ICAR
PUBLICATIONS
Annual Report

1987-88

DEPARTMENT OF
AGRICULTURAL RESEARCH AND EDUCATION
MINISTRY OF AGRICULTURE, GOVERNMENT OF INDIA
NEW DELHI
Minister of Agriculture, and President, ICAR

Shri Bhajan Lal

Minister of State, Agricultural Research and Education, and Vice-President, ICAR

Shri Hari Krishna Shastri

Secretary, DARE, and Director-General, ICAR

Dr N.S. Randhawa
Contents

1. Introduction 1
2. Administration 6
3. Conservation of Resources 11
4. Research Accomplishments 14
   Crops 14
   Plant Protection 64
   Soil Science 70
   Dryland Research 77
   Arid Zone Research 81
   Agronomic Research 82
   Agricultural Engineering and Technology 90
   Animal Sciences 98
   Fisheries 112
   Agricultural Economics, Statistics and Marketing 119
5. Agricultural Education 123
6. Transfer of Technology 129
7. Research for Tribal and Backward Areas 134
8. International Co-operation 144
9. Publications and Information 149

Appendices
I. Awards 152
II. Officers at the Headquarters of the DARE and the ICAR 154
III. Directors of ICAR Institutes, National Bureaux and National Research Centres 157
IV. Project Directors and Project Co-ordinators of All-India Co-ordinated Research Projects 161
V. Vice-Chancellors of Agricultural Universities 168
VI. Total Number of Employees in the ICAR and its Research Institutes and the Number of Scheduled Castes (SC) and Scheduled Tribes (ST) Employees among them on 31 July 1987 170
<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AARRO</td>
<td>Afro-Asian Rural Reconstruction Organization</td>
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<tr>
<td>AAU</td>
<td>Assam Agricultural University</td>
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<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>AGRIS</td>
<td>International Information System for Agricultural Sciences and Technology</td>
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<td>AGROVOC</td>
<td>Multilingual Thesaurus of Agricultural Terminology</td>
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<tr>
<td>AICRP</td>
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<td>APAU</td>
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<td>AP Cess Funds</td>
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<td>Birsa Agricultural University</td>
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<td>BCKVV</td>
<td>Bidhan Chandra Krishi Vishwa Vidyalaya</td>
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<tr>
<td>BHK</td>
<td>Baby Hamster Kidney</td>
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<td>BHU</td>
<td>Banaras Hindu University</td>
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<tr>
<td>BLV</td>
<td>Bovine Leukaemia Virus</td>
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<td>BWFF</td>
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<td>CAB</td>
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<td>CARI</td>
<td>Central Avian Research Institute</td>
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<td>CAZRI</td>
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<td>CFETC</td>
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<td>CFTC</td>
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<td>Consultative Group on International Agricultural Research</td>
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<td>CICFRI</td>
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<td>CICR</td>
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<td>CIE</td>
<td>Counter Immunoelectrophoresis</td>
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<td>CIFRI</td>
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<td>ACRONYMS</td>
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<td>CIFT</td>
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<td>CIHNP</td>
<td>Central Institute of Horticulture for Northern Plains</td>
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<td>CIMMYT</td>
<td>Centro Internacional de Mejoramiento de Maize y Trigo</td>
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<td>(International Improvement Centre for Maize and Wheat)</td>
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<td>CIP</td>
<td>Centro Internacional de la Papa</td>
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<tr>
<td>(International Potato Research Institute)</td>
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<tr>
<td>CIRB</td>
<td>Central Institute for Research on Buffaloes</td>
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<td>CIRG</td>
<td>Central Institute for Research on Goats</td>
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<td>CMFRI</td>
<td>Central Marine Fisheries Research Institute</td>
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<td>CP</td>
<td>Colombo Plan</td>
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<td>CPRI</td>
<td>Central Potato Research Institute</td>
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<td>CRIDA</td>
<td>Central Research Institute for Dryland Agriculture</td>
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<td>CRRI</td>
<td>Central Rice Research Institute</td>
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<td>CSAUAT</td>
<td>Chandra Shekhar Azad University of Agriculture and Technology</td>
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<td>CSIR</td>
<td>Council of Scientific and Industrial Research</td>
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<td>CSSRI</td>
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<td>CSWCRTI</td>
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<td>Central Sheep and Wool Research Institute</td>
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<td>CTCRI</td>
<td>Central Tuber Crops Research Institute</td>
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<td>CTRI</td>
<td>Central Tobacco Research Institute</td>
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<td>CTRL</td>
<td>Cotton Technological Research Laboratory</td>
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<tr>
<td>2, 4-D</td>
<td>2, 4-Dichlorophenoxyacetic Acid</td>
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<tr>
<td>DANIDA</td>
<td>Danish International Development Agency</td>
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<td>DARE</td>
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<td>DNA</td>
<td>Deoxyribonucleic Acid</td>
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<td>DOD</td>
<td>Department of Ocean Development</td>
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<td>DRDA</td>
<td>District Rural Development Agency</td>
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<td>EC</td>
<td>Electrical Conductivity</td>
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<td>EDCIL</td>
<td>Education Consultants India Ltd</td>
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<td>EDS</td>
<td>Egg-Drop Syndrome</td>
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<td>EEZ</td>
<td>Exclusive Economic Zone</td>
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<td>EIA</td>
<td>Equine Infectious Anaemia</td>
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<td>ESCAP</td>
<td>Economic and Social Commission for Asia and the Pacific</td>
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<td>ESP</td>
<td>Exchangeable Sodium Percentage</td>
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<td>EYCG</td>
<td>Egg-Yolk Citrate Glucose</td>
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<td>FAO</td>
<td>Food and Agriculture Organization</td>
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<tr>
<td>FMD</td>
<td>Foot-and-Mouth Disease</td>
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<tr>
<td>FMDV</td>
<td>Foot-and-Mouth Disease Virus</td>
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<tr>
<td>FSH</td>
<td>Follicle Stimulating Hormone</td>
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<td>GA</td>
<td>Gibberellic Acid</td>
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<td>GAU</td>
<td>Gujarat Agricultural University</td>
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<td>GBUAT</td>
<td>Govind Ballabh Pant University of Agriculture and Technology</td>
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<td>GnRH</td>
<td>Gonadotropic Releasing Hormone</td>
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<td>HAU</td>
<td>Haryana Agricultural University</td>
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<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
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<td>HPKVV</td>
<td>Himachal Pradesh Krishi Vishwa Vidyalaya</td>
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</tbody>
</table>
HRD  Human Resources Development
IARI  Indian Agricultural Research Institute
IASRI  Indian Agricultural Statistics Research Institute
IBD  Infectious Bursal Disease
IBPGR  International Board of Plant Genetic Resources
ICAR  Indian Council of Agricultural Research
ICRISAT  International Crops Research Institute for the Semi-Arid Tropics
IDA  International Development Agency
IDRC  International Development Research Centre
Ig  Immunoglobulin
IGFRI  Indian Grassland and Fodder Research Institute
IGKVV  Indira Gandhi Krishi Vishwa Vishalaya
IIHR  Indian Institute of Horticultural Research
IISR  Indian Institute of Sugarcane Research
IIT  Indian Institute of Technology
IJO  International Jute Organization
ILRI  Indian Lac Research Institute
INRA  L’Institut National de la Recherche Agronomique (National Institute of Agricultural Research)
IPC  International Potato Centre
IRDC  International Research and Development Council
IRRI  International Rice Research Institute
ITEC  Indian Technical and Economic Co-operation
IVDMD  In Vitro Dry Matter Digestibility
IU  International Unit
IVRI  Indian Veterinary Research Institute
IW:CPE  Irrigation Water: Cumulative Pan Evaporation
JARI  Jute Agricultural Research Institute
JNKVV  Jawaharlal Nehru Krishi Vishwa Vishalaya
JTRL  Jute Technological Research Laboratories
KAU  Kerala Agricultural University
KKV  Konkan Krishi Vidyapeeth
KVIC  Khadi and Village Industries Commission
KVK  Krishi Vigyan Kendra
LA  Latex Agglutination
LDPE  Low Density Polyethylene
LE  Larval Equivalent
LLP  Lab-to-Land Programme
LPS  Lipopolysaccharides
LRDC  Land Resources Development Centre
MADECOR  Mandala Agricultural Development Corporation
MAU  Marathwada Agricultural University
MCC  Microcrystalline Cellulose
ME  Metabolizable Energy
MPEDA  Marine Products Export Development Authority
MPKV  Mahatma Phule Krishi Vidyapeeth
NAA  Naphthalene Acetic Acid
<table>
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<th>Acronym</th>
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<td>NAARM</td>
<td>National Academy of Agricultural Research Management</td>
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<td>NABARD</td>
<td>National Bank for Agriculture and Rural Development</td>
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<td>NAFED</td>
<td>National Agricultural Co-operative and Marketing Federation of India Ltd</td>
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<td>NARP</td>
<td>National Agricultural Research Project</td>
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<td>NBAGR</td>
<td>National Bureau of Animal Genetic Resources</td>
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<td>NBFGR</td>
<td>National Bureau of Fish Genetic Resources</td>
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<tr>
<td>NBPGR</td>
<td>National Bureau of Plant Genetic Resources</td>
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<td>NBRI</td>
<td>National Botanical Research Institute</td>
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<tr>
<td>NBSSLP</td>
<td>National Bureau of Soil Survey and Land-Use Planning</td>
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<td>NCERT</td>
<td>National Council of Educational Research and Training</td>
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<td>NDRI</td>
<td>National Dairy Research Institute</td>
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<td>NDUAT</td>
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<td>NPV</td>
<td>Nuclear Polyhedrosis Virus</td>
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<td>NRC</td>
<td>National Research Centre</td>
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<td>NRCC</td>
<td>National Research Centre for Camels</td>
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<td>NRCE</td>
<td>National Research Centre for Equines</td>
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<tr>
<td>NRDC</td>
<td>National Research and Development Council</td>
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<td>NSC</td>
<td>National Seeds Corporation</td>
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<td>ODA</td>
<td>Overseas Development Administration</td>
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<td>ORP</td>
<td>Operational Research Project</td>
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<td>OUAT</td>
<td>Orissa University of Agriculture and Technology</td>
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<td>PAU</td>
<td>Punjab Agricultural University</td>
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<td>PEG</td>
<td>Poly Ethylene Glycol</td>
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<td>PKV</td>
<td>Punjabrao Krishi Vidyapeeth</td>
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<tr>
<td>PMS</td>
<td>Pregnant Mare Serum</td>
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<tr>
<td>PMSG</td>
<td>Pregnant Mare Serum Gonadotropin</td>
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<tr>
<td>PPD</td>
<td>Purified Protein Derivative</td>
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<tr>
<td>ppb</td>
<td>Parts Per Billion</td>
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<td>ppm</td>
<td>Parts Per Million</td>
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<td>RAU, Bihar</td>
<td>Rajendra Agricultural University, Patna, Bihar</td>
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<tr>
<td>RAU, Rajasthan</td>
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<td>RNA</td>
<td>Ribonucleic Acid</td>
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<td>RNAM</td>
<td>Regional Network for Agricultural Machinery</td>
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<td>RPHA</td>
<td>Reverse Passive Haemagglutination</td>
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<td>SAARC</td>
<td>South Asian Association for Regional Co-operation</td>
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<td>SAR</td>
<td>Sodium Adsorption Ratio</td>
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<td>SAREC</td>
<td>Swedish Agency for Research Co-operation with Developing Countries</td>
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<td>SBI</td>
<td>Sugarcane Breeding Institute</td>
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<tr>
<td>SCAAP</td>
<td>Special Commonwealth African Assistance Programme</td>
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<tr>
<td>SDS</td>
<td>Sodium Dodecyl Sulphate</td>
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<td>SDI</td>
<td>Selective Dissemination of Information</td>
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<tr>
<td>SGPT</td>
<td>Serum Glutamic Pyruvic Transaminase</td>
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<td>SIDA</td>
<td>Swedish International Development Agency</td>
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<td>SKUAST</td>
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SNF
SPACE
TCA
TCS
TCTP
TCYG
TDRI
TNAU
TRYSEM
TS
TSS
TTC
UAS
UDP
UGC
UHT
UNDP
USAID
USDA
VAM
VPKAS
WAPCOS
WHO
YSPUHF

Solids-Not-Fat
Solid Phase Aggregation of Coated Erythrocytes
Technical Committee on Agriculture
Technical Co-operation Schemes
Third Country Training Programme
Tris Citrate Yolk Glucose
Technical Development and Research Institute
Tamil Nadu Agricultural University
Training Rural Youth for Self Employment
Total Solids
Total Soluble Sugars
Trainers' Training Centre
University of Agricultural Sciences
Undegradable Protein
University Grants Commission
Ultra Heat Treatment
United Nations Development Programme
United States Agency for International Development
United States Department of Agriculture
Vesicular Arbuscular Mycorrhizae
Vivekananda Parvatiya Krishi Anusandhan Shala
Water and Power Consultancy Services (India) Ltd
World Health Organization
Dr Yashwant Singh Parmar University of Horticulture and Forestry
1 Introduction

1987 was one of the worst drought years. It gave an opportunity to review and reorient our research strategies to match the realities which surfaced as a result of recurrent droughts. To assist the development departments in planning immediate strategies, 5 bulletins incorporating the package of practices for increasing the production of drylands of different regions were brought out. Similarly, information relating to the technologies for mitigating the effects of drought in kharif 1987 and measures for increasing production during 1987–88 was shared with the development departments and state agricultural universities.

Crop Improvement work was continued and intensified, particularly in relation to breeding of high-yielding varieties of varying durations with accent on pest and disease resistance and tolerance to stress situations. In priority areas such as oilseeds and pulses, an attempt was made to utilize exotic sources of germplasm in both breeding and direct introduction programmes. Short-duration crop varieties were specially bred for fitting them into intercropping and multiple-cropping systems and under rainfed situations.

The major research effort in rice was concentrated on releasing varieties for increasing production under rainfed situations, particularly in eastern India. Twenty varieties suitable for cultivation in diverse ecosystems were released in 9 states, and 49 varieties were identified for minikit testing. In addition, 15 varieties were identified by the agricultural universities in Andhra Pradesh, Assam, Karnataka, Maharashtra and Tamil Nadu.

Two high-yielding varieties of wheat were released for cultivation in the irrigated areas of north-eastern plains and rainfed areas of peninsular zone respectively. ‘HD 2385’ — a double-dwarf wheat variety — was recommended for cultivation in eastern zone and ‘UP 1109’ was released for the hill areas of Uttar Pradesh. The first dwarf hull-less barley variety ‘Neelam’ with a yield potential of 50 q/ha was recommended for release in the Indo-Gangetic plains, and a hulled barley variety ‘Kedar’ (tolerant to yellow-rust and pests) with a yield potential of 30 q/ha was released for the north-eastern plains.

In maize, 4 yellow flint-grained composites, 2 of early and 2 of medium maturity, were recommended for release. Kharif sorghum varieties ‘SPV 462’ and ‘SPV 475’ with a yield potential of 33 q/ha were recommended for release. Early-maturing pearl millet hybrid ‘Pusa 23’ was released for the drought-prone areas of Gujarat and Rajasthan. Four finger millet varieties were recommended for cultivation in different regions. The Tamil Nadu Agricultural University released finger millet variety ‘TRY 1’, having a yield potential of 48 q/ha. Five varieties of small millets were also released for different regions.

Pigeonpea ‘TTB 7’, with a yield potential of 40 q/ha, was recommended for the red soil areas of Karnataka. The Punjab Agricultural University released a chickpea variety ‘PBG 1’, which is resistant to blight. Two Kabuli-type chickpea varieties, with a yield potential of 28 q/ha, were identified for the north-western plains. One mung bean variety (‘PDM 1’) and 2 urd bean varieties (‘PDU 1’ and ‘LBG 17’) were released for cultivation in non-traditional rabi, spring and summer seasons.
Rajmash has successfully been introduced as a rabi pulse crop in the northern plains, and the ideal time of planting was found to be the first week of September in Punjab and Haryana and the last week of October in the north-eastern, central and peninsular zones. Cowpea variety 'TVX' was released for cultivation in the red soils of Karnataka, particularly for growing in rice fallows.

Nine promising varieties of oilseeds having regional and national importance were identified. Of these, 4 were of groundnut, 3 of sesame, and 1 each of sunflower and linseed. 'GSL 1' variety of 'gobhi sarson' (Brassica napus), which showed a yield potential of 23 q/ha if 60-day-old seedlings were transplanted during the third week of November, could be cultivated in large areas in Haryana and Punjab following kharif rice and cotton. Breeder's seed production of oilseed crops was increased by 34% over that of the previous year. A high-yielding non-lodging soybean variety 'MACS 58' was recommended for pre-release trials in the central zone.

In sugarcane, 'Co LK 8001' developed by the Indian Institute of Sugarcane Research, Lucknow, having drought tolerance, fertilizer responsiveness and resistance to red-rot, wilt and smut, was recommended for the western zone. Similarly, a sugarbeet variety 'LS 6', possessing high yield potential and tolerance to root-rot, was recommended for commercial cultivation.

Ten improved varieties and hybrids of cotton were recommended for cultivation in view of their superiority in yield, ginning outturn, spinning quality and earliness. Among these was one desi hybrid for Karnataka.

For strengthening Horticultural Research, 5 Task Forces were constituted to find out the relevance and suggest programmes of work of 1 new institute and 5 national research centres (NRCs) proposed to be set up during the Seventh Plan. The Task Forces have submitted their reports. New NRCs on citrus, cashew and spices have started functioning at Nagpur (Maharashtra), Puttur (Karnataka) and Calicut (Kerala) respectively. Under the All-India Co-ordinated Research Project (AICRP) on Potato, 3 new centres were started at Faizabad, Aurangabad and the Andaman and Nicobar Islands. In addition, 5 new AICRP centres were established in 5 states for research on plantation crops.

In citrus fruits 'Nagpur Santra 182', having fewer seeds, has been recommended for the Vidarbha region. Kagzi-lime types 'NS 2', 'Hybrid 2' and 'Hybrid 3' were found to be resistant to canker at Parbhani. Seven seedless and 14 seeded grape hybrids were identified for multilocation testing.

Research on post-harvest technology of horticultural crops related chiefly to the pre- and post-harvest treatment of fruits and vegetables for controlling disorders, testing of different packaging materials, storage units and also utilization of processing wastes.

Several promising varieties of vegetable crops were identified for their resistance to plant diseases. Five varieties of cauliflower resistant to stalk-rot were identified at Solan. Three okra varieties resistant to yellow-vein mosaic, 2 varieties of garlic resistant to leaf-blight and thrips, and 5 selections of pea showing resistance to powdery-mildew were also developed.

Potato is traditionally raised from seed tubers. In recent years, the possibility of raising it from true potato seed (TPS) is being explored. Three promising TPS hybrids have been developed for large-scale testing. About 1,200 tonnes of breeder's seed of 7 major potato varieties were distributed to various seed agencies of state governments for further multiplication.

Among the high-yielding varieties of tuber crops released during the year were 'Sree Prakash' of cassava, 'Sree Vardhini' of sweet-potato, 'Sree Rashmi' of Colocasia, 'Sree Keerti', 'Sree Subhra' and 'Sree Priya' of Dioscorea.

Research on button mushroom led to iden-
tification of alternate substrates, better nutrition techniques and new methods of chemical sterilization of substrates.

Two high-yielding coconut varieties and 3 cashewnut varieties producing 24 to 30 kg raw, bold nuts per tree have been recommended and released for Kerala. A high-yielding ginger variety was recommended for Orissa and a turmeric variety for the whole of India.

Among medicinal crops, a high-yielding opium-poppy variety 'Trishna' was recommended for cultivation in the western region.

The National Bureau of Soil Survey and Land-Use Planning (NBSSLUP) continued its efforts to bring out a soil map in the established time-frame. A linkage programme with the Land Resource Development Centre, UK, was finalized to elevate the training centre at the NBSSLUP to an international level.

A major emphasis in Rainfed Farming Research related to the evaluation of watershed approach to the management of drylands, besides the evaluation of remunerative intercropping systems, water-conservation measures and water-harvesting systems. Amelioration of saline- and alkali-affected soils, micronutrient deficiencies and their correction, and agrometeorology, were other areas where significant research effort was devoted.

Agronomic Research chiefly related to the evaluation of multiple-cropping, intercropping and mixed-cropping sequences to find out the most promising and remunerative ones for maximizing returns to farmers in different regions. Research was strengthened on the improvement of diara lands, weed control and agroforestry, particularly with reference to silvi-pastoral systems.

Agricultural Engineering and Technological Research helped in the development of a safety device for diesel irrigation engine, a chain pump for lifting water in tribal areas, improved drainage techniques, tractor-operated basin lister, seed-metering device for sowing mustard, seed-cum-fertilizer drills, tractor-mounted groundnut planter, sweep-type cultivator, self-propelled sprayer, multicrop thresher, castor sheller, etc. These machines and devices would help in increasing the efficiency and output of field operations per unit of time and energy input.

Several technological innovations have been developed which would enable farmers to start ancillary agro-industries. These include control of storage pests with biogas, process for bottling sugarcane juice, briquetting coir pith, process for production of soyflakes, development of bagasse dryer, animal-powered agroprocessing complex, process for producing microcrystalline cellulose from agricultural wastes, preparation of super-absorbents, tea-cheasts from jute-stick board, paper from jute-sticks, lac-based slow-release weedicides, horizontal-axis windmill, etc.

In Animal Sciences Research, under the project Directorate on Cattle Improvement, evaluations were made of the milk yield, age at first calving, calving interval and effect of challenge feeding on milk production in half-breds and 3/4-breds which showed significant higher milk yield potential.

In researches on sheep for wool, a marked improvement in all the production traits, without much deterioration in fertility, except at a very high level of exotic inheritance, was observed when Nilgiri sheep were crossed with exotic Stavropol Merino and Ram-bouillet rams. The work on sheep for mutton revealed that Nellore synthetic lambs (crosses of Suffolk and Dorset) weaned at 60 days and kept on intensive feeding up to 150 days had higher average daily gains and better efficiency of feed conversion than the Nellore lambs.

Under the Project Directorate on Poultry Improvement, further improvement was noticed in egg production in White Leghorn purelines.

Improvement of wool yield in rabbits has been made through crossing Russian Angoras with British and German Angoras.

Normal chromosome profiles of some of
the breeds of indigenous cattle, camel, buffalo, goat, sheep and yak have been established at the National Institute of Animal Genetics, Karnal. Comprehensive breed descriptors for cattle, buffaloes and poultry have been developed and computerized at the National Bureau of Animal Genetic Resources, Karnal.

In animal nutrition, a two-stage fungal treatment of straw under the Indo-Dutch project on bioconversion of fibrous crop residues has been developed at the National Dairy Research Institute, Karnal. The institute has also identified good calcium supplements for animals. Emphasis was laid on studies on aflatoxin in feed, nitrogen for microbial digestion in ruminants, camel and goat. Embryo-transfer technology has been adopted to indigenous breeds and crossbreds in cattle.

A mathematical model was worked out at the Indian Veterinary Research Institute (IVRI), Izatnagar, for estimating the economic losses to form a basis for evaluating the merits of various strategies used for the control of the foot-and-mouth disease (FMD). In the biotechnology research at the IVRI, Izatnagar, recombinant DNA for FMD virus type ‘A’, ‘A22’ and ‘Asia 1’ were prepared and analysed for production of genetically engineered FMD vaccine. Under the All-India Co-ordinated Research Project on blood protozoan disease, methods were standardized for the propagation of Theileria annulata schizonts in lymphocyte cultures and for the evaluation of suitably adapted strains in vaccination trials.

Considerable research on handling and processing of milk and milk products with particular emphasis on indigenous dairy products has been in progress and has formed the basis for evolving the processes for reducing the cost of handling of milk and also for effectively conserving the milk solids when milk is abundantly available during the flush season. Concrete steps have already been taken for initiating organized research efforts for the modernization of abattoir facilities available at the IVRI through the establishment of a National Research Centre on Meat and Meat Products Technology.

Fisheries Research was accorded high priority during the Seventh Plan through reorganization and strengthening of the research and education sector and by incorporating resource-specific research mandates.

To standardize degree-orientated research, the demand for converting the Central Institute of Fisheries Education into a deemed-to-be university has received positive support from the University Grants Commission recently.

In the marine sector, due attention has been given to the vast fisheries resources in and around the Andamans, Nicobar and Lakshadweep. In the field of mariculture, breeding and rearing of the black-lipped pearl-oyster was another breakthrough. Breakthrough in breeding of the Indian white prawn, Penaeus indicus, by in-vitro fertilization adds to the scope of commercial prawn production with yet one more species. Similarly, the first-ever successful trial of breeding the giant edible garden-snail attracted the interest of the Marine Products Export Development Authority in view of its excellent export potential in West European countries.

Advances in fisheries technology related to the design and fabrication of a biogas digester and a solar processing monitor for measuring environmental parameters during dry processes. Regular monitoring of pollution in Ganga and Yamuna rivers has indicated that heavy metal concentration is still within the prescribed limits of potable waters but, in certain cases, exceeds the tolerance limits for fishes.

Agricultural Education made significant progress during the year. On the persuasion of the ICAR, the Rajasthan Government established the Rajasthan Agricultural University with headquarters at Bikaner. In Madhya Pradesh, a second agricultural university, named the Indira Gandhi Krishi Vishwa Vidyalaya, was established at Raipur. A pro-
INTRODUCTION

Project proposal for the establishment of a Central Agricultural University for 7 states of the north-eastern region was finalized. Three new agricultural engineering colleges at Hisar (Haryana), Parbhani (Maharashtra), Jorhat (Assam) and a veterinary college at Palampur (Himachal Pradesh) were established. Under the UNDP-assisted project on post-graduate agricultural education and research, 11 new centres of advanced studies were established.

The National Agricultural Research Project, designed to strengthen the regional research capability of the state agricultural universities, also continued to forge ahead, and the number of research subprojects increased from 109 to 114.

A high-level committee of agricultural scientists has been constituted to review and update the curricula for Master's and Doctoral programmes in various branches of agricultural and allied sciences.

The Transfer-of-Technology Projects of the ICAR are devoted for promptly demonstrating the latest agricultural technologies to the farmers as well as the extension functionaries of the state departments of agriculture. The National Demonstrations Project is operating in 48 districts and organizes about 5,000 demonstrations on farmers' fields to show the production potentiality of crops.

Testing and verification of technologies and constraint analysis are being done in field conditions through 152 Operational Research Project centres. The Operational Research Projects on Watershed Management have been demonstrating the techniques of water harvesting and new cropping systems by using protective irrigations. The Watershed Operational Research Projects have especially proved their efficacy in terms of mitigating the adverse effects of droughts in the respective areas. Eighty-nine Krishi Vigyan Kendras have been organizing a number of vocational skill-training courses benefiting over 150,000 farmers, farm women and young farmers annually. Through 101 Lab-to-Land Centres, the low-cost agricultural technologies are being demonstrated to small and marginal farmers for improving productivity, creating employment and generating income.

The tempo of activity in the sphere of International Co-operation was maintained during the year. Particular mention may be made of (i) the activities under the South Asian Association for Regional Co-operation (SAARC), and the successful organization of the sixth meeting of the Technical Committee on Agriculture of SAARC in New Delhi during 5-7 October 1987, (ii) evaluation of the impact of agricultural universities on agricultural production in India by a team of US and Indian scientists, and (iii) the follow-up of the Agreement between the Prime Minister of India and the President of USA during October 1987, by the fifth meeting of the Indo-UN Subcommission on Agriculture held in New Delhi during 7-11 December 1987. The subcommission has recommended, inter-alia, that distinct and identifiable projects should be developed in the priority areas of arid-zone agriculture, water management and evaluation of groundwater resources.
The Department of Agricultural Research and Education (DARE) of the Ministry of Agriculture provides the necessary governmental linkages for the Indian Council of Agricultural Research (ICAR). The major functions of the DARE are:

(i) To look after all aspects of agricultural research and education (including animal sciences and fisheries) involving co-ordination between the central and state agencies;

(ii) To attend to all matters relating to the Indian Council of Agricultural Research; and

(iii) To attend to all matters concerning the development of new technologies in agriculture, animal husbandry and fisheries, including such functions as plant and animal introduction and exploration, and soil and land-use survey and planning.

The DARE carries out such functions of the government as are necessary for the effective working of the ICAR. The Director-General of the ICAR is also the Secretary to the Government of India in the DARE.

The DARE is intended basically to provide administrative services and support to the ICAR. Within the overall framework of government policies, the ICAR is vested with full authority to determine basic strategies, formulate operational policies, develop necessary programmes, and ensure their implementation on sound technical and economic principles. The main idea of the reorganized set-up of the ICAR is to vest it with the autonomy essential for the effective functioning of a scientific organization and to deal with sister departments of the central government, with state governments and with international agricultural research centres through the DARE.

A Technology Mission on Oilseeds Production headed by an Additional Secretary to the Government of India (Mission Director, Oilseeds Production) was created in this Department, along with supplementary staff. Its main task is to locate and augment the viable sources to increase the production of oilseeds in the country.

The ICAR was set up on 16 July 1929 as a Registered Society under the Societies Registration Act, 1860. It was reorganized in 1966 and again in 1975.

Aims and Objectives

The aims and objectives of the ICAR are:

(i) To undertake aid, promote and coordinate agricultural, animal husbandry and fisheries education research and its application;

(ii) To act as a clearing-house of research and general information relating to agricultural and veterinary matters;

(iii) To maintain a research and reference library;

(iv) To do other things considered necessary to attain the above objectives; and

(v) To provide consultancy services in the fields of education, research and training in agriculture and allied sciences.

Organizational Set-up

The main bodies and committees of the ICAR are:

(a) General Body

(b) Governing Body
The ICAR is an apex organization for all agricultural and animal husbandry research and education in the country, with 41 institutes in operation as on 31 March 1987. Officers on Special Duty were appointed for handling initial work pending the decision on the location of some institutes. The Project Directorate on Dryland Agriculture was upgraded to Central Research Institute for Dryland Agriculture. There are 10 National Research Centres (NRCs), and 10 more have been cleared by the Project Implementation Committee and the Expenditure Finance Committee for implementation either independently or as a part of other institutes. The new NRCs are (1) Integrated Pest Management, (2) Water Technology Centre for the Eastern Region, (3) Weed Science, (4) Agroforestry, (5) Soybean, (6) Coldwater Fisheries, (7) National Biotechnology Centre on Crop Sciences as a part of the Indian Agricultural Research Institute, (8) National Biotechnology Centre on Animal Health as a part of the Indian Veterinary Research Institute, (9) National Biotechnology Centre on Animal Production as a part of the National Dairy Research Institute, and (10) Meat and Meat Products as a part of the Indian Veterinary Research Institute. The Advanced Centre for Black Cotton Soils has been proposed to be merged with the Indian Soils Research Institute. There are also 4 National Bureaux, one each under Crop Sciences, Soil Science, Animal Sciences and Fisheries. In addition, as on 31 March 1987, there are in operation 78 All-India Coordinated Projects, including 9 Project Directorates, 4 Transfer-of-Technology Projects in Agricultural Extension and 5 Projects from Agricultural Produce Cess Funds cleared for implementation (Guar, Betelvine, Acarology, Weed Control and Animal Energy).

There are 26 state agricultural universities, which have functional linkages with the ICAR. The erstwhile Central Staff College, now redesignated as the National Academy of Agricultural Research Management, has been functioning since 1976 and is training new entrants to the Agricultural Research Service, besides giving orientation courses to senior scientists including directors of institutes. The ICAR has also established 89 Krishi Vigyan Kendras, has undertaken operational research projects, and launched a massive lab-to-land programme for the transfer of appropriate technology. The ICAR also finances a number of ad-hoc research schemes from Cess Funds.

A committee has been set up under the Chairmanship of Dr G.V.K. Rao, former member of the Planning Commission, to look into the various aspects of the functioning of the ICAR.

Policy Formulation and Scrutiny

The ICAR has been reorganized as a compact body reflecting its scientific character. The Minister of Agriculture, Government of India, is the President of the ICAR. The ICAR is assisted in its task by a Governing Body headed by the Director-General, ICAR, who is also Secretary to the Government of India in the Department of Agricultural Research and Education. Three members of Parliament (2 from the Lok Sabha and 1 from the Rajya Sabha), eminent agricultural and other scientists, 3 vice-chancellors of agricultural universities, 3 directors of the ICAR institutes, Secretaries to the Government of India in the Ministry of Finance (Department of Expenditure), Planning, and Department of Agriculture, the Chairman of the University Grants Commission, the Chairman of the Atomic Energy Commission and 3 farmers' representatives constitute the Governing Body of the ICAR. The Governing Body assists in the formulation of policies of the ICAR, scrutinizes and approves research programmes and projects, and controls the budget. The recommendations of the Governing Body become operative only after they are approved by the President of the ICAR.
The Governing Body in its turn is assisted by the following Committees.

1. **Standing Finance Committee.** It examines proposals, including the annual budget of the ICAR having financial implications.

2. **Norms and Accreditation Committee.** It deals with matters pertaining to agricultural universities.

3. **Regional Committees.** There are 8 regional committees which review the research and training needs of the 8 major agro-ecological regions.

4. **Scientific Panels of the ICAR.** The panels consider research schemes in different disciplines.

5. **Joint Panels.** These are formed between the ICAR and related research organizations like the Council of Scientific and Industrial Research, the Indian Council of Medical Research, and the Indian Council of Social Sciences Research.

**NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT**

The National Academy of Agricultural Research Management (NAARM) organized 1 workshop and conducted 9 courses during the year.

**Workshop**

A Workshop on National Agricultural Research Projects (NARP) was organized during 24 to 26 February 1987 to strengthen the capabilities of the state agricultural universities to conduct location-specific, production-oriented research in the agro-climatic zones identified in their areas.

There were 40 participants, including vice-chancellors from agricultural universities and directors of research and extension from all over the country.

**Courses**

Senior research managers and heads of different divisions in the ICAR institutes participated in 3 courses on Agricultural Research Project Management conducted from 16 to 30 January, 2 to 13 March, and 31 August to 11 September 1987. The courses covered the topics of project planning, selection, monitoring and evaluation, organizational structure, group dynamics, leadership, conflicts, and organizational and mass communication.

A course on Instructional Technology and Teaching Methods for senior faculty members of agricultural universities was conducted from 10 to 24 February 1987. It was designed to expose the teachers to the need for appropriate planning of instructional strategies and making optimum use of instructional resources, keeping in view the complexities of teaching and learning processes coupled with the increase in the number of students, the various educational streams they come from, as well as the ever-expanding horizons of modern knowledge. Twenty senior faculty members of agricultural universities participated in the course.

A course on Human Resources Management was organized from 8 to 23 April 1987 to expose the research managers to the concepts of human behaviour and management of human resources in agricultural research.

The course dealt with topics such as the individual and the organization, motivation of scientists, interpersonal relationships, transactional analysis, group dynamics, leadership, team-work, conflicts, personnel policies, structure and design of organization, organizational and mass communication, and management of research projects. Thirty-five senior scientists from the ICAR institutes participated in the course.

Three Foundation Courses for fresh recruits to the Agricultural Research Service (ARS) were organized during the year for the benefit of 160 scientists. The main objectives of the Foundation Course are: (i) to develop an awareness of the background of rural setting, rural socio-economic system, and the role of agriculture in national development; (ii) to get an insight into the objectives, structure and
organization of the Indian Council of Agricultural Research; (iii) to develop an understanding of integrated rural development in the country, with special reference to agricultural development; (iv) to understand how the ICAR discharges its responsibilities of coordination of research, higher education and training in the field of agriculture, animal husbandry and fisheries in the country; and (v) to give an orientation to the Agricultural Research Service.

The 21st Orientation Course on Agricultural Research Management (ARMOCS) was conducted from 20 January to 19 February 1987. The course exposed the S-I scientists to the modern techniques of management in relation to agricultural research projects and equipped them with the skills needed for becoming better scientists. Eighty-four scientists participated in the course.

AGRICULTURAL SCIENTISTS RECRUITMENT BOARD

The Agricultural Scientists Recruitment Board (ASRB) was set up in December 1973 with the approval of the Government of India as an independent recruiting agency of the ICAR. The functions of the ASRB are:

(i) To make recruitment to (a) all scientific posts equivalent of Class I in the field of agriculture, animal husbandry and allied sciences, (b) technical posts equivalent to Senior Class I in the ICAR and its institutes, and (c) such other posts and services as may be specified by the President from time to time;

(ii) To conduct 5-yearly assessments for promotion; and

(iii) To render such assistance to the ICAR in personnel matters, including promotions, as may be required by the President.

The ASRB is now restructured on the lines of the Union Public Service Commission, with a Chairman and 2 Members. The reconstituted Board has started functioning from July 1987.

Recruitment and Assessment

So far 3,262 scientists have been inducted into the Agricultural Research Service (ARS).

From January to September 1987, the ASRB issued 3 advertisements for the recruitment of 95 posts in different grades and disciplines through open selection. Interviews were held for 25 posts and recommendations given.

Five-yearly assessment and recommendations were made for merit promotion or advance increments to 23 scientists in different grades and disciplines. Of the 456 cases of the assessment results relating to the period 1980 to 1983 received for review, 138 were processed and finalized.

In 1986 the ASRB had advertised 459 vacancies of S-I for recruitment in different disciplines through the ARS Examination.

Examinations for Administrative Posts

Interviews for 14 posts of accounts officer and 15 posts of administrative officer were conducted and the recommendations of the Board sent to the ICAR headquarters.

The ASRB is now working out various steps towards an effective Human Resources Development Policy for the ICAR scientists.

RESERVATION OF POSTS FOR SCHEDULED CASTES AND SCHEDULED TRIBES

A statement showing the total number of employees in the ICAR and its research institutes and the number of scheduled castes and scheduled tribes amongst them as on 31 July 1987 is given in Appendix VI.

The position regarding reservation of posts in the category of scheduled castes is satisfactory except in scientific posts. This is because the reservation orders for this category have been implemented only 8–9 years ago. The position about scheduled tribes is not satisfactory. This is mainly because suitable candidates belonging to this community are not
easily available. However, efforts are being made to make good the quota reserved for scheduled tribes in filling vacancies reserved for them.

PROGRESSIVE USE OF HINDI

A Hindi Unit consisting of an Assistant Director (Official Language), a Hindi Translator and a Hindi Typist has been created in this Department. All the posts have been filled.

A Joint Official Language Implementation Committee of the DARE and ICAR has been constituted under the Chairmanship of the Joint Secretary, DARE, who is also the Secretary, ICAR. This committee reviews the quarterly reports on the use of Hindi in the DARE and ICAR at the end of every quarter and deliberates on the difficulties encountered in the progressive use of Hindi. Similar Official Language Implementation Committees have also been constituted in most of the ICAR institutes to review the progress made in the use of Hindi.

This Department has been doing all the work in Hindi in respect of grant of all kinds of leave in its Establishment Section since 1985-86. All staff members have been advised to write their noting and drafting in Hindi, as far as possible.

VIGILANCE

During the year an Administrative Vigilance Training Course was organized by the ICAR from 10 to 18 August 1987 for 7 working days at the IARI, New Delhi, for the benefit of the scientists and officials of some of the ICAR institutes. Vigilance Inspections have also been carried out in some of the research institutes. As a part of the effort to combat corruption, the ICAR institutes have been advised to take up review of cases under FR 56 (j) on a specific time-schedule. The institutes have also been advised to expeditiously conclude all oral enquiries initiated under the CCS (CC & A) Rules.
Conservation of Resources

Plant Genetic Resources

The NBPGR intensified its activities of collection, introduction, evaluation, documentation and conservation of plant genetic resources during the year.

Germplasm Collection

Explorations were undertaken, both independently and in collaboration with research institutes and agricultural universities, in parts of south-western Rajasthan, Uttar Pradesh, parts of Madhya Pradesh, Bihar, Orissa, Kerala, Karnataka, Western Ghats and the north-western Himalayas. Over 2,000 diverse collections were made in wheat, maize, barley, rice, sorghum, millets, cowpea, chickpea, urdbean, mungbean, rapeseed, mustard, fruits and vegetables. Specific crop-diversity surveys were also made for collection of the germplasm of mango from Orissa, banana and jack-fruit from Kerala, oil-yielding Brassica species from western parts of Bihar, cucurbits, chilli and vegetables from north-western Madhya Pradesh, rice from parts of Bihar and Orissa, lime, medicinal plants and Coptis teeta from Arunachal Pradesh, and wild chickpea (Cicer microphyllum) from Kargil (Ladakh).

Germplasm Introduction and Exchange

From 60 countries, 40,539 samples of different agri-horticultural and agri-silvicultural crops were introduced. They included 21,423 cereals and pseudocereals, 2, 682 oilseeds, 1, 482 pulses, 1,264 vegetables, 382 medicinal plants, and 309 fruits and other crops. The NBPGR also supplied 2, 879 samples to 57 countries and 3,912 samples to research institutes, universities, growers and progressive farmers throughout the country.

Some of the promising introductions included *Vigna radiata* from Taiwan with high methionine content and resistance to *Cercospora* and yellow-vein mosaic; aphid-resistant cowpea lines; high-yielding sunflower types from the USSR; rapeseed (type ‘Canola’) from Canada; ‘EC 201878–975’ rice possessing multiple resistance to diseases and pests, from the Philippines; rust-resistant wheat lines from Mexico; cold-tolerant maize types from the USSR; sorghum with high lysine content; high-yielding tomato types tolerant to nematodes, mosaic and *Fusarium* wilt; high-yielding carotene-rich carrot; promising onion hybrids from Germany; nematode-resistant watermelon types from the USA; and bollworm-resistant ‘EC 200305’ cotton (*Gossypium hirsutum*) from the USA.

Plant Quarantine

The exchange of germplasm was carried out under strict phytosanitary conditions, and 43,231 germplasm samples consisting of seeds and other vegetative propagules were processed for quarantine clearance. These included 39,760 samples imported from different countries and 3,471 samples of indigenous origin intended for export. Out of the 1,683 infested or contaminated samples, 1,586 were made free from the pest or pathogens through mechanical cleaning, X-ray radiography, hot-water treatment, acid treatment and pesticide treatment.

A total of 6,459 seed samples of wheat, barley and triticale, 26 of sunflower, and 395 of safflower were grown in the International
Post-Entry Quarantine Nursery and regularly inspected for any exotic pests and diseases.

Germplasm Evaluation and Utilization

For evaluation and utilization, the NBPGR had grown about 24,400 crop varieties, including wheat, triticale, barley, maize, sorghum, pearl millet, pigeon pea, cow pea, chick pea, cluster bean, oil seeds, tomato, brinjal, lab lab bean, broad bean, cucurbit, garlic and onion.

'La Bonita' tomato introduction, and 'Naveen', an early maturing cluster bean variety developed by the NBPGR, were recommended for release. 'PLG 85', an unbranched type of cluster bean, and 'Improved Peredovik' sunflower variety were recommended for pre-release multiplication. Among other promising materials were sorghum and pearl millet types jointly evaluated by the NBPGR and ICRISAT, heat tolerant tomato types, powdery mildew free pea lines, vetiver types from Rajasthan yielding a high amount of essential oil, and periwinkle types with a high content of alkaloid in roots and leaves.

Germplasm Conservation

Over 15,250 accessions of different crop plants were processed for conservation. They include 2,950 accessions of cereals, 2,328 of

There is an immediate need to conserve and multiply the double-humped (Bactrian) camels, as hardly 56 of them inhabit the Ladakh region. They are not only well suited for transport but also provide milk, wool and meat in the cold desert.
millets, 4,320 of oilseeds, 4,654 of legumes and 1,000 of vegetable crops. Currently, there are about 76,000 collections in the germplasm bank. Four more cold-store modules would soon be installed to increase the storage capacity of the NBPGR gene bank to 200,000 seed samples.

Work was initiated on the in-vitro conservation and cryopreservation of priority crops such as onion, sweet-potato, taro, yams, snake-gourd, Musa spp., Citrus spp., papaya, pomegranate, oilpalm, ginger, turmeric, pepper, medicinal and aromatic plants and wild endangered species such as Rauvolfia serpentina, Tylophora indica, Coptis teeta, Pogostemon heyneanus (syn. P. patchouli) and Coleus species.

**UNDER-UTILIZED PLANTS**

Grain-amaranth ‘IC 35463’ gave the highest grain yield of 17.9 q/ha in Gujarat. At Bhubaneshwar, ‘IC 5564’ (9.96 q/ha) was significantly superior to ‘Annapurna’. The optimum N dose for grain-amaranth was 60 kg/ha. The right time of sowing was found to be the first week of June in the hills and the middle of September in the southern region.

Buckwheat varieties ‘Kulu Gangari’ and ‘VHC 26’ gave high yields at Shimla and Shillong respectively.

Winged-bean (Goa-bean) ‘IHR Sel 12’ excelled others in multilocation trials, yielding 4.25 q/ha. Good results were obtained when it was fertilized with 30 kg N, 60 kg P₂O₅ and 40 kg K₂O/ha.

Ricebean ‘RB 53’ was most promising at Shillong and yielded 9.3 q/ha.

Guayule strains ‘Cal 1’, ‘HG 8’ and ‘G 4’ showed promise at Urlikanchan, and ‘Cal 1’ and ‘Arizona 101’ at Delhi. ‘Arizona 1’ had the highest rubber content of 4.96% at the 2-year growth stage.

At Jodhpur, 6-year-old jojoba strains ‘P 2-2’, ‘P 2-5’ and ‘P 4-10’ gave superior performance. The ideal planting density was 10,000 plants/ha at Mettupalayam.

The promising fodder chenopod varieties were ‘BDJ 171’, ‘BDJ 285’ and ‘BDJ 519’.

**Animal and Fish Genetic Resources**

A survey in the Ladakh area revealed that there are approximately 56 double-humped (Bactrian) camels in India. Because of the small number, this species is in the danger of extinction from our country and there is an immediate need for its conservation and multiplication.

The double-humped camels have excellent potential as providers of draught power for short-distance transport, wool, milk and meat in the cold desert area of Ladakh to the terrain of which they are well adapted.

The adult double-humped camels have a well-developed muscular body, weighing 450 to 550 kg. The body colour varies from light to dark brown. They have long, fine and soft hair and woolly undercoat. The annual yield of total hair is 2-4 kg. The two humps are plump and pliable, varying in size according to nutrition. Their normal load-carrying capacity is about 35 to 40% of live body weight, or 150 to 200 kg.

The NBFRG, Allahabad, reported valuable genetic information on 17 commercially important fishes.

*Oreochromis mossambicus* stock was improved at the NBFRG, Allahabad, by obtaining monosex population.

Rohu-catla hybrids attained maturity at 3 years of age. Reciprocal cross of catla-rohu was also obtained. Crossing and reciprocal crossing of mrigal females with common carp males was also done.

The genetic value of triploids and tetraploids of rohu was being studied.
4

Research Accomplishments

CROPS

RICE

Research on rice was conducted at the Central Rice Research Institute, the Directorate of Rice Research, various centres of the All-India Co-ordinated Rice Improvement Project, and the agricultural universities in the rice-growing regions. The main research related to the development of high-yielding varieties of different durations suitable for cultivation in the various agroclimates of the country, with emphasis on resistance to pests and diseases and tolerance to stress situations, such as salinity, alkalinity, deep water and drought. As a result, a wide spectrum of varieties with diverse genetic base has been created. These varieties could sustain rice production at 59.5 million tonnes in 1986-87 despite adverse weather in Andhra Pradesh, Tamil Nadu and the eastern states.

New Varieties

'VL Dhan 163', evolved by the VPKAS, Almora, was released for cultivation in the June-sown rainfed lands of the mid-hills of Uttar Pradesh.

Twenty varieties suitable for cultivation in diverse ecosystems were released by different states (Table 1).

A number of promising cultures were identified for different agroclimatic situations (Table 2). They would be evaluated under the minikit testing programme.

The CRRI, Cuttack, developed a number of short-duration varieties. Some of the promising ones are given in Table 3. The Rice Research Workers' Workshop recommended 5 varieties developed by the CRRI for minikit trials in different states (Table 4).

The agricultural universities also developed a number of promising varieties for the specific needs of different states (Table 5).

Crop Production

Rainfed, lowland rice. Trials conducted by the CRRI, Cuttack, showed that on lands with semi-deep water of 15-50 cm in Orissa, it is feasible to grow semi-tall and extra-early varieties (85-95 days) along with photosensitive late-duration varieties (165 days). The yield of 'Utkal Prabha', a tall improved variety of 150-day duration grown on lands inundated by 15-50 cm of water, could be increased by 25% with 'beushan' operation. (In 'beushan' operation the seed is uniformly broadcast; when the seedlings are 2 weeks old, the field is ploughed with a wooden plough; the upturned seedlings with clods of earth are adjusted in rows on either side of the ploughline.) When green-manuring in-situ is combined with 'beushan' operation, rice yield increased by a further 16%, equivalent to the yield obtained with 40 kg N/ha.

In flooded soils, the adverse effects of cadmium, nickel and chromium on dry-matter production could be mitigated with the addition of compost. The harmful effects of tannery waste could be significantly reduced with the addition of phosphorus. The growth and nitrogen-fixing ability of Aphanothece sp., a blue-green alga, as well as the grain yield of rice increased with the application of phosphorus in rice fields.

At Pattambi, Mohanpur and Titabar, basal
Over 35 rice varieties have been released this year for cultivation in different agroclimates of the country. Among the promising types developed by the Central Rice Research Institute are 2 quick-maturing varieties that come to harvest in 66-70 days on rainfed lowlands.

Placement of urea supergranules was found to be better than split application of urea, the response being 31 kg of grain for every kilogram of nitrogen up to a dose of 29 kg N/ha compared with 9 kg of grain for every kilogram of nitrogen in split application. Basal application of sulphur-coated urea also was promising at Pattambi and Titabar, the yield response being 24 kg of grain for every kilogram of nitrogen. Placement of urea with fertilizer-applicator was found to be economical and feasible on farmers’ fields.

On the rainfed lowlands of Goghraghat (Uttar Pradesh) direct seeding with 50% extra seed together with the application of the normal dose of fertilizer before the onset of the monsoon resulted in a rice yield of 2.3 tonnes/ha, compared with 1.2 tonnes/ha obtained with the farmers’ practice.

Irrigated rice. ‘Mandya Vijaya’ at Mandya, ‘IR 42’ at Mohanpur, and ‘Manoharsali’ and ‘CNM 539’ at Titabar could withstand the adverse effects of late planting and outyielded ‘IET 7251’ by 5 to 11 q/ha.

By a combination of organic and inorganic fertilizers, up to 50% of the inorganic fertiliz-
Table 1. New improved rice varieties suitable for cultivation in different states

<table>
<thead>
<tr>
<th>State</th>
<th>Varieties and situations</th>
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<tbody>
<tr>
<td>Gujarat</td>
<td>‘GR 120’ (irrigated)</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>‘Himalaya 741’ (cold-tolerant)</td>
</tr>
<tr>
<td>Karnataka</td>
<td>‘Mandyar Vijaya’ (irrigated), ‘JET 7191’ (for blast-endemic areas)</td>
</tr>
<tr>
<td>Kerala</td>
<td>‘Bhagya’ (upland), ‘Onam’ (irrigated), ‘Rasmi’ (irrigated), ‘Swarna Prabha’ (irrigated)</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>‘ACK 5’ (upland)</td>
</tr>
<tr>
<td>Punjab</td>
<td>‘PR 108’, ‘PR 109’ (irrigated)</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>‘Asd 16’ (saline areas), ‘TPS 2’ (irrigated)</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>‘Narendra 80’ (irrigated)</td>
</tr>
<tr>
<td>West Bengal</td>
<td>‘Kiran’ (upland), ‘Mandira’ (lowland), ‘Jgen’ (lowland), ‘Sabita’ (lowland)</td>
</tr>
</tbody>
</table>

ers (which are an expensive non-renewable source) could be saved in most of the rice-growing regions.

At Bangalore, Mandya and Nagenhalli (Karnataka) rice responded to K application up to 60 kg K₂O/ha. At Nagenhalli the response was significant only when K was applied in 2 splits—as a basal application and at tillering.

Rice-groundnut was found to be the best sequence at Hyderabad when 2 irrigations could be given to the groundnut crop—one at germination and the other at the pod-formation stage. When only one irrigation was available, the best rabi crop to be grown in sequence with rice was found to be sorghum, which should be irrigated at the germination stage. The second best sequence was rice-pigeonpea at Hyderabad and rice-chickpea at Ramachandrapuram (Andhra Pradesh).

Studies at the CRRI showed that ‘IR 36’ used in crop sequences yielded 1.1 tonnes/ha more when it was transplanted than when it was puddle-seeded. Groundnut grown in sequence with rice yielded 45% more when it received one irrigation at flowering than when grown entirely on residual moisture. On acid lateritic rainfed uplands, groundnut + pigeonpea in rabi in a 5:1 ratio was more remunerative than a sole rice crop.

**Plant Protection**

Gall-midge incidence was noticed in the Srikakulam district of Andhra Pradesh, where the pest probably developed a new biotype. Hispa infestation was seen in Andhra Pradesh, West Bengal and parts of north-eastern India. Blast was a problem in the hills as well as in the irrigated areas during the dry season in the peninsular region. False-smut caused damage in Andhra Pradesh, Bihar, Karnataka and western Uttar Pradesh. Zinc deficiency prevailed in several parts of Bihar, Andhra Pradesh and Haryana, as well as in isolated areas on other states.

**Biological control.** A species of amoeba belonging to the family Vampyrellidae, which was isolated from the rhizosphere after the harvest of early-maturing rice, was found to be predacious on the infective juveniles of the root-knot nematode (*Meloidogyne graminicola*), root nematode (*Hirschmanniella* sp.) and stunt nematode (*Tylenchorhynchus* sp.).

Augmentative release of 100 mirid bugs per square metre of the field at 10-day intervals checked the build-up of brown plant-hopper better than spraying of 0.2% Methyl Parathion at the same intervals.

**Orseolia sp.** (a gall-midge) attacked *Paspalidium geminatum* (a weed) much earlier than *Orseolia oryzae* attacked rice. Several parasites, including an unidentified species of *Platygaster*, attacked the gall-midge of the weed, the parasitism reaching 90% by late August. *Tetrastrongylus* sp. also attacked the pupae of *Orseolia* sp.

**Neem products for pest control.** In greenhouse, water extracts containing 2,500 ppm of neemseed kernel, as well as neem oil at 50% concentration could check the nymphs of the brown plant-hopper. However, in field trials at 13 locations, neem oil from Orissa and
Table 2. Rice cultures identified for minikit-testing programme

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rainfed uplands</strong></td>
<td></td>
</tr>
<tr>
<td>Orissa and Bihar</td>
<td>‘IET 7978’ (‘RAU 4045–10’)</td>
</tr>
<tr>
<td>West Bengal and eastern</td>
<td>‘IET 8681’ (‘NDR 118’)</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>‘IET 8682’</td>
</tr>
<tr>
<td>Madhya Pradesh,</td>
<td>‘IET 8682’</td>
</tr>
<tr>
<td>Maharashtra and Karnataka</td>
<td>(‘RP 2086–74–6–1’)</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>‘IET 7720’ (‘NRR 1446’)</td>
</tr>
<tr>
<td>Orissa and Assam</td>
<td>‘IET 7983’ (‘NDR 86’)</td>
</tr>
<tr>
<td><strong>Rainfed lowlands</strong></td>
<td></td>
</tr>
<tr>
<td>Assam, Andhra Pradesh,</td>
<td>‘IET 8021’ (‘CR 149–206’)</td>
</tr>
<tr>
<td>Karnataka, Orissa,</td>
<td>‘IET 8037’ (‘CR 98–8081’)</td>
</tr>
<tr>
<td>West Bengal and</td>
<td></td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td></td>
</tr>
<tr>
<td>Andhra Pradesh, Orissa,</td>
<td>‘IET 8540’ (‘CN 836–3–6’)</td>
</tr>
<tr>
<td>West Bengal, Uttar Pradesh and Assam</td>
<td>‘IET 8543’ (‘CR 376–KR–1’)</td>
</tr>
<tr>
<td>Andhra Pradesh, Assam, and Bihar</td>
<td>‘IET 8543’ (‘CR 376–KR–3’)</td>
</tr>
<tr>
<td><strong>Deep-water areas</strong></td>
<td></td>
</tr>
<tr>
<td>Bihar and West Bengal</td>
<td>‘IET 9009’ (‘TCA 269’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 9060’ (‘CN 704–7–3’)</td>
</tr>
<tr>
<td>Andhra Pradesh, Assam, and Orissa</td>
<td>‘IET 7975’ (‘OR 143–77’),</td>
</tr>
<tr>
<td>Uttar Pradesh and</td>
<td></td>
</tr>
<tr>
<td>West Bengal</td>
<td>‘IET 9078’ (‘NC 491’),</td>
</tr>
<tr>
<td>West Bengal and Bihar</td>
<td>‘IET 9077’ (‘NC 487/77’),</td>
</tr>
<tr>
<td><strong>High-altitude areas</strong></td>
<td></td>
</tr>
<tr>
<td>Kashmir and Himachal Pradesh</td>
<td>‘IET 8439’ (‘RP 1845–122–4–1–3’)</td>
</tr>
<tr>
<td><strong>Irrigated areas</strong></td>
<td></td>
</tr>
<tr>
<td>Haryana, Punjab and Jammu</td>
<td>‘IET 7959’ (‘RP 1898–6’)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irrigated areas</strong></td>
<td></td>
</tr>
<tr>
<td>Andhra Pradesh, Uttar Pradesh, Bihar, Orissa and Maharashtra</td>
<td>‘IET 8585’ (‘RP 2151–21–22’), ‘IET 9671’</td>
</tr>
<tr>
<td>Andhra Pradesh, Madhya Pradesh, Punjab and Haryana</td>
<td>‘IET 7520’ (‘RP 1854–566–1–1’), ‘IET 8613’</td>
</tr>
<tr>
<td>Andhra Pradesh, Assam</td>
<td></td>
</tr>
<tr>
<td>Madhya Pradesh, Bihar</td>
<td></td>
</tr>
<tr>
<td><strong>Saline-alkali areas</strong></td>
<td></td>
</tr>
<tr>
<td>Sodic soils and saline areas</td>
<td>‘IET 6990’ (‘TR 17’),</td>
</tr>
<tr>
<td>Saline areas</td>
<td>‘IET 9338’ (‘FPAR 7543’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 9337’ (‘FPAR 7403’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 9785’ (‘AD 85022’),</td>
</tr>
<tr>
<td>Saline-alkali areas</td>
<td>‘IET 9341’ (‘CST 7–1’),</td>
</tr>
<tr>
<td><strong>Resistance to insect pests and diseases</strong></td>
<td></td>
</tr>
<tr>
<td>Gali-midge</td>
<td>‘IET 8360’ (‘RP 2137–59–1’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 8360’ (‘OR 447–20’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 8344’ (‘RP 2243–28–2’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 8655’ (‘RP 1579–1863–73–32–53’),</td>
</tr>
<tr>
<td>Brown plant-hopper</td>
<td>‘IET 8558’ (‘CR 146–7003’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 8110’ (‘RP 2095–1–10–19’),</td>
</tr>
<tr>
<td></td>
<td>‘IET 8680’ (‘RP 2095–22–78–9’),</td>
</tr>
<tr>
<td>Rice tungro virus</td>
<td>‘IET 8592’ (‘RP 1213–43–2’),</td>
</tr>
<tr>
<td>Bacterial leaf-blight</td>
<td></td>
</tr>
</tbody>
</table>

Coimbatore, when used up to concentrations of 4%, gave inconsistent results and was not as effective as the recommended commercial pesticide formulations in controlling stem-borer, hispa, whorl-maggot, leaf-folder, green leaf-hopper and white-backed plant-hopper.

