around 0.3 Mt year^{-1}, which represents 150% of its production (Table 1). Other major importers are Italy and Spain, whose productions do not satisfy their domestic needs. On the contrary, other modest producers do not need to resort to great imports. No country in the area is a major exporter.

After having visited all these statistical data, the question arises: what future, then, for faba bean in the countries on the shore of the Mediterranean? In these first years of the 21st century, the decline in the area of cultivation of legumes in the Mediterranean Basin has continued, with production showing important variation in yields (Fig. 3). Faba bean area and production, on the contrary, have remained rather constant. We believe, however, that faba bean deserves a more prominent role, and has the potential to achieve it. There is an important margin for growth of demand, both for human and animal consumption. Now that there is an increasing awareness of the need of a sustainable agriculture, faba bean has a

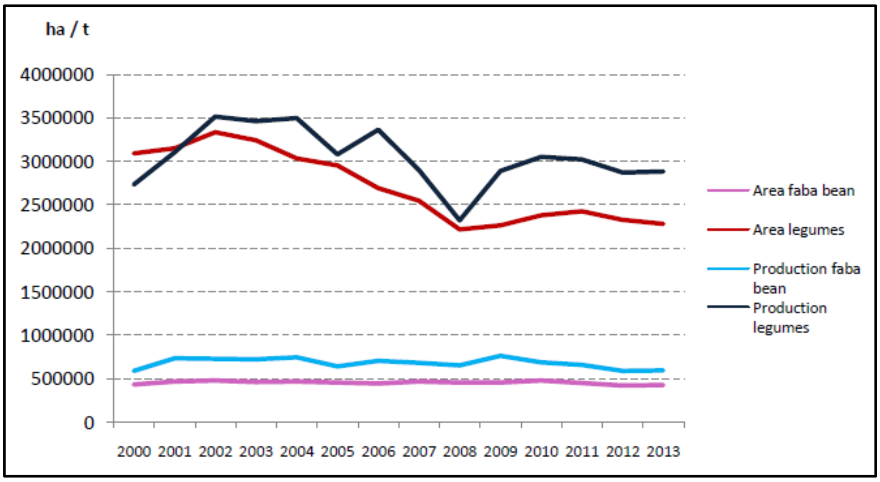

Figure 3. Comparison between area harvested (ha) and production (t) of faba bean against area harvested and production of the total of legumes in the Mediterranean Basin from 2000 to 2013

window of opportunity to recover its place in crop rotations. The desire of a healthier nutrition by consumers should favour the employment of faba bean to elaborate feed, or even make it an alternative to meat as a source of proteins. There is too a technical margin for the growth of yield, as divergences in this factor among countries reveal. Improved agronomic practises and enhanced varieties may be introduced, especially in those zones with poorest yields. A great breeding effort is being made to overcome threats limiting yield, such as biotic and abiotic stresses (4, 5, 6), an effort that will pay off in the coming years. If things are done right and chances are taken, we foresee a promising future for faba bean in the Mediterranean Basin.

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Common vetch production in Mediterranean Basin

by Eva María CÓRDOBA*, Salvador NADAL, Clara Isabel GONZÁLEZ-VERDEJO

Abstract: The Europe 2020 strategy address the challenge of improving the profitability of protein crops in Europe in order to make it an attractive crop for farmers while satisfying the requests of the animal feed industry. Common vetch (*Vicia sativa* ssp. *sativa*) is one of the most important annual forage legumes in the Mediterranean Basin where it is specifically adapted, and due to its agronomic characteristics, as well as its potential for feed production. In this sense, common vetch plays an important role in sustainable agriculture where the use of legumes presenting high productivity in low input systems an efficient water use and value in crop rotation systems is desirable.

Key words: forage, grain, Mediterranean legume, protein crop, *Vicia sativa*

Introduction

The common vetch (*Vicia sativa* L. ssp. *sativa*) is the largest, most vigorous leguminous plant in the *Vicia* genus. This genus includes over 160 species being various cultivated from ancient times (1) and their use as feed crops dates back to antiquity. As many other annual legume species, it is considered to have originated in the Near Eastern centre (2).

Vicia sativa L. is one of the genetically and phenotypically most variable species of this genus (3). It is a self-pollinating species facilitating significantly the conventional breeding programmes based on knowledge of relation-ships between forage yield components and economically important characteristic (4).

The common vetch includes a large number of varieties, forms and botanical or agricultural races which differ between them by one or more characters of morphological or agronomic type. The general morphology of vetch is an annual plant of 10 cm - 80 cm in height, roughly pubescent. Stems are thin, branched, and usually smooth. The alternate compound leaves (paripinnadas) are composed of 4 to 10 paired leaflets, terminate with a tendril. Flowering is from April to May depending on the regions and ripens seed from mid to late June. Red purple or violet flowers, solitary or in inflorescences up to 4 flowers (Fig. 1).

It has a taproot that can reach depths of 1.5 m. This quality makes that vetch is adapted to rainfed and semiarid systems of the Mediterranean region. Also, it is well adapted to warm environments and is moderately resistant to cold. Vetch withstands high temperatures but need greater than 350 mm annual rainfall. It grows on a wide range of soils but it does not tolerate extended flooding.

Moreover, the common vetch varieties developed are very versatile because they enable cropping for grain or hay production, grazing as green pasture or for dry grazing and its use as green manure. Also, they differ in flowering time which is important in their adaptation to length of growing season in different environments. Actually, there are 129 vetch varieties registered in Common Catalogue Agricultural species.

According to FAOSTAT (6), the world vetch grain production is approximately 734,566 t with an average yield of 1,500 kg ha^{-1} (Fig. 2). In the Mediterranean Basin, it is considered one of the most important winter annual forage legume. The extent of cultivation of vetches is of equal importance in the Mediterranean to that of faba bean (*Vicia faba* L.), being Turkey and Spain the main grain producing countries. These countries grew around 90,000 ha and 75,000 ha and produced 114,200 t and 67,000 t respectively (Fig. 3) (6). There is a second group of producing countries formed by Albania, Greece, Italy and Morocco. The area cultivated by all these countries is around 60,000 ha - 10,000 ha having a production of 2,000 t and 9,000 t (Fig. 3).

Why common vetch crops for the future Mediterranean Basin agriculture?

Because of its easy handling and its ability to grow over a wide range of climatic and soil conditions, its high nutritional value (fodder and grain), and its multiple uses, common vetch is considered a good alternative in Mediterranean region.

