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Integrated Disease Management of Grain Legumes in Algeria and Strategies of Agricultural Development: A Review

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ABSTRACT

Grain legumes have an important role in Algerian agriculture contributing towards food, nutritional security and sustainable farming systems. This kind of culture has a several diseases can reduce the global production and yield. Causes of these major diseases we have to propose the integrated disease management for minimize the damage caused by these diseases. The term Integrated Pest Management was first based on the concept of 'integrated control' given by the entomologists from University of California, who defined it as "applied pest control" which combines and integrates cultural, biological and chemical control. Chemical control was used only if necessary and in a way which was least disruptive to cultural and biological control.

Key words: Constraints, Development, Grain legumes, Management, Production.

Grain legumes are represented by around 13,000 species spread around the world (Aykroyd and Doughty, 1982). The Fabacaea family is the most represented (around 10,000 species) and exploited by humans (Rasool *et al*., 2019). From a food point of view, food legumes are used mainly for their protein-rich seeds (broad 'faba' beans, field peas, beans, lentils and chickpeas), (Graham and Vance, 2003). Grain legumes have been cultivated for a long time in the world, they occupy an important place in the human diet for many developing countries (Rasool *et al*., 2019). These rich in proteins allow to a certain extent to correct the deficiencies in animal proteins of a population whose food is exclusively based on cereals (Rasool *et al*., 2019). According to Obaton (1980), one hectare of pulses produces 1 ton of protein, ten times more than the production of a meat farm on the same surface.

At present, in the world, grain legumes occupy more than 104 Million Hectares, with total production more than 169MT (Fig 1), (FAO, 2020). This production was distributed as: 4.9 MT of Faba bean; 3.4 MT of Peas; 17MT of Chickpeas; 6.3 MT of Lentil; and 5.5 MT of Bean (FAO, 2020). The yield varies according to the kind of grain legume and phenological criteria like number of seeds per pod, seed size and weight (Fig 2), (FAO, 2020). In contrast, in Algeria faba beans is the first class concerning the harvest areas and annual production, with yield 13.5 Quintals/Ha (Fig 2 and 3), (FAO, 2020).

In Algeria, the cultivation of food legumes has a national interest because it must meet protein needs, reduce imports and limit our economic independence from abroad (Boudjenouia and Fleury, 2002). Despite the cultivation of several food legumes in our country, their current situation is not encouraging (Toulaiti, 1988). Indeed, the cultivation of food legumes occupies an important place in the diet, but it is far from having a place equivalent to that of cereals and legumes crops in the production system (Kebede, 2020). Problems related to the installation of the legume culture (date and dose of sowing), phytosanitary protection (pests, diseases and weeds), losses during the harvest and the unavailability of adapted varieties, are the causes main reasons for low yields (Maatougui, 2002).

The purpose of this review is therefore to present the constraints of growing food legumes in Algeria, with a proposal for a model to cure or limit these constraints in order to achieve sufficient production for our population and reduce imports.

Situation of grain legumes cultivation in Algeria

Cultural aspects and importance

In Algeria, food legumes (pulses) have been part of the agricultural landscape for millennia. These crops are used in rotation with cereals because they enrich the soil with nitrogen (Rasool *et al*., 2019). Legumes are also cultivated, because they are an important protein source capable of

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replacing animal proteins that are difficult to access for a large section of the population (Jukanti *et al*., 2017). They are as calorific and rich in carbohydrates as wheat (Jukanti *et al*., 2017). Their total area over the last decade 2009-2018 has been around 1.31 million hectares, production does not exceed 14.79 MT per year (Fig 3) and the yield does not reach 23.00 Q/Ha on average was good where compared with world yield average (23.8Q/Ha), (Fig 2),(FAO, 2020). The most cultivated species are in order of importance, faba bean, peas, chickpeas, beans and lentils (Table 1), (Seetharamu *et al*., 2020). The marginal production very remarkable for the cultivation of beans and lentils (Fig 3).