**Control of pest complex.** The best chemicals for controlling the pest complex in rice were Chlorpyriphos, Oncol, Cartap and Isazophos, all at 1 kg ai/ha.

**Blast.** The blast fungus was found to be more virulent in the plains—both in the uplands and in irrigated areas—than in the hilly regions, and could infect ‘IR 36’ and ‘Rasi’ generally considered to be blast-resistant. Tricyclazole (Beam; 75 WP@ 0.6 g/litre) was the most promising fungicide against seedling blast. As a seed-dressing (4 g/kg) of direct-seeded rice, it protected seedlings from blast up to 40 days after sowing, and was comparable with Pyroquilon (Fongorene; 50 WP @ 4 g/kg).

_Hydrolea zeylanica_ was identified as an alternate or collateral dicot host of tungro virus.

_Oryza barthii_, a wild rice, was confirmed to
Table 3. Promising short-duration rice varieties developed by the CRRI, Cuttack

<table>
<thead>
<tr>
<th>Variety</th>
<th>Cultural conditions</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'CR 666-36-4',</td>
<td>Rainfed lowlands</td>
<td>65-70</td>
</tr>
<tr>
<td>'CR 455-1-2',</td>
<td></td>
<td>(extra early)</td>
</tr>
<tr>
<td>'CR 222-MW-10',</td>
<td>Rainfed lowlands</td>
<td>81-100</td>
</tr>
<tr>
<td>'CR 404-48',</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 289-1045',</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 401-7',</td>
<td>Medium lands</td>
<td>120-140</td>
</tr>
<tr>
<td>'CRM 25'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 1014',</td>
<td>Lowlands</td>
<td>120-140</td>
</tr>
<tr>
<td>'CR 210-1018',</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 260-171',</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 260-30',</td>
<td>Lowlands</td>
<td>145-160</td>
</tr>
<tr>
<td>'CR 260-136-121',</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 260-292'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Promising rice cultures developed by the CRRI, Cuttack, recommended for minikit trials

<table>
<thead>
<tr>
<th>Culture</th>
<th>Area of adoption</th>
<th>Specific features</th>
</tr>
</thead>
<tbody>
<tr>
<td>'CR 146-206',</td>
<td>For kharif in West Bengal, Orissa, Andhra Pradesh and Karnataka</td>
<td>4-5 tonnes/ha; tolerant to whitebacked plant-hopper</td>
</tr>
<tr>
<td>'CR 98-8081'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'CR 146-7003'</td>
<td>For kharif in Orissa and Karnataka</td>
<td>4-5 tonnes/ha; tolerant to whitebacked plant-hopper</td>
</tr>
<tr>
<td>'CR 620-2',</td>
<td>For early rabi sowing</td>
<td>5 tonnes/ha; 105-110 days; cold-tolerant</td>
</tr>
<tr>
<td>'CR 628-5'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

be immune to bacterial leaf-blight and offers promise as a breeding material.

Weed Control

Granular formulation of Bentiocarb G, and granular as well as liquid fromulations of Molinate + Propanil EC (2 kg ai/ha) were found to be effective in controlling the weeds of transplanted as well as direct-seeded rice. The yields from the plots on which these weedicides were used were comparable with the yields of plots hand-weeded twice and kept weed-free.

Half the recommended dose of Butachlor (0.625 kg/ha) followed by one hand-weeding was found to be better than the full dose of Butachlor@ 1.25 kg/ha (without hand-weeding) in controlling weeds in a rice-cowpea sequence at Bangalore.

Physiology

Grain-production efficiency. Six rice varieties representative of the high-yielding varieties released from 1968 to 1986 were evaluated at Kanpur (Uttar Pradesh) and Mandya (Karnataka) to assess their efficiency of converting solar radiation into dry matter and its partitioning into grain and vegetative parts at N levels of 30, 60, 90 and 120 kg/ha. The results (Table 6) indicate that 'Jaya' continues to lead the other varieties in the amount of biomass produced per day. But 'Vijaya' produced higher yield as it diverted most of the biomass for grain production. When an allowance is made for differences in crop duration most of the present-day varieties were not much superior to 'Jaya' in their physiological efficiency. However, apart from personal preferences for grain quality, the suitability to different agroclimates, the need to have varieties with different durations to fit rice in rotations with other crops, and the importance of genetic diversity to stall any serious outbreaks of pests and diseases, seem to justify the need to have a spectrum of varieties for different rice-growing regions.

Yield in clouded weather. Kharif rice is grown under an overcast sky, when the intensity of light—essential for food production—is low. An assessment of 6 promising varieties that were entered in the Uniform Varietal Trial 1 showed that seedling mortality in 'IET 5688' due to poor light was 55% at Maruteru and 40% at Cuttack. Shading reduced dry matter by 18.1%, number of leaves by 4.2% and leaf weight by 8.3%. The varieties that performed best at Calcutta were 'IET 6080' (6,426 kg/ha), 'IET 7302' (5,824 kg/ha) and 'IET 7585' (5,820 kg/ha).

Grain-filling. An assessment of 7 early-duration pre-release cultures at 6 locations showed that grain-filling was more in panicles...
Table 5. Rice varieties identified or released by the agricultural universities for cultivation in different states

<table>
<thead>
<tr>
<th>Released by</th>
<th>Variety</th>
<th>Suitability and traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAU, Jorhat</td>
<td>&quot;Biraj&quot;, 'Kmj 1-42-1', 'Kmj 1-52-30'</td>
<td>Late planting; tolerant to flood</td>
</tr>
<tr>
<td>APAU, Hyderabad</td>
<td>'Satya' ('RNR 1446')</td>
<td>120 days; 5.5 tonnes/ha; tolerant to bacterial leaf-blight and sheath-blight Rabi as well as kharif; 135 days; 5.5 tonnes/ha; resistant to blast and bacterial blight</td>
</tr>
<tr>
<td>'Pinakini'</td>
<td>160-170 days; ('NLR 9672-96')</td>
<td>120 days; 5.5 tonnes/ha; tolerant to bacterial leaf-blight and sheath-blight Rabi as well as kharif; 135 days; 5.5 tonnes/ha; resistant to blast and bacterial blight</td>
</tr>
<tr>
<td>UAS, Bangalore</td>
<td>'IET 7191'</td>
<td>145-150 days; 4-5 tonnes/ha; for uplands, mid-lands and blast-endemic areas of Karnataka</td>
</tr>
<tr>
<td>MAU, Parbhani</td>
<td>'MAU Sel 9'</td>
<td>Drilled sowing on rainfed lands of the Marathwada region; resistant to drought and tolerant to blast</td>
</tr>
<tr>
<td>TNAU, Coimbatore</td>
<td>'TPS 21'</td>
<td>125-130 days; 4.3 tonnes/ha</td>
</tr>
<tr>
<td>'Adt 27'</td>
<td></td>
<td>6 tonnes/ha; resistant to yellowing, blast, brown-spot, brown plant-hopper and green leaf-hopper</td>
</tr>
</tbody>
</table>

Table 6. Grain-production efficiency of some high-yielding rice varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Days to maturity</th>
<th>Total dry matter (kg/m²)</th>
<th>Yield (kg/ha)</th>
<th>Harvest index (%)</th>
<th>Biomass/day (g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Jaya'</td>
<td>135</td>
<td>1.468</td>
<td>4.772</td>
<td>32.5</td>
<td>10.87</td>
</tr>
<tr>
<td>'Vijaya'</td>
<td>135</td>
<td>1.312</td>
<td>5.846</td>
<td>44.5</td>
<td>9.72</td>
</tr>
<tr>
<td>'Vani'</td>
<td>150</td>
<td>1.444</td>
<td>4.121</td>
<td>28.5</td>
<td>9.63</td>
</tr>
<tr>
<td>'Vikas'</td>
<td>130</td>
<td>1.235</td>
<td>4.451</td>
<td>36.0</td>
<td>9.50</td>
</tr>
<tr>
<td>'Manasarovar'</td>
<td>152</td>
<td>1.569</td>
<td>3.773</td>
<td>24.0</td>
<td>10.32</td>
</tr>
<tr>
<td>'Vikramarya'</td>
<td>150</td>
<td>1.587</td>
<td>4.998</td>
<td>31.5</td>
<td>10.58</td>
</tr>
</tbody>
</table>

produced by primary tillers than in those produced by secondary and tertiary tillers. Calculations showed that if all spikelets develop into filled grains, the potential improvement in grain yield would be 45%.

Dormancy. A study of 24 promising cultures being evaluated at Hyderabad, Chinsurah and Patna in the Uniform Varietal Trial 4 showed that none of the cultures was strongly dormant. Most of them could germinate soon after harvest at Patna. Seed dormancy was about 27 days at Hyderabad and 30 days at Chinsurah. Lack of dormancy is a useful trait because soon after harvest non-dormant seeds can be used for sowing whenever the field is ready.

WHEAT

Wheat production during 1986–87 remained good because winter rains were well distributed in the major wheat-growing areas.

However, a sudden rise in temperature during the grain-filling period reduced the grain size in the northern region. In Punjab, Haryana, western Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir, unseasonal heavy rains in April and May at the harvest stage reduced the yield and affected the processing qualities of the grain, which tended to germinate on the spike. In parts of Maharashtra, Karnataka, Madhya Pradesh, Gujarat and Rajasthan, the rainfed crop suf-
'HD 2428' is one of the 7 high-yielding wheat varieties developed for growing on the manganese-deficient soils of the northern plains.

Suffered because of failure or early cessation of the monsoon.

In spite of these adverse factors wheat production is expected to have remained at a level comparable with that of last year.

**Varietal Improvement**

The Central Subcommittee on Crop Standards, Notification and Release of Varieties released 2 improved high-yielding varieties. 'K 8020' was released for the late-sown irrigated regions of the north-eastern plains. 'MACS 1967', a macaroni type (*Triticum durum*) suitable for semolina production, was released for cultivation in the timely-sown rainfed regions of the peninsular zone.

The Variety Release Committee of Uttar Pradesh released 'UP 1109' for the hilly regions of the state.

*Newly identified varieties.* The 26th All-India Wheat Workshop held in 1987 identified 'Raj 3077' for the timely-sown and irrigated regions of the north-western plains.

The double-dwarf 'HD 2385', developed by the IARI, was recommended for cultivation in the rainfed far-eastern wheat zone comprising Chhota Nagpur (Bihar), West Bengal, Assam, Arunachal Pradesh, Meghalaya and Nagaland, where it yielded 15.3% more than 'Sonalika' and showed resistance to both black-rust and brown-rust.

The variety release committees of the agri-
Table 7. Wheat varieties having special characteristics

<table>
<thead>
<tr>
<th>Characteristic features</th>
<th>Tolerant strains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerance to Karnal-bunt</td>
<td>'H 5159', 'HW 740', 'MG 23-19', 'HD 29' and 'IST 277-5'</td>
</tr>
<tr>
<td>Shoot-fly</td>
<td>'HUW 234', 'HD 2189', 'WH 283', 'Raj 3077'</td>
</tr>
<tr>
<td>Brown-mite</td>
<td>'C 306', 'Bijaja Yellow', 'Hyb 65', 'PBW 65', 'PBW 175', 'WL 410', 'WL 2265'</td>
</tr>
<tr>
<td>Stored-grain pests</td>
<td>'Kalyansona', 'PBW 175', 'K 68'</td>
</tr>
<tr>
<td>Saline and alkali soils</td>
<td>'KRL 2-22', 'KRL 4-4', 'WH 157', 'Raj 1972', 'PBW 65'</td>
</tr>
<tr>
<td>Drought</td>
<td>'HI 1136', 'C 306', 'Sujata'</td>
</tr>
<tr>
<td>High temperature</td>
<td>'Hindi 62', 'HI 1136', 'K 8027', 'HI 1140', 'HI 1167', 'NI 5439'</td>
</tr>
<tr>
<td>Late sowing (January)</td>
<td>'HD 2285', 'HD 2307'</td>
</tr>
<tr>
<td>High-protein types</td>
<td>'MP 852', 'RD 6', 'CPAN 2016', 'CPAN 2019', 'UP 301', 'K 8354' (all bread wheat), 'NI 146' (macaroni wheat)</td>
</tr>
</tbody>
</table>

Cultural universities identified 'BW 1008' for West Bengal, 'AKW 381' and 'AKW 385' for the late-sown regions of Maharashtra, and 'BR 3016' for the rainfed saline soils of Bihar.

Varieties for manganese-deficient soils. In co-operation with the All-India Co-ordinated Research Project on Micronutrients, a number of wheat varieties were screened to assess their suitability for cultivation in manganese-deficient soils. The following varieties showed tolerance to manganese deficiency: 'HD 2204', 'HD 2329', 'PBW 154', 'WH 416', 'HD 2009', 'HD 2428' and 'WH 331'.

Germplasm with superior traits. A large number of released and newly identified varieties were screened for special characteristics like superior grain and tolerance to diseases, pests, problematic soils and high temperature. The most promising types are listed in Table 7.

By substituting wheat chromosomes into varied cytoplasmic backgrounds of Aegilops species, the IARI developed 25 male-sterile lines which might prove useful in the exploitation of hybrid vigour in wheat.

Crop Production

On moist soils, application of nitrogen in 2 splits—half as a basal dose and half at the time of the first irrigation—gave yields as good as or better than those obtained with 3 or 4 split applications.

Irrespective of the nitrogen dose used, economic returns increased by 2 to 18% in intercropping trials with wheat + mustard (8:2). Though there was a slight decrease in the yield of wheat, it was more than offset by mustard (Table 8).

Crop Protection

The general incidence of diseases during the year was low, though leaf-rust incidence showed a marked increase towards the end of March in Punjab, Haryana and western Uttar Pradesh.
Pradesh. Loose-smut incidence was 2–3% in these regions. Except in isolated pockets, Karnal-bunt infection was low.

An analysis of 900 samples showed that stem-rust 40A was predominant in the southern hills and stripe-rust K in the northern hills. Leaf-rust 77 group prevailed in both these regions.

Tilt and Baycor were effective against Karnal-bunt when sprayed at the time of ear emergence.

Aldrin continued to be the best treatment for controlling termites. It was effective even at lower doses of 0.6 and 0.9 g/kg of seed (as against the currently used dose of 1.2 g ai/kg of seed). Chlorpyrifos 0.9 g ai and Endosulfan 2.4 g ai/kg of seed were equally good. Cypermethrin was the best chemical to control shoot-fly. In controlling the ‘molya’ disease caused by nematode, Carbofuran was most effective, although promising results were obtained with Diazinon at Jaipur, and Thimet at Delhi and Hisar.

BARLEY

The first dwarf barley variety, ‘Neelam’ (‘Karan 16’), was recommended by the Central Variety Release Committee for cultivation in both irrigated and rainfed lands of Punjab, Haryana, Uttar Pradesh and Bihar. This amber-grained hull-less variety has a yield potential of 50 q/ha.

‘Kedar’, a 6-rowed hulled barley tolerant to yellow-rust and pests, developed at the IARI, was recommended for cultivation in timely-sown and late-sown regions of the northeastern plains. It yielded 27.5–33.7 q/ha (10–11% more than the check) when sown in time, and 20–30 q/ha (15–21% more than the check) when sown late.

‘Karan 521’, ‘Karan 351’ and ‘Karan 265’ were recommended for minikit testing.

In multilocation trials, 5 hull-less and 9 hulled varieties were found promising (Table 11).


Though the range of variability for protein and lysine was narrow, most of the hull-less barley varieties showed higher content of lysine than the wheat variety ‘C 306’ (Table 9).

Crop Production

Compared with the traditional, tall, hulled varieties, the dwarf, hull-less varieties respond to better management (Table 10) and yield 50–55 q/ha."

Table 9. Protein and lysine contents of hull-less barley varieties and wheat variety ‘C 306’

<table>
<thead>
<tr>
<th>Variety</th>
<th>Protein (%)</th>
<th>Lysine (g/100 g of protein)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Karan 3’</td>
<td>12.78</td>
<td>3.77</td>
</tr>
<tr>
<td>‘Karan 16’</td>
<td>11.36</td>
<td>4.00</td>
</tr>
<tr>
<td>‘Karan 18’</td>
<td>13.63</td>
<td>3.58</td>
</tr>
<tr>
<td>‘Karan 19’</td>
<td>13.09</td>
<td>3.24</td>
</tr>
<tr>
<td>‘Karan 201’</td>
<td>13.63</td>
<td>3.77</td>
</tr>
<tr>
<td>‘Karan 163’</td>
<td>12.21</td>
<td>4.08</td>
</tr>
<tr>
<td>Wheat, ‘C 306’</td>
<td>12.21</td>
<td>2.39</td>
</tr>
</tbody>
</table>

Table 10. Seed rate and fertilizer needs of hull-less barley varieties

<table>
<thead>
<tr>
<th>Crop condition</th>
<th>Seed rate (kg/ha)</th>
<th>Fertilizer needs (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Irrigated (2 or 3 light irrigations)</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Rainfed</td>
<td>100–110</td>
<td>50</td>
</tr>
<tr>
<td>Late planting</td>
<td>110</td>
<td>60</td>
</tr>
</tbody>
</table>

*Half the N and the full dose of P should be applied at the time of planting.

MAIZE

Variatel Improvement

Four yellow, flint-grained composites were
The hull-less ‘Karan 231’ barley is suitable for growing on diarea lands.

Table 11. Promising barley varieties identified for different regions

<table>
<thead>
<tr>
<th>Variety</th>
<th>Cropping condition</th>
<th>Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hull-less</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Karan 741’</td>
<td>Irrigated</td>
<td>All barley-growing zones</td>
</tr>
<tr>
<td>‘Karan 521’</td>
<td>Rainfed</td>
<td>North-western plains and central zone</td>
</tr>
<tr>
<td>‘Karan 748’</td>
<td>Irrigated</td>
<td>North-western plains and central zone</td>
</tr>
<tr>
<td>‘Karan 743’</td>
<td>Late-sown</td>
<td>All barley-growing zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The above 4 varieties are semi-dwarfs, hull-less, have free-threshing ability, and are resistant to yellow-rust, smut and aphids</td>
</tr>
<tr>
<td>‘VL 233’</td>
<td>Rainfed</td>
<td>Valleys of Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh</td>
</tr>
<tr>
<td><strong>Hulled</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘DL 456’</td>
<td>Late-sown</td>
<td>North-western plains</td>
</tr>
<tr>
<td>‘P 490’, ‘K 409’</td>
<td>Irrigated</td>
<td>North eastern plains</td>
</tr>
<tr>
<td>‘B Lt 169’</td>
<td>Late-sown</td>
<td>North-western plains</td>
</tr>
</tbody>
</table>
recommended for release—'Super 1' and 'J 684' of medium maturity, and 'J 660' and 'PK Hunius' of early maturity.

'MCU 508', a very early-maturing composite, was recommended for cultivation in Rajasthan, Uttar Pradesh, Madhya Pradesh, peninsular India, and the entire north-eastern Himalayan region. In the Himalayan region its grain yield was 4,830 kg/ha—quite high for a very early variety.

The PAU, Ludhiana, released a semi-flint composite 'Prabhat' (46 q/ha in 95 days) and hybrid 'Sartaj' (51 q/ha in 90 days) for cultivation in Punjab.

The AAU, Jorhat, released a white, bold-seeded, early-maturing variety for the flood-prone areas of Assam.

At Mandyat, Karnataka, hybrid 'EH 5731' showed tolerance to both downy-mildew and leaf-blight (2.43% infection) and yielded 6,024 kg/ha when 'Deccan 103' (the check) yielded 5,465 kg/ha.

Elite kharif hybrids and composites. The 30th All-India Maize Workshop identified a number of promising maize types for different maize-growing regions (Table 1). Each of them gave at least 10% more yield than the best check in its own maturity group.

Elite rabi hybrids and composites. Based on multilocation trials, 6 high-yielding rabi maize types were identified for advanced trials (Table 13).

Crop Production

A 3-year study showed maize to be a more profitable crop than wheat or sorghum for cultivation in rabi at Kolhapur (Table 14).

Hybrid 'EH 5131' and composites 'Hemant' and 'J 54 (CT) C 4' showed wide adaptability to sowing dates in rabi.

Four irrigations were found to be adequate for maize, and irrigation at the knee-high stage of the crop could be dispensed with to save water.

Among the soybean varieties intercropped with maize at Udaipur, 'T 49' was found to be the best.
### Table 12. Elite maize hybrids and composites identified for cultivation in *kharif* in different regions

<table>
<thead>
<tr>
<th>Type</th>
<th>Maturity group</th>
<th>Grain</th>
<th>Recommended area of cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'EH 5041'</td>
<td>Full season</td>
<td>Yellow, semi-flint</td>
<td>All over the country</td>
</tr>
<tr>
<td>'EH 21083'</td>
<td>Full season</td>
<td>Yellow, semi-flint</td>
<td>All over the country</td>
</tr>
<tr>
<td>'EH 2123'</td>
<td>Medium maturity</td>
<td>Yellow, semi-flint</td>
<td>North-western plains, north-eastern plains, and <em>diara</em> lands</td>
</tr>
<tr>
<td>'EH 401075'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>Composite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'EVB 21'('BFS 2')</td>
<td>Full season</td>
<td>Yellow, semi-flint</td>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>'A 82'</td>
<td>Medium maturity</td>
<td>Yellow, semi-flint</td>
<td>Peninsular India</td>
</tr>
<tr>
<td>'B XXI'</td>
<td>Medium maturity</td>
<td>Yellow, semi-flint</td>
<td>Peninsular India</td>
</tr>
<tr>
<td>'EVA 61-80'</td>
<td>Medium maturity</td>
<td>Yellow, semi-flint</td>
<td>Peninsular India</td>
</tr>
<tr>
<td>'J 2030'</td>
<td>Medium maturity</td>
<td>Yellow, semi-flint</td>
<td>North-western plains</td>
</tr>
<tr>
<td>'EFP'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>North-western plains, north-eastern plains, and peninsular India</td>
</tr>
<tr>
<td>'R 2'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>North-eastern plains</td>
</tr>
<tr>
<td>'D 765' x 'D 787'</td>
<td>Very early maturity</td>
<td>Yellow, semi-flint</td>
<td>All over the country</td>
</tr>
<tr>
<td>'MCU 508 (W)'</td>
<td>Very early maturity</td>
<td>White, semi-flint</td>
<td>All over the country</td>
</tr>
</tbody>
</table>

### Table 13. Elite *rabi* maize types identified for advanced trials

<table>
<thead>
<tr>
<th>Type</th>
<th>Maturity group</th>
<th>Grain</th>
<th>Recommended area of cultivation</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'EH 5131'</td>
<td>Full season</td>
<td>Yellow, semi-flint</td>
<td>Sub-Himalayan region</td>
<td>6,356</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Peninsular India</td>
<td>5,646</td>
</tr>
<tr>
<td>Composite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'J 54(CT) C4'</td>
<td>Full season</td>
<td>Yellow, semi-flint</td>
<td>North-western plains</td>
<td>6,879</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Diara</em> areas of Bihar</td>
<td>4,835</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>as well as Uttar Pradesh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All over the country except Zone 1</td>
<td>5,202</td>
</tr>
<tr>
<td>'PK Hunius U 18'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>All over the country except Zone 1</td>
<td>4,839</td>
</tr>
<tr>
<td>'PK Hunius C2 U 156'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>All over the country except Zone 1</td>
<td>4,344</td>
</tr>
<tr>
<td>'PK Hunius C2 U 5'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>All over the country except Zone 1</td>
<td>4,423</td>
</tr>
<tr>
<td>'PK Hunius C2115'</td>
<td>Early maturity</td>
<td>Yellow, semi-flint</td>
<td>All over the country except Zone 1</td>
<td></td>
</tr>
</tbody>
</table>

Zone 1 comprises Jammu and Kashmir, Himachal Pradesh, and Almora and Dehra Dun regions of Uttar Pradesh.

### Plant Protection

Extensive screening has resulted in the identification of a number of maize genotypes showing resistance or tolerance to important insect pests and diseases (Table 15).

Table 16 summarizes the chemical control measures that proved effective in controlling the major pests of maize.

Army-worm infestation was only 7.9% when maize was intercropped with pea, compared with 24.5% when it was intercropped with lentil.

At Bangalore, November-sown crop had lower incidence of downy-mildew (11.68%) than June- or January-sown crops.

Premature drying of maize was high when
63-day-old plants were inoculated with *Fusarium moniliforme*. Stem-borer attack predisposed maize plants to *Fusarium* infection.

Up to 74.7% of army-worm larvae were found to be parasitized by *Apaniella* sp. in the field during March.

**Nutritional Quality**

Up to the fifth day after germination, there was an increase in the lysine and tryptophan in the sprouted kernels of hybrid 'Ganga 5' (having normal endosperm) as well as com-

### Table 14. Comparative performance of maize, wheat and sorghum grown in *rabi* at Kolhapur (mean of 3 years)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety and fertilizer dose</th>
<th>Grain yield (q/ha)</th>
<th>Stover yield (q/ha)</th>
<th>Cost of cultivation (Rs/ha)</th>
<th>Gross return (Rs/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>'Manjari' composite NPK 120:60:40</td>
<td>82.9</td>
<td>130.9</td>
<td>2,145</td>
<td>13,838</td>
</tr>
<tr>
<td>Wheat</td>
<td>'HD 2189' NPK 120:50:30</td>
<td>34.5</td>
<td>41.0</td>
<td>2,140</td>
<td>7,940</td>
</tr>
<tr>
<td>Sorghum</td>
<td>'CSH 8R' NPK 120:50:30</td>
<td>27.9</td>
<td>146.2</td>
<td>1,935</td>
<td>5,170</td>
</tr>
</tbody>
</table>

### Table 15. Maize genotypes showing resistance or tolerance to important insect pests and diseases

<table>
<thead>
<tr>
<th>Insect pest or disease</th>
<th>Genotypes showing resistance or tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kharif</strong> Stem-borer</td>
<td>'WRF 9', 'EH 2065', 'J 3022', 'EH 2082', 'J 3019', 'J 3037', 'PK Hunius', 'EH 5131', 'EH 2435', 'EH 2425', 'EH 401075', 'EH 2033', 'Pool 3' × 'Pool 13', 'EH 40934', 'EH 40914', 'EH 201778', 'L 21', 'R 2', 'D 765' × 'D 787'</td>
</tr>
<tr>
<td>Downy-mildew</td>
<td>'EH 5131', 'Co 1', 'Nagdi White', 'EH 5041'</td>
</tr>
<tr>
<td>Late-wilt and Turcicum leaf-blight</td>
<td>'EH 20778', 'EH 5131', 'EH 5041', 'Diara' ('ZFS 8')</td>
</tr>
<tr>
<td>Maydis leaf-blight</td>
<td>'Renuka'</td>
</tr>
</tbody>
</table>

### Table 16. Chemical control measures effective against major pests of maize

<table>
<thead>
<tr>
<th>Pest</th>
<th>Chemical control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem-borer</td>
<td>Spraying of 10–25-day-old crop with Endosulfan 35 EC 0.1% or Decis 2.8 EC</td>
</tr>
<tr>
<td></td>
<td>Seed treatment with Carbofuran 35 ST @ 10 kg/g of seed</td>
</tr>
<tr>
<td>Borer in <em>rabi</em></td>
<td>Soil application of Carbofuran 3 G @ 1 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Spraying of 10–25-day-old crop with Carbofuran 35 ST or Endosulfan 35 EC 0.1% followed by Carbofuran 3 G @ 7.5 kg/ha</td>
</tr>
<tr>
<td>Borer in Punjab Army-worm in Punjab</td>
<td>Ripcord 10 EC (a pyrethroid)</td>
</tr>
<tr>
<td></td>
<td>Thiodan 35 EC</td>
</tr>
<tr>
<td></td>
<td>Endosulfan</td>
</tr>
<tr>
<td></td>
<td>Cymbush 25 EC (Cypermethrin)</td>
</tr>
<tr>
<td></td>
<td>Sumicidin 20 EC (Fenvalerate)</td>
</tr>
</tbody>
</table>

Site 'Opaque 2 SO/SN' (with hard endosperm) when compared with unsprouted kernels, but their *in-vitro* protein digestibility and crude-fibre content showed a decrease. However, when the plumule and radicle of the sprouted kernels were removed, *in-vitro* protein digestibility also showed an increase. Feeding experiments with rats as test animals indicated that one-day-old germinated kernels provided better lysine and tryptophan, with a slight decrease in digestibility. But when kernels with 4-day-old sprouts were used, the growing sprouts reduced the biological availability of protein. Removal of the plumule and radicle increased the protein quality, with a slight decrease in total dry matter.
RESEARCH ACCOMPLISHMENTS

SORGHUM

Varietal Improvement

The 17th All-India Annual Sorghum Workshop recommended the release of kharif varieties ‘SPV 462’ and ‘SPV 475’, whose average grain yield was 32.5 q/ha, matching that of ‘CSH 5’, a landmark in sorghum improvement.

Among the promising entries were ‘CSH 10’, ‘SPV 462’ and ‘SPV 475’ for late kharif, and ‘SPV 489’ and ‘SPH 280’ for rabi. ‘UPFS 23’, ‘S 241’, ‘S 281’ and ‘S 301’ were the most promising forage varieties.

To diversify the genetic base and bring about qualitative improvement, a number of new male-sterile lines were developed. Hybrids derived from male-sterile ‘81 A’, ‘205 A’, ‘11 A’, ‘M 9 A’ and ‘M 12 A’ showed excellent performance. Likewise, ‘SB 401 B’, ‘AKMS 3 B’, ‘M 9 B’, ‘M 10 B’ and ‘205 B’ gave high grain yields in evaluation trials conducted during the past 3 years.

The MPKV, Rahuri, identified ‘SSV 53’, which gave high yield of green stalks (48.99 tonnes/ha) as well as grain (24.9 q/ha). It is a promising variety for jaggery production as its sap contains 60.3% non-reducing sugars and 17.5% reducing sugars.

The PKV, Akola, evolved hybrid ‘AKSH 73’ (‘SPH 388’), which was comparable to ‘CSH 9’ in grain yield but produced 27% more fodder. ‘AKSV 69–1’ (‘SPV 734’), maturing in 107 days, gave as much grain yield as ‘CSH 1’ but gave 48% more fodder. Its grain did not get discoloured in wet weather. ‘AKSV 37’ ‘SPV 475’ sorghum variety is identified for cultivation in kharif all over the country. On an average it yields 33 q/ha.
('SPV 669') showed high tolerance to grain mould and produced easily threshable grains of good bread-making quality.

**Crop Production**

When *kharif* sorghum was planted on dry soil before the onset of the monsoon, the crop grew vigorously and produced higher yields of grain and fodder.

In *rabi*, planting ‘CSH 12 R’, ‘Swati’ and ‘CSV 8 R’ in paired rows (45–90 cm) or wide rows (60 cm) resulted in higher yields of both grain and fodder.

Row spacing had no effect on the yield of sorghum grown for forage, the yield being the same whether the row spacing was 25 cm or 75 cm.

When grown as intercrops, cowpea, clusterbean and sunhemp had no adverse effect on sorghum yield.

Groundnut, mungbean, soybean and sunflower were found suitable high-value crops for intercropping with sorghum in a 3:3 or 4:2 row ratio. The yields obtained from the intercropped plots were 80% of the sorghum yield and 50% of the intercrop yield when compared with the yields of the sole crops. Such intercropping proved to be remunerative.

On irrigated lands at Coimbatore, the net return was Rs 4,950/ha when sorghum was intercropped with ‘Co 1’ cowpea.

In Andhra Pradesh, intercropping of ‘CSH 6’ sorghum and pigeonpea in a 2:1 row ratio was found to be as advantageous as growing a sole crop of sorghum.

Spraying of boron 200 ppm on the timely-sown female parent ‘296 A’ had significantly decreased the bursting of pollen tubes and increased the seed setting (59.72%) at Rahuri. For timely or late sowing, ‘296 B’ was found to be better than other males.

In a multilocation trial conducted in 7 environments with 100 selected genotypes, ‘SPV 775’, ‘ICVS 112’, ‘IS 20969’ and ‘IS 12611’ showed tolerance to drought.

The MPKV has developed ‘SSV 53’ sorghum variety, which yields 24.9 quintals of grain and 49 tonnes of green stalk per hectare. The sap contains 80.3% non-reducing sugars and 17.5% reducing sugars and is hence suitable for jaggery production.

**Crop Protection**

The parasite *Bucelatoria bryani* was successfully raised on *Heliothis*, and the midge predator *Orius maxidentex* on *Drosophila*.

With inundative release, *Trichogramma chilonis* parasitized 61.5% of the eggs of the sorghum stem-borer, and *Apanteles flavipes* parasitized 32.5% of the larvae.* Steinernema feltiae*, an entomophagous nematode, could successfully be raised on the stem-borer, army-worm and *Heliothis*. When released on leaf whorls, the nematode caused mortality of the army-worm.

At Coimbatore, *Scymnus gracilis* (a coccinellid beetle) was found to be a potential predator of *Oligonychus indicus*, the sorghum mite. A single grub consumed 41 to 72% eggs, and an adult beetle 40 to 50 nymphs and adults of the sorghum-mite per day.

When the soil or seed of sorghum was inoculated with *Azospirillum*, the plants accumulated more phenolic content, which seemed to have a deterrent effect on shoot-fly, whose damage was reduced by 30%.
Table 17. Sorghum genotypes showing resistance or tolerance to important pests and diseases

<table>
<thead>
<tr>
<th>Resistance or tolerance to</th>
<th>Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem-borer</td>
<td>‘IS 18695’, ‘IS 21871’, ‘PM 6751’, ‘PM 13553’</td>
</tr>
<tr>
<td>Shoot-fly, stem-borer</td>
<td>‘IS 14332’, ‘IS 3443’</td>
</tr>
<tr>
<td>Multiple resistance</td>
<td>‘IS 2123’, ‘IS 1855–1’</td>
</tr>
<tr>
<td>Shoot-fly (at APAU)</td>
<td>‘IS 2123’, ‘IS 1855–1’</td>
</tr>
<tr>
<td>Ear-bug (at APAU)</td>
<td>‘IS 2309’</td>
</tr>
<tr>
<td>Charcoal-rot (at MAU)</td>
<td>‘SPV 496’, ‘SPV 570’, ‘SPV 655’, ‘SPV 720’</td>
</tr>
</tbody>
</table>

Screening of the germplasm has resulted in the identification of 41 genotypes showing resistance or tolerance to important pests and diseases (Table 17).

PEARLMILLET

Varietal Improvement

Hybrid ‘Pusa 23’, having a maturity period of 77 days, was released in 1987 for cultivation in the drought-prone areas in Gujarat and Rajasthan.

‘MH 208’, released earlier in Haryana, was recommended for all the pearl millet-growing states as it outyielded ‘MBH 110’.

‘MH 143’ and ‘MH 169’ did well in Rajasthan, Gujarat, Uttar Pradesh and Haryana. ‘MH 143’ performed well in Punjab, Andhra Pradesh, and Karnataka.

Among the much-sought-after white-grained pearl millet types, ‘MW 38’, ‘MW 41’, ‘MW 31’, and ‘MW 30’ gave grain yields of 2,000 to 2,240 kg/ha.

Using 4 inbred lines and 116 restorers from the ICRISAT and other sources, the MAU, Parbhani, made a number of test crosses, of which 40 promising hybrids yielded 21–24% more than the currently recommended hybrids.

Crop Production

At narrow or wide spacing (45 cm × 15 cm or 90 cm × 15 cm) planting 2 seedlings to a hill was found to be better than planting a single seedling, indicating the need to increase the planting density.

_Azospirillum_ and vesicular arbuscular mycorrhizae (VAM), when applied individually, increased pearl millet yields. Their combined application, which was better, effected a saving in the N and P fertilizers required to sustain high yields. When _Azospirillum_ + VAM + 30 kg each of N and P/ha were applied, the grain yield was 2,179 kg/ha, compared with 571 kg/ha in the control.

In times of drought, pearl millet plants severely compete with each other for water. Most of them wither and die when the soil moisture is not adequate to sustain them. Research showed that under such circumstances, if 60% of the plants are pulled out 40 days after sowing, the remaining 40% would grow to maturity and give at least 82% yield. The yield will be about 64% if 60% of the plants are pulled out as late as 70 days after planting.

Seed and soil treatment with Jalashakti (a polymer known to capture moisture and minimize transpiration losses) increased pearl millet yields by 7.5 to 16.4%. Jalashakti marginally decreased the height but increased the leaf area (at ear emergence) and 1000-grain weight.

Of the 4 pigeonpea varieties tried for interplanting with pearl millet, the semi-spreading ‘BDN 7’ not only gave the highest yield of 795 kg/ha but also enabled pearl millet to achieve the highest yield level of 1,575 kg/ha in the interplanting trial.

Good management, fertilizer application and irrigation, individually as well as jointly, significantly increased the yields of pearl-
millet, whether the variety used was a local one, an improved one or a hybrid. The hybrid and the improved variety gave higher yields at all levels of treatments.

When pearl millet was sown in furrows prepared before the monsoon to conserve rainwater, it gave 98% more yield than the flat-sown crop at MPKV, Rahuri. When the dry spell lasted for 6 weeks or more, foliar application of 3% urea or diammonium phosphate was beneficial to the crop.

Crop Protection

Research showed that downy-mildew is more a soil-borne disease than a seed-borne one.

The incidence of white-grubs was less when pearl millet was intercropped with mungbean. It was also less when 1.2 kg of 10% BHC was mixed with farmyard manure and used as a bait for white-grubs.

**FINGER MILLET**

**Varietal Improvement**

The first Small Millets Workshop held in April 1987 recommended 4 fingermillet varieties for cultivation in different regions (Table 18).

The TNAU, Coimbatore, released 'TRY 1', capable of yielding 4,676 kg/ha in 100 days. It outyielded 'Co 12' by 24%.

The VPKAS, Almora, has identified 'VL 124' and 'VL 130' for minikit trials in the hills of Uttar Pradesh.

Based on the performance in multilocation trials, the white-grained 'OUAT 2' was identified for minikit trials in different states. After extensive screening, many new sources of blast resistance were identified, and the following 10 genotypes are being used in hybridization programmes: 'GE 75', 'GE 156', 'GE 406', 'GE 639', 'GE 669', 'GE 844', 'GE 1424', 'GE 1423', 'GE 1546' and 'GE 1916'.

**Crop Production**

Seed inoculation with *Azospirillum*, *Azotobacter* and a phosphate-solubilizing fungus was effective in increasing grain yields. A combination of phosphate-solubilizing fungus and *Azospirillum* increased grain yield by 10–15%.

At Bangalore it was found remunerative to intercrop fingermillet with pigeonpea (8:2). Sowing of pigeonpea in June along with cowpea as green-manure crop, followed by transplanting of fingermillet in August was found to be more remunerative than sowing a mixed crop of fingermillet and pigeonpea.

At many locations fingermillet responded up to 60 kg N/ha, which appeared to be the optimum dose.

At Bangalore, seed-coating with Jalashakti @ 20 g/kg of seed + soil application @ 8 kg/ha gave a yield of 33.62 q/ha, compared with 25.81 q/ha in the control.

**SMALL MILLETS**

**Varietal Improvement**

Little millet variety 'Paiyur l' ('DPI 1213') was released for cultivation in the Salem and Dharmapuri districts of Tamil Nadu. In 100 days it yielded 870 kg/ha—20% more than 'Co 2'.

Foxtail millet 'K 5' was released for general cultivation in the southern districts of Tamil Nadu.

The TNAU, Coimbatore, released proso-millet 'Co 4' (1,400 kg/ha in 75 days) and foxtail-millet 'K 3' (1, 620 kg/ha in 82 days).
At the VPKAS, Almora, barnyard-millet variety 'VL 21' outyielded 'VL 8' by 30%.

The APAU, Hyderabad, released foxtail-millet varieties 'SIA 2566' and 'SIA 2571'. Little-millet 'PRC 17' and foxtail-millet varieties 'TNAU 46' and 'GPUS 1' were identified for minikit trials.

Several small millet varieties showed superior performance in multilocation trials (Table 19).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foxtail-millet</td>
<td></td>
</tr>
<tr>
<td>'SIA 2593', 'GPUS 1', 'SIC 34', 'SIC 14', 'SIA 2592'</td>
<td>Outyielded 'Arjuna' and 'SIA 326' by 30%</td>
</tr>
<tr>
<td>Kodomillet</td>
<td></td>
</tr>
<tr>
<td>'PSC 12', 'PSC 9'</td>
<td>Outyielded 'IPS 147-1' by 10-12%</td>
</tr>
<tr>
<td>Barnyard-millet</td>
<td></td>
</tr>
<tr>
<td>'RAU 12', 'ECC 6',</td>
<td></td>
</tr>
<tr>
<td>'ECC 22'</td>
<td></td>
</tr>
</tbody>
</table>

Crop Production and Protection

When a mixture of farmyard manure, Azosprillum and 10 kg N/ha was applied, small millets gave yields comparable with those obtained with 20 kg N/ha.

Mixed-cropping of little-millet + urdbean was remunerative at Kanke, Bihar.

At the APAU, Hyderabad, when foxtail-millet was intercropped with pigeonpea in a 5:1 ratio, the monetary gains were as high as Rs 6,804/ha on rainfed lands.

In screening trials with small millets, useful types of foxtail-millet and barnyard-millet with tolerance to diseases and pests were identified (Table 20).

PULSES

Pigeonpea

'TTB 7' was recommended for areas having red soils in Karnataka, where it yielded 40–52 q/ha.

Table 20. Genotypes of foxtail-millet and barnyard-millet showing tolerance to diseases and pests

<table>
<thead>
<tr>
<th>Millet</th>
<th>Genotype</th>
<th>Tolerant to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foxtail-millet</td>
<td>'RHRR 29', 'SIA 2591', 'S 115'</td>
<td>Rust and smut</td>
</tr>
<tr>
<td></td>
<td>'GS 418', 'GS 455'</td>
<td>Army-worm</td>
</tr>
<tr>
<td>Barnyard-millet</td>
<td>'KE 11', 'KE 12'</td>
<td>Grain-smut</td>
</tr>
</tbody>
</table>

In soils with excessive moisture, 'T 7', 'Bahar' and 'DA 11' performed better than others at Dholi, Bihar.

In the light soils of Hisar, basal application of zinc sulphate @ 25 kg and borax @ 10 kg/ha increased the productivity of pigeonpea by 346 kg/ha (24.8%) over the control. Borax @ 10 kg/ha was beneficial on the acid soils of Chhota Nagpur also.

In the irrigated lands of the peninsular region, when the medium-maturing unratoooned crop of 'Vishakha' yielded 1,726 kg/ha, the early-maturing ratooned 'ICPL 87' produced 2,710 kg/ha, the optimum population being 320,000 plants/ha. In the northern plains, however, the yield of the ratooned crop was inferior to that of the unratoooned, late-maturing 'Bahar'.

On rainfed lands, the critical period for weeding was the first 45 days when early pigeonpea was intercropped with urdbean or mungbean, and the first 30 days when medium-duration pigeonpea was intercropped with pearl millet. Unchecked weeds reduced the average pigeonpea and intercrop yields by 73% and 81% in the central zone, 43% and 56% in the north-eastern plains and 46% and 31% in the north-western plains, respectively.

At Dholi, the time of planting was the most important non-monetary factor in increasing pigeonpea yields—followed by the choice of the variety and timely and adequate weed control. When compared with the checks, timely planting increased the yield by 120%, the recommended variety by 33%, and proper weed control by 19%.

Mixed-cropping of late pigeonpea (100% planting density) with sesame or urdbean or sorghum or Setaria (30% planting density)
The time of planting is an important factor in obtaining high yields of pigeonpea. At Dholi, timely planting has increased the yield by 120%, the recommended variety by 33%, and weed control by 19% over the check.

was more productive than the sole crop of pigeonpea. Planting paired rows of pigeonpea and one row of mixed crops was distinctly superior to broadcasting.

Chickpea

Two Kabuli-type chickpea varieties were identified for the north-western plains—'BG 267' (salmon-white bold seed, 2,776 kg/ha in 140-155 days) and 'GNG 149' (2,810 kg/ha in 145-170 days).

At the AAU, Jorhat, the most promising varieties identified were 'BG 240', 'BGM 425', 'GNG 174' and 'G 114'.

Pod-borer resistance was noticed in 'ICC 4835', 'E 2793', 'DPR/CE 3-1', 'GL 1002' and 'ICCL 86101'.

The PAU, Ludhiana, released 'PBG 1' (16 q/ha), which showed resistance to blight.

Seven chickpea varieties were identified for late-sown irrigated tracts (Table 21).

Late-sown chickpea responded to 2 irrigations—the first at branching and the second at pod initiation—the increase being

431 kg/ha (55.2%) over no irrigation (780 kg/ha).

Jalashakti gave better results when planted in furrows than when broadcast or incorporated in the soil. Rainfed chickpea yielded 186 kg more grain than the control (1,314 kg/ha) when Jalashakti @ 2 kg/ha was placed in the furrows at the time of planting chickpea.

At Coimbatore, a pre-plant incorporation of Fluchloralin @ 0.75 kg/ha or a pre-emergence spray of Pendimethalin effectively controlled the weeds of chickpea + coriander intercropping. Jalashakti had no adverse effect on the effectiveness of the weedicides.

Mungbean and Urdbean

One mungbean and 2 urdbean varieties were released for cultivation in the non-traditional rabi, spring and summer seasons. Mungbean 'PDM 11' would be suitable for cultivation in spring in the central zone. Urdbean 'PDU 1' has been recommended for cultivation in spring in northern Rajasthan, Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh, Gujarat and Maharashtra, and 'LBG 17' for rabi in the southern zone. Urdbean 'Adt 4' was developed by the TN AU, Coimbatore.

The following rabi, spring and summer mungbean and urdbean varieties were under final testing.

Mungbean, rabi/spring: 'LGG 407', 'Lam M 2'

spring: 'SML 68', 'PDM 84-143'

summer: 'MH 81-7', 'PDM 16', 'PDM 54'

<table>
<thead>
<tr>
<th>Region</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-western plains</td>
<td>'KPG 59' (3,047 kg/ha)</td>
</tr>
<tr>
<td></td>
<td>'GL 769'</td>
</tr>
<tr>
<td>North-eastern plains</td>
<td>'Radhey' (1,560 kg/ha)</td>
</tr>
<tr>
<td></td>
<td>'Pant G 114'</td>
</tr>
<tr>
<td>Eastern zone</td>
<td>'Pant G 114' (1,927 kg/ha)</td>
</tr>
<tr>
<td></td>
<td>'RSG 44'</td>
</tr>
<tr>
<td>Central zone</td>
<td>'BG 244' (1,990 kg/ha)</td>
</tr>
<tr>
<td></td>
<td>'BDNG 25'</td>
</tr>
</tbody>
</table>
Urdbean, rabi/summer: 'UH 80-4' 
   spring: 'DU 4', 'UPU 83-2', 'PDU 104', 'PDU 101'
Mungbean 'LGG 450' (1, 583 kg/ha), resistant to pre-harvest sprouting, was found to be superior to 'Pusa 105'.
Fertilizer use, weed control and pest management increased the yield of urdbean by 813 kg, of kharif mungbean by 517 kg and of spring mungbean by 472 kg/ha. Summer mungbean responded significantly to P2O5 application up to 40 kg/ha, with an additional yield of 246 kg/ha, ammonium polyphosphate proving more efficient than single superphosphate. The critical input was irrigation in spring, and weed control in kharif.
Mungbean 'Pusa 326' and 'ML 372' proved highly resistant to white-fly, jassids, yellow-mosaic and pod-borer.

Lentil
Bold-seeded lentil varieties 'Lens 4076' and 'K 75' gave superior performance.
The PAU, Ludhiana, released 'LL 147' (13.5 q/ha), 'LL 298' and 'LL 56' showed minimum damage due to borer.

Rajmash
Rajmash, hitherto grown in the hills, has been successfully introduced in the plains as a rabi pulse. 'PDR 14' (average 1,724 kg/ha) was the top yielder in most of the regions. The ideal time for its planting is the first week of September in Punjab and Haryana, and the last week of October in the north-eastern plains, central zone and the peninsular region.

Cowpea
The drought-tolerant 'TVX' was released for cultivation in the red soils of Karnataka. The UAS, Bangalore, recommended 'KBG 1' for the southern districts of Karnataka.

Field-pea
In multilocation trials, the promising types were 'Pant P 9', 'HEP 4', 'KPMR 85' and 'JP

The release of 'PDR 14' has now made it possible to grow rajmash as a rabi pulse in the plains. On an average this variety yields 1,724 kg/ha when planted in the first week of September in Punjab and Haryana, and in the last week of October in the north-eastern plains, central zone and the peninsular region.

4–1' in the tall group, and 'KFPD 2', 'DFPD 10', 'HVIP 2' and 'DDR 4' in the dwarf group.
With a row spacing of 15 to 22.5 cm, dwarf genotypes 'HFP 4' and 'KPSD 1' (31–35 q/ha) outyielded 'Rachna' (26 q/ha) at Hisar and in the north-western plains.

Cropping Systems with Pulses
In sequential cropping, kharif pulses—particularly cowpea, clusterbean and urdbean—increased the grain yield of the succeeding wheat crop by 3 to 13 q/ha and economized the N needs of wheat by 40 to 80 kg/ha.
For growing in the rice falls at Bangalore, cowpea, with a grain yield of 1,488 kg/ha, was the most productive legume, followed by pigeonpea and field-bean.
In pigeonpea + sorghum intercropping, unchecked weeds caused a yield loss of 1,253 kg/ha (pigeonpea equivalent). When compared with the weed-free check, dicot weeds on an average caused a yield loss of 406 kg, sedges 657 kg, and other monocot weeds 758 kg/ha.
Physiology

Rising temperature and low humidity were found to affect grain development in late-planted chickpea. ‘BG 261’, ‘886 B’ and ‘L 550’, in which grain growth was rapid, suffered less.

Even when supplied with the required inputs, chickpea varieties grown in cooler places developed only 16.6% total dry matter by the 60th day after sowing. They also showed a lag period of 25-46 days for initiating pod.

In early-maturing varieties of pigeonpea, waterlogging 25 days after sowing was detrimental to plant growth and reduced grain yield, the least reduction being in ‘ICPL 87’.

Crop Protection

In large-scale pest-control demonstrations, pigeonpea yields could be stepped up by 72-157%, mungbean by 323%, chickpea by 178% and field-pea by 18-21%.

The use of nuclear polyhedrosis virus (NPV) @ 250 or 500 larval equivalent (LE)/ha was effective against the chickpea pod-borer. A combination of 0.035% Endosulfan with NPV 250 LE/ha was as good as 0.07% Endosulfan (full dose).

In screening trials, 120 genotypes of different pulses were found to show tolerance or resistance to important diseases.

SOYBEAN

The NRC for soybean at Indore added 1,850 new germplasm accessions to the existing collection and identified a number of promising early-maturing genotypes for use in breeding programmes.

‘MACS 58’ was recommended for pre-release adaptive trials in the central zone (Madhya Pradesh, Maharashtra, Gujarat and parts of Rajasthan). It is a high-yielding, non-lodging variety of semi-determinate habit, is suitable for mechanical harvesting, and has resistance to bacterial pustules, yellow-mosaic, leaf-spot and bud-blight.

Rhizobium strain UASB 229, developed by the UAS, Bangalore, proved to be superior to IARI 2 strain.

Basalin @ 5 kg ai/ha followed by a hand-weeding 30 days after sowing was effective in controlling weeds in soybean fields.

The most effective measures for controlling soybean pests are given in Table 22.

Table 22. Measures for controlling soybean pests

<table>
<thead>
<tr>
<th>Pest</th>
<th>Control measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem-fly, girdle-beetle and green semi-loopers</td>
<td>2 sprays of Monocrotophos 0.05% or Endosulfan 0.07% or Quinalphos 0.0%5, the first spray when infestation is noticed and the second spray 10-15 days later</td>
</tr>
<tr>
<td>Leaf-miner</td>
<td>Phosphamidon 0.02%, 20 and 50 days after sowing</td>
</tr>
<tr>
<td>Bihar hairy-caterpillar and tobacco caterpillar</td>
<td>0.05% on the first and second instars of the caterpillar</td>
</tr>
</tbody>
</table>

OILSEEDS

Groundnut

Two promising varieties were developed for cultivation in the peninsular region (Table 23).

Table 23. Groundnut varieties developed for cultivation in the peninsular region

<table>
<thead>
<tr>
<th>Varieties identified</th>
<th>Region</th>
<th>Specific features</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘ICGS 2271 (VB)*</td>
<td>Tamil Nadu, Kerala</td>
<td>Tolerant to jassids, thrips and leaf-miner; 30% higher yield than ‘TMV 10’ and ‘M 13’</td>
</tr>
<tr>
<td>‘ICGS (FDRS 10 (SB)*</td>
<td>Andhra Pradesh (excluding the north coastal areas), Karnataka, south-eastern Maharashtra and the check</td>
<td>Tolerant to foliar diseases; yields 25% more pods and 21% more kernels than the check</td>
</tr>
</tbody>
</table>

In large-scale adaptive trials, rabi/summer variety ‘RSHY I’ (SB) outyielded* ‘AK 12-24’ by 18% in Orissa, and ‘ICGS 44’ out-

*The yield of groundnut refers to pod yield.
The tropical oil palm with stout, coarsely ringed stems bears large clusters of ornamental red fruits which yield over 6 tonnes of commercial palm oil per hectare in a year. It does best in warm regions.

yielded ‘GG 2’ by 26% in Gujarat and western Rajasthan.

Of the 5,800 collections evaluated at the NRCG, Junagadh, 68 collections gave a pod yield of 26-30 g/plant. A number of interspecific triploids and tetraploids with economic attributes were developed by utilizing cultivars and wild species.

The TNAU evolved two Spanish bunch varieties, ‘VRI 1’ (‘VG 18’) for rainfed and irrigated areas, and ‘ALR 1’, resistant to foliar diseases, for the Pollachi tract. ‘VRI 1’ outyielded ‘Co 1’ by 33.5% on rainfed lands and by 13.5% in irrigated areas.

A 5-year study in different groundnut-growing regions showed that the returns could be boosted up by Rs 525 to Rs 2,186/ha just by raising 1 row of sunflower in between 2 rows of rainfed groundnut. Such intercropping would insure farmers against fluctuations in groundnut production in rainfed areas.
Paired-row planting increased groundnut yields by about 28% over the traditional method of sowing at a distance of 90 cm, widely followed in the Saurashtra region.

Some Spanish bunch varieties gave 14 to 40% higher pod yield when irrigated just before flowering, even when there was a drought stress during the vegetative phase. 'GG 2' showed resistance to water stress. Basal incorporation of coir dust @ 5 tonnes/ha a fortnight before sowing reduced soil-crusting and improved groundnut yields. A combined spray of diammonium phosphate (0.5%), Planofix (40 ppm) and ammonium sulphate (0.2%) increased yields by 18%.

Three new sucking pests of groundnut, along with a predatory fly and a parasitic mite, were recorded for the first time. 'TMV 7', 'TMV 9', 'NRGS (FDRS) 1', and 'CGC 4002' showed resistance to Spodoptera litura. Soil application of Phorate or Carbofuran @ 1.0 kg ai/ha at the time of sowing was effective in controlling the pest complex of summer groundnut.

*Rhizobium* culture IGR 40 increased the pod yields of summer bunch groundnut by about 30%. Nitrogen fixation was drastically reduced under water stress in all varieties except 'GAUG 1' and 'GG 2'. Virginia runner types, in general, had a lower nitrate-reductase activity and a higher nitrogen-fixing efficiency. Even at a low level of 25 ppm, Thiram inhibited the growth of *Rhizobium* in pure culture. When quality seed from authorized sources was used, pod yields were higher by 37% at Akola, 54% at Durgapur, 71% at Faizabad, 74% at Jagtial, 16% at Jaggaon, 26% at Khargaon and 29% at Vridhachalam.

**Rapeseed-mustard**

Over 360 new accessions of different species of the tribe Brassicae were added to the existing collection at Hisar. Extensive screening showed that a number of promising germplasm lines possessed tolerance or resistance to aphids, *Alternaria* blight, white-rust and downy-mildew.

In the Krishna-Godavari region of Andhra Pradesh as well as in Vidarba and western Maharashtra, mustard showed a good potential for cultivation as an irrigated *rabi* crop, with an average yield of 1,000 to 1,200 kg/ha. Rapeseed could successfully be grown as a summer crop at high altitudes in Himachal Pradesh (1,200 kg/ha). 'RW 85-89' ('Sarma'), 'Varuna' and 'ND 8501' showed high adaptability to late sowing.

In rainfed areas of mid-western Uttar Pradesh intercropping mustard in wheat in a row ratio of 1:9 gave an additional return of Rs 678/ha over the farmers' practice of broadcasting mustard in wheat.

Studies have shown that 'GSL 1' variety of 'gobhi sarson' (*Brassica napus*) would yield 21.5 to 24.6 q/ha if 60-day-old seedlings are transplanted in the third week of November. Large areas vacant after the harvest of *kharif* rice and cotton in Haryana and Punjab can hence be brought under 'gobhi sarson'.

**Sesamum**

Over 3,200 germplasm collections were evaluated for economic traits at Jabalpur. Three high-yielding sesamum varieties were released. In Punjab 'TC 289' yielded 14% more seed than 'Punjab Til 1'. In Maharashtra, the white bold-seeded 'Tapi', maturing in 71 to 82 days, gave 35% higher seed yield than the best check and was tolerant to leaf-roller and capsule-borers. Its seed contained 50.5% oil. 'Krishna' was released in Bihar for *rabi/summer* cultivation under irrigation.

In western Madhya Pradesh, intercropping of sesamum with mungbean (3:1) or soybean or kodomillet gave a monetary return of Rs 6,440/ha. In western Uttar Pradesh, sesamum + pigeonpea intercrop (1:1) gave the highest monetary return of Rs 6,790/ha, as well as higher land-equivalent ratio.