Figure 1. Flowers of *Vicia sativa* L. (common vetch)

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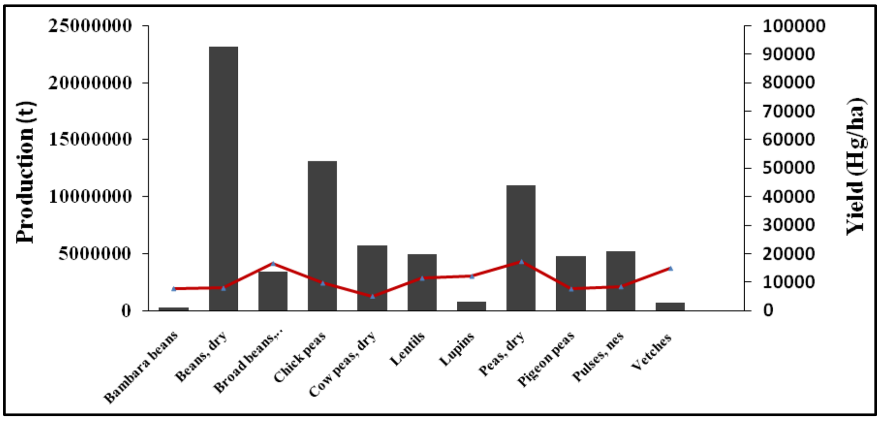

Figure 2. The global production (t) and yield (hg ha⁻¹) obtained by pulses in 2013 (6)

As a feed for ruminants common vetch may be used as green forage, dry forage, forage meal or as silage and haylage (7) and it has a nutritional value similar to alfalfa (*Medicago sativa* L.), clovers (*Trifolium* spp.), sainfoin (*Onobrychis viciifolia* Scop.) and others legumes. Other nutrients such as the lipid content in the forage is low (2% - 5%) but the proportion of PUFA (polyunsaturated fatty acids) is high. The grain of common vetch is rich in globulins and albumins (8) and is used as a valuable source of plant protein for feeding animals (9).

Moreover, *V. sativa* has a high ability to fix nitrogen provided that the seeds are inoculated with an adequate rhizobium strain or that it has been sown previously in the field (5, 10). It can provide N either to the companion cereal when sown in mixed pastures, or to the following crop when sown alone. The best stage is full bloom, *V. sativa* residues are easily ploughed down with a disc harrow (11). They provide a moisture-conserving mulch in strip-tillage systems. Thanks to N fixation, common vetch lowers the overall C:N ratio of mixed pastures (common vetch : cereal), and speeds up decomposition (10). Therefore, the crop residues are an appreciated green manure. As cover crop, the vetch helps with the suppression of spring weeds and it is a valuable cover crop in vineyards and orchards (10). Weed suppression is increased when the legume is associated with a cereal plant (11).

Common vetch has a high potential to be part of crop rotations. Its inclusion in these systems is considered a precondition to increase the overall production (12). It could

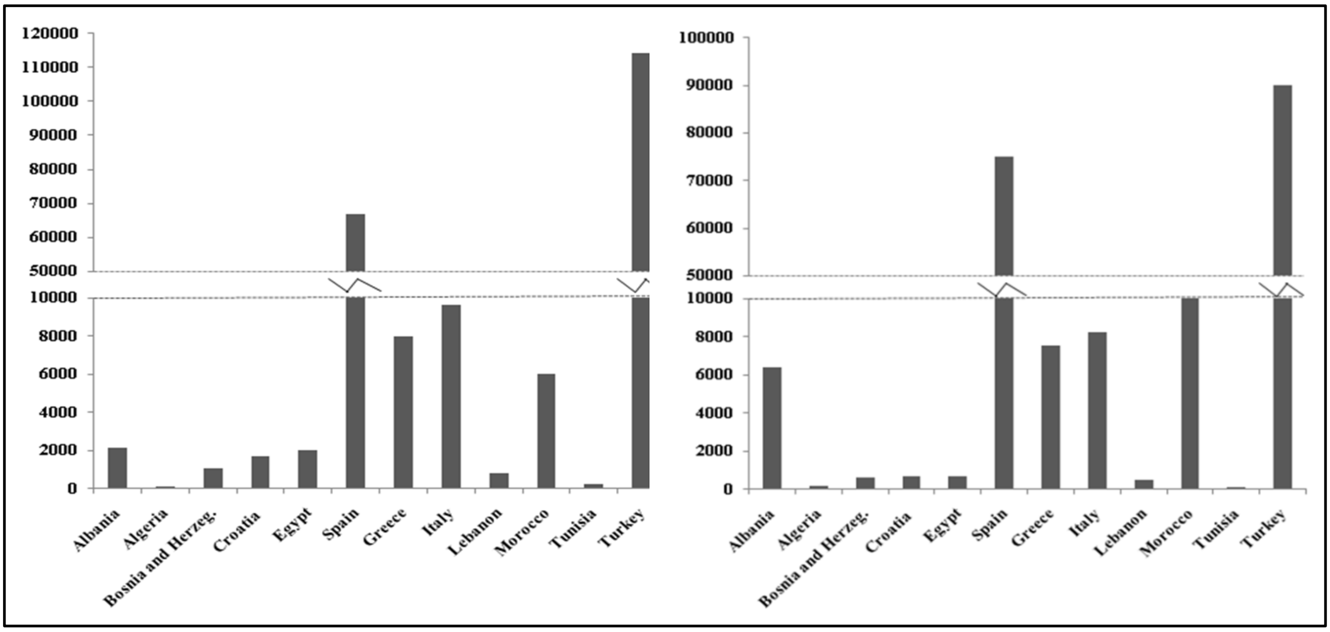

Figure 3. Common vetch grain production (t, left) and area harvested (ha, right) in the Mediterranean basin in 2013 (6)

be a solution to the increasing demand of food for cattle, because they are one of the best options to alternate with cereal monoculture or to replace fallow in arid area. The advantages of growing vetch and wheat together are that vetch has a well-development taproot system while wheat has a hair root system and therefore, they do not compete with each other for nutrients available in soil. In addition to this, it produces higher seed and protein yields than cereal monocultures.

In conclusion, among other advantages, vetch is valued for its benefits to subsequent crops in the rotation and these benefits are generally greater than from other pulses particularly in lower rainfall areas. Therefore, we believe that *V. sativa* will maintain an important place in the Mediterranean Basin agriculture.

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Several less-read articles from Viciapedia - On some neglected and wild vetches with benefits for the Mediterranean agricultures

by Aleksandar MIKIĆ* and Vojislav MIHAILOVIĆ

Abstract: This short survey presents selected neglected and wild vetch species of a possible interest for the Mediterranean agricultures, such as bitter (*Vicia ervilia*), large-flowered (*V. grandiflora*), Narbonne (*V. narbonensis* L.), Noë's (*V. noeana*), Hungarian (*V. pannonica*) and French (*V. serratifolia*) vetches. The data on their production are extremely scarce, but point out how seriously they are in danger of completely disappearing. However, numerous results witness many benefits vetches may bring to the economies of the regions to which they undoubtedly belong both by their origin and by their performance, especially by quality yield of forage and grain and prominent stress tolerance.

Key words: cultivation potential, Mediterranean agricultures, neglected crops, *Vicia ervilia*, *Vicia grandiflora*, *Vicia narbonensis*, *Vicia noeana*, *Vicia pannonica*, *Vicia serratifolia*

Introduction

The genus vetch (*Vicia* L.) comprises at least 150 species, with faba bean (*Vicia faba* L.) and common vetch (*Vicia sativa* L.) as the economically most important (12). Unlike faba bean that is grown almost exclusively for grain, common vetch is a common forage plant (11).

The available data on the cultivation area and other production parameters of vetches in the countries with a Mediterranean climate may give an impression of a heavy underutilisation of these crops, with few exceptions, such as Spain, Syria, Morocco and Australia (6, Table 1). Although these data surely relate mostly to common vetch, they may provide us with a good insight on the status of other vetch crops, that is, rather obviously, even more endangered.

