ICAR
now and ahead...

भाकृअनुप
ICAR

Website Link : https://icar.org.in/

"Modern agriculture faces the uphill task of feeding billions when an individual's share into the nature's bounties is on the decline...modern varieties that replaced the heirloom varieties in the sixties and paved the way for heterosis breeding in willing and unwilling crops will be replaced by transgenics in the 21st century. Agriculture is back on centrestage the world over...with stronger public-private sector nexus and even stronger links among the National Agricultural Research Systems."

PUSA BASMATI 1 is the world's first high-yielding dwarf aromatic rice

foreword

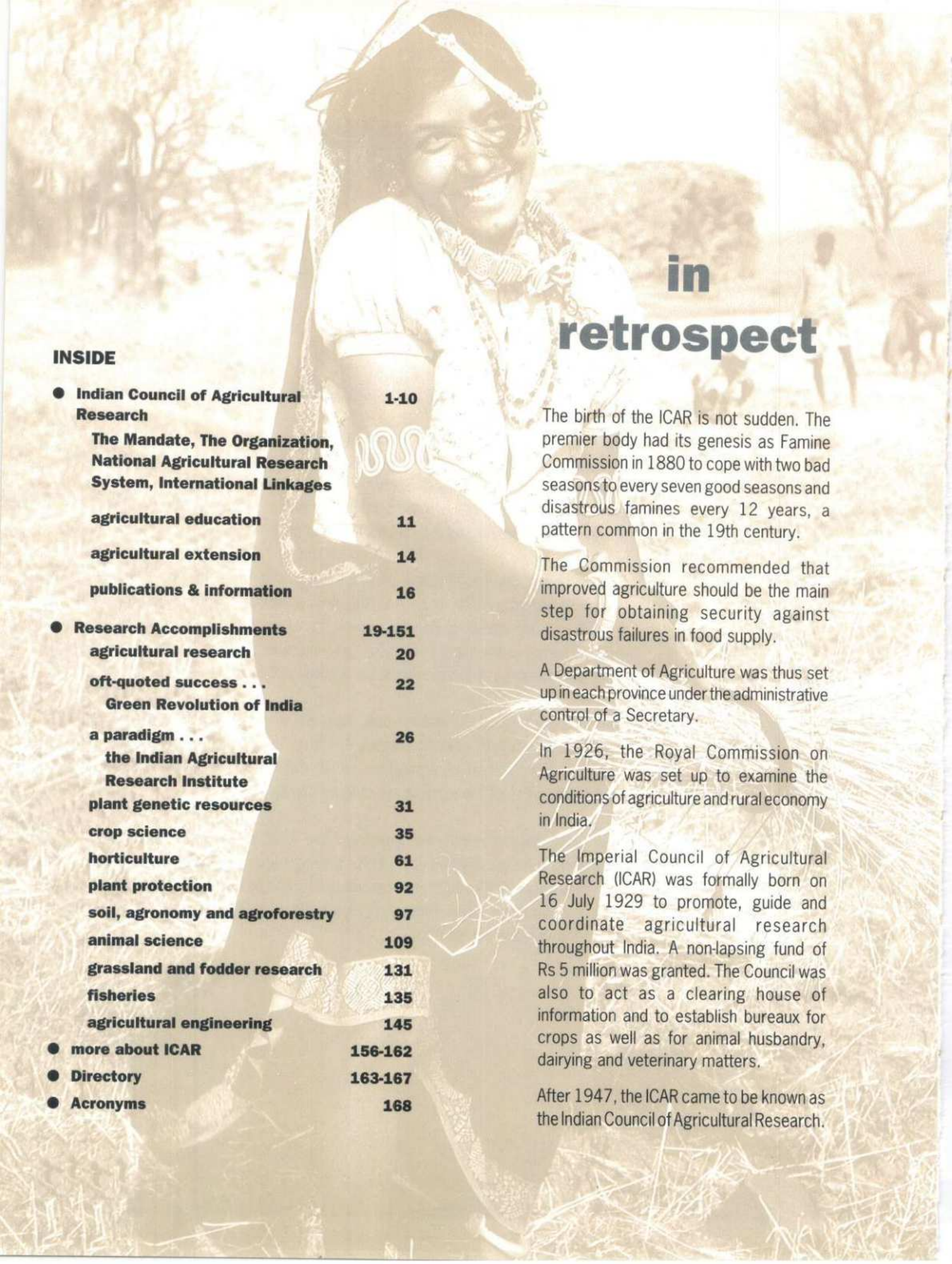
The Indian Council of Agricultural Research since its inception in 1929 has come a long way, overcoming an era of national food deficits to that of self-sufficiency with an adequate foodgrains reserve. The valuable contributions made by the agricultural scientists have helped the nation in maintaining a balance between its population growth and agricultural production.