**Niger**

Niger + urdbean (2:2) was the best intercropping system at Similiguda, Orissa (Rs
'MSFH 10' is suitable for all the sunflower-growing regions. In Karnataka, Madhya Pradesh and Rajasthan it has outyielded 'BSH 1' by 32 to 67%.

1,250/ha), and niger + pigeonpea was most remunerative at Kanke, Bihar (Rs 5,300/ha).

In Maharashtra, Orissa and Bihar, 'IGP 72' and 'IGP 76' significantly responded to a N dose of up to 30 kg/ha, the optimum density being 200,000 plants/ha at a spacing of 30 cm × 15 cm.

**Castor**

During the year, 96 exotic collections were added to the existing germplasm at Hyderabad.

In screening trials in wilt-sick plots at Dantiwada, Gujarat, 17 accessions showed resistance to wilt, and 6 to root-rot.

**Sunflower**

At Bangalore, 179 exotic accessions were added to the existing germplasm.

'MSFH 10' was recommended for cultivation in all the sunflower-growing regions. It yielded 11% more seed and 8% more oil than 'MSFH 8'. In large-scale adaptive trials in Karnataka, Madhya Pradesh and Rajasthan, 'MSFH 8' outyielded 'BSH 1' by 32 to 67%.

**Safflower**

The adaptability, productivity and other useful traits were evaluated in 681 germplasm collections.

In eastern Uttar Pradesh, cultivation of legumes in sequence reduced the N needs of safflower from 40 to 20 kg/ha in drylands.

In the Malwa region of Madhya Pradesh, intercropping of 2 rows of safflower after every 2 or 3 rows of linseed gave better returns and cost:benefit ratio than the cultivation of a sole crop of linseed.

In vertisols with limited irrigation in Maharashtra, safflower gave a better cost:benefit
ratio and higher monetary returns (Rs 5,092/ha) than sorghum (Rs 2,364/ha), wheat (Rs 1,423/ha) and chickpea (Rs 2,343/ha).

Linseed
Ten economic characters, including resistance to diseases and pests, were evaluated in 1,964 collections. ‘RLC 6’ was recommended for cultivation in the central and peninsular regions as it showed multiple resistance to diseases and yielded 50.6% more than the locals and 25.6% more than ‘Jawahar 23’.

The dual-purpose ‘Gaurav’, released last year for cultivation in Assam, West Bengal, Bihar and Uttar Pradesh, excluding the Bundelkhand region, matched the best seed type in seed yield (1,000 kg/ha) and the best flax type in fibre yield.

The best intercropping systems were linseed + lentil (1:3) at Berhampore, West Bengal (additional income Rs 602/ha), and linseed + chickpea (1:3) in the drylands of Madhya Pradesh (extra income Rs 1,650/ha).

Breeder’s Seed of Oilseed Crops
During the year, breeder seed production was increased by 34% over that of the preceding year.

<table>
<thead>
<tr>
<th>Crop</th>
<th>1985-86 (in quintals)</th>
<th>1986-87 (in quintals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td>1,762.45</td>
<td>2,644.23</td>
</tr>
<tr>
<td>Soybean</td>
<td>852.80</td>
<td>887.00</td>
</tr>
<tr>
<td>Rapeseed-mustard</td>
<td>38.95</td>
<td>33.34</td>
</tr>
<tr>
<td>Sesamum</td>
<td>8.79</td>
<td>9.25</td>
</tr>
<tr>
<td>Linsed</td>
<td>24.55</td>
<td>44.02</td>
</tr>
<tr>
<td>Castor</td>
<td>34.78</td>
<td>23.20</td>
</tr>
<tr>
<td>Sunflower</td>
<td>17.38</td>
<td>28.16</td>
</tr>
<tr>
<td>Safflower</td>
<td>21.08</td>
<td>26.39</td>
</tr>
<tr>
<td>Niger</td>
<td>1.22</td>
<td>4.41</td>
</tr>
<tr>
<td>Total</td>
<td>2,762.00</td>
<td>3,700.00</td>
</tr>
</tbody>
</table>

In addition, 633 quintals of foundation seed of sunflower were produced.

**SUGARCANE**

**Varietal Improvement**
‘CoLK 8001’, developed at the IISR, Lucknow, was recommended for upland areas of the western zone. It is a thick, tall, fertilizer-responsive, drought-tolerant variety resistant to red-rot, wilt and smut.

A total of 21.4 kg fluff from 299 crosses and 58 general collections produced at the SBI, Coimbatore, was supplied to 18 sugarcane research centres. Twelve somaclones incorporating smut resistance were derived from ‘CoC 671’, ‘SD 8201’ and ‘G 80-454’. Seven somaclones with translocations involving the chromosomes of *Saccharum officinarum* and *Sclerotachya fusca* were identified from a population obtained by gamma-irradiation of the callus of *Saccharum spontaneum* by photoperiodic treatment. Spraying of ethrel during floral initiation suppressed flowering. Application of Glyphosate, a plant growth-regulator, on sugarcane foliage in October or November or January enhanced the concentration of sucrose in the juice. A rapid biochemical test was developed to detect drought resistance in sugarcane. Bactrinol-100, a wide-spectrum bactericide, was found to be useful in the preservation of juice for 24 hours.

**Crop Production**
At the IISR, Lucknow, a combined application of N and K was better than the single application of either of the nutrients in increasing sugarcane yield as well as the percentage of sugar in the juice. Closer interpit distances in the ring method of planting produced taller and more millable canes. The first and second ratoons of sugarcane raised from the pit system yielded more than the conventional ratoons. Harvesting of the crop at the ground level followed by stubble-shaving and application of 200 kg N/ha gave a good ratoon crop.

At the SBI, Coimbatore, 3 short-duration
The drought-tolerant, thick, tall, fertilizer-responsive 'ColK 8001' is recommended for the uplands of the western zone.

crops (1 plant crop + 2 ratoons) in 2 years gave about 25% more cane and sugar yields than 2 crops (1 plant + 1 ratoon) of normal duration.

In the co-ordinated trials trash-mulching proved superior to all other methods in reducing transpiration. Combination of surface and vertical mulch showed better effect.

Crop Protection

At the IISR, Lucknow, grassy-shoot disease could be controlled when the setts were treated with moist hot air at 52 to 54°C for 42 hours. Brown leaf-spot disease could be checked with sprays of Bavistin and diesel-oil. Planting of smut-resistant variety of mustard, coriander or wheat between healthy and diseased rows of sugarcane prevented the lateral movement of smut spores in the field.

Application of neem-cake, green manure and their combinations was effective in reduc-
ing nematode populations in sugarcane ratoons. A crop rotation involving rice followed by mustard intercropped with maize or marigold also was effective in reducing the nematode population in sugarcane-based cropping systems.

In co-ordinated trials black-bug and shoot-borer in the ratoon crop could be effectively controlled with Endosulfan or gamma BHC. In biological control, Empiricania melano-leuca was found to have successfully established itself on sugarcane Pyrilla at Parvaranagar.

**Implements and Post-harvest Technology**

The IISR, Lucknow, designed a 2-row stubble-shaver with attachment for off-barring and fertilizer application. A harvester and pit-digger were also designed and fabricated.

A room temperature of 20 to 35.4°C and a relative humidity of 55 to 65% were found to be optimum for safe storage of jaggery.

**SUGARBEET**

**Variatel Improvement**

‘I.S 6’, developed at the IISR, Lucknow, was recommended for commercial cultivation. It not only recorded higher yields of root and gross sugar, with low impurity index, but was also tolerant to Sclerotium root-rot, leaf-spot, and high temperatures in April and May. ‘Mezzanopoly-R’ and ‘Tribel’ were also recommended for commercial cultivation.

As a reclamatory crop, sugarbeet is well suited to the saline-alkali soils of Sunderbans, Karnal, Banthara and Sultanpur. It removes sodium from the soil and improves its texture.
Crop Production

Autumn-planted sugarcane intercropped with sugarbeet gave good yields of both the crops at Jalandhar and Sriganganagar.

Sugarbeet was successfully cultivated on saline-alkali lands in Sunderbans, Karnal, Banthara and Sultanpur. Sugarbeet not only grew well in such soils but also removed sodium from the soil and improved the soil texture.

A nitrogen level of 120 kg/ha was found to be the optimum for higher yield combined with higher sucrose content.

The potential of sugarbeet for production of alcohol was successfully demonstrated in tests conducted by Sriganganagar Sugar Mills and IFB Agro-Industries, Calcutta. Pharmaceutical-grade sugar was also produced at Sriganganagar.

Crop Protection

At Pantanagar, defoliators could be controlled with Endosulfan. Pelleting of sugarbeet seed with clay and methyl cellulose mixed with a fungicide was successful in controlling seedling disease of sugarbeet. Drenching of soil with Brassicol or Vitavax effectively controlled Sclerotium root-rot.

COTTON

Varietal Improvement

The Cotton Workshop recommended the release of 10 improved varieties and hybrids (Table 24). In addition, a number of intra- and interspecific hybrids performed well in advanced trials.

The CICR, Nagpur, evolved 2 cytoplasmic male-sterile hybrids. ‘RRB 22-4’ (Gossypium barbadense) outyielded the top-ranking ‘Suvin’ by 112%.

Crop Production

The new varieties and hybrids showed excellent response to fertilizer application. ‘GHH 334’ responded up to 320 kg N/ha in Gujarat. Fertilizer response varied from 100 to 225 kg N/ha in the northern zone, whereas it was 80 kg N/ha in the southern zone.

Mulching with straw, polythene and legumes, as well as preparation of ridges and furrows at the end of the rainy season was helpful in conserving moisture and stepped up cotton yields by 100 kg/ha.

The remunerative intercrops were soybean at Kvilipatti, cowpea at Coimbatore, and urdbean and soybean at Nagpur.

Stomp and Antor effectively controlled the weeds of cotton crop.

Foliar spray of diammonium phosphate and Pix reduced physiological boll-shedding and increased the yields of seed-cotton.

Early- and medium-duration varieties with compact frames had a specific advantage in dry-matter production.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Variety or hybrid</th>
<th>Yield and salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>‘HS 45’</td>
<td>Higher yield and better ginning than ‘H 777’; suitable for early-sown tracts</td>
</tr>
<tr>
<td></td>
<td>‘LH 886’</td>
<td>Outyielded ‘F 286’ by 20%</td>
</tr>
<tr>
<td></td>
<td>‘LH 900’</td>
<td>Suitable for late-sown tracts</td>
</tr>
<tr>
<td></td>
<td>‘F 505’</td>
<td>To replace ‘F 286’</td>
</tr>
<tr>
<td>Central</td>
<td>‘AKH 081’</td>
<td>Early-maturing and high-yielding, suitable for double-cropping with wheat in the Vidarbha region</td>
</tr>
<tr>
<td></td>
<td>‘GHH 334’</td>
<td>An intra-hirsutum hybrid for rainfed tracts in place of ‘Hybrid 6’</td>
</tr>
<tr>
<td>Southern</td>
<td>‘Kanchana’</td>
<td>Tolerant to white-fly</td>
</tr>
<tr>
<td></td>
<td>‘T 7’ × ‘M 12’</td>
<td>An intra-hirsutum hybrid with spinning capacity of 60% and 40% higher yield than ‘MCU 5’</td>
</tr>
<tr>
<td></td>
<td>‘Lam Hybrid 2’</td>
<td>An intra-hirsutum hybrid superior to ‘H 6’ and ‘JKHY 1’</td>
</tr>
<tr>
<td></td>
<td>‘DDHY 2’</td>
<td>A desi hybrid for Karnataka</td>
</tr>
</tbody>
</table>
The new cotton hybrids respond to 100 to 225 kg N/ha in the northern zone and up to 320 kg N/ha in Gujarat. High tolerance to white-fly has made 'Kanchana' a much-sought-after cotton variety in the southern zone.

Crop Protection

In co-ordinated trials ‘LK 861’, ‘Kanchana’ ('LPS 141') and ‘Supriya’ showed tolerance to the white-fly.

At the CICR, Lucknow, neemseed-kernel and garlic extracts at 10% concentrations were more effective than Endosulfan in reducing bollworm incidence. Some pyrethroids increased the populations of aphids, mites, white-fly and defoliators.

The measures that proved effective in controlling the major pests and diseases of cotton are summarized in Table 25.

Table 25. Control measures against major pests and diseases of cotton

<table>
<thead>
<tr>
<th>Disease or pest</th>
<th>Control measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>White-fly</td>
<td>Triazophos, Amitraj, Profenophos, Phosalone, fish-oil resin-soap, neem oil</td>
</tr>
<tr>
<td>Grey-mildew</td>
<td>Soil amendment with neem-cake or mahua-cake, @ 200 kg/ha</td>
</tr>
<tr>
<td>(showed sudden spurt in the southern region)</td>
<td>Seed-treatment with Trichoderma harzianum</td>
</tr>
<tr>
<td>Bacterial-blight</td>
<td>Seed-pelleting with Trichoderma harzianum</td>
</tr>
<tr>
<td>Root-rot</td>
<td>Soil amendment with neem-cake or mahua-cake, @ 200 kg/ha</td>
</tr>
<tr>
<td>Seedling mortality due to Rhizoctonia solani and R. bataticola, the incitants of root-rot</td>
<td>Seed-pelleting with Trichoderma harzianum</td>
</tr>
<tr>
<td>Fusarium wilt in Punjab</td>
<td>Seed treatment with Carbendazim</td>
</tr>
</tbody>
</table>

JUTE

Varietal Improvement

In the national evaluation trials, among the white jute varieties (Corchorus capsularis) ‘UPC 7716’ gave the highest yield at Bahrawich (19.70q/ha) and ‘JRC 7447’ at Kendrapara (24.99 q/ha). Among tossa jute varieties (C. olitorius) ‘S 18’ gave the highest fibre yield at Nowgong (30.65 q/ha) and ‘S 19’ at Purnea (18.43 q/ha).

A theoretical jute ideotype was worked-out on the basis of physiological parameters and leaf characteristics.
Scanning under electron microscope has shown that the base by which the fibre is attached to the seed determines the cleanliness of cotton lint. The large fibre base of 'Waged' cotton (top) pulls out a part of the seed-coat, whereas the narrow base of 'Suvin' cotton (bottom) comes out clean.

Crop Production and Protection

Application of growth-regulator Morphactin up to a concentration of 150 ppm appreciably enhanced seed production and increased the carbohydrate and oil contents of jute seed. The uptake of sulphur was more in white jute than in tossa jute. The yield increased when the crop received MgSO₄, 10 kg/ha along with NPK fertilizers.

In co-ordinated trials with white jute, inorganic nitrogen was found to be better than organic nitrogen. The crop gave maximum yield (25.78 q/ha) when it received 80 kg N, 40 kg P and 40 kg K/ha and was harvested when it was 140 days old.

Trials conducted at the JARI, Barrackpore, showed that on well-managed medium-high and highlands the most suitable crops for growing in rotation with jute were wheat ('UP 262'), short-duration mustard ('B 54'), urd-bean ('T 9'), mungbean ('PS 16'), pigeonpea ('BS 1') and cowpea ('C 779').

Seed treatment with Bavistin @ 2 g/kg of seed followed by 2 sprays of 0.1% Bavistin at 20–25-days intervals reduced stem-rot and root-rot in tossa jute. The red spider-mite (Oliquonychus coffeae) on jute could be controlled with Dicofol at the JARI, Barrackpore.

**Mesta and Sunnhemp**

The mesta varieties that performed well in advanced trials are listed in Table 26.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fibre yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hibiscus cannabinus</em></td>
<td></td>
</tr>
<tr>
<td>'AMC 1'</td>
<td>21.28</td>
</tr>
<tr>
<td>'JBM 4'</td>
<td>18.34</td>
</tr>
<tr>
<td><em>H. sabdariffa</em></td>
<td></td>
</tr>
<tr>
<td>'AS 73 CP 363'</td>
<td>20.93 at Sarbhog</td>
</tr>
<tr>
<td>'AMV 2'</td>
<td>16.08 at Amadalavalasa</td>
</tr>
<tr>
<td>'AS 76 C 12-4'</td>
<td>21.70 at Coimbatore</td>
</tr>
</tbody>
</table>

For maximum fibre and pulp production, the optimum N dose was 40 kg/ha.

In co-ordinated trials, foot-rot and stem-rot of *Hibiscus sabdariffa* could be controlled when the seed was treated with Dithane M-45 @ 5 g/kg of seed, and the soil surface as well as the basal region of plants were sprayed...
twice with 0.2% Dithane M-45, the first spray given when the disease first appeared and the second one 20–25 days later.

Mealy-bug incidence ranged from 16 to 47% in West Bengal, Bihar and Assam. Jassid and flea-beetle incidence was 15.9 to 33% in Assam and Uttar Pradesh. In West Bengal there was 20 to 30% infestation by spiral-borer and 5 to 8% incidence of hairy-caterpillar. The red cotton-bug caused 8% damage in Uttar Pradesh.

At Pratapgarh, *Fusarium* wilt of sunn hemp could be controlled with 2–4% of aqueous extract of decomposed neem-cake combined with 0.01% zinc sulphate. Application of 0.1% Kloricin or 0.07% Bavistin checked seedling-blight.

In a year of severe drought, flue-cured Virginia tobacco varieties 'L 1031', 'V 3189' and 'V 3190' have yielded 9–10 q/ha.

### Tobacco

#### Varietal Improvement

Among flue-cured Virginia types, 'Line 1494' and 'Line 621' were identified for pre-released trials in Karnataka. 'G 8/1' and 'G 11/1', developed at Guntur, were selected for advanced trials. Resistance to caterpillars was shown by 'BOT 17' and 'BOT 20' at Rajahmundry. 'L 1031', 'V 3189' and 'V 3190' yielded 9–10 q/ha even when there was a severe drought.

Ovule-culture method was perfected to produce interspecific hybrids.

#### Crop Production

At Rajahmundry green-manuring with sunn-
hemp increased tobacco yields. Intercropping of safflower with tobacco gave an additional income of Rs 500/ha. Application of farmyard manure (or poultry manure) @ 7.5 tonnes/ha increased the yield of cured leaf by 20% and that of bright-grade leaf by 9%.

For the high-yielding 'FCH 13', the optimum population was 16,667 plants/ha and the optimum N dose 40 kg/ha in Karnataka.

At Anand, bidi tobacco produced the maximum number of transplants when the seed rate was 6 kg/ha, and the plots received 150 tonnes of farmyard manure and 250 kg N, 180 kg P and 100 kg K/ha. Accotab was the best suckericide for natu tobacco.

When used as a source of P, Meusoriphos effected a saving of Rs 250/ha.

Sunnhemp green-manure in kharif followed by hookah tobacco in rabi and maize in summer was the most remunerative sequence at Pusa, Bihar. Among the oilseed crops, groundnut showed promise when grown after the harvest of hookah tobacco.

At Anand, the best 2-year crop rotation was tobacco-summer pearlmillet-castorfallow. The cured-leaf yield was maximum in this rotation.

The yellowing of tobacco seedlings raised in the light soils of East Godavari was found to be due to magnesium deficiency, and was corrected with the application of 45-60 g of magnesium sulphate to a seedbed of 10 m², applied in 3 splits along with irrigation water.

At the CTRI, Rajahmundry, a pilot-scale study was taken up to assess the economics and viability of a new process developed to isolate nicotine from tobacco waste.

Protein N and ammoniacal N, besides nicotine, were found to have the maximum association with quality score and valuation of bidi tobacco.

**Crop Protection**

Studies at the CTRI, Rajahmundry, showed that if pesticides are applied in split doses at intervals, their residues on tobacco leaves could be kept to a minimum.

The sudden and serious outbreak of the late-instar caterpillars of Spodoptera litura in tobacco nurseries could be effectively controlled with one-third of the normally recommended dose of Endosulfan or Fenvalerate or Quinalphos or Monocrotophos or Chlorpyriphos, applied mixed with jaggery and rice bran as a bait.

The early stages of S. litura could be checked with nuclear polyhedrosis virus, whose efficiency was increased with the addition of boric acid and tannic acid, which also improved the micronutrient status of the soil. Margosa-o, a neemseed formulation having azadirachtin as an active ingredient, was developed and effectively used in controlling S. litura.

Damping-off could be controlled with 2 sprays of Metalaxyl ZM 280 W and Apron 35 SD. Soil incorporation of antagonistic fungi Trichoderma viride and T. harzianum, followed by 3 sprays of Fytolan was also effective.

In co-ordinated trials Phenamiphos controlled the root-knot nematode.

**PLANTATION CROPS**

New centres were located at Aduthurai (Tamil Nadu), Vijayarai (Andhra Pradesh), Mulde (Maharashtra) and Gangavati (Karnataka) for oilpalm, and Jalalgarh (Bihar) and Jagadalpur (Madhya Pradesh) for coconut.

**Coconut**

'Banawali Green Round' was recommended for Maharashtra (22.89 kg of copra/palm) and 'East Coast Tall' x 'Malaysian Yellow Dwarf' for Tamil Nadu (16.6 kg of copra/palm).

At the KAU, Pilicode, 'Andaman Ordinary' x 'Gangabondam' and 'West Coast Tall' x 'Gangabondam' consistently gave copra yields of 20 kg/palm/year.

The promising drought-tolerant hybrids were 'Laccadive Ordinary' x 'Chowghat Ora-
'Laccadive Ordinary' × 'Chowght Orange' is a promising drought-tolerant coconut hybrid.

Dwarf and 'Laccadive Ordinary' × 'Gangabondam'.

NP 26:4 tablets, developed to release fertilizers slowly to the coconut palms, were found to be more than 50% intact beyond one year after placement in coconut basins at drip points.

In transmission studies of root 'wilt' disease, 3 out of 4 seedlings inoculated with the lace-bug and 1 out of 2 seedlings trailed with dodder reacted positively to mycoplasma-like organisms.

In attempts to culture the root 'wilt' pathogen, pleomorphic, non-helical, wall-less bodies were noticed in a few cases.

In addition to Ceratostomella paradoxa (syn. Thielaviopsis paradoxa), Phomopsis cocosina was found to be associated with the stem-bleeding disease.

Of the 26,889 palms affected with 'thatipaka' disease in the East Godavari district, 4,512 palms were identified for eradication.

In palms affected by the 'Thanjavur' wilt, Ganoderma lucidum caused more profuse bleeding than G. applanatum.

Oilpalm

Over 200 plants were produced from tender leaf explants, 40 raised in polybags, and a few directly planted from the tube to the garden soil.

Embryos could successfully be cultured in artificial medium. This technique would economize the maintenance of germplasm.

Bunch weight could be increased from 6.6 kg to 19.2 kg when adequate pollination was ensured and the pathogenic fungus Marasmius palmivora was controlled by spraying 0.2% Carbendazim.

Arecanut

'VTL 11', 'Mahua B' and 'VTL 29-e' were found to be tolerant to infestation by the nematode Radopholus similis.

A garden-to-garden survey in 3 taluks of Karnataka showed that 9,219 palms were affected by yellow-leaf disease.

Cacao

Poison-baiting with Warfarin or Fumarin and placement of 30 traps/ha continuously for 6 days gave good results in controlling rats and squirrels, which otherwise damaged 30% of cacao-beans.

Cashewnut variety 'NDR 2-1' produces bold, attractive nuts.
Cashewnut
The NRC for Cashew established a large bud-wood orchard with a potential for producing 100,000 grafts by 1990, and in cooperation with other centres supplied 72,000 grafts for distribution during the year.

In addition to ‘NDR 2-1’, which produced bold, export-quality nuts, ‘BLA 39-4’ and ‘K 22-1’ were released in Kerala as their average yields ranged from 13.2 to 17.14 kg.

The sudden build-up of leaf-webber due to drought in Andhra Pradesh could be effectively checked with 0.05% Fenitrothion or Phosphamidon or Endosulfan or with 0.15% Carbaryl.

A judicious combination of Phosalone during the pre-blossom stage and Endosulfan during the flowering period was found to effectively control the tea-mosquito without harming the beneficial predators, parasites and honeybees.

Top-working of inferior trees with superior scion material was taken up on a large scale by the UAS, Ullal.

Pepper
Of the 7,000 entries evaluated, 11 promising ones were put under multilocational trials ‘Kuthiravally’ gave a stable yield of 2.32 kg of dry pepper per vine.

‘Kuthiravally’ gives a stable yield of 2.32 kg of dry pepper per vine.

In view of the recurrent drought, 40 drought-tolerant types were placed under an evaluation trial.

In demonstrations at Pathupadi, when the check vines yielded 0.4 kg, vines trained on Ailanthus averaged 2.12 kg. In first-line demonstrations in Pannikoture and Peruvarna villages of Kerala, pepper grown as a mixed crop in coconut orchards yielded 1.11 kg of dry pepper per vine.

Six hybrids showed tolerance to Meloidogyne incognita, a major endoparasitic nematode, which occurred frequently with Raphidophorus similis in northern Karnataka.

Ridomil 5G granules @ 20 g/vine checked Phytophthora infection.

Cardamom
‘Cl 679’, ‘Cl 683’ and ‘Cl 726’ with a yield potential of 130 to 190 grams of green cardamom per clump were under on-farm trials.

In Karnataka the outbreak of thrips could be checked with a combination of Nuvacron 40% EC and Ekalux 25% EC sprayed at 1-month intervals.

Ginger and Turmeric
‘PGS 35’ was recommended for release in Orissa. It yielded 16.6 tonnes of green rhizomes per hectare, with 1.9% essential oil and 4.4% crude fibre.

Rhizome-rot could be checked when the seed-rhizomes were treated with 1000 Apron (Metalaxyl) and the infested soil drenched with Ridomil/Ziram (100 ppm Metalaxyl).

‘PTS 10’ was released for cultivation all over the country. It yielded 20.7 tonnes of green rhizome with 9.3% curcumin and 4.3% essential oil.

Fenugreek
The TNAU, Coimbatore, released ‘Co 1’, which yielded 4 tonnes of green leaf in addition to 5-6 quintals of grain per hectare.

Cumin and Fennel
The wilt-tolerant cumin variety ‘UC 19’ was
recommended for Rajasthan, the fennel variety ‘VC 14-3-3’, maturing in 120 days, was recommended for Gujarat. Both these varieties had a yield range of 5-9 q/ha, with 2.6% volatile oil.

MEDICINAL AND AROMATIC PLANTS

Crop-specific explorations resulted in the collection of useful germplasm material of Chlorophytum from southern Rajasthan and Madhya Pradesh, Coleus forskohlii and Urginea indica from the north-western hills of Uttar Pradesh, Catharanthus roseus from Kerala and Vetiveria from the western and central parts of Uttar Pradesh. Promising material of lavender, rosemary, sage, silybum, melissa, papaver and datura were screened from over a 100 exotic entries.

Artemisia
‘EC 172510’ accession of Artemisia annua, useful in the treatment of malignant malaria, adapted well to the climate of Bhowali (hills of Uttar Pradesh). Its bushy, branched plants, 1-1.7m tall, flowered profusely and set seeds. The essential oil of its dried foliage contained artemesitin, sesquiterpene and lactone.

Opium-poppy
‘Trishna’ was released for cultivation in view of its high yield in the western region. The optimum fertilizer dose was 90 kg N/ha (half at sowing and the other half at the rosette stage) and 45 kg P₂O₅/ha. Seed treatment with Apron 35 SD @ 10 g/kg of seed, together with 2 sprays of 0.1% Ridomil 20 and 45 days after sowing reduced downy-mildew infection and increased latex yield.

Since the morphine content is maximum in the husk of the capsules, opium-poppy may be left to set seed and morphine extracted from the husk of the capsules through solvent extraction. An HPLC method was developed for simultaneous estimation of 5 major opium alkaloids in the opium latex. The method would be useful in screening germplasm material for breeding.

Solanum
The IIHR developed spineless diploid lines of Solanum viarum with adequate amounts of commercial solasodine in the berries. Some eutetraploids and aneuploids of S. viarum contained up to 4.42% solasodine. Promising colchiploids of S. lacinatum were developed at Solan.

Liquorice
August was found to be a better time than early winter months for planting stem cuttings of liquorice in the field.

Digitalis
The second-generation progeny was successfully raised in the interspecific crosses of Digitalis lanata with D. ambigua (syn. D. grandiflora).

Matricaria
Matricaria chamomilla could be successfully introduced into Solan. At a spacing of 20 cm x 20 cm, with 60 kgN/ha it gave a high yield of flowers containing 0.34% oil.

Periwinkle
At 240 days, thin roots of Catharanthus roseus had more alkaloids and ajmalicine than thick roots.

Scented Geranium
‘Algerian’ had more oil than ‘Reunion’. The bound form of geraniol was found to be geraniol-B-D glucoside.

Vetiver
Short and thick-rooted lines of vetiver had more oil, and their superior aroma was because of a high amount of free vetiverol and khusol.

The varieties included in multilocation tests were ‘NC 66403’, ‘NC 66404’ and ‘NC 66416’. The latter, with 79.09% free vetiverol, was
RESEARCH ACCOMPLISHMENTS

found to have a rare odour with a saffron-like
top-note and a long-lasting, sweet
balsamic-note.

TUBER CROPS

Cassava
The germplasm accessions at the CTCRI,
Trivandrum, now number 1,354, including 14
new accessions received from Fiji.

Apical buds were more suitable than axil­
lary buds for tissue culture. The CTCRI
established 18 germplasm collection in-vitro.
A set of 81 meristem tips from 28 accessions of
Manihot species were collected to eliminate
cassava mosaic.

The Central Variety Release Committee
released ‘Sree Prakash’, whose tuber yield was
35–40 tonnes/ha in 200–210 days. ‘Sree Sahya’,
‘Sree Vishakam’ and ‘H 226’ gave high yields
in Kerala, Tamil Nadu and West Bengal.

The best shade-tolerant types were ‘Clone
15 x 6 N’, ‘C 167’, ‘CE 139’ and ‘CL 620’, which
yielded more than 1 kg/plant.

Irrigation increased the tuber yield by 91%.
The irrigated crop responded to fertilizer
doses up to 150 kg N, 100 kg P and 150 kg
K/ha. On rainfed lands of Andhra Pradesh,
‘H 165’ gave good yields with 60 kg N and 60
kg P/ha, applied 60 days after planting. For

India ranks first in the world in the productivity of cassava, an inexpensive source of food calories. Since
cassava can be raised on marginal lands that cannot support other crops, there is much scope for increasing
production. Cassava meal is a low-cost diet of poultry and sun-dried chips of the tubers can form an excellent
feed for our large animal population. The leaves, which contain protein, can form a supplement to the starch
ration of animals.
supplying tubers to the sago factories, 'H 165' could be harvested in 6 months and 'H 226' in 8 months.

In crop sequences on lowlands, 'H 1687' gave 51 tonnes/ha when grown after vegetable cowpea, and short-duration 'H 119' yielded 29.5 tonnes/ha when it followed rice.

Solid-state fermentation of cassava flour and waste with *Trichoderma pseudokoningii* enriched the protein content by 14 to 16%.

Sweet-potato

Of the 733 accessions at the CTCRI, 278 were evaluated for culinary qualities and 15 were found promising.

'Sree Nandini' and 'Sree Vardhini' performed well in all-India trials, and the latter was released for cultivation.

'Kalmegh' and 'S 30', which gave economic yield in 90 days, would be suitable for being fitted into multiple-cropping sequences.

Monocropped sweet-potato, which suffered from weevil attack, gave a tuber yield of 4 tonnes/ha. But when grown in rotation with 2 crops of rice or a crop of rice and cowpea, weevil incidence was considerably reduced and tuber yield increased to 10.2–11 tonnes/ha.

'S 69', 'S 89', 'S 92' and 'S 101' were found to have 0.2–0.3% epicuticular wax, which favours drought tolerance.

Application of 100 ppm Cycoce 30 and 45 days after planting reduced the luxuriant vegetative growth and increased the tuber yield at Assam.

Colocasia

The CTCRI received 14 new accessions of *Colocasia* from Fiji.

'Sree Rashmi' variety of *Colocasia esculenta*, with a yield potential of 15–20 tonnes/ha in 200–210 days, was released.

'Shatamukhi', 'White Gauria' and 'Sahasramukhi' performed well in northern India. In Andhra Pradesh, 'Shatamukhi' gave profitable yields with 120 kg N, 60 kg P and 120 kg K/ha.

Ascorbic acid and gibberellic acid (GA3) could effectively induce flowering and seed set in 8 non-flowering strains.

A mutant was identified which could be stored in an excellent condition up to 6 months—vs against 2 months in most varieties.

A noodle-like product could be made from *Colocasia* flour with a hand-press, and the colour of the product could be improved when the dough was treated with 2% ascorbic acid.

The *Phytophthora*-blight of *Colocasia* could be effectively controlled with 4 sprays of 0.25% Zineb at 15-day intervals.

Dioscorea

'Sree Keerti' variety of *Dioscorea alata* was released by the Central Variety Release Committee, and 'Sree Subhra' and 'Sree Priya' varieties of *D. rotundata* were released in Kerala because of their high yield of quality tubers.

Amorphophallus

In tissue culture, 310 meristem tips of *Amorphophallus* produced plantlets free from diseases.

In West Bengal and Andhra Pradesh, *Amorphophallus* gave a profitable yield of more than 100 tonnes/ha with the application of 20 tonnes of farmyard manure, 150 kg N, 60 kg P and 100 kg K/ha.

POTATO

Under the All-India Co-ordinated Potato Improvement Project, 3 new centres were started at Faizabad, Aurangabad and in the Andaman and Nicobar Islands. A Division of Social Science was started at the CPRI, Shimla.

Varietal Improvement

Potato is traditionally raised from seed tubers. In recent years the possibility of raising a potato crop from true potato seed (TPS)
is being explored. Of the 7 TPS lines and 3 open-pollinated varieties that gave promising results, 'HPS 1/13' and 'HPS II/III' were identified for large-scale trials on farmers' fields to evaluate their ability to produce tuberlets for raising a commercial crop.

Four high-yielding hybrids with resistance to late-blight ('JH 222', 'E 4486', 'JI 1857' and 'JI 5857') were identified for pre-release large-scale trials on farmers' fields.

The wart-resistant, red-skinned hybrid 'SE/1 1307' performed well in the Darjeeling district. It produced tubers of attractive shape and good keeping quality.

**Agrotechniques**

In north Gujarat, the second fortnight of November was found to be the best time for planting seed potato (either cut or whole tubers, each weighing 25 g). A pre-emergence application of Metribuzin @ 1 kg/ha or Basalin @ 2 litres/ha, or a post-emergence application of Paraquat @ 2.5 litres/ha (in 1,000 litres of water) effectively controlled weeds.

**Crop Protection**

Tuber-borne common-scab and black-scurf could be controlled by a 30-minute treatment with 3% aqueous solution of boric acid, which is non-hazardous.

Research showed that *Pseudomonas solanacearum*, which incites bacterial wilt, does not survive in the soil for more than 25 weeks in Indian plains. The pathogen seemed to survive on infected tubers, including symptomless ones, and weeds.

The control measures for insect pests are summarized in Table 27.

**Seed Production**

About 1,200 tonnes of breeder's seed of 7 major potato varieties were produced and distributed to the state departments of agriculture, horticulture and other seed agencies.

**MUSHROOMS**

Of the 84 specimens of fleshy fungi collected, 7 were found edible. Five more edible mushrooms were added to the germplasm, bringing the total to 47.

The giant *Stropharia rugoso-annulata*, each, mushroom weighing about 500 g, collected in 1985 in Himachal Pradesh, could be successfully cultivated on composted wheat straw + rice straw or on autoclaved dehulled maize cobs. The spawn of this fungus could be developed on wheat grain, dehulled maize cobs, sugarcane bagasse and wheat straw.

Apple pomace was found to be a suitable substrate for growing *Pleurotus* (oyster mushroom) and *Auricularia* (Jew's ear fungus). The latter could also be successfully raised on autoclaved wheat straw without any supplement.

When compost was supplemented with 5% of formalin-treated cottonseed-meal at the time of spawning, the yield of white-button mushroom (*Agaricus bisporus*) increased by 25%. For its cultivation, polythene bags proved to be a highly suitable and cheaper substitute to wooden trays. A 22.5-cm-deep compost layer in polythene bags was ideal for mushroom cultivation. A casing medium consisting of 2 parts of dried moss and 1 part of soil proved to be better than the conventional casing medium of 1 part each of farmyard manure and soil. White-button mushroom gave 19% more yield on the new casing medium.

Six promising single-spore isolates of *Agaricus*...
White-button mushroom gives 90% higher yield if grown on a casing medium consisting of 2 parts of dried moss and 1 part of soil.

*Agaricus bisporus* were supplied to different mushroom-growing centres for multilocation testing.

The National Centre for Mushroom Research and Training, Solan, developed the technique of chemical sterilization of substrates with 500 ppm formalin and 75 ppm Bavistin for 18 hours in place of the cumbersome steam-pasteurization. All the 10 *Pleurotus* species could be successfully cultivated on sterilized substrates including equal proportions of rice straw and wheat straw, which proved to be superior to either of the straws used singly.

*Cladobotryum variospermum* was found to be pathogenic to *Agaricus bisporus* as well as *Pleurotus sp.

*Cladosporium apiculatum* was also noticed on substrates during *Pleurotus* cultivation.

Extracts of castor, neem, chrysanthemum, eucalyptus and marigold leaves were found toxic to the dreaded mushroom nematode *Aphelenchoides compositicola*. When 2-3 kg of the dried leaves of these plants were incorporated in a quintal of compost at the time of spawning, the nematodes could be controlled, and the yield of white-button mushroom increased by 23-25%. *Arthrobotrys conoides*, a nematophagous fungus, when multiplied on boiled wheat grain and added to the infested compost, reduced the nematode population and significantly increased mushroom yields.

White-button mushrooms stored best when kept inside unperforated polythene bags at 5°C. Washing with 0.05% potassium metabisulphate improved their whiteness, which lasted longer during storage.

Weed fungi *Trichoderma* and *Chaetomium*, which contaminate rice straw and hamper the growth of *Calocybe indica*, can be effectively controlled with Bavistin 0.1%.

**VEGETABLES**

**Brinjal**

Ten promising varieties of brinjal were identified during the year (Table 28).

**Cauliflower**

‘Early Winter’, ‘Adam’s White’, ‘Janavan’, ‘Aghani’ and ‘Punjab Giant 26’ were resistant at Solan to the *Sclerotinia* stalk-rot.
Table 28. Promising brinjal varieties and their important characteristics

<table>
<thead>
<tr>
<th>Variety</th>
<th>Chief characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Punjab Barsati' (PAU, Ludhiana)</td>
<td>Dwarf, erect, thornless, medium-long fruits; tolerant to fruit-borer; performs well in the rainy season; 64 days</td>
</tr>
<tr>
<td>'Punjab Sada Bahar' (PAU, Ludhiana)</td>
<td>31 tonnes/ha in 67 days; long fruits; tolerant to fruit-borer; performs well throughout the year</td>
</tr>
<tr>
<td>'IIHR 12', 'IIHR 21', 'IIHR 54' (IIHR, Bangalore)</td>
<td>Resistant to bacterial-wilt in Karnataka</td>
</tr>
<tr>
<td>'GKV K Composite 1', 'GKV K Composite 2' (UAS, Bangalore)</td>
<td>Tolerant to wilt</td>
</tr>
<tr>
<td>'Muktakeshi', 'Annamalai'</td>
<td>Resistant to important pests and diseases at Samba during kharif</td>
</tr>
<tr>
<td>'ABV' (MAU, Parbhani)</td>
<td>Suitable for cultivation in Maharashtra for high yield</td>
</tr>
</tbody>
</table>

Radish

The PAU, Ludhiana, developed 'Punjab Ageti', which would yield 42 tonnes/ha when sown during April to August. The tapering, 25.5-cm-long, medium-thick non-pithy roots have red skin at the top, with white lower half.

Tomato

At Solan, Lycopersicon esculentum var. cerasiform showed resistance to the fruit-rot caused by Phytophthora parasitica.

Complete tissue-cultured plantlets were successfully induced and transplanted in the field.

The MAU, Parbhani, released tomato variety 'ATU 1' and hybrid 'ATU 10'. Four lines possessing resistance to bacterial wilt were isolated at Palampur. Other important tomato lines selected during the year are listed in Table 29.

Chilli

Two accessions showed field resistance to thrips. The MAU, Parbhani, made 2 selections (a tall and a dwarf), which outyielded the currently recommended varieties.

The amount of phenyl alanine ammonia-lyase in the youngest fully expanded leaves was more in the varieties resistant to powdery-mildew than in those susceptible to it.

Onion

'IIHR 500-1-12', a line of yellow onion, performed well at the IIHR, Bangalore. 'Karagal Red', 'No. 999' and 'No. 778' were selected at the MPKV, Rahuri.

Okra

'IIHR 4' and 'IIHR 10', highly resistant to the yellow-vein mosaic, yielded 18 tonnes/ha in 110 days in multilocation trials.

'PBN 57' (from a cross of 'Pusa Sawani' × Abelmoschus manihot) was resistant to yellow-vein mosaic and yielded 11.5 tonnes per hectare in Bihar, Andhra Pradesh and the newly released rabi onion 'Arka Kalyan' yields 45 tonnes per hectare.
Karnataka. It was released as ‘Parbhani Kranti’ in Marathwada.

Garlic
‘Great-Headed’, promising at Palampur, was put under multilocation testing. ‘Godavari Gulab’ and ‘Godavari Saled’, with high yield and resistance to leaf-blight and thrips, were developed at the MPKV, Rahuri.

Dolichos-bean
Photo-insensitive, dwarf, bushy, vegetable-podded ‘Sel 1’ and ‘Sel 2’, developed at the IIHR, Bangalore, yielded 15-16 tonnes/ha in adaptive trials at Godhra.

Clusterbean
A tall, single-stemmed, non-branching, vegetable-podded type produced up to 35 clusters to a plant with 8-10 pods in a cluster. It yielded 5-6 tonnes/ha in 90-100 days.

Two dwarf, bushy, vegetable-podded Dolichos-bean varieties have been developed at Bangalore. They are photo-insensitive and can be grown any time of the year.

The tall, non-branching, vegetable-podded clusterbean ‘Sel Ches 13-7’ produces 35 clusters, each having 8-10 pods, from bottom to top. It yields 5-6 tonnes/ha in 90-100 days.

Peas
‘Kinnauri’ × ‘P 6183’ (developed at Palampur), ‘TIC’, ‘P 6583’ and ‘P 6587’ were totally free from powdery-mildew. Three IIHR selec-
tions showed combined resistance to powdery-mildew and rust in multilocation tests.

Chinese Cabbage
The PAU, Ludhiana, developed a non-heading, semi-erect, light-green, quick-growing Chinese cabbage which yielded 38.7 tonnes/ha in 6-8 cuttings.

Muskmelon
The PKV, Akola, developed 'M 4-1-4-12' and 'M 22-1-4-8' suited for riverbed cultivation.

VEGETABLE VARIETIES FOR DIFFERENT REGIONS
During the year, 26 varieties of 8 different vegetables were recommended for cultivation. Their yields and the regions for which they are suitable are summarized in Table 30.

Crop Production and Protection
Some of the highly remunerative production and protection practices for different vegetable crops are summed up in Table 31.

FRUITS

Mango
The CIHNP, Lucknow, which has the world's largest germplasm collection (including 470 field-planted varieties), added 55 seedling mango introductions from Orissa.
At the IARI, exotic 'Eldon' showed good bearing, with 20.5% total soluble sugars in the

Table 30. Improved varieties of vegetables recommended for different regions

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Region</th>
<th>Yield and other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brinjal (long)</td>
<td>'ARU 2C'</td>
<td>Almor, Kalyanpur, His, Coimbatore, Hessaghatta</td>
<td>41 tonnes/ha</td>
</tr>
<tr>
<td>Brinjal (round)</td>
<td>'Kat 4'</td>
<td>Anand</td>
<td>45 tonnes/ha</td>
</tr>
<tr>
<td>Chilli</td>
<td>'K 202-9'</td>
<td>Srinagar, Kalyanpur, Bhubneshwar, His, Ambajogai, Rahuri, Akola</td>
<td>45 tonnes/ha</td>
</tr>
<tr>
<td></td>
<td>'X 235'</td>
<td>Sabour, Bhubneshwar, His, Ambajogai, Rahuri, Akola, Coimbatore</td>
<td>9.5 tonnes/ha</td>
</tr>
<tr>
<td></td>
<td>'Musawadi'</td>
<td>Sabour, Kalyanpur, Bhubneshwar, Rahuri, Coimbatore, Lam, Hessaghatta</td>
<td>6.3 tonnes/ha on rainfed lands</td>
</tr>
<tr>
<td>French-bean</td>
<td>'Arka Komal'</td>
<td>Almor, Katrain, Solan, Rahuri, Hessaghatta</td>
<td>7.4 tonnes/ha</td>
</tr>
<tr>
<td></td>
<td>'UPF 191'</td>
<td>Pantnagar, Rahuri</td>
<td>30 tonnes/ha</td>
</tr>
<tr>
<td>Onion (rahi)</td>
<td>'Arka Kalyan' (red)</td>
<td>Sabour, Ludhiana, Junagadh, Ambajogai, Rah, Coimbatore, Hessaghatta</td>
<td>21 tonnes/ha</td>
</tr>
<tr>
<td></td>
<td>'Line 102' (red)</td>
<td>Almor, Kalyanpur, Junagadh, Rahuri, Ambajogai</td>
<td>45 tonnes/ha</td>
</tr>
<tr>
<td>Onion (kharif)</td>
<td>'Arka Niketan' (red)</td>
<td>Nasik</td>
<td>33 tonnes/ha</td>
</tr>
<tr>
<td>Peas (early)</td>
<td>'Agri Found Dark Red'</td>
<td>Karnal</td>
<td>Good yield; resistant to powdery-mildew</td>
</tr>
<tr>
<td>Peas (mid-season)</td>
<td>'VL 3'</td>
<td>Solan, Kalyanpur, Almor, Kalyanpur, Pantnagar, Hisar, Durgapura</td>
<td>9.5 tonnes/ha</td>
</tr>
<tr>
<td></td>
<td>'Lincoln'</td>
<td>Solan, Almor, Katrain, Kalyanpur, Hisar, Rahuri</td>
<td>11 tonnes/ha</td>
</tr>
</tbody>
</table>
56

Pumpkin

<table>
<thead>
<tr>
<th>Variety</th>
<th>Region</th>
<th>Yield and other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>'CM 14'</td>
<td>Delhi, Bhubaneshwar, Coimbatore, Solan</td>
<td>45 tonnes/ha</td>
</tr>
<tr>
<td>'Pusa Vishwas'</td>
<td>Coimbatore, Hessaraghatta, Delhi, Bhubaneshwar</td>
<td>30 tonnes/ha</td>
</tr>
<tr>
<td>'Arka Chandan'</td>
<td>Kalyani, Almora, Sabour, Bhubaneshwar, Junagadh, Ambajogai, Rahul, Hessaraghatta</td>
<td>40 tonnes/ha</td>
</tr>
<tr>
<td>'Arka Suryamukhi'</td>
<td>Solan, Hessaraghatta</td>
<td>35.5 tonnes/ha</td>
</tr>
<tr>
<td>'Arka Manik'</td>
<td>Ambajogai, Akola, Hessaraghatta</td>
<td>60 tonnes/ha; resistant to powdery-mildew; tolerant to downy-mildew; high total soluble sugars 40 tonnes/ha</td>
</tr>
</tbody>
</table>

Watermelon

<table>
<thead>
<tr>
<th>Variety</th>
<th>Region</th>
<th>Yield and other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Arka Vikas'</td>
<td>Solan, Kalyani, Ranchi, Ludhiana, Kalyanpur, Pantnagar, Bhubaneshwar, Navsari, Rahul, Ambajogai, Hessaraghatta</td>
<td>40 tonnes/ha</td>
</tr>
<tr>
<td>'Arka Saurabh'</td>
<td>Solan, Almora, Sabour, Hisar, Bhubaneshwar, Junagadh, Ambajogai, Rahul, Hessaraghatta</td>
<td>31 tonnes/ha; wide adaptability</td>
</tr>
<tr>
<td>'Pant T 3'</td>
<td>Katrain, Almora, Kalyani, Sabour, Kalyanpur, Pantnagar, Ranchi, Delhi, Navsari, Bhubaneshwar, Hisar</td>
<td>42 tonnes/ha</td>
</tr>
</tbody>
</table>

Tomato (indeterminate)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Region</th>
<th>Yield and other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Co 3'</td>
<td>Katrain, Pantnagar, Ranchi, Sabour, Kalyanpur, Navsari, Bhubaneshwar, Junagadh, Ambajogai</td>
<td>42 tonnes/ha</td>
</tr>
<tr>
<td>'Punjab Kesari'</td>
<td>Katrain, Solan, Kalyanpur, Delhi, Pantnagar, Junagadh, Hisar, Navsari, Rahul, Durgapur</td>
<td>41 tonnes/ha</td>
</tr>
<tr>
<td>'La Bonita'</td>
<td>Katrain, Solan, Kalyanpur, Delhi, Pantnagar, Junagadh, Hisar, Navsari, Rahul, Durgapur</td>
<td>44 tonnes/ha</td>
</tr>
</tbody>
</table>

Tomato (determinate)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Region</th>
<th>Yield and other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Pusa Early Dwarf', 'Pusa Ruby' and 'Arka Vikas', 150 kg N, 60 kg P, 60 kg K/ha</td>
<td>Additional yield 150 q/ha and additional income Rs 13,000-14,000/ha at Ambajogai, Maharashtra</td>
<td></td>
</tr>
<tr>
<td>Against purple-blotch in both bulb and seed crops, 5 sprays of 0.2% Dithane M-45, using 0.1% Sandrif sticker, at 15-day intervals from transplanting</td>
<td>Additional income Rs 11,000/ha, 43.4% increase in yield</td>
<td></td>
</tr>
<tr>
<td>Against Stemphylium-blight, 5 curative or 5 preventive sprays of 0.25% Mancozeb at 15-day intervals from planting</td>
<td>Net profit Rs 9,886/ha from bulb crop, Rs 23,972 from seed crop</td>
<td></td>
</tr>
<tr>
<td>HYDROPONIC CULTURE</td>
<td>Yields 100 tonnes/ha in 5-6 months</td>
<td></td>
</tr>
<tr>
<td>For 'Pusa Early Dwarf', 'Pusa Ruby', 'Arka Vikas', 150 kg N, 60 kg P, 60 kg K/ha</td>
<td>Additional yield 200 q/ha, additional profit Rs 9,000-10,000/ha</td>
<td></td>
</tr>
<tr>
<td>For weed control, pre-plant application of 0.25 kg ai Goal or Basalin 1 kg ai/ha</td>
<td>Additional yield 50 q/ha, additional income Rs 7,547/ha</td>
<td></td>
</tr>
<tr>
<td>Against early-blight, 3 sprays of 0.1% Bavistin or 0.2% Dithane Z-78 or 0.2% Dithane M-45 at 15-day intervals</td>
<td>Additional yield 170%</td>
<td></td>
</tr>
<tr>
<td>Against late-blight, 0.1% Difolatan 80 or 0.3% Bilitox at 15-day intervals from the day of first appearance of disease</td>
<td>Additional yield 37.2%, profit Rs 2,573/ha</td>
<td></td>
</tr>
</tbody>
</table>

Table 31. Remunerative production and protection practices recommended for different vegetable crops

Crop, and its production or protection practice | Benefit
---|---
Onion For 'N 53', 15 cm x 10 cm, 75 kg N/ha | Additional yield 150 q/ha and additional income Rs 13,000-14,000/ha at Ambajogai, Maharashtra
| Additional income Rs 11,000/ha, 43.4% increase in yield |
| Additional yield Rs 9,886/ha from bulb crop, Rs 23,972 from seed crop |

Tomato HYDROPONIC CULTURE | Yields 100 tonnes/ha in 5-6 months
| For 'Pusa Early Dwarf', 'Pusa Ruby', 'Arka Vikas', 150 kg N, 60 kg P, 60 kg K/ha | Additional yield 200 q/ha, additional profit Rs 9,000-10,000/ha
| For weed control, pre-plant application of 0.25 kg ai Goal or Basalin 1 kg ai/ha | Additional yield 50 q/ha, additional income Rs 7,547/ha
| Against early-blight, 3 sprays of 0.1% Bavistin or 0.2% Dithane Z-78 or 0.2% Dithane M-45 at 15-day intervals | Additional yield 170%
| Against late-blight, 0.1% Difolatan 80 or 0.3% Bilitox at 15-day intervals from the day of first appearance of disease | Additional yield 37.2%, profit Rs 2,573/ha
Crop, and its production or protection practice | Benefit
---|---
**CAULIFLOWER**
For ‘Pusa Synthetic’, 60 cm x 40 cm, 150 kg N and 120 kg P/ha | Additional yield 100 q/ha
For ‘Snowball 16’, 90 kg N and 30 kg P, 120 kg K/ha in north Gujarat | Additional income Rs 35,140/ha in north Gujarat
**CABBAGE (‘Pride of India’)**
At Jabalpur, 75 cm x 30 cm, 180 kg N, 50 kg P, 50 kg K/ha | Additional yield 120 q/ha, additional profit Rs 8,817/ha at Jabalpur
In Haryana, 70 cm x 30 cm, 60 kg N, 50 kg P, 50 kg K/ha | Additional yield 40 q/ha, additional income Rs 3,500/ha
**OKRA (‘Pusa Sawani’)**
For weed control, Fluchloralin 1.5 kg ai/ha or Basalin 3 kg ai/ha as pre-plant incorporation + one hand-weeding 45 days after planting | Additional yield 54 q/ha, additional income Rs 8,100/ha
For control of jassids and fruit-borer, Endosulfan sprays @ 500 g ai/ha 15 days after germination, followed by 3 sprays of Decamethrin @ 10 g ai/ha or Fenvalerate @ 50 g ai/ha | Additional yield 31 q/ha, additional income Rs 2,511 to Rs 5,299/ha
**BRINJAL (‘Manjari Gota’)**
For control of jassids, aphids and fruit-borer, Carbofuran granules @ 1.5 kg ai/ha at transplanting, followed by 3 sprays of Cypermethrin @ 30 g ai/ha at 10-day intervals | Additional yield 124 q/ha, additional income Rs 10,774/ha
**MUSKMELON (‘Durgapura Madhu’)**
Spacing of 350 cm x 60 cm and 100 kg N, 60 kg P and 60 kg K/ha | Additional yield 100 q/ha, additional income Rs 7,000-8,000/ha at Durgapura
**CLUSTERBEAN**
Against bacterial-wilt, seed treatment with Paushamycin 200 ppm for 2 hours before sowing, and a spray of 0.3% Blitox 50 at the first sign of disease | Additional yield 80%, additional income Rs 3,788/ha
**TURNIP**
Against phyllody disease, dipping of roots for 30 minutes in a solution of Tetracyclin, 200 ppm + Bavistin 1,000 ppm before transplanting, and 2 sprays of the same fungicides at 15-day interval beginning with the onset of flowering | Additional yield 105%, additional income Rs 18,154/ha
**CHILI (‘Pant C1’)**
90 kg N, 60 kg P and 40 kg K/ha | Additional yield 23 q/ha
For control of fruit-rot, powdery-mildew and thrips 3 sprays of Dithane M-45 + Karathane (0.1%) + Metasystox (0.1%) at 15-day intervals at the first sign of disease | Additional yield 35.46%

Sweet pulp. The thick leathery skin makes this variety suitable for long-distance transport. From crosses of ‘Amrapali’ with ‘Sensation’, ‘Lal Sundari’ and other varieties, 20 new promising hybrids were produced. From open-pollinated ‘Amrapali’, the following useful types were selected.

‘AOP 9 R 1 T 5’ : Dwarf, 68 fruits/plant
‘AOP 9 R 16 T 25’ : Very dwarf, bunch type 17 fruits in a bunch
‘AOP 9 R 16 T 24’ : Red-fruited
‘AOP 9 R 1 T 21’ : Sweet, 22.5% total soluble sugars
‘AOP 9 R 1 T 25’ : Sweet, 20.5% total soluble sugars
‘AOP 9 R 1 T 10’ : Sweet, 20.5% total soluble sugars

In ‘Totapuri’ and ‘Langra’ accessory multiple embryos were induced at the JARI, New Delhi, in explanted embryonal axes and nucelli.

The red-fruited ‘Lal Sundari’ showed resistance to powdery-mildew. At the IIHR, Bangalore, ‘Fazari’, ‘Jahangir’, ‘Suvarnarekha’, ‘Hybrid 13’ and ‘Hybrid 14’ were resistant to bacterial canker.
Veneer-grafting was successful in Uttar Pradesh, Madhya Pradesh and the Hyderabad region, whereas epicotyl-grafting during May to July was the suitable method of propagation in mango in the Konkan region.

Bavistin 0.1% was effective against anthracnose at Vengurla. In the Malihabad and Kakori regions of Uttar Pradesh, where hoppers *Idioscopus nitidulus* and *Amritodus atkinsoni* proliferated during April-May, Fenvalerate 0.015% or Ripcord 0.01% or Basathrin 0.13% proved very effective.

**Citrus**

*Citrus indica* and *C. latipes*, which are on the verge of extinction, were collected from Meghalaya. Rough-lemon, kesar-lime, *C. hystrix* and *C. amblicarpa* showed drought resistance at the APAU, Hyderabad. ‘Mandarin Thorny’, ‘Mandarin Small’, ‘Nagpur Mandarin’ and ‘Hill Orange’ performed exceedingly well at Chethalli.

‘Nagpur Santra 182’, with negligible seeds, was recommended for the Vidarbha region by the PKV, Akola.

The IIHR, Bangalore, evolved 3 hybrid rootstocks resistant to the citrus nematode, *Tylenchulus semipenetrans*. Kagzi-lime types ‘NS 2’, ‘Hybrid 2’ and ‘Hybrid 4’ were resistant to canker at the PKV, Akola.

The effective measures for controlling important citrus pests and diseases are summed up in Table 32.

**Papaya**

At Bangalore, an interspecific hybrid of *Carica papaya × C. cauliflora* showed resistance to mosaic.

Tissue-cultured papaya plants were transplanted in the fields at the IARI. They had larger fruiting area and better photosynthetic ability. Totipotency was maintained, and plants raised from female plant tissues produced female plants only.

When stored in silica gel at room temperature, papaya seeds remained viable for 4 years. When stored in liquid nitrogen (-196°C), the pollen remained viable for 5 years.

**Grape**

The MACS, Pune, has so far collected 66 species belonging to Vitaceae.

Seven seedless and 4 seeded grape hybrids were under co-ordinated pre-release testing at several centres.