The aim of this short survey was to present selected vetch species of a possible interest for the Mediterranean agricultures, other than faba bean and common vetch. One group of them comprises those already cultivated, but are also heavily neglected, such as bitter (*V. ervilia* (L.) Willd.), Narbonne (*V. narbonensis* L.) and Hungarian (*V. pannonica* Crantz) vetches. Another one consists of large-flowered (*V. grandiflora* Scop.), Noë's (*V. noeana* Reut. ex Boiss.) and French (*V. serratifolia* Jacq.) vetches.

These six species share a common origin in the Mediterranean centre and a similar number of chromosomes of $2n = 12$ or $2n = 14$ (17). It is also quite noteworthy that the largest collection of these species and the greatest breeding efforts are made at the International Center for Agricultural Research in the Dry Areas (ICARDA).

Grown, but heavily neglected

Bitter vetch (Fig.1, top, left) is one of the most ancient domesticated plant species in the world and one of the carriers of the so-called 'agricultural revolution' in Neolithic West Asia, Europe and North Africa (18). In the Mediterranean basin, it is cultivated exclusively for grain, with average yields of

Table 1. The cultivation area (ha) under vetches (*Vicia* spp.) in the Mediterranean countries, including Australia, in 2013 (6)

Country	Cultivation area
Albania	6,400
Algeria	200
Australia	48,000
Bosnia and Herzegovina	613
Bulgaria	517
Croatia	660
Cyprus	112
Egypt	700
Greece	7,500
Italy	8,200
Jordan	2,773
Lebanon	505
Malta	200
Morocco	10,000
Occupied Palestinian Territory	405
Serbia	8,358
Spain	75,000
Syrian Arab Republic	15,345
The former Yugoslav Republic of Macedonia	2,900
Tunisia	115
Turkey	90,000

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Figure 1. Some of the neglected vetch crops and wild *Vicia* species with a potential benefit for the Mediterranean agricultures: *Vicia ervilia* (top, left), *Vicia grandiflora* (top, right), *Vicia narbonensis* (middle, left), *Vicia noeana* (middle, right), *Vicia pannonica* (bottom, left), *Vicia serratifolia* (bottom, right)

between 300 kg ha^{-1} and 800 kg ha^{-1}. Today, bitter vetch is also used solely in animal feeding and considered having a great nutritional value by the local farmers. The presence of canavanine, leading to a poorer palatability, has removed it from human diets a considerable time ago. Apart from improving grain yield, enhancing the potential of the bitter vetch crop for these regions includes increasing the resistance to black aphids (*Aphis fabae* Scopoli) and broomrape (*Orobanche* spp.), as well as its reintroduction as a forage plant (5).

The very Linnean name of Narbonne vetch (Fig. 1, middle, left) witnesses that one of the centres with it greatest diversity was in the region of the ancient Roman province of Narbonne and its town with the same name, quite close to the Mediterranean Sea. Although sometimes an object of breeders' practical jokes as being 'yield-resistant', the programme on this crop, carried out at ICARDA, produced many cultivars able to produce a grain yield of nearly 1500 kg ha^{-1} with an annual precipitation sum of only about 250 mm. Narbonne vetch is characterised by numerous additional desirable traits, important for the agricultures of North Africa and West Asia, such as 28% of crude protein content in grain dry matter and about 9% in straw, stable yield, good winter hardiness and vigorous winter growth (1). All this makes Narbonne vetch a promising legume crop not only for the Mediterranean countries, but also for the regions with a very similar climate, such as south-western Australia (14).

Hungarian vetch (Fig. 1, bottom, left) is a common part of urban and rural floras not only in the countries of the Mediterranean Basin, but also in numerous regions with temperate climate across Europe and Asia (9). It is a traditional crop mostly in the West Mediterranean, especially Turkey, where it is cultivated for both forage and grain and plays an important role in crop rotations (12). Hungarian vetch demonstrates a considerable tolerance to drought and has narrower yield variability among years in comparison to other vetch crops (16). What makes it even more interesting for the local agricultures is the fact that its seed does not contain any known anti-nutritional factor, thus enabling its use in feeding monogastric animals as a safe and rich source of protein (7).

Wild, but with a cultivation potential

Large-flowered vetch (Fig. 1, top, right) is one of the most widely distributed wild vetch species and is a regular component of many local floras, including various regions with temperate climates across Europe and Asia. In the Mediterranean Basin, it is more typical for its eastern part, with an emphasis upon the southern Aegean environments. Large-flowered vetch is characterised by a prominent earliness in various agroecological conditions, regardless of the geographic origin of a tested population, and thus may be very useful member of diverse crop rotations by fitting between two main crops. So far, the greatest effort in assessing its cultivation potential has been made regarding forage production, where yield may reach 40 t ha^{-1} of fresh forage (11). Among the further steps in developing first large-flowered vetch cultivars for both Mediterranean and cooler climates is achieving a reliable seed yield and thus provide this promising plant species with a necessary market value.

The wild populations of Noë's vetch (Fig. 1, middle, right) grow mostly in dry areas such as southern Greece, Syria and Turkey. This plant species is a fine example of a plant species that once had been used in both human diets and animal feeding and then was gradually neglected and finally returned to the wild flora, only to be rediscovered as having a cultivation potential. Its charred seeds were found at a very large Neolithic proto-city settlement Çatalhüyük, existing between 7,500 BC and 5,700 BC, while it was relatively recently remarked as a suitable wild vetch species for developing into a forage plant (8). The results of long-term trials with the wild populations of Noë's vetch from the ICARDA collection show that some of them may produce up to 8 t ha^{-1} of forage dry matter and more than 1 t ha^{-1} of forage dry matter crude protein yield.

As a typical Mediterranean plant species, French vetch (Fig. 1, bottom, right) is a part of numerous local wild floras. Together with Narbonne vetch, it is familiar as being the closest botanical relative to faba bean (10). There are reports indicating that French vetch has little to offer to agronomy in the eastern Mediterranean countries (2). However, wild populations of French vetch may produce more than 6 tha^{-1} of forage dry matter (4). Among the desirable traits of French vetch are lower concentrations of condensed tannins, phenolics and proteinase inhibitors than in other vetch species (3) and the resistance to *Uromyces viciae-fabae* (Pers.) J. Schröt and *U. pisi* (Pers.) Wint., although with still limited knowledge (13), and broomrape (15).

Conclusions

Legumes are often considered *orphan* crops. Thinking in a similar way, it may be said that the vetches, even regarded together with common vetch, are much more *orphan* crops than many others. Although we are witnessing how many vetch crops become more and more neglected and how numerous are those that are wild but never seriously attempted to be domesticated, we may be convinced that the smallest possible effort would be sufficient enough to (re)introduce vetches in the Mediterranean agricultures, where they undoubtedly belong both by their origin and by their performance.

Acknowledgements

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Relevance, constraints and perspectives of cowpea crops in the Mediterranean Basin

by Raúl DOMÍNGUEZ-PERLES[1]*, Valdemar CARNIDE[2], Guilhermina MARQUES[1], Isaura DE CASTRO[2], Manuela DE MATOS[2], Márcia CARVALHO[2] and Eduardo ROSA[1]

Abstract: Cowpea is a quite limited crop in Europe, except in the Mediterranean region where is grown in a small area associated to a folk cuisine and peasant farming. Cowpea has a fairly genotype diversity and can be used as a multipurpose legume, for its green pods, green beans and dry beans, featured by its relatively high nutritional content properties. Also plays a relevant role on the sustainability of farming systems by improving soil characteristics, particularly under the current climate changes. Thus, it is likely the cowpea expansion beyond the Mediterranean area. The ongoing molecular charaterization and genotype selection surely will contribute to foster this crop in the near future.