For improving the social fabric of our society, the tasks before agricultural research are mammoth since it is the driving force of an overall economic growth—employment generation, poverty alleviation, food security and environmental sustainability. In India, any economic growth is inconceivable without a commensurate growth in the agricultural sector.

Towards the year 2000 and beyond, agricultural development in the country would be faced with new challenges—of food, population and environment. Besides, globalization of agriculture would call for improved efficiency and competitiveness of the existing agricultural production systems.

This publication presents the growth of the ICAR as an institution that has triumphed in the past and is now set for sharing opportunities with our partners in order to increase productivity, improve quality and profitability notwithstanding the population pressures. Through rigorous efforts at 'Renewal of ICAR', we are poised to achieve our goals.

(R.S. PARODA)
Director-General
ICAR



INSIDE

in retrospect

The birth of the ICAR is not sudden. The premier body had its genesis as Famine Commission in 1880 to cope with two bad seasons to every seven good seasons and disastrous famines every 12 years, a pattern common in the 19th century.

The Commission recommended that improved agriculture should be the main step for obtaining security against disastrous failures in food supply.

A Department of Agriculture was thus set up in each province under the administrative control of a Secretary.

In 1926, the Royal Commission on Agriculture was set up to examine the conditions of agriculture and rural economy in India.

The Imperial Council of Agricultural Research (ICAR) was formally born on 16 July 1929 to promote, guide and coordinate agricultural research throughout India. A non-lapsing fund of Rs 5 million was granted. The Council was also to act as a clearing house of information and to establish bureaux for crops as well as for animal husbandry, dairying and veterinary matters.

After 1947, the ICAR came to be known as the Indian Council of Agricultural Research.

भाकृअनुप
ICAR

Indian Council of Agricultural Research

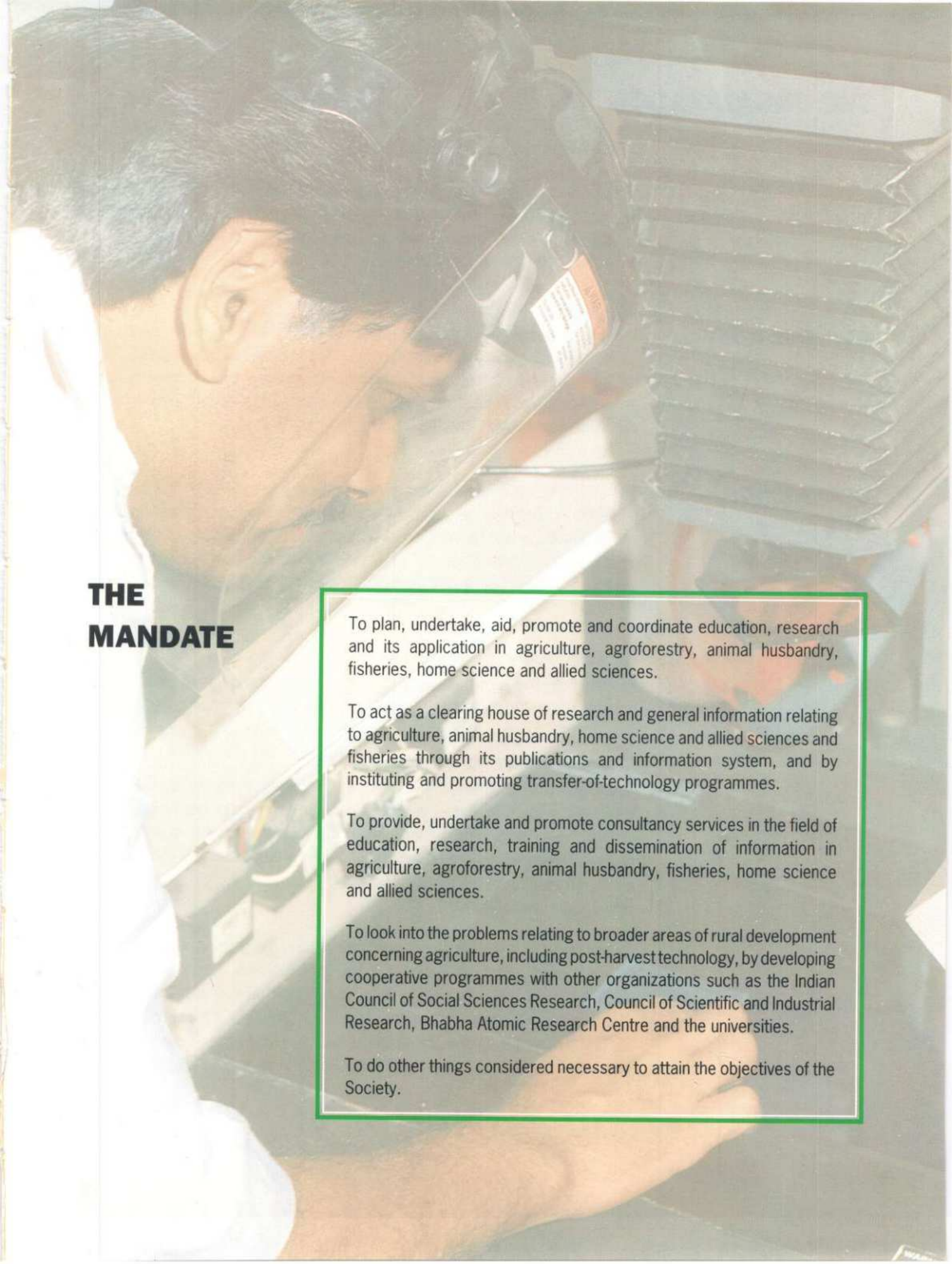
The Indian Council of Agricultural Research is an autonomous apex body responsible for the organization and management of research and education in all disciplines of agricultural sciences. It has been reorganized twice.

