Lentil

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An Ancient Crop for Modern Times

Edited by

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FOREWORD

On behalf of the United States Department of Agriculture, I am pleased to introduce the book *Lentil: An Ancient Crop for Modern Times*. The articles and essays in this volume, submitted by nearly 100 researchers, educators, and other experts, contain comprehensive information on a variety of topics of significance for lentil growers, researchers, and consumers worldwide.

Cultivated lentils (*Lens culinars*), an annual legume crop, have been grown as an important food source for over 8,000 years. They come in two main varieties: macrosperma (with large seeds and little pigmentation), and microsperma (with small seeds and some pigmentation). Depending on their variety and breed, however, lentil seeds can range in color from red-orange, to yellow, green, brown, or black. They are cultivated and consumed throughout the world, with Canada, Turkey and India being the top producers.

Although the production of lentils and other pulse legume crops lags far behind cereal production in most nations, including the United States, production remains highly important because of its benefits for producers and consumers alike. Lentil seeds provide high levels of protein and, when consumed in combination with cereals, they provide adequate amounts of essential amino acids for the human diet. Their relatively short cooking time provides an additional advantage. Lentil production is equally beneficial for producers, as lentils have a high tolerance for extreme environmental conditions such as drought and hot temperatures, and can be grown in semiarid regions without irrigation. Moreover, the crop can be grown in rotation with cereal crops to reduce soil erosion, improve disease and weed control, and reduce demand for nitrogen fertilizers. Beyond their longstanding food and agronomic attributes, there is increasing interest in using lentils as a biomass energy crop and for other industrial non-food uses.

USDA scientists are among many participants in a global effort to enhance lentil quality and promote its growth as a crop. The Agricultural Research Service partners with university researchers and other cooperators worldwide to improve crop disease resistance, develop effective insect and weed control practices, and identify other effective crop production strategies for lentils. This effort also includes international-scale lentil breeding and improvement programs to collect, introduce, maintain, and exchange germplasm. These programs are essential for improving lentils' genetic diversity, which, in turn, is important for increasing the yield and crop quality of the legume as well as for limiting the impact that diseases, weeds,

and insect pests have on lentil crops. Although lentils tend to suffer less from disease than do other legume crops, they are still impacted by root rots and wilts, rusts, blights, and viruses. Lentils are also susceptible to damage from weeds, which can reduce yields by up to 75 percent, as well as from aphids, beetles, maggots, wireworms, grasshoppers, and other insects. Ongoing efforts to develop improved technologies to manage these threats as well as to enhance the end-use attributes of lentils for food, nutrition, and industrial uses will be critical to ensuring the long-term sustainability of these crops.

Lentil, edited by Shyam S. Yadav, David McNeil, and Philip C. Stevenson, provides a valuable overview of the history and background behind lentils as well as a detailed analysis of the research that has been conducted on lentil breeding and production strategies. As such, it will be useful to breeders, producers, researchers, educators, nutritionists, and anyone interested in obtaining an insight into the world of lentils.

Edward B. Knipling
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ABOUT THE EDITORS

Dr. Shyam Singh Yadav

Shyam Singh Yadav is a principal legume breeder at Division of Genetics, Indian Agricultural Research Institute, New Delhi, India. He received his B Sc degree in agricultural sciences from University of Agra, UP, his M Sc degree in plant breeding from University of Meerut, UP, before completing his PhD in Genetics & Plant Breeding from the Indian Agricultural Research Institute, New Delhi, India in 1986. During his PhD research program he worked on the genetic & physiological basis of plant architecture of chickpea (*Cicer arietinum* L.) He started his scientific journey as assistant wheat breeder in January 1969 at the Division of Genetics, Indian Agricultural Research Institute (IARI) New Delhi, India. Since then he has worked on various breeding positions in India and abroad till April 2007. As Principal Legume Breeder he used different breeding options/approaches for genetic enhancement, varietal development, germplasm enrichment and participatory breeding etc. More than 20 high yielding, widely adapted multiple resistant chickpea varieties were released for commercial cultivation in different eco-geographical under his leadership. He has also developed excellent germplasm lines and distributed to many international legume breeders around the world. These lines are being utilized in many countries by legume breeders. Along with this, he worked on the development of integrated crop production and management technologies and its dissemination and popularization in farmers fields. Professional collaborations were also developed under his leadership with international organizations like ACIAR, Australia, USDA, ICRISAT, ICARDA etc. during this period. The post graduate school at IARI, New Delhi provides Graduate and Doctoral research programs to national and international students. During the last 30 years, Yadav has been a faculty member at post graduate school of IARI and taught various professional courses in Genetics and Plant Breeding at Graduate and Doctoral level. He has published more than 125 research papers in national and international journals and written 10 book chapters for international books. In March 2007, a book on chickpea breeding and management was published by CABI, UK for which Yadav was senior editor.

Prof. David Leslie McNeil

David McNeil started his career in agricultural science in 1971 as a trainee crop physiologist with the New South Wales (NSW) Department of Agriculture followed