Key words: changing climate, genetic diversity, Mediterranean Basin, multipurpose crop, *Vigna unguiculata*

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the most widely adapted and nutritive grain legumes. Production of cowpea is spread over equatorial and subtropical areas with a world production between 2009 and 2013 of 5.68 Mt of dry seeds, on average (6). In Europe, cowpea has been traditionally grown in Italy and, over the last years, there was an effort to introduce this crop in other southern countries (1). Cowpea can fit into the European policy concerning increase of legumes cultivation due to its multi-purpose uses as grain legume and as a vegetable crop as well as for fodder, exhibiting a great relevance for the sustainability of farming systems particularly under the current climate changes. More-over of different uses, it is raised another relevant aspect, the exploitation under distinct growing cycles. Although dry grain is the major product for human consumption, leaves, fresh beans, and fresh green pods are novel valuable food products with interesting dietary uses. The multipurpose use and crop length of cowpea are innovative features, which can support their introduction not only in the Mediterranean basin area, but also in northern Europe.

Table 1. Parameters relating cowpea cultivation in the Mediterranean Basin (2)

Country	Year	Area (ha)	Yield (kg ha^{-1})	Production quantity (t)	Seeds (t)
Bosnia and Herzegovina	2013	200	1500.0	300	6
	2012	500	2124.0	1062	6
	2011	500	2400.0	1200	15
	2010	500	2400.0	1200	15
Croatia	2013	80	3937.5	315	2
	2012	80	3750.0	300	2
	2011	71	3859.2	274	2
	2010	70	4285.7	300	2
Cyprus	2013	244	680.3	166	8
	2012	217	677.4	147	8
	2011	191	916.2	175	8
	2010	160	1043.8	167	8
Egypt	2013	2000	3500.0	4700	130
	2012	2000	3500.0	7000	130
	2011	1805	3407.2	6150	130
	2010	1946	3293.9	6410	120
Occupied Palestinian Territories	2013	6	5333.3	32	1
	2012	6	5000.0	30	1
	2011	6	4500.0	27	1
	2010	6	4000.0	24	1
Republic of Macedonia	2013	2000	3800.0	7600	250
	2012	2000	3800.0	7600	250
	2011	1966	3828.0	7632	250
	2010	2000	3650.0	7300	250
Serbia	2013	4465	3524.3	15821	134
	2012	4712	2824.3	13808	134
	2011	4557	3523.4	16056	141
	2010	5122	3797.5	19451	137

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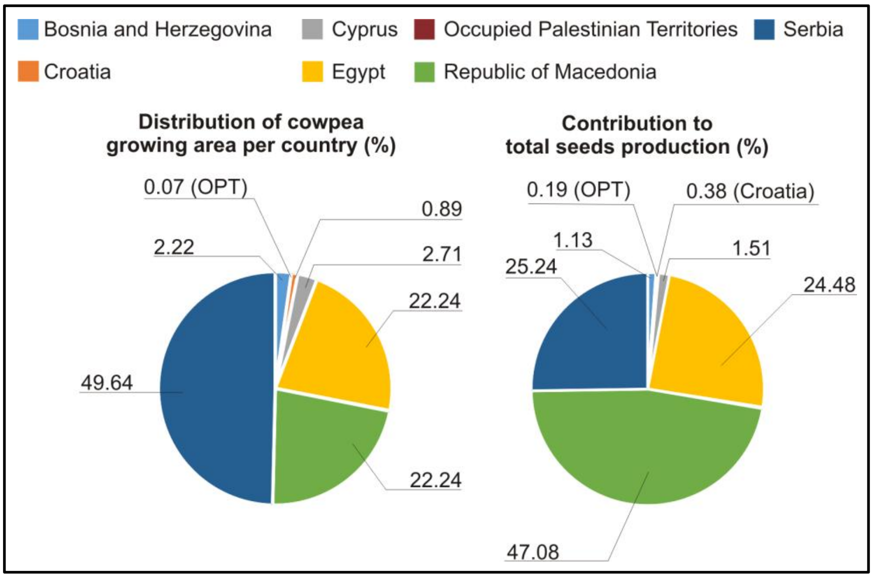

Figure 1. Contribution of the individual countries to the cowpea growing area and seeds production (2)

Table 2. Nutritional and phytochemical composition of cowpea (*Vigna unguiculata* (L.) Walp.); average values per 100 g de dry seeds (7)

Crop	Cowpea	Pea	Faba bean	Lupines	Lucerne
Macronutrients (unit)					
Energy (kcal)	336.00	352.00	88.00	352.00	23.00
Proteins (g)	23.52	23.82	7.92	24.63	3.99
Saturated fatty acids (mg)	331.00	161.00	118.00	154.00	69.00
Total monounsaturated fatty acids (mg)	106.00	242.00	104.00	193.00	56.00
Total polyunsaturated fatty acids (mg)	542.00	495.00	342.00	526.00	409.00
Ash (g)	3.24	2.66	1.12	2.71	0.40
Carbohydrates (g)	60.03	63.74	17.63	63.35	2.10
Total fiber (g)	10.60	25.50	7.50	10.70	1.90
Total sugars (g)	6.90	8.00	9.21	2.03	0.20
Micronutrients (unit)					
Minerals					
Calcium (mg)	110.00	37.00	37.00	35.00	32.00
Iron (mg)	8.27	4.82	1.55	6.51	0.96
Magnesium (mg)	184.00	49.00	33.00	47.00	27.00
Phosphorus (mg)	424.00	321.00	129.00	281.00	70.00
Potassium (mg)	1112.00	853.00	332.00	677.00	79.00
Sodium (mg)	16.00	15.00	25.00	6.00	6.00
Zinc (mg)	3.37	3.55	1.00	3.27	0.92
Cupper (mg)	0.85	0.82	0.40	0.75	0.16
Manganese (mg)	1.53	1.22	0.66	1.39	0.19
Selenium (µg)	9.00	4.10	0.80	0.10	0.60
Vitamins					
Vitamin C (mg)	1.50	1.80	3.70	4.50	8.20
Tiamin (mg)	0.85	0.73	0.13	0.87	0.08
Roboflavin (mg)	0.23	0.22	0.29	0.21	0.13
Niacin (mg)	2.08	2.89	0.25	2.61	0.48
Pantotenic acid (mg)	1.50	1.76	0.22	2.14	0.56
Vitamin B-6 (mg)	0.36	0.74	0.10	0.54	0.03
Total Folic acid (µg)	633.00	274.00	148.00	479.00	36.00
Vitamin A (µg)	3.00	7.00	17.00	2.00	8.00

Current production in the Mediterranean basin

Although data available on cowpea production refers mainly to Africa, data from FAO (2) show that the cowpea area in the Mediterranean basin was of 9,352.5 ha, on average, in the period 2010-2013, remaining almost constant during this period (Table 1).

From the analysis of the relative contribution of each country to the total cowpea grown area in the Mediterranean Basin, Serbia, Republic of Macedonia, and Egypt rank first with a total growing area of 49.6%, 22.2%, and 22.2%, respectively. These data contrast with the seed production in the same countries since Republic of Macedonia appears as the major producer concerning seeds, 47.08% of the total, followed by Serbia and Egypt, with 25.2% and 24.5%, respectively (Fig. 1).

