Resource Conserving Techniques in Crop Production

RESOURCE CONSERVING TECHNIQUES IN CROP PRODUCTION

Editors

A.R. Sharma
U.K. Behera

Published by
SCIENTIFIC PUBLISHERS (INDIA)

Jodhpur –

5 A, New Pali Road
P.O. Box 91
Jodhpur - 342 001 INDIA

Delhi –

4806/24, Ansari Road
Daryaganj
New Delhi - 110 002 INDIA

Print: 2017

ISBN: 978-81-7233-704-9

Visit the Scientific Publishers (India) website at
http://www.scientificpub.com

Printed in India

FOREWORD

Resource degradation problems are manifesting in several ways. Declining water tables in many agriculturally important regions imply increasing pumping costs, replacement of shallow gravity tubewells with submersible pumps at huge cost, adverse effects on water quality and overall ecology of the region. Similarly, declining soil carbon and fertility are reflecting in loss of biodiversity, multiple nutrient deficiencies, increasing input use to maintain yields, and implications for quality of produce and environment. Inefficient input use and management practices are leading to widespread contamination of surface and groundwater with connected health hazards.

Major research and development efforts in the green-revolution era focused on enhancing productivity of selected foodgrain crops. In the post-green revolution era, the issues of conservation have assumed greater importance in view of widespread resource degradation problems and the need to reduce production costs, and make farming more profitable and competitive. The new challenges demand efficient resource use, and conservation agriculture systems should receive high priority to ensure that earlier gains are sustained and further enhanced to meet the emerging needs.

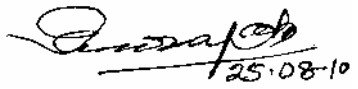
Conservation agriculture technologies involve minimum soil disturbance, providing a soil cover through crop residues or other cover crops, and dynamic crop rotations. These technologies lead to sustainable improvements in the efficient use of water and nutrients by improving nutrient balance and availability, infiltration and retention by soils, reducing water losses due to evaporation, and improving the quality and availability of ground and surface water. Global warming has become an issue of serious concern nowadays. It is widely recognized that conservation agriculture can go a long way in combating emission of greenhouse gases and mitigating climate change.

In India, efforts to adopt and promote resource conserving technologies have been underway for nearly two decades and the technologies are now finding acceptance by the farmers. The focus of developing and promoting conservation technologies has been on zero-

till seed-cum-fertilizer drill for sowing of wheat in rice-wheat system. In addition, raised-bed planting and laser land leveling are also being increasingly adopted by the farmers of the north-western region.

Resource conservation practices have a long-term and broader perspective, which go beyond yield improvement. Zero tillage and surface maintained crop residues result in resource improvement only gradually and benefits come about only with time. In many situations, the benefits in terms of yield enhancement may not come about in early years. Thus, there is a need to understand long-term system interactions and develop management strategies involving teams of scientists across disciplines working together.

It is indeed a matter of immense satisfaction that the available information on resource conserving technologies has been compiled in the form of a book, which will be very useful for all those working on resource management in the country. I find that the book is appropriately divided into different sections, and each section includes chapters by eminent scientists who have made significant contributions in this area. Dr. A.R. Sharma and Dr. U.K. Behera have done a commendable job in compiling the available information and presenting it in an easily understandable manner. I congratulate both of them as well as various authors who have contributed for this book.



(I.C. Mahapatra)
Former Vice Chancellor,
OUAT, Bhubaneswar & BAU, Ranchi
Managing Director
Agro-Consultancy Services

PREFACE

Fertilizer, water, energy and other agro-chemicals including herbicides are the essential inputs in modern day intensive cropping systems for increasing productivity. Indiscriminate and injudicious use of these monetary inputs for achieving potential yield of crops has not only enhanced the cost of cropping but also threatened the environment. Major research and development efforts in the green revolution era focused on enhancing productivity of selected foodgrains and a few other crops. In the post-green revolution era, the issues of resource conservation have assumed greater importance in view of stagnating productivity, increasing production costs, and widespread resource degradation problems, such as deteriorating soil health, declining water table and increasing environmental pollution. Of late, resource conservation systems have drawn the attention of Agronomists and other crop production scientists to devise modified tillage and crop establishment techniques for higher productivity and improving input-use efficiency. Innovative approaches are also being worked out to supplement nutrient needs and provide other benefits like moisture conservation, weed control, erosion control etc.

