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Introduction: Legumes in sustainable agriculture

Diego Rubiales[1] and Aleksandar Mikic[2]

[1]*Institute for Sustainable Agriculture, CSIC, Apdo.4048, 14080 Córdoba, Spain*

[2]*Institute of Field and Vegetable Crops, Novi Sad, Serbia*

World population is predicted to double by 2050 (http://www.fao.org), imposing an increasing demand for food that comes together with an increasing concern on environment and food security. Under this pressing scenario for agriculture, the widely acknowledged beneficial role of legumes in cropping systems, by increasing biological nitrogen fixation, reducing energy costs, improving soil physical conditions and biodiversity, is more needed than ever (Curty et al., 2014; Peix et al., 2014). In addition to this, legumes are important food and feed crops, being key components of the Mediterranean diet, and even staple crops in other regions (Vaz Paatto et al., 2014), with an increasing role as forage producing high-quality meat and milk (Boelt et al., 2014). Legumes are also gaining importance for their health benefits (Arnoldi et al., 2014).

Despite these advantages, legume cultivation did not meet the expectations and remains below that of other crops, such as cereals. This has been accompanied by a progressive replacement of traditional farming systems with industrialized, largely cereal-based systems, heavily reliant upon fossil fuels. As a result, acreage of most temperate legumes (pea, faba bean, vetches, lupin) has declined worldwide in the last 50 years (table 1). We can be more optimistic on the trend showed by warm-season legumes (soybean, cowpea, common bean, groundnut, pigeonpea). These are increasing in acreage, with the remarkable boost in soybean, but still, far below major cereals. Regional tendencies are also particularly notorious, with a remarkable European general trend for decrease of most legumes, including common bean, in spite of the political efforts made by the European Union and national governments to promote legume cultivation with subsidies. Soybean is the only legume whose acreage is continuously increasing in Europe, reaching 3.45 million ha in 2012, more than all other legumes together. This contrasts with the general increasing trend of all legumes in America and Oceania in which legumes where they are traded at world prizes.

Many reasons have been given for this decline, but low and unstable yields as well as susceptibility to biotic (Rubiales et al., 2014) and abiotic stresses (Araujo et al., 2014) are chiefly to blame. In fact, average yield of temperate legumes has increased relatively little during past 50 years, with a just about 50% increase for most legumes. The highest yield increases (around 100%) have been achieved for lentil, groundnut and soybean, which are still below the increases achieved by major cereal crops (130 to 160%) (FAOSTAT, 2013).

Given the limited resources of fossil energy, and renewing health and environmental concerns, it is time to reassess the potential role of legumes as source of N for cropping systems. To stimulate wider adoption, the crop should be improved to be more attractive both to producers and to users. Breeding for improved crop cultivars, to better sustain livelihood and increase the economic return to farmers, has been undertaken for many years. Significant progress in breeding annual (Duc et al., 2014) and perennial (Annicchiarico et al., 2014; Boelt et al., 2014) legumes are being achieved. Important genetic variation for all these traits of interest exists, providing an excellent resource for plant breeders (Mykal et al., 2014). Fast and reliable screening methods have been adjusted to fulfil the needs of breeding programmes for quality traits for food (Vaz Patto et al., 2014) and feed uses (Phelan et al., 2014), as well as for resistances to biotic (Rubiales et al., 2014) and abiotic stresses (Araujo et al., 2014). Many of these traits of interest have already been incorporated into modern cultivars, but several others, many of which are controlled quantitatively by multiple genes, have been more difficult to handle. Breeding effectiveness will soon increase with the adoption of the new improvements in marker technology together with the integration of comparative mapping and functional genomics (Annicchiarico et al., 2014; Duc et al., 2014; Varshney et al., 2014). Enhanced seed production technologies will ensure that the benefits from the improvements brought about by modern plant breeding are made readily available to farmers (Boelt et al., 2014).

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Table 1. Trend for word acreage (Million hectares) per major legume crops in past 50 years compared to major cereal crops (source FAOSTAT, 2013)

	1962	1972	1982	1992	2002	2012
Cool-season legumes						
Chickpea (*Cicer arietinum*)	12,2	10,5	10,3	9,3	10,4	12,1
Pea (*Pisum sativum*)	10,3	8,0	7,4	7,2	6,0	6,3
Faba bean (*Vicia faba*)	6,1	4,2	3,3	2,9	2,7	2,4
Lentil (*Lens culinaris*)	1,6	1,8	2,6	3,3	3,6	4,2
Vetches (*Vicia* sp.)	2,4	1,7	1,0	1,0	0,9	0,6
Lupins (*Lupinus* sp.)	1,4	0,8	0,6	1,2	1,2	0,9
Warm-season legumes						
Soybean (*Glycine max*)	23,8	31,7	52,4	56,2	79,0	106,6
Common bean (*Phaseolus vulgaris*)	23,5	22,8	26,2	24,8	27,5	28,8
Peanut (*Arachis hypogea*)	17,5	20,1	18,4	20,6	23,0	24,6
Cowpea (*Vigna unguiculata*)	2,7	4,2	3,9	8,5	9,9	10,7
Pigeonpea (*Cajanus cajan*)	2,7	2,7	3,4	4,2	4,4	5,3
Major cereals, for comparison						
Wheat (*Triticum aestivum*)	207,6	213,8	238,5	222,5	213,8	216,7
Rice (*Oryza sativa*)	119,5	132,2	141,6	147,4	147,6	163,5
Maize (*Zea mays*)	103,5	114,9	124,4	136,8	137,6	177,0