Concerning yield, data from Serbia (2012) and Cyprus (2010-2013) showed that cowpea is a marginal crop, very dependent on agro-environmental conditions, probably as a result of a low input cultivation system. It is clear that this crop deserves special attention focused on improving the management of the crop system and ultimately the yield.

Improving soil properties

Apart from the good adaptability of cowpea, it must be stressed the potential to improve the soil characteristics by biological nitrogen fixation (BNF) achieved through the interaction of legume plants with soil microorganisms namely *Rhizobium Bradyrhizobium*, *Sinorhizobium*, *Mesorhizobium*, and *Azorhizobium*. These microorganisms induce the formation of root's nodules, specialized for assimilating atmospheric nitrogen for plants (6), which is of great ecological relevance, since it reduces the use of mineral nitrogen fertilizers (5).

It is also expected that these bacteria also have plant growth-promoting properties, enhancing the elongation of roots (4). Thus, the characteristics of the radicular system of cowpea, concerning deep rooting (up to 100 cm), help to improve the chemical properties of soil in an intercropping system moving upwards the nutrients and water (3). Moreover, the organic matter content and water-absorbing capacity of soils are also enhanced providing a positive impact on the next crops. In this way, cowpea crops can also contribute to reduce soil erosion, and increase the soil carbon content (4).

Cowpea can also form symbiotic associations with arbuscular mycorrhizal fungi (AMF). By exploring a greater volume of soil through the fungal hyphae, AMF, improves plant growth in low soil fertility, enhances plant tolerance to biotic and abiotic stresses, and contributes to plants' health and soil structure. Rhizobia, AMF and other beneficial soil microorganisms can be used as a management tools to improve crop productivity and resilience to climate change.

Genetic diversity

The current scarce production of cowpea in the Mediterranean Basin prompts the opportunity to diversify the legume crops in this area. In order to enhance the cowpea crops in the Mediterranean Basin, it is required the identification of accessions compatible with the agro-climatic conditions in these areas. Nowadays, extensive genetic resources are available through the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria, with 15,200 cultivated and 1646 wild accessions, the USDA Plant Introduction Station in Griffin, Georgia, USA, with 7400 accessions, and the University of California in Riverside, USA, with 5275 cultivated and 50 wild accessions. Following the recent breeding programmes of cowpea, it was possible to improve the adaptability and resistance to biotic and abiotic stress (1). Despite the efforts on the selection of cowpea accessions, to date, the lack of improved accessions, the knowledge of good agronomic practices, the unavailability of good seeds for farmers, and the poor marginal economical returns are discouraging factors, which limit cowpea expansion. Therefore, the evaluation of the genetic diversity of cowpea and the selection of the best accessions is essential to improve growth performance and yield in the conditions of the Mediterranean Basin.

To perform this selection, the analysis of complex genetic systems by molecular characterizations and the evaluation of interaction of genotypes and environment is an essential approach to be explored in the near future.

Nutritional facts

Nowadays, the European Union has a 70% deficit in protein-rich grains that is met primarily by imports of soya bean (*Glycine max* (L.) Merr.) and soya bean meal. Therefore, there is an opportunity to increase the production of additional legume species. With respect to the nutritional properties of legumes, cowpea has been stressed as a valuable source of proteins, essential and nonessential amino acids, carbohydrates of slow absorption, dietary fiber, and essential micronutrients, in a concentration comparable with to the described for other legume species traditionally grown in the Mediterranean Basin (Table 2). Cowpea also constitutes an interesting dietary source of micronutrients (vitamins and minerals) required for normal development of human physiologic functions. Indeed, cowpea seeds were especially relevant concerning to their mineral composition as well as a source of tiamin and folic acid, which turn this species in much interesting to contribute to balanced diets.

Acknowledgements

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A specialized research-and-production journal Leguminous and Groat Crops has been published since May, 17th, 2011. Its main objective is all-round and purposeful informing of scientific assemblage on biological features and technology of cultivation of leguminous and groat crops. The similar journal among domestic mass media is not present, though the demand for it during the last decades was understood by scientific community.

All organizational and financial expenses for its printing are carried out by the All-Russia Research Institute of Leguminous and Groat Crops in Orel.

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The Editorial Council includes well-known scientists and organizers of agricultural science and production, ensuring that the publications widely cover not only results of the scientific researches from regions of the country, but also achievements of work collectives of various forms of ownership, large agricultural affiliations and, of course, the farmers specializing on cultivation of leguminous and groat crops.

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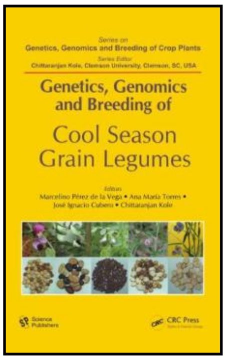
The journal *Legume and Groat Crops* is published in the form of four issues a year.



Genetics, Genomics and Breeding of Cool Season Grain Legumes

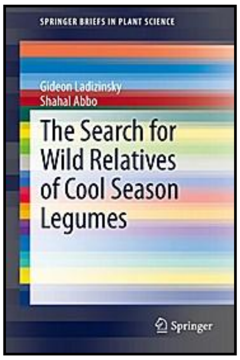
Editors: Marcelino Pérez de la Vega, Ana María Torres, José Ignacio Cubero and Chittaranjan Kole

Publisher: CRC Press, Boca Raton

Year: 2011

ISBN: 978-1-57808-765-5

Cool season grain legumes including pea, faba bean, lentil, chickpea, and grass pea are extensively grown in many parts of the world. They are a primary source of proteins in human diet. This volume deals with the most recent advances in genetics, genomics, and breeding of these crops. The "state of the art" for the individual crops differs; however, their phylogenetic proximity justifies the utility of the knowledge available in one crop for speeding up research and improvement in other crops. The first five chapters are devoted individually to the five crops, followed by four chapters presenting comprehensive reviews on recent advances in the fields of functional genomics, comparative genomics, proteomics and metabolomics, and transgenesis as well as three general chapters on nitrogen fixation, broomrapes, and future prospects. This book contains information useful not only to the scientists and scholars working on the cool season grain legumes but also to those working on other legume species.



The Search for Wild Relatives of Cool Season Legumes

Authors: Gideon Ladizinsky and Shahal Abbo

Publisher: Springer International Publishing Switzerland, Cham

Year: 2015

ISBN: 978-3-319-14504-4

The study of origin and domestication of legumes described in this book emerged when it became apparent that while this kind of information is adequate for cereals, the pulses lagged behind. At the end of the 1960s the senior author initiated a study on the chickpea's wild relatives followed by similar attempts for broad bean, fenugreek, common vetch, bitter vetch, and lentil. The junior author joined the project in the late 1980s with a study of the genetics of interspecific hybrid embryo abortion in lentil and later has extensively investigated chickpea domestication and wild peas. While this book mainly describes our research findings, pertinent results obtained by others are also discussed and evaluated. The main findings include the discovery of the chickpea wild progenitor; studies of lentil in three crossability groups; wild peas proceeded in two lines of study; faba bean and fenugreek and their wild progenitors have not yet been identified; common vetch and its related form were treated here as an aggregate; gene flow between members of different karyotypes was found possible; the relation between bitter vetch and its domesticated form was established by breeding trials.

