BURLEIGH DODDS SERIES IN AGRICULTURAL SCIENCE

Achieving sustainable cultivation of soybeans

Volume 2: Diseases, pests, food and other uses

Edited by Professor Henry T. Nguyen
University of Missouri, USA

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Introduction

Soybeans are one of the most widely-grown crops in the world. As the world's main source of vegetable protein, they have a wide range of food and non-food uses. Current yields need to increase significantly to meet growing demand but in a way that reduces input use, does not damage the environment and is resilient to climate change. These challenges are addressed in the two volumes of *Achieving sustainable cultivation of soybeans*:

- Volume 1: Breeding and cultivation techniques
- Volume 2: Diseases, pests, food and other uses

Volume 2 reviews advances in understanding and managing the range of diseases and pests that continue to cause significant crop losses. The volume offers detailed coverage of oomycete, fungal, viral and bacterial diseases affecting soybeans. It reviews developments in disease and pest-resistant varieties of soybean as well as integrated pest and weed management. Finally, the volume summarises research on developing the food and non-food uses of soybean, from improving nutritional properties to uses in animal feed and biodiesel.

Part 1 Diseases, pests and weeds

Soybean losses due to diseases of all kinds are estimated to be about 14% of total soybean production. Part 1 discusses fungal, viral and bacterial diseases as well as developments in disease-resistant varieties and integrated pest and weed management. Chapter 1 provides an overview of oomycete and fungal pathogens of soybean. Soybean production faces numerous biotic challenges, leading to significant yield losses each year. The chapter presents cases studies on the oomycete pathogens *Phytophthora sojae* and the *Pythium* species and the true fungi *Cercospora sojina, Phakopsora pachyrhizi, Macrophomina phaseolina* and the *Fusarium* species. Through these case studies, the chapter emphasizes the diversity of the pathogens which affect soybean, including their genetic diversity, different modes of infection and different host ranges, focusing especially on pathogens that affect roots and foliage. The chapter also considers the diverse range of management options, as well as future trends in research which should improve our ability to manage soybean diseases.

Chapter 2 moves from oomcyte and fungal pathogens to consider bacterial and viral diseases affecting soybean production. The chapter reviews bacterial blight, pustule, tan spot and wilt, as well as a few other bacterial diseases affecting soybean. It then discusses in detail some important viral diseases of soybean, namely alfalfa mosaic virus, bean pod mottle virus, soybean mosaic virus, soybean vein necrosis virus, tobacco ringspot virus, and tobacco streak virus. The chapter also considers how the impact of bacterial and viral pathogens can be mitigated through management practices such as crop rotation, utilization of pathogen-free seed, better use of synthetic and non-synthetic pesticides for vector control, and deployment of resistant cultivars. Chapter 3 considers another important group of soybean pests: nematodes. The chapter examines the origins and management of a variety of parasitic nematodes affecting soybean,

including soybean cyst nematodes, root-knot nematodes, lesion nematodes, reniform nematodes and lance nematodes. The chapter also reviews nematode resistance in soybean.

Complementing the focus of the first three chapters on specific soybean pests, Chapter 4 concentrates on integrated pest management (IPM) for soybean. The chapter includes a detailed case study on the development of an IPM program for an invasive soybean pest (the case of soybean aphid in the US Midwest). The chapter also examines programmes to manage multiple pests in South America and assesses the barriers to achieving sustainable pest management.

Chapter 5 then reviews recent advances in disease-resistant varieties of soybean. Advances in breeding techniques have facilitated the development of soybean cultivars with broader and more durable resistance, but continued reliance on a small number of major resistance genes remains a concern. Introgression of resistance genes from unadapted germplasm sources with a reduced risk of linkage drag has become more efficient with marker-assisted selection. Advances in DNA sequencing and other technologies have made it possible to identify novel resistance loci and candidate genes. The chapter summarizes what is currently known about resistance to some of the major diseases affecting soybean production, particularly in North America, and genes that condition resistance to those diseases. It explores the possibilities of selection for disease resistance, as well as assessing the contribution of soybeans genomics research to breeding strategies. The chapter also examines the genomics of the pathogens themselves, and focuses particularly on disease resistance from *Glycine soja* and perennial *Glycine* species, as well as discussing transgene-mediated disease resistance.

