Using host plant resistance to manage biotic stresses in cool season food legumes

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Key words: multiple disease resistance, germplasm, integrated pest management breeding, selection

Abstract

The cool season food legumes are seriously affected by diseases and pests that collectively cause yield reductions variously estimated at over 50% on a world wide basis. The use of host plant resistance to increase and stabilize yields depends on a well planned plant breeding program, i.e., germplasm evaluation, hybridization with otherwise adapted material, and screening and selection methods that efficiently identify segregants with combined resistance to multiple diseases and insect pests. Sequential and simultaneous screening has successfully combined resistance to Ascochyta blight and Fusarium wilt of chickpea; Fusarium wilt, powdery mildew, and viruses of pea; and Fusarium wilt and rust of lentil.

Resistance has generally been durable for the soilborne diseases; however, resistance to Ascochyta blight has often been overcome by new pathotypes. Resistance to powdery mildew, pea enation mosaic and other viruses has been durable. Some of the most serious biotic stresses of the cool season food legumes remain as chronic production constraints. These include Aphanomyces root rot of pea, rust and Ascochyta blight of lentil, root rot of chickpea, chocolate spot of faba bean, and Orobanche ssp. that parasitize all of the cool season food legumes.

The use of host plant resistance to control insect pests is almost non-existent; however, resistance to Heliothis and leaf miner of chickpea has been identified and work is underway toward developing resistant cultivars. The control of Bruchus spp. and Sitona spp. through host plant resistance remains as a remote possibility.

Cultivars which are resistant or tolerant to one or more biotic stresses are a critical component of integrated pest management. Decisions as to crop rotations, monitoring of field populations of pathogens or insects, pesticides or biological control agents, tillage, planting dates, method of planting, and other factors can all be critical to reducing the effects of biotic stresses. Successful production of cool season food legumes appears to depend on the creation of cultivars with genetic resistance to one or more pests followed by management decisions designed to delay development of pathotypes or biotypes capable of overcoming the available resistance.

Introduction

The cool season food legumes are often severely damaged by disease and insect pests that individually and collectively reduce yields and crop quality. Biotic stresses have been estimated to be responsible for 5 to 15% yield reductions in the temperate regions and 50 to 100% yield losses in the tropics (Van Emden et al., 1988). Van Emden et al. (1988) listed the biotic stresses affecting the cool season food legumes. In addition, broomrape (Orobanche spp.) has proved to be a debilitating parasite of all cool season food legumes, particularly of faba bean in the Mediterranean region.

Host plant resistance along with suitable crop rotations and other cultural practices offer the most economical, long term, and environmentally acceptable
means of controlling disease and insect pests of the cool season food legumes. Until very recently, nearly the entire world’s crop was produced from plantings of indigenous landraces. Those landraces having evolved in the presence of pathogens, insects, and parasites are able to not only survive but produce valuable products for local populations. Legumes have been and continue to be completely intertwined in farming systems of many developing countries. The replacement of those landraces by homogeneous cultivars can entail a significant loss of genetic variation for resistance to pests. Improved cultivars, usually selected for yield and quality, may not possess the combined resistances already present in the land races they are intended to replace. Fortunately, germplasm collections, which include many landraces, have been established and are being preserved in gene banks. These collections provide breeders with genetic variation not found in available cultivars or enhanced germplasm.

While crop improvement efforts have largely focused on yield and quality, progress is also being made to incorporate disease and pest resistance. Incorporation of resistance to biotic stresses is of high priority to stabilize yields and quality, the lack of which is often cited as a major limitation to more widespread use of grain legumes in farming systems. Breeding for and using host plant resistance to manage biotic stresses in the cool season food legumes and particularly its place in pest management systems is reviewed and discussed.

**Host plant resistance**

Host plant resistance can range from single gene resistance to multigenic resistance (Parlevliet, 1981; Bernier et al., 1988). Numerous examples are available in the cool season food legumes. Resistance to the different races of the Fusarium wilt fungus in pea and chickpea is controlled by single genes. Likewise, resistance to pea enation mosaic and bean leaf roll viruses of pea and pea seedborne mosaic virus of pea and lentil is controlled by single genes in all cases. Resistance to powdery mildew of pea is still unclear but there is general agreement that two recessive genes control resistance. Resistance to Ascochyta blight of chickpea (Cicer arietinum, lentil (Lens culinaris), and pea (Pisum sativum) appears to be under multigenic control. Resistance to Fusarium and Pythium root rot of pea and common root rot of pea (incited by Aphanomyces) is considered to be multigenic. Resistance to aphids and weevils in pea and lentil is incomplete and considered to be multigenic.

Resistance to pests may entail avoidance and/or resistance mechanisms (Parlevliet, 1981). Avoidance such as brought about by glandular hairs on plant surfaces, secretion of volatile repellant compounds that effectively ward off insect pests, or growth out of synchronization with the pest are prime examples (see Clement et al., 1994, this issue), for a more complete treatment of this area). Actual resistance may be in the form of chemical compounds in the host that are either naturally occurring (e.g., pre-formed phenolics in seed) or are induced during contact of the pathogen with the host (e.g., phytoalexins). Generally, resistance is the ability of the host to limit infection and disease spread.

Escape, although not considered resistance per se, can take on many forms in the cool season food legumes. A prime example is the semi-leafless trait of pea with its reduced leaf area and increased tendril number which in turn keeps the plants and canopy more erect, allows more air movement, and thus creates an environment less conducive to foliar fungal pathogens which thrive in humid environments (e.g., Ascochyta, Sclerotinia).

The erect plant habit of chickpea also contributes to foliar disease control, especially Ascochyta blight, by providing greater air movement through the canopy and reducing relative humidity to a range less favorable to the pathogen. As an example, chickpea lines resistant to Ascochyta blight in the Mediterranean region are tall, erect, and late maturing (Singh & Reddy, 1991).

**Major germplasm collections**

Major collections of cool season food legumes are maintained in the USA by the National Plant Germplasm System, at the International Centers in Syria and India, and at facilities of national programs in several countries (Table 1).

Germplasm collections of pea are available from several sources and include accessions which have resistance to important diseases. The Weibullsholm genetic stocks collection maintained by the Nordic Gene Bank at Alnarp, Sweden is the World Pisum germplasm collection as designated by the International Board of Plant Genetic Resources (IBPGR) (Betancourt et al., 1989). This World collection is the work of the late Professor Herbert Lamprecht and more