Interspecific hybrid ‘No. 80’ at Pune, and ‘E

<table>
<thead>
<tr>
<th>Pest or disease</th>
<th>Control measure</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psylla</td>
<td>Monocrotophos 0.025%</td>
<td>Ludhiana, Bhatinda, Coorg</td>
</tr>
<tr>
<td>White-fly</td>
<td>Monocrotophos 0.5%</td>
<td>Ludhiana, Bhatinda</td>
</tr>
<tr>
<td>Leaf-miner</td>
<td>Quinalphos 0.5%</td>
<td>Akola</td>
</tr>
<tr>
<td></td>
<td>Decamethrin 0.01% or</td>
<td>Akola</td>
</tr>
<tr>
<td></td>
<td>Monocrotophos 0.05% or</td>
<td>Akola</td>
</tr>
<tr>
<td></td>
<td>Permethrin 0.01% or</td>
<td>Akola</td>
</tr>
<tr>
<td></td>
<td>Fenvalerate 0.01% or</td>
<td>Akola</td>
</tr>
<tr>
<td></td>
<td>Cypermethrin 0.05%</td>
<td>Coorg</td>
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<tr>
<td></td>
<td>Fenvalerate 0.01%</td>
<td>Vidarbha</td>
</tr>
<tr>
<td></td>
<td>Phosalone 0.025%</td>
<td>Srirampur</td>
</tr>
<tr>
<td><em>Colletotrichum</em> of mandarins</td>
<td>Pruning of deadwood and regular spraying of Bordeaux mixture</td>
<td>Vidarbha</td>
</tr>
<tr>
<td>Foot-rot and gummosis caused by <em>Phytophthora palmivora</em></td>
<td>Drenching with Foltaf 0.2% or</td>
<td>Srirampur</td>
</tr>
<tr>
<td>Canker on acid-lime</td>
<td>Ridomil 0.2% thrice at monthly intervals</td>
<td>Srirampur</td>
</tr>
<tr>
<td>Pre-harvest stem-end rot</td>
<td>Difolatan 0.2%</td>
<td>Ludhiana, Bhatinda, Tinsukia</td>
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</tbody>
</table>
18-5', 'F 35-3' and 'G 10-2' at Bangalore had high total soluble sugars.

The IIHR, Bangalore, developed seedless hybrids 'F 29-4' and 'E 13-3', which gave high yield of quality berries.

The IARI, New Delhi, developed 3 mutants of 'Beauty Seedless' that matured earlier than the parent, and evolved 6 hybrids with bold as well as seedless berries. Tissue-cultured grape plants were successfully transplanted in the field.

'Gulabi' rootstock imparted the highest bud fertility in 'Anab-e-Shahi'. It was possible to harvest 'Thompson Seedless' twice, in November and June, when its renewal-spurs and fruiting-canes were alternately pruned in July and December. Bud-break improved when canes were drenched in July with 3-4.4% thiourea.

Spraying of Ethrel 600 ppm induced early ripening in 'Perlette'. When 'Perlette' bunches were densely filled with too many berries to result in abrasion of the fruit-skin, a spray of gibberellic acid at the full-bloom stage reduced the number of berries to the satisfactory extent.

Carbofuran 2 g ai and 0.02% Fevel 20 EC were effective against nematodes. Powdery-mildew could be controlled with 0.1% Beyleton and 0.05% PP 523.

Jujube (Ber)

'Gola' was most tolerant to salinity and alkalinity. 'Darkhi 1', 'Darkhi 2', 'Guli' and 'Vilaiti', collected from the vicinity of Rahuri, were resistant to powdery-mildew and would be used in breeding programmes.

Powdery-mildew could be controlled with 2 to 4 sprays of 0.2% Sulfix or 0.1% Karathane or 0.2% Bavistin, at 20-day intervals. Fruit-fly could be checked with 2 sprays of either Phosphamidon or Dimethoate or Monocrotophosph 0.03% at monthly interval.

Emblıc (Aonla)

Six promising types which are prolific bearers of quality fruits were identified at

'Seb' variety of jujube (ber) is tolerant to irrigation with saline water in the arid zone.

Faizabad—'Krishna', 'Kanchan', 'FA 6', 'FA 7', 'FA 8' and 'FA 9'.

On alkaline soils (32 ESP and 10 ECE) emblic could be successfully raised when 6-month-old seedlings were planted and budded subsequently. Patched and modified ring method of budding during June to August gave maximum success.

Bael

'NBI' and 'NB 5', with mild fragrance, good taste and low mucilage, were identified at Faizabad. Six-month-old bael seedlings could be successfully grown in alkaline soils after adding half the recommended amount of gypsum.

Datepalm

From Saudi Arabia, 180 female and 10 male offshoots of 6 varieties were introduced.

When a third of the central strands of datepalm bunches were removed immediately after fruit set, the fruits grew to a bigger size and ripened early. Aerva javanica (syn. A. persica), a local weed called bui, when used as a 10-cm-thick mulch in datepalm orchards at Bikaner, reduced soil temperature and moisture depletion.
Tissue-cultured date palm plants could successfully be raised at Hisar.

**Apple**

Of the 7 scab-resistant varieties introduced from the USA, 2 were found suitable for commercial cultivation at Solan. They are the early, sweet, red-fruited 'Coop 12', and the yellow-fruited 'Sir Prize'.

Oak leaves were the best mulch at Chaubatia, and black polythene in the mid-hills of Himachal Pradesh.

Karathene EC 0.05% was most effective against the powdery mildew.

**Almond**

The SKUAT, Kashmir, found 'Non-Pariel' to be suitable for cultivation in almond-growing regions experiencing frost in early spring. Among the other promising varieties identified were exotics 'Nikitiskij', 'Merced', 'Pranayaj' and 'Pimorskij' and indigenous types 'HS 8', 'HS 9', 'ZWS 2', 'AS 4', 'AS 8' and 'HS 10'.

**Peach**

'Kante 5' and 'Shimunu Hakuto' were found suitable for cultivation at Solan.

**Walnut**

'Wussan 1', 'WS 3' and 'WS 4' produced appealing walnuts with high shelling.

**Apricot**

High yields were obtained from 'Nugget' and 'New Castle', and quality fruits were produced by 'Australia', 'Safeda', 'Jakava' and 'Para Parela'. San-Jose scale could be controlled with a mixture of 0.1% boric acid, 0.25% zinc sulphate and 0.10% manganese oxide.

**ORNAMENTALS**

**Rose**

The IARI, New Delhi, developed 5 Hybrid Teas and 3 promising open-pollinated seedlings of 'Frolic'. Sixteen Indian rose varieties were entered in the national trial. 'Raja Surendra Singh of Nalagarh' was found to be a suitable variety for cut flowers.

Three natural mutants for flower colour were spotted in 'IIHR 101' and one in 'Besancon'.

Callus formation and successful shoot-bud production were achieved in cultured rose embryos at the IARI, New Delhi.

**Gladiolus**

'Poonam' was recommended for commercial cultivation at Bangalore and the hills of Uttar Pradesh, and 'Sapna' and 'Nazrana' at Bangalore. 'Sincere' and 'Yellow Stones' were good for cut flowers.

Six promising hybrid seedlings were identified—2 each at New Delhi, Bangalore and Ludhiana. 'Mayur' and 'Suchitra' did well at New Delhi, Ludhiana and Chaubatia.

'Australian Fair', 'Mansoor', 'Margaret Pulton', 'Poonam' and Gladiolus callianthus showed tolerance to Fusarium wilt.

Gladiolus corms soaked in 50 ppm naphthale acetic acid (NAA), produced 14.1 cormels/corm compared with 8.3 cormels produced by the unsoaked corm.

**Chrysanthemum**

'IHHR Sel 3' and 'IIHR Sel 6' produced flowers in great abundance. 'Kum Kum' and 'Shabna' were evolved by the NBRI, Lucknow.

**China Aster**

Colourful flowers of elegant size and attractive length were noticed in 'IIHR 3', 'IIHR 18' and 'IIHR 19'.

**Amaryllis (Hippeastrum)**

Fifteen hybrid seedlings produced attractive flowers whose colours ranged through pink, striped red and deep red.

**Orchids**

Interspecific cross-incompatibility was overcome through the use of mentor pollen and successful crosses were produced in Phalaenopsis and Dendrobium groups.

Phalaenopsis embryos, when cultured in vitro, preferred fructose to glucose or sucrose. Protocorm-like bodies were obtained from
leaf segments of *Phalaenopsis* cultured on Murashige-Skoog's medium supplemented with NAA (1 mg/litre) and benzyl adenine (BA) at 10 mg/litre.

**Bougainvillea**

Shoot tips of Bougainvillea were induced to form multiple shoots *in vitro* through successive subculturing. Fully developed plants were successfully transplanted in the field.

**POST-HARVEST TECHNOLOGY OF HORTICULTURAL CROPS**

**Pre-harvest Treatment for Better Produce**

Spraying of 0.6% calcium as calcium chloride was helpful in reducing the physiological loss in weight and retaining the vitamin C content of mango fruits. When combined with 0.1% boric acid, it checked the black-tip. More mangoes could be retained on the trees when the fruits were sprayed with 4% calcium nitrate containing 50 ppm boric acid. Anthracnose and fruit-rot in mango as well as banana could be checked with Bavistin 0.1%. Maleic hydrazide 2,500 ppm reduced the storage losses and sprouting in potato and onion.

**Packaging**

Bruising, ripening, spoilage and shrivelling in transport and storage were less when mango fruits were packed in collapsible corrugated fibre-board boxes.

**Storage**

*Botryodiplodia* fruit-rot and anthracnose in banana could be effectively controlled with Topsin M 1,000 ppm and Bavistin 1,000 ppm. Cool-chamber storage was helpful in prolonging the freshness, firmness and nutritive qualities of mango, apple, guava and green tomato, but was not found suitable for potato.

When wrapped in sulphur-coated paper, grapes could be stored up to 6 weeks at 5°C. Storage losses and rotting could be checked if onion was kept in storage structures ventilated with perforated bamboo poles.

**Processing**

A pH of 4.5 and a Brix of 14° were optimum for producing banana juice. Banana puree could be used as a substitute for milk in the preparation of flavoured ice-cream.

Sapota could be dried and preserved in powdered form.

A waste-fired dryer was designed in which 200 kg of fresh red chilli could be dried. For drying cardamom in 20-kg batches, a low-cost cardamom dryer was developed. It uses agricultural wastes as fuel and costs Rs 4,000.

A low-cost natural-convection dryer is under fabrication for drying a batch of 3,000 coconuts at a time.

A concentrate could be prepared with 1 part of date-pulp extracted with 2 parts of water, after adjusting the Brix to 15° and acidity to 0.25%. A ready-to-serve beverage could be prepared if the concentrate is diluted 3–4 times with water. Jujube (*ber*) could also be processed for the preparation of candy and beverage. Simple and effective methods have been standardized for preparing lime-based carbonated drinks and preserving whole lime, tomato and raw mango slices.

**Waste Utilization**

Anthocyanin and total soluble solids could be extracted from *jamun* pomace for making an acceptable beverage. Wild apricots could be used for preparing tasty sauce and chutney.

Starch could be extracted from solar-dried potato waste. After steeping into solution, it could be converted into glucose, using solar energy.

**FORAGE AND FODDER CROPS**

**Varietal Improvement**

After extensive testing in different agroclimates, a number of high-yielding forage and fodder crops were identified for different regions (Table 33).

**Forage and Fodder Production**

The most promising variety for cultivation
Table 33. High-yielding forage and fodder varieties for different regions

<table>
<thead>
<tr>
<th>Crop and variety</th>
<th>Area of adaptation</th>
<th>Yield (q/ha)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Green forage</td>
<td>Dry forage</td>
</tr>
<tr>
<td><strong>Cowpea</strong></td>
<td></td>
<td></td>
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<tr>
<td>'UPC 287'</td>
<td>Central</td>
<td>255</td>
<td>56</td>
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<tr>
<td>'UPC 2201'</td>
<td>Southern</td>
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<tr>
<td>'UPC 4200'</td>
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<td><strong>Clusterbean</strong></td>
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<td></td>
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<tr>
<td>'HFG 156'</td>
<td>Northern, saline-alkali soils</td>
<td>156</td>
<td>31</td>
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<tr>
<td>'GL 18'</td>
<td>North-western</td>
<td>238</td>
<td>55</td>
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<tr>
<td>'GL 14'</td>
<td>North-western</td>
<td>238</td>
<td>55</td>
</tr>
<tr>
<td>'HFG 43'</td>
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<tr>
<td><strong>Dinanath-grass</strong></td>
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<tr>
<td>'JP 13'</td>
<td>Temperate</td>
<td>478</td>
<td>131</td>
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<tr>
<td>'IGFRI 2-2-2'</td>
<td>North-eastern</td>
<td>162</td>
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<tr>
<td>'IGFRI 32-1'</td>
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<td>93</td>
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<tr>
<td><strong>Maize</strong></td>
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<td>Early composite, local (small, coloured seed)</td>
<td>Temperate</td>
<td>417</td>
<td>83</td>
</tr>
<tr>
<td>'Ganga 5'</td>
<td>Northern, saline-alkali soils</td>
<td>358</td>
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<td><strong>Guinea-grass</strong></td>
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<td>'PGG 9'</td>
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<td>63</td>
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<td>'PGG 9', 'PGG 20'</td>
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<td>'PGG 14'</td>
<td>Central</td>
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<td>'PGG 13'</td>
<td>Southern</td>
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<td>'PGG 18'</td>
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<td><strong>Napier-pearmillet hybrid</strong></td>
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<td>'PBN 87', 'T 2'</td>
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<td>'IGFRI 7', 'IGFRI 6'</td>
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<tr>
<td><strong>Sorghum, single-cut, early-maturing</strong></td>
<td>North-eastern</td>
<td>482</td>
<td>101</td>
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<td>'S 301', 'UPFS 23'</td>
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<td>365</td>
<td>75</td>
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<td>'S 281', 'UPFS 23'</td>
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<tr>
<td><strong>Sorghum, single-cut, late-maturing</strong></td>
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<td>'UPFS 22', 'IS 7002'</td>
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<td><strong>Sorghum, multi-cut</strong></td>
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<tr>
<td>'Pioneer 988'</td>
<td>North-eastern and southern</td>
<td>618</td>
<td>116</td>
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<td>'PC 68'</td>
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<td><strong>Pearlmillet</strong></td>
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<td>'TNSC 1', 'Syn 15'</td>
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<td>99</td>
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<tr>
<td>'JFB 817', 'UUJ IV-M'</td>
<td>Northern and central</td>
<td>335</td>
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<td><strong>Birdwood-grass</strong></td>
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<tr>
<td>'CAZR 413'</td>
<td>For pasture in arid and semi-arid lands</td>
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<td><strong>Berseem</strong></td>
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<td>'BL 52'</td>
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<td>'BL 10', 'BL 52', 'JB 3'</td>
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<td>Crop and variety</td>
<td>Area of adaptation</td>
<td>Yield (q/ha)</td>
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<td></td>
<td></td>
<td>Green forage</td>
<td>Dry forage</td>
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<td>'BL 42', 'HFB 483'</td>
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<td>'HFB 114', 'HFB 112'</td>
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<td>'HFB 114', 'BL 22'</td>
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<td>'BL 2', 'HFB 114'</td>
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<td><strong>Oat, single-cut</strong></td>
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<td>'PLP 1', 'JHO 810'</td>
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<td>'OS 129', 'OS 96'</td>
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<td>'OS 108', 'OL 9', 'OS 96'</td>
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<td>'OS 129', 'OL 125', 'OS 121'</td>
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<td>'OL 99', 'OL 88'</td>
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<td>'UPO 94', 'UPO 212'</td>
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<td>'OL 88', 'BO 353'</td>
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<tr>
<td>'OL 88', 'OL 99'</td>
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<td>'OL 125', 'OL 9', 'PO 3'</td>
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<tr>
<td>'SS 627'</td>
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<td>'NDFS 1'</td>
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<th>Area of adaptation</th>
<th>Yield (q/ha)</th>
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<td>'DL 36'</td>
<td>Temperate</td>
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</tr>
<tr>
<td>'DL 454', 'DL 452'</td>
<td>Northern</td>
<td>152</td>
</tr>
<tr>
<td>'DL 417', 'DL 436'</td>
<td>North-eastern</td>
<td>312</td>
</tr>
<tr>
<td>'DL 260', 'DL 452'</td>
<td>Central</td>
<td>99</td>
</tr>
<tr>
<td>'DL 157', 'DL 348'</td>
<td>Entire country</td>
<td>215</td>
</tr>
</tbody>
</table>

in the temperate and subtemperate areas of the country is *Setaria 'Narok'* (green fodder 350 q/ha). In subtemperate regions, it could adapt itself to shade-affected grasslands also, though the yield was less.

When grown in the interspaces of coconut orchards, 'Congo Signal'('Ruzi-grass')+ *Cen­trosema* gave a forage yield of 350 q/ha in Kerala. The yield was high when they received 150 kg N/ha and were cut at intervals of 45 days.

For year-round production of forage in the tarai (foothill) region of Uttar Pradesh, the best rotation was Dinanathgrass-berseem-
The grain yield increased when they received a basal application of 30 kg N/ha, followed by a similar dose after the harvest for forage.

Fodder oat ‘OS 7’ was superior to ‘Kent’ for intercropping with white-clover (senjij) in a 2:2 ratio.

Winter maize gave high forage yield (343.5 q/ha) when intercropped with pea and a high amount of crude protein (670 kg/ha) when intercropped with *Lathyrus sativus*. Such intercropping economized the N needs by 40 kg/ha.

Both oat and lucerne gave good yields with the application of Jalashakti up to a dose of 5 kg/ha. Further increase in the dose was not beneficial.

For alley-cropping with subabul (*Leucaena*), the best crop rotation was wheat (‘UP 115’), sorghum (‘PC 6’) and groundnut, the gross return being Rs 38,535. Wheat variety ‘Raj 1555’, which produced a grain yield of 3.97 tonnes/ha when grown as a sole crop, yielded marginally less (3.8 tonnes/ha) when alley-cropped with *Leucaena*.

On moist wastelands, a 6½-year-old *Leucaena* plantation of 10,000 plants/ha produced an above-ground biomass yield of 68.9 tonnes/ha/year.

Napier-grass ‘IGFRI 3’ proved superior to ‘NB 21’, for growing in mixture with *Sesbania* in a 1:1 ratio. Calves fed on the mixture showed very good nitrogen balance.

**Production of Forage Seed**

Cowpea produced 79.7% higher seed yield when sown in the second week of July than when sown on 31 July. ‘NP 3’ recorded the highest seed yield of 8.3 q/ha. The normal as well as the late-sown crop benefited considerably when 40 kg P$_2$O$_5$/ha was applied.

With a basal application of diammonium phosphate @ 150 kg/ha, berseem yielded 210 kg more seed than the control (502 kg/ha).

**PLANT PROTECTION**

Research findings relating to plant protection, an important part of all crop-improvement programmes, have been included under the respective crops. This section highlights the major achievements of the all-India co-ordinated programmes on biological control of crop pests and weeds, white-grubs, rodent control, pesticide residues, economic ornithology, honeybees, agricultural acarology, seed-borne diseases, betelvine and nematode pests.

**Biological Control**

*Hyposoter didymator*, a natural parasite introduced from Australia, preferred to parasitize 4–5-day-old larvae of *Spodoptera litura* when it was a pest of castor, beetroot and cauliflower. However, the parasite did not attack the same larvae when they were feeding on cowpea, okra, cabbage and tobacco. In controlling *Heliothis armigera*, *Hyposoter didymator* was not as effective as *Cotesia kuzak*.

The parasites and predators that proved effective against crop pests are listed in Table 34, and the durations and temperatures at which they could be stored are indicated in Table 35.

<table>
<thead>
<tr>
<th>Crop and pest</th>
<th>Parasite or predator of the pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guava</td>
<td><em>Aeniaspis advena</em>, <em>Scyamus coccivora</em>, <em>Cryptolaemus montrouzieri</em></td>
</tr>
<tr>
<td><em>Ferrisia virgata</em> (striped mealy-bug)</td>
<td></td>
</tr>
<tr>
<td><em>Aphis gossypii</em> (aphid)</td>
<td><em>Menochilus sexmaculatus</em>, <em>Scyamus</em> sp. (predators)</td>
</tr>
<tr>
<td><em>Citrus</em></td>
<td><em>Leptomastix daetyllopia</em> (exotic parasitoid; established)</td>
</tr>
<tr>
<td><em>Planococcus citri</em> (mealy-bug)</td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td><em>Encarsia perniciosa</em>, <em>Aphytis</em> sp. (9.1 to 13.4% parasitism in Jammu and Kashmir)</td>
</tr>
<tr>
<td>San-Jose scale</td>
<td></td>
</tr>
<tr>
<td>Okra</td>
<td><em>Phytoseiulus persimilis</em></td>
</tr>
<tr>
<td>Red spider-mite</td>
<td></td>
</tr>
</tbody>
</table>
Crops and pest | Parasite or predator of the pest
---|---
(predatory mite, established within a month after release)

**Large-scale Field Releases**

<table>
<thead>
<tr>
<th>Crop and pest</th>
<th>Parasite or predator of the pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugarcane</td>
<td>Trichogramma chilonis, T. japonicum in Punjab; Allorhogas pyralophagus at Tega Nagar, Sardar Nagar, Lucknow, Simbhaoli, Yamuna Nagar, Jagadhari</td>
</tr>
<tr>
<td>Chilo infuscatellus at Parvananagar, Maharashtra; C. auricilus and C. infuscatellus at Shakarnagar, Andhra Pradesh</td>
<td>Sticholotis madagassae, adults, Adelenecyrus mayurai, adults at Parvananagar; parasitoids more pronounced on ratoon crop</td>
</tr>
<tr>
<td>Borer</td>
<td>Trichogramma chilonis, T. japonicum in Punjab; Allorhogas pyralophagus at Tega Nagar, Sardar Nagar, Lucknow, Simbhaoli, Yamuna Nagar, Jagadhari</td>
</tr>
<tr>
<td>Melanpsis glomerata (scale-insect)</td>
<td>Sticholotis madagassae, adults, Adelenecyrus mayurai, adults at Parvananagar; parasitoids more pronounced on ratoon crop</td>
</tr>
<tr>
<td>Cotton</td>
<td>Trichogramma chilonis, Chrysopa scelestes, Chelonus blackburni</td>
</tr>
<tr>
<td>Bollworms and Hispaprmiagera at Anand, Gujarat</td>
<td>Trichogramma brasiliensis, T. achaea, Chelonus blackburni</td>
</tr>
<tr>
<td>Bollworms in Punjab</td>
<td>Trichogramma japonicum, Telenomus dignoides, Tetrastichus schoenobi; egg-masses parasitized by 57.1 to 100% in rabi, and by 84.6 to 100% in kharif; Quinalphos and Phosalone sprayed to control pests had no adverse effect on the parasites</td>
</tr>
<tr>
<td>Rice</td>
<td>Trichogramma japonicum, Telenomus dignoides, Tetrastichus schoenobi; egg-masses parasitized by 57.1 to 100% in rabi, and by 84.6 to 100% in kharif; Quinalphos and Phosalone sprayed to control pests had no adverse effect on the parasites</td>
</tr>
<tr>
<td>Scirpophaga incertulas (stem-borer) at Cuttuck, Orissa</td>
<td>Trichogramma japonicum, Telenomus dignoides, Tetrastichus schoenobi; egg-masses parasitized by 57.1 to 100% in rabi, and by 84.6 to 100% in kharif; Quinalphos and Phosalone sprayed to control pests had no adverse effect on the parasites</td>
</tr>
</tbody>
</table>

**Table 35. Periods for which important parasites of crop pests could be stored**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Duration of storage and temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotesia marginiventris, cocoons</td>
<td>20 days at 5°C</td>
</tr>
<tr>
<td>Allorhogas pyralophagus, cocoons</td>
<td>35 days at 10°C</td>
</tr>
<tr>
<td>Strumiopsis inferens, puparia</td>
<td>50 days at 10°C</td>
</tr>
<tr>
<td>Trichogramma achaeae, T. chilonis, T. japonicum, Sticholotis madagassae, all pupae</td>
<td>30 days at 15°C</td>
</tr>
<tr>
<td>Sticholotis madagassae, adults</td>
<td>28 days at 10°C</td>
</tr>
<tr>
<td>Neochetina eichhorniae and N. bruchi</td>
<td>60 days at 15°C</td>
</tr>
</tbody>
</table>

---

* Salvinia, an important aquatic weed, was controlled with the release of *Crytobagus salviniae* in Kerala. In Kuttanad area, about 500 km² have been cleared of this weed. With the release of *Neochetina eichhorniae* and *N. bruchi*, there was a 90% reduction in the troublesome water-hyacinth weed in inundated tanks covering 900 ha in Bangalore. These weed-killing weevils, capable of flight, migrated to all pools and tanks around Bangalore up to a distance of about 30 km. About 30,000 adults of these weevils were released in Bangalore, about 900 hectares of tanks and ponds have been cleared of the troublesome water-hyacinth weed after an inundative release of its weevil pests *Neochetina eichhorniae* and *N. bruchi*. 
Salvinia is a weed that chokes tanks and pools. In the Kuttanad area of Kerala, about 500 square kilometres of natural water reservoirs have been cleared of the weed with a mass-scale release of Cryptobagus salviniae, a pest that attacks Salvinia.

Loktak lake in Manipur, Mula-Mutha river in Pune, and in water-bodies at Nasik, Mandya and Mysore.

White-grubs

The severe drought in kharif adversely affected the population of white-grubs in most parts of the country.

In Rajasthan the beetles of Holotrichia consanguinea failed to emerge and continue their new life-cycle. But their grubs survived in pockets where irrigated crops were grown or light showers were received.

In the Marathwada, Kolhapur-Sangali regions, the emergence of the beetles of H. serrata was normal but the population of their grubs was low because of prolonged dry spell.

In the hills of Uttar Pradesh, drought affected the emergence of the beetles of H. seticollis and Anomala dimidiata, but in their absence an unidentified minor species appeared predominantly.

The black cotton soils of the Nipani region of Karnataka generally turn very sticky during the wet season, becoming unfavourable for the movement of the grubs. This year's drought kept them dry enough to facilitate grub movement. Consequently, tobacco crop was severely damaged due to grubs. Seed treatment with Chlorpyriphos 20 EC or Quinalphos 20 EC @ 2 litres/80 kg of seed was as effective against white-grubs as soil treatment with Phorate 10 G @ 25 kg/ha before sowing. Sugarcane crop could be protected from grub damage with a pre-sowing application of Phorate 10 G @ 25 kg/ha.

*Campsomeriella collaris*, the Scolid parasite of white-grubs, established itself in the sugarcane fields at Kolhapur. The cocoons of this parasite were seen from May to October.

*Bacillus popilliae*, which causes the milky-disease of white-grubs, established itself in some endemic pockets of Rajasthan. The infection of grubs which was 6.6% in August, increased to 73.6% by October. A dust formulation having the spores of this bacterium was prepared for field tests.

*Metarrhizium anisopliae*, a fungus, also attacked the grubs in their early stages.

At Kolhapur, puddled rice fields had no white-grubs, whereas unpuddled fields had 7 grubs/m².

When sugarcane fields infested with *Leucopholis* were ploughed twice, crow, myna and egrets avidly fed on the exposed grubs, reducing their number by 47%.

Rodent Control

An all-India survey showed the bandicoot, *Bandicota bengalensis*, to be the most serious rodent pest. With the laying of the canal system for irrigation, it recently migrated to some pockets of Rajasthan where it was hitherto unknown.

In the north-eastern hills, *Rattus nitidus* formed about 45% and *Mus musculus* about 34% of the rodent population, *Bandicota bengalensis* forming about 8%. In the coconut and cacao plantations of Kerala and Andhra Pradesh, *Rattus rattus wroughtonii* and *Mus booduga* were predominant.
Rice and groundnut suffered considerable loss due to rodents in Punjab. In Uttar Pradesh, rodents accounted for a loss of 4.59 q/ha in wheat and 2.07 q/ha in rice. Chickpea suffered 16.5% loss in Madhya Pradesh. In Andhra Pradesh, bandicoots caused severe losses to rice from the tillering to the harvest stage, and an average burrow contained 377.4 g of rice stems, leaves and ears. In the north-eastern hills rodents damaged 11–18% of rice and 10–20% of pineapple fruits.

*Rattus rattus* and *Mus musculus* were most common in poultry farms. In addition, *Tatera indica* was frequent in Rajasthan and *Bandicota bengalensis* in most places.

In field trials, a single dose of anticoagulants like Bromadiolone, Brodifacoum and Flocoumasen at 0.005% concentration checked the rodent pests of rice, wheat, chickpea, sugarcane, groundnut and chilli. Zinc phosphide 2%, followed by Bromadiolone 0.005% was better than a single application of either of these chemicals in the jujube (*ber*) orchards of the arid zone. In Kerala, raw rice grain sweetened with 2% jaggery was found to be an ideal bait for controlling *Rattus rattus wrightoni*. Three baits of wax formulations of Warfarin or Fumarin at 3-day intervals reduced the rodent damage by 94–100% in coconut gardens. A non-poisonous one-touch glue trap was found superior to the Sherman trap for use at homes and in poultry farms.

**Pesticide Residues**

HCH(BHC), a pesticide commonly used in our country has alpha, beta, gamma and delta isomers, of which only the gamma isomer is insecticidal. The rest of the isomers, including the most stable beta isomer, are left in the form of residues, whose accumulation can be toxic to mammals and hazardous to the environment. Supervised trials at Ludhiana, Hisar, Coimbatore and Kalyani showed that when 10% HCH dust @ 2.5 kg ai/ha was applied in the rice fields, high amounts of the non-insecticidal isomers accumulated on rice bran and straw. When such bran and straw are fed to cattle, the HCH residues would find their way into milk. Since the insecticidal gamma HCH (Lindane) did not constitute a residue hazard, it may be recommended in place of technical HCH for pest control.
No detectable residues of Phorate on groundnut, Endosulfan on jujube (ber) fruits, and Carbofuran on sweet lime and grape were detected. Endosulfan residues on mustard seeds (0.065 to 0.114 ppm) were within the maximum permissible limits.

Vendors around Kanpur often use copper sulphate to keep vegetables fresh. Monitored studies showed that pointed-gourd (parwal) and okra (bhendi) so treated should be thoroughly washed before they are cooked.

Honeybees

The details of plants that are of value, both as nectar and as pollen, to foraging honeybees in different seasons were prepared for various regions.

Pollination by bees increased the fruit-set in different varieties by 9.5 - 52.6% in apple, 10.6 - 22.2% in plum, 9.5 - 27.5% in pear, and 18.9 - 25.4% in apricot. Research showed that honeybee colonies should have queens younger than 16 months so that there would be a large population of worker-brood that collects honey. Formic acid and Thymol fumigation controlled the acarine mites of bees. Since insecticides Endosulfan and Fenitrothion are poisonous, they should be sprayed on crops in the evening, when honeybees return to their hives, instead of in the morning or afternoon. Phosalone was safe for bees, but not Malathion. High-volume spraying was safer than low- or ultra-low-volume spraying. Spraying of citronella oil, a gustatory repellent, effectively kept away bees for 2 hours from fields where insecticides were used.

Acarology

Euseius concordis (Phytoseiidae) was identified as a potential predator of Tetranychus and Eriophyid mites. When mass-reared at 25° - 30°C on castor pollen and released in small-scale experiments at a predator: prey ratio of 1:10, it suppressed the population of Tetranychus neocaledonicus, Brevipalpus phoenicis, Aculus sp. and Raoiella indica.

Oribatid mites Monoscelobates sp. and Brachychthonius sp. were recorded for the first time in India as parasites of water-hyacinth.

Two species of winter and summer mushrooms were found to be attacked, particularly at the bud stage, by mushroom mites Rhizoglyphus echinopus, Tyrophrophus dimidiatus, Histriostoma heinemanni and Hyphoaspis mites, which could not tolerate temperatures beyond 35°C.

The methods of controlling important mite pests are summarized in Table 36.

Table 36. Control measures of important mite pests

<table>
<thead>
<tr>
<th>Crop and mite</th>
<th>Control measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guava</td>
<td>Dicofol 0.3 kg ai/ha or Cyhexatin 0.5 kg ai/ha</td>
</tr>
<tr>
<td><em>Eotetanycthus bicorni</em></td>
<td></td>
</tr>
<tr>
<td>Chilli</td>
<td>Dicofol 200 g ai/ha or 10% BHC 500 g ai/ha or wettable sulphur 675 g ai/ha</td>
</tr>
<tr>
<td><em>Polypagotarsonemus latus</em></td>
<td></td>
</tr>
<tr>
<td>Jasmine</td>
<td>Monocrotrophos</td>
</tr>
<tr>
<td><em>Acria jasmin</em></td>
<td></td>
</tr>
<tr>
<td>Mulberry</td>
<td>Dicofol or Triazophos (did not kill silkworms reared a month after spraying on mulberry leaves)</td>
</tr>
<tr>
<td><em>Acria mori</em></td>
<td></td>
</tr>
<tr>
<td>Mushrooms</td>
<td>Sterilization of straw in beds; Dichlorvos 0.04-0.005%</td>
</tr>
</tbody>
</table>

Seed-borne Diseases

Areas free from diseases during different periods were identified for seed production of rice, wheat, mungbean, urdbean, groundnut and other crops.

Since loose-smut spores were found to travel up to 75 m, an isolation distance of 150 m was recommended for the production of certified seed of wheat.

Pearl millet could be protected from downy-mildew when seed treated with Metaxyl was sown, followed by 2 sprays of Ridomil 30 and 60 days later.

Aspergillus flavus and A. niger could be controlled with treatment of groundnut seeds with Bavistin + Thiram (1:1).
Parakeets and crows can be kept away from maize, sunflower and safflower fields if reflective polythene tapes are fixed a little above the crop level.

**Economic Ornithology**

The common bird pests of crops were found to be rose-ringed parakeet, weaverbird, crow, sparrow, common myna, munia and pigeon. In some places, peacock, babbler, sarus-crane, bank-myna, red-vented bulbul, rosy-pastor and bunting also caused occasional damage.

In the Rangareddi district of Andhra Pradesh, bird damage was less than 10% in *kharif* sorghum, 16.60% in *rabi* sorghum and 10–30% in sunflower in cultivated fields.

There was 10–20% loss in yield due to birds in wheat, barley, mustard and chickpea around Delhi.

At Ludhiana, the loss was 0.79 to 1.81% in wheat, 0.84 to 5.85% in rice, up to 7% in maize, and 19.3% in jujube (*ber*).

At Anand, bird damage was negligible in rice, but wheat suffered 15 to 22% damage. Pearl millet suffered 8.6% loss in *kharif* and 21.46% loss in *rabi*.

At Kota, the damage was 4.85 to 39.2% in maize cobs, and 9.92 to 29.78% in sorghum.

Studies at Hyderabad and Anand showed that the rose-ringed parakeet, a pure vegetarian, feeds on a variety of cereals, millets, oilseeds and fruits. Its diet also includes seeds of *Pongamia* and *Dalbergia*, and fruits of *Peltosphorum pterocarpum*, *Casuarina equisetifolia* and *Lantana camara*.

At Ludhiana, wheat and rice were the most abundant food items of ring-dove and pigeon. The common myna fed mostly on pearl millet, wheat, maize and rice. Bank-myna and starling were predominantly insectivorous.

The beneficial birds which devoured mustard aphids, white-grubs, castor semi-looper and cotton bollworms were blue jay, drongo, cattle egrets, green bee-eater, common myna, crow, grey-shrike, starling and rosy-pastor. They were voracious feeders of the white-grub, reducing their population by 44.86 to 63.5%. The common myna and bank-myna devoured 73% of the population of *Heliothis* larvae in chickpea fields. Bird predation considerably reduced the damage caused to tobacco nurseries by the larvae of *Spodoptera litura*.

Seed treatment with Carbofuran @ 3 g/kg of seed prevented bird damage to sown seeds of sorghum, maize or sunflower. Spraying of
neem-cake solution @ 300 g/litre of water reduced damage to maize cobs at the milk stage by parakeets and crows.

Shining polythene tapes, with red on one side and silver on the other, could keep away parakeets and crows from maize, sunflower and safflower fields. Each tape should be 10-12 mm wide, about 6 m long, and should be fixed just above the crop level after they are slightly twisted and held between bamboo poles. About 60 such tapes are required to protect a hectare.

**Betelvine Protection and Production**

‘Awani’ was resistant to bacterial leaf-blight, and ‘Bangla’ (Mandsour), ‘Vellaipachaikodi’ and ‘Karupupachaikodi’ were resistant to bacterial leaf-spot. Among the pungent varieties, ‘Karapaku’, ‘Gachipan’ (Assam), ‘Bangla’ (Madhya Pradesh) and ‘Kakair’ (Bihar) were resistant to the decline disease. ‘Kalkatia’, ‘Kankar’, ‘Novahut’, ‘Valrai’ and ‘Karupupachaikodi’ were resistant to foot-rot disease.

A sap- and graft-transferable virus disease revealed rod-shaped particles under an electron microscope.

The methods of controlling important pests and diseases of betelvine are indicated in Table 37.

Application of 300 kg N/ha, half as ammonium sulphate and half as neem-cake was better than the full dose applied as ammonium sulphate. Split application of 125 and 150 kg K₂O/ha reduced disease incidence at many centres.

The storage life of betel leaves could be prolonged when the leaves were sprayed with 1% arecanut extract before packing.

**Nematodes**

The white-tip disease of rice was prevalent in Tamil Nadu, Assam, Bihar and Madhya Pradesh and the ‘ufra’ disease of rice in Assam and West Bengal. In Tamil Nadu, *Meloidogyne hapla* was noticed with fingermillet and *Heterodera zeae* with vetiver.

<table>
<thead>
<tr>
<th>Disease or pest</th>
<th>Control measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decline</td>
<td>Surface runoff irrigation, along with gypsum @ 2.5 tonnes/ha at planting</td>
</tr>
<tr>
<td>Foot-rot and leaf-rot</td>
<td>Drenching with 1% Bordeaux mixture, and spraying 0.5% Bordeaux mixture</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Foliar spray of 0.5% Bordeaux mixture or 0.25% copper oxychloride</td>
</tr>
<tr>
<td>Bacterial leaf-spot</td>
<td>Foliar application of Streptocycline 500 ppm or 0.1% Bactrinol-100 + 0.25% Bordeaux mixture</td>
</tr>
<tr>
<td>Bacterial leaf-blight and vine-rot (Xanthomonos campestris var. betlicola)</td>
<td>Soil dusting with bleaching powder @ 12 or 16 kg/ha</td>
</tr>
<tr>
<td>Seedvine rotting, <em>Phytophthora</em> wilt, Xanthomonos leaf-spot and nematodes</td>
<td>Exposure of beds to sunlight after covering them with polythene sheets of 100-gauge thickness for 15 days</td>
</tr>
<tr>
<td>Root-knot nematode</td>
<td>Neem-cake @ 0.5-1 tonne/ha along with Carbofuran @ 0.75 kg/ha before planting; in established gardens, neem-cake @ 2 tonnes/ha</td>
</tr>
</tbody>
</table>

The population of the root-knot nematode was reduced by 50% when rice seeds were soaked overnight in 1% Phosphamidon or Metasystox or Carbofuran. Seed treatment with 3% Marshal 25 ST (Carbofuran) followed by field application of Phorate @ 0.5 kg/ha gave a good control of the root-knot nematode in mungbean. Leaf extracts of *Calotropis*, *Chrysanthemum* and *Eucalyptus* killed nematodes in mushroom-beds without affecting the growth of *Agaricus bisporus*.

**SOIL SCIENCE**

**SOIL RESOURCES**

In association with the state governments, the National Bureau of Soil Survey and Land-Use Planning (NBSSLUP) has launched a
programme to prepare the soil-resource map of 12 states and 1 union territory in the scale of 1:250,000, and of India in the scale of 1:1,000,000. During the year, work has been completed in 3 states and 1 union territory. It was started as a part of a Technical Mission Project and as per the recommendation of the National Workshop on Soil Map of India, held at Nagpur in September 1986.

With the co-operation of different states and other organizations involved in soil survey, 24 well-defined and widely distributed soil series were delineated in 1986-87. This work would facilitate the effective transfer and modification of agrotechnology in different soil classes.

A linkage programme has been initiated with the Land Resource Development Centre (LRDC), UK, and the NBSSLUP to elevate the training centre at Nagpur to international level and to strengthen the training centre at Bangalore. During the year, both these centres trained 45 candidates from various states and central agencies. In addition, about 376 state officials were trained in field mapping, soil taxonomy and laboratory analysis.

**SOIL AND WATER CONSERVATION**

A 3-year study (1984-87) at Agra showed that loss of soil as well as runoff could considerably be reduced by surface-mulching of the soil with contour-cultivated pearl millet or with strip-cropping of pearl millet and mung bean (3:1), although putting the land under grass cover was the best conservation practice (Table 38).

<table>
<thead>
<tr>
<th>Practice</th>
<th>Percentage of rainfall runoff</th>
<th>Soil loss (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated fallow</td>
<td>34.5</td>
<td>29.8</td>
</tr>
<tr>
<td>Grass over</td>
<td>9.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Pearl millet along slope</td>
<td>25.3</td>
<td>13.4</td>
</tr>
<tr>
<td>Pearl millet on contour + mulch</td>
<td>13.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Strip-cropping of pearl millet and mung bean (3:1)</td>
<td>19.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>

3.5-m-wide runon surface, which is mulched with dry grass @ 2 tonnes/ha.

**Conservation Practices in ORP Areas**

In the Bajar-Ganiyar and Siha region (Mohindergarh district, Haryana), effective conservation practices limited the fluctuation of water-table to 1.5-2.5 m inside the ORP watershed compared with 5-6 m outside the watershed in 1987, a year of severe drought. In the Bunga area (Ambala district, Haryana), the crop loss due to the severe drought of 1987 was estimated at about 20% inside the ORP watershed, compared with 65-80% outside it.

A 16-m-high earthen dam having a storage capacity of 59.6 ha-m has been constructed in the Bunga ORP area to harvest runoff water from a catchment area of 127 ha. As a result, in August 1987, when drought was severe, 15.68 ha-m of stored water was available to provide 2 irrigations to a cropped area of 103 ha.

**Waterlogging**

A study of the false-colour composite and black-and-white satellite pictures in a 1:1 million scale showed that out of a geographical area of 44,212 square kilometres in Haryana, 8,620 square kilometres have been affected by waterlogging. Sonepat and Rohtak districts have the most severely affected areas, followed by Jind, Karnal and Hisar. Ambala
Navsari, Hisar, Madurai and Jaggayapeta realized that they would have got more yields had they used less water.

**Crop Sequences with Less Irrigation**

At Ludhiana, 6 crop sequences were tried with limited water to supply 4 and 2 irrigations in a year. Mungbean-wheat was the best sequence when 4 irrigations were available, and fallow-wheat was found suitable when there was enough water for only 2 irrigations in a year (Table 40).

**Irrigation Schedules**

Trials at Almora showed that rice need not be continuously submerged. About 34% of irrigation water could be saved, without any yield loss, when rice was irrigated 2 days after the water in the field subsided.

On the moisture-retaining sandy-loams of Ludhiana, wheat gave an optimum yield of 4.4 tonnes/ha with 3 or 4 irrigations, depending upon rainfall.

The optimum irrigation schedules for important pulses and oilseeds in different soils and climates are summarized in Tables 41 and 42.

**SOIL TEST AND CROP RESPONSES**

The response of crops to recommendations based on soil tests was tested in farmers’ fields in 228 verification and demonstration trials. The results indicated that (i) fertilizer recommendations based on soil tests are superior to general recommendations, (ii) the efficiency of fertilizer use is 20% more when fertilizers are used according to the recommendations based on soil tests, (iii) the response of crops (in terms of kilograms of grain for every kilogram of nutrient) is more when fertilizers are applied on the basis of soil tests, and (iv) targeted yields can be achieved within a deviation of 10% if fertilizer use is based on soil tests (Table 43).
Table 39. Effect of efficient water use on crop yields at selected places

<table>
<thead>
<tr>
<th>Place and crop</th>
<th>Recommended practice</th>
<th>Farmers' practice</th>
<th>Increase in yield over farmers' practice (%)</th>
<th>Water saved compared with farmers' practice (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigation (cm)</td>
<td>Grain yield (tonnes/ha)</td>
<td>Irrigation (cm)</td>
<td>Grain yield (tonnes/ha)</td>
</tr>
<tr>
<td>Navsari Rice</td>
<td>61.3</td>
<td>5.65</td>
<td>124.8</td>
<td>5.52</td>
</tr>
<tr>
<td>Hisar Cotton</td>
<td>17.9</td>
<td>2.47*</td>
<td>26.8</td>
<td>1.93*</td>
</tr>
<tr>
<td>Mungbean</td>
<td>4.7</td>
<td>1.10</td>
<td>7.3</td>
<td>0.69</td>
</tr>
<tr>
<td>Wheat</td>
<td>28.3</td>
<td>3.51</td>
<td>33.1</td>
<td>2.97</td>
</tr>
<tr>
<td>Mustard</td>
<td>12.5</td>
<td>1.00</td>
<td>18.0</td>
<td>0.78</td>
</tr>
<tr>
<td>Madurai Rice</td>
<td>63.3</td>
<td>5.49</td>
<td>75.2</td>
<td>5.19</td>
</tr>
<tr>
<td>Jaggayyapeta Groundnut</td>
<td>35.0</td>
<td>1.50</td>
<td>45.0</td>
<td>1.37</td>
</tr>
</tbody>
</table>

*Raw-cotton yield.

Table 40. Economics of crop sequences at Ludhiana with limited irrigations

<table>
<thead>
<tr>
<th>Number of irrigations and crop sequence</th>
<th>Equivalent wheat yield (kg/ha)</th>
<th>Net returns (Rs/ha)</th>
<th>Net returns/ha-cm of water (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four irrigations a year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum-mustard</td>
<td>4,248</td>
<td>2,596</td>
<td>39</td>
</tr>
<tr>
<td>Mungbean-mustard</td>
<td>4,800</td>
<td>3,380</td>
<td>49</td>
</tr>
<tr>
<td>Mungbean-lentil</td>
<td>3,498</td>
<td>1,593</td>
<td>25</td>
</tr>
<tr>
<td>Mungbean-wheat</td>
<td>5,709</td>
<td>3,890</td>
<td>49</td>
</tr>
<tr>
<td>Pigeonpea-lentil</td>
<td>3,121</td>
<td>1,042</td>
<td>13</td>
</tr>
<tr>
<td>Fallow-wheat</td>
<td>4,101</td>
<td>3,052</td>
<td>65</td>
</tr>
<tr>
<td>Two irrigations a year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigeonpea-lentil</td>
<td>2,636</td>
<td>442</td>
<td>8</td>
</tr>
<tr>
<td>Pearl millet (fodder)-mustard</td>
<td>3,707</td>
<td>2,277</td>
<td>36</td>
</tr>
<tr>
<td>Pearl millet (fodder)-lentil</td>
<td>3,164</td>
<td>1,661</td>
<td>28</td>
</tr>
<tr>
<td>Fallow-mustard</td>
<td>2,591</td>
<td>1,758</td>
<td>59</td>
</tr>
<tr>
<td>Fallow-wheat</td>
<td>4,391</td>
<td>2,707</td>
<td>89</td>
</tr>
<tr>
<td>Fallow-lentil</td>
<td>3,012</td>
<td>2,692</td>
<td>82</td>
</tr>
</tbody>
</table>

Table 41. Optimum irrigation schedules for pulse crops (in addition to irrigation just before or after sowing)

<table>
<thead>
<tr>
<th>Location and soil type</th>
<th>Number of irrigations and stages (days after sowing)</th>
<th>Depth of irrigation (cm)</th>
<th>Yield (tonnes/ha)</th>
<th>Percentage increase in yield over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickpea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sriganganagar, sandy-loam</td>
<td>2; vegetative, pod development (42, 122)</td>
<td>14</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>Delhi, sandy-loam</td>
<td>2; branching, pod development</td>
<td>12</td>
<td>2.36</td>
<td>46</td>
</tr>
<tr>
<td>Morena, sandy-loam</td>
<td>1; pod development (109)</td>
<td>7.5</td>
<td>2.68</td>
<td>16</td>
</tr>
<tr>
<td>Kota, clay</td>
<td>1; pod development (78)</td>
<td>6</td>
<td>2.41</td>
<td>82</td>
</tr>
</tbody>
</table>
Table 42. Optimum irrigation schedules for oilseed crops (in addition to irrigation just before or after sowing)

<table>
<thead>
<tr>
<th>Location and soil type</th>
<th>Number of irrigations and stages (days after sowing)</th>
<th>Depth of irrigation (cm)</th>
<th>Yield (tonnes/ha)</th>
<th>Percentage increase in yield over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mustard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sriganganagar, sandy-loam</td>
<td>2; branching, flowering*seed development (32, 87)</td>
<td>14</td>
<td>1.98</td>
<td>18</td>
</tr>
<tr>
<td>Delhi, sandy-loam</td>
<td>2; IW/CPE 0.6</td>
<td>12</td>
<td>1.66</td>
<td>53</td>
</tr>
<tr>
<td>Morena, sandy-loam</td>
<td>2; pre-flowering, seed development (43, 70)</td>
<td>15</td>
<td>1.63</td>
<td>61</td>
</tr>
<tr>
<td>Pusa, sandy-loam</td>
<td>2; branching, flowering (41, 92)</td>
<td>12</td>
<td>1.79</td>
<td>75</td>
</tr>
<tr>
<td>Jhargram, sandy-loam</td>
<td>2; branching, flowering (30, 42)</td>
<td>8</td>
<td>1.42</td>
<td>216</td>
</tr>
<tr>
<td>Groundnut, rabi and summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navsari, clay</td>
<td>7; CPE 100</td>
<td>52</td>
<td>2.18</td>
<td>34</td>
</tr>
<tr>
<td>Parbhani, clay-loam</td>
<td>23; CPE 50</td>
<td>138</td>
<td>2.10</td>
<td>87</td>
</tr>
<tr>
<td>Chalakudy, sandy-loam</td>
<td>7; CPE 80</td>
<td>35</td>
<td>2.07</td>
<td>67</td>
</tr>
<tr>
<td>Bilaspur, sandy-loam</td>
<td>12; CPE 60</td>
<td>84</td>
<td>3.26</td>
<td>42</td>
</tr>
<tr>
<td>Chiplima, sandy-loam</td>
<td>9; CPE 50</td>
<td>54</td>
<td>1.88</td>
<td>38</td>
</tr>
<tr>
<td>Safflower, rabi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raburi, clay</td>
<td>2; branching, flowering</td>
<td>15</td>
<td>2.36</td>
<td>93</td>
</tr>
<tr>
<td>Parbhani, clay-loam</td>
<td>5; IW/CPE 0.8</td>
<td>30</td>
<td>1.74</td>
<td>200</td>
</tr>
<tr>
<td>Jhargram, sandy-loam</td>
<td>3; branching, flowering, seed development (42, 102, 135)</td>
<td>15</td>
<td>1.49</td>
<td>188</td>
</tr>
<tr>
<td>Linseed, rabi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delhi, sandy-loam</td>
<td>4; IW/CPE 0.6</td>
<td>24</td>
<td>1.86</td>
<td>232</td>
</tr>
<tr>
<td>Kota, clay</td>
<td>2; branching, capsule development (65, 85)</td>
<td>12</td>
<td>1.07</td>
<td>—</td>
</tr>
<tr>
<td>Sesamum, summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bhavanisagar, sandy-loam</td>
<td>2; sowing, seed development (1, 51)</td>
<td>10</td>
<td>0.77</td>
<td>—</td>
</tr>
<tr>
<td>Chalakudy, sandy-loam</td>
<td>5; IW/CPE 0.75</td>
<td>20</td>
<td>0.60</td>
<td>95</td>
</tr>
</tbody>
</table>

SALINITY AND ALKALINITY RESEARCH

To ameliorate waterlogging and high salinity in the village Sampla (Rohtak district, Haryana), cement-concrete drains having a diameter of 10 cm were laid 1.75 m below the ground level at a lateral spacing of 25, 50 and 75 m, covering an area of 10 ha. The lateral drain spacings of 25 and 50 m reduced the surface salinity from 50 dSm⁻¹ at the start of the experiment (1984) to 10 dSm⁻¹ by 1987. Because of low rainfall in 1987, the salt level may remain the same this year.
Table 43. Increased efficiency of fertilizers used on the basis of soil tests

<table>
<thead>
<tr>
<th>Location and soil type</th>
<th>Crop and variety</th>
<th>Soil-test values (kg/ha)</th>
<th>Yield target (q/ha)</th>
<th>Fertilizer used (kg/ha) based on soil tests</th>
<th>Yield obtained (q/ha)</th>
<th>Response ratio (kg of product/kg of nutrient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangalore, Red</td>
<td>Sorgbhum, 'CSH 1'</td>
<td>392</td>
<td>33.7</td>
<td>321</td>
<td>35</td>
<td>41.43</td>
</tr>
<tr>
<td>Bangalore, Red</td>
<td>Wheat, 'Sonalika'</td>
<td>392</td>
<td>33.7</td>
<td>321</td>
<td>35</td>
<td>35.95</td>
</tr>
<tr>
<td>Barrackpore, Gangetic alluvial</td>
<td>Jute, 'JRO 7835'</td>
<td>374</td>
<td>34.8</td>
<td>400</td>
<td>25</td>
<td>36.67</td>
</tr>
<tr>
<td>Coimbatore, Black</td>
<td>Cotton, 'Suvin'</td>
<td>384</td>
<td>35.0</td>
<td>760</td>
<td>35</td>
<td>36.00</td>
</tr>
<tr>
<td>Dholi, Alluvial</td>
<td>Potato, 'Kufri Sindhuri'</td>
<td>230</td>
<td>4.2</td>
<td>32</td>
<td>25</td>
<td>28.03</td>
</tr>
<tr>
<td>Jabalpur, Black</td>
<td>Pigeonpea, 'JA 3'</td>
<td>314</td>
<td>8.0</td>
<td>627</td>
<td>25</td>
<td>22.85</td>
</tr>
<tr>
<td>Barrackpore, Gangetic alluvial</td>
<td>Rice, 'Pankaj'</td>
<td>299</td>
<td>27.8</td>
<td>339</td>
<td>45</td>
<td>40.80</td>
</tr>
</tbody>
</table>
Optimum yields are obtained when fertilizers are applied on the basis of soil tests and crop needs. Generalized application of fertilizers often results in the wastage of the expensive inputs and may even depress yields.

Agroforestry in Alkali Soils

Plantations of mesquite (Prosopis chilensis; syn. P. juliflora) could be established in the highly deteriorated alkali soil at Gudha (Aquic Natrustalf, pH 10.4, ESP 90) when the saplings of the tree are planted in trenches 30 cm x 30 cm, filled with a mixture of 3 kg of gypsum and 8 kg of farmyard manure per tree. Karnal-grass (Diplachne fusca; syn. Leptochloa fusca) grown in the inter-row of mesquite produced 25.3 tonnes of green forage per hectare in 8 cuts taken during 26 months.

Crops for Coastal Saline Soils

In acid saline coastal soils where no crop could be grown earlier, application of lime @ 6 tonnes/ha facilitated the cultivation of rice, watermelon and bittergourd. An alternative to lime was powdered oyster-shell, available in plenty in the Sunderbans area.

Rice variety ‘CSR 6’ (‘IET 5997’) gave a high mean yield of 3.05 tonnes/ha on the saline coastal soils and was recommended in Orissa and West Bengal. ‘CST 7-1’ (‘IET 9341’) consistently performed well in saline as well as saline-alkali soils, and was included in minikit trials.

Rice-cum-Fish Culture in Coastal Areas

Kharif rice is the only crop normally grown in rainfed coastal areas. A 6-year study has shown that growing freshwater fish in rice fields in kharif, with vegetables on the field bunds, followed by growing brackishwater fish in summer (when sweet water is rare) would increase the net income 8 times, without deteriorating the soil.

Irrigation with Saline Water

At Agra, Bapatla and Dharwad, a number
of crop varieties showed high tolerance to irrigation with saline water (Table 44). At Jobner, the grasses that gave maximum yields when irrigated with saline water were Rhodes-grass (*Chloris gayana*), blue-panic (*Panicum antidotale*) and para-grass (*Brachiaria mutica*).

**Table 44.** Crop varieties showing high tolerance to irrigation with saline water

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agra</td>
<td>Wheat</td>
<td>'WL 2385', 'PBW 138', 'PBW 120', 'WH 838',</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Raj 2325', 'Raj 2005', 'PBW 124', 'HD 2379',</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'HD 2270', 'HD 2374'</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>'DL 348', 'DL 356', 'Ratna', 'DL 85', 'DL 349'</td>
</tr>
<tr>
<td>Mustard</td>
<td></td>
<td>'T 59', 'Kranti', 'DIRA 342', 'Pusa Bold'</td>
</tr>
<tr>
<td>Bapatla</td>
<td>Rice</td>
<td>'NLR 30981', 'Mtu 4870' (both of long duration), 'Surekhana' (medium to short duration)</td>
</tr>
<tr>
<td>Dharwad</td>
<td>Cotton</td>
<td>'MF 16'</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>'DWR 244-20'</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>'SPV 86', '5-4-1'</td>
</tr>
</tbody>
</table>

**Sewage Water for Irrigating Trees**

Eucalyptus, subabul and poplar trees raised on furrows and ridges grew well when irrigated with untreated sewage water. There was no salinity build-up nor was there any adverse effect on soil properties. The Air Force Station at Sirsa and the Municipal Committees of Yamuna Nagar and Sahabad (Haryana) have adopted this technology.

**MICRONUTRIENTS IN SOILS AND PLANTS**

**Micronutrient-deficient Areas**

Analysis of 9,715 soil samples and 765 plant samples collected from 8 states during the year showed that 44% of soils were deficient in zinc, 11% in copper, 10% in iron and 6% in manganese.

In Ludhiana district 42% of the 676 soil samples analysed were deficient in sulphur.

**Response to Zinc**

Application of 25 kg of zinc sulphate (ZnSO₄ · 7H₂O) per hectare in cultivators’ fields of rice, sorghum and wheat increased yields by more than 2 q/ha in most places in Andhra Pradesh, Bihar, Punjab and Gujarat.

**Correcting Boron and Iron Deficiencies**

In boron-deficient calcareous soils of Dholi (Bihar) application of boron @ 1.5 kg and 2.0 kg/ha to maize and chickpea respectively increased yields by 10.5 q and 7.4 q/ha.

Both soil application of iron @ 10 kg/ha and 3 foliar sprays of 1% ferrous sulphate solution at 10-day intervals were effective in overcoming iron deficiency in the alkaline clay of Powarkheda Farm, Hoshangabad. The yield of wheat increased by 2.7 q/ha and of soybean by 3.9 q/ha.