Input-use efficiency depends on several factors including tillage and crop establishment practices. Most studies in India during 1970s and 1980s focused on comparison of conventional tillage and deep tillage. In most of these studies, it was reported that deep tillage was invariably superior to conventional tillage for obtaining higher yields. However, actual adoption of deep tillage practices on farmers' fields was meager because of higher energy and heavy machinery requirements. In the 1990s when issues relating to stagnating yields, declining factor productivity, increased use of chemical fertilizers and resultant pollution hazards, deterioration in soil health, emergence of multiple nutrient deficiencies, lowering of groundwater table, weeds and their resistance to commonly-used herbicides, produce quality etc. cropped up, emphasis was given on development of resource conserving techniques.

Conservation agricultural systems employing resource conserving techniques particularly zero or minimum tillage, residue management and cover crops, and innovative cropping systems have been adopted

on nearly 100 million ha worldwide. Adoption of these technologies has led to efficient resource conservation, improvement in crop productivity ad soil health, and environmental benefits, such as mitigation of greenhouse gases and global warming. Such systems are being advocated for resource-poor farmers of South-Asia, and major strides have been made in rice–wheat cropping system of the Indo-Gangetic plains including north-western plain zone of India over the last one decade. The acreage under zero-till sowing of wheat has been increasing consistently, leading to considerable saving of money, water, time, energy and other resources.

Recent researches on resource conserving techniques have provided exciting opportunities for improving input-use-efficiency, productivity and sustainability. These techniques include: zero tillage, minimum tillage, rotary tillage, bed planting, surface seeding, laser land leveling, pressurized irrigation systems, system of rice intensification, aerobic rice, soil solarization, residue management, site-specific nutrient management, crop diversification, precision farming employing use of modern tools and procedures etc. Adoption of these techniques is the need of the hour as a method of 'low-input agriculture' to reduce costs and achieve sustainability in Indian agriculture.

This book provides the most updated and comprehensive information on resource conserving techniques for improving crop productivity. The text is divided into 9 sections: (i) Concept and approaches, (ii) Cropping systems and diversification, (iii) Soil use and management, (iv) Improving nutrient-use efficiency, (v) Water-saving techniques, (vi) Weed dynamics and herbicide use, (vii) Energy conservation and farm machinery, (viii) Modern tools and approaches, and (ix) On-farm testing and evaluation. In each section, there are chapters on specific topics, contributed by eminent scientists, who have made notable research contributions in their field of specialization. The chapters have been thoroughly edited and presented in an easily understandable manner.

We are highly grateful to all the contributors who responded to our invitation to compile the available information on “Resource Conserving Techniques in Crop Production”. It is hoped that this information will be useful to all those associated with conservation agriculture in the country.

Dated: 25 July, 2010 **Editors**
Place: New Delhi

CONTRUBUTORS

Dr. A. Sarangi, Senior Scientist, Water Technology Center, Indian Agricultural Research Institute, New Delhi 110 012

Dr. A.P. Srivastava, National Co-ordinator (NAIP), Indian Council of Agricultural Research, New Delhi 110 012

Dr. A.R. Sharma, Professor, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012 (Email: sharma.ar@rediffmail.com)

Dr. A.S. Sidhu, Director, Indian Institute of Horticultural Research, Hessarghata, Bangalore, Karnataka (Email: amrik_sidhu1@rediffmail.com)

Dr. Anand Swarup, Head, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 110 012 (Email: anandswarup1950@yahoo.co.in; swarup.iari@gmail.com)

Dr. Ashok K. Patra, Principal Scientist, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 110 012 (Email: patraak@gmail.com)

Dr. B.B. Pattanaik, Chairman-cum-Managing Director, National Seeds Corporation, Beej Bhawan, Pusa Complex, New Delhi 110 012

Dr. C.L. Acharya, Former Director, Extension Education, CSK HPKV, Palampur, Himachal Pradesh 176 062; and Former Director, Indian Institute of Soil Science (ICAR), Bhopal, Madhya Pradesh (Email: cl_acharya@yahoo.co.in)

Dr. D. Chakraborty, Senior Scientist, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. D.M. Hegde, Project Director, Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500030 (Email: dmhegde@rediffmail.com; director@dor-icar.org.in)

Dr. D.S. Rana, Principal Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

Dr. Dinesh Kumar, Senior Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012 (Email: dineshctt@yahoo.com)