In 1965, the ICAR became the nodal agency for coordinating agricultural research in the country. It gained administrative control over the various institutes and commodity research institutes. Late Dr B.P. Pal took over as the first scientist Vice-President. Dr Pal instituted the All-India Coordinated Research Projects on various crops to integrate different disciplines and different institutions and universities for an effective national grid of coordinated experiments. He has been internationally acclaimed for this contribution.

In 1973, the Agricultural Research Service (ARS) was started by Dr M.S. Swaminathan, the first Director-General and Secretary to the Government of India, and Dr Pal's successor, to enable scientists to move to other institutes within the system or sister organizations — the CSIR, BARC, etc.

This Agricultural Research Institute, Pusa, north Bihar, was the first crop-based institute to be set up in 1905 with financial assistance of Mr Henry Phipps, an American philanthropist.

Beginning with research on the sugarcane, tobacco, potato and lac, the renamed relocated Indian Agricultural Research Institute, at New Delhi since November 1936, is a premier research institute of the ICAR conducting research on all aspects of agricultural sciences excepting animal sciences and fisheries and has grown to the status of a deemed university.



THE MANDATE

To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.

To act as a clearing house of research and general information relating to agriculture, animal husbandry, home science and allied sciences and fisheries through its publications and information system, and by instituting and promoting transfer-of-technology programmes.

To provide, undertake and promote consultancy services in the field of education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.

To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology, by developing cooperative programmes with other organizations such as the Indian Council of Social Sciences Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities.

To do other things considered necessary to attain the objectives of the Society.

THE ORGANIZATION

Union Minister of Agriculture is the President of the ICAR.

Director-General is the principal executive officer. He is also Secretary to the Government of India in the Department of Agricultural Research and Education (DARE), set up to link the ICAR with the Central and State Governments and for promoting International Collaboration.

GENERAL BODY

The supreme authority of the ICAR is headed as President of the Society by the Minister of Agriculture, Government of India. It comprises the Ministers of State for Agriculture, Animal Husbandry and Fisheries, senior officers of various state governments, representatives of the Parliament, industry, educational institutions, scientific organizations and the farmers' representatives.

GOVERNING BODY

The chief executive and decision-making authority is chaired by the Director-General. It consists of eminent agricultural scientists, educationists, parliamentarians and farmers' representatives. Standing Finance Committee, Standing Policy Planning Committee, Accreditation Board, Regional Committees, several Scientific Panels and a Publications Committee assist the Director-General.