**AGROMETEOROLOGY**

An analysis of the rainfall data of the last 30 years at Anand (Table 45) has shown that if the south-west monsoon arrives after 1 July, it would recede before 9 September. If it arrives before 1 July, an annual rainfall of more than 1,000 mm can be expected (P = 0.29).

On the basis of the field experiments conducted at Anantapur, a mathematical model was worked out to predict the pod yield and dry matter of groundnut on the basis of water use. The model would be useful in monitoring groundnut production in drylands.

\[
Y_d = 1.2548 + 0.0151 X \quad (r = 0.9770**)
\]

\[
Y_p = 1.2747 - 0.0089 X \quad (r = 0.9846**)
\]

\[
y_d \text{ is total dry matter; } y_p \text{ is pod yield; } x \text{ is water use in millimetres; } ** \text{ highly significant.}
\]

**DRYLAND RESEARCH**

In view of the unprecedented drought in *kharif* 1987 in most parts of the country, the
package of practices that increase production in drylands of different regions were compiled and printed, both in English and Hindi, for free distribution. A policy document dealing with the technology for mitigating the adverse effects of kharif drought by increasing production during rabi 1987-88 was prepared for the use of policy-implementing agencies.

At the dryland centre at Bhilwara, intercropping of groundnut and sesame in a row ratio of 5:1 has resulted in a land-equivalent ratio of 1:58.

A number of genotypes of barley, pulses and oilseeds were screened and the types that performed best in drylands of different regions were identified (Table 46).

### Table 45. Association between dates of onset and withdrawal of south-west monsoon and the annual rainfall at Anand (1957-1986)

<table>
<thead>
<tr>
<th>Date of commencement of south-west monsoon</th>
<th>Number of years with occurrence</th>
<th>Number of years with monsoon rainfall continued up to</th>
<th>Number of years with annual rainfall more than 1,000 mm</th>
<th>Mean annual rainfall (mm) average of 30-year data</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-17 June</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>18 June to 1 July</td>
<td>16</td>
<td>16</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>2-15 July</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16-29 July</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 June to 29 July</td>
<td>30</td>
<td>30</td>
<td>23</td>
<td>18</td>
</tr>
</tbody>
</table>

**Making the Most of the Limited Land**

At CRIDA, Hyderabad, alley-cropping of pearlmillet with subabul (*Leucaena*) was found to be beneficial. Subabul made effective use of the off-season precipitation, and mulching of its leaves not only improved the soil structure but also supplied nutrients. Consequently, pearlmillet gave 40% more yield than when it was grown as a sole crop (Table 49). In addition, subabul yielded 2.2 tonnes of fuelwood and 0.8 tonnes of fodder per hectare.

At Anantapur, a combination of 25% agroforestry with 75% arable farming (crop cultivation) resulted in more grain and fodder yields than with 100% arable farming.

**N Fixation by Tree Legumes**

Studies on the pattern of N fixation showed...
Table 46. Genotypes of barley, pulses and oilseeds that performed well on drylands of different regions

<table>
<thead>
<tr>
<th>Crop</th>
<th>Centre</th>
<th>Genotypes (in order of performance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Rakh Dhiansar</td>
<td>'Sonu', 'BHS 169', 'HBL 316', 'HEL 329'</td>
</tr>
<tr>
<td>Pigeonpea, rabi</td>
<td>Akola</td>
<td>'MAUE 175', 'ICPL 84008', 'AS 71–37', 'BWR 370'</td>
</tr>
<tr>
<td>Horsegram</td>
<td>Bhubaneshwar</td>
<td>'DHS 82–3', 'DHS 82–2', 'DS 2–1', 'DS 2–2'</td>
</tr>
<tr>
<td></td>
<td>Sholapur</td>
<td>'D 40–1', 'JND 2'</td>
</tr>
<tr>
<td></td>
<td>Bangalore</td>
<td>'BGM 1–1–8–3', 'CODB 6', 'IC 11095', 'IC 42'</td>
</tr>
<tr>
<td></td>
<td>Bijapur</td>
<td>'GPM 108', 'GPM 118', 'GPM 14', 'GPM 34', 'DS 40–1', 'DS 2–2', 'IC 11095'</td>
</tr>
<tr>
<td>Chickpea</td>
<td>Arjia</td>
<td>'BG 209', 'BGM 428', 'GNG 146'</td>
</tr>
<tr>
<td></td>
<td>Rewa</td>
<td>Large seeds: 'BG 303', 'BG 256A', 'GP 16', 'BG 256'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium-sized seeds: 'BGM 428', 'GP 2–20', 'GP 9060', 'PDG 83–84'</td>
</tr>
<tr>
<td>Safflower</td>
<td>Agra</td>
<td>'BG 256', 'Gaurav', 'BG 244', 'L 550'</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Ranchi</td>
<td>'KM 55', 'KM 40', 'KM 44', 'KM 25'</td>
</tr>
<tr>
<td>Taramira</td>
<td>Bijapur</td>
<td>'SS 49', 'EC 68145', 'KSF 4–1', 'SS 56'</td>
</tr>
<tr>
<td>Lentil</td>
<td>Varanasi</td>
<td>'RTM 2–1', 'RTM 522', 'TMH 851', 'JOBTC 1'</td>
</tr>
<tr>
<td></td>
<td>Rewa</td>
<td>Small seeds: 'K 333', 'HUL 8', 'JL 1', 'JL 299'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bold seeds: 'L 4–126', 'L 4076', 'L 4125', 'K 75'</td>
</tr>
<tr>
<td>Mustard</td>
<td>Varanasi</td>
<td>'Pant L 4076', 'Sehore 74–3', 'Pant L 639', 'JL 1'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small seeds: 'PDL 2', 'HUL 8', 'HUL 31', 'PDL 1'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bold seeds: 'K 303', 'L 4126', 'L 4125', 'L 4132'</td>
</tr>
</tbody>
</table>

Table 47. Optimum plant densities and land-equivalent ratios of intercropping systems

<table>
<thead>
<tr>
<th>Centre</th>
<th>Intercrops and plant density</th>
<th>Yield (q/ha)</th>
<th>Land-equivalent ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Base crop</td>
<td>Intercrop</td>
</tr>
<tr>
<td>Agra</td>
<td>Pearlmillet 100% + Mungbean 100%</td>
<td>8.2</td>
<td>11.5</td>
</tr>
<tr>
<td>Akola</td>
<td>Cotton 75% + Mungbean 100%</td>
<td>7.5</td>
<td>12.8</td>
</tr>
<tr>
<td>Ranchi</td>
<td>Sorghum 100% + Urdbean 100%</td>
<td>53.1</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Table 48. Optimum row ratios and land-equivalent ratios of intercropping systems

<table>
<thead>
<tr>
<th>Centre</th>
<th>Intercrops</th>
<th>Row ratio</th>
<th>Yield (q/ha)</th>
<th>Land-equivalent ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Base crop</td>
<td>Intercrop</td>
</tr>
<tr>
<td>Dantiwada</td>
<td>Pearlmillet + Cowpea</td>
<td>2:1</td>
<td>2.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Bhilwara</td>
<td>Groundnut + Sesamum</td>
<td>2:1</td>
<td>3.1</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5:1</td>
<td>7.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Agra</td>
<td>Pigeonpea + Mungbean (paired rows)</td>
<td>2:2</td>
<td>8.5</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Pigeonpea + Mothbean (paired rows)</td>
<td>2:2</td>
<td>8.2</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Pigeonpea + Urdbean (paired rows)</td>
<td>2:2</td>
<td>7.8</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>Pigeonpea + cowpea (paired rows)</td>
<td>2:2</td>
<td>6.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
that nodule initiation was the earliest in Sesbania, followed by Gliricidia and Leucaena. The nodules of Leucaena had more leghaemoglobin than the nodules of the other 2 species. However, the highest amount of N was fixed by Gliricidia as it had higher nodule biomass.

**Organic Manures for Drylands**

Incorporation of organic matter resulted in a saving on the use of chemical fertilizers and enhanced the yields of crops on drylands (Table 50).

A 5-year study in different groundnut-growing regions has shown that income can be stepped up by Rs 525 to Rs 2,186/ha if one row of sunflower is grown between 3 rows of rainfed groundnut. Such intercropping will also insure farmers against fluctuations in groundnut production in rainfed areas.

**Table 49. Yields of pearl millet and subabul in alley-cropping at Hyderabad**

<table>
<thead>
<tr>
<th>Width of subabul alleys</th>
<th>Grain yield of pearl millet (q/ha)</th>
<th>Dry matter of subabul (q/ha)</th>
<th>Nitrogen (kg/ha) added through mulch</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6 m, mulch</td>
<td>21.5</td>
<td>Fuel 36.1</td>
<td>43</td>
</tr>
<tr>
<td>3.6 m, fodder</td>
<td>18.1</td>
<td>Fodder 11.4</td>
<td></td>
</tr>
<tr>
<td>7.8 m, mulch</td>
<td>24.9</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>7.8 m, fodder</td>
<td>16.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No subabul; pearl millet grown as sole crop</td>
<td>17.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Time of Sowing Rainfed Crops**

Models have been developed to work out the yields of rainfed crops as influenced by the commencement of rains at the time of sowing. The results showed that at Jodhpur pearl millet would give good yields when the first showers are received any time between 18 June and 15 July. Likewise, analysis of the last 8-year data showed that groundnut would yield more than 7.2 q/ha if it is sown before 1 July with the commencement of rains.

**Seeding Devices**

For use on drylands, Factory seed-cum-fertilizer drill was found to be efficient for upland rice at Bhubaneshwar, CIAE drill for soybean at Indore, and the 3-tyned Eenati Gorru for groundnut seeding at Anantapur.

**Watershed Management**

When the whole watershed of Chevella (vertisol) was treated as a unit and crops were grown with improved practices, the yields within the watershed were significantly higher than the yields obtained outside the watershed (Table 51) even in 1987, when the rainfall was subnormal.

**Transfer of Technology**

Even though the rainfall was scanty in 1987, 98 families in the Yellammatanda village of the Ranga Reddi district of Andhra Pradesh adopted under the Lab-to-Land Programme were able to harvest 18–32 q of sorghum, 1.2–2.5 q of pigeonpea, 6.8–12.4 q
The ridge-and-furrow system of planting and mulching with straw, polythene and legumes are helpful moisture-conserving measures in most drylands.

Table 50. Effect of incorporation of organic matter on the yields of crops grown on drylands

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without organic matter</td>
<td>With organic matter</td>
</tr>
<tr>
<td></td>
<td>With 30 kg N, 20 kg P and 10 kg K (half the recommended dose)</td>
<td>+ legume residue @ 5 tonnes/ha</td>
</tr>
<tr>
<td></td>
<td>With 40 kg N/ha (in the form of urea)</td>
<td>with subabul leaves @ 2 tonnes/ha + 20 kg N/ha</td>
</tr>
</tbody>
</table>

Bangalore
- Fingermillet: 38.3
- Groundnut: 16.8

Hoshiarpur
- Maize: 31.4

Rakh Dhiansar
- Maize: 25.0

Hyderabad
- Sorghum: 29.3

of pearemillet, and 5.4–12.4 q of castorbean per hectare.

**ARID ZONE RESEARCH**

Because of severe drought, sewan (*Lasiurus sindicus*), burgas (*Cymbopogon jwarancusa*), murut (*Panicum turgidum*) and karad (*Dichanthium annulatum*) failed to sprout. As a result, undershrubs not generally considered palatable to livestock formed the major source of browsing material. They include *bui*
Table 51. Yields of crops within and outside the Chevella (vertisol) watershed

<table>
<thead>
<tr>
<th>Crop</th>
<th>Grain yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Within the watershed</td>
</tr>
<tr>
<td>Mungbean</td>
<td>4.2</td>
</tr>
<tr>
<td>Urdbean</td>
<td>3.2</td>
</tr>
<tr>
<td>Sunflower</td>
<td>2.7</td>
</tr>
<tr>
<td>Sorghum</td>
<td>15.6</td>
</tr>
</tbody>
</table>

(Aerva javanica; syn. A. persica and A. pseudotomentosa) and sannia (Crotalaria burhia).

Crop Management

Clusterbean variety ‘2470/12’ could withstand the severe moisture stress caused by acute drought in the arid zone (kharif rainfall 28.7 mm). Almost half the plants planted in the ridge-furrow system on 26 August 1987 survived after a rainfall of only 11.5 mm, whereas all the flat-planted plants died.

For cultivation on arid lands, ‘CZH 43-859’, a bold-seeded hybrid pearl millet that matures in 75 days, was developed. It consistently gave 10% more yield than ‘MBH 110’.

On problem soils of the arid region, safflower could be grown up to 9.3 pH, and sunflower up to ECE 15 dSm⁻¹. Taramira showed some promise on alkali soils.

Fodder Trees

Ten years after tree plantation on the rocky rangelands of Borunda, the maximum herbage was produced by Colophospermum mopane (9.77 q/ha), followed by Cailliea glomerata (syn. Dichrostachys nutans) (9.02 q/ha). Azadirachta indica (3.40 q/ha) and Acacia tortilis (2.68 q/ha) gave low yields.

The fruits of Balanites aegyptiaca (syn. B. roxburghii) collected from western Rajasthan seemed to be a promising source of diosgenin.

Arid Horticulture

Well waters are generally saline in the districts of Jodhpur, Pali, Jalore, Nagaur, Sikar and Jhunjhunu. Screening trials with fruit crops have shown that ‘Seb’ variety of jujube (ber) and ‘Khog’ variety of pomegranate have considerable tolerance to saline irrigation.

Solar Cooker

A community-size solar cooker has been designed and fabricated. In a day, it could cook 30 kg of dry food such as rice, lentil and potato for about 60 people. It would be useful for providing mid-day meals to schoolchildren, scouts and trekking parties.

AGRONOMIC RESEARCH

Crop Sequences

The crop sequences found most promising in different regions and soil groups are presented in Table 52.

Rice yielded 5.89 tonnes/ha at Raipur, and wheat produced 5.1 tonnes/ha at Honnaville, indicating a high potential for increasing cereal production in Madhya Pradesh and Karnataka.

The date of sowing, fertilizer application and density of planting are the factors important for achieving high yields. Table 53 indicates the extent to which yields would be less if there are constraints to the implementation of any of these recommendations.

Intercropping and Mixed Cropping

When 2 rows of soybean were grown in a normal maize crop at Ranchi, maize yielded 47.9 q and soybean 11.8 q (per hectare). In fingermillet + urdbean mixed cropping (6:2), fingermillet yielded 22.1 q and urdbean 11.8 q per hectare at Sabour. In wheat + mustard system in 6:2 alternate rows, wheat yielded 43.5 q and mustard produced 8.3 q. In this system, the yield of wheat was reduced only by half a quintal, the mustard yield being a bonus.

In farmers’ fields, growing of pulses in between the rows of a regular main crop proved highly remunerative when both the crops received the recommended doses of fertilizers (Table 54).
### Table 52. Yields and gross returns from promising crop sequences in different regions

<table>
<thead>
<tr>
<th>Agro-climatic region</th>
<th>Location</th>
<th>Crop sequence</th>
<th>N:P:K</th>
<th>Yield (q/ha)</th>
<th>Total grain yield (q/ha)</th>
<th>Gross returns (Rs/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Kharif</td>
<td>Rabi</td>
<td>Summer</td>
<td>Kharif</td>
<td>Rabi</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Ranbir Singh Pura</td>
<td>Rice</td>
<td>Wheat</td>
<td>Fodder sorghum + cowpea</td>
<td>200:131:49</td>
<td>38.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Kalyani</td>
<td>Rice</td>
<td>Wheat</td>
<td>Fallow</td>
<td>200:110:60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rice</td>
<td>Potato</td>
<td>Jute</td>
<td>280:220:160</td>
<td>58.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rice</td>
<td>Potato</td>
<td>Maize</td>
<td>410:240:200</td>
<td>41.6</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Ranchi</td>
<td>Soybean</td>
<td>Wheat</td>
<td>120:110:65</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groundnut</td>
<td>Wheat</td>
<td>—</td>
<td>125:100:50</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bichpuri</td>
<td>Pearl millet</td>
<td>Chickpea</td>
<td>150:140:65</td>
<td>26.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pearl millet</td>
<td>Wheat</td>
<td>Mungbean</td>
<td>245:150:80</td>
<td>25.7</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Raipur</td>
<td>Rice</td>
<td>Berseem</td>
<td>Cluster bean (vegetable)</td>
<td>230:130:90</td>
</tr>
<tr>
<td></td>
<td>VI</td>
<td>Hanumangarh</td>
<td>Groundnut</td>
<td>Wheat</td>
<td>Mungbean</td>
<td>255:145:120</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pearl millet</td>
<td>Wheat</td>
<td>Mungbean</td>
<td>240:80:0</td>
<td>32.5</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>Sehore</td>
<td>Soybean</td>
<td>Wheat</td>
<td>120:140:60</td>
<td>21.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Akola</td>
<td>Sorghum</td>
<td>Wheat</td>
<td>260:160:120</td>
<td>42.6</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>Parbhani</td>
<td>Rice</td>
<td>Potato</td>
<td>200:130:110</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groundnut</td>
<td>Wheat</td>
<td>145:110:85</td>
<td>22.3</td>
<td>24.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rahuri</td>
<td>Mungbean</td>
<td>Sorghum</td>
<td>165:160:60</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>VIII</td>
<td>Honnayville</td>
<td>Cowpea</td>
<td>Sunflower</td>
<td>237:230:125</td>
<td>20.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groundnut</td>
<td>Wheat</td>
<td>Finger millet</td>
<td>225:130:125</td>
<td>25.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Siruguppa</td>
<td>Mungbean</td>
<td>Cotton</td>
<td>Sunflower</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sorghum</td>
<td>Urd bean</td>
<td>Sorghum</td>
<td>—</td>
<td>27.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thanjavur</td>
<td>Groundnut</td>
<td>Rice</td>
<td>Mungbean</td>
<td>182.5:122.5:110</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finger millet</td>
<td>Rice</td>
<td>Soybean</td>
<td>265:152.5:112.5</td>
<td>39.4</td>
</tr>
<tr>
<td></td>
<td>Karamana</td>
<td>Rice</td>
<td>Rice</td>
<td>Mungbean</td>
<td>180:90:90</td>
<td>32.6</td>
</tr>
</tbody>
</table>
Double-cropping

In the rainfed regions of Goalpara, Manipur, Singhbhum, Shahdol and Nagpur districts, where a single crop of rice is predominantly grown, the introduction of short-duration varieties of rice was highly profitable, as they not only yielded as much as the varieties traditionally grown, but made it possible for the farmers to raise a second crop of wheat or cowpea or other legumes after rice. With the recommended fertilizer doses, the net returns increased by 200 to 400%.

On irrigated lands, growing a pulse or an oilseed after a cereal crop gave higher net returns than growing a cereal after cereal in several districts (Table 55).

Table 55. Profitable cereal, pulse and oilseed rotations on rainfed lands of selected districts

<table>
<thead>
<tr>
<th>District</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sangrur</td>
<td>Mungbean-wheat</td>
</tr>
<tr>
<td>Aligarh</td>
<td>Maize-chickpea</td>
</tr>
<tr>
<td>Pratapgarh and Ghazipur</td>
<td>Rice-chickpea</td>
</tr>
<tr>
<td>Hardoi</td>
<td>Urdbean-wheat</td>
</tr>
<tr>
<td>Mehsana</td>
<td>Mungbean-mustard</td>
</tr>
<tr>
<td>Narsinghpur and Kota</td>
<td>Soybean-wheat</td>
</tr>
<tr>
<td>Nagpur and Kolhapur</td>
<td>Groundnut-chickpea</td>
</tr>
<tr>
<td>Nanded</td>
<td>Groundnut-wheat</td>
</tr>
</tbody>
</table>

Long-term Fertilizer Experiments

Long-term experiments at a number of places clearly indicated the need to apply balanced doses of recommended fertilizers for
maintaining a high level of productivity.

When N alone was applied, the native P in the soil declined, and the crop response showed a declining trend after 8 cropping cycles at Barrackpore, Hyderabad and Pan­
nagar; after 3 years at Jabalpur, Coimbatore and Palampur; and after just 1 year in the acid red-loam soils of Ranchi and Bangalore.

Likewise, when the soil K became the limiting factor, crop response to applied P started diminishing after the first crop itself at Jabal­
pur, Coimbatore, Bangalore, Hyderabad, Ranchi, Palampur and Ludhiana. The crops started giving a high response when the depleted native soil K was made good with K application.

The long-term experiments also showed that continuous use of high-analysis fertilizers containing N, P and K in the pure, sulphur­
free form would make sulphur a limiting nutrient in the soils of Barrackpore, Bhubanesh­
war, Pantnagar, Jabalpur and Palampur. When the available sulphur in such soils diminished to 3–5 mg/kg, the addition of sulphur to NPK fertilizers resulted in a high response from crops. The use of sulphur-containing ammonium sulphate, single superphosphate and farmyard manure maintained the initial level of sulphur in the soil.

The study also showed that unless zinc is periodically added after soil tests, the zinc content in the alluvial sandy soils of Ludhiana would diminish and there would be a significant fall in production after 9 annual cropping cycles.

At Palampur, soil application of lime @ 5.5 tonnes/ha was beneficial to rice in *kharif* as well as to wheat in *rabi*.

Thus it is important to monitor the application of not only major nutrients but also of micronutrients to sustain high levels of crop production.

**Nutrient Supply and Efficiency**

Research at Pantnagar showed that chemical fertilizers were superior to organic fertilizers in the *tarai* region (foothills). At most other places, 25 to 50% of N could be given as an organic source to *kharif* rice grown in rotation with other crops, without appreciably affecting the total yield of the rotation system.

Root-zone placement of urea supergranules was best for rice-based crop sequences at Bhubaneshwar, Pantnagar, Kharagpur, Masodha, Pura Farm, Varanasi, Raipur, Banswara and Jabalpur, but split application of prilled urea was found to be the best practice at Ludhiana, Hisar and Honnaville. Urea coated with rock phosphate gave encouraging results at Chiplima, Rajendranagar, Kathulia Farm and Karjat.

Urea supergranules and sulphur-coated urea were the best N sources at almost all places, though neemcake-coated urea was comparable with them at Navsari. Rice responded up to a nitrogen dose of 150 kg/ha in the black soils of Navsari and Aduthurai, up to 112 kg/ha in coastal Mangalore and Karamana, and up to 75 kg/ha at Ranchi and Palampur. At Maruteru, rice did not respond much to N doses beyond 37.5 kg/ha.

At Ranbir Singh Pura, Kharagpur, Varanasi and Raipur, rice responded to P,O, doses ranging from 30 to 90 kg/ha. Diammonium phosphate was the best source at Varanasi,
RESEARCH ACCOMPLISHMENTS

87

Gross returns
Rs 23,740/ha

Yields and gross returns from groundnut-rice-
mungbean at Thanjavur.

whereas a combination of superphosphate and rock phosphate was better at Kharagpur.

At Palampur, kharif maize responded linearly to phosphorus application (up to 90 kg P$_2$O$_5$/ha), rock phosphate and nitrophosphate being statistically on a par with superphosphate. In rabi, wheat responded up to 60 kg P$_2$O$_5$/ha. Similar results were obtained at Ludhiana.

Single superphosphate proved to be the best source of P at Hanumangarh. At Honna ville, finger millet and maize responded up to 90 kg and urdbean up to 60 kg P$_2$O$_5$/ha.

At most centres, soybean and groundnut responded to N and P$_2$O$_5$ doses up to 60 kg/ha. In groundnut the response ranged from 5 to 32 kg of grain for every kilogram of N, and 3 to 20 kg of grain for every kilogram of P$_2$O$_5$.

In Patiala and Rohtak districts mustard responded with 8 kg of grain for every kilogram of N up to a dose of 60 kg N/ha.

IMPROVEMENT OF DIARA LANDS

For the flood-prone and diara areas of the Brahmaputra valley in Assam, 3 varieties of toria (Brassica napus; Indian rapeseed) were identified—'Kola Sarioh', 'M 27' and 'Sangam'. On farmers' fields in Majuli diara, they yielded 7.8, 7.4 and 6.6 q/ha with 40 kg N, 35 kg P$_2$O$_5$, and 15 kg K$_2$O/ha.

In the Ganga diara of Sabour, toria varieties 'RAU TS 17', 'Type 9' and 'BR 23' yielded 13.5, 10.9 and 9.2 q/ha with 50 kg N, 25 kg P$_2$O$_5$ and 25 kg K$_2$O and one irrigation. When grown as rainfed crops, they yielded 8.5, 7.2 and 5.9 q/ha with 25 kg each of N, P$_2$O$_5$, and K$_2$O per hectare.

In the Sarayu Diara at Faizabad, the seed yield of mustard increased by 59% when the crop was sprayed with Cycocel 100 ppm on the 30th and 60th day after sowing.

In the Ganga diara of Bihar, the most profitable fertilizer doses per hectare were 123.7 kg N and 98.4 kg P$_2$O$_5$ for wheat, and 63.8 kg N and 83 kg P$_2$O$_5$ for maize.

A survey of 100 farmers from 10 villages in the Ganga diara of Bihar showed that before the installation of tubewells the net profit of the farmers used to range from Rs 1,000/ha (from monocropped barley) to Rs 4,000/ha (from urdbean for fodder followed by pointed-gourd; parwal). After the installation of tubewells there was a marked increase in cropping intensity and net profit (Table 56).

A tubewell covered 3–3.5 ha in winter and 1.25–1.5 ha in summer, and 20–30 hours were required to irrigate one hectare. The working-life of a tubewell would be 12 years, and the installation cost, including the pump and 5-hp diesel engine, is Rs 12,000 to Rs 14,000.

WEED CONTROL

A survey showed Mollugo pentaphylla to be the most dominant weed of transplanted rice in western Uttar Pradesh, constituting 90% of the weed population, with a density of
Table 66. Crops for pre-flood and post-flood periods and the net income of farmers in the Ganga diala* of Bihar (crops grown with tubewell irrigation)

<table>
<thead>
<tr>
<th>Pre-flood period</th>
<th>Crops</th>
<th>Post-flood period</th>
<th>Net profit (Rs/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer maize</td>
<td>Urdbean (fodder)-wheat</td>
<td>8,000</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>Urdbean (grain)-wheat (late)</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>Urdbean (fodder)-rabi maize</td>
<td>11,000</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>Toria-wheat (late)</td>
<td>12,000</td>
<td></td>
</tr>
</tbody>
</table>

* Diara lands are lands prone to submergence by floods during the wet season.

250 weeds per square metre. In Madhya Pradesh, *Parthenium hysterophorus* was the dominant weed of several *kharif* and *rabi* crops, particularly in the vicinity of urban areas. *Striga lutea* and *S. densiflora* were the common phanerogamous parasites of sorghum, *Orobanche* of brinjal and tomato, and *Cuscuta* of niger, pulses, berseem and lucerne.

Photo-insensitivity and the ability to produce up to 630 non-dormant viable seeds per plant contributed to the rapid spread of *Parthenium hysterophorus*. When its seeds were treated with a cold-water extract of *Cassia uniflora* (syn. *C. sericea*), their germination was reduced by 87.5% and the dry matter of the weed 95.9% less. In fields where *Cassia uniflora* (a fodder plant) was cultivated, the *Parthenium* population was reduced by 93%. At the UAS, Bangalore, the weed could effectively be checked by growing *Cassia uniflora* with either *Leucaena latisiliqua* (syn. *L. leucocephala*) or *Stylosanthes hamata* (all fodder crops) in a 1:1 ratio.

In recent years *Cuscuta chinensis* has been causing heavy damage to pulses grown in rotation with rice. Chickpea, pigeonpea and horsegram proved to be resistant to the parasite, but mungbean, urdbean, cowpea, lucerne and chilli were susceptible and were completely parasitized by *Cuscuta*, resulting in total crop failure. The seeds of the parasite germinated within 4 days and needed no stimulus from the host plants.

*Isoproturon* @ 1 kg/ha was the best treatment for controlling weeds in wheat fields. A half of this dose of the weedicide was effective when wheat was sown in closer rows or cross-rows. Tall-growing wheat varieties were more effective than dwarf varieties in suppressing the growth of *Phalaris minor*, *Chenopodium album* and *Melilotus alba*.

The IITWAM-82 weeder was modified to reduce the weight from 15 kg to 8 kg, and the cost from Rs 500 to Rs 100. The new odel required much less working-space.

A simple and effective force-recorder was developed which records the force exerted on different types of weeding-blades on a chart paper moving at a speed of 908.7 mm/minute. A pair of level gears and a groundwheel provide the power to it.

**AGROFORESTRY**

**Himalayan Region**
A survey showed an acute shortage of fuel, fodder and wood for packages in the submontane region, mid-hills and high hills of Himachal Pradesh. The other problems were soil and water erosion and cultivation of trees on small widths of field bunds.

In the Dehra Dun region, the preference of farmers was 78.3% for agri-horticulture, 71.2% for agri-silviculture, 15.8% for silvi-pasture and 1.2% horti-pastoral systems. The following agroforestry models were recommended for the different regions of Himachal Pradesh.

Submontane and low hills, subtropical: Agri-silviculture
Mid-hills and subhumid: Horti-silviculture
High hills, temperate

Grevillea robusta attained a height of 9.21 m by the time it was 6 years old, with an annual increase of 1.31 m, followed by Eucalyptus globulus, Populus × euramerica ‘65/27’, Albizia lebbek and Melia azedarach. Bole volume was more in indigenous species than in exotics. It was maximum in Ailanthus excelsa (21.9 cm) with an average annual increase of 3.1 cm, followed by Moringa oleifera (syn. M. pterygosperma), Albizia lebbek, Grevillea robusta, Melia azedarach, Morus alba and Bauhinia purpurea.

On the rocky, gravelly soils of Sikkim, Ficus hookeri attained a height of 4.31 m, a basal diameter of 11.94 cm and had 8 primary branches by the time it was 5 years old. It produced a biomass of 27.45 kg on fresh-weight basis and 10.70 kg on dry-weight basis. The biomass contribution was 47.57% from the bole, 15.42% from the branches, 12.71% from the leaves and 24.3% from the roots.

**Mulching with Tree Leaves**

Chopped leaves of Pueraria lobata (syn. P. hirsuta) were better than those of Eucalyptus and Leucaena latisiliqua (syn. L. leucocephala; subabul) in conserving moisture and recycling nutrients in maize-wheat rotation, the increase in wheat yield being 4.5 q/ha over the control that received no mulch.

**Gangetic Plains**

Subabul at a spacing of 3 m × 1 m was better than babul (Acacia nilotica) at a spacing of 3 m × 3 m for growing wheat or rapeseed in rabi or sesame or pearl millet in kharif in the interspaces between trees. After 2 years, subabul canopy had to be trimmed to prevent the intercrops from getting shaded.

Grasses grew better in the interspaces of babul than of subabul (Table 57).

**Arid and Semi-arid Regions**

Clusterbean, pearl millet, castor and mungbean were not found suitable for intercropping with Acacia tortilis, which drastically reduced their yields. Though Albizia lebbek had no adverse effect on intercrops, the intercrops affected its growth. Pearl millet and castor had an adverse effect on the growth of A. lebbek even when grown 180 cm away from the treeline.

**Tropical Region**

Of the 39 species of trees (3,324 plants) evaluated in the Khanapur block of Maharashtra Dalbergia sissoo (shisham) and Pongamia pinnata (karanj) proved better. The fast-growing species in this region were Eucalyptus umbellata (syn. E. tereticornis), E. camaldulensis, Casuarina equisetifolia and Leucaena latisiliqua.

In addition to producing good biomass, Casuarina was more compatible with agricultural crops. Food crops could be grown with the tree for the first 2 years. Thereafter,

### Table 57. Grass production in the interspaces of babul and subabul

<table>
<thead>
<tr>
<th>Grass</th>
<th>Interspaces of Eucalyptus umbellata (syn. E. tereticornis)</th>
<th>Interspaces of Leucaena latisiliqua</th>
<th>Interspaces of Acacia nilotica</th>
<th>Interspaces of Acacia catechu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eulatiopsis binata</td>
<td>11.0</td>
<td>Nil</td>
<td>16.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Cenchrus setigerus</td>
<td>45.5</td>
<td>12.5</td>
<td>52.0</td>
<td>109.0</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘CP 59956’</td>
<td>106.0</td>
<td>46.0</td>
<td>53.0</td>
<td>40.0</td>
</tr>
<tr>
<td>‘CP 59972’</td>
<td>64.0</td>
<td>56.0</td>
<td>112.5</td>
<td>99.0</td>
</tr>
</tbody>
</table>
shallow-rooted fodder sorghum and fodder cowpea fared better. Trees planted at a spacing of 1 m × 4 m in the east-west direction made a better use of sunlight and permitted easier intercultivation.

**Humid and Subhumid Region**

Of the 49 tree species planted so far at Kalyani, 8 showed good growth—Acacia auriculiformis, Leucaena latissiliqua, Eucalyptus hybrid, Gmelina arborea, Dalbergia sissoo, Madhuca indica (syn. Bassia latifolia), Bauhinia purpurea and Tamarindus indica. Maize yielded 10.2 q/ha when grown in association with Acacia auriculiformis, and Stylomasnthes gave a green fodder yield of 28.43 q/ha when intercropped with Eucalyptus. The dry weight of the prunings of trees was maximum in Acacia (22.6 q/ha) when it was grown with groundnut, and in Eucalyptus (19.2 q/ha) when it was grown with Stylomasnthes (Table 58).

**AGRICULTURAL ENGINEERING AND TECHNOLOGY**

Research on agricultural engineering and technology was conducted by the CIAE, CTRL, JTRL, ILRI, 8 co-ordinated research projects, 30 ad-hoc schemes, 3 foreign-aided projects funded from RNAM (ESCAP), USAID and UK by colleges and departments of agricultural engineering at the state agricultural universities and the ICAR institutes.

<table>
<thead>
<tr>
<th>Tree and its intercrop</th>
<th>Tree height (cm)</th>
<th>Tree girth at base (cm)</th>
<th>Tree girth at breast (cm)</th>
<th>Dry matter of tree prickings (q/ha)</th>
<th>Grain yield of intercrops (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia with Adventage</td>
<td>326</td>
<td>11.2</td>
<td>7.1</td>
<td>15.8</td>
<td>6.51</td>
</tr>
<tr>
<td>Urdbean</td>
<td>313</td>
<td>16.2</td>
<td>7.0</td>
<td>16.4</td>
<td>7.85</td>
</tr>
<tr>
<td>Rice</td>
<td>296</td>
<td>15.0</td>
<td>6.4</td>
<td>13.2</td>
<td>1.94</td>
</tr>
<tr>
<td>Sesamum</td>
<td>323</td>
<td>15.7</td>
<td>7.5</td>
<td>16.2</td>
<td>2.86</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>325</td>
<td>16.3</td>
<td>7.5</td>
<td>20.7</td>
<td>3.96</td>
</tr>
<tr>
<td>Groundnut</td>
<td>312</td>
<td>15.2</td>
<td>7.3</td>
<td>13.5</td>
<td>10.21</td>
</tr>
<tr>
<td>Maize</td>
<td>285</td>
<td>14.6</td>
<td>6.3</td>
<td>16.3</td>
<td>—</td>
</tr>
<tr>
<td>Acacia sole crop</td>
<td>319</td>
<td>15.1</td>
<td>7.8</td>
<td>1.85</td>
<td>2.02</td>
</tr>
<tr>
<td>Eucalyptus with</td>
<td>277</td>
<td>12.3</td>
<td>6.1</td>
<td>1.90</td>
<td>1.63</td>
</tr>
<tr>
<td>Urdbean</td>
<td>297</td>
<td>13.8</td>
<td>7.4</td>
<td>1.84</td>
<td>2.46</td>
</tr>
<tr>
<td>Horsegram</td>
<td>316</td>
<td>13.5</td>
<td>7.0</td>
<td>1.76</td>
<td>0.87</td>
</tr>
<tr>
<td>Cowpea</td>
<td>280</td>
<td>13.6</td>
<td>6.8</td>
<td>1.92</td>
<td>28.43</td>
</tr>
<tr>
<td>Stylomasnthes green fodder</td>
<td>252</td>
<td>12.4</td>
<td>6.1</td>
<td>1.79</td>
<td>—</td>
</tr>
</tbody>
</table>
SOIL AND WATER ENGINEERING

Safety Device for Irrigation Engine
An automatic device to shut off the engine and prevent dry running of pump was developed by the Ludhiana centre. It is under commercial manufacture in Punjab, and costs about Rs 100.

Chain Pump for Water-lifting in Tribal Areas
Chain pumps installed by the Jabalpur centre in tribal villages of Mandla district have increased the irrigation facilities, improved crop production and augmented the income of the farmers by Rs 500-800.

Improved Drainage Techniques
The subsurface burnt-clay tile-drainage system costing about Rs 9,000/ha, installed in the Kuttanad region of Kerala, has been able to remove up to 144 kg of salt per hectare-centimetre of drained water from the soil. The drainage system, on an average, increased the yield of rough rice by 1.93 tonnes/ha.

The surface drainage network developed in the Barna Command Area in Madhya Pradesh has increased crop yields by 15 to 35%.

The results of the drainage-cum-water management in the coastal Midnapur region of West Bengal have motivated the local farmers in practising agriculture in lands lying fallow for years in the absence of appropriate drainage and water management.

Boulder drains have been recommended by the MPKV in preference to subsurface drains in view of the economics and the local availability of materials.

Sprinkler and Drip Irrigation Systems
Trials conducted by the MPKV showed that when compared with the conventional irrigation systems, sprinkler irrigation saved 30% water and drip irrigation saved 55% water.

FARM IMPLEMENTS AND MACHINES

Tractor-operated Basin Lister
A tractor-operated basin lister has been developed at Coimbatore for forming basins of 240 cm x 30 cm x 15 cm for in-situ conservation of rainwater. Three ridger bottoms actuated by cam-and-roller-type follower arrangement along with groundwheels have been assembled on standard cultivator frame.

Seed-metering Device for Sowing Mustard
The conventional fluted rollers used in seed drills are not quite suitable for sowing small seeds like rapeseed and mustard, whose seed rates for sowing are low. A split-type fluted roller has been developed at Pantnagar and Ludhiana for achieving seed rates of 5 kg/ha. The improved rollers can be used in conventional seed drills with minor modifications.

Prilled Urea Applicator
The prilled urea applicator designed by the IRRI operable by one person was found to cover 0.55 ha/day with 100% application of recommended dose of nitrogen. With its use the yield and income increased by about 30%.

Seed-cum-Fertilizer Drill for Groundnut
At Bangalore, the conventional bullock-high-clearance power sprayer, operated by a 5-hp diesel engine, has been developed in Ludhiana for spraying tall crops like cotton and sugarcane.
operated seed-cum-fertilizer drill used in black soils has been improved for sowing groundnut in 4 rows at a time in red soils. The implement costs about Rs 450 and can cover about 2 hectares in a day.

Seed-cum-Fertilizer Drill
A power-tiller-operated seed-cum-fertilizer drill, at an estimated cost of Rs 2,500, has been developed at Bhopal. At a time it would sow 5 rows of wheat, 4 of chickpea, 3 of soybean or sorghum, and 2 of pigeonpea. The field capacity of the machine is 0.14, 0.15, 0.16 and 0.21 ha/hr, with unit operating cost of Rs 193, 174, 169 and 129 per hectare.

Tractor-mounted Groundnut Planter
A tractor-mounted 9-row groundnut planter, using a cup-type metering attachment to cultivator, has been developed at Coimbatore. This can also be used for planting their bold seeds like maize and chickpea. It costs about Rs 4,000 and can cover about 4 hectares in a day.

Sweep-type Cultivator
A power-tiller-operated 3-row sweep-type cultivator costing Rs 500 has been developed at Bhopal for interculture operations in row crops like soybean, sorghum, pigeonpea, groundnut and cotton. The field capacity of the implement is 0.2 ha/hr, with an operating cost of Rs 120/ha.

Manual Weeder
A long-handle weed-slasher has been developed at Shillong for cleaning the terrace raisers.
A light-weight wheel-hoe has been developed at Bhopal. It was found to be very good for controlling the weeds of soybean crop raised in vertisol. The field capacity of the unit is 0.08 ha a day, with weeding efficiency of 78%.

Self-propelled Power Sprayer
A power sprayer has been developed at Ludhiana for spraying tall crops like cotton and sugarcane. Powered by a 5-hp diesel engine, the sprayer has a ground clearance of 930 mm. It has a 175-litre tank and 5-m-wide boom. Atomization is through hydraulic pressure. The field capacity of the sprayer is 1 ha/hr at a working speed of 2 to 2.5 km/hr. The unit has received favourable response from farmers in Punjab.

Tractor-operated Hoist
A tractor-operated hoist costing about Rs 1,700 has been developed at Coimbatore. It uses a 4-bar linkage mechanism actuated by the 3-point linkage of tractor. A worker standing on the platform can be lifted up to a height of 7 m for pruning or plucking operations.

Khurpa-cum-Sickle
A multipurpose khurpa-cum-sickle, named ‘Pusa Khurpa’, has been developed at the IARI, New Delhi, for hoeing, weeding and cutting of trouble weeds and for detopping vegetable crops. The hand tool is available for Rs 12 from the IARI’s sales-counter.

Lawn-mower Attachment to Power Tiller
A lawn-mowing attachment to power tiller, costing about Rs 2,500 has been developed at Coimbatore for cutting grasses up to a height of 280 mm. With a field capacity of 0.109 ha/hr, it saves about 90% of operational time required by the manual lawn-mower.

Multicrop Thresher
The CIAE multicrop thresher has been further improved for threshing sunflower, rapeseed, linseed and safflower. Using a 5-hp motor, it gives an hourly output of 239 kg of sunflower, 89.5 kg of rapeseed-mustard, and 230 kg of linseed. Its threshing efficiency ranges from 92 to 100% and the cleaning efficiency from 73 to 98.9%.

Plot Thresher
For threshing of crops like wheat, chick-
For threshing wheat, chickpea, sorghum and soybean in field-plot experiments, the CIAE has developed a thresher as an import substitute. It has a threshing efficiency of 98-99%.

...pea, sorghum and soybean in field-plot experiments, a thresher has been developed by the CIAE as an import substitute. The machine has an enclosed adjustable spike-type threshing cylinder having a diameter of 250 mm, a set of 3 sieves (with separate outlets) and an aspirator. Its capacity ranges from 20 to 35 kg/hr with a threshing efficiency of 98 to 99%. Its cleaning efficiency was 92 to 94% for wheat, 87 to 88% for chickpea, 96 to 98% for sorghum and 88% for soybean.

Castor Sheller
A manual and power-operated castor sheller has been developed at Coimbatore. It has a shelling efficiency of 98%. It shells castor seeds by rubbing them between 2 hard-rubber-lined wooden discs. The output of the manual unit is 40 kg and that of the power-operated unit 158 kg an hour.

**POST-HARVEST ENGINEERING AND TECHNOLOGY**

Control of Storage Pests with Biogas
Exposure of *Stegobium* and *Tribolium*, the storage pests of turmeric, to biogas at a rate of 20 litres per minute resulted in 100% mortality within 60 seconds. Stored turmeric required an exposure of 5-6 hours.

Technology for Bottling Sugarcane Juice
The technology developed at the TNAU for bottling sugarcane juice has now been taken up for commercial exploration by entrepreneurs in Coimbatore and Anand (Gujarat).

Technology for Briquetting Coir-pith
Commercial production of coir-pith briquettes based on the technology developed at the TNAU has been started by a firm in Coimbatore. The plant has a capacity to produce 125 kg of briquettes an hour at a production cost of Rs 158/tonne. The market price of the briquettes is Rs 250/tonne.

Technology for Production of Soyflakes
At Bhopal a package of equipment along with the process for production of soyflakes at the cottage level has been developed. The package consists of units for cleaning, splitting, winnowing, blanching, drying, flaking and grading. Soyflakes can be blended with other flakes for consumption as a breakfast item.

Bagasse Dryer
Sugarcane bagasse produced in sugar mills is mainly used as a fuel for firing boilers. Experiments have shown that a 20% saving of bagasse can be achieved when it is dried in a bagasse dryer that uses waste heat of flue gases.

Transportation Model for Rice Bran
At Pantnagar, which has concentration of rice mills in its vicinity, a model has been developed for transportation of fresh rice bran such that it does not require stabilization before solvent extraction for production of edible-grade oil.

Cereal Storage and Milling
For dissipation of accumulated heat in large storage systems where wheat is stored,
an air-flow rate of 1 m³/tonne/minute was found to be optimum at Pantnagar.

The breakage in rice during milling was minimum when rough rice (paddy) was dried to 14% moisture with air at a temperature of 50°C and milled 36 hours after drying.

**Oil Expulsion from Mustard**

Trials at Pantnagar showed that when rapeseed or mustard seed is cleaned and milled at an optimum moisture of 10 ± 1%, the oil recovery would be 2–3% higher.

**Animal-powered Agro-processing Complex**

At Bhopal an agro-processing complex was developed which uses animal power for water pumps, flour grinder, soyflaking machine, grain cleaner, paddy thresher and groundnut decorticator. Utilization of animal power during lean periods would result in economic benefit to farmers owning such equipments.

**COTTON TECHNOLOGY**

**Fibre Quality**

In order to predict the approximate spinning performance rapidly without actually spinning the new fibre strains, the CTRL has evolved a simplified function involving major fibre properties, determined by using fibrograph and stelometer. The actual and predicted values-count-strength product showed a difference of ± 3–4%.

**Non-destructive Composition Analysis of Fibre Blends**

A simple non-destructive method for quantitative analysis of polyester-cotton or polyester-viscose blends has been developed. The method (using a digital fibrograph) is based on the difference in the optical properties of component fibres.

**Microcrystalline Cellulose from Agricultural Wastes**

Microcrystalline cellulose (MCC) prepared by hydrolysis of wood pulp is widely used in pharmaceutical, food, cosmetic, paint and other industries. In view of the shortage of wood pulp, agricultural wastes like bagasse, cotton stalks and wheat straw were tried for preparation of MCC. The percentage of crystallinity, degree of polymerization, particle length, pH, moisture regain, ash content and bulk density of the MCC prepared from agricultural wastes are well in agreement with those reported for standard MCC.

**Preparation of Super-absorbents**

Super-absorbents are polymers having immense capacity to imbibe and retain water and can be used in items like diapers, bed pads and sanitary napkins. In agriculture these can be utilized as soil additives for improving the water-holding capacity and conserving fertilizers and soil nutrients. Coating of seeds with super-absorbents facilitates germination on drylands. Laboratory trials undertaken to prepare super-absorbents by suitably modifying non-cellulosic materials like starch and clusterbean gum have resulted in a polymer of promising value. In pot experiments conducted with this polymer, a water sensitive plant could survive without irrigation for 48 hours.

**JUTE TECHNOLOGY**

**Jute-spinning Machinery**

A field trial-cum-demonstration unit of a mini jute-spinning machinery developed earlier by the JTRL, would be set up at Kamarpukur in Hooghly district of West Bengal in collaboration with Pallimangal unit of the Ramakrishna Mission. The funds for the machinery of the unit would be provided by West Bengal Science and Technology Committee and the Union Department of Science and Technology.

**Tea Chest from Jute-stick Board**

Tea chests were made from 6-mm-thick boards made out of jute-sticks. The impact strength of the boards was found to be 9.5 kg f-cm. These tea chests would relieve pressure
on scarce wood resources currently being used for packaging.

Light Fabric for Postal Bags
Light postal bags made of jute and high-density polyethylene (HDPE) in 80:20 proportion were developed by the JTRL on the request of the postal authorities. The fabric is 28% lighter than the postal bags now in use, and has slightly lower strength. These bags were under trial.

Paper Pulp from Jute-sticks
A combination of microbial and chemical treatments was found to yield better pulp from jute-sticks compared with either of the treatments alone. With the combination treatment, 4 days of pulping was enough to get paper of desired quality.

Paper from Jute and Other Fibres
The pulp produced from 150-day-old mesta plants yielded stronger paper than that produced from the pulp of 120-day-old mesta plants.

The JTRL has developed a process for production of speciality paper utilizing agro-wastes like jute-sticks and mesta-sticks. The paper has been given lamination treatment with melamine-type resin to improve its strength and other properties.

LAC TECHNOLOGY

Management of Lac Predators
Studies at the ILRI have revealed that Trichlorfon and Thiocarbam insecticides are effective against lac predators but safe for lac insects. Intercropping of cotton and okra with lac grown on bhalia (Moghania macrophylla) has also been found to be effective in controlling lac predators.

Lac-based Slow-release Weedicide
The problematic Parthenium weed could be controlled effectively with a slow-release formulation made of lac and 2,4-D in combination with Isoproturon or Di-comba. The slow-release formulation also increased the period of biological activity of the pesticide.

Modification of Lac Wax
Wax obtained from lac mud, a waste of lac industry, with a melting-point of 77°—78°C and penetration value of 5, has been modified with sodium bisulphite to obtain a wax of better properties, viz. melting-point 84°—85°C and penetration value of 2.

ENERGY IN AGRICULTURE

Seedbed Preparation
On bullock-operated farms in Punjab, 2 passes of a disc harrow followed by 2 passes of a planker was adequate for seedbed preparation and consumed 50% less energy than the conventional practice. Tractor-owning farmers can have seedbed prepared through one pass each of disc harrow, cultivator and planker, or one pass of rotavator followed with planker.

Bose plough and puddler were recommended in West Bengal for farm-holdings up to 4 hectares while power tiller with matching implements were found to be suitable for farm holdings in the range of 4 to 10 hectares.

The Central Plantation Crops Research Institute has developed a cabinet dryer costing Rs 2,000. It can be used for effective drying of copra, blackpepper and arecanut, using solar energy.
Bed-furrow Farming

Bed-furrow farming in Tamil Nadu was most energy-efficient, saving 32% energy in sorghum cultivation and 17% in cotton cultivation. Table 59 gives the component energies used in cotton production at Coimbatore, with a yield of 18 q/ha.

Table 59. Energy consumption in cotton production

<table>
<thead>
<tr>
<th>Source of energy</th>
<th>Consumption of energy (MJ/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>4,860</td>
</tr>
<tr>
<td>Bullock</td>
<td>675</td>
</tr>
<tr>
<td>Petroleum (petrol and diesel)</td>
<td>3,530</td>
</tr>
<tr>
<td>Electric</td>
<td>25,400</td>
</tr>
<tr>
<td>Seed</td>
<td>190</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>5,560</td>
</tr>
<tr>
<td>Chemical</td>
<td>1,360</td>
</tr>
<tr>
<td>Mechanical</td>
<td>425</td>
</tr>
<tr>
<td>Total</td>
<td>42,000</td>
</tr>
</tbody>
</table>

Energy-efficient Weeding

Chemical weeding was found to save 50 to 60% energy, and the use of wheel hoe 30 to 50% energy, compared with conventional weeding.

Use of Draught Animals

A survey showed that the annual use of draught animals is low in selected villages of Bhopal, Ludhiana, Raichur and Rewari (Table 60).

Table 60. Utilization of draught animal power in selected villages

<table>
<thead>
<tr>
<th>Villages located around</th>
<th>Average annual utilization in hours</th>
<th>Operation-wise utilization (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Seedbed preparation</td>
</tr>
<tr>
<td>1. Bhopal</td>
<td>281</td>
<td>71.9</td>
</tr>
<tr>
<td>2. Raichur</td>
<td>828</td>
<td>65.6</td>
</tr>
<tr>
<td>3. Rewari</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Bullock</td>
<td>429</td>
<td>70.6</td>
</tr>
<tr>
<td>b) Camel</td>
<td>475</td>
<td>46.2</td>
</tr>
<tr>
<td>4. Ludhiana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Bullock-owning farmer</td>
<td>1,590</td>
<td>26.2</td>
</tr>
<tr>
<td>b) Tractor-owning farmer</td>
<td>980</td>
<td>0.1</td>
</tr>
<tr>
<td>c) Marginal farmer</td>
<td>505</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Draught animals are mostly used for tillage and sowing operations in Bhopal, Raichur and Rewari area. In Ludhiana they are used mainly for transport of agricultural produce. For lifting of irrigation water, animal power has increasingly been substituted with the more convenient electro-mechanical pumping sets. New uses need to be developed to keep the draught animals economically competitive.

Loading-car for Scientific Study of Draught Animals

A loading-car using hydraulic principles has been designed and developed by the CIAE for studying the draughtability of animals. With a recording instrumentation it is capable of loading animals in the draught range of 30 to 500 kgf with reliable load settings. There is a good demand for the loading-car among organizations undertaking research on draught animals.

Improvement of Stoves

An improved 2-pot, seat-fixed model chulha (nada) with a reduced firebox hole was developed at the APAU, Hyderabad. It has an overall thermal efficiency of 17-20%, with favourable operational characteristics. Incorporation of perforated grate in fixed model stoves was found to increase heat utilization and simultaneously lower charcoal
formation by 49 to 65% without sacrificing thermal efficiency.

**Horizontal-axis Windmill**

An 8-bladed horizontal-axis windmill having a rotor diameter of 5 m and mounted atop a 7.5-m tower has been designed and developed at the CIAE. This scaled-up prototype is based on parameter-optimization studies conducted with 0.5-m-diameter rotors in wind tunnel. A maximum efficiency of 35.5% was obtained in the 8-bladed rotor with design tip speed ratio of 2.

**Biogas-plant**

At Bhopal the construction costs of Janata and KVIC-design biogas-plants could be brought down by 20% with the use of stone cubicles.

When the outlet level of Janata biogas-plants was lowered by 10 cm, there was an increase in biogas production. In KVIC-design plants a height:diameter ratio of 1:1 was found to be suitable for installation at places where the water-table is high.

**Partial Fuel Replacement in Diesel Engines**

Studies at Panthnagar have indicated that in dual-fuel engines 10% diesel could be effectively replaced with ethanol produced from biomass.

**Slurry-handling Machine**

A slurry-handling machine to separate solid and liquid fractions of the biogas-plant slurry has been developed at Ludhiana. It would facilitate the utilization of fractions as and when required.

**Industrial Liaison and Transfer of Technology**

About 500 drawings of improved tools and implements were supplied to interested manufacturers and individuals. The CIAE and prototype-production centres produced and supplied 3,056 prototypes of improved equipment to interested research and extension groups, manufacturers and progressive farmers.

The KVK and TTC attached to the CIAE arranged trainings to farmers, extension workers and entrepreneurs.

Six courses of 2-week duration on cotton-testing methods were run by the CTRL for training 120 officials of Cotton Corporation of India and the Maharashtra Cotton Growers Marketing Federation. A 2-month-course was held for the officers of the private cotton-trading organizations and the Directorate of agricultural Marketing. Three 2-week courses were offered to gin fitters and supervisors on cotton ginning.

The ILRI liaised with the unit of the Central Mine Planning and Design Institute for the production of briquetted fuel from coal dust and igniter using coal dust and kiri (a waste of lac industry) for use in defence. Three
ANIMAL SCIENCES

ANIMAL BREEDING

Cattle

Under the Project Directorate on Cattle Improvement, in less than 300 days Friesian crosses produced 3,870 kg of milk at the IVRI, Izatnagar, 3,240 kg (second lactation) at the HAU, Hisar, and 4,040 kg (fifth lactation) at the MPKV, Rahuri. Among halfbreds, the age at first calving and calving interval were lowest in Jersey crosses, and among 3/4-breeds they were lowest in Friesian-Jersey-local groups. Under the challenge feeding experiment at the IVRI, Izatnagar, Friesian × Hariana halfbreds produced 4,839.5 kg of milk in 300 days. In Friesian-Brown Swiss-Hariana, Friesian-Jersey-Hariana, the milk production in 300 days ranged from 4,400 to 4,514 kg. The dry-matter consumption by these crosses ranged from 16.5 to 17.5 kg/day/animal. Making use of the facilities available at the military dairy farm, Meerut, the Project Directorate on Cattle Improvement plans to improve the indigenous Hariana and Ongole breeds by using associated herd-testing concept and genetic aspects of performance of Holstein × Sahiwal crossbreds.

At the NDRI, Karnal, Karan Fries bulls which donated freezable-quality semen came from dams that were 1.1 lactations older and gave 507 kg more milk than the average.

Buffalo

Under the AICRP on Buffaloes, the daughters of proven bulls produced 2,058 to 3,860 kg milk in 305 days, the maximum being 4,005 kg. In buffaloes having lactation milk yield of more than 2,600 kg, the service period was 161.5 days and the number of services per conception was 3.04. In contrast, in buffaloes giving 2,200 kg to 2,600 kg of milk per lactation, the service period was 127.8 days and the number of services per conception was 2.87. High-yielding buffaloes thus showed a lower breeding efficiency.

A buffalo that had calved twice but developed breeding problems later was found to have 51 chromosomes instead of the normal 50.

At Anand, the age at first conception in Surti buffaloes varied from 21.4 to 61.7 months, the average being 28.67 months. So far, the project had supplied more than 150,000 straws of semen of Murrah and Surti breeds in India and abroad.

At the CIRB, Hisar, there was a significant improvement in the milk production of buffaloes. The overall wet average was 5.46 kg a day, with a record peak yield of 6.87 kg a day in December. The wet average was 37% higher than in the last year. The overall fat content was 7.28%, solids-not-fat 9.35%, and total solids 16.5%. More than 60% calvings were recorded in August, September, and October.

The CIRB, Hisar, provided 24 breedable bulls to various states.

Sheep

At Sandynallah (Tamil Nadu), under the AICRP on Sheep, when Nilgiri sheep were crossbred with exotic Stavropol Merino and Rambouillet rams, there was a marked improvement in all the production traits, without much deterioration in fertility except at a very high level of exotic inheritance. The best performance was noticed in crosses with 75% exotic inheritance.

The annual greasy-fleece production from females was 2.26 kg in Chokla, 2.6 kg in Nali synthetic and 2.51 kg in Chokla synthetic, against the fixed target of 2.5 kg. The average fibre diameter of 25.9 microns in Nali synthetic and 25.8 microns in Chokla synthetic
Dorset halfbred lambs performed better than indigenous lambs and Merino halfbreds under intensive feedlot experiments at Rahuri.

was quite near the target of 24 microns. Chokla synthetic with 9.55% medullation was closer to the medullation target of less than 5% than the Nali synthetic (16.35%) and Chokla (18.95%).

Chokla ewes with 93.5% tupping and 83.6% lambing were superior to the ewes of Nali synthetic (84.8% and 70.9%) and Chokla synthetic (91.2% and 74.2%).

At the CSWR, Avikanagar, the average birth weight was 3.5 kg in Avivastra and 3.32 kg in Avikalin. The corresponding values for average yearling weight were 22.3 and 22.8 kg. The preweaning survivability was 97 to 99% in these strains, while the postweaning survivability ranged from 95 to 99%. The annual greasy-fleece yield was 2.2 kg in Avivastra and 2.09 kg in Avikalin. The lambing percentage on the basis of ewes available was 73.33 in Avikalin and 72.28 in Avivastra.