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CGIAR Research Program (CRP) on Grain Legumes

Pulses in Drylands

Chickpea, faba bean, lentil, common bean, field pea, mung bean, black gram, pigeon pea, cow pea, and grasspea are the major pulse crops produced globally. They specially play an important role in food and nutritional security and sustainable agricultural production systems in the drylands which cover over 40% of the world's land area and are home to approximately 2.5 billion people. These crops are the mainstay of agriculture and diets in these regions, constituting a major source of protein for billions. With an ever-growing health conscious population, the demand for pulses is increasing and so is the opportunity.

ICARDA research station at Marchouch, Morocco

Pulses: Good for the Planet, Good for the People

Given the World Economic Forum's recent assessment on water scarcity posing a significant risk to sustainable development goals, pulses may offer a part of the solution – pulses are efficient users of water and nutrients, offering more crop per drop in terms of protein and micro-nutrients. With prevailing child malnutrition at 27% in Africa and as much as 37% in India, the high-protein, micronutrient-rich caloric values of pulses offer the opportunity for eradicating malnutrition in challenging soil and climatic environments.

According to UNCCD, today 52% of the land used for agriculture is moderately or severely affected by degradation of soil, a non-renewable resource. The worsening land degradation scenario is challenging sustainable food production, particularly in drylands where natural resources are scarce. Pulses have the ability to replenish soil nutrients through nitrogen fixation, making them valuable to improve production systems through crop rotation.

About the Conference

The International Conference on Pulses for Health, Nutrition and Sustainable Agriculture in Drylands is being held on the occasion of the 2016 International Year of Pulses to provide a platform to various stakeholders, including scientists, policy-makers, extension workers, traders and entrepreneurs, to discuss the various contributions of pulses to food and nutritional security and ecosystem health. Challenges ahead to driving greater production and benefits for all will be addressed with a focus on Central and West Asia, and North Africa. A roadmap will be developed for increasing productivity and profitability of pulses through diversification and intensification of cereal/livestock-based cropping systems.

The Conference, to be held April 13-15, 2016 in Rabat, Morocco, is being organized by ICARDA and INRA (Morocco) in partnership with FAO, OCP Foundation and CRP Grain Legumes. Conference advisory partners include (alphabetically):

- Ethiopian Institute of Agricultural Research (EIAR), Ethiopia
- General Directorate of Agricultural Research and Policy (GDAR), Turkey
- Indian Council of Agricultural Research (ICAR), India
- Institut National de la Recherche Agronomique (INRA), France
- Institute for Sustainable Agriculture (CSIC), Cordoba, Spain
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- University of California, Davis (UC Davis), USA
- The University of Western Australia (UWA), Perth, Australia

Conference Themes

1. Global pulses scenarios – production, consumption and trade
2. Innovative techniques for pulses improvement and adaptation
3. Diversification & sustainable intensification of agri-food systems through pulses
4. Seed systems, input markets and mechanization
5. Nutrition, fortification, health and food security
6. Social, economic and policy issues – increasing adoption and impacts assessment
7. Country successes, lessons learnt and challenges (knowledge-sharing event)

Preliminary Conference Program

- Six technical sessions with keynote addresses by distinguished scientists
- A poster exhibition around major themes
- A knowledge-sharing event on country experiences for mutual learning
- A field visit to research experiments on pulse crops at the Marchouch Research Station and farmers' fields

Call for Papers

Participants of the Conference are invited to contribute abstracts of papers for oral or poster presentation on pulses on areas that pertain to themes 1 to 6. Abstracts should not exceed 250 words and must be submitted online.

Important Deadlines

- Submission of Abstract: Dec 31, 2015
- Notification of Acceptance: Jan 31, 2016
- Submission of Full Paper: March 30, 2016

Date and Venue

13-15 April, 2016 in Rabat, Morocco

ICARDA has established its Global Research Platform for Intensification and Diversification of Cereal-Based Production Systems in Morocco and the office for its North Africa Regional Program in Rabat, both graciously hosted by the Institut National de la Recherche Agronomique (INRA).

Rabat is the capital city of Morocco, one of the most diverse countries in Africa, rich in culture and nature. The weather in Rabat is pleasant with temperatures around 15-25°C during April.

Conference Organizing Committees

International

- Dr. Mahmoud Solh (ICARDA), Chair
- Prof. Mohamed Badraoui (INRA), Morocco
- Dr. David Bergvinson (ICRISAT), India
- Mr. Dost Muhammad, Regional Plant Production Officer, FAO/RNE
- Mr. Nawfel Roudies (Program Director, OCP-Foundation), Morocco
- Dr. Masum Burak (GDAR), Turkey
- Dr. B.B. Singh (ICAR), India
- Dr. Asnake Fikre (EIAR), Ethiopia
- Dr. Fred Muehlbauer (USDA/ARS), USA
- Dr. Doug Cook (UC-Davis), USA
- Prof. Kadambot Siddique (University of Western Australia), Australia
- Prof. Diego Rubiales (CSIC), Spain
- Dr. Marie Hélène Jeuffroy (INRA), France
- Dr. Michael Baum (ICARDA), Morocco
- Dr. Shoba Sivasankar (ICRISAT)
- Dr. Ennaany Driss,Mohamed VI Polytechnic University, Morocco

Local

- Dr. Rachid Dahan INRA, Chair
- Dr. Shiv Kumar Agarwal, ICARDA
- Dr. Mohamed El Mourid, ICARDA
- Dr. Rachid Mrabet, INRA
- Dr. Mohamed El Asri, INRA
- Prof. Ahmed Bamouh, IAV- Hassan II
- Mr. Rouini Imadeddine, OCP Foundation
- Ms. Hassina Moukhariq, OCP Foundation
- Dr. Ashutosh Sarker, ICARDA
- Dr. Sripada Udupa, ICARDA
- Dr. Seid Kemal, ICARDA
- Dr. Ahmed Amri, ICARDA
- Dr. Moustafa El-Bouhssini, ICARDA

Registration fee: 250 USD
(to cover lunches, Conference dinner, coffee breaks)

A conference website will be launched soon, providing event updates and allowing online registration, abstract/paper submission and fee payment (for latest information, visit www.icarda.org).

For more information, contact:

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ICARDA
Science for Better Livelihoods in Dry Areas

Second International Legume Society Conference (ILS2) *2016: Legumes for a Sustainable World*

Tróia, Portugal, 12-14 October 2016

http://www.itqb.unl.pt/meetings-and-courses/legumes-for-a-sustainable-world/welcome#content

The International Legume Society and the Instituto de Tecnologia Química e Biológica of the Universidade Nova de Lisboa cordially invite you to join us at the Second International Legume Society Conference, scheduled from 12-14 October, 2016 at Tróia resort, in the vicinity of Lisbon, Portugal.

In a world urgently requiring more sustainable agriculture, food security and healthier diets the demand for legume crops is on the rise. This growth is fostered by the increasing need for plant protein and for sound agricultural practices that are more adaptable and environmentally sensitive. Food, feed, fiber and even fuel are all products that come from legumes – plants that grow with low nitrogen inputs and in harsh environmental conditions. The Second Legume Society Conference will be held during 2016 - the United Nations' International Year of Pulses. The goals of this UN International Year include: the encouragement of connections throughout the food chain that would better utilize pulse based proteins; increase global production of pulses; better utilization of crop rotations; and to address challenges in the trade of pulses.