Complementing Chapter 5, Chapter 6 moves on to discuss advances in pest-resistant varieties of soybean. A number of insect pests have been threatening soybean production in North America, including lepidopteran defoliators, coleopteran defoliators and hemipteran sap-suckers. Among various control methods, host-plant resistance has been of the greatest interest as it is economically and environmentally friendly. The chapter reviews recent advances in research on improving soybean with host-plant resistance in North America, and discuss challenges of developing highly insect-resistant cultivars with competitive yield performance. The chapter discusses attempts to genetically engineer soybean with Bt insecticidal protein genes as well as gene pyramiding in order to gain broad and durable resistances against multiple insects. The chapter also includes a case study on key issues in developing aphid-resistant varieties.

Concluding the first part of the volume, Chapter 7 examines the challenge of integrated weed management in soybean cultivation. Almost all soybean fields have a weed infestation that must be managed for farmers to sustain economic viability. The chapter reviews the practicalities of integrated weed management, which combines plant breeding, cultural, mechanical and chemical practices in suppressing weed populations and minimizing the impacts of weeds on yield. After establishing the importance of a diverse weed management strategy, the chapter examines how farmers set goals for weed management and the importance of focusing on managing the weed seed bank. The chapter then reviews the wide range of management tactics available, and considers interactions between weeds and other pests. Finally, the chapter discusses the factors which limit the adoption of integrated weed management.

Part 2 Food and other uses

The second part of the volume addresses food uses of soybean and other non-food uses. Chapter 8 is devoted to the nutritional, nutraceutical and functional properties of soybeans. Soybeans have desirable nutritional properties, since they contain about twice the protein of other legumes per serving. The chapter examines recent research on the nutritional and nutraceutical efficacy of soybean foods and food or dietary supplement ingredients, including soybean oils, proteins, isoflavones and other compounds for which soybeans are a significant source.

Building on the theme of Chapter 8, Chapter 9 focusses on improving the nutritional value of soybean. Soybean is grown for its high oil and protein concentration in the seed. Numerous studies have been carried out to determine the underlying genetics of soybean seed composition traits and develop molecular markers that can aid in the breeding of soybean cultivars with enhanced nutritional quality. The chapter considers genetics and breeding of soybean to improve the nutritional value of the seed as the end product. The chapter describes the protein content and profile of soybean seeds before considering breeding soybean for a modified fatty acids profile that could extend the shelf life of soybean oil or enhance nutritional and nutraceutical function. Finally, the chapter explores how breeding could improve the content of tocopherols, isoflavones and saponins in soybean seeds, which are known to have important health benefits for humans.

Continuing the focus on the use of soybean as a food source, Chapter 10 considers the problem of allergens in soybean. Soybean protein is one of the most significant sources of food allergens and intolerance, causing both IgE-mediated allergy and food protein induced endocolitis syndrome (FPIES). The chapter first discusses the mechanisms causing allergies and infantile food intolerance. It reviews what we know about adverse food responses, the gut's response to food, the multiple IgE binding proteins in soybean as well as P34, the major soybean allergen. The chapter also discusses how to reduce allergens in soybean plants as well as the particular problem of intolerance in salmonids with implications for aquaculture. The chapter also examines the challenge of mitigating soybean allergens, assessing the potential role of biotechnology and the risk of extrinsically-introduced allergens.

The volume's final chapter, Chapter 11, moves to considering soybean as a source of animal feed, addressing the nutritional considerations for soybean meal use in poultry diets. The poultry feed industry uses about 50% of the soybean meal (SBM) produced in the USA each year. The meal is valuable to the animal feed industry because it is an excellent source of amino acids that would otherwise be lost to the human food chain after the oil has been removed from the bean. The chapter assesses the nutritional content of SBM, as well as its anti-nutritive compounds, and considers the effects of genetic modification on improving SBM as a poultry feed.

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