Under the Mutton component of the AICRP on Sheep Breeding, researches at the APAU (Palamner) revealed that Nellore synthetic lambs weaned at 60 days kept on intensive feeding up to 150 days had higher average daily gains and better efficiency of feed conversion than the Nellore lambs. Nellore synthetics were also superior to Nellore lambs in carcass yield and loin-eye area.

At the MPKV, Rahuri, Dorset halfbred lambs performed better than indigenous and Merino halfbreds under intensive feedlot experiment, and their body weights were higher both at 90 days (17.7 kg) and 180 days (30.3 kg). The daily gain in body weight, efficiency of feed conversion, carcass yield of ram
lambs and dressing percentage were higher in Dorset halfbreds than in indigenous and Merino halfbreds. But wool production was high in Merino halfbreds, followed by that in Dorset halfbreds.

Goat
Under the AICRP on Goats the average body weight of 6-month-old male kids was 21.9 kg in Sirohi, 21.0 kg in Marwari and 19.9 kg in Kutchi at the Western Regional Station of the CIRG, Avikanagar. Male kids that were provided with 2% concentrate feed supplement after browsing attained higher body weight and higher hot-carass weight, and showed better dressing percentage (based on live weight at slaughter and lean content) than the kids that were allowed only to browse and provided with no feed supplement. Autumn-born kids were superior to spring-born ones in all the carcass parameters.

Poultry
Under the Project Directorate on Poultry Improvement at the CAR, Izatnagar, KAU, Mannuthy, and JNKVV, Jabalpur, improvement was noticed in egg production in White Leghorn. For eggs per generation, the realized genetic gains were 3.12 for strain G, 2.45 for strain H, 2.90 for strain K, 2.60 for strain N and 2.10 for strain P.

A younger age at the time of laying the first clutch and an improvement in the rate of lay contributed to an increase in the egg number in selected lines. Egg weight and age at sexual maturity declined as a correlated response to selection for egg number. The decrease in age at sexual maturity was greater when the selec-

The Central Institute for Research on Goats at Makhdoom has developed an elite flock of Jamunapari goats based on selection for high milk yield, fast growth and wide adaptability.
A high-yielding quail strain has been released for commercialization. The best time for slaughtering is when the quails are five weeks old. Maximum returns over feed cost will be obtained if quail broilers are reared on a diet containing 27% protein and 2,800 kcal of metabolizable energy per kilogram of body weight.

The criterion was egg number than when it was the percentage rate of lay. The decline in egg weight was more when the criterion of selection was the rate of lay.

Strain-cross layers developed at Mannuthy centre of the project topped the 17th random-sample test at Bangalore. The hen-house production was a record 266.76 eggs, and the margin of profit over feed costs was Rs 23.27. The previous hen-house record of 262.0 eggs was for ILI-80 commercial layers, developed at the same Project. A tinted-egg-layer strain developed at the CARI utilizing Rhode Island Red and White Leghorn breeds got the second position at the 17th random-sample egg-laying test among breed-cross entries. The hen-house production was 255.35 eggs, and the profit over feed cost was Rs 19.20.

The realized genetic gains for 6-week body weight were positive and significant in most broiler populations. Conformation traits like breast angle and shank length improved as a correlated response to selection for broiler weight in the male line. Feed efficiency improved as a correlated response to selection in both sire and dam lines, but the resulting gains were very small and statistically nonsignificant. The CARI, Izatnagar, received the National Productivity Council Award 1986-87 for its contribution to poultry.

Pig

At the IVRI, Izatnagar, under the AICRP on Pigs, the third-generation indigenous pigs had an average litter size of 7.64 ± 0.36 at birth and 6.35 ± 0.35 at weaning. It was 4.0 ± 0.57 at Tirupati for mixed population. At the AAU, Khanapara, the litter size was 4.88 ± 0.39 for purebred pigs and 5.38 ± 0.31 for crossbred first-crop pigs at birth. At weaning it was 4.00 ± 0.58 and 4.75 ± 0.95 respectively.

The overall weight gain for the third-generation indigenous pigs at the IVRI, Izatnagar, was 0.70 ± 0.01 kg at birth, 7.22 ± 0.10 kg at the 8th week, 13.23 ± 0.23 kg at the 16th week and 46.06 ± 0.64 kg at the 32nd week. For the first crop of purebred and crossbred piglets the average body weight at birth was 0.86 ± 0.13 kg and 0.87 ± 0.04 kg at Tirupati, and 0.90 ± 0.01 kg and 1.13 ± 0.02 kg at Khanapara. The overall efficiency of feed utilization on the basis of the fourth-generation indigenous barrows was 1:5.60.

The high-producing layer strain ILI-80 developed at the Central Avian Research Institute has been released for commercial production.
(8 to 52 weeks) at Jabalpur and 1:4.76 (8 to 32 weeks) at Khanapara. This efficiency from birth to 28 weeks was 1: 4.97 for barrows of the third-generation indigenous pigs raised at the IVRI.

Camel
At the NRC on Camel, Bikaner, the average body weight was 341.35 ± 34.38 kg in camels of 2 years of age, 453.27 ± 63.49 kg in camels of 3-4 years of age, 626.40 ± 87.84 kg in camels of 6-7 years of age, and 703.86 ± 115.57 kg in camels of 8-9 years of age. An analysis of data of the last 20 years revealed that calving interval varied from 699.14 days (3rd parity) to 797.00 days (5th parity). Between the first and the fourth year, the animals showed an increase of 24.2% in leg length, 47.3% in body length, 46.5% in heart girth, 34.9% in tail length, 32.3% in height at withers, and 41.5% in neck length.

Rabbit
At Avikanagar, the average litter size of rabbits at birth was 6.8, the highest being 7.62 in White Giant. The average litter size at weaning was more than 5, while it was 6.23 in White Giant. The rabbits achieved a body weight of 1.6 to 1.8 kg by the time they were 3 months old. In view of these encouraging results, a programme of rabbit improvement was undertaken through selective breeding.

At Garsa, Soviet Chinchilla × Grey had the highest litter size at birth and weaning, while the individual weights at weaning and slaughter were higher among cross-combinations of White Giant and New Zealand White.

The performance of German Angora with Russian Angora, British Angora and British Angora × Russian Angora have been evaluated. The results indicated the possibility of significant improvement in the wool yield over the existing breeds.

In the crossbreds of British Angora × Russian Angora, castration induced a significant improvement in wool yields. A 3-month shearing-interval was the best for optimum wool production in British and Russian breeds.

At Mannavanur, the litter size at birth was 6.07 in White Giant, 5.55 in New Zealand White, 5.44 in Grey Giant and 4.86 in Soviet Chinchilla, as against a target of 5. The body weight at 12 weeks pooled over breeds was 1.71 kg, compared with the target of 2 kg.

ANIMAL GENETICS

Animal Cytogenetics and Biochemical Genetics
At the National Institute of Animal Genetics, Karnal, normal chromosome profiles of different breeds of indigenous cattle, camel, buffalo, goat, sheep and yak have been established.

Some animals exposed to methyl isocyanate in Bhopal gas tragedy were screened for exposure-induced chromosomal anomalies.

Swamp buffaloes showed 48 chromosomes compared with 50 in riverine buffaloes. Toda buffaloes have been classified as riverine on the basis of chromosome number. Reagents for 6 cattle blood groups have been prepared. Six polymorphic traits of blood, viz. haemoglobin, transferrin, albumin, carbonic anhydrase, ceruloplasmin and alkaline phosphatase, have been standardized. Techniques relating to the study of histocompatibility complex of bovines have been standardized and antisera raised.

At the National Bureau of Animal Genetic Resources, Karnal, comprehensive breed descriptors for cattle, buffaloes and poultry have been developed and computerized. A model programme and proforma have also been developed for undertaking surveys in villages.

ANIMAL NUTRITION

Bioconversion of Crop Residues
The NDRI, Karnal, is developing a 2-stage fungal treatment of straw under the Indo-Dutch Project on bioconversion of fibrous crop residues. At the first stage, cereal straw
was treated with 4% urea at 40% moisture and kept for 30 days under airtight polyethylene cover. At the second stage, this straw was treated with 1% single superphosphate and 0.1% calcium oxide, with moisture adjusted at 65% and then inoculated with 3% culture of *Coprinus* fungus. The treated material was put in an enclosure with bricks placed in such a way that there was enough aeration on the sides. The material was then covered with gunny bags. Within 8 days a profuse cotton-like mycelial growth was visible. *Coprinus* traps the excess of ammonia produced during the process of solid-substrate fermentation, without causing any appreciable loss of dry matter.

**Mineral Supplementation**

At the NDRI, Karnal, chalk powder, marble, lime and filter-press mud waste were found to be good calcium supplements for animals. For phosphorus supplementation rock phosphate and superphosphate could be alternative sources to dicalcium phosphate. Growth studies suggested that if an initial adaptation period is allowed for sufficient intake, rock phosphate and superphosphate can sustain medium growth rate in animals. The results could be utilized by those engaged in the manufacture of mineral mixtures.

**Apple Pomace in Livestock Rations**

Apple pomace can be an energy source in livestock feed. It has 5% crude protein, 17% crude fibre, 1.6% digestible crude protein and 65% total digestible nutrients. It can form up to 50% of the concentrate fed to growing buffaloes. When treated with 3% urea, 40% of apple pomace could replace 40% of maize grain in the concentrate given to growing crossbreed calves.

**Aflatoxins in Feeds**

Aflatoxins could be tolerated at the dose levels of 260 ppb in neonatal calves and 147 ppb in neonatal kids. In chicks, 1 ppm of aflatoxin in the diet was endured well.

**Neem-cake as Animal Feed**

At the IVRI, Izatnagar, a water-washing process was developed for neem-cake as well as its solvent-extracted counterpart. Animals could maintain their growth rate on a ration containing 45% of water-washed neem-cake in the concentrate mixture. An attempt was made to detoxify the mahua seed-cake by alcohol extraction. Serum glutamic pyruvic transaminase (SGPT) could give a good indication of the extent of toxicity or adverse effect of untreated mahua seed-cake in animals and the toxicity could be assessed without slaughtering the animals.

**Nitrogen for Microbial Digestion in Ruminants**

Straws and grass-hay contain rumen-degradable nitrogen for microbial nutrition. The available undegradable nitrogen was the highest in paddy straw, followed by those in low-grade grass-hay and wheat straw. The wide variation of 9.86 to 22.74% in the crude protein of maize, oat, cowpea and berseem fodders harvested at two stages of growth was considerably narrowed down to 5.77 to 13.11% when the value of N was reckoned in terms of rumen-escaped undegradable protein (UDP).

**Rumen Urease in Buffaloes**

Buffalo rumen urease was purified and its properties studied. Buffalo rumen urease closely resembled cattle rumen urease but differed in many respects from jack-bean urease. Studies on the improvement of urea utilization suggested that (i) feeding urea along with inhibitors of rumen urease has no potential, (ii) urea utilization by the ruminants can be increased by complexing urea with formaldehyde under conditions which give rise to simple urea formaldehyde complexes, and (iii) reduction of the activity of rumen urease by producing antibodies against rumen urease has a potential in buffalo nutrition.
Subabul in Camel Nutrition

At the NRC on Camel at Jorbeer (Bikaner), 2-3-year-old camel calves showed no adverse effects when their feed contained up to 20% subabul. Their dry-matter consumption was 11 kg a month when subabul was added to moth-chara (straw) and 12.7 kg a month when it was not added.

Utilization of Agroindustrial Byproducts

In the AICRP on Agroindustrial Byproducts, Hyderabad unit, sunflower straw or heads could form 50% of the complete rations for sheep. At Ranchi, expeller-processed Kusum seed-cake could be included up to 50% in the rations of crossbred calves. The cake could also be included up to 17% in the feed of broilers. At Guwahati, decaffeinated tea waste could be included up to 10% in the broiler rations, without any adverse effect. At Trichur, cocoa pods could be incorporated in the concentrate rations of growing calves up to 20%.

Goat Nutrition and Feed Development

Research at the CIRG, Makhdoom, showed that Capparis zeylanica (syn. C. horrida: "heens", "ardanda"), Balanites aegyptiaca ("hingota") and Salvadora persica ("kharjal", "kheddyar") could be used as goat feed. In general, their crude protein, ether extract, total ash, calcium and phosphorus were more in the leaves than in the stem. A live herbarium of feed plants for goats was developed on an area of 1.75 ha.

When compared with natural Heteropogon type pasture, a 3-tier sylvipasture from Leucaena leucocephala (syn. L. leucocephala), Acacia nilotica and Cenchrus ciliaris increased the production of biomass by 2.6 times, of energy by 3.3 times and of crude protein by 3 times. Goats preferred browse material to grasses. Hence they would not prevent the spread or establishment of grasses, so essential for soil conservation.

Sun-dried poultry excreta may be utilized in the concentrate mixture of male goats to meet 20% of protein requirement without any adverse effect on palatability, digestibility of crude protein and dry-matter intake.

Poultry Nutrition and Feed Technology

A biotechnological approach to help degrade the gum present in the guar (clusterbean)-meal to its constituent sugars was adopted to enhance the feeding value of guar for poultry. Guar-meal was wetted to have about 30% moisture and then incubated with a soil isolate of Aspergillus sp. at 30°C for 60 hours, mixed and dried to 8-10% moisture. As a result of fermentation by the fungus, there was a slight increase in the crude protein and phosphorus content, and a significant decrease in the viscosity of the meal extract. Consequently, the feeding value of the meal had improved.

Research at Mannuthy showed that the ideal ration of broiler quail is 2,800 kcal ME per kg of diet, given in a caloric : protein ratio of 96 up to the first 2 weeks and of 107 for the next 3 weeks. At the end of 5 weeks the quail produced meat of excellent quality and gave maximum economic returns. For caged layer birds, a diet containing 16 to 18% protein and 2,400 kcal ME per kg of diet was the best.

ANIMAL PHYSIOLOGY

Nutrition-Reproduction Interrelations

Optimum nutrition could overcome the adverse effects of summer stress in buffaloes, whereas undernutrition and high temperature showed a synergistic effect on the absence of oestrus in buffalo heifers.

Immunoglobulins in Reproduction

Repeat-breeding cows and buffaloes had higher quantities of immunoglobulins (Ig A and Ig G) in uterine secretions and serum than the control animals.

Superovulation, Embryo Collection and Transfer

At the NDRI, superovulation was induced
RESEARCH ACCOMPLISHMENTS

in cattle with follicle-stimulating hormone (FSH). Of the 61 embryos collected, 13 were transferred and 4 pregnancies were confirmed. In buffaloes, 7 embryos were recovered from 11 buffaloes using either FSH or pregnant mare serum (PMS). Three embryos were transferred.

At the IVRI, the procedure connected with superovulation was standardized. Nonsurgically by gravitational method 12 fertilized ova at late morula or blastocyst stage were collected from 2 animals and 3 ova from each were transferred to synchronous recipients.

Freezability of Buffalo Semen

A simple plastic ‘kool’ pack, was developed for testing the freezability of semen under field conditions. With its aid, the time for freezing semen could be reduced to 3 hr, as against the normal 6-8 hr. The freezability of buffalo semen was inferior and inconsistent in April and May, but it showed improvement in June when semen of almost all the bulls became freezable. The level of glycerol appears to be critical in freezing buffalo semen. A glycerol level of 6 or 7% gave optimum results. Quantitative and qualitative changes in acrosomal proteins due to freezing and thawing in liquid nitrogen were studied in buffalo spermatozoa. Hydrophilic interactions were more affected than hydrophobic interactions. Disulphide formation was found to be the cause of membrane destruction in buffalo acrosomes during freezing.

Biotechnology

Nonsurgical harvesting of embryos and impregnation of 4 recipient cows was successfully accomplished.

The use of GnRH was extended to rural buffalo herds, with the result that fertility increased among buffaloes with a history of poor fertility.

Induction of Heat in Buffaloes

At the GBPUAT, Pantnagar, lactating buffaloes showed signs of heat within 48 hr when 25 mg of progesterone was injected subcutaneously for 7 days followed by 3,000 IU of PMSG I/M on the eighth day. With natural mating 8 out of 10 such buffaloes became pregnant without any deleterious effect on milk production during the treatment period or immediately thereafter.

Eruption of Teeth in Camel

Studies on eruption of teeth from birth to 1 year revealed that the first, second and third pairs of incisors erupted by 4.17, 18.10 and 40.93 days respectively. Three pairs of molars were normally present at the time of birth. In some cases, 1 pair of incisor in the lower jaw was present right at birth.

Draft Capacity of Camels

Experiments on the draft capacity of camels showed that loads up to 15.5 q increased the pulse rate by 50% and respiration rate by 100%; the temperature increased by 2° - 4.5° C.

Salinity in Drinking Water

Studies at the CAZRI, Jodhpur, indicated that the upper limit of nitrate in drinking water that desert Marwari sheep and Magra sheep could tolerate without incurring any productive or reproductive losses is 1,000 ppm in drinking water having 2,000 ppm of total soluble salts.

Goat Reproduction

At the CIRG, Makhdoom, TCYG and EYCG diluents were found to be suitable for freezing buck semen. When fructose was added in place of glucose, there was an improvement in post-thaw motility. Post-thaw sperm mortality was higher when freezing was rapid.

The damage in acrosome was mostly due to swelling. The incidence of ‘separating’ and ‘entirely lost’ acrosome was very low. The fertility rate achieved with frozen buck semen was about 35%.

There was a seasonal trend in the oestrus pattern in Jamunapari, Jakhrana and Barbari...
goats in the semi-arid zone. The seasonal trend was distinct in Jamunapari. A technique for the synchronization of oestrus has been standardized in different breeds of goats. Through ultrasonic technique pregnancy could be diagnosed from 60 days onward with reasonable accuracy.

Shelter Management in Goats

Studies at the CIRG, Makhdoom, indicated that 'lite roof' is not a suitable roofing material for goat houses in hot climate, as they created a stressful micro-environment.

Barbari and Jamunapari goats showed similar heat-tolerance ability.

Cross-sectional survey, which is more economical, was found to be as efficient as longitudinal technique in determining age through dentition.

Goat Behaviour

Jamunagari, a fast browser, spent more time browsing than Barbari. Within a breed, group behaviour was evident, and there was competition for the foliage of the same plant. The studies indicated that goats could defoliate the smallest branch of a tree or bush without damaging the twigs. From March to November, goats should be taken out for grazing about half an hour before sunrise since their activity started 35-40 minutes before sunrise. In winter (December to February) the activity of goats started very late.

Poultry Physiology and Reproduction

At the CARI, Izatnagar, research was conducted on hydrolytic enzymes, transaminases, ATP and angiotensin-converting enzyme of the chicken spermatozoa to study the characters of semen. The information would be helpful in promoting artificial insemination in chicken for better fertility and production. A simple technique was developed to record the rate of yolk deposition in the ovarian follicles of Rhode Island Red and White Leghorn during the rapid phase of development. A fat-solvent dye was injected intravenously, and the yolk-bearing dye was measured after boiling the eggs. In White Leghorn hens the rate of daily yolk deposition continued to increase from the sixth day before the day of ovulation. In Rhode Island Red it started to rise from the ninth day to the third day before ovulation, after which the rate dropped as the follicle advanced towards the ovulatory stage.

Studies were conducted on the effect of stocking density of adult quails on the physiochemical changes of their blood, including acid phosphomonoesterases, aspartate and alanine amino-transferases, total protein, cholesterol and ascorbic acid. The information will be useful in developing proper housing with adequate floor-space for each bird, and may help large poultry farmers to utilize minimum space without stress for optimal quail production.

Studies on the metabolic status and absorption pattern of secretory epithelia of various parts of the chicken alimentary canal revealed calcium to be important for the absorption of monosaccharides from the chicken intestine. The dosages of calcium needed in the economic rations for the birds at different stages of growth and production are being worked out so that nutrients can be optimally absorbed and assimilated by the bird.

Poultry Housing

Various housing equipments for quails (including battery brooder, rearing-cage, colony and individual cages, pedigree hatching-box, feeders and waterers) have been developed at the CARI, Izatnagar, and are in extensive use.

Quail eggs weighing 11 to 12 g hatched better than eggs of other sizes. The eggs hatched better when they were fumigated on the day of collection with 40 g of potassium permanganate and 80 ml of formaldehyde per m³ for 10 minutes. Female quails weighing 181 to 200 g laid the maximum number of eggs.
ANIMAL HEALTH

Epidemiological Studies

Intensive studies carried out under the AICRP for Epidemiological Studies on Foot-and-Mouth Disease (FMD) revealed that the loss in milk yield of diseased individual animals was up to 50% during and after the outbreaks. Cows and heifers that recovered from the disease suffered from anoestrus and other complications.

Monitoring of the virus types showed a high activity of type ‘O’ virus in the southern and western regions of the country. In the northern region, the situation remained uncertain with the occurrence of ‘O’, ‘A’ and ‘Asia-1’ virus types.

The Central Laboratory of the AICRP generated the required facilities for characterizing the virus isolates as per the internationally accepted protocol and standardizing the methods for the detection of antibody.

On the basis of data collected from several outbreaks of the FMD in different parts of the country, a mathematical model was worked out at the IVRI. The model could be applied to estimate the economic losses and evaluate the merits of various strategies used for the control of the FMD.

An estimation by the IVRI of the economic losses due to animal diseases showed that the major disease conditions are diarrhoea, skin diseases, high fever, FMD, surra, parasitic infestations and haemorrhagic septicaemia. The total economic loss (including morbidity and mortality losses) was 9.40% of the total livestock asset. The economic losses incurred by marginal and middle farmers in different seasons on account of morbidity and mortality, and for the purchase of medicines and vaccines for providing health care were also estimated.

The IVRI, for the first time recorded from the Andaman and Nicobar Islands the association of lungworm infestation (Metastrongylosis) in swine with outbreak of swine fever.

The IVRI, Izatnagar, recorded the following disease findings: (i) The incidence of fowl typhoid in West Bengal, Bihar and Tamil Nadu was confirmed to be due to Salmonella gallinarum. (ii) The incidence of chlamydia was 11% on the basis of exfoliative cytology. (iii) The disease was produced experimentally in rabbits. The other noticeable findings were aflatoxicosis in rabbits, calf diphtheria, glanders in equines (Kashmir), hepatitis diaetatica in pigs, rinderpest in cattle (Madhya Pradesh), thyroid carcinoma in canine, ethmoid and ocular carcinoma in cattle, and lung fibrosarcoma and squamous cell skin carcinoma in buffaloes.

A large number of Murrah buffaloes and their crosses slaughtered in the abattoirs at Bareilly, Bombay and Trivandrum revealed flake-like, nipple-like or cauliflower-like lesions on serosal surface of different organs, but not in the underlying parenchyma, lymphnodes and spleen. These animals did not show any clinical signs during life. This was not observed in the nondescript buffaloes and cattle. No microbial agent could be either isolated or demonstrated by electron microscopy in these lesions. The pathological conditions could be due to genetical factors.

In and around Bareilly district the clinical incidence of goitre (hypothyroidism) was 12% in goats. The kids suffered more than the adults. Concurrent existence of goitre in human beings could also be seen.

An outbreak of swine fever in Car Nicobar Islands, reported almost 20 years after the last outbreak, was identified by isolating the virus. The outbreak was controlled in time.

Three isolates of virus (EDS-76) were recovered from suspected outbreaks of egg-drop syndrome in Orissa and Uttar Pradesh. They were partially characterized and propagated in baby hamster kidney (BHK-21) cell-culture.

The NRCE, Hisar, furnished the first authenticated report on the occurrence of equine influenza in the country. The causal agent was isolated and identified as Influenza A/Equi-2 virus. The disease occurred in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh,
Equine influenza caused by Influenza A/Equi-2 virus has been noticed in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, Delhi and Chandigarh. The mortality due to the disease, which was initially high, has been drastically curtailed through timely diagnosis.

Madhya Pradesh, Haryana, Punjab, Delhi and Chandigarh. The initial high mortality was curtailed drastically through timely diagnosis and advice to the concerned authorities.

The NRCE in collaboration with the State Animal Husbandry Department did monitoring, surveillance and testing of glanders in equines in Haryana. As a result no clinical case was noticed during the year under report. Detailed serological examination indicated the existence of equine infectious anaemia (EIA), a dreaded disease of equines, in southern India.

At the NRCC, Bikaner, the mortality rate per 1,000 camel days was as low as 0.156 during the year under report.

**Diagnostic Techniques**

Microagglutination test for the identification of flagellar antigen of salmonella serotypes and a method for the detection of bacteriocin (colicin) were standardized. Antigenic analysis on leptospiroa revealed a carbohydrate fraction which seems to be serospecific. The protein antigen of SDS-extracted patoc cells was successfully used, after adsorption on latex particles, for the detection of leptospiroa antibodies in cattle.

Modified solid phase aggregation of coated erythrocyte (SPACE) and latex agglutination (LA) tests were standardized for the detection of rinderpest antigen. They were equally sensitive and better than reverse passive haemagglutination (RPHA) and counter-immunoelectrophoresis (CIE).

FMD virus type ‘Asia-1’ hybridoma clones were prepared. The secreted monoclonal antibodies neutralized ‘Asia-1’ virus specifically without any cross-reaction with other types of FMD virus.

Techniques were standardized for the evaluation of total plate count and coliform count for food samples using droplet techniques, and for the isolation of Staphylococcus aureus using various modified enrichment and selective media.

The NRCE, Hisar, developed a suitable, quite effective and stable diagnostic antigen for equine influenza.

**Prophylactic Measures**

At the IVRI, Izatnagar, the available attenuated virus strains of sheep-pox were evaluated for efficacy and production constraints. The vaccines prepared with Roumanian strain were safe and efficient in sheep of various age groups and exotic inheritance, both in the laboratory and the field. The parameter of vaccinal ‘take’ in the susceptible sheep with this vaccine was advantageously utilized for assessing the immunogenetic response and monitoring vaccination programmes in the field.

The bovine tuberculin PPD standardized
at the IVRI, was as effective as the one imported from UK both in the laboratory and in comparative field trials. The sensitins, it is hoped, will replace the old bovine tuberculin presently in vogue.

At the IVRI, an inactivated gel-adsorbed saponified vaccine against goat-pox was developed with 'Sambalpur' strain of goat-pox virus. This vaccine was protective in a minimum dose of 0.5 ml. The vaccinated animals withstood natural challenge 14 days after vaccination. An allergic test was standardized for assessing the protection.

The technology for the production of live schizont theileria vaccine was standardized, and field testing was successfully completed in over 600 crossbred calves. The production protocol and draft standards of usage were considered by the National Advisory Committee on Animal Vaccines. The vaccine is being released shortly.

Polyethylene Glycol (PEG) concentrated, freeze-dried and oil-adjuvant experimental FMD vaccines were stable and potent under laboratory and a few controlled field trials. The immune response was satisfactory among vaccinates over a period of time tested so far.

Inactivated oil-adjuvant vaccines were produced against EDS-76 and Infectious Bursal Disease (IBD) infections in poultry. They induced protective level of antibodies 4 weeks post-vaccination without any immuno-suppressive effect. BHK-adapted IBD virus at the 12th passage was safe and immunogenic with no potential of reversion in virulence. Fowl-pox vaccine could be stored without loss of its immunogenicity up to 4 years at 20°C, for 39 days at 37°C and for 21 days at 45°C.

The attenuated and inactivated vaccines against caprine pleuropneumonia afforded 100% protection in goats to challenge infection. The antibody could be detected in goats by spot agglutination with coloured and latex antigen for up to 3 months following vaccination. Potash-alum-treated enterotoxaemia vaccine proved to be better immunologically than aluminium hydroxide-gel adsorbed and anaculture vaccines as seen from seroconversion values in rabbits. Of the different strains of Clostridium perfringens type D, NCTC 8,346 proved to be more toxigenic than CSL 78 and Mukteswar strains.

Approximately 3.6 million monovalent doses of inactivated FMD virus 'O', 'A', 'C' and 'Asia-1' vaccines were produced. Three million monovalent doses passed quality-control tests and were supplied for field use. Thirty-three immunobiologicals were produced, tested and supplied for field use.

At the NRCE, Hisar, a formalized, aluminium hydroxide gel-adsorbed vaccine was prepared using a recently isolated strain of Salmonella abortus equi. It showed promising results in experimental trials.

The AICRP on Intracellular Blood Protista with particular reference to immunoprophylactic control was implemented from April 1987 with one co-ordinating unit, a central laboratory and 4 research units. Research on Theileria annulata was mainly carried out to develop prophylactic measures against bovine theileriosis. In the first approach cell-lines of T. annulata macroschizonts were propagated in vitro in lymphocyte culture for variable periods and tested for immunogenicity or pathogenicity at different passages. Experimental immunization trials gave encouraging results. Bulk cultivation, cryopreservation and use of vaccine in field conditions were being undertaken to monitor the host-immune responses. The second approach consisted of infecting the susceptible cattle with tick-derived sporozoites followed by treatment with buparvaquone. This method proved highly successful in immunizing cattle of all age groups, but was beset with the limitation in that the cost of the drug and the labour needed was prohibitive. Immunological studies indicated both humoral and cellular immune responses.

**Basic Research**

In rats change in sodium ion concentration...
adversely affected the smooth muscle functions. A nonspecific immunostimulator provided partial to full protection against anaplasmosis in calves. Splenectomized sheep did not remain as carriers of *Anaplasma marginale*. Swiss albino mice proved to be an animal model for experimental secondary hydatidosis.

In pigs a model of gastric ulcer using reserpine was developed. An indigenous herbal preparation comprising emblic, cheubic and belleric myrobalans effectively treated and controlled experimental gastric ulcers in pigs.

*In-vivo* and *in-vitro* coronary angiographic studies in cattle revealed intense blood supply to myocardium through arteries emerging from the base of the aorta. This reduced the chances of myocardial infraction. In bovine fracture autogenous grafts were accepted with no signs of new bone formation. However, homogenous cortical bone grafts were rejected and new bone formation took place.

Basic research on lymphokines such as interleukin-2 (II-2), migration inhibition and blastogenic factors, and on various other aspects of immune mechanism by using immunostimulants were in progress. The identification of serum-neutralizing substances (infectivity inhibiting substances) induced by immunostimulants offers scope for the development of better immunoprophylactics if suitable technologies could be developed for large-scale production employing biotechnological methods.

The gel-electrophoretic pattern of the soluble and membrane-associated proteins from buffalo lymphocytes and neutrophils was studied. Digitonin and lipopolysaccharides (LPS) each at 30 μ concentration depressed the trypsin inhibitor by about 90% and 75% inhibition, respectively, of the T-lymphocytes activity.

In the biotechnology research at the IVRI, recombinant cDNAs for FMD virus types 'A', 'A2' and 'Asia-1' were prepared and analysed for the production of genetically engineered FMD vaccine. DNA plasmids were isolated from cloned *Clostridium perfringens* type D and curing done to determine the toxin production.

**ANIMAL PRODUCTS TECHNOLOGY**

**Dairy Microbiology**

At the NDRI, Karnal, paneer dipped completely in salt solution (2 to 5% concentration) preserved better than that dipped partially. The keeping quality of paneer increased 3-fold when stored at 15°C than at 30°C. Coliforms in paneer can be detected within 4 hours with rapid coliform tests. At this Institute the effect of stabilizers of plant origin like tapioca, water chestnuts and gum acacia on the physical qualities of fermented dairy products was studied. The yoghurt prepared from buffalo skim milk containing 0.5 to 1% tapioca showed better texture, flavour and acidity than normal yoghurt without stabilizer. *Streptococcus thermophilus* cultures possessing satisfactory amount of acetaldehyde and volatile acids with a moderate proteolytic activity were isolated from buffalo-milk *dahi* (curd) samples. These cultures were suitable for preparing fermented milk products. A fermented beverage using sweet-cream butter-milk developed at the NDRI with a combination of lactobacilli cultures was grown under controlled conditions. The product possessed desirable acidity, and showed antibacterial activity against *E. coli* and *B. cereus*. The fermented beverage remained in satisfactory condition for 30 days at refrigerated temperature on addition of sodium metabisulphite. The psychrotrophic organisms belonging to coliforms and aerobic spore-forming bacilli were isolated from pasteurized cow milk. Coliform groups comprised *Escherichia coli*, *Enterobacter aerogenes*, *E. cloacae* and *Citrobacter freundii*. Aerobic spore formers belonged to *B. cereus*, *B. circulans* and *B. subtilis*. All these organisms cause spoilage of pasteurized milk.

The UAS, Bangalore, studied the toxin-producing *Bacillus* spp. in *khoa*- and *chhana*-
based sweet preparations. Isolates belonging to *Bacillus larve*, *Bacillus subtilis* and *B. brevis* have the potential to produce toxin.

**Dairy Chemistry**

The NDRI, Karnal, developed a price scale for milk based on protein (formal titre value) and fat percentage, simple and efficient methods for estimating vitamin A in milk and milk products using TFA, and detecting neutralized milk and milk powder. In all the dairies total solids are determined to assess the quality of milk. An accurate formula was developed to calculate total solids of milk from the fat percentage and specific gravity of milk. The formula

\[
\text{SNF} = \frac{LR + F + D}{4}
\]

(LR, Lactometer reading; F, Fat percentage; D, Density.) is being considered by the Bureau of Indian Standards for uniform adoption in the country.

**Dairy Technology**

A process for manufacturing *chakka* powder was developed at the NDRI. It involves heating of milk to 90°C for 15 minutes, and culturing with IF-40 at 22°C for 12 to 14 hours to 0.9% lactic acid. Whey was partially removed from the curd to obtain *chakka* (30% total solids). The *chakka* was then ground in a colloid mill after adding sugar @ 25 kg/100 kg of *chakka*. The slurry was then adjusted to 30% total solids and spray dried (190°C inlet air and 95°C outlet air). The average chemical composition (percentage) of *chakka* powder was: total solids, 96.02; protein, 27.91; reducing sugar, 10.13; sucrose, 53.68; ash, 3.3; and acidity, 3.65.

A process was developed for the enhancement of flavour in *cheddar* cheese from buffalo milk. *Cheddar* cheese of quite acceptable quality can be produced within 4-6 months of ripening. The development of the most desirable flavour in cheese depends on (i) the standardization of milk for optimum casein/fat (C/F) ratio (0.65-0.70), (ii) the use of high heat treatment, (iii) the addition of lipase and protease enzymes, and (iv) the use of lactose hydrolysed milk. The flavour was positively correlated to the extent of biochemical changes, i.e. glycolysis, proteolysis and lipolysis.

At the NDRI, mozzarella cheese could be manufactured (i) using 4.0% fat in milk, (ii) adding 2.0% starter culture consisting of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (1:1), (iii) using microbial rennet, (iv) partial cheddaring of curd under whey (0.40-0.43%) at 41° to 42°C, and (v) stretching the curd at 0.70 to 0.75% acidity and salting the curd up to 1.6 to 1.8% level.

The cheese made with these combinations possessed excellent flavour, body and texture, stretching and melting characteristics. Packaging of cheese in polyethylene pouches with vacuum and cryovac improved the shelf-life. Packaging with low-density polyethylene and polystyrene did not afford as effective protection to processed cheese as tin cans.

*Chhana* of improved quality was produced using buffalo milk with 4 to 4.5% fat homogenizing at 140 kg/cm², adding 0.05% sodium citrate prior to boiling and diluting with 25% potable water followed by coagulation with 1% citric or lactic acid solution. The use of calcium lactate as *chhana* coagulant further improved the body, texture and flavour of the product.

**Dairy Engineering**

At the NDRI, a continuous ghee-making plant with a capacity to handle 500 to 600 kg of creamery butter was designed on the principle of hydrodynamics and heat transfer in horizontal thin-film-scraped surface heat exchange. A stainless-steel conical process vat with variable heating surface area was developed to process milk to *khoa* and butter/cream to ghee. An indirect type ultra-heat treatment (UHT) milk sterilizer was also developed. It consists of 3 horizontal thin-film-scraped surface heat exchangers to work
as regenerator, sterilizer and cooler. For chhana making a prototype machine was designed and developed. It had a capacity of 40 kg chhana per hour with major components of balance tank, injection chamber holding coils, cooling chamber and strainer.

Meat and Egg Technology
A method for the preparation of gelatin from buffalo and goat bones was standardized at the IVRI, Izatnagar. Studies on primal cuts of buffalo/cattle carcass at the slaughterhouses of Bareilly, Bombay, Calcutta and Delhi yielded useful information. This will be of immense help to improve the present condition of slaughterhouses in the country. At the TNAU, Madras, heat treatment was found to be very effective for tenderizing the tough mutton.

Investigation carried out at the CARI, Izatnagar, indicated that quail eggs pickled in vinegar solution could be conveniently and economically packaged in either high-density polyethylene (HDPE 330 G) or polypropylene (PP: 140 G) or PFP (12 micron polyester/0.09 mm aluminium foil/150 GLDPE) laminated pouches and safely stored for 4 and 12 months at mean ambient temperature (24°C, 58% relative humidity) and refrigeration (5°C ±1°C, 80-85% RH) temperature respectively. Oil-based egg pickle had a shelf-life of 6 months in polypropylene package but up to 3 months in HDPE or PFP laminate at mean ambient temperature (28°C, 61% RH) and up to 15 months in either of these flexibles under refrigeration (5°C, 80-85% RH).

Investigation at this Institute conclusively showed that broilers subjected to a minimum of 8 hours of ageing before freezing could successfully be stored for 6 months at −18°C with better shelf-life. Changes in physicochemical, functional and sensory characteristics were also within acceptable limits. Research at the BAU, Ranchi, revealed that desi birds had the highest dressing percentage of 77.35 and could be more profitable under village conditions.

Animal Fibre Technology
At the CSWRI, Avikanagar, stress-strain and relaxation properties of wool to differentiate wool types were successfully evaluated. Attempts were made to evaluate, stress-strain properties of Australian Merino and Chokla wool fibres under different speeds of testing, stress-strain cycling of Merino and Nali wool fibres in water, stress-strain properties of Chokla wool fibre treated with citrate-phosphate buffer at pH values of 2.5, 4.5, 6.5 and treated in boiling water for 1 hour and 3 hours. At this Institute studies on ‘mishrabasra’ involving the processing and evaluation of rabbit hair blends, camel hair and camel hair blended fabrics, wool polyester blends, mohair blends, and ramie and half-blended fabrics were also conducted. Some colour-yielding natural resources for dying of wool were identified by using different mordants.

FISHERIES

MARINE FISHERIES

Marine Fish Production
The provisional estimate of marine fish production for 1986 was 1,726 million tonnes, an increase of about 12.4% over the 1985 production. This increase was due to the unprecedented bumper catch of carangids, about 91,100 tonnes more than in the previous year in Kerala and Karnataka, and the very high landings (23,841 tonnes) of mackerel in Andhra Pradesh. The landings of oil-sardine declined by about 36,000 and of Bombay Duck by 18,000 tonnes. There was also gain in the landings of anchovy (+36,600 tonnes), perches (+22,600 tonnes), mackerel (+19,600 tonnes), silver-bellies (+18,400 tonnes), penaeid prawns (+16,200 tonnes) and ribbon fish (+11,000 tonnes). The catches from mechanized fishing accounted for 75% of the landings in the country.

The increased production of tuna as estimated for 1986 was about 34,057 tonnes as compared to 30,722 tonnes in 1985.
Survey of Lakshadweep Group of Islands
The CMFRI continued as the nodal organization for the planning and execution of the research programme of FORV Sagar Sampa of the Department of Ocean Development.

Special surveys of the Lakshadweep Islands were conducted to make an overall assessment of various types of fishery and ancillary living resources and their potentials.

Surveys indicated considerable damage to the coral reefs around Minicoy and certain other islands due to dredging, silting and sand mining.

Skipjack (Katsuwonus pelamis) and young yellowfin tuna (Thunnus albacares) constituted the major tuna resources. The islanders exploited them by live-bait pole and line. There was no scarcity for live baits in the islands surveyed. Over 45 species of live baits and over 70 species of ornamental fishes were recorded. Thirty of the latter were exportable.

The survey teams collected information on seaweeds, sponges, echinoderms, crustacean resources and other invertebrates and gathered interesting data on marine mammals and seabirds, and identified the locations which could be developed as marine parks.

Prawn Culture
Intensive efforts at breeding the tiger prawn (Penaeus monodon) resulted in the production of thousands of postlarvae in several cycles. In a farmer's pond at Attipattu near Ennore, 8,700 postlarvae of PL-30 stage were stocked. The growth in the nursery phase was encouraging (28 mm/g in 1 month).

Several experiments on breeding of white prawn (Penaeus indicus) were carried out at the Ennore hatchery and 0.1 million postlarvae were supplied to the Tamil Nadu State Fisheries Department.

Collaborative work on semi-intensive prawn culture was being taken up with the Tamil Nadu Fisheries Department in a farm at Eripurakarai in Tanjore District.

Penaeus latisulcatus (above) is suitable for culturing in the sandy areas. This prawn has completed its full lifecycle at the Muttukadu farm near Madras. P. canaliculatus (below) is another species suitable for culture in sandy, saline lagoons.
Breakthrough in Prawn Breeding: At the Narakkal Research Centre of the CIBA for the first time larvae of the Indian white prawn *Penaeus indicus* were successfully produced by *in-vitro* fertilization thus overcoming the problem of lack of mating in prawns.

Viable eggs were obtained by mixing dense sperm suspensions collected from the lyceum and terminal ampoules with gravid ovaries of eyestalk-ablated *Penaeus indicus*. The eggs were fertilized and healthy larvae obtained. The hatching rate was as high as 88%.

This technique will be immensely useful in selective breeding and hybridization of commercially important species of prawns.

In the Muttukadu farm near Madras, a new candidate species *Penaeus latisulcatus* suitable for culturing in sandy coastal area, was grown to adult size and induced to mature and spawn in captivity. The larvae were successfully reared to postlarval and juvenile stages and restocked in the ponds, thus completing the life-cycle in the farm itself. This is a major breakthrough. The growth potential of another prospective candidate species *Penaeus canaliculatus* was also assessed at the Muttukadu farm.

Molluscan Culture

The black-lipped pearl oyster (*Pinctada margaritifera*) was successfully bred and reared under controlled conditions in the hatchery at Tuticorin. A total of 48,000 spat of this oyster were produced. It is known for the expensive black pearls in the cultured pearl industry. In India, the oyster occurs only in the Andaman and Nicobar Islands.

The pearl oyster (*Pinctada fucata*), in the harbour farm of CMFRI at Tuticorin, showed per month a growth of 2.6 to 3.6 mm in size and 1.87 to 2.25 g in weight. In the pearl oyster surgery programme by single and double implantations pearl production rate (gross) of 29 to 31.5% was achieved.

Under the hatchery programme at Tuticorin on edible oyster *Crassostrea madrasensis* out of the 18 batches conditioned, 14 batches spawned and seed could be obtained from 8 spawnings.

Finfish Culture

Experiments on mono- and polyculture of selected finfish species in ponds, cages and pens were carried out at different centres on the east and west coasts, with emphasis on the rearing of new species such as *Lates calcarifer*, *Epinephelus* spp. and *Sillago* spp. Attempts were made to raise pond-grown grey mullets to broodstock level.

At Puri Centre mature specimens of *bhetki* (*Lates calcarifer*) were procured from Chilka lake, and attempts made to breed them by hormone injections.

From Pulicat 3,000 *Chanos* fingerlings were collected and were being reared in cages for subsequent stocking in pens.

INLAND FISHERIES

Heavy Metal Monitoring in Rivers Ganga and Yamuna

Zinc (Zn), copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb) and mercury (Hg) were analysed at the CICFRI in water sam-
Rohu-catla hybrids have been successfully bred through hypophysisation. The fish at the bottom is catla.

Studies collected from the river stretches adjoining the cities Rishikesh, Hardwar, Kanpur, Allahabad, Varanasi, Patna, Barauni and Bhagalpur along the River Ganga, and the cities Delhi, Mathura, Agra and Allahabad along the Yamuna. Atomic Absorption Spectrophotometer was used for analysis. The concentrations of metals in water at these centres did not exceed the drinking water standard limits prescribed by the WHO, but frequently exceeded safe limits prescribed for fish and other aquatic life.

Monitoring of Pesticides Pollution
At the CICFRI, Barrackpore, most of the commonly used pesticides were screened to evaluate their toxicity to fish and fish food organisms. Plankton and benthos were found to be more sensitive to these chemicals than fish.

Bhetki as a Biocontrolling Agent for Tilapia
Tilapia (Oreochromis mossambicus) by profuse breeding has created enormous management problems related to overall fish production in some estuarine and freshwater wetlands. Laboratory experiments and field trials were conducted at the CICFRI to assess the efficacy of bhetki (Lates calcarifer) in controlling tilapia. In the laboratory trials, L. calcarifer of 45-72 mm size were observed to actively predate upon tilapia of 11.0 to 18.5 mm size.

Edible Inland Molluscs
The CICFRI investigated the populations and production biology of the giant edible land snail, Achatina fulica at the instance of the Marine Products Export Development Authority (MPEDA). It is a prized delicacy in West European countries, especially France. The demand in France alone is about 20,000 tonnes per year, according to the MPEDA. The CICFRI supplied a sample consignment of 25 kg of Achatina to the MPEDA for trial export to France. The MPEDA has arranged...
to exhibit three blocks of processed snail meat in Cologne Trade Fair. If trade in edible molluscs can be developed successfully, besides earning valuable foreign exchange, it will also be useful in controlling agricultural pests.

**Nutritional Requirements of Fry and Fingerlings**

Studies at the CIFA, Dhauli, revealed that catla fingerlings require 40% protein, 24% carbohydrates and 6% fat in their diet to achieve maximum growth.

The milkfish fry prefer a diet containing a mixture of sardine-oil and groundnut-oil incorporated in the compounded feed with 40% protein, 45% carbohydrate, 6% lipid, 1% vitamin mix and 3% mineral mixture with gelatin as a binder.

**Fish Pathology**

Mass mortality of *Catla catla* due to a severe ulcerative disease caused by bacteria similar to *Aeromonas hydrophila* and *Staphylococcus aureus* was recorded. It was controlled by a dip in 500 ppm potassium permanganate solution followed by an injection of chloromycetin @ 30 mg/fish. Argulosis in broodstock ponds was effectively controlled by a combination of dip (500 ppm potassium permanganate solution) and pond (0.25 ppm malathion) treatment repeated after a week's interval.

**Fish Genetics**

Cytogenetic studies at the NBFGR, Allahabad, on chromosome number and structure of 17 commercially important fishes yielded valuable genetic information.

Studies at the NBFGR on gonadal sex manipulation for stock improvement by obtaining monosex *Oreochromis mossambicus* through steroid administration yielded high percentage of males by converting genotypic females into phenotypic males. Such converted males which are genetically females but phenotypically males when crossed with normal females yielded 100% female offspring.

Rohu-catla hybrids are viable. They attained their first maturity when 3 years old. They were bred successfully through hypophysation. Rohu-catla hybrid was backcrossed with male of rohu. Reciprocal cross of catla-rohu was also obtained. Further hybridization was achieved by crossing mirgals with common carp males. Reciprocal cross was also obtained.

There has been good progress in genetic engineering. The first gynogenetic (G1) mirgal, about 2.5 kg in weight and 3 years in age, was bred and G2 progeny obtained. The genetic value of triploids and tetraploids of rohu was being studied.

**Successful Hatchery Breeding During Drought**

Indian major carps were successfully bred during this year of unprecedented drought, at Powarkheda Fish Farm of the CIFE under regular projects, as well as at Sahadra Fish Farm, Delhi, under ORP, Sultanpur, Haryana. At Powarkheda 27.29 million spawn and at Sahadra 15 million spawn were produced.

**FISHERIES TECHNOLOGY**

**Harvest Technology**

Scarcity of quality wood and abnormal increase in its cost led to search for alternative materials for construction of fishing vessels. The CIFT, Cochin, designed an aluminium craft of 5 m OAL for inshore fishing.

The CIFT designed a 38 m hybrid trawl for exploitation of neretic squid resources, a bobbin trawl of 32 m head rope length for demersal trawling and a 12.75 m bottom trawl from the artisanal sector for operation from motorised country craft.

At the CIFT bottom trawls fitted with tapering jibs recorded better catches of both shrimp and fish than nets with straight jib. A 10.3 m unequal panel mid-water trawl towed
RESEARCH ACCOMPLISHMENTS

At 2 knots gave better performance than when towed at 1.75 and 2.5 knot speed. Operation of mackerel gill nets was remarkably more effective at dusk than at dawn. A new type of trawl, viz. rope trawl, with minimum fuel consumption was designed, fabricated and tested.

Post-Harvest Technology
At the CIFT, process details were finalized for canning deep sea fish Elacate niger and P. cyanae. The textural changes in frozen stored and canned E. niger was found to be due to decrease in water-soluble protein during frozen storage.

Fish proteins reduce serum cholesterol levels when used as the sole source of proteins in diet. Fatty acid composition of proteins of several species of deep sea fishes and amino acid composition of several brackish-water fish species were determined.

At the CIFT thread fin bream, lizard fish, carangids and croakers were found acceptable up to 20-25 weeks when frozen stored at -18°C. A method was also worked out for minimizing loss of water-soluble material from commercially produced frozen prawn meat.

Protein beverages developed at the CIFT using hydrolysates from different species of fish, successfully masked the bitter taste.

An intermediate moisture food product with about 50% moisture content and 0.85 water activity was prepared at the CIFT from sciaenids, a low cost fish. It was acceptable and could be stored for more than 3 months at ambient temperature.

A butyric agar medium was developed for culturing strains of marine bacteria. The methodology for the isolation and identification of Vibrio cholerae from seafoods was also perfected.

At the CIFT, a methodology was developed for the preparation of dehydrated fish pickles and fish wafers from low value marine fishes.

A deodorant for masking foul odours in fish-processing plants and an antiseptic ointment for healing blisters on palms of prawn handlers, were also taken up for commercial production by another firm.

Instruments Developed at CIFT
A biogas digester and other accessories required for the production of biogas were designed and fabricated.

A solar processing monitor for measuring 11 environmental and functional parameters pertaining to solar- and tunnel-drying processes was designed and developed. A modified mechanical spray-chumming system was developed and installed for pole and line fishing in Laccadive islands. The trawl operation monitor developed at the Institute for monitoring the operational and environmental conditions under water was successfully operated and valuable data collected.

Fisheries Education and Extension
The CIFE continued to impart 2-year postgraduate Diploma in Fishery Science at Bombay, 1-year Certificate Course in Inland Fisheries Development and Administration at the Inland Fisheries Training Centre, Barrackpore, 10 months Fisheries Extension and Training Course at the Fisheries Extension and Training Centre, Hyderabad (the Centre has now been shifted to Kakinada), and 9 months Certificate Course in the Inland Fisheries Operatives at Agra Centre (now shifted to Chinhat, Lucknow).

The Post-graduate Education and Research Programme in Mariculture of the CMFRI—a continuation of the Centre of Advanced Studies in Mariculture—imparted training in mariculture leading to M.Sc. and Ph.D. degrees.

Short-term Training Programme
Two short-term training programmes on “Management of Freshwater Fish Farms” were successfully completed at the CIFE’s freshwater fish farms at Balabhadrapuram (Andhra Pradesh) and Powarkheda (Madhya Pradesh). At Balabhadrapuram 31 trainees
and at Powarkheda 14 trainees from different parts of the country underwent training. The participants, many of whom were unemployed youth and private entrepreneurs, underwent training in fish breeding, hatchery management, nursery management and freshwater fish culture.

Another short-term training programme on “Management of Brackishwater Fish Farms” was held at the CIFE’s Brackishwater Fish Farm, Kakinada (Andhra Pradesh); 36 participants from 11 states underwent training in prawn and fish culture, prawn larval rearing and live feed culture.

Under the second 1-month training programme on ‘Fish Culture’ at the CIFE’s Freshwater Fish Farm, Powarkheda (Madhya Pradesh), 31 selected fishermen of Madhya Pradesh were trained. The training was arranged in collaboration with MAPCOST and Directorate of Fisheries, Madhya Pradesh.

At CIFE’s Brackishwater Fish Farm, Kakinada, 2 months TRYSEM training programme for 14 unemployed youths on fish prawn seed collection and rearing was completed. This programme was sponsored by DRDA, Yanam, Pondicherry.

Seven fisheries officers of Andhra Pradesh underwent 4 weeks training programme on brackishwater fish and prawn culture at the Central Fisheries Extension Training Centre, Kakinada.

A 1-week training programme on Mesh Regulation and Selective Fishing was organized for the benefit of the State Fisheries Officials by CIF.

The CIF gave short-term training to interested parties in analysis in quality control of seafoods, net fabrication, extension methods, refrigeration and air-conditioning, and production of speciality and byproducts.

A new project “Gainful employment for coastal women” sponsored by the Department of Science and Technology, Government of India, was initiated for imparting training in the production of various fish products to coastal women. So far, 50 women have been trained under this programme.

**EXTENSION**

**Fish Seed Production**

About 15 million spawn of Indian major carps, exotic carps and hybrids, and 4.4 million fry were produced at the CIFE’s Freshwater Fish Farm, Balabhadrapuram (Andhra Pradesh). At the Central Fisheries Extension Training Centre (CFETC), Kakinada, 3.093 million spawn were produced under field training programme at the FWFF, Balabhadrapuram.

The CIFE’s Central Fisheries Operatives Training Centre, Chinhat, Lucknow (Uttar Pradesh) produced 6.0 million spawn of rohu and catla in private farms and the Freshwater Fish Seed Farm, Powarkheda (Madhya Pradesh), produced 190 million spawn.

The IFTC, Barrackpore, under the field training programme produced 19.1 million spawn by breeding carps in Bangla bandh system, hypophysation and stripping eggs both in traditional hapas and ecohatcheries. In addition 0.15 million spawn was produced through bundh breeding at Julit bundh, Midnapore district, West Bengal.

The Brackishwater Fish Farm, Kakinada, produced 80,000 zoea (prawn larvae).

**TRANSFER OF TECHNOLOGY**

**KVK/TTC**

The Krishi Vigyan Kendra of the CMFRI conducted 37 training courses. It trained 1,146 farmers (322 men and 824 women). It also conducted short duration courses on Agriculture, Animal Husbandry, Home Science, Health and Hygiene, etc.

The Trainers’ Training Centre of the CMFRI organized training course for senior level officers of the Maritime States. Under this programme, 48 personnel from the University, State Fisheries Department and MPEDA were trained.
The CICFRI conducted 6 short-term training courses for 71 fish farmers, research scholars and fisheries extension officers on fish nutrition, carp culture, fish pathology, brackishwater aquaculture and fisheries extension. Five hundred farmers took part in the two Fish Farmers’ Days conducted by the Institute.

**Lab-to-Land Programme**

Under the Lab-to-Land Programme the CICFRI, adopted 100 fish farm families at new Barrackpore area of West Bengal.

Under the Lab-to-Land Programme of the CIFE, 25 fishermen and fisherwomen, traditionally engaged in net fabrication, were given detailed training in design reading, tailoring, mounting, rigging etc. of the high-opening trawl.

**AGRICULTURAL ECONOMICS, STATISTICS AND MARKETING**

**Agricultural Economics**

A study conducted by the IARI on the interregional disparities in input subsidies revealed that Punjab, Uttar Pradesh and Maharashtra, which together account for 30% of the gross cropped area, enjoyed 50% of input subsidies. But Rajasthan, Madhya Pradesh and Orissa, which account for 27% of the country’s gross cropped area, had to be content with only 9% input subsidies.

Among the states, Punjab enjoyed an input subsidy of Rs 216.18 for every hectare of gross cropped area, whereas the subsidy was Rs 15.21 in Orissa and only Rs 12.45 in Rajasthan. Likewise, for every tonne of foodgrains produced, Punjab, Tamil Nadu, Uttar Pradesh and Gujarat had the benefit of over Rs 100 in the form of input subsidies, whereas the subsidy was Rs 27.25 in Rajasthan and only Rs 22.25 in Orissa.

The study indicates the need for higher subsidies for critical inputs such as fertilizers and electricity in the less-advanced regions, and particularly to small and marginal farmers.

A study conducted by the IASRI showed wide disparities among states in the institutional credit to agriculture on the basis of unit gross cropped area, though the disparities in credit-flow have been reducing over the years.

Projections made at the IARI on the growth and production of oilseeds and the requirements of edible oils in the country indicated that by 1990 our oilseeds production should be increased by at least 1½ times the present output if our imports of 2.24 million tonnes of edible oils are to be stopped.

A socio-economic survey conducted in the areas covered by the Operational Research Projects conducted by the NDRI, Karnal, showed that the new agricultural technology has increased the labour employment both in animal and crop enterprises. On a standard animal unit, employment increased from 45 man-days in 1974–75 to 50 man-days in the non-ORP area and to 62 man-days in the ORP area in 1984–85. Similarly, in crop enterprises employment increased from 62 man-days in 1974–75 to 68 man-days in the non-ORP area and 95 man-days in the ORP area.

The new technology has also significantly increased the income per household labour. In dairy enterprise, the annual income, which was Rs 413 in 1974–75, increased to Rs 1,109 in the non-ORP area and to Rs 3,190 in the ORP area in 1984–85, the increase being 6.72 times in the 10-year period. In crop enterprises the annual income during the same period increased by 4.1 times in the non-ORP area and 6.15 times in the ORP area. Interestingly, marginal farmers recorded the highest net income from crop enterprises.

Projections made at the IVRI, Izatnagar, showed that by 1990 the production of cow milk would be 27.738 million tonnes, buffalo milk 23.269 million tonnes, goat milk 1.983 million tonnes, and total milk 52.990 million tonnes. The production of beef and veal would be 107,000 tonnes, buffalo meat 153,000 tonnes, mutton and lamb meat
A study conducted by the IARI has shown wide disparities in input subsidies.

160,000 tonnes, goat meat 394,000 tonnes, pig meat 96,000 tonnes, poultry meat 234,000 tonnes, and total meat 1.281 million tonnes.

In Himachal Pradesh 94.21% of the large farms grew high-yielding varieties of wheat. The variable expenses on the average farm were Rs 1,084/ha, seed accounting for 33%, followed by hired machinery and fertilizers.

The area under wheat increased in the Kulu district but decreased in Kangra because of land submergence by the Pong dam. The area under rice declined whereas that under maize increased in both the districts. Most of the farmers in these districts were not alert to risks.

In the Ranchi area of Bihar, the average daily cost of maintaining a creeper pig was 11 paise and that of an adult pig Rs 1.20, feed accounting for 60% of the cost, followed by unpaid labour (30%). The unit cost came down when a large number of pigs were reared.

