No-tillage Seeding in Conservation Agriculture

2nd Edition

C. J. Baker, K. E. Saxton, W. R. Ritchie, W. C. T. Chamen,
D. C. Reicosky, F. Ribeiro, S. E. Justice and P. R. Hobbs

Food and Agriculture Organization of the United Nations

www.cabi.org

No-tillage Seeding in Conservation Agriculture

Second Edition

This book is dedicated to the scientists and students whose work is reviewed, together with their long-suffering families. Such people were driven by a desire to make no-tillage as sustainable and risk-free as possible, and in the process to make food production itself sustainable for the first time in history. The odds were great but the results have been significant and will have far-reaching consequences.

No-tillage Seeding in Conservation Agriculture

Second Edition

C.J. Baker, K.E. Saxton, W.R. Ritchie, W.C.T. Chamen, D.C. Reicosky, M.F.S. Ribeiro, S.E. Justice and P.R. Hobbs

Edited by

C.J. Baker and K.E. Saxton

Published by
Food and Agriculture Organization of the United Nations

CABI is a trading name of CAB International

CABI Head Office
Nosworthy Way
Wallingford
Oxfordshire OX10 8DE
UK

Tel: +44 (0)1491 832111
Fax: +44 (0)1491 833508
E-mail: cabi@cabi.org
Website: www.cabi.org

CABI North American Office
875 Massachusetts Avenue
7th Floor
Cambridge, MA 02139
USA

Tel: +1 617 395 4056
Fax: +1 617 354 6875
E-mail: cabi-nao@cabi.org

© FAO and CAB International 2007. All rights reserved. No part of this publication may be reproduced in any form or by any means, electronically, mechanically, by photocopying, recording or otherwise, without the prior permission of the copyright owners.

A catalogue record for this book is available from the British Library, London, UK.

Library of Congress Cataloging-in-Publication Data

No-tillage seeding in conservation agriculture/C.J. Baker . . . [et al.] edited by C.J. Baker and K.E. Saxton.-- 2nd ed.
p. cm.
Rev. ed. of: No-tillage seeding/C.J. Baker. 1996.
Includes bibliographical references and index.
ISBN 1-84593-116-5 (alk. paper)
1. No-tillage. I. Baker, C.J. (C. John) II. Saxton, Keith E., 1937- III. Baker, C.J. (C. John). No-tillage seeding. IV. Food and Agriculture Organization of the United Nations. V. Title.

S604.B36 2006
631.5′31--dc22

2005035401

Published jointly by CAB International and FAO.
Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla, 00100 Rome, Italy
Website: www.fao.org

ISBN-10: 1-84593-116-5 (CABI)
ISBN-13: 978-1-84593-116-2 (CABI)
ISBN: 92-5-105389-8 (FAO)

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The designations ‘developed’ and ‘developing’ economies are intended for statistical convenience and do not necessarily express a judgement about the stage reached by a particular country, territory or area in the development process.

The views expressed herein are those of the authors and do not necessarily represent those of the Food and Agriculture Organization of the United Nations.

All rights reserved. Reproduction and dissemination of material in this information product for educational or other non-commercial purposes are authorized without any prior written permission from the copyright holders provided the source is fully acknowledged. Reproduction of material in this information product for resale or other commercial purposes is prohibited without written permission of the copyright holder. Applications for such permission should be addressed to the Chief, Publishing Management Service, Information Division, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy or by email to copyright@fao.org.

Typeset by AMA DataSet Ltd, Preston, UK.
Printed and bound in the UK by Cromwell Press, Trowbridge.

Contents

Contributors

C.J. Baker, *Centre for International No-tillage Research and Engineering (CINTRE), Feilding, New Zealand*
W.C.T. Chamen, *4Ceasons Agriculture and Environment, Maulden, Bedfordshire, UK*
P.R. Hobbs, *Department of Crops and Soil Science, Cornell University, Ithaca, New York, USA*
S.E. Justice, *National Agriculture and Environment Forum (NAEF), Kathmandu, Nepal*
D.C. Reicosky, *United States Department of Agriculture, Agricultural Research Service, Morris, Minnesota, USA*
M.F.S. Ribeiro, *Instituto Agronômico do Paraná (IAPAR), Ponta Grossa, Parana, Brazil*
W.R. Ritchie, *Centre for International No-tillage Research and Engineering (CINTRE), Feilding, New Zealand*
K.E. Saxton, *Retired, formerly United States Department of Agriculture, Agricultural Research Service, Pullman, Washington, USA*

Foreword to the Second Edition

The Food and Agriculture Organization (FAO) has a history of supporting the development and extension of conservation agriculture cropping systems. No-tillage seeding is one of the key operations of conservation agriculture; no-till seeding, together with the principles of cover crops and crop rotation, constitute conservation agriculture. The availability of suitable technology and equipment is a necessary precondition for making conservation agriculture work. Special equipment is required not only for direct seeding and planting, but also for the management of crop residues and cover crops.