Major constraints of grain legumes cultivation

The stagnation in the production of food legumes has often been explained by the low yields due to the climatic conditions most often unfavorable for this type of crop, the insufficient and poorly distributed rains compared to the needs of the vegetative cycle of the leguminous plant (Maatougui, 2002). In a semi-arid and arid climate, the most appropriate technique is that of seeking to wedge the cycle of the plant to that of the rains (Winter sowing) and carrying out cultivation operations which mobilize water in the soil (Deep plowing) or which limit water losses (Weeds) (Boudjenouia and Fleury, 2002). Despite the fact that cultivated food legumes have been benefited from some development programs (ITGC, 1987), national production of food legumes has not experienced the expected improvement, in terms of both area and seed production. On the contrary, all species, particularly the lentil, experienced a decline. The reasons for this situation are biotic, technical and agronomic, but also socio-economic (ITGC, 1999).

Technical and agronomical constraints

We can explain this kind of constraints by these points:
- Low productivity of the plant material used.
- Regression of areas.
- Lack of certified seeds.
- Traditional management of cultures.
- Inadequate weed control.
- Lack of mechanization.
- Existing research assets poorly transferred.

Major grain legumes diseases

The major diseases can causes a damages to grain legumes in Algeria are mainly: Anthracnose (*Colletotrichum lindemethianum*), Ascochyta blights (*Ascochyta* sp.), Fusarium wilt (*Fusarium oxysporum*), Powdery mildew (*Erysiphe polygoni*), Downy Mildew (*Peronospora viciae*), Rust (*Uromyces viciae-fabae*) and gray mould or Chocolate spot (*Botrytis cinerea, B. fabae*) and some viral plant diseases (Gautam *et al*., 2013; Boumaaza *et al*., 2018; Kumar *et al*., 2019; Benzohra *et al*., 2020), (Table 1).

Social and economical constraints

There is a lot of social and economic factors can limit the grain legumes production in Algeria:
- Low profit margin (low productivity and heavy load).
- Difficulties in financing.
- Cultures considered family (self-consumption).
- Competition of imported products often of better quality and well packaged.
- Low capacity processing industry (canned peas and beans) or absent (broad beans, chickpeas and beans).
- Low promotion during marketing (packaging and presentation of poor quality products).

Intgrated Disease Management

Agronomical techniques

Look for varieties better suited to less intensive cropping systems with less irrigation needs, because the majority of our climate is semi-arid or arid and the type of cultivars are spring protein varieties (peas, beans, chickpeas, lentils), many situations require the use of irrigation to secure yields. For this purpose, it is preferable in Algeria to cultivate the varieties of winter type, because they consume only 300 mm of water per year and there will be no coincidence with the period of drought (Munier-Jolain and Carrouée, 2003). With the exception of the arid zones where the water deficit

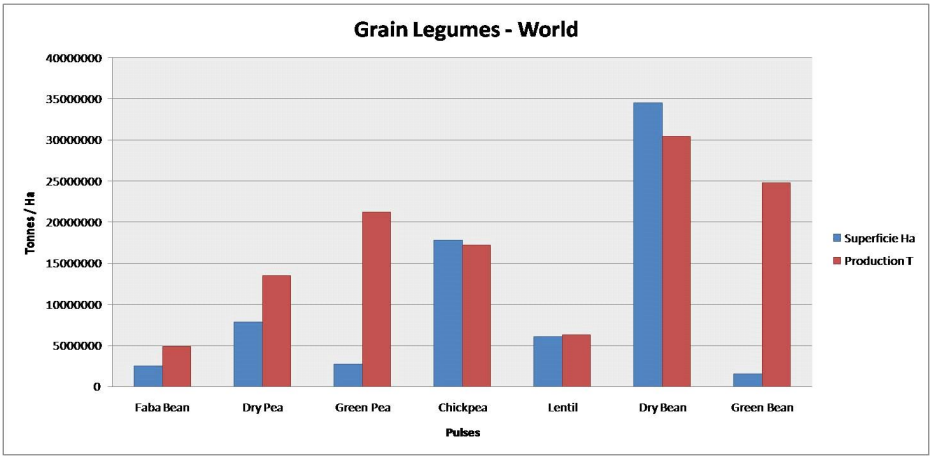


Fig 1: Superficies development and annual productions of grain legumes pulses in the world in the period 2009-2018 (FAO, 2020).