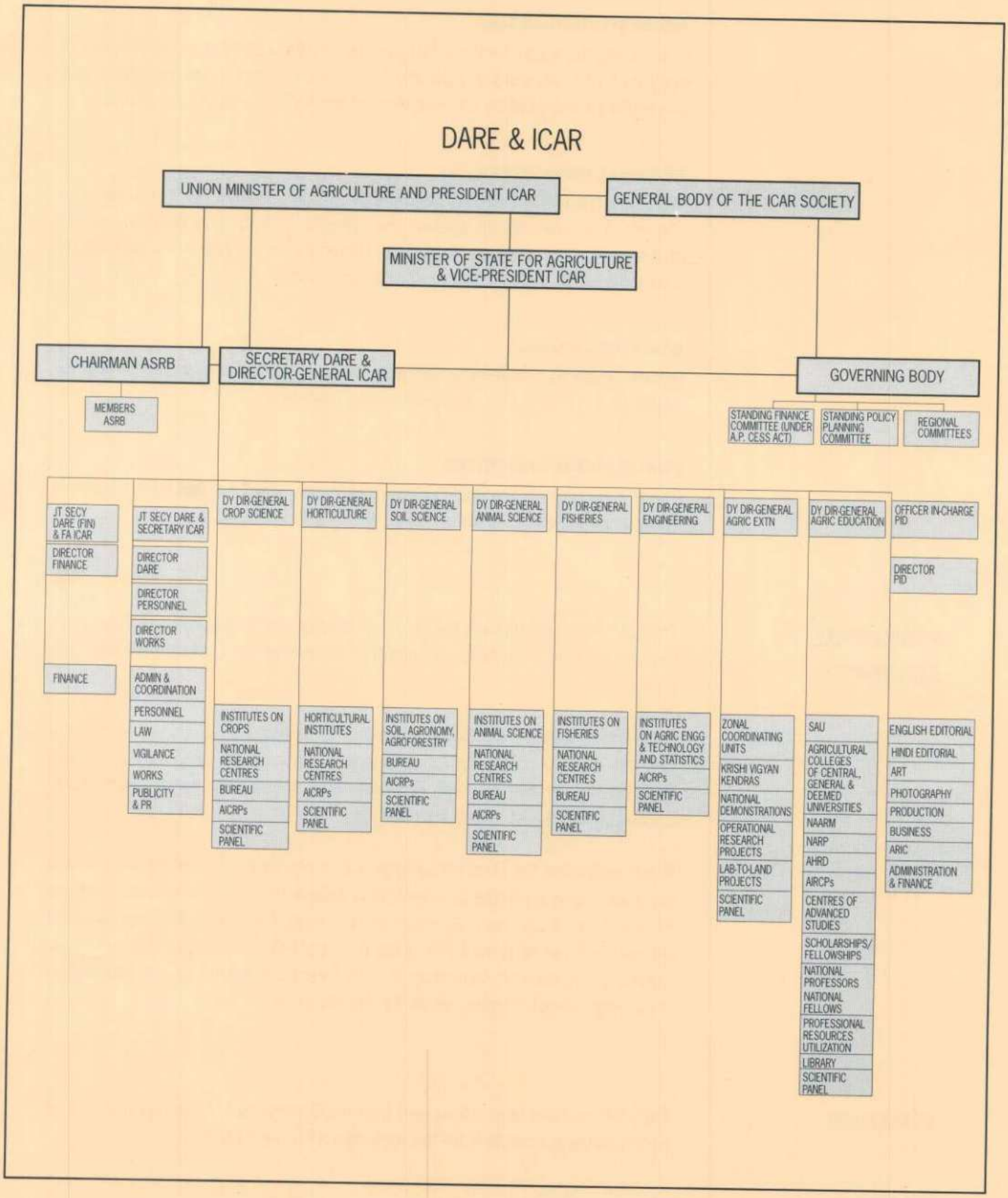
STANDING FINANCE COMMITTEE

Examines the budget proposals, approves or sanctions budget of the unfunded projects and those funded by other government or non-government organizations.

STANDING POLICY PLANNING COMMITTEE

The newly constituted twenty-five member committee is headed by an eminent economist-planner. It advises the ICAR on policy; research collaborations; inter-institutional linkages; infrastructure development; human-resource management; reorganization and modernization; resource generation; incentives and rewards; and strengthening of partnership nationally between the ICAR and the SAUs, public and private institutions.

Representatives from Departments of Agriculture, Commerce, Biotechnology, Environment and Forestry, Industry, Planning Commission, Council of Scientific and Industrial Research, eminent scientists and entrepreneurs who constitute the Standing Policy Planning Committee prepare the National Agricultural Research System to face the challenges posed by the new world order in the immediate future and to ensure sustainable diversification of Indian Agriculture.