The earlier book, entitled *No-tillage Seeding: Science and Practice*, by Baker, Saxton and Ritchie, was, at the time of its publication, one of the most comprehensive publications covering the engineering aspects of no-tillage seeding as well as the agronomic and environmental background for no-tillage farming. It has been valuable as a reference for scientists and students, and also as a guide for practitioners. A case was reported where a farmer after reading this book bought a no-till planter and converted his farm to no-till.

This new book, *No-tillage Seeding in Conservation Agriculture*, provides a broader picture of the equipment used in conservation agriculture cropping systems. It includes chapters on material not previously covered, for example, the management of crop residues and cover crops, preparation for the no-tillage seeding operation, and controlled-traffic farming as a complementary technology. There are also new chapters describing no-tillage seeding technologies for small-scale farmers. Technology developments from South America and South Asia are described, including manual equipment, draught-animal equipment and equipment for power tillers. The subject of greenhouse gases as driving forces for climate change is also discussed in a chapter on carbon sequestration under no-tillage farming systems.

We hope that this book contributes to a better understanding of the engineering components of conservation agriculture. It is also our wish that it helps with the introduction and expanded application of this technology. Conservation agriculture is a valuable approach to cropping that can lead to more productive, competitive and sustainable agricultural systems with parallel benefits to the environment and to farmers and their families.

Shivaji Pandey
Director
Theodor Friedrich
Senior Agricultural Engineer
Agricultural Support Systems Division
FAO
Rome, November 2005

Preface

And he gave for his opinion, that whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together.

Jonathan Swift, *Gulliver's Travels* (1726)
'A Voyage to Brobdingnag'

The authors of this book describe and analyse no-tillage technologies, particularly those related to no-tillage seed drilling, from a variety of accumulated experiences over the past 40 years. Most of us set out to discover why no-tillage did not always work and how to overcome these obstacles. The more we learned the more appealing no-tillage farming became. The understanding and system science have now been acquired and tested to the point where we are ever more confident it represents the future of farming.

Some of the reported research started from knowledge that none of the traditional drills, planters or opener technologies used for tillage farming then provided a fail-safe methodology for untilled, residue-covered soils. Inevitably that resulted in new machine designs and evaluations, and combined associated technologies. The guiding premise was that every functional part of any new design had to have a verifiable scientific reason and performance, which often resulted in a long evolution.

No functional assumptions were made. All commonly held ideas about what seeds required were challenged or discarded and new experiments set up to determine their requirements specifically in untilled soils. This new knowledge was combined with whatever existing knowledge proved still to be applicable. In other cases the rules for tilled soils simply did not apply, or were proved wrong, when applied to untilled soils. Undisturbed soils were found to provide different resources and challenges from those of tilled soils, thus requiring different approaches to seed sowing.

Other authors report what happened to soil when ploughing ceases. Everyone by now knows that no-tillage is good and ploughing is bad for the soil, but what are the causal mechanisms and can the improvements or damage be quantified? Can the gains be further improved by techniques such as controlled-traffic farming? Still other authors studied available equipment and management methods and relate these to no-tillage systems and

applications, large and small. Only when the capabilities of modern no-tillage equipment are understood and fully integrated into a crop production enterprise can it be fully quantified and realistic local recommendations made.

Collectively these authors have provided a comprehensive overview of what makes a successful no-tillage enterprise work. This includes machinery design and operating principles, the interactions of machines with the soil, the importance of parallel inputs, such as herbicides, pesticides and controlled traffic, and the management of the system as a whole, including quantifying the importance of soil carbon and tracking carbon dioxide emissions as a function of soil disturbance. They have also provided a guide to experimental procedures for evaluation of variables.

The book is not intended to be a blueprint on how to design any one style of no-tillage machine, component or system. It is a record of the comparative performances of several different machine design options and management practices, tested under controlled scientific conditions, and how these have been found to integrate into a whole no-tillage system. Much of the information is about the biological performance of machines and soils, since both primarily perform biological functions. But mechanical performance is not ignored either. The interface between the two is particularly important.

The reader is invited to place his or her own value on the relevance of the data presented. The relevance some of the authors placed on the data led to the design of the disc version of a winged opener, called Cross Slot®. Others will see different things in the data. However, independent research and field experience have increasingly shown that the data and the conclusions drawn from them have been remarkably accurate and prophetic.

The relevance of the book is that it illustrates that there are now ways and means to make no-tillage more fail-safe than tillage and to obtain crop yields not only equal to those from tillage but, in many cases, superior. Untilled soils contain greater potential to germinate, establish and grow plants than tilled soils ever did. And, of course, they are much more environmentally friendly. The problem for humankind has been to learn and understand how to harness that potential. We hope this book goes some way towards achieving that objective.

The book expands on the first edition, entitled *No-tillage Seeding: Science and Practice* (Baker, Saxton and Ritchie, ISBN 0 85199 103 3, first published by CAB International in 1996 and reprinted in 2002).