Dr. H. Pathak, Associate Research Scientist, International Rice Research Institute, India-Office, NASC Complex, DP Shastri Marg, Pusa, New Delhi 110 012 (Email: hpathak@cgiar.org)

Dr. I.C. Mahapatra, Former Vice-Chancellor, BAU, Ranchi, Jharkhand 834 006 and OUAT, Bhubaneswar, Orissa 751 003

Dr. J.K. Ladha, International Rice Research Instt., India-Office, NASC Complex, DP Shastri Marg, Pusa, New Delhi 110012 (Email: j.k.ladha@cgiar.org)

Dr. K.P. Singh, Principal Scientist, Directorate of Maize Research, Pusa Campus, New Delhi 110 012

Dr. M.L, Jat, Senior Scientist, Directorate of Maize Research, Pusa Campus, New Delhi 110 012

Dr. Mahesh Gathala, International Rice Research Institute, India-Office, NASC Complex, Pusa New Delhi 110 012

Dr. Man Singh, Principal Scientist, Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012 (Email: mansingh@iari.res.in)

Dr. Manoj Khanna, Principal Scientist, Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012

Dr. N.T. Yaduraju, National Coordinator, National Agricultural Innovation Project, ICAR, Krishi Anusandhan Bhawan II, New Delhi 110 012 (Email: ntyaduraju@icar.org.in)

Dr. Naveen Kalra, Head, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. P.K. Ghosh, Principal Scientist, ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103

Dr. P.K. Sahoo, Senior Scientist, Division of Agricultural Engineering, Indian Agricultural Research Institute, New Delhi 110 012

Dr. P.S. Minhas, Director of Research, Punjab Agricultural University, Ludhiana, Punjab 141 004 (Email: minhas_54@yahoo.co.in; drpau@pau.edu)

Dr. Rajendra Prasad, INSA Senior Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi

Dr. R.K. Rattan, Professor, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 110 012

Dr. R.K. Sharma, Principal Scientist, Directorate of Wheat Research, Karnal, Haryana 132 001

Dr. R.K. Tomar, Principal Scientist, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. R.L. Yadav, Director, Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh 226 002 (Email: iisrlko@sancharnet.in)

Dr. R.N. Garg, Principal Scientist, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. R.N. Sahoo, Senior Scientist, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. R.R. Sharma, Senior Scientist, Division of Post-Harvest Technology, Indian Agricultural Research Institute, New Delhi 110 012

Dr. S.K. Dubey, Head, Regional Centre, Central Soil and Water Conservation Research and Training Institute, Chhalesar, Agra, Uttar Pradesh

Dr. S.K. Sharma, Ex-Project Director, Project Directorate of Cropping Systems Research, Modipuram, Meerut, Uttar Pradesh

Dr. S.K. Shukla, Senior Scientist, Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh 226 002

Dr. S.N. Sudhakara Babu, Principal Scientist, Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500 030

Dr. S.P. Datta, Senior Scientist, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 110 012

Dr. Sain Dass, Project Director, Directorate of Maize Research, Pusa Campus, New Delhi 110 012

Dr. Shiv Kumar, Principal Scientist, Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. Subedar Singh, Emeritus Scientist, Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012

Dr. Suraj Bhan, Ex. Additional Commissioner, Ministry of Agriculture, Govt. of India, New Delhi

Dr. T.B.S. Rajput, Principal Scientist, Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012

Dr. T.K. Das, Senior Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi (Email: tkdas8@yahoo.com)

Dr. U.K. Behera, Senior Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

Dr. V.K. Gupta, Senior Scientist, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi 110 012

Dr. Y.S. Saharawat, International Rice Research Institute, India – Office, NASC Complex, Pusa, New Delhi 110 012

Dr. Y.S. Shivay, Senior Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012 (Email: ysshivay@hotmail.com)

Dr. Yadvinder Singh, Professor and Head, Department of Soils, Punjab Agricultural University, Ludhiana, Punjab 141 004 (Email: yadvinder16@rediffmail.com)

CONTENTS

Foreword *v*

Preface *vii*

Contributors *ix*

I. CONCEPT AND APPROACHES

1 Resource Conserving Techniques for Improving Input-Use Efficiency and Crop Productivity
— A.R. SHARMA AND U.K. BEHERA 1

