Chapter 17
Weedy Orobanchaceae: The Problem

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Not many Orobanchaceae species are weedy and parasitize agricultural crops. Nonetheless, they have a tremendous impact on agriculture, as described in Chap. 18. The weedy species damage crops by sucking nutrients or, as in the case of *Striga* spp., also by poisoning the crops and turning them into zombies (see Sect. 7.3). In many geographical areas, they parasitize key agricultural crops, thus negatively affecting human nutrition and leading to heavy economic losses. Their common English names, 'broomrape' and 'witchweed', indicate the impact of and damage done by these parasites to crops. The following chapters specifically present the updated knowledge about these weedy Orobanchaceae and their management.

For far too long, most research efforts to manage these parasitic weeds were per se without truly understanding their biology and physiology. Millions of dollars were spent each year for decades in the USA in trying to eradicate a small infestation of *Striga asiatica*, but less than 1 % went to research on the nature of infestation. Not listening to the ancient incantation 'know your enemy' is like fighting a war without reconnaissance. The parasites seemed far more intelligent and sophisticated than the fighters, as described in detail in the first part of the book (Chaps. 2–16), which presents the various mechanisms of parasitism, the interactions of the parasitic Orobanchaceae with host and non-host plants, and the environmental, genetic and evolutionary mechanisms that may be involved in the parasitic habit.

Before discussing the various means to control the weedy parasites and manage them in agricultural areas, we present three additional basic aspects that need to be considered in any effort to control them. Chapter 18 describes the weedy species and presents a morphological key to their taxonomy, maps of their world

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distribution and a description of their hosts and the damage they cause; Chap. 19 deals with the diversity of their populations and the factors affecting their dispersal and determining the spatial and temporal changes in their diversity, together with discussion of the various molecular methods for diversity analysis, and Chap. 20 suggests means to diagnose the parasite seedbanks in soil.

In the old days, if one wished to know which species exist in the seedbank and how many seeds abide there, one had to take soil samples and use physical methods to separate the tiny seeds from the soil and to separately identify each tiny seed under the microscope. This was complicated and therefore rarely done before planting crops, which led to surprises, e.g. cases in Spain and Israel when beans and tomatoes were attacked by dormant broomrape seeds, forgetting that there had been a heavy infestation in the same fields many years before. Testing for dormant seeds in the soil was not performed, which would have predicted the damage to the ‘new’ bean and tomato crops. Now there are excellent and easier to perform sampling techniques and molecular diagnostic tools for estimating who, what and how many seeds are there before planting a mistake, as outlined in Chap. 20.

Breeding crops resistant to parasitic weeds is believed to be the safest method for parasitic weed control and should be one of the key elements in the management of parasitic weeds. However, this method had first been ‘trial and error’ so that newly developed resistant crop lines broke down soon after their release, overcome by new strains of the parasites. The resistant genes were first only given names, as were the strains that overcame them. That was all that was really known about them until recently. This situation changed when breeders began taking a good look at the resistant lines, classifying the different modes of resistance and tolerance, and localizing the chromosomal positions of different modes of resistance. This allowed the development of physiology-based marker-assisted breeding of some crop lines with more than one mode of resistance, which are more resistant to the parasites and are far more resilient to having the parasites evolve new races that are able to parasitize them, as widely discussed in Chap. 21.

The agronomic management of parasitic weeds, which is a very basic element in any integrated pest management, also became more sophisticated as researchers better understood the ‘enemy’. Far better recommendations to minimize the parasite distribution and its damage could thus be made. None of the agronomic procedures used alone provides complete or even adequate control—they must be integrated with each other, as outlined in Chap. 22, and also with the tools and technologies outlined in the other chapters to further minimize the damage.

Conventional chemical control of parasitic weeds had been problematic; to minimize damage to the crop, the parasites must be killed in the soil long before they emerge. But soil-applied herbicides seemed mostly ineffectual, requiring that the herbicide is sprayed on the crop, which posed another conundrum. Systemic herbicides, which are selective and do not kill the crop, should go from host leaves through its conductive system to the roots and then into the attached parasites. Such herbicides are mostly degraded by the crop before they reach the host–parasite junction. Thus, there can be control only for a short duration after application, necessitating repeated applications, with all the environmental and economic consequences. Low doses of some herbicides that are sublethal to the crop can also be used for parasite control, but accurate low doses are not only hard to achieve; they can also cause crop phytotoxicity and/or require many treatments throughout the season. All these issues and the ways to overcome them, including the use of crops with target-site herbicide resistances, are dealt with in Chap. 23, with a discussion on how phenological phenomena can be used in the crop/parasite systems to predict the best time to apply herbicides.

Biotechnology should bridge some gaps in the ability of conventional methods to control the parasitic weeds. Biotechnologically rendering crops resistant to herbicides, whether transgenically or by mutation or gene conversion, can achieve season-long control without crop phytotoxicity. Transgenic approaches also allow transfer of various parasite-resistant genes to sensitive crops from plant species that are naturally resistant, without need of herbicides. It may be eventually possible to design systemically moving crop-encoded RNAi that will move from the host crops to parasites, targeting and suppressing vital, parasite-specific genes. These and other options of using biotechnology for parasitic weed management are discussed in Chap. 24.

Allelopathy has long been proposed as a method for parasitic weed control, but so far only one known forage crop was found to secrete a promising parasitic plant inhibiting allelochemical, which is currently being field tested against *Striga*. More importantly, the biosynthesis pathway of the allelochemical is being elucidated such that eventually the genes for its biosynthesis can be isolated and be transformed into major crops, eliminating the ‘middle man’. This issue is discussed in Chap. 25.

Biological control of the parasites by seed-eating insects is so far insufficiently effective to be considered as a biocontrol method against any parasitic weed. Nonetheless, microorganisms, especially fungi, can supply a sufficient modicum of control, as described in Chap. 26. Efforts to genetically or transgenically enhance the virulence of these biocontrol agents are believed to lower the costs and increase the benefits of biocontrol (but may be hampered by governmental regulations).

The more we elucidate and understand the basic biological aspects of the parasitic weeds, which are introduced in the first chapters of the book, the more we can come up with novel ideas and integrated strategies for their control. This basic knowledge should open new windows on how to deal with the parasites, including the use of agronomic, physiological, chemical, ecological, genetic and biotechnological tools. In the future, the preferred technologies should be integrated with those that can be put in or on the crop seed, whether bred genes or transgenic genes, or by herbicides or biocontrol agents that can be incorporated on the seed of the susceptible crop. The combination of two or more protection technologies in a single seed should be preferred when possible, in order to prevent escape of even single parasites that evolved resistance to any one methodology. This should allow seed companies to provide the elite seed, for most cost-effective crop yield, that will not only prevent parasitism but also repel or kill the parasites and reduce their productivity and dispersal to a minimum. With such in- and/or on-seed technologies, the farmers may not need other specialized technologies to deal with the parasites nor have the costs of additional inputs.

No useful agricultural weed control practice remains forever and can stand by itself; parasitic weed populations are usually highly polymorphic, and continue to evolve, particularly under the selective pressures in agricultural areas. Thus, it is imperative that growers not become overly enamoured with a single control strategy to the exclusion of others. Sustained parasite control will only prevail through integrating the practices outlined in the following chapters as well as by novel practices that should further be developed in the future.