by PhD on lupin physiology at the University of Western Australia. Since then he has swung between Departments of Agriculture and Universities with a strong involvement in pulse and grain legume crop research, development and extension. A key area of effort has been to expand scientific understanding of new crops and develop new productive, viable and sustainable industries around these new crops with pulses as a major area of effort. He has published well over 100 scientific papers as well as a similar number of extension publications. Professor McNeil's research publications have covered a wide range; from molecular mapping, GM, mutation and traditional breeding through crop/plant agronomy and physiology to market testing and consumer evaluation of new crops. David McNeil's work with legumes has included a period with NifTAL in Hawaii promoting N fixation world wide, including consulting for the UNEP program on N fixation. He has also developed super nodulation in soybeans as well as led major Australian breeding programs for a range of temperate pulses including lentils. Professor McNeil's career has included acting as researcher, lecturer, program manager and extension expert based at locations in the USA, New Zealand and Australia, usually with goals spanning both developing and developed country agricultural systems. Professor McNeil has worked at the Boyce Thompson Institute at Cornell, the University of Hawaii, the Australian National University, the WA Department of Agriculture, Lincoln University in New Zealand, the Victorian Department of Primary Industries, with the University of Melbourne in the Joint Centre for Crop Innovation. Presently he occupies the Chair of Agricultural Sciences in the School of Agricultural Science at the University of Tasmania. This school incorporates the Tasmanian Institute of Agricultural Sciences and as such is the predominant source of research in Tasmania for horticulture, dairy, vegetable, cropping and food safety. Professor McNeil's commitment to linking research and industry development continues with a strong interest in retaining pulses as a major component of a total cropping system particularly in high rainfall zone cropping. His interest in other areas of plant physiology, breeding and agronomic research continue including attempts to use biotechnological approaches in lentil, pea and chickpea breeding. Thus from his present position Professor McNeil continues his interest in combining detailed science with industry development of pulse, horticultural and other new crops in the Tasmanian, Australian and global environment.

Dr. Philip. C. Stevenson

Phil Stevenson is a Reader in Plant Chemistry at the Natural Resources Institute (NRI), University of Greenwich, UK, and holds a joint position between NRI and the Jodrell Laboratory at the Royal Botanic Gardens, Kew, UK. He received his B.Sc degree in Applied Biology from Brunel University of West London, before completing his PhD at University of London in 1992. During his PhD he worked on the chemical basis of resistance in wild species of groundnut (*Arachis* spp.) to the tobacco armyworm (*Spodoptera litura*) and so began a transformation from plant biologist to plant chemist. The compounds identified during this work were demonstrated to inhibit development of *S. litura* larvae and have subsequently been

used as markers for breeding resistant groundnut cultivars in India. His interest in natural resistance in crop plants continued into his postdoctoral work at NRI when he studied Fusarium wilt and Botrytis grey mould of chickpea (*Cicer arietinum*) and extended this to other non-cultivated (wild) species of *Cicer*. He has also studied the chemistry of resistance in wild and cultivated pigeon pea and chickpeas to the pod borer (*Helicoverpa armigera*) and in *Cedrela odorata* to leaf weevils (*Exophthalmus* spp.). Much of this work has been in collaboration with the ICRISAT, India. He is working presently on the biological activity of pesticidal plants against storage insect pests developing ways to optimise their use, collection and even cultivation. He is also exploring resistance on Sweet potato (*Ipomoea batatas*) to sweetpotato weevils (*Cylas* spp). Phil has now published over 50 peer reviewed papers and book chapters on this work and other aspects of natural product chemistry and the role of plant compounds in biological systems, agriculture and medicine. He is a member of the Editorial Board of *Crop Protection*; the official journal of the International Association of Plant Protection Services.

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PREFACE

Lentils are believed to have originated and been consumed since pre-historic times. They are one of the first crops to have been cultivated. Lentil seeds dating back 8,000 years have been found at archeological sites in the Middle East. Lentils were mentioned in the Bible, both as the item that Jacob traded to Esau for his birthright and as a part of bread that was made during the Babylonian captivity of the Jewish people. In the modern and technologically advanced world, they are under cultivation in more than 35 countries of 5 different continents. It is this ancient origin and modern diversity that makes lentil an "ancient crop for modern times".

Lentils are an important cool season food legume. Traditionally they are a low input crop grown extensively for subsistence or local consumption in rainfed agro-ecosystems. However, in the last 20 years they have also increasingly been grown in extensive, export oriented, production systems in north America. The increasing world interest in legumes has stimulated the need to document what is known about them in order to develop efficient agronomic production systems and breed widely adapted multiple resistant cultivars for wider ecologies. This book provides a comprehensive review of current constraints, achievements and future prospects for lentil crop improvement, production, protection and management technologies. The chapters, each written by specialists help teachers, scientists, students, extension workers, farmers, consumers, traders and administrators in increasing their understanding of the lentil crop.

This book on lentil comprises 23 chapters. Chapters 1–6 present the history, origin, biodiversity, ecology, consumption pattern, nutritional value along with geographic distribution and world trade. Chapters 7–11 explain the role of lentils in the cropping system, rhizobium management and nitrogen fixation, nutrient, weed, irrigation management and profitability in cultivation. Chapters 12–17 explain genetics, cytogenetics, mutation breeding, wild relatives, breeding methods, varietal adaptation and new plant type, genomics and molecular approaches and quality seed production. Chapters 20–23 highlight biotic and abiotic stresses, insect-pest management, post harvest management and lentil growers around the world.

In the modern world knowledge tends to be interdisciplinary and global and lentil systems are no exception. Therefore, most chapters have involved collaboration of 3 or more diverse international authors. Thus the book represents a truly global perspective consistent with the nature of world production, trade and consumption. The book also stress the interactions that have arisen globally for

lentil technologies for international marketing, breeding, production and protection approaches, domestic consumption and economic issues arising internationally. This book offers the latest reviews of lentil technologies and publications as well as presenting new findings direct from leading researchers for use by researchers, professionals, technologists, economists, students, traders, consumers and growers. We are certain you will find it both a timely, interesting and valuable addition to the literature on an extraordinary crop.

Shyam S. Yadav
David Mc Neil
Philip C. Stevenson

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GENERAL NOTE

References to any chemical control products, uses and operations in this book should not be considered an endorsement of their use in areas for which they have not been approved. Their incorporation here is to provide information on research that has been carried out and not to propose their use where not registered.