Table 1: Major Grain legumes diseases with its causal agents.

Pulses	Disease name	Causal agent
Broad (Faba) beans(*Vicia faba* L.)	Chocolate spot	*Botrytis fabae, B. cinerea*
	Ascochyta blight	*Ascochyta fabae*
	Powdery Mildew	*Microsphaera penicillata var. ludens*
	Rust	*Uromyces viciae - fabae*
	Necrotic yellow	FBNYV (Faba Bean Necrotic Yellow Virus)
Field pea (*Pisum sativum* L.)	Ascochyta blight	*Ascochyta pisi, A. pinodes, A. Pinodella.*
	Powdery Mildew	*Erysiphe polygoni*
	Downy Mildew	*Peronospora viciae*
	Rust	*Uromyces viciae - fabae*
Chickpea (*Cicer arietinum* L.)	Ascochyta blight	Ascochyta rabiei
	Wilt	*Fusarium oxysporum* f. sp. *ciceris*
	Powdery Mildew	*Erysiphe polygoni*
	Phoma blight	*Phoma medicaginis*
	Rust	*Uromyces ciceris-arietini*
Lentil (*Lens culinaris* Medik.)	Ascochyta blight	*Ascochyta lentis*
	Wilt	*Fusarium oxysporum* f. sp. *lentis*
	Rust	*Uromyces viciae - fabae*
	Powdery Mildew	*Erysiphe trifolii*
Beans (*Phaseolus vulgaris* L.)	Anthracnose	*Colletotrichum lindemethianum*
	Rust	*Uromyces phaseoli typica*
	Powdery Mildew	*Erysiphe polygoni*
	Common Bacterial Blight	*Xanthomonas phaseoli*
	Ascochyta Leaf Spot	*Ascochyta phaseolorum*
	White Mould	*Sclerotinia scleroteorum*

Source: Pande *et al*. (2009), Benzohra *et al*. (2012) and Arasu *et al*. (2016).

Table 2: Antagonistic and mycorhizical strains species used in the biocontrol against grain legumes diseases.

Disease name	Causal agent	Antagonistic strain species
Chocolate spot	*Botrytis fabae, B. cinerea*	*Trichoderma harzianum, T. viride, T. Atro-album*
Ascochyta blight	*Ascochyta fabae, A. Rabiei, A. pisi, A. pinodes, A. Pinodella ...*	*Trichoderma harzianum, T. viride*
Powdery Mildew	*Microsphaera penicillata var. ludens Erysiphe polygoni*	*Streptomycies spiralis*
Rust	*Uromyces viciae – fabae*	*Stenotrophomonas maltophilia C3*
Downy Mildew	*Peronospora viciae*	*Trichoderma harzianum, Glomus versiform*
Wilt	*Fusarium oxysporum*	*Trichoderma harzianum, T. Viride, Bacillus subtilus*

Source: Pande *et al*. (2009).

is very remarkable and precocious and can be spread out in all the season of production what requires to introduce by an irrigation of 50 to 80 mm at least at the end of spring is enough between flowering and the start of seed filling (Duc *et al*. 2011).

Biocontrol

The use of pesticides must be reduced in the program of IDM (Integrated Disease Management), for combating the diseases, with other methods of cultural control (rotations, types of cultivars, sowing dates, *etc*.), (Arasu *et al*. 2016). The biocontrol based on using of antagonistic fungi (*Trichoderma harzianum, T. viride*) and bacteria (*Bacillus subtilus, Pseudomonas* spp.) against fungal diseases (Table 2). And also genetics method can be used (creation and selection of varieties), (Graham and Vance, 2000).