The conference will address the following themes: Legume Quality and Nutrition; Farming Systems/Agronomy; Abiotic and Biotic Stress Responses and Breeding; Legume Genetic Resources; and New "Omics" Resources for Legumes. The health and environment benefits, as well as, the marketing of legumes will be transversal topics throughout the conference. Special attention will be given to foster the interaction of researchers and research programs with different stakeholders including farmers and farmer associations, seed/feed and food industries, and consumers. For this, the conference will also be the site of the Final Meeting of the EU-FP7 ABSTRESS project, the Annual Meeting of EU-FP7 LEGATO project; and final dissemination events of EU-FP7-ERANets MEDILEG and REFORMA. The results and conclusions from these four important research programs will be shared with conference attendees.

Please join us in beautiful Tróia, Portugal from 12-14 October, 2016! Plan now to include the Second ILS Conference in your busy agenda. Kindly share this information with any colleagues dealing with legumes.

Diego Rubiales, on behalf of the Scientific Committee
Pedro Fevereiro, Carlota Vaz Patto and Susana Araújo, on behalf of the Organizing Committee

Local Organizers
The Instituto de Tecnologia Química e Biológica / Universidade Nova de Lisboa (ITQB/UNL) will be responsible for organising the Conference, in cooperation with the International Legume Society. The official language of the Conference will be the English.

INSTITUTO DE TECNOLOGIA QUÍMICA E BIOLÓGICA ANTÓNIO XAVIER /UNL
Knowledge Creation

Conveners
Pedro Fevereiro - Universidade Nova de Lisboa (ITQB/UNL)
Carlota Vaz Patto - Universidade Nova de Lisboa (ITQB/UNL)
Susana Araújo - Universidade Nova de Lisboa (ITQB/UNL)

Scientific Coordinator
Diego Rubiales - CSIC, Córdoba, Spain

Local Organizer Committee (in alphabetic order)
Nuno Almeida - ITQB/UNL
Susana Araújo - ITQB/UNL
Ana Barradas - Fertiprado
Manuela Costa - Universidade do Minho
Isabel Duarte - Instituto Nacional de Investigação Agrária e Veterinaria (INIAV)
Sofia Duque - ITQB/UNL
Pedro Fevereiro - ITQB/UNL
Susana Leitão - ITQB/UNL
Eduardo Rosa - Universidade de Trás-os-Montes e Alto Douro
Marta Vasconcellos - Escola Superior de Biotecnologia, Universidade Católica
Carlota Vaz Patto - ITQB/UNL
Manuela Veloso - INIAV

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Shiv Kumar Agrawal - ICARDA, Syria
Paolo Annicchiarico - CREA-FLC, Italy
Stephen E. Beebe - CIAT, Colombia
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Judith Lichtenzveig - Curtin University, Australia
Kevin McPhee - North Dakota State University, USA
Aleksandar Mikić - Institute of Field and Vegetable Crops, Serbia
Eduardo Rosa - Universidade de Trás-os-Montes e Alto Douro, Portugal
Diego Rubiales - Institute for Sustainable Agriculture, CSIC, Spain
Fred Stoddard - University of Helsinki, Finland
Richard Thompson - INRA, France
Tom Warkentin - University of Saskatchewan, Canada

Venue

The conference will be held in Tróia in the vicinity of Lisbon, Portugal. Tróia is a beautiful sand peninsula dividing the Sado River from the Atlantic Ocean.

The nearest airport is the Lisbon International Airport, about 50 Km away. Shuttles will be made available from and to Lisbon International Airport.

During the period of Roman occupation, date from the 1st century to the 6th century AD, Tróia was an island of Sado delta, called Ácala Island.

The Sado Estuary Nature Reserve, where dolphins swim, and the Serra da Arrábida Natural Park, where a full developed Mediterranean forest can be seen, are two of the main natural attractions nearby Tróia peninsula.

The Tróia Golf Championship Course is considered the best course in Portugal in the categories of difficulty and variety. It also stands in 20th place in the list of the best golf courses in Europe drawn up by the Golf World magazine.

First tentative programme

October 10th and 11th, 2016

Ascochyta Workshop
Satellite projects meetings (to be defined)

October 11th, 2016

Evening: ILS2 Conference Registration

October 12th, 2016

08:00 Registration
09:00-09:30 Welcome addresses

09:30-10:30 Session 1, plenary: Legumes vale chain: market requirements and economic impact
09:30-10:00 Key lecture 1
10:00-10-30 Key lecture 2

10:30-11:00 Coffee break

11:00-12:00 Session 2, plenary: Legumes and environment
11:00-11:30 Key lecture 1
11:30-12:00 Key Lecture 2

12:00-13:00 Poster viewing

13:00-14:30 Lunch

14:30 – 16:00 Parallel sessions
Session 3, parallel: Session 3, parallel: Mechanisms of beneficial legume-microbe interactions
14:30-15:00 Key lecture
15:00-15:15 Oral presentation 1
15:15-15:30 Oral presentation 2
15:30-15:45 Oral presentation 3
15:45-16:00 Oral presentation 4

Session 4, parallel: Genetic resources
14:30-15:00 Key lecture
15:00-15:15 Oral presentation 1:
15:15-15:30 Oral presentation 2
15:30-15:45 Oral presentation 3
15:45-16:00 Oral presentation 4

16:00-16:30 Coffee break

16:30-17:30 Parallel sessions
Session 5, parallel: Legumes value chain: market requirements and economic impact (cont.)
16:30-16:45 Oral presentation 1
16:45-17:00 Oral presentation 2
17:00-17:15 Oral presentation 3
17:15-17:30 General discussion on Legumes value chain

Session 6, parallel: Legumes and environment (cont.)
16:30-16:45 Oral presentation 1
16:45-17:00 Oral presentation 2
17:00-17:15 Oral presentation 3
17:15-17:30 General discussion on Legumes and environment

17:30-18:30 Poster session 1
Slots of 3 min flash presentations (+ 2 min questions) from 12 selected posters on the sessions of the day

20:45 Third International Legume Football Cup: semi-finals

October 13th, 2016

8:30-10:00 Session 7, plenary: Legumes in food and feed and other alternative uses
08:30-09:00 Key lecture 1
09:00-09:30 Key lecture 2
09:30-10:00 Highlighted oral presentation

10:00-10:30 Coffee break;

10:30-12:00 Session 8, plenary: Frontiers in legume genetics and genomics
10:30-11:00 Key lecture
11:00-11:30 Highlighted oral presentation
11:30-12:00 Highlighted oral presentation

12:00-13:00 Poster session 2
Slots of 3 min flash presentations (+ 2 min questions) from 12 selected posters from the sessions of the day

13:00-14:30 Lunch

14:30 – 16:00 Parallel sessions
Session 9 parallel: Legumes in food and feed and other alternative uses (cont.)
14:30-14:45 Oral presentation 1
14:45-15:00 Oral presentation 2
15:00-15:15 Oral presentation 3
15:15-15:30 Oral presentation 4
15:30-15:45 Oral presentation 5
15:45-16:00 General discussion on Legumes in food and feed and other uses