According to a survey conducted by the NDRI in the Kangra district, the short-term credit requirements of dairy farming on small farms were Rs 2,459 at the existing level of
technology and Rs 4,174 (65% more) with improved technology. On large farms the credit requirements were Rs 3,205 at the existing level of technology and Rs 4,174 (30% more) with improved technology. The capital requirement per cow at the current and improved technologies were Rs 7,984 and Rs 10,425 on small farms, and Rs 9,148 and Rs 10,633 on large farms.

A liberal 60 to 80% subsidy proved a success in the installation of biogas-plants in Himachal Pradesh. Biogas-plants of all sizes were economically viable with 50% subsidy, and the pay-back period was found to be 7½ years for all sizes of biogas-plants.

Because of kharif drought and lack of power for irrigation 32% of the area earmarked for rice was not transplanted in the Karnal region. In addition, the land kept fallow this year was 28%, compared with 6% in last kharif. In 1987, the yield of rice per hectare was estimated at 30 quintals for high-yielding varieties and 11 quintals for ‘Basmati’.

The widespread dry spell was estimated to lead to 46% reduction in fodder yield in the Karnal region. Subsoil water went down by about 4.2 metres at several places, and about Rs 840 had to be spent on lowering pumping-sets. The dry spell adversely affected the prices of milk, fodder and foodgrains.

In the ORP villages around Karnal, drought reduced the milk yield by 52% in local cows and 47% in buffaloes and crossbred cows in July 1987, compared with July 1986. The shortage of green fodder led to 42% decline in its use as cattle feed. About 32% of the surveyed households reported toxic effects of feeding sorghum fodder. Because of the depression in feed rate, there was an all-round decline in animal health and conception rate. A strategy was chalked out to mitigate the sufferings of farmers.

Agricultural Marketing
A study conducted at the IARI indicated that to provide fruits to the consumer at reasonable prices, and to increase the fruit-grower’s profit, regulated markets should be introduced for selling fruits. There is also a need to form co-operative societies that would popularize low-cost techniques for storing and processing fresh and perishable fruits, in addition to adequate and timely supply of inputs and credit for increasing productivity of fruits.

A study at Shillong showed that out of every rupee spent by the housewife on buying potatoes, 29.4 paise go to meet the cost of production, 22.1 paise to the intermediaries, and 48.5 paise to the grower. Out of every rupee spent on pineapple, 36.3 paise meet the cost of production, 40.7 paise are the middlemen’s share, and 23 paise the grower’s profit. The farmer gets only 20.2 paise after spending 26.5 paise in producing ginger, the middlemen’s share being 53.3 paise.

Agricultural Statistics
During the Fourth and Fifth Plan periods the majority of the rice-growing districts showed a significant variation over the years in the average yields of rice and the use of chemical fertilizers. The size of the holding did not have a significant effect either on the average yield or on the fertilizer used per hectare.

Replacement of old rice varieties with newer ones was more frequent in districts where rice was traditionally grown for a long time. In districts where rice was newly introduced, farmers seemed to rely on the safety-first tactics of sticking to the old and proven varieties.

In crossbreeding experiments with cattle, when the exotic parent was the cow, genetic improvement was seen in the weight of the cow at the time of calving and the total milk yield of the first 3 lactations. When the exotic animal was the bull, almost all economic traits showed improvement.

Epidemiological studies involving parametric and non-parametric techniques indicated that in terms of longevity and produc-
tivity 3/8 crossbreds are best adapted and 7/8 crossbreds least adapted to Indian conditions.

Non-linear, dynamical, stochastic growth models were developed for optimum harvesting of single-species and multispecies fish populations.

For estimating the mortality rates in the rural populations of cattle and buffaloes, the average population method (adjusted) gave reasonably accurate results. Other methods were not satisfactory.

A case study in West Bengal (financed by the ICAR out of Agricultural Produce Cess Funds) revealed that with an increase in the size of the holding, the net income per hectare was increasing in Burdwan village but falling in Birbhum village. The study indicates that enterprising farmers may be encouraged to take up (individually or collectively or through financial assistance) mechanical tillage on large farms so as to increase the level of profitability.
Agricultural Education

The Education Division of the ICAR has been operating several schemes, including a National Agricultural Research Project (NARP), for strengthening the regional research capabilities of the agricultural universities through establishment of research centres in various agroclimatic zones. Till 1986-87, there were 24 agricultural universities in the country. The Sukhadia University, Udaipur, was functioning as an agricultural university, but remained outside the agricultural university system of the country. On the persuasion of the ICAR, the Government of Rajasthan has decided to establish an agricultural university with headquarters at Bikaner. In Madhya Pradesh, a second agricultural university was established during the year with headquarters at Raipur. It amalgamates the Agricultural College (Raipur), Veterinary College (Durg), and Dairy Science College (Raipur), which were constituent units of the JNKVV, Jabalpur.

At present, there are agricultural universities in the entire country except the North-Eastern Hills Region. The ICAR has been providing education facilities to the students of the North-Eastern Hills Region through reservation of seats under the ICAR quota. To fulfil the aspirations of the people of this region, which is economically not viable to establish separate agricultural universities, the ICAR has prepared a project proposal for the establishment of a Central Agricultural University for the North-Eastern Hills Region and sent it to the constituent states. The proposal will be submitted to Parliament for approval as soon as the location of the university is decided.

The ICAR also gave its approval for starting a veterinary college under the HPKVV and 3 agricultural engineering colleges under the HAU (Hisar), the MAU (Parbhani) and the AAU (Jorhat). The proposals for the establishment of 2 agricultural colleges, one under the TNAU at Kilikulam and the other under the UAS (Dharwad) at Raichur, are under consideration. Similar proposals for the establishment of a home science college under the KAU, and a veterinary college each under the TNAU and the MAU are under consideration.

The forestry education programmes started during the beginning of the Seventh Plan period received further thrust. In 1987 the ICAR deputed 42 teachers belonging to 19 agricultural universities for training in forestry education in specialized institutions in the USA and UK.

On the recommendation of the Scientific Panel on Agricultural Education, a proforma for self-assessment of agricultural universities was finalized in 1987 and sent to all the agricultural universities.

The ICAR continued to offer a large number of fellowships and scholarships for promotion of agricultural education in the country. It also arranged the admission of 180 foreign students in various educational programmes in India in addition to the allocation of seats to candidates from various states and union territories, which have not so far developed educational facilities in agriculture. The details are given below.

Establishment and Development of Agricultural Universities

During 1987-88, the University Grants Commission accorded clearance to the Indira
Gandhi Krishi Vishwa Vidyalaya at Raipur (Madhya Pradesh) under 12-B of the UGC Act. The Government of Rajasthan has also established an agricultural university at Bikaner.

The ICAR has accredited 3 colleges of agricultural engineering, one each at Hisar (HAU), Parbhani (MAU) and Jorhat (AAU) and a college of veterinary science at Palampur (HPKV) to assess their technical feasibility and financial viability. The report of the accreditation would be put up to the Norms and Accreditation Committee of the ICAR for consideration and approval. The academic proposals to establish colleges of veterinary sciences at Namakkal (TNAU), Rahuri (MPKV) and Bidar (UAS, Dharwad) and colleges of agriculture at Raichur (UAS, Dharwad) and Killikulam (TNAU) have been processed and would be accredited soon. The ICAR has also accredited the post-graduate programmes of veterinary sciences of the BCKVV, Mohanpur. In 1987, the ICAR approved the establishment of departments of forestry in 9 state agricultural universities, and suitable funds have also been provided. By 1987–88, 23 state agricultural universities would have departments of forestry.

The draft project proposal and draft report for the establishment of a Central Agricultural University in the North-Eastern Hills Region have been finalized, and comments have been invited from the concerned ministries and constituent states of the North-Eastern Hills Region.

In 1987, 42 members of the department of forestry from 19 state agricultural universities were deputed for training in the field of forestry; 30 to the USA and 12 to the UK.

Out of the total outlay of Rs 366.2 million for the establishment and development of agricultural universities during the Seventh Plan, Rs 82.8 million would be released to state agricultural universities for the approved development programmes of 1987–88. Similarly Rs 3 million would be released during 1987–88 for the development of faculties of agriculture at 3 central universities—Banaras Hindu University, North-Eastern Hills University and Vishwa Bharati. In addition, Rs 2.8 million would be released towards the development of some private colleges of agriculture.

**Professors of Eminence and National Fellows**

This is an on-going Plan scheme started in 1978. At present 7 Professors of Eminence and 17 National Fellows are working under this scheme at agricultural universities and ICAR institutes for undertaking fundamental research in agriculture and allied fields. This scheme has been revised and approved by the Governing Body. The revised titles of the scheme would be ‘ICAR Professors for Mission-oriented Fundamental Research’, in a combined scale of Rs 2,000–3,000 (pre-revised). A total outlay of Rs 40 million with 100% assistance by the ICAR has been sanctioned during the Seventh Plan for the revised scheme.

**Summer Institutes**

During the year, 450 scientists, teachers and extension workers participated in the following 19 summer institutes and short courses organized in various agricultural universities and ICAR institutes.

1. Efficient use of brackish water in crop production
2. Modern analytical techniques in agricultural biochemistry
3. Water resource management in command areas
4. Chemical analysis of pesticides and their quality control
5. Land evaluation for agriculture and forestry
6. Field-plot machinery for mechanization of agricultural research
7. Quantitative techniques to evaluate returns to investments on agricultural development projects
8. Prospects of utilizing plant genetic re-
sources of the north-eastern India
9. Recent advances in seed-borne viruses with special reference to detection, diagnosis, ecology and management
10. Training for agricultural development, strategy and methodology
11. Advances in production, orchard management and post-harvest management of temperate fruits
12. Recent advances in surgical infections of urogenital systems of farm animals
13. Recent trends in clinical diagnosis techniques in internal medicine
14. Recent advances in reproductive physiology in poultry
15. Neuro-pharmacology
16. Camel management and production
17. Advances in rabbit production
18. Recent advances in fin-fish and shellfish nutrition, and
19. Modern quantitative techniques in fisheries research.

Admission of Students under the ICAR Quota
During the year the ICAR allotted 650 seats to states and union territories under the under-graduate and post-graduate programmes, and 180 seats to foreign students selected by the Government of India, various foreign governments and international agencies.

AICRP on Home Science
(a) Foods and Nutrition. The research work under the project has generated sufficient information about the nutritional value and cooking quality of newly developed, high-yielding varieties of wheat, pearlmillet, chickpea, urdbean, mungbean, mothbean, groundnut and other cereals and pulses. The cooking qualities of pulses and cereals have been assessed. The effects of different domestic cooking methods on the contents of anti-nutrients and their digestibility and bio-availability from food legumes have also been studied. Some unconventional foods have been found to possess good nutritive values.

(b) Home and Farm Management. An assessment has been made of the home and farm resources and their management, the constraints related to the utilization of resources available to farm families and certain guidelines were prepared to overcome them. The following specific studies were taken up:
   1. Resource-endowment structure of rural families in Haryana
   2. Decision-making pattern of rural households and participation of rural women in home- and farm-related activities
   3. Constraints to the availability and effective utilization of resources
   4. Training and demonstration of improved technologies appropriate to each stratum
   5. Impact of improved technology introduced in the rural family.

(c) Child Development. The developmental levels of children were studied through anthropometry, cognitive development, motor development, mental development, social development, emotional development and language development.

Post-graduate Agricultural Education and Research (UNDP/ICAR Projects)
Sanction for the continuation of the 2 ongoing projects (IND/78/020 and IND/83/020) and the initiation of 2 new projects (IND/85/020 and IND/86/012) in respect of the ICAR funds during the Seventh Plan was issued at a total cost of Rs 46.631 million for the Centres of Post-graduate Agricultural Education and Research under these UNDP/ICAR Projects.

Six centres established in 1979 under the project IND/78/020 have fully utilized the UNDP inputs worth US $ 5.535 million towards training of scientists in foreign countries, consultancy services of foreign experts and scientific equipment. Assistance to this project has been phased out on 31 December 1986.

Five centres established in 1983 under the
project IND/83/020 have utilized 179 man-months for training of scientists at foreign institutions, and 48 man-months of expert consultancy. The centres have received scientific equipment worth US $ 1.3 million.

Eleven centres were established in 1987 under the project IND/85/020. The total UNDP contribution for this project for a period of 5 years is US $ 12 million. Eight subproject co-ordinators have already undertaken study tours and 24 scientists have received training at foreign institutions. Twelve consultants have visited the centres, and equipment worth US $ 1.5 million was received.

With a UNDP contribution of US $ 1.2 million, 5 centres have been established on 1 October 1986 under the project IND/86/012 at 5 agricultural universities, viz. PAU, HAU, APAU, GBPUAT and MAU. Five subproject co-ordinators and one co-ordinator have completed their study tours, and a key consultant has visited the project areas. Equipment worth US $ 30,000 was received at various centres.

Utilization of Internal Competence for the Development of Agricultural Universities

The scheme has been introduced to replace the international technical assistance for the development of younger institutions by utilizing the expertise available in the developed institutions. Assistance was provided to the APAU to undertake an assessment-study of the functioning of the university. A panel of experts available has been prepared and circulated to all the universities.

Best Teacher Award

This scheme was instituted as an incentive to outstanding teachers in the field of agriculture and allied sciences. Twenty-five awards, each of Rs 8,000, would be given biennially under this scheme.

Best Author Award

This award has been instituted to encourage Indian authors to write quality books in agriculture and allied sciences. It is proposed to give 12 awards of Rs 8,000 each for the best book written in English or Hindi every year.

University-level Books

In India there is an acute shortage of university-level books in agriculture and allied sciences written by Indian authors. Most teachers have to depend on the books written by foreign authors, whose experience is often not relevant in India. This scheme has been introduced to encourage the writing of university-level books by Indian authors. An honorarium of Rs 10,000 to Rs 15,000 has been proposed to the best author. The guidelines for the operation of the scheme has been finalized and the scheme is expected to be implemented in 1988.

Scholarships and Fellowships Programme

Since early sixties, the ICAR has been providing various types of scholarships and fellowships in the field of agriculture and allied sciences to attract talented students towards agricultural education. These fellowships include merit-cum-means scholarships for study at the master's level, senior fellowships for study at doctoral level, and post-doctoral fellowships. A separate post-matric scholarship scheme is also being operated exclusively to promote agricultural education among scheduled castes and scheduled tribes.

Merit-cum-Means Scholarships. These scholarships are meant to promote agricultural education at the bachelor's degree level. Based on the merit of the candidates in the qualifying examination and a 'means test', 7.5% students admitted to various undergraduate programmes in agriculture and allied sciences are given the scholarship. The value of the scholarship is Rs 170 a month. In 1987 the ICAR offered 700 fresh scholarships in addition to 2,000 continuing ones. The budget allocation for the scheme is Rs 18.81 million and the allocation for the year is Rs 3 million.

Post-matric Scholarships. This scheme was
introduced in the Seventh Plan to support the students belonging to scheduled castes and scheduled tribes for pursuing the bachelor's degree programme in agriculture and allied sciences. The scheme provides for a scholarship of Rs 300 a month, in addition to a contingent grant of Rs 750 a year to meet the expenditure such as payment of fees, purchase of books, etc. The budget allocation for the scheme is Rs 6 million and the allocation for the year is Rs 1.34 million.

**Junior Fellowships.** An all-India competitive examination for selection of candidates for this fellowship (under 1987-88 programme) was held on 14 June 1987. Under this scheme, 350 junior fellowships (including 20% for scheduled castes and scheduled tribes), each of Rs 800 a month, are awarded, with a contingent grant of Rs 2,000 a year.

**Senior Fellowships.** In May 1987 senior fellowships were awarded to 149 candidates, of which 17 belonged to scheduled castes and scheduled tribes. In addition, 39 fellowships have been earmarked for the faculty members of the agricultural universities and 13 fellowships to the in-service candidates of the ICAR. The rate of the fellowship is Rs 1,000 a month for the first two years and Rs 1,200 a month for the next 1 1/2 years, with a contingent grant of Rs 5,000 a year.

The Plan allocation for the senior and junior fellowships combined together is Rs 72 million and allocation for 1987-88 is Rs 13.5 million.

**Post-doctoral Fellowships.** To provide opportunities to young scientists for continuing research after completion of their Ph.D. programme, the ICAR introduced this scheme during the Sixth Plan. In 1987, 8 candidates were selected for this award.

The value of the fellowship is Rs 1,600 a month with a contingent grant of Rs 5,000 a year. The plan allocation for the scheme is Rs 1.98 million and allocation for the year Rs 0.40 million.

**Internship and Apprenticeship Scheme**

This scheme was introduced during the Sixth Plan based on the recommendations of the Universities Review Committee with a view to promoting practical training to veterinary graduates. Under this scheme, financial assistance is given to B.V.Sc. students at the rate of Rs 400 a month for 6 months to undergo internship training. A sum of Rs 13.86 million was provided for the scheme during the Seventh Plan and the budget allocation for 1987-88 is Rs 3.0 million.

**Emeritus Scientists Scheme**

Since 1959 the ICAR has been operating the scheme to support eminent retired scientists to continue their research in various fields of agriculture and allied sciences. In 1987, 15 scientists continued to work under this scheme. An advertisement has been issued for recruiting more scientists. So far, more than 100 applications have been received, which are being processed.

**National Agricultural Research Project**

The National Agricultural Research Project (NARP) was started in January 1979, assisted by a loan from the World Bank to strengthen the research capabilities of the agricultural universities situated in different regions.

The number of research subprojects sanctioned for the establishment and strengthening of zonal research stations or for undertaking basic research increased from 109 on 31 March 1986 to 114 on 31 March 1987. Of these 114 subprojects, 85 are research subprojects, 5 are basic research projects, 2 are training subprojects and 22 are administrative subprojects for strengthening the office of the Director of Research of various state agricultural universities. For the implementation of these subprojects the committed expenditure and disbursement increased to Rs 789.7 million and Rs 543.4 million respectively in March 1987 compared with Rs 707.1 million.
and Rs 443 million respectively, in March 1986.

Thirty-one of the 85 research subprojects, 3 of the 5 basic research subprojects and 15 of the 22 administrative subprojects have already completed the 5-year period on 31 March 1987. These subprojects have been taken over by the respective state agricultural universities or state governments for their further continuance after termination of assistance from the NARP. The subprojects are being strictly monitored by the Zonal Associate Directors, Directors of Research of the state agricultural universities, officers of the Project Unit and the Supervision Mission of the International Development Agency.

The following components included in the Phase-II of the NARP have become operative from April 1986:

1. Continuous monitoring of the subprojects sanctioned in Phase-I which have not completed their 5-year period.
2. Strengthening of research in the remaining agroclimatic zones not covered during Phase-I.
3. Provision of additional support (restricted to 4 years) to all the zones covered during Phase-I in respect of additional components such as water management, animal nutrition, agroforestry, horticulture, farm implements, commercial crops and post-harvest technology.
4. Provision for special subprojects for assisting research on specific problems not covered by any of the research programmes.

Efforts are being made to take up the appraisal of research subprojects in the remaining agroclimatic zones not covered during Phase-I so that these subprojects may complete their normal span of 5 years during Phase-II of the NARP itself. In this direction, 13 out of the remaining 36 subprojects have already been appraised.

Phase-II components have been identified for all the states and most of the states have finalized their Phase-II proposals. Phase-II proposals for Tamil Nadu and Kerala have already been appraised and cleared technically by the inter-disciplinary scientific panel.

The number of research reviews increased from 23 in 1986 to 24 in 1987. These reviews have proved useful in outlining the agroclimatic zones in each state, in identifying investment proposals for strengthening the research infrastructure and in rationalizing the existing research organizations. The research review of Andaman and Nicobar Islands has also been completed, while the research reviews of other union territories are in progress.

To ensure that the technical programme is need-based, status reports are being prepared. The status report gives a detailed analysis of each zone and forms the basis for formulating technical programmes. Such status reports have already been prepared in respect of most of the zonal research stations. These reports are being updated and improved in accordance with the model status report prepared by the representatives of the ICAR and World Bank. The model status reports recently completed for the TNAU (Paiyur subproject) and the APAU (Lam subproject) have been circulated to the Directors of Research of all agricultural universities. The model status reports for GAU (Dantiwada subproject) and of GBPUAT (Ranichouri subproject) are nearing completion.

To develop an appreciation for the NARP concept, a workshop was organized at the NAARM, Hyderabad, during 24–26 February 1987, for Vice-Chancellors, Directors of Agriculture and Directors of Research of state agricultural universities.
Transfer of Technology

THE ICAR institutes, agricultural universities and selected voluntary agencies have been implementing 6 first-line projects of extension education, viz. National Demonstrations Project (NDP), Operational Research Projects (ORPs), Krishi Vigyan Kendras (KVKs), Lab-to-Land Programme (LLP), ORP for Tribal Areas, and ORP on Socio-Economic Upliftment of Scheduled Castes and Backward Communities. These first-line extension projects aim at (i) organizing demonstrations by scientists to show the production potentiality of the latest technologies to farmers and extension functionaries without loss of time, (ii) getting the feedback for modifying research and education programmes, and (iii) developing extension approaches to suit the socio-economic conditions of the farmers.

NATIONAL DEMONSTRATIONS

The National Demonstrations Project was in operation in 48 districts. A team of scientists conducted 1,098 demonstrations on 0.4-hectare fields of small farmers. Of these 151 demonstrations were with a single crop, 511 with 2 crops and 138 with 3 crops. In addition 18 demonstrations were conducted on problem soils, 217 on

<table>
<thead>
<tr>
<th>Crop</th>
<th>Highest yield (q/ha)</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice-rice</td>
<td>141.40</td>
<td>Goa</td>
</tr>
<tr>
<td>Rice-wheat</td>
<td>145.00</td>
<td>Sirsa, Haryana</td>
</tr>
<tr>
<td>Rice</td>
<td>93.75</td>
<td>Mysore, Karnataka</td>
</tr>
<tr>
<td>Wheat</td>
<td>58.75</td>
<td>Hamirpur, Himachal Pradesh</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>30.00</td>
<td>Ajmer, Rajasthan</td>
</tr>
<tr>
<td>Groundnut</td>
<td>56.00</td>
<td>Anantapur, Andhra Pradesh</td>
</tr>
<tr>
<td>Mustard</td>
<td>19.75</td>
<td>Vaishali, Bihar</td>
</tr>
<tr>
<td>Sesamum</td>
<td>13.50</td>
<td>Hooghly, West Bengal</td>
</tr>
</tbody>
</table>

Table 61. Highest yields of important crops and crop rotations in different regions under National Demonstrations

<table>
<thead>
<tr>
<th>Crop</th>
<th>Highest yield (q/ha)</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice irrigated</td>
<td>23.55</td>
<td>48.85</td>
</tr>
<tr>
<td>Wheat irrigated</td>
<td>20.32</td>
<td>38.06</td>
</tr>
<tr>
<td>Maize</td>
<td>11.72</td>
<td>33.82</td>
</tr>
<tr>
<td>Sorghum</td>
<td>6.41</td>
<td>34.00</td>
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<tr>
<td>Pearl millet</td>
<td>3.45</td>
<td>13.58</td>
</tr>
<tr>
<td>Groundnut</td>
<td>13.66</td>
<td>19.53</td>
</tr>
<tr>
<td>Mustard</td>
<td>6.94</td>
<td>10.61</td>
</tr>
<tr>
<td>Mungbean</td>
<td>3.40</td>
<td>6.19</td>
</tr>
<tr>
<td>Sesamum</td>
<td>2.21</td>
<td>6.13</td>
</tr>
</tbody>
</table>

Table 62. Yields (q/ha) of cereals, pulses and oilseeds in National Demonstrations, compared with the average national yields (1985–86)

<table>
<thead>
<tr>
<th>Crop</th>
<th>National average</th>
<th>Average yield in National Demonstrations</th>
<th>Highest yield in National Demonstrations</th>
<th>Percentage increase in average yield in Demonstrations over national average</th>
<th>Ratio of mean yield and state average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice irrigated</td>
<td>23.55</td>
<td>48.85</td>
<td>93.75</td>
<td>107.4</td>
<td>2.07</td>
</tr>
<tr>
<td>Wheat irrigated</td>
<td>20.32</td>
<td>38.06</td>
<td>58.75</td>
<td>87.3</td>
<td>1.87</td>
</tr>
<tr>
<td>Maize</td>
<td>11.72</td>
<td>33.82</td>
<td>65.00</td>
<td>188.5</td>
<td>2.88</td>
</tr>
<tr>
<td>Sorghum</td>
<td>6.41</td>
<td>34.00</td>
<td>52.50</td>
<td>430.4</td>
<td>5.30</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>3.45</td>
<td>13.58</td>
<td>30.00</td>
<td>293.6</td>
<td>3.94</td>
</tr>
<tr>
<td>Groundnut</td>
<td>13.66</td>
<td>19.53</td>
<td>56.00</td>
<td>42.9</td>
<td>1.43</td>
</tr>
<tr>
<td>Mustard</td>
<td>6.94</td>
<td>10.61</td>
<td>19.75</td>
<td>52.8</td>
<td>1.53</td>
</tr>
<tr>
<td>Mungbean</td>
<td>3.40</td>
<td>6.19</td>
<td>12.15</td>
<td>82.0</td>
<td>1.82</td>
</tr>
<tr>
<td>Sesamum</td>
<td>2.21</td>
<td>6.13</td>
<td>13.50</td>
<td>177.3</td>
<td>2.77</td>
</tr>
</tbody>
</table>
At many of the transfer-of-technology projects, housewives evinced keen interest in the easy-to-operate tubular maize sheller.

rainfed lands, and 63 dealt with entire farming systems, including vegetable and fruit production, dairying and related activities. At the time of conducting field operations, 1,079 field-days were organized to disseminate the new technologies quickly. Over 50,780 farmers, besides several extension workers, participated in these fields. Special training programmes were also organized to expose farmers to new technologies.

**OPERATIONAL RESEARCH PROJECTS**

During the year 146 centres conducted operational research on crop husbandry, plant protection, dry farming, mixed farming, watershed management, soil reclamation, fisheries, etc.

In Bhilwara, Rajasthan, the increase in crop yields ranged from 30 to 293% in cereals, 40 to 163% in pulses, and 54 to 342% in oilseeds.

In the waterlogged coastal soils of Orissa, rice yields could be increased by over 400% (from 1.2 to 5.4 tonnes/ha). The new technology involved (i) the use of new varieties like 'CR 1018', 'CR 1016' and 'CR 1030', (ii) early planting, (iii) high basal dose of fertilizers, (iv) use of phosphatic fertilizers, (v) top-dressing of nitrogen after recession of floods, and (vi) plant protection.

In the Bhatinda district of Punjab, non-
pests the ORP villagers had spent Rs 396 (as against Rs 324 in the non-ORP villages) on pest control and obtained an income of Rs 9,970.80 (Rs 2,241.50 more).

In Jodhpur, Rajasthan, the ORP farmers used low-pressure, high-discharge drip system and reduced the cost of irrigation by Rs 5,000/ha.

In the Binda diara of Bariarpur (Monghyr, Bihar), early-maturing maize yielded 22.88 q/ha. ‘Suwan’, ‘Ganga 2’ and ‘Ganga 5’ yielded 37.8 to 39.5 q/ha.

The NDRI, Karnal, implemented an ORP on integrated milk and crop production in Karnal, Haryana. In the ORP area wheat yielded 42.35 q/ha, oat 546.62 q/ha, mustard 13.4 q/ha and Indian rapeseed (toria) 12.87 q/ha. Of the 2,298 crossbred calves born, 72% belonged to the landless, marginal and small farmers. The landless households accounted for 38% of the crossbred calves.

The farmers of the ORP village in Khammam, Andhra Pradesh, increased their cropping intensity in rice-based cropping systems. They found zinc to be very useful in increasing the productivity of rice grown on alkali soils. Neem-coated urea was found to be beneficial to rice but adequate quantities were not available to meet the demand.

In the ORP area in Tenali, Andhra Pradesh, the brown plant-hopper—a serious endemic pest hitherto causing heavy losses—was reduced to a pest of no importance, and shoot-blight incidence was effectively checked. Pesticide use was brought down to one-fifth of what it was 5 years ago, and rice yields increased from 34.4 to 49.7 q/ha, and urdbean yield from 4.9 to 13.9 q/ha during this period.

The ORP in the Guntur district (up to May) and Rangareddy district (June onward), Andhra Pradesh, showed that the average working-cost of rice cultivation in kharif was Rs 3,914, the cost:benefit ratio of 1:2.24. ‘Mtu 5249’ gave a cost:benefit ratio of 1:2.56. The working-cost of urdbean was Rs 1,799/ha, the cost:benefit ratio being 1:1.66.

Feedback

Rice root-weevil was found to be a problem localized in certain low-lying areas in Guntur district. The APAU was requested to undertake further research on its management.

The false-smut of rice and orange-leaf virus and its vector, Recilia dorsalis, were found to be severe at some places. The Directorate of Rice Research has initiated new research programmes for their control.

KRISHI VIGYAN KENDRAS

At present there are 89 Krishi Vigyan Kendras (KVKs) and 8 Trainers’ Training Centres (TTCs) spread all over the country. Based on the needs and technological gaps assessed through village and family surveys, short- and long-term training courses were started in crop production, livestock production, horticulture, home science, agricultural engineering, fisheries and related disciplines. The courses were organized on the campuses of the KVKs as well as in the villages for the benefit of extension personnel and rural masses, particularly of the weaker sections of the society.

The KVKs organized 6,856 training courses for 170,292 farmers, farm women, rural youth and school dropouts. The TTCs conducted 161 training courses for the teachers of the KVKs (Table 63).

LAB-TO-LAND PROGRAMME

The Lab-to-Land Programme (LLP), initially launched in 1979, was converted into a scheme of the Seventh Plan from 1 October 1986, and is implemented through 102 centres located in 8 zones. The participants of the programme are 26 agricultural universities, 8 other universities and affiliated colleges, 30 ICAR institutes and 38 voluntary and government organizations. Because of financial constraints, only 24,658 families were adopted under the programme, and the ICAR institutes were advised to run the programme
In the Krishi Vigyan Kendra at Narakkal, many women have taken active part in the collection of prawn seeds from backwaters.

Table 63. Number of training courses organized and persons trained at the Krishi Vigyan Kendras

<table>
<thead>
<tr>
<th>Subject</th>
<th>1986-87</th>
<th>1987-88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production</td>
<td>1,948</td>
<td>54,946</td>
</tr>
<tr>
<td>Livestock production</td>
<td>997</td>
<td>18,667</td>
</tr>
<tr>
<td>Horticulture</td>
<td>1,434</td>
<td>31,734</td>
</tr>
<tr>
<td>Home science</td>
<td>998</td>
<td>30,805</td>
</tr>
<tr>
<td>Agricultural engineering</td>
<td>475</td>
<td>7,716</td>
</tr>
<tr>
<td>Fisheries</td>
<td>317</td>
<td>3,881</td>
</tr>
<tr>
<td>Others (beehkeeping, sericulture, mushroom cultivation, forestry, etc.)</td>
<td>687</td>
<td>22,543</td>
</tr>
<tr>
<td>Total</td>
<td>6,856</td>
<td>170,292</td>
</tr>
</tbody>
</table>

from the budget savings of the institutes.

Educational and motivational in nature, the LLP transferred low-cost, location-specific technology packages to small farmers and landless labourers, with special emphasis on prawn cultivation.
on scheduled castes and backward communities.

Landless labourers were mostly involved in dairying, sheep-rearing, goat-keeping, poultry-keeping, duck-rearing, piggy, beekeeping, fisheries, mushroom cultivation and in vocational enterprises like weaving, leather work and basket-making. Farm women were trained in kitchen gardening, tailoring, embroidery, vegetable and fruit preservation and bakery. Where small farmers were involved, special attention was given to the production of pulses and oilseeds in all zones, and to rice production in the eastern zone.

The LLP laid emphasis on the introduction of low-cost technologies and varieties suitable to the socio-economic needs of poor farmers, crop diversification, and fitting in an additional crop in rotation with the principal crops.

Extension Activities of Agricultural Universities

Besides taking active part in all the transfer-of-technology projects of the ICAR, the agricultural universities in the country organized well-spread extension activities in their states, such as Kisan Melas, on-farm demonstrations, training courses, field days, exhibitions, campaigns, preparation of audiovisual aids and materials for broadcasting and telev-casting, and publication of low-priced and free literature in all Indian languages.
Research for Tribal and Backward Areas

For the benefit of farmers belonging to the scheduled tribes, scheduled castes and other ecologically and economically handicapped farm families, research is conducted at the Central Agricultural Research Institute for the Andaman and Nicobar Group of Islands, Port Blair, the ICAR Research Complex for the North-Eastern Hills Region, the Vivekananda Parvatiya Krishi Anusandhan Shala, Almora, and the Indian Lac Research Institute, Namkum (Ranchi, Bihar). An all-India co-ordinated research project is also under operation at 19 centres in 16 states for the benefit of scheduled castes and backward communities.

Research for Tribal Areas

The new varieties and the low-cost technologies developed at the central institutes and the agricultural universities are evaluated and those that are relevant to the socio-economic needs of the tribals are demonstrated and popularized for increasing productivity.

Crop Production

Over 3,000 tribal families in different states were helped to raise a second crop, which gave a benefit of more than Rs 1,600/ha to a family. Tribal farmers evinced great interest in crop sequences like cotton + pigeonpea; castor + cowpea; hybrid cotton intercropped with maize or urdbean; groundnut + pigeonpea; tapioca + groundnut or soybean or vegetables; maize + urdbean or soybean or castor; maize + cucumber; and kharif cereals followed by rabi vegetables. On an average they got a net profit of over Rs 3,000/ha, which works out to approximately Rs 1,000 per family since the tribals have small pieces of land.

Horticultural Production

About 3,000 tribal farm families in the ORP area took up the cultivation of vegetables and fruits. Many tribals have shown interest in the cultivation of potato, which was newly introduced in their regions. The cultivation of vegetables after rice, kitchen gardening in the backyard, nursery management, rejuvenation of wild jujube (ber) and mango with superior clones was taken up at all places. As a result, each family could get an extra income of Rs 1,000. Fruit gardens were developed at Dungarpur, Banswara (Rajasthan) and Dharni (Maharashtra). For the supply of seedlings of vegetables and fruits, community nurseries were developed at Chikhaldara and Keonjhar (Orissa).

At Aberi, each farm family, on an average, could earn more than Rs 8,000/ha by growing vegetables after rice. At Seethampetta, farmers who grew banana with the recommended package of practices could obtain an income of more than Rs 10,000 from plots of 0.1 ha. Some farmers raised more than a tonne of vegetables per hectare in the inter-spaces of banana plants. At Keonjhar, farmers obtained a gross profit of Rs 21,500/ha from ginger, and Rs 11,000/ha from turmeric. At Phulbani, ginger + chilli, turmeric + pigeonpea, cauliflower + knolkohl, and tapioca + groundnut or soybean or vegetables were popular.

Animal Production

Landless tribals were involved in co-opera-
RESEARCH FOR TRIBAL AND BACKWARD AREAS

10,600 families have so far been benefited by the operational research project for tribals. 5,000 families are now free from debt. Average family income in 1986 was Rs 3,500 before the start of the project the average family income was only Rs 1,000.

Benefits accrued as a result of Tribal Area Project.

In recent years, there was a significant increase in the productivity of the farms of the Umarkote tribal region in Orissa.

Table 64. Yield and income from principal crops in different tribal areas

<table>
<thead>
<tr>
<th>State and centre</th>
<th>Crops and varieties</th>
<th>Yield and income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maharashtra, Kinwat</td>
<td>Cotton ‘Hy 4’, ‘NHH 44’</td>
<td>Net profit Rs 2,500/ha</td>
</tr>
<tr>
<td>Madhya Pradesh, Dindori</td>
<td>Sorghum ‘CSH 9’ followed by wheat</td>
<td>Net profit Rs 3,000/ha</td>
</tr>
<tr>
<td>Sidhi</td>
<td>Short-duration rice</td>
<td>18.75 q/ha</td>
</tr>
<tr>
<td></td>
<td>Sorghum ‘Suwan’ as a sole crop or mixed with mungbean or urdbean</td>
<td>Net profit Rs 2,300/ha</td>
</tr>
<tr>
<td>Gujarat, Waghai</td>
<td>Rice</td>
<td>14 q/ha</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>17 q/ha</td>
</tr>
<tr>
<td></td>
<td>Mungbean or chilli in summer</td>
<td>Net income Rs 1,200/ha</td>
</tr>
<tr>
<td>Dahad</td>
<td>Maize + Pigeonpea or urdbean</td>
<td>Net income Rs 900/family</td>
</tr>
<tr>
<td>Deesa</td>
<td>Rice on medium lands</td>
<td>20 q/ha</td>
</tr>
<tr>
<td>Orissa, Keonjhar</td>
<td>Groundnut</td>
<td>Net income Rs 3,300/ha</td>
</tr>
<tr>
<td></td>
<td>Niger</td>
<td>Net income Rs 1,400/ha</td>
</tr>
<tr>
<td></td>
<td>Mustard</td>
<td>Net income Rs 1,300/ha</td>
</tr>
<tr>
<td></td>
<td>Rice + Pigeonpea</td>
<td>Net income Rs 1,500/family</td>
</tr>
<tr>
<td>Phulbani</td>
<td>Rice</td>
<td>Improved variety 50 q/ha; local variety 26.5 q/ha</td>
</tr>
</tbody>
</table>

(Contd.)
Local goats were upgraded by crossing them with Deogarh, Malabari and Barberi bucks. Milk yield increased by 7 to 15% in places where the growing of green fodder was introduced on a selective basis.

**Homestead Vocations**

The tribals were given adequate training in maintaining oil-engines, electric motors and plant-protection equipment, as well as in carpentry, tailoring, basket-making, mushroom cultivation and collection and sale of minor forest products like gum, honey, and mahua flowers. Ambar-charkha and soap-making were popular in Gujarat and rope-making in Rajasthan. Beekeeping was a profitable venture in Kerala, Madhya Pradesh, Maharashtra and Orissa.

**Health, Hygiene and Nutrition**

Tribal women and girls were given training in tailoring, grain storage, chopping of fodder, dairy, poultry-keeping, health, hygiene, nutrition and child care. Demonstrations were organized in the preparation of nutritious snacks from locally available food materials. Special attention was paid to the treatment of skin and eye diseases.

**RESEARCH FOR SCHEDULED CASTES AND BACKWARD COMMUNITIES (ORP)**

Under the All-India Co-ordinated Project on Scheduled Castes and Backward Communities, 19 centres were established in 16 states to develop integrated models to improve the socio-economic conditions of backward farmers.

**Crop Production**

About 1,500 families were covered in 1987. The yield and income from some of the popular crops and varieties are given in Table 65.
Table 65. Yield and income from principal crops in the AICRP for scheduled castes and backward communities

<table>
<thead>
<tr>
<th>State and centre</th>
<th>Crops and varieties</th>
<th>Yield and income</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maharashtra</strong></td>
<td>Sorghum 'CSH 9'</td>
<td>16.50 q/ha</td>
</tr>
<tr>
<td></td>
<td>Cotton 'AKA 5'</td>
<td>4.60 q/ha</td>
</tr>
<tr>
<td></td>
<td>Sorghum intercropped with mungbean or pigeonpea; cotton 'NHH 44' + Soybean 'PS 13', followed by summer groundnut</td>
<td>Net income Rs 2,360/ha</td>
</tr>
<tr>
<td><strong>Madhya Pradesh, Bhopal</strong></td>
<td>Rice 'IR 36', 'Shivari'</td>
<td>Gross income Rs 7,820/ha</td>
</tr>
<tr>
<td><strong>Rajasthan, Udaipur</strong></td>
<td>Maize 'Ganga 5', Soybean 'Gaurav'</td>
<td>Gross income Rs 5,000/ha</td>
</tr>
<tr>
<td><strong>Andhra Pradesh, Palam</strong></td>
<td>Maize 'Ageti 76', 'G 2'; Groundnut 'JL 24'</td>
<td>11 q/ha</td>
</tr>
<tr>
<td><strong>Gujarat, Arnej</strong></td>
<td>Maize 'Gang 5', Soybean 'Gaurav', irrigated</td>
<td>9.12 q/ha</td>
</tr>
<tr>
<td><strong>Bihar</strong></td>
<td>Mustard 'T 9'; Barley 'RD 103', Chickpea 'C 235'</td>
<td>Yields comparable with those of progressive farmers</td>
</tr>
<tr>
<td><strong>Punjab, Jalandhar</strong></td>
<td>Finger millet 'Rahlagir'</td>
<td>14.83 q/ha</td>
</tr>
<tr>
<td><strong>Haryana, Gurgaon</strong></td>
<td>Castor 'Aruna'; Wheat 'Lok 1'</td>
<td>9.26 q/ha</td>
</tr>
<tr>
<td><strong>Assam, Jorhat</strong></td>
<td>Wheat 'GW 120', rainfed</td>
<td>26.01 q/ha</td>
</tr>
<tr>
<td><strong>Himachal Pradesh, Palampur</strong></td>
<td>Wheat 'GW 120', rainfed</td>
<td>16.70 q/ha</td>
</tr>
<tr>
<td><strong>Uttar Pradesh, Barabanki</strong></td>
<td>Pearl millet, summer</td>
<td>15.15 q/ha</td>
</tr>
<tr>
<td><strong>Karnataka, Bangalore</strong></td>
<td>Maize 'Laxmi', 'Hemant'; Mungbean 'NP 18' in summer</td>
<td>32 to 45 q/ha</td>
</tr>
<tr>
<td></td>
<td>Rice 'CR 4004-109', 'Secta'; Wheat, irrigated</td>
<td>5.50 q/ha</td>
</tr>
<tr>
<td></td>
<td>Wheat 'PBW 120', 'HD 2329'</td>
<td>20 q/ha</td>
</tr>
<tr>
<td></td>
<td>Rice 'PR 108', 'PR 109'</td>
<td>62.4 q/ha</td>
</tr>
<tr>
<td></td>
<td>Bold-seeded mustard (raja)</td>
<td>18 q/ha</td>
</tr>
<tr>
<td></td>
<td>'Pusa Bold'; Wheat 'WH 283'</td>
<td>40 q/ha</td>
</tr>
<tr>
<td></td>
<td>Chickpea</td>
<td>20 q/ha</td>
</tr>
<tr>
<td></td>
<td>Wheat 'Sonlaka'</td>
<td>18.37 q/ha</td>
</tr>
<tr>
<td></td>
<td>Rice 'Pankaj'</td>
<td>More than 55 q/ha</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>28.5 q/ha</td>
</tr>
<tr>
<td></td>
<td>Barley 'Sonu'</td>
<td>12.5 q/ha</td>
</tr>
<tr>
<td></td>
<td>Barley</td>
<td>40 q/ha</td>
</tr>
<tr>
<td></td>
<td>Wheat 'RR 21', 'K 7410', 'HD 1553'</td>
<td>Gross income more than Rs 6,500/ha</td>
</tr>
<tr>
<td></td>
<td>Chickpea 'Radhey', 'Kailash'</td>
<td>Gross income more than Rs 6,000/ha</td>
</tr>
<tr>
<td></td>
<td>Finger millet 'Indaf 5'; 'Indaf 9'; 'Indaf 8'; 'PR 202' (all rainfed)</td>
<td>Net return Rs 1,500/ha</td>
</tr>
<tr>
<td></td>
<td>Groundnut 'TMV 2'</td>
<td>Net income Rs 1,800/ha</td>
</tr>
<tr>
<td></td>
<td>Pigeonpea + Mungbean; Maize + Soybean; Groundnut + Pigeonpea; Finger millet + Soybean</td>
<td>Net income more than Rs 2,000/ha</td>
</tr>
<tr>
<td></td>
<td>Finger millet or cowpea rainfed in khari, followed by finger millet or potato or vegetables, irrigated in rabi</td>
<td>Net income more than Rs 10,000/ha</td>
</tr>
<tr>
<td></td>
<td>Finger millet in khari, followed by potato, French-bean and cabbage in rabi</td>
<td>Net income more than Rs 30,000/ha</td>
</tr>
</tbody>
</table>
Horticultural Production
About 1,200 families covered by 19 centres grew vegetables in their backyards as well as in fields after short-duration kharif crops. Orchards of citrus, mango, pear, peach and plum were developed in Himachal Pradesh, and of sapota, lemon and oranges in Rajasthan and Maharashtra. Papaya and mulberry cultivation was taken up at Gurgaon. In Kerala, a year-round vegetable farming was developed which fetched an income of Rs 300–500 a month to each family. At Bilaspur, Madhya Pradesh, vegetable crops were grown in rabi by 120 families, who got an average gross income of Rs 6,000/ha. At Bhubaneshwar, shaded land was profitably put under turmeric (PTS 10°), which yielded 28.6 q/ha on an average.

Animal Production
Livestock programmes covered 1,000 families in 1987. With improved feeding local cattle gave 15–20% more milk yield. Facilities were created for artificial insemination and health care of animals at all the centres. Landless farmers evinced great interest in piggery, poultry, duck-rearing and goat-keeping. Loans were arranged by 10 centres for the purchase of milch animals and poultry by farmers of the low-income group.

Fish Culture
At Bhubaneshwar, Barabanki and Jorhat, many scheduled caste families have taken up pisciculture on scientific lines and harvested 900 kg of fish from each pond.

Health, Hygiene and Homestead Vocations
Programmes of health, hygiene, nutrition, child care and homestead vocations were continued on the lines similar to those started for scheduled tribes. Making ropes from grass and coir was a common vocation, which gave each family an income of Rs 450 to Rs 500 at Gurgaon, Barabanki, Bhubaneshwar and Udaipur. Smokeless chulah was popular among women.

OPERATIONAL RESEARCH PROJECT ON WATERSHED MANAGEMENT
In 1987, work was started on 3 more watersheds, bringing their total to 46. Land-leveling, contour-bunding, gully-ploughing and check-dams have been completed in 75 to 80% of the proposed master plan.

In a majority of the watersheds, the surplus runoff water was collected in water-harvesting structures and recycled to crops when they required critical irrigation. Consequently, in the year of unprecedented drought, crop and agroforestry components performed much better inside the watersheds than outside them. On degraded lands of the watersheds, suitable vegetative and grass covers were introduced. Because of soil conservation and land development, the recharge of groundwater has increased substantially in Tejpura (Jhansi), Chhajawa (Kota), Behdela-Chattara (Una), Fatehpur-Kangra (Hoshiarpur) and Chinnatekur (Kurnool).

In many of the watersheds, runoff water has been collected in small ponds and used for providing critical irrigations to crops in a year of severe drought.
Table 66. Impact of watersheds on increasing crop production.

<table>
<thead>
<tr>
<th>Locality, crop and variety</th>
<th>Yield (q/ha)</th>
<th>Within watershed in 1986-87</th>
<th>At the start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chhajawa (Kota)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum 'CSH 5'</td>
<td>22.7</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>Soybean 'Gaurav'</td>
<td>19.1</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Kalyan Sona'</td>
<td>24.4</td>
<td>11.25</td>
<td></td>
</tr>
<tr>
<td>'WH 147'</td>
<td>24.8</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>'Raj 1555'</td>
<td>21.3</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Mustard 'Varuna'</td>
<td>10.7</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>Bunga (Ambala)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>28.0</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Chickpea</td>
<td>10.0</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Pigeonpe</td>
<td>12.0</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Groundnut</td>
<td>10.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Sorghum, fodder</td>
<td>150.0</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>Mustard, intercrop</td>
<td>8.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Mir (Udhampur)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>14.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Mustard</td>
<td>4.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>15.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>38.0</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>37.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Mungbean and urdbean</td>
<td>5.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td>150.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

With the release of ‘IET 5656’ (4.3 tonnes/ha) and ‘IET 6314’ (4.5 tonnes/ha), two crops of rice are possible now in the Andaman and Nicobar Islands, where traditionally only one crop is grown.

The third-generation short-legged Nicobari fowls are resistant to diseases prevalent in the Andaman and Nicobar Islands. They lay on an average 168 eggs in a year and attain a weight of 1,384 g in 177 days when raised on deep-litter systems.

The upgraded third generation fowls of the short-legged Nicobari fowl, which is adapted to the Andaman and Nicobar Islands and is resistant to the diseases prevailing in the region, had laid on an average 168 eggs in a year and attained a weight of 1,384 grams in 172 days when raised on deep-litter systems.

Stephanofilarial dermatitis, the humpsore, occurs throughout the year in both cows and bulls of all ages. Subcutaneous injection of
The humpsore, Stephanofilaria dermatitis, occurs throughout the year in both cows and bulls of all ages in the Andaman and Nicobar Islands. Subcutaneous injection of 10% diethyl carbamazine citrate around the sore cures the wound in 10-20 days. An ointment containing 10 g of boric acid, 1 g of resorcinol and 79 g of white vaseline was also effective. The medicine is cheap and has no side-effects.

For the first time in brackishwater creeks, spiny lobsters (*Panulirus* sp.) were noticed to have taken shelter on coir ropes suspended for spat collection. Green mussels were transported by the 'dry' method and successfully transplanted in distant islands.

The CARIANGI conducted 18 national demonstrations, and 100 farm families were covered under the lab-to-land programme. From south Andaman, fish seed were transported in specially fabricated bags filled with oxygen and supplied to the farmers in Hut Bay. Twenty Nicobari tribal youth were given training in the cultivation of oyster-mushroom.

ICAR RESEARCH COMPLEX FOR THE NORTH-EASTERN HILLS REGION

On the basis of extensive trials, a number of varieties of cereals, pulses and oilseeds were identified for cultivation in the north-eastern hills region (Tables 67 to 69).

Crop Production

Dipping the roots of rice seedlings in water mixed with *Aspergillus awamori* increased the grain yield of rice by 8.49 q/ha over the control yield of 27.9 q/ha.

On uplands, application of 60 kg N/ha in the form of urea supergranules increased the rice yields to 30.8 q/ha when the control yielded 24.6 q/ha. However, in most parts of the north-eastern hills region the efficiency of nitrogen use was only 5-15%.

Rice did not respond to the application of lime, although there was considerable improvement in the yields of maize and soybean. All the 3 crops responded well to the
In recent years, dwarf types of coconut are becoming increasingly popular at Port Blair as they are easy to manage.
Table 67. Promising crop varieties identified for cultivation in the north-eastern hills region

<table>
<thead>
<tr>
<th>Crop</th>
<th>Region and variety</th>
<th>Variety</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland rice</td>
<td>Meghalaya: 'HPU 2201', 'HPU 5101'</td>
<td>'HPU 2201'</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Mizoram: 'VL 206', 'CR 23-3-2-99'</td>
<td>'VL 206'</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>Nagaland: 'ET 7565'</td>
<td>'ET 7565'</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>Sikkim: 'Bali', 'Yamuk', 'Yabon'</td>
<td>'Bali'</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td>Tripura: 'Annapurna', 'TRCM 408'</td>
<td>'Annapurna'</td>
<td>6.1</td>
</tr>
<tr>
<td>Lowland rice</td>
<td>Meghalaya: 'Prasad'</td>
<td>'Prasad'</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>Mizoram: 'ET 3126', 'VL 206', 'DR 92'</td>
<td>'ET 3126'</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>Sikkim: 'DR 92', 'Phichung', 'Prasad'</td>
<td>'DR 92'</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>Arunachal Pradesh: 'Veera', 'Ahusali', 'ARU 1', 'ARU 3'</td>
<td>'Veera'</td>
<td>12.0</td>
</tr>
<tr>
<td>Maize</td>
<td>Meghalaya: 'G 44'</td>
<td>'G 44'</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>Mizoram: 'Ageti', 'MCU 5'</td>
<td>'Ageti'</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>Sikkim: 'NLD White Composite'</td>
<td>'NLD White Composite'</td>
<td>7.2</td>
</tr>
<tr>
<td>Fingermillet</td>
<td>Nagaland: 'VL 204'</td>
<td>'VL 204'</td>
<td>8.0</td>
</tr>
<tr>
<td>Mustard</td>
<td>Sikkim: 'RH 843'</td>
<td>'RH 843'</td>
<td>17.6</td>
</tr>
<tr>
<td>Sesamum</td>
<td>Tripura: 'BS 18-6 (G)'</td>
<td>'BS 18-6 (G)'</td>
<td>12.0</td>
</tr>
</tbody>
</table>

application of farmyard manure @ 10 tonnes/ha.

Groundnut varieties 'JL 24', 'NRCG 49' and 'Chandra' performed well in Manipur, Meghalaya and Arunachal Pradesh. With 20 kg N, 60 kg P₂O₅ and 30 kg K₂O/ha, groundnut gave good yields in Meghalaya, Manipur, Mizoram, Arunachal Pradesh, Tripura and Nagaland. It could also be grown as an intercrop with maize or rice in rainfed uplands.

French-bean responded to P doses up to 20 kg/ha. When boron @ 1 kg/ha was applied with P, the crop flowered 15 to 20 days earlier.

Crop Protection

White-rust was the common disease of mustard, tikka leaf-spot on groundnut and leaf-blight on sunflower. Groundnut varieties 'ICGB 76', 'HYQ (CG) S 21', 'HYD (CG) S 14' and 'HYQ (CG) S 11' showed moderate resistance to tikka leaf-spot. The rice varieties showing resistance to leaf-blast, neck-blast and sheath-blight were 'PP 215-14', 'PP 2-34-155-7', 'PP 4-6-66-18' and 'PP 4-3-35-61'.

Table 68. Promising pulse varieties identified for cultivation in the north-eastern hills region

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mungbean</td>
<td>'PDM 54'</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>'PDM 62'</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>'ML 326'</td>
<td>17.9</td>
</tr>
<tr>
<td>Urdbean</td>
<td>'B 3-8-8'</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>'B 12-4-5'</td>
<td>17.2</td>
</tr>
<tr>
<td>Cowpea</td>
<td>'V 385'</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>'V 271'</td>
<td>17.2</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>'T 21'</td>
<td>17.6</td>
</tr>
<tr>
<td>Rice-bean</td>
<td>'RB 7-17'</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>'SKRB 1'</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>'EC 37235'</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>'EC 37246'</td>
<td>17.2</td>
</tr>
<tr>
<td>French-bean</td>
<td>'HUR 67'</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>'HUR 120'</td>
<td>17.4</td>
</tr>
<tr>
<td>Field-pea</td>
<td>'DMR 4'</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>'T 163'</td>
<td>17.4</td>
</tr>
<tr>
<td>Chickpea</td>
<td>'PDG 83-25'</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>'K 850'</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>'Radhey'</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>'GL 83-118'</td>
<td>17.0</td>
</tr>
<tr>
<td>Lentil</td>
<td>'PL 639'</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>'L 4162'</td>
<td>17.0</td>
</tr>
</tbody>
</table>

Table 69. Promising groundnut varieties identified for cultivation in Meghalaya

<table>
<thead>
<tr>
<th>Groundnut group</th>
<th>Variety</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valencia</td>
<td>'NRCG 1186'</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>'NRCG 5339'</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>'NRCG 4471'</td>
<td>16.8</td>
</tr>
<tr>
<td>Spanish</td>
<td>'NRCG 6346'</td>
<td>24.9</td>
</tr>
<tr>
<td></td>
<td>'NRCG 6420'</td>
<td>22.9</td>
</tr>
<tr>
<td></td>
<td>'NRCG 6428'</td>
<td>21.8</td>
</tr>
<tr>
<td>Virginia bunch</td>
<td>'NRCG 3166'</td>
<td>21.4</td>
</tr>
<tr>
<td></td>
<td>'NRCG 5953'</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>'NRCG 1955'</td>
<td>22.1</td>
</tr>
<tr>
<td>Virginia runner</td>
<td>'NRCG 1904'</td>
<td>31.2</td>
</tr>
<tr>
<td></td>
<td>'NRCG 3012'</td>
<td>29.4</td>
</tr>
<tr>
<td></td>
<td>'NRCG 7589'</td>
<td>26.5</td>
</tr>
</tbody>
</table>

Rattus nitidus was the dominant rodent pest. Rattus tissae was a new species recorded.
this year. Zinc phosphide, Bromadiolone and Brodifacoum effectively controlled rats.

**Animal Diseases**

*Pasteurella multicoda* serotype B 2 has been reported for the first time in India, causing swine pasteurellosis in the north-eastern hills region. Rabbits immunized with it could be fully protected against serotype B 2 as well as B 6.

Manipur has made an extensive use of the vaccine newly developed against the black-quarters-like disease.

**Fisheries**

The chocolate-mahseer fingerlings collected from Arunachal Pradesh have attained a weight of 300 g in running water (which has also a larger carrying capacity) and 248 g in ponds. Because of the cold climate, the major carps showed poor growth in the hills and could only be used in composite fish culture.

**Lab-to-Land Programme**

‘Kufri Jyoti’ yielded up to 320 q/ha in 100 pre-kharif demonstrations.
Foreign-aided Projects

The following externally aided projects were approved.

1. Ford Foundation-assisted project on field trials of farming systems associated with marginal farmers to be implemented at the Orissa University of Agriculture and Technology, Bhubaneshwar, spread over a period of 2 years, with an estimated input of US $13,000.

2. Ford Foundation-assisted project on experimental integration of women into public-sector extension system in agriculture to be implemented at the Birsa Agricultural University, Ranchi, spread over a period of 5 years, with an input of US $68,000.

3. Collaborative research project on rapeseed-mustard improvement at 10 centres spread over a period of 5 years with the assistance from the Swedish Government through Swedish Agency for Research Cooperation with Developing Countries (SAREC), with an estimated input of Swedish Kr. 2,590,000.

4. IDRC-assisted project on development of economic feeding systems for goats and sheep in India to be implemented at the Andhra Pradesh Agricultural University, Hyderabad, spread over a period of 3 years, with an input of Canadian $245,000.

5. IDRC-assisted research project on lathyrus to be implemented by the Indira Gandhi Agricultural University, Raipur, spread over a period of 5 years, with an input of Canadian $202,000.

6. IDRC-assisted project on environmental, physiological and nutritional effects on draught capacity in Indian Murrah buffaloes to be implemented at the Central Research Institute for Buffaloes, Hisar, spread over a period of 3 years, with an input of Canadian $110,000.

7. IDRC-assisted project on domestication of cultivated Indian major carps to be implemented at the College of Fisheries, University of Agricultural Sciences, Mangalore, spread over a period of 3 years, with an input of Canadian $101,700.

8. IDRC-assisted project on rural food enterprises for production of low-cost supplementary foods using sorghum, millets and legumes to be implemented at the Andhra Pradesh Agricultural University, Hyderabad, spread over a period of 5 years, with an input of Canadian $285,200.

9. IDRC-assisted project on oilseed processing to be implemented at the Central Institute of Agricultural Engineering, Bhopal, and 3 other centres, spread over a period of 3 years, with an estimated input of Canadian $453,100.

10. IDRC-assisted project for the provision of post-graduate fellowship leading to Ph. D. in sesamum research to be implemented at the Tamil Nadu Agricultural University, Coimbatore, spread over a period of 3 years, with an estimated input of Canadian $103,000.