Although the genetic approach described above is important, other innovative research is currently being developed. Thus, with regard more specifically to peas, the fight against ascochyta blight is mainly based on fungicide treatments applied systematically: at least three applications are made on peas and winter chickpeas (Duc *et al*. 2011). New directions in environmental protection lead to an attempt to cut the number of fungicide applications in half. Research aimed at reducing the number of chemical applications, through better management of the architecture of the pea cover, has been developed for several years. The characteristics of the plant and the plant cover (resistance levels and architecture) are indeed major determinants of the epidemic development of aerial diseases and therefore of their control in integrated phytoprotection strategies (Le May *et al*., 2005). The architectural characteristics of plants and cutlery are linked, on the one hand, to the varietal

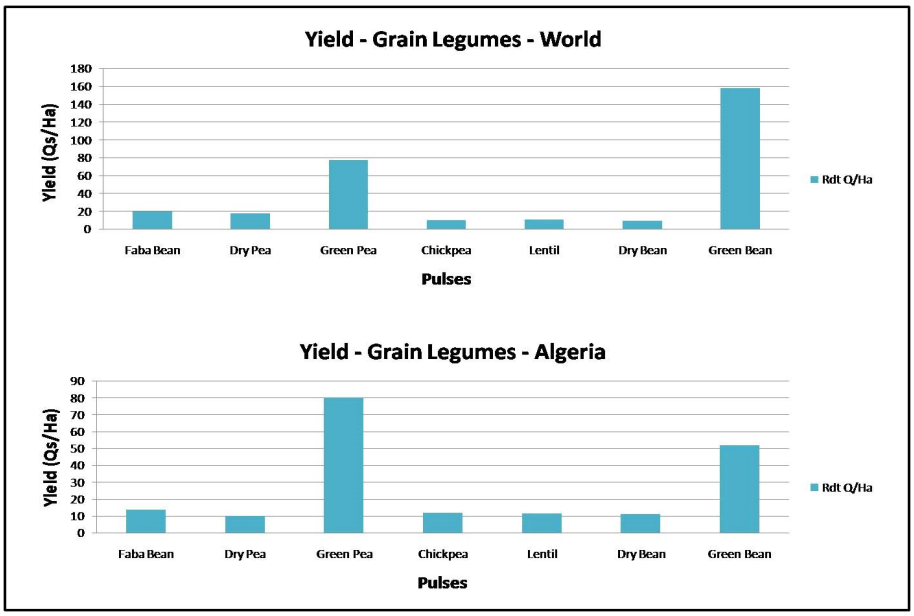


Fig 2: Yields of grain legumes (Q/Ha) in the world and Algeria in the period 2009-2018 (FAO, 2020).

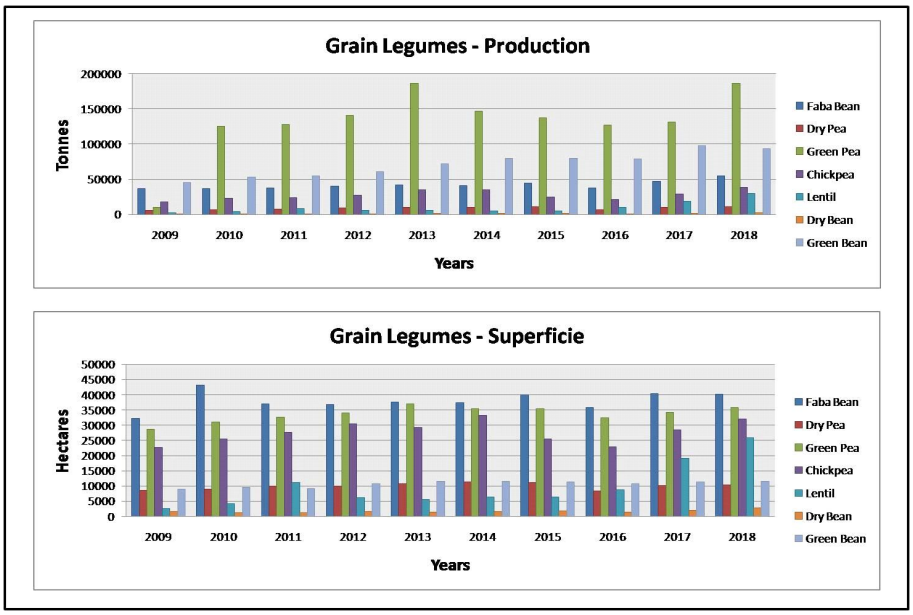


Fig 3: Superficies development and annual productions of grain legumes pulses in Algeria in the period 2009-2018 (FAO, 2020).