2 Conservation Agriculture – Problems and Prospects in Indian Context
— SURAJ BHAN 16

3 Resource Conserving Technologies in Hill Farming Systems
— C.L. ACHARYA 24

4 Biodiversity for Soil Health and Efficient Resource Utilization
— ASHOK K. PATRA 39

5 Quality Seed for Agricultural Prosperity
— B.B. PATTANAIK 52

II. CROPPING SYSTEMS AND DIVERSIFICATION

6 Resource Conserving Technologies for Sustainability of Rice–Wheat System
— R.K. SHARMA 61

7 Resource Management in Maize-based Cropping System
— SAIN DASS, M.L. JAT AND K.P. SINGH 74

8 Resource Conserving Techniques in Sugarcane-based Cropping System
— R.L. YADAV AND S.K. SHUKLA 87

9 Resource Conservation and Management for Sustainable Oilseed Production
— D.M. HEGDE AND S.N. SUDHAKARA BABU 97

10 Sustainability of Small Farm Diversification with Reference to Eastern India
— I.C. MAHAPATRA
— 108

11 Resource Conserving Techniques in Fruit Crops
— R.R. SHARMA 124

12 Diversification through Vegetable Cultivation
— A.S. SIDHU 141

III. SOIL USE AND MANAGEMENT

13 Carbon Sequestration and Agricultural Production in India
— R.K. RATTAN AND S.P. DATTA 155

14 Crop Residue Management for Improving Soil and Crop Productivity
— YADVINDER-SINGH 166

15 Resource Conserving Technologies and Soil Physical Environment
— R.K. TOMAR, R.N. SAHOO, R.N. GARG, V.K. GUPTA, D. CHAKRABORTY AND NAVEEN KALRA 190

IV. IMPROVING NUTRIENT-USE EFFICIENCY

16 Options for Improving Nitrogen Use Efficiency
— H. PATHAK AND J.K. LADHA 209

17 Strategies for Efficient NPK Management
— RAJENDRA PRASAD 225

18 Site-Specific Nutrient Management for Sustained Higher Productivity
— S.K. SHARMA 230

19 Resource Conserving Techniques for Improving Nutrient-Use Efficiency
— Y.S. SHIVAY 243

20 Nutrient Management for Sustaining Crop Production in Salt-affected Soils
— ANAND SWARUP 251

21 Deficiency and Management of Micronutrients for Sustainable Crop Production
— S.P. DATTA AND R.K. RATTAN 260

V. WATER SAVING TECHNOLOGIES

22 Rainwater Harvesting in Hill Farming
— P.K. GHOSH 279

23 Irrigation Scheduling to Crops under Adequate and Limited Water Supplies
— SUBEDAR SINGH 295

24 System of Rice Intensification for Enhancing Rice Yield and Water Economy
— DINESH KUMAR 304

25 Sustainable Use of Saline and Alkali Waters for Irrigation
— P.S. MINHAS 313

26 Pressurized Irrigation Systems for Efficient Water Use
— T.B.S. RAJPUT 330

27 Sub-surface Drainage System for Improving Agricultural Productivity in Coastal Areas
— MAN SINGH 343

28 Surface Irrigation Automation for Enhancing Water Use Efficiency
— MANOJ KHANNA 356

VI. WEED DYNAMICS AND HERBICIDE USE

29 Resource Conserving Techniques and Weed Control Efficiency
— T.K. DAS 367

30 Problem of Herbicide Resistance in Weeds and its Management
— N.T. YADURAJU 383

VII. ENERGY CONSERVATION AND FARM MACHINERY

31 Energy Use in Production Agriculture
— P.K. SAHOO AND U.K. BEHERA 397

32 Energy Efficient Machinery for Conservation Agriculture
A.P. SRIVASTAVA 415

33 Farming for Energy Security
— D.S. RANA 423

VIII. MODERN TOOLS AND TECHNIQUES

34 Precision Farming: Concept, Limitations and Opportunities in Indian Agriculture
— R.N. SAHOO 439

35 Use of Modern Tools and Techniques in Agricultural Water Management
— A. SARANGI 451

IX. ON-FARM TESTING AND EVALUATION

36 Farming System Research for Sustainable Development of Small and Marginal Farmers
— U.K. BEHERA AND A.R. SHARMA 471

37 On-farm Development and Evaluation of Resource-Conserving Technologies
— M.L. JAT, Y.S. SAHARAWAT, MAHESH GATHALA AND K.P. SINGH 487

38 On-farm Water Management Practices for Higher Crop Productivity
— S.K. DUBEY 500

39 Mode of Operation and Performance of Contract Farming – A Case Study of Cotton in Haryana
— SHIV KUMAR 508

Section - I

Concept and Approaches