11. IDRC-assisted project on on-farm research on sesamum to be implemented at the Tamil Nadu Agricultural University, Coimbatore, spread over a period of 5 years, with an input of Canadian $160,800.

12. Participation of India in Phase IV of the UNDP-assisted research project on regional network of agricultural machinery was approved.
13. Indo-Dutch research project on bio-conversion of ligno-cellulosic crop residues was extended into Phase II from 1 July 1987 to 1 May 1990.

14. The duration of the grant of the Ford Foundation-assisted project on research and development in rice-centered agricultural system being implemented at the Central Rice Research Institute, Cuttack, was extended by 3 years from 1 September 1987 to 31 August 1990.

Indian Delegations to Foreign Countries

1. A 2-member Indian delegation led by Dr M.V. Rao, Special Director-General, ICAR, was deputed to France for attending the first meeting of the Joint Steering Committee under the ICAR-INRA Agreement, from 8 to 9 April 1987.

2. Dr S.P. Malhotra, Director, CAZRI, Jodhpur, was deputed to Saudi Arabia as a member of the Government of India multidisciplinary delegation for identifying the areas of co-operation between the two countries, from 9 to 20 April 1987.

3. A 3-member Indian delegation of soil experts led by Dr B.K. Sinha, Chief Scientist, Water Management, Rajendra Agricultural University, was deputed to Hungary for 2 weeks under the Indo-Hungarian Programme of Co-operation in Science and Technology from 4 May 1987.

4. Dr P.K. Uppal, Project Director, National Research Centre for Equines, Hisar, was deputed to UK for 3 weeks from 18 October 1987 for holding discussions with the Overseas Development Administration (ODA) for developing project proposals for collaborative research on equines.

5. Dr S.L. Seth, Senior Scientist, ICAR, was deputed to Damascus, Syrian Arab Republic, as a member of the Indian delegation led by Shri Yogendra Makwana, Minister of State for Agriculture, from 9 to 12 May 1987.

6. Dr K. Giriraj, Senior Scientist (Oilseeds), University of Agricultural Sciences, Dharwad, was deputed to the USSR as a member of the Indian delegation for the purchase of sunflower seeds, etc., from 24 August to 6 September 1987.

Work-plans, Agreements and Memoranda of Understanding

1. An Agreement was signed on 20 June 1987 between the ICAR and the IRRI for collaborative research programme on the development of rainfed rice production in eastern India.

2. A Memorandum of Understanding between the ICAR and the IBPGR was signed on 23 November 1987 on plant genetic resources.

3. A work-plan for 1988 and 1989 for scientific and technical co-operation in the field of agriculture was concluded in August 1987, under the agreement for co-operation in agriculture between the Government of the Republic of India and the Government of the Islamic Republic of Pakistan, during the Indo-Pakistan Joint Commission meeting held in New Delhi.

4. A work-plan for 1988 and 1989 on (a) potato improvement, and (b) sweet-potato improvement and (c) an Amendment of Memorandum of Agreement between the ICAR and the CIP for scientific and technical co-operation in research on potato improvement concluded during the visit of the DG, ICAR, from 30 November to 4 December 1987 to Lima, Peru.

5. A work-plan for 1988 and 1989 for cooperation between the ICAR and INRA was signed on 14 December 1987 by the Director-General, ICAR, and the Director-General, INRA.

Foreign Experts and Delegations to India

1. Dr B. Singleton, British Expert, visited the ICAR headquarters and the National Research Centre for Equines, Hisar, from 9 to 14 April 1987.

2. Mr R. Friendship and Mrs N.J. Evans, of the Tropical Development Research Insti-
tute, London, visited the CIFT, Cochin, for 6 weeks from 1 June 1987 under the Indo-UK Memorandum of Understanding and collaborative links between the CIFT and the TDRI.

3. Dr D.C. Kemp and Mr Peter Howell, British Experts, visited the Central Institute of Agricultural Engineering, Bhopal, from 21 June to 16 July 1987 under the collaborative links between the CIAE, Bhopal, and the NIAE, Silsoe.

4. A 3-member Japanese team led by Dr H. Roshi Ikehashi, Professor, Department of Horticulture, Chiba University, visited the ICAR headquarters, NBPGF, IARI and CICR, Nagpur, from 21 to 25 July 1987.

5. Dr A.D. Webster, British Expert, visited India from 16 to 28 August 1987 for holding discussions relating to Indo-UK collaboration in temperate horticulture.

6. Mr Brain Sim, Agricultural Engineer, ODA, visited the CIAE, Bhopal, in October 1987 for 4 weeks, under the CIAE/NIAE collaborative links.

7. Dr Pinson, Senior Scientific Officer, TDRI, London, visited the CIAE, Bhopal, for 4 weeks from 20 July 1987 under collaborative links.

8. Sixteen USAID scientists visited India on different occasions in batches of 5-6 scientists each, to study the impact of the state agricultural universities on Indian agriculture.

9. Two USAID scientists came in June 1987 for holding a workshop under the USAID subproject, post-harvest technology of fruits and vegetables for training Indian scientists in conducting survey to examine losses taking place in different commodities during post-harvest stages.

10. Three USAID scientists came to India in May–June 1987 for preparing the design of a new subproject, plant genetic resources, under the USAID project on agricultural research.

11. Four US consulting scientists visited India for conducting an on-site review of the work being done under various PL-480 Projects.

12. Mr Ronald Venezia, Director, ANE/PD, USAID, Washington, along with 4 officials of the USAID, New Delhi, visited the NDRI and CSSRI, Karnal, on 13 October 1987 to meet the scientists associated with the USAID-assisted subprojects on embryo transfer technology and conversion of biodegradable animal wastes.


14. Two Bulgarian scientists visited India under the science and technology programme of co-operation between India and Bulgaria in the field of agriculture.

15. A 4-member Chinese delegation visited India during November 1987 under the science and technology programme of co-operation.


17. A 5-member delegation led by Dr J. Poly, President Director-General, INRA, visited India during 9–14 December 1987 to finalize the work-plan for 1988 and 1989 between the ICAR and INRA.

18. A work-plan for 1987 and 1988 for scientific and technical co-operation in the field of agriculture was concluded on 10 September 1987 between the ICAR and Bangladesh Agricultural Research Council (BARC), under the Memorandum of Agreement between them by exchange of correspondence.

International Training Courses, Seminars, Workshops and Meetings Organized in India

1. The IDRC-sponsored second consultative meeting of South Asian officials was convened during 9–10 April 1987 at New Delhi.

2. An international seminar on sugarcane germplasm was organized during August–September 1987, at the SBI, Coimbatore.

3. An international symposium on integrated pest control, progress and perspectives was organized during 15–17 October 1987 at
the University of Kerala, in collaboration with KAU, at Trivandrum.

4. A meeting-cum-workshop on genetic resources in South and South-East Asia was organized during 23–25 November 1987 at the NBPRGR, New Delhi.

5. A national symposium on the first Indian fisheries forum was organized by the UAS, Bangalore, during 4–8 December 1987.

6. An international seminar on agricultural research systems and management in the 21st century was organized during 8–10 December 1987 by the NAARM at Hyderabad.

7. The 16th international training course on modern methods in potato production was held at the CPRI, Shimla, from 1–30 June 1987 in collaboration with the International Potato Centre.

8. A post-graduate course on research methodology in potato, jointly sponsored by the CIP and ICAR/CPRI, was held in Shimla from 1 to 31 July 1987.

9. A training course on potato tuber-moth management and control, jointly sponsored by the CIP and ICAR/CPRI, was held at Pune from 20–29 August 1987.

10. A training course on germplasm collection, characterization, etc., of jute, kenaf and other allied fibres, sponsored by the IJO, was held at the NBPRGR, New Delhi, in September 1987.

SAARC Activities

India actively participated in the South Asian Association for Regional Co-operation (SAARC) programme. India has taken over the Chairmanship of Technical Committee on Agriculture (TCA) of the SAARC for a period of 2 years from August 1987. In the agricultural sector, the following activities were organized in India during 1987.

1. Regional meeting on plant exploration and related activities held during 26–28 May 1987, at the NBPRGR, New Delhi.

2. Sixth meeting of the Technical Committee on Agriculture of the SAARC held during 5–7 October 1987 at New Delhi.

Foreign Assignments, Visits, Training, Attachments, Scholarships, etc.

Over 400 officers from the ICAR, its research institutes, agricultural universities and the DARE were deputed abroad on foreign assignments, visits, training, attachments, scholarships, participation in meetings, and as members of various delegations.

Training Facilities

Training facilities for both short-term and long-term courses were provided to the foreign nationals, under the following programmes and on requests received from the following agencies.

(a) Technical Co-operation Schemes of the Colombo Plan (CP);
(b) Technical Co-operation Scheme of the Special Commonwealth African Assistance Programme (SCAAP);
(c) Indian Technical and Economic Co-operation (ITEC);
(d) Commonwealth Fund for Technical Co-operation (CFTC);
(e) Cultural Exchange Programme (CEP);
(f) Third Country Training Programme (USAID, ADB, etc.).
(g) United Nations Development Programme (UNDP);
(h) Food and Agriculture Organization (FAO);
(i) Sponsorship by home country by offering scholarship;
(j) International Development Research Centre (IDRC);
(k) Afro-Asian Rural Reconstruction Organization (AARRO);
(l) Mandala Agricultural Development Corporation, Philippines (MADECOR);
(m) Water and Power Consultancy Services (India) Ltd (WAPCOS);
(n) Educational Consultants India Ltd (EDCIL).

During the year, 10 students successfully completed their training courses and returned to their home countries. By the end of October 1987, 39 candidates, mostly from
Nepal, under the TCS of the Colombo Plan were receiving training. In addition, 13 new candidates from Nepal had joined different degree and post-graduate courses. Besides, several nominations are being finalized, as admissions to post-graduate courses in many agricultural universities are still on.

Over 350 nominations of foreign candidates have been received for both short-term courses and long-term regular academic courses.

In addition to the requirement for regular academic courses placed by the DARE, certain demands by different sources were also placed direct with the ICAR. Hence, the ICAR reserved 164 seats for degree courses and 110 for post-graduate courses for foreign nationals.

<table>
<thead>
<tr>
<th>Name of the agency</th>
<th>Short-term courses</th>
<th>Degree courses</th>
<th>Post-graduate courses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAID</td>
<td>4</td>
<td>8</td>
<td>—</td>
<td>12</td>
</tr>
<tr>
<td>FAO</td>
<td>42</td>
<td>1</td>
<td>4</td>
<td>47</td>
</tr>
<tr>
<td>EDCIL</td>
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| Total               | 237                | 44            | 70                    | 351   |
Publications

The Publications and Information Division of the ICAR brought out 55 publications in 1987-88, 40 in English and 15 in Hindi. Another 19 publications, 14 in English and 5 in Hindi, are expected to be brought out by 31 March 1988.

Technology bulletins outlining the package of practices for increasing production in all major crops were brought out in English and Hindi for free distribution. Five of these dealt exclusively with the dry-farming practices recommended for the northern, eastern, southern, central and western regions.

All the ICAR journals, viz. *The Indian Journal of Agricultural Sciences* (monthly), *The Indian Journal of Animal Sciences* (monthly), *Indian Farming* (monthly), *Indian Horticulture* (quarterly), *Kheti* (Hindi, monthly), *Phal-Phool* (Hindi, quarterly), *Krishi Chayanika* (Hindi, quarterly), *ICAR Samachar* (Hindi, quarterly) and *ICAR Reporter* (English, quarterly) were printed on time.

Accent issues of the *Indian Farming* were brought out on small farmers and grasslands, and the *Kheti* brought out accent issues on oilseeds, dairy, plant protection, agricultural engineering, dryland farming, rice production, hill agriculture, wasteland management, small farmers and fodder research. The *Indian Farming* brought out a special number on Buffalo, and the *Indian Horticulture* published a special number on Horticulture in the North-west Himalayas.

The Indian Languages Unit was renamed the Science Popularization Unit for taking up the new role of popularization of agricultural sciences among the masses. The Unit will also provide an ICAR input to and associate with the activities of the National Council for Science and Technology Communication (NCSTC). The Unit released features on agricultural sciences to the language press, radio and television. The achievements of the ICAR, especially on income-generating scientific technologies for rural areas and scientific techniques for drought management were projected through weekly news programme of *Krishi Darshan*.

Sales and Advertisements

The ICAR earned a revenue of Rs 1,217,000 from the sale of its publications including journals and Rs 199,681.87 from advertisements during 1986-87.

For promoting sale of its publications, the ICAR participated in 21 exhibitions, book fairs, Kisan Melas and seminars. Literatures for publicity like circulars, letters, price lists and catalogues were mailed throughout the country and abroad. The Council released advertisements in 71 newspapers published in different languages from various parts of the country.

Art and Photography Units

The Art and Photography Units provided colour and black-and-white slides, charts, maps, histograms and illustrated panels to scientists, as well as for display at different exhibitions, besides the preparation of artwork for ICAR publications. The Units also helped the institutes and agricultural universities in designing and displaying their exhibits.
Publicity and Public Relations

The Public Relations Unit of the ICAR helped in highlighting its activities and achievements during the year and also of its research institutes and projects in an effective manner by using various media such as the press, radio, television, films, exhibitions and trade fairs.

It also collected and compiled ready-for-release material for press conferences, press briefings and other special occasions like Economic Editors’ Conference held in June, on forty years of India’s independence, and the centenary of the birth of Jawaharlal Nehru. A series of features were also issued to highlight the problems caused by the unprecedented drought of 1987 and the long- and short-term steps recommended by the ICAR research institutes to tide over the drought problems.

The *ICAR Reporter* (English) and *ICAR Samachar* (Hindi) continued to disseminate the activities and achievements of the Council, to the specialized group of readers in India and Indian missions abroad. Press coverage of various functions held at ICAR headquarters and its various institutes, convocations, symposia, conferences, Krishi Vigyan Melas and jubilees was arranged.

Effective co-ordination and liaison was also maintained with the Department of Parliamentary Affairs for dissemination of research findings to the members of Parliament.

The Unit organized ICAR’s participation in various national and international exhibitions at the USSR, at the International Trade Fair in India, and on drought management and national westland development.

A short film entitled ‘Improved Dryland Agriculture Technology’ was produced, and a colour documentary on ‘Potato Production’ is under production.

A regular enquiry-assistance service was maintained for the public, scientists, students and farmers on various ICAR technologies.
Agricultural Research Information Centre

The Agricultural Research Information Centre (ARIC) continued to discharge its role as a central source of current research information on the nature, type and location of all agricultural research projects and schemes. It also acted as the National Input Centre for AGRIS.

As a safeguard against duplication of research efforts, the ARIC played a vital role by furnishing comments on 248 ad-hoc research schemes to the various scientific panels before they were considered for sanction.

The ARIC brought out several information products and rendered information services to users of agricultural research information. Some of these are given below:

1. Lists of Current Research Schemes in Agriculture and Animal Sciences (1986–87)
3. Centres of All-India Co-ordinated Research Projects during the Seventh Plan (1985–90)

The ARIC continued to send inputs to the AGRIS data base at Vienna by indexing and abstracting the periodicals and other non-conventional literature of Indian origin. In return, AGRIS magnetic tapes comprising world literature continued to be received from the FAO through which a computerized SDI Service was offered to agricultural scientists in India. The ARIC brought out an ‘Indian National Agricultural Bibliography’ in 4 volumes comprising 2,222 pages covering a period of 10 years from 1975–1984. It contains a wealth of bibliographic information at one place and covers 38,551 citations from Indian and foreign journals, reports, conference proceedings, technical bulletins, books and monographs in all aspects of agriculture, animal husbandry, forestry, fisheries, food, etc. The contents are classified in 85 subjects covering more than 950 commodities and products of animal and plant origin.

Library

During the year 1,268 publications including books, reports, and bulletins were added to the library. About 1,449 readers visited the library and consulted 14,700 publications for reference and information searches. Inter-library loan facilities were extended to other libraries of the country and reference services were rendered. The ‘List of monthly additions’ and the ‘List of periodicals received during the fortnight’ were prepared and circulated. Document-delivery services were extended to the various libraries abroad against specific requests for supply of Indian documents identified by them from the AGRIS data base.

The collection of theses of the ICAR research fellows, so far maintained in the ICAR library, has been transferred to the IARI library, New Delhi.

The library supplied 181,656 photo-copies of useful literature to its users.

The film library lent out films to its members against specific requests.

The Hindi library, established to promote Hindi language, issued 2,520 books to its 485 members.

Publicity Activities of Institutes and Universities

Most of the ICAR institutes and the state agricultural universities have need-based publications and information divisions. They brought out journals, low-priced publications, and free literature, and prepared audiovisual aids and materials for broadcasting and telecasting in all Indian languages.
APPENDIX I

Awards

The ICAR has instituted 9 awards for encouragement to scientists and for recognition of outstanding research in the field of agriculture and allied sciences. Brief information about these awards is given below.

**Rafi Ahmed Kidwai Memorial Prizes for Agricultural Research**

This award was instituted in 1956 in the memory of the late Shri Rafi Ahmed Kidwai, who was President of the ICAR during 1952-54. The award is made for fundamental or applied research work, including inventions and discoveries leading to results of practical value in the field of agricultural production. Eleven prizes of the value of Rs 10,000 each are given biennially. So far 176 scientists have received this award.

**Fakhruddin Ali Ahmed Award for Agricultural Research in Tribal Areas**

This award was instituted in 1977 in the memory of the late Shri Fakhruddin Ali Ahmed, who was President of the ICAR. Two prizes of the value of Rs 10,000 each are made biennially to encourage and promote agricultural research in tribal areas. So far 25 scientists have received this award.

**Jawaharlal Nehru Award for Outstanding Post-graduate Research**

This award was instituted in 1969 to create incentives for high-quality fundamental or applied research among post-graduate students in India in agriculture and allied sciences. Ten prizes of the value of Rs 5,000 each are given annually. So far 111 scientists have received this award.

**Dr Rajendra Prasad Puraskar**

This award was instituted in 1975 to give incentives to writers of original books on agriculture and animal sciences in Hindi, to fill the gap in Hindi literature in these fields. Three prizes of the value of Rs 5,000, Rs 2,500 and Rs 1,500—now raised Rs 10,000, Rs 5,000 and Rs 3,000—as first, second and third prizes, respectively, are given annually. So far 41 authors have received this award.

**Hari Om Ashram Trust Awards**

It is an endowment created by Hari Om Ashram Trust by donating Rs 300,000 to the ICAR. Three prizes of the value of Rs 10,000 each are given annually (1 each in the field of agriculture, animal sciences and forest farming and social forestry) as an encouragement to scientists to conduct research in these fields. So far 62 scientists have received this award.

**Dr P.B. Sarkar Endowment Prize**

This is an endowment created by a donation of Rs 27,700 made by Dr P.B. Sarkar, formerly director, Jute Technological Research Laboratory, Calcutta. Under this endowment, one prize of Rs 5,000 is given triennially. The aim of the award is to create incentives for research leading to enhanced food production in India. So far 8 scientists have received this award.

**Dr R.D. Asana Endowment Prize**

This is also an endowment created with a donation of Rs 17,000 made by Dr R.D. Asana, former Head, Division of Plant Physiology, IARI, New Delhi. Under this endowment, one prize of Rs 5,000 is given
triennially. The aim of the award is to recognize outstanding original research on plant physiology, plant breeding, soil chemistry, agricultural physics, agronomy and agricultural engineering relating to dryland agriculture. So far 6 scientists have received this award.

**ICAR Awards for Team Research**

These awards were instituted in 1972 to promote interdisciplinary research in India and to recognize teams of research workers who have set high standards of co-operative endeavour in the field of agriculture, animal husbandry, fisheries and allied sciences. Two prizes in the field of agriculture and 1 each in the field of animal husbandry and fisheries are given biennially. The award is in the form of a scroll of honour and a medal. So far 15 teams have received this award.

**Kheti Puraskar**

Under this award 2 prizes of the value of Rs 2,000 each are awarded in a calendar year, 1 in the field of agriculture and 1 in animal sciences, to the contributors of original articles in Hindi in the ICAR monthly magazine *Kheti*. So far 31 authors have received this award.
APPENDIX II

Officers at the Headquarters of the DARE and the ICAR
(as on 31 December 1987)

Dr N.S. Randhawa
Director-General, ICAR, and Secretary to the Government of India
Department of Agricultural Research and Education

Dr M.V. Rao
Special Director-General
Department of Agricultural Research and Education

Dr N.G.P. Rao
Chairman, Agricultural Scientists Recruitment Board

Dr Kissen Kanungo
Member, Agricultural Scientists Recruitment Board

Dr R.P.S. Tyagi
Member, Agricultural Scientists Recruitment Board

Shri S.S. Dawra
Secretary, ICAR, and Joint Secretary to the Government of India
Department of Agricultural Research and Education

Smt. Krishna Bhatnagar
Financial Adviser
Department of Agricultural Research and Education

Deputy Directors-General

Dr R.M. Acharya
Deputy Director-General (Animal Sciences)

Dr P.V. Dehadrai
Deputy Director-General (Fisheries)

Dr Maharaj Singh
Deputy Director-General (Education)

Dr C. Prasad
Deputy Director-General (Agricultural Extension Education)

Directors (ICAR/DARE)

Shri S. Vasudev
Director (Personnel)

Dr V.S. Bhatt
Director (Publications and Information)

Shri S.W. Oak
Director (Finance)

Shri R.S. Duggal
Director (Works)

Vacant
Director (Department of Agricultural Research and Education)

Dr S.P. Ghosh
Project Director (National Agricultural Research Project)

Assistant Directors-General

Dr Shankar Lal
Assistant Director-General (Food and Fodder Crops)

Dr C. Kempanna
Assistant Director-General (Commercial Crops)

Dr G.L. Kaul
Assistant Director-General (Horticulture)
**APPENDICES**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position and Specialization</th>
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<tbody>
<tr>
<td>Dr P.C. Bhatia</td>
<td>Officiating Assistant Director-General (Agronomy)</td>
</tr>
<tr>
<td>Dr M. Velayutham</td>
<td>Assistant Director-General (Soils)</td>
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<tr>
<td>Dr A. Alam</td>
<td>Assistant Director-General (Agricultural Engineering)</td>
</tr>
<tr>
<td>Dr S.C. Adlakha</td>
<td>Assistant Director-General (Project Implementation Unit)</td>
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<tr>
<td>Dr C.C. Maji</td>
<td>Assistant Director-General (Agricultural Economics, Statistics and Marketing)</td>
</tr>
<tr>
<td>Dr C.L. Arora</td>
<td>Assistant Director-General (Animal Production and Breeding)</td>
</tr>
<tr>
<td>Dr S.C. Jain</td>
<td>Assistant Director-General (Dairying and Animal Products Technology)</td>
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<tr>
<td>Dr C. Natarajan</td>
<td>Assistant Director-General (Animal Health)</td>
</tr>
<tr>
<td>Dr M.Y. Kamal</td>
<td>Officiating Assistant Director-General (Fisheries)</td>
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<tr>
<td>Dr U.C. Upadhyay</td>
<td>Assistant Director-General (Agricultural Education)</td>
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<tr>
<td>Dr P.B. Mathur</td>
<td>Assistant Director-General (Animal Sciences Education)</td>
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<tr>
<td>Dr P.N. Mathur</td>
<td>Assistant Director-General (Agricultural Extension)</td>
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<tr>
<td>Dr A.P. Saxena</td>
<td>Assistant Director-General (I) (National Agricultural Research Project)</td>
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<td>Vacant</td>
<td>Assistant Director-General (II) (National Agricultural Research Project)</td>
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<tr>
<td>Dr M.N. Sadaphal</td>
<td>Assistant Director-General (Centre-State Co-operation)</td>
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<td>Vacant</td>
<td>Assistant Director-General (Agroforestry)</td>
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<tr>
<td>Shri A. Balasubramaninan</td>
<td>Scientific Secretary to the Director-General</td>
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<td><strong>Officers on Special Duty</strong></td>
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<td>Dr Mangala Rai</td>
<td>Officer on Special Duty (Oilseeds)</td>
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<td>Dr S. Chandra</td>
<td>Officer on Special Duty (Pulses)</td>
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<td>Dr N.C. Ganguli</td>
<td>Officer on Special Duty (Project Implementation and Monitoring)</td>
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<td>Dr Chokhey Singh</td>
<td>Officer on Special Duty (National Agricultural Research Project)</td>
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<td><strong>Deputy Secretaries</strong></td>
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<td>Shri R.C. Misra</td>
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<td>Shri Kishori Lal</td>
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<td>Shri C.R. Mohapatra</td>
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<td>Shri K.P. Singh</td>
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<td><strong>Secretary (ASRB)</strong></td>
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<td>Shri R.P. Shukla</td>
<td>Secretary, Agricultural Scientists Recruitment Board</td>
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<td>Dr V.S. Bhatt</td>
<td>Chief Artist</td>
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<td>Director (Publications and Information)</td>
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<td>Shri Krishan Kumar</td>
<td>Chief Publicity and Public Relations Officer</td>
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<td>Joint Director (Publications and Information) and Chief Production Officer</td>
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<td>Shri S.N. Tata</td>
<td>Business Manager</td>
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<td>Shri R.D. Sharma</td>
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<td>Chief Editor (Hindi and other Indian Languages)</td>
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<td>Shri B.N. Prasad Pathak</td>
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<td>Legal Adviser</td>
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APPENDIX III

Directors of ICAR Institutes, National Bureaux and National Research Centres (as on 31 December 1987)

ICAR Institutes

Dr A.M. Michael
Director
Indian Agricultural Research Institute
New Delhi 110 012

Dr Prem Narain
Director
Indian Agricultural Statistics Research Institute
Library Avenue
New Delhi 110 012

Dr S. Patnaik
Officiating Director
Central Rice Research Institute
Cuttack (Orissa) 753 006

Dr Kishan Singh
Director
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002

Dr K.M. Naidu
Director
Sugarcane Breeding Institute
Coimbatore (Tamil Nadu) 641 007

Dr N.D. Mannikar
Officiating Director
Central Institute for Cotton Research
Panjari Farm, Wardha Road
Nagpur (Maharashtra) 440 010

Dr V. Sundaram
Director
Cotton Technological Research Laboratory
Adenwala Road, Matunga
Bombay (Maharashtra) 400 019

Dr N. Mukherjee
Officiating Director
Jute Agricultural Research Institute
Barrackpore (West Bengal) 743 101

Dr S.N. Pandey
Director
Jute Technological Research Laboratories
12 Regent Park
Calcutta (West Bengal) 700 040

Dr M.S. Chari
Director
Central Tobacco Research Institute
Rajahmundry (Andhra Pradesh) 533 105

Dr M.K. Nair
Officiating Director
Central Plantation Crops Research Institute
Post Kudlu
Kasaragod (Kerala) 670 124

Dr R.M. Pandey
Director
Indian Institute of Horticultural Research
255 Upper Palace Orchards
Bangalore (Karnataka) 560 080

Dr R.P. Srivastava
Officiating Director
Central Institute of Horticulture for Northern Plains
B-217 Indira Nagar
Lucknow (Uttar Pradesh) 226 016

Dr N.M. Nayar
Director
Central Potato Research Institute
Shimla (Himachal Pradesh) 171 001
Dr Tarun Kumar Pal  
Officiating Director  
Central Tuber Crops Research Institute  
Sreekariyam  
Trivandrum (Kerala) 695 017

Dr V.V. Dhrulu Narayana  
Director  
Central Soil and Water Conservation Research and Training Institute  
218 Kaulagarh Road  
Dehra Dun (Uttar Pradesh) 248 195

Dr R.C. Mondal  
Officiating Director  
Central Soil Salinity Research Institute  
Karnal (Haryana) 132 001

Shri S.P. Malhotra  
Officiating Director  
Central Arid Zone Research Institute  
Jodhpur (Rajasthan) 342 003

Dr R.P. Singh  
Director  
Central Research Institute for Dryland Agriculture  
Saidabad  
Hyderabad (Andhra Pradesh) 500 659

Dr T.P. Ojha  
Director  
Central Institute of Agricultural Engineering  
Shri Guru Tegh Bahadur Complex  
Bhopal (Madhya Pradesh) 462 003

Vacant  
Director  
Indian Institute of Soil Science  
Bhopal (Madhya Pradesh)

Dr R.P. Kapil  
Director  
Indian Lac Research Institute  
Namkum  
Ranchi (Bihar) 834 010

Dr R.N. Prasad  
Officiating Director  
ICAR Research Complex for North-Eastern Hills Region  
Shillong (Meghalaya) 793 003

Dr K.D. Koranne  
Director  
Vivekananda Parvatiya Krishi Anusandhan Shala  
Almora (Uttar Pradesh) 263 601

Dr N.T. Singh  
Director  
Central Agricultural Research Institute for Andaman and Nicobar Group of Islands  
Port Blair (Andamans) 744 101

Dr Panjab Singh  
Director  
Indian Grassland and Fodder Research Institute  
Gwalior-Jhansi Road  
Jhansi (Uttar Pradesh) 284 003

Vacant  
Director  
Indian Institute of Agricultural Economics Research  
New Delhi 110 012

Dr R. Nagarcenkar  
Director  
National Dairy Research Institute  
Karnal (Haryana) 132 001

Dr P.N. Bhat  
Director  
Indian Veterinary Research Institute  
Izatnagar (Uttar Pradesh) 243 122

Dr D.S. Balaine  
Director-in-Charge  
National Institute of Animal Genetics  
NDRI Complex  
Karnal (Haryana) 132 001

Dr V.D. Mudgal  
Director  
Central Institute for Research on Buffaloes  
Hisar (Haryana) 125 001

Dr A.L. Chaudhry  
Director
Central Sheep and Wool Research Institute
Avikanagar (Rajasthan) 304 501
Dr N.K. Bhattacharyya
Director
Central Institute for Research on Goats
Makhdoom
Farah (Uttar Pradesh) 281 122
Dr B. Panda
Director
Central Avian Research Institute
Izatnagar (Uttar Pradesh) 243 122
Dr (Mrs) T. Rajyalaxmi
Officiating Director
Central Institute of Brackishwater Aquaculture
No. 12 Leith Castle Street, Santhona
Madras (Tamil Nadu) 600 028
Shri S.D. Tripathi
Director-in-Charge
Central Institute of Freshwater Aquaculture
Kaushalyagang
Dhauli
Bhubaneswar (Orissa) 751 002
Dr A.G. Jhingran
Director
Central Inland Capture Fisheries Research Institute
Barrackpore (West Bengal) 743 101
Dr P.S.B.R. James
Director
Central Marine Fisheries Research Institute
Cochin (Kerala) 682 018
Shri M.R. Nair
Director
Central Institute of Fisheries Technology
Willington Island
Matsyapur
Cochin (Kerala) 682 029
Dr Y. Sreekrishna
Officiating Director
Central Institute of Fisheries Education
Jaipurkash Road
Versova
Bombay (Maharashtra) 400 061

National Bureaux
Dr R.K. Arora
Officiating Director
National Bureau of Plant Genetic Resources, FCI Building, Pusa
New Delhi 110 012
Dr J.L. Sehgal
Director
National Bureau of Soil Survey and Land-Use Planning
Amravati Road
Nagpur (Maharashtra) 440 006
Dr D.S. Balaine
Director
National Bureau of Animal Genetic Resources
NDRI Campus
Karnal (Haryana) 132 001
Dr P. Das
Project Director
National Bureau of Fish Genetic Resources
2 Bagambari Housing Scheme
Shivangan, Allahpur
Allahabad (Uttar Pradesh) 211 006

National Research Centres
Dr R.V. Vidyabhushanam
Officiating Director
National Research Centre for Sorghum
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030
Dr P.S. Bhatnagar
Officiating Director
National Research Centre for Soybean
Bhawerkua Farm, Khandwa Road
Indore (Madhya Pradesh) 452 001
Dr P.S. Reddy
Director
National Research Centre for Groundnut
Timbawadi P.O.
Junagadh (Gujarat) 362 015
Dr H.S. Sohi
Director
National Centre for Mushroom Research and Training (ICAR)
Chambaghat
Solan (Himachal Pradesh) 173 213
Vacant
Project Director
National Research Centre for Citrus
Central Research Station of the IIHR
National Bureau of Soil Survey and Land-Use Planning
Amravati Road
Nagpur (Maharashtra) 440 006
Vacant
Project Director
National Research Centre for Spices
Calicut (Kerala) 673 012
Vacant
Project Director
National Research Centre for Cashew
CPCRI Regional Research Station
Puttur (Karnataka) 574 201
Dr V.L. Chopra
Director
Biotechnology Centre at the Indian Agricultural Research Institute
New Delhi 110 012
Vacant
Director
National Research Centre on Integrated Pest Management
Faridabad (Haryana) 121 001
Dr A.S.P. Murthy
Chief Soil Scientist
Advanced Centre for Research on Black Cotton Soils
University of Agricultural Sciences
Dharwad (Karnataka) 580 007
Vacant
Director
Water Technology Centre for Eastern Region
Bhubaneshwar (Orissa) 751 001
Vacant
Director
National Research Centre for Weed Science
Jabalpur (Madhya Pradesh) 482 001
Vacant
Director
National Research Centre for Agroforestry
Jhansi (Uttar Pradesh) 284 003
Dr N.D. Khanna
Project Director
National Research Centre for Camel
Bikaner (Rajasthan) 334 001
Dr P.K. Uppal
Project Director
National Research Centre for Equines
Hisar (Haryana) 125 001
Vacant
Director
National Research Centre for Yak
Nikamadang (Arunachal Pradesh)
Vacant
Director
National Research Centre for Mithun
Purba Village, P.O. Pufutsero
Nagaland 797 107
Dr K.L. Sehgal
Officer on Special Duty
National Research Centre for Coldwater Fisheries
Haldwani (Uttar Pradesh) 263 139

National Academy of Agricultural Research Management
Dr K.V. Raman
Director
National Academy of Agricultural Research Management
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030
APPENDIX IV

Project Directors and Project Co-ordinators of All-India Co-ordinated Research Projects (as on 31 December 1987)

Dr E.A. Siddiq
Project Director (Rice)
Directorate of Rice Research (ICAR)
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030

Dr J.P. Tandon
Project Director (Wheat)
Directorate of Wheat Research (ICAR)
Cereal Research Laboratory
Indian Agricultural Research Institute
New Delhi 110 012

Dr Mahabal Ram
Project Co-ordinator (Barley)
All-India Co-ordinated Barley Improvement Project
Regional Research Station of the
Indian Agricultural Research Institute
Karnal (Haryana) 132 001

Dr Joginder Singh
Project Co-ordinator (Maize)
All-India Co-ordinated Maize Improvement Project
Cereal Research Laboratory
Indian Agricultural Research Institute
New Delhi 110 012

Dr R.V. Vidyabhushanam
Project Co-ordinator (Sorghum)
All-India Co-ordinated Sorghum Improvement Project
Regional Research Station of the Indian Agricultural Research Institute
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030

Dr G. Harinarayana
Project Co-ordinator (Pearl millet)
All-India Co-ordinated Pearl millet Improvement Project
College of Agriculture, Shivaji Nagar
Pune (Maharashtra) 411 005

Dr A. Seetharam
Project Co-ordinator (Small Millets)
University of Agricultural Sciences
Gandhi Krishi Vigyan Kendra Campus
Bangalore (Karnataka) 560 065

Dr Nawab Ali
Project Director (Soybean Processing and Utilization)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 018

Dr Shankar Lal
Project Director (Pulses)
Directorate of Pulses Research (ICAR)
Kanpur (Uttar Pradesh) 208 024

Dr P.S. Bhatnagar
Project Co-ordinator (Soybean)
National Research Centre for Soybean
Bhawerkua Farm, Khandwa Road
Indore (Madhya Pradesh) 452 001

Dr T.A. Thomas
Project Co-ordinator (Cluster bean)
National Bureau of Plant Genetic Resources, FCI Building, Pusa
New Delhi 110 012

Dr V. Ranga Rao
Project Director (Oil seeds)
Directorate of Oil seeds Research (ICAR)
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030
Dr P.R. Kumar  
Project Co-ordinator (Rapeseed and Mustard)  
Haryana Agricultural University  
Hisar (Haryana) 125 004  
Vacant  
Project Co-ordinator (Castor)  
Directorate of Oilseeds Research (ICAR)  
Rajendranagar  
Hyderabad (Andhra Pradesh) 500 030  
Vacant  
Project Co-ordinator (Groundnut)  
National Research Centre for Groundnut  
Timbawadi P.O.  
Junagadh (Gujarat) 362 015  
Dr S.M. Sharma  
Project Co-ordinator (Sesame and Niger)  
Jawaharlal Nehru Krishi Vishwa Vidyalaya  
Jabalpur (Madhya Pradesh) 482 004  
Dr Mangala Rai  
Project Co-ordinator (Linseed)  
Chandra Shekhar Azad University of Agriculture and Technology  
Kanpur (Uttar Pradesh) 208 002  
Correspondence address:  
Officer on Special Duty (Oilseeds)  
Indian Council of Agricultural Research  
Krishi Bhavan  
New Delhi 110 001  
Dr S.S. Sindagi  
Project Co-ordinator (Sunflower)  
University of Agricultural Sciences  
Bangalore (Karnataka) 560 065  
Vacant  
Project Co-ordinator (Safflower)  
145 Railway Lines  
Sholapur (Maharashtra) 413 001  
Dr S.C. Srivastava  
Project Co-ordinator (Sugarcane)  
Indian Institute of Sugarcane Research  
Lucknow (Uttar Pradesh) 226 002  
Dr M.M. Srivastava  
Senior Breeder-in-Charge  
All-India Co-ordinated Sugarbeet Improvement Project  
Indian Institute of Sugarcane Research  
Lucknow (Uttar Pradesh) 226 002  
Dr A.K. Basu  
Project Co-ordinator (Cotton)  
Regional Research Station of the Central Institute for Cotton Research  
Coimbatore (Tamil Nadu) 641 007  
Dr N. Mukherjee  
Project Co-ordinator (Jute and Allied Fibres)  
Jute Agricultural Research Institute  
Barrackpore (West Bengal) 743 101  
Dr B.G. Jaisani  
Project Co-ordinator (Tobacco)  
Gujarat Agricultural University  
Kheda (Gujarat) 387 411  
Dr P. Rethinam  
Project Co-ordinator (Palms)  
Central Plantation Crops Research Institute  
Kasaragod (Kerala) 671 024  
Dr E.V.V. Bhaskar Rao  
Project Co-ordinator (Cashew)  
Central Plantation Crops Research Institute  
Regional Research Station  
Vittal (Karnataka) 574 243  
Dr S. Edison  
Project Co-ordinator (Spices)  
National Research Centre for Spices  
Calicut (Kerala) 673 012  
Dr C.L. Khushu  
Project Co-ordinator (Potato)  
Central Potato Research Institute  
Shimla (Himachal Pradesh) 171 101  
Dr S.P. Verma  
Project Co-ordinator (Tuber Crops)  
Central Tuber Crops Research Institute  
Regional Station
A/16, Unit-4, Kharvelanagar
Bhubaneshwar (Orissa) 751 001
Dr Rajendra Gupta
Project Co-ordinator (Medicinal and Aromatic Plants)
National Bureau of Plant Genetic Resources
FCI Building, Pusa
New Delhi 110 012

Dr C.P.A. Iyer
Project Co-ordinator (Tropical Fruits)
Indian Institute of Horticultural Research
255 Upper Palace Orchards
Bangalore (Karnataka) 560 080

Dr O.P. Pareekh
Project Co-ordinator (Arid Fruits)
Department of Horticulture
Haryana Agricultural University
Hisar (Haryana) 125 004

Dr I.S. Yadav
Project Co-ordinator (Subtropical Fruits)
Central Institute of Horticulture for Northern Plains
B-217, Indira Nagar
Lucknow (Uttar Pradesh) 226 016

Dr H.S. Gill
Officer-in-Charge
Project Directorate on Vegetables
Division of Vegetable Crops
Indian Agricultural Research Institute
New Delhi 110 012

Dr H.S. Sohi
Director
National Centre for Mushroom Research and Training (ICAR)
Chambaghat
Solan (Himachal Pradesh) 173 213

Dr B. Singh
Project Co-ordinator (Floriculture)
Division of Floriculture and Landscaping
Indian Agricultural Research Institute
New Delhi 110 012

Dr Bhagmal
Project Co-ordinator (Under-utilized and Under-exploited Plants)
National Bureau of Plant Genetic Resources, FCI Building, Pusa
New Delhi 110 012

Dr R.C. Misra
Project Co-ordinator (Honeybee Research)
Division of Zoology, Entomology
Haryana Agricultural University
Hisar (Haryana) 125 004

Dr S.K. Roy
Project Co-ordinator (Post-harvest Technology of Horticultural Crops)
Division of Horticulture and Fruit Technology
Indian Agricultural Research Institute
New Delhi 110 012

Dr P.K. Agrawal
Head and Co-ordinator
(Seed Technology Research)
Division of Seed Science and Technology
Indian Agricultural Research Institute
New Delhi 110 012

Dr S.P. Singh
Project Co-ordinator
(Dryland Agriculture)
Dryland Agriculture Building
Saidabad
Hyderabad (Andhra Pradesh) 500 659

Shri K.R. Kulkarni
Project Co-ordinator (Cropping Systems)
University of Agricultural Sciences
BSH College Building
Gandhi Krishi Vigyan Kendra Campus
Bangalore (Karnataka) 560 065

Dr K.K.M. Nambiar
Project Co-ordinator (Long-term Fertilizer Experiments)
Division of Soil Science and Agricultural Chemistry
Indian Agricultural Research Institute
New Delhi 110 012
Dr K.C.K. Reddy
Project Co-ordinator-in-Charge (Soil Tests and Crop Response)
Dryland Agriculture Building
Saidabad
Hyderabad (Andhra Pradesh) 500 659

Dr P.N. Takkar
Project Co-ordinator (Micronutrients)
Department of Soils
Punjab Agricultural University
Ludhiana (Punjab) 141 001

Dr V.N. Saraswat
Project Co-ordinator (Weed Control)
Central Rice Research Institute
Cutack (Orissa) 753 006

Dr R.P. Gupta
Project Co-ordinator (Soil Physical Conditions)
Department of Soil Physics
Indian Agricultural Research Institute
New Delhi 110 012

Dr R.K. Rajput
Project Co-ordinator (Water Management)
Central Soil Salinity Research Institute
Karnal (Haryana) 132 001

Dr A.K. Bhattacharya
Project Co-ordinator (Agricultural Drainage)
Water Technology Centre
Indian Agricultural Research Institute
New Delhi 110 012

Dr H.C. Sharma
Project Co-ordinator (Diara Lands)
Bihar Agricultural College
Rajendra Agricultural University
Sabour (Bihar) 813 210

Dr B.V. Ramana Rao
Project Co-ordinator (Agrometeorology)
Dryland Agriculture Building
Saidabad
Hyderabad (Andhra Pradesh) 500 659

Dr R.C. Mondal
Project Co-ordinator (Use of Salt-affected Soils and Saline Water)
Central Soil Salinity Research Institute
Karnal (Haryana) 132 001

Dr G.S. Venkataraman
Project Director (National Facility for Blue-green Algae)
Division of Microbiology
Indian Agricultural Research Institute
New Delhi 110 012

Dr K.V.B.R. Tilak
Project Co-ordinator (Biological Nitrogen Fixation)
Division of Microbiology
Indian Agricultural Research Institute
New Delhi 110 012

Dr K.K.R. Bhardwaj
Project Co-ordinator (Microbiological Decomposition)
Himachal Pradesh Krishi Vishwa Vidyalaya
Palampur (Himachal Pradesh) 176 062

Dr A.S. Varshney
Project Co-ordinator (Power Tillers)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 018

Dr R.S. Devnani
Project Co-ordinator (Farm Implements and Machinery)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 018

Dr A.K. Bhattacharya
Project Co-ordinator (Wells and Pumps)
Water Technology Centre
Indian Agricultural Research Institute
New Delhi 110 012

Dr B.D. Shukla
Project Co-ordinator (Post-harvest Technology)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 018
Dr J.P. Mittal
Project Co-ordinator (Energy Requirements)
Department of Farm Power and Machinery
Punjab Agricultural University
Ludhiana (Punjab) 141 001
Dr R.C. Maheshwari
Project Co-ordinator (Renewable Energy Resources)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 018
Dr S.A. Alvi
Co-ordinator (Agri-electronics)
Division of Agricultural Engineering
Indian Agricultural Research Institute
New Delhi 110 012
Dr P.B. Mathur
Project Co-ordinator (Home Science)
Indian Council of Agricultural Research
Krishi Anusandhan Bhavan
New Delhi 110 012
Dr M.R. Sidiqqui
Project Co-ordinator (Seed-borne Diseases)
Division of Seed Science and Technology
Indian Agricultural Research Institute
New Delhi 110 012
Dr S.J. Singh
Acting Project Co-ordinator (Betelvine Diseases)
Indian Institute of Horticultural Research
255 Upper Palace Orchards
Bangalore (Karnataka) 560 080
Dr C.P.S. Yadav
Project Co-ordinator (White-grubs)
Agricultural Experiment Station
Sukhadia University, Durgapura
Jaipur (Rajasthan) 302 015

Dr J.S. Gill
Project Co-ordinator (Nematode Pests)
Division of Nematology
Indian Agricultural Research Institute
New Delhi 110 012
Dr B.K. Nagesh Chandra
Project Co-ordinator
(Agricultural Acarology)
University of Agricultural Sciences
Gandhi Krishi Vigyan Kendra Campus
Bangalore (Karnataka) 560 024
Dr A.P. Jain
Project Co-ordinator (Rodent Control)
Central Arid Zone Research Institute
Jodhpur (Rajasthan) 342 003
Dr N. Shivnarayan
Ornithologist
All-India Co-ordinated Research Project
On Economic Ornithology
Veterinary College Campus
Andhra Pradesh Agricultural University
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030
Dr S.P. Singh
Project Co-ordinator (Biological Control)
Indian Institute of Horticultural Research
Hessaraghatta Lake Post
Bangalore (Karnataka) 560 089
Dr S.K. Handa
Project Co-ordinator (Pesticide Residues)
Division of Agricultural Chemicals
Indian Agricultural Research Institute
New Delhi 110 012
Dr C.R. Hazra
Project Co-ordinator (Forage Crops)
Indian Grassland and Fodder Research Institute
Jhansi (Uttar Pradesh) 284 003
Dr A.K. Sinha
Senior Scientist (Soil)
All-India Co-ordinated Research Project on Agroforestry
Indian Council of Agricultural Research
Krishi Bhavan
New Delhi 110 001
Dr V.K. Taneja
Officer on Special Duty
Project Directorate (Cattle)
Military Dairy Research Centre
and School
Meerut (Uttar Pradesh) 250 001

Dr V.D. Mudgal
Project Co-ordinator (Buffalo)
Central Institute for Research on
Buffaloes
Sirsa Road
Hisar (Haryana) 125 001

Dr S.D.J. Bohra
Project Co-ordinator (Sheep)
All-India Co-ordinated Research
Project on Sheep Breeding
Division of Carpet Wool and Pelt
Production
Central Sheep and Wool
Research Institute
Gajner Road
Bikaner (Rajasthan) 334 001

Dr R.K. Mishra
Project Co-ordinator (Goats)
Central Institute for Research on Goats
Makhdoom
Farah (Uttar Pradesh) 281 122

Dr R.R. Mishra
Officiating Project Co-ordinator (Pigs)
Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122

Dr S.C. Mohapatra
Officiating Project Director
(Poultry Improvement)
Directorate on Poultry Improvement
Andhra Pradesh Agricultural University
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030

Dr A.K. Mukhopadhyay
Project Co-ordinator (Foot-and-Mouth
Disease)
Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122

Dr P.S.C.R. Murti
Senior Scientist (Livestock Health)
All-India Co-ordinated Research Project
for Surveillance of Animal Disease
Indian Council of Agricultural Research
Krishi Bhavan
New Delhi 110 001

Dr M.N. Malhotra
Senior Scientist (Animal Health)
Immunoprophylactic Control of
Intracellular Blood Protista
Indian Council of Agricultural Research
Krishi Bhavan
New Delhi 110 001

Dr R.R. Mishra
Project Co-ordinator (Byproducts and
Waste Materials for Livestock Rations)
National Dairy Research Institute
Karnal (Haryana) 132 001

Shri N.S.L. Shrivastava
Co-ordinator (Animal Energy)
Central Institute of Agricultural
Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 018

Shri V.N. Bodade
Project Co-ordinator
(Tribal Area Research Project)
Regional Research Centre, Punjabrao
Krishi Vidyapeeth
Akola (Maharashtra) 444 603

Shri V.N. Bodade
Project Co-ordinator
All-India Rapid Improvement Project of
Agricultural Technology (Upliftment
of Scheduled Castes, Scheduled Tribes
and Backward Areas)
Punjabrao Krishi Vidyapeeth
Akola (Maharashtra) 444 603

Dr Prem Narain
Director and Chief Co-ordinator
(Primary Data Collection)
Indian Agricultural Statistics Research
Institute
New Delhi 110 012
Zonal Co-ordinators, Lab-to-Land Programmes

Dr O.P. Malhotra
Zonal Co-ordinator (LLP)
Punjab Agricultural University
Ludhiana (Punjab) 141 001

Dr J.P. Yadav
Zonal Co-ordinator (LLP)
Chandra Shekhar Azad University of Agriculture and Technology
Kanpur (Uttar Pradesh) 208 002

Dr D.J. Roy
Zonal Co-ordinator (LLP)
Bidhan Chandra Krishi Vishwa Vidyalaya
Mohanpur
Nadia (West Bengal) 741 246

Dr A.K. Saha
Zonal Co-ordinator (LLP)
ICAR Research Complex for North-Eastern Hills Region
Cedar Lodge

Shillong (Meghalaya) 793 003
Dr P.L. Digarsey
Zonal Co-ordinator (LLP)
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur (Madhya Pradesh) 482 004

Dr N.K. Sanghi
Zonal Co-ordinator (LLP)
CRIDA Complex
Saidabad
Hyderabad (Andhra Pradesh) 500 659

Dr S.D. Rai
Zonal Co-ordinator (LLP)
National Dairy Research Institute
Adugodi Campus
Bangalore (Karnataka) 560 030

Prof. H.N. Patel
Zonal Co-ordinator (LLP)
Gujarat Agricultural University
Shahibag, Bungalow No. 6
Ahmedabad (Gujarat) 380 004
APPENDIX V

Vice-Chancellors of Agricultural Universities
(as on 31 December 1987)

Dr A. Appa Rao
Vice-Chancellor
Andhra Pradesh Agricultural University
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030

Dr P.C. Bora
Vice-Chancellor
Assam Agricultural University
Jorhat (Assam) 785 013

Dr G. Trivedi
Vice-Chancellor
Rajendra Agricultural University
Veterinary College Campus
Patna (Bihar) 800 014

Shri J.C. Kundra
Vice-Chancellor
Birsa Agricultural University
Kanke
Ranchi (Bihar) 834 006

Shri R. Parthasarathy
Vice-Chancellor
Gujarat Agricultural University
Sardar Krishi Nagar
Banaskantha (Gujarat) 385 506

Shri M.S. Ratti
Acting Vice-Chancellor
Haryana Agricultural University
Hisar (Haryana) 125 004

Dr G.C. Negi
Vice-Chancellor
Himachal Pradesh Krishi Vishwa Vidyalaya
Palampur (Himachal Pradesh) 176 062

Dr M.R. Thakur
Vice-Chancellor

Dr Yashwant Singh Parmar University of Horticulture and Forestry
Solan (Himachal Pradesh) 173 230

Prof. A. Ahmad
Vice-Chancellor
Sher-e-Kashmir University of Agricultural Sciences and Technology
In Summer
Raja Zaman's Building
Dalgate
Srinagar 190 001

In Winter
45-B Gandhinagar
Jammu-Tawi 180 004

Dr S.V. Patil
Vice-Chancellor
University of Agricultural Sciences
Hebbal
Bangalore (Karnataka) 560 024

Dr J.V. Goud
Vice-Chancellor
University of Agricultural Sciences
Dharwad (Karnataka) 580 005

Dr E.G. Silas
Vice-Chancellor
Kerala Agricultural University
Vellanikkara (Kerala) 680 654

Dr D.K. Sharma
Vice-Chancellor
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur (Madhya Pradesh) 482 004

Dr V.P. Shukla
Vice-Chancellor
Indira Gandhi Krishi Vishwa Vidyalaya
Krishak Nagar
Raipur (Madhya Pradesh) 492 001
Dr Shri H.B. Ulemale
Vice-Chancellor
Punjabrao Krishi Vidyapeeth
Krishinagar
Akola (Maharashtra) 444 104
Dr P.V. Salvi
Vice-Chancellor
Konkan Krishi Vidyapeeth
Dapoli (Maharashtra) 415 712
Dr K.R. Pawar
Acting Vice-Chancellor
Marathwada Agricultural University
Parbhani (Maharashtra) 431 401
Dr K.N. Nag
Vice-Chancellor
Rajasthan Agricultural University
Bikaner (Rajasthan) 334 001
Dr V. Rajagopalan
Vice-Chancellor
Tamil Nadu Agricultural University
Coimbatore (Tamil Nadu) 641 003
Dr Kirti Singh
Vice-Chancellor
Narendra Deva University of Agriculture and Technology
Faizabad (Uttar Pradesh) 224 001
Dr Sayeed Shumshad Ahmed
Vice-Chancellor
Chandra Shekhar Azad University of Agriculture and Technology
Kanpur (Uttar Pradesh) 208 002
Dr Mahatim Singh
Vice-Chancellor
Govind Ballabh Pant University of Agriculture and Technology
Pantnagar (Uttar Pradesh) 263 145
Shri Dilip Kumar Das Gupta
Vice-Chancellor
Bidhan Chandra Krishi Vishwa Vidyalaya
Haringhatta
Mohanpur (West Bengal) 741 246

Shri K. Ramamurty
Vice-Chancellor
Orissa University of Agriculture and Technology
Bhubaneshwar (Orissa) 751 003
Dr. Sukhdev Singh
Vice-Chancellor
Punjab Agricultural University
Ludhiana (Punjab) 141 001

Dr. K.N. Nag
Vice-Chancellor
Rajasthan Agricultural University
Bikaner (Rajasthan) 334 001
Dr V. Rajagopalan
Vice-Chancellor
Tamil Nadu Agricultural University
Coimbatore (Tamil Nadu) 641 003
Dr Kirti Singh
Vice-Chancellor
Narendra Deva University of Agriculture and Technology
Faizabad (Uttar Pradesh) 224 001
Dr Sayeed Shumshad Ahmed
Vice-Chancellor
Chandra Shekhar Azad University of Agriculture and Technology
Kanpur (Uttar Pradesh) 208 002
Dr Mahatim Singh
Vice-Chancellor
Govind Ballabh Pant University of Agriculture and Technology
Pantnagar (Uttar Pradesh) 263 145
Shri Dilip Kumar Das Gupta
Vice-Chancellor
Bidhan Chandra Krishi Vishwa Vidyalaya
Haringhatta
Mohanpur (West Bengal) 741 246
APPENDIX VI

Total Number of Employees in the ICAR and its Research Institutes and the Number of Scheduled Castes (SC) and Scheduled Tribes (ST) Employees among them on 31 July 1987

<table>
<thead>
<tr>
<th>Class of posts</th>
<th>No. of posts sanctioned</th>
<th>No. of employees in position</th>
<th>No. of SC employees</th>
<th>SC (%)</th>
<th>No. of ST employees</th>
<th>ST (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific Posts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientist S</td>
<td>847</td>
<td>120</td>
<td>10</td>
<td>8.33</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scientist S-1</td>
<td>2,935</td>
<td>1,477</td>
<td>95</td>
<td>6.43</td>
<td>12</td>
<td>0.81</td>
</tr>
<tr>
<td>Scientist S-2</td>
<td>1,627</td>
<td>1,811</td>
<td>89</td>
<td>4.91</td>
<td>11</td>
<td>0.60</td>
</tr>
<tr>
<td>Scientist S-3</td>
<td>724</td>
<td>872</td>
<td>29</td>
<td>3.32</td>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td>Scientist S-4 and above</td>
<td>139</td>
<td>94</td>
<td>2</td>
<td>2.12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,272</td>
<td>4,374</td>
<td>225</td>
<td>5.14</td>
<td>28</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Technical Posts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Category I</td>
<td>4,302</td>
<td>3,373</td>
<td>617</td>
<td>18.29</td>
<td>167</td>
<td>4.95</td>
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<tr>
<td>Category II</td>
<td>3,057</td>
<td>2,251</td>
<td>302</td>
<td>13.41</td>
<td>75</td>
<td>3.33</td>
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<tr>
<td>Category III</td>
<td>615</td>
<td>301</td>
<td>36</td>
<td>11.96</td>
<td>5</td>
<td>1.66</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7,974</td>
<td>5,925</td>
<td>955</td>
<td>16.11</td>
<td>247</td>
<td>4.16</td>
</tr>
<tr>
<td><strong>Administrative Posts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior Administrative Officers, Administrative Officers, Accounts Officers</td>
<td>163</td>
<td>116</td>
<td>18</td>
<td>15.51</td>
<td>3</td>
<td>2.58</td>
</tr>
<tr>
<td>Section Officers, Desk Officers</td>
<td>67</td>
<td>67</td>
<td>8</td>
<td>11.94</td>
<td>2</td>
<td>2.98</td>
</tr>
<tr>
<td>Assistant Administrative Officers, Superintendents, Superintendents (Accounts)</td>
<td>456</td>
<td>351</td>
<td>54</td>
<td>15.38</td>
<td>11</td>
<td>3.13</td>
</tr>
<tr>
<td>Assistants</td>
<td>889</td>
<td>776</td>
<td>118</td>
<td>15.20</td>
<td>28</td>
<td>3.60</td>
</tr>
<tr>
<td>Stenographers</td>
<td>951</td>
<td>647</td>
<td>62</td>
<td>9.58</td>
<td>32</td>
<td>4.94</td>
</tr>
<tr>
<td>(Senior and Junior) Senior Clerks</td>
<td>1,154</td>
<td>1,146</td>
<td>203</td>
<td>17.71</td>
<td>54</td>
<td>4.71</td>
</tr>
<tr>
<td>Junior Clerks</td>
<td>1,735</td>
<td>1,465</td>
<td>219</td>
<td>14.94</td>
<td>77</td>
<td>5.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5,445</td>
<td>4,568</td>
<td>682</td>
<td>14.97</td>
<td>207</td>
<td>4.53</td>
</tr>
<tr>
<td><strong>Supporting Staff</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Excluding Safaiwala)</td>
<td>11,413</td>
<td>10,221</td>
<td>2,391</td>
<td>23.39</td>
<td>568</td>
<td>5.55</td>
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