DARE & ICAR
UNION MINISTER OF AGRICULTURE AND PRESIDENT ICAR
GENERAL BODY OF THE ICAR SOCIETY
MINISTER OF STATE FOR AGRICULTURE & VICE-PRESIDENT ICAR
CHAIRMAN ASRB
SECRETARY DARE & DIRECTOR-GENERAL ICAR
GOVERNING BODY
MEMBERS ASRB
STANDING FINANCE COMMITTEE (UNDER A.P. CESS ACT)
STANDING POLICY PLANNING COMMITTEE
REGIONAL COMMITTEES
JT SECY DARE (FIN) & FA ICAR
DIRECTOR FINANCE
FINANCE
JT SECY DARE & SECRETARY ICAR
DIRECTOR DARE
DIRECTOR PERSONNEL
DIRECTOR WORKS
ADMIN & COORDINATION
PERSONNEL
LAW
VIGILANCE
WORKS
PUBLICITY & PR
DY DIR-GENERAL CROP SCIENCE
INSTITUTES ON CROPS
NATIONAL RESEARCH CENTRES
BUREAU
AICRPs
SCIENTIFIC PANEL
DY DIR-GENERAL HORTICULTURE
HORTICULTURAL INSTITUTES
NATIONAL RESEARCH CENTRES
AICRPs
SCIENTIFIC PANEL
DY DIR-GENERAL SOIL SCIENCE
INSTITUTES ON SOIL, AGRONOMY, AGROFORESTRY
BUREAU
AICRPs
SCIENTIFIC PANEL
DY DIR-GENERAL ANIMAL SCIENCE
INSTITUTES ON ANIMAL SCIENCE
NATIONAL RESEARCH CENTRES
BUREAU
AICRPs
SCIENTIFIC PANEL
DY DIR-GENERAL FISHERIES
INSTITUTES ON FISHERIES
NATIONAL RESEARCH CENTRES
BUREAU
SCIENTIFIC PANEL
DY DIR-GENERAL ENGINEERING
INSTITUTES ON AGRIC ENGG & TECHNOLOGY AND STATISTICS
AICRPs
SCIENTIFIC PANEL
DY DIR-GENERAL AGRIC EXTN
ZONAL COORDINATING UNITS
KRISHI VIGYAN KENDRAS
NATIONAL DEMONSTRATIONS
OPERATIONAL RESEARCH PROJECTS
LAB-TO-LAND PROJECTS
SCIENTIFIC PANEL
DY DIR-GENERAL AGRIC EDUCATION
SAU
AGRICULTURAL COLLEGES OF CENTRAL, GENERAL & DEEMED UNIVERSITIES
NAARM
NARP
AHRD
AIRCPs
CENTRES OF ADVANCED STUDIES
SCHOLARSHIPS/ FELLOWSHIPS
NATIONAL PROFESSORS
NATIONAL FELLOWS
PROFESSIONAL RESOURCES UTILIZATION
LIBRARY
SCIENTIFIC PANEL
OFFICER IN-CHARGE PID
DIRECTOR PID
ENGLISH EDITORIAL
HINDI EDITORIAL
ART
PHOTOGRAPHY
PRODUCTION
BUSINESS
ARIC
ADMINISTRATION & FINANCE

ACCREDITATION BOARD

Determines the norms for financial assistance to the agricultural universities and ensures a high standard of education. Five vice-chancellors of the agricultural universities nominated by the President of the ICAR constitute the Board.

REGIONAL COMMITTEES

Are an interface between users of technology and producers of technology in 8 regions. The committees apprise the Governing Body with location-specific problems. Representatives of the State Departments of Agriculture, agricultural universities and central institutes are its members.

SCIENTIFIC PANELS

Review research schemes funded with the Agriculture Produce Cess and draw attention to existing gaps in research and training.

PUBLICATIONS COMMITTEE

Periodically reviews the publications programme and identifies titles of topical importance from time-to-time.

PRINCIPAL ADVISER

The ICAR functions through the Director-General, who is the Principal Adviser to the Government of India in all matters concerning agricultural research and education.

In scientific matters the Director-General is assisted by 8 Deputy Directors-General, each in-charge of Crop Science; Horticulture; Soil, Agronomy and Agroforestry; Animal Science; Fisheries; Agricultural Engineering; Agricultural Education and Agricultural Extension.