Session 10 parallel: Frontiers in legume genetics and genomics (cont.)
14:30-14:45 Oral presentation 3
14:45-15:00 Oral presentation 4
15:00-15:15 Oral presentation 6
15:15-15:30 Oral presentation 7
15:30-15:45 Oral presentation 8
15:45-16:00 General discussion of genetics and genomics

16:00-16:30 Coffee break;

16:30-18:00 Parallel sessions
Session 11, parallel: Frontiers in plant and crop physiology
16:30-17:00 Key lecture
17:00-17:15 Oral presentation 1
17:15-17:30 Oral presentation 2
17:30-17:45 Oral presentation 3

Session 12 parallel: Integrated pest and disease management
16:30-17:00 Key lecture
17:00-17:15 Oral presentation 1
17:15-17:30 Oral presentation 2
17:30-17:45 Oral presentation 3

17:45-19:00 ILS General Assembly

20:45 Third International Legume Football Cup: finals

October 14th, 2016

8:30-10:00 Session 13 plenary: Frontiers in legume breeding
08:30-09:00 Key lecture
09:00-09:30 Highlighted oral presentation
09:30-10:00 Highlighted oral presentation

10:00-10:30 Coffee break;

10:30-12:00 Session 14, plenary: Frontiers in legume agronomy
10:30-11:00 Key lecture
11:00-11:30 Highlighted oral presentation
11:30-12:00 Highlighted oral presentation

12:00-13:00 Poster session 3
Slots of 3 min flash presentations (+ 2 min questions) from 12 selected posters from the sessions of the day

13:00-14:30 Lunch

14:30 – 16:00 Parallel sessions
Session 15, parallel: Advances in legume breeding (cont.)
14:30-14:45 Oral presentation 1
14:45-15:00 Oral presentation 2
15:00-15:15 Oral presentation 3
15:15-15:30 Oral presentation 4
15:30-15:45 Oral presentation 5
15:45-16:00 General discussion on advances in legume breeding

Session 16 parallel: Advances in legume agronomy (cont.)
14:30-14:45 Oral presentation 1
14:45-15:00 Oral presentation 2
15:00-15:15 Oral presentation 3
15:15-15:30 Oral presentation 4
15:30-15:45 Oral presentation 5
15:45-16:00 General discussion on advances in legume agronomy

16:00-16:30 Coffee break;

16:30-18:00 Parallel sessions
Session 17, parallel: Seed technology, marketing and knowledge-transfer
16:30-17:00 Key lecture
17:00-17:15 Oral presentation 1
17:15-17:30 Oral presentation 2
17:30-17:45 Oral presentation 3
17:45-18:00 Oral presentation 4

Session 18 parallel: Resistance to biotic and abiotic stresses
16:30-17:00 Key lecture
17:00-17:15 Oral presentation 1
17:15-17:30 Oral presentation 2
17:30-17:45 Oral presentation 3
17:45-18:00 Oral presentation 4

18:00-19:00 Concluding session
Posters and oral presentations awards
ILS Honorary member's awards

20:00 Farewell Dinner

International Legume Society (ILS)

is publicly announcing

A CALL FOR TENDERS
TO HOST
THIRD ILS CONFERENCE (ILS3)
IN 2019

All interested organisations
are kindly invited to express their interest to
Professor Diego Rubiales, the ILS President,
at diego.rubiales@ias.csic.es,
at the earliest convenience.

The venue of ILS3 will be defined and announced
by the ILS Executive Committee
in December 2015.

12th European Nitrogen Fixation Conference
Budapest, Hungary, 25-28 August 2016
http://enfc2016.hu/

20th Eucarpia General Congress
Zurich, Switzerland, 29 August - 1 September 2016
http://eucarpia2016.org

26th General Meeting of the European Grassland Federation
Trondheim, Norway, 5-8 September 2016
http://www.egf2016.no

XIV Congress of the European Society for Agronomy
Edinburgh, UK, 5-9 September 2016
http://esa14.org.uk

10th World Soybean Research Conference
Savannah, USA, 10-16 September 2017
http:// www.wsrc10.com

Legume Perspectives is an international peer-reviewed journal aiming to interest and inform a worldwide multidisciplinary readership on the most diverse aspects of various research topics and use of all kinds of legume plants and crops.

The scope of *Legume Perspectives* comprises a vast number of disciplines, including biodiversity, plant evolution, crop history, genetics, genomics, breeding, human nutrition, animal feeding, non-food uses, health, agroecology, beneficial legume-microorganism interactions, agronomy, abiotic and biotic stresses, agroeconomy, sociology, scientometrics and networking.

The issues of *Legume Perspectives* are usually thematic and devoted to specific legume species or crop, research topic or some other issue. They are defined by the Editorial Board, led by the Editor-in-Chief with the help from Assistant Editors, who select and invite one or more Managing Editors for each issue. Having accepted the invitation, the Managing Editor agrees with the Editorial Board the details, such as the deadline for collecting the articles and a list of the tentative contributors, from whom he, according to his own and free choice, solicit the articles fitting into the defined theme of an issue. A possibility that every member of the global legume research community, with a preference of the International Legume Society members or established authorities in their field of interest, may apply to the Editorial Board to be a Managing Editor and suggest a theme for his issue is permanently open and can be done simply by contacting the Editor-in-Chief by e-mail, with a clearly presented idea, structure and authors of the potential issue.

Since one of the main missions of *Legume Perspectives* is to provide as wide global readership with the insight into the most recent and comprehensive achievements in legume science and use, the articles published in *Legume Perspectives* are usually concise, clear and up-to-date reviews on the topic solicited by the Managing Editor from each author. Managing Editor is solely responsible for collecting the articles from the authors, anonymous peer-review, communicating with the Technical Editor and providing the authors with the proofs of their manuscript prior to the publication.

Apart from review articles, *Legume Perspectives* is keen on publishing original research articles, especially if they present some preliminary results of an outstanding significance for legume research and before they are published in their full volume, as well as brief reports on already held and announcements about the forthcoming national and international events relating to legumes, descriptions of the projects on legumes, book reviews, short articles on legumes in popular culture or everyday life, fiction stories on legumes and obituaries. The authors of such contributions are advised to contact the Editor-in-Chief first, in order to present the draft of their idea first and receive a recommendation if it is appropriate.

Regardless of the article category, *Legume Perspectives* prefers a clear, simple and comprehensive writing style that would make its articles interesting and useful for both academic and amateur audience. Your article is expected to assist in the exchange of information among the experts in various fields of legume research.

Legume Perspectives welcomes either longer (900-1,100 words + up to 3 tables, figures or photos + up to 10 references) or shorter (400-500 words + 1 table, figure, photograph or drawing + up to 4 references) manuscripts. The Editor-in-Chief, depending on the opinion of the Managing Editor, may allow any variation in length or structure, from case to case.

The manuscripts for *Legume Perspectives* should be prepared in Microsoft Office Word, using Times New Roman font, 12 points size and single spacing. Please provide each manuscript with a 100-word abstract and 4-6 key words listed alphabetically. The references should follow the style of the published papers in this issue, be given in full and listed alphabetically. The tables may be incorporated in the manuscript, while figures, photographs or drawings should be submitted separately as jpg files with a resolution of at least 600 dpi. The authors whose native language is not English are strongly advised to have their manuscripts checked by a native English speaker prior to submission and be persistent in following only one of all the variants of English they themselves prefer.

Publishing articles in *Legume Perspectives* is free.

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