type and its physiological and phenotypic characteristics and on the other, to the methods of cultivation. If we take the example of the *Mycosphaerella pinodes*-Pea pathosystem, the density of stems, the height of the stem, the number of nodes and the distribution of leaf area according to the stages contribute to the establishment of a particular architecture which influences the microclimate within the plant cover (variation in temperature and duration of wetness) and therefore, the development, but also the spread of the disease (Le May *et al*., 2009a, b; Tivoli *et al*., 2006). The simplification of rotations and varieties and the intensive use of fungicides have reduced survival and diversity in different microbial organisms, animals, plants associated with the cultivated plot. However, in rotations or crops in combinations, winter or spring protein crops can potentially serve as habitat or nutritional reserve for different associated organisms and we can hypothesize that the development of these crops especially in integrated or organic farming conduits can lead to a greater diversity of soil microflora and microfauna, preserve auxiliary insects and pollinators and contribute to the diversity of cultivated plant and weed species in large crops (Duc *et al*. 2011).

Resistant cultivars

Host resistance is the most acceptable component in virus control for environment protection and also by farmers (Pande *et al*., 2009).

The information that will be collected and analyzed relates to the main socio-economic and technical constraints of farmers of this type of crop, it allows to:

- Identify the constraints and solutions at the level of the different socio-economic categories of farmers in all communities.
- Develop more effective extension methods and farmer field school programs.
- Identify the needs of other more in-depth studies.
- Identify and prioritize research problems, emphasizing the research program required by the request.

Since the 1980s, studies have been developed on the resistance of grain legumes to diseases: research of sources of resistance, development of screening tests for resistance, studies of the mechanisms and genetics of resistance (Moussart and Tivoli, 2005; Duc *et al*., 2011). These studies made it possible to highlight sources of resistance and to develop methods for assessing varietal behaviour for grain legume/ascochyta blight pathosystem (Onfroy *et al*., 2007; Wicker *et al*., 2001a, b), faba beans/Botrytis and ascochyta blight pathosystems (Tivoli *et al*., 1986, 1987, 1988, 2006; Maurin *et al*., 1993; Kharrat *et al*., 2006). In addition, the French institute INRA research program in France has made it possible to define *Medicago truncatula* as a model species for a molecular analysis of resistance to diseases of grain legumes (Moussart *et al*., 2007). The results of this research are passed on to grain legume breeders.

Therefore, the development of pulses is a necessity that must focus on the following objectives: organize the sector “profession-development-research), organize the environment (market-price), put in place the necessary incentives” FNR (national research fund) - development of food legumes and allow the emergence of local development projects, particularly in areas where these crops are popular, as in the case of northwest Algeria (Ain-Temouchent, Tlemcen, Mascara and Sidi-Bel-Abbes) (Labdi, 1995). It’s necessary to take all measuring to increase the productivity and harvested areas, as well as developing the grain legumes production sector, must be strategic objectives to pursue.

CONCLUSION

In this review, the development of strategies of integrated disease management (IDM) of grain legumes has been discussed.

Improving the competitiveness of protein crops (pulses) compared to other crops and in particular compared to cereals, seems essential. This presupposes acting simultaneously on increasing and stabilizing yields (varieties more tolerant of biotic and no biotic stresses, efficient in the use of water and mineral inputs), on improving the composition of these seeds (content in proteins and vitamins) and on production costs. In addition, the possible evolution of pulse production towards greater consideration of the multi-functionality of agriculture and sustainable development should favour the “economic” development of the environmental advantages of protein crops. It will be facilitated if we assess more precisely their advantages in rotations and if we adapt the lines and varieties, so as to maximize these environmental advantages.

Research work on grain legumes deserves to be retained by technical and research institutions in Algeria, like CRSTRA, INRAA and ITGC to highlight the approach to be taken, taking into account the constraints of legumes and the socio-economic rationality of farmers.

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