In administration the Director-General is assisted by the Secretary (who is also the Joint Secretary to the Government of India in the Department of Agricultural Research and Education), Directors of Personnel, Finance and Works. The Joint Secretary (Finance) in the DARE is the principal financial adviser; Director DARE collaborates international protocols while Director Publications and Information is incharge of publications, publicity and information.

FINANCE

The ICAR receives financial support from the Government of India annually. It also accumulates proceeds from the Agriculture Produce Cess.

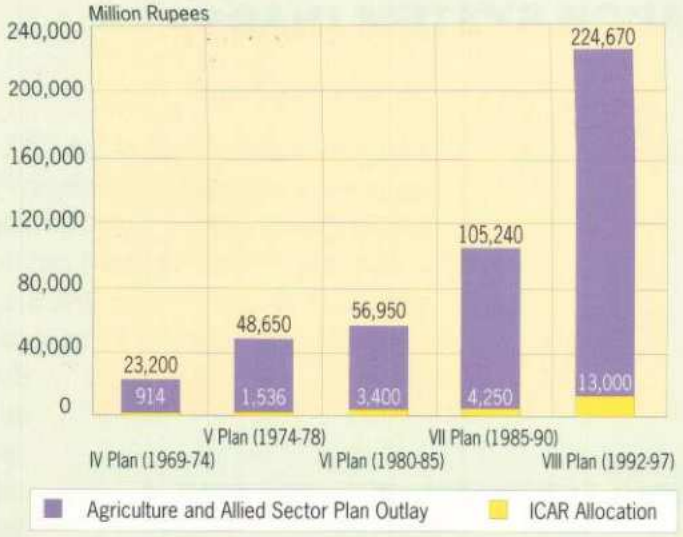
FUNDING

The funds advanced to the ICAR from the budget for Agriculture and allied sector have been 3.9% in the IV Plan; 3.2% in V Plan; 6% in VI Plan; 4% in VII Plan and 5.8% in the VIII Plan.

The grants to the ICAR are small compared with the role played by the ICAR in shaping the National Agricultural Research System and in setting the national and state agricultural research agenda for improving the productivity of the country's farmlands, rangelands, forests, oceans, lakes and rivers.

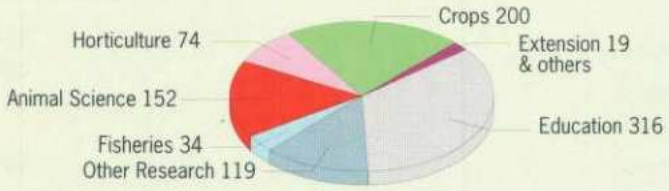
The expenditure on major activities at the ICAR varies with national priorities.

ICAR ALLOCATION THROUGH DIFFERENT FIVE YEAR PLANS



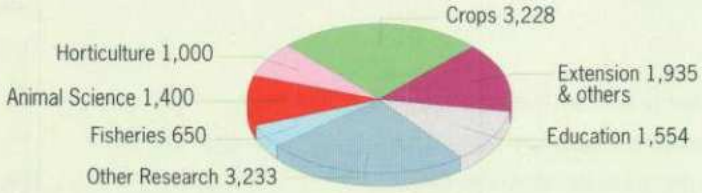
ICAR PLAN ALLOCATIONS: BREAK-UP

IV PLAN: Rs 914 million*



VI PLAN: Rs 3,400 million*

VIII PLAN: Rs 13,000 million*



*At 1970-71 prices: IV Plan, Rs 865 million; VI Plan, Rs 1,177 million; VIII Plan, Rs 2,145 million.
Figures denote the value in million Rupees.

NATIONAL AGRICULTURAL RESEARCH SYSTEM (NARS)

INFRASTRUCTURE

The growth and spread of the ICAR has been phenomenal starting from the Imperial Bacteriological Laboratory, Pune, in 1889 and the Agricultural Research Institute, Pusa, Bihar, in 1905. On date, the ICAR comprises 46 central research institutes (CRIs) that include 4 national institutes : Indian Agricultural Research Institute, New Delhi; Indian Veterinary Research Institute, Izatnagar; National Dairy Research Institute, Karnal and the Central Fisheries Research Institute, Bombay; 4 national bureaux: for plant, animal, fish genetic resources and for soils; 10 project directorates (PDs); 26 national research centres (NRCs); the National Academy of Agricultural Research Management (NAARM) and 84 all-India coordinated research projects (AICRPs). It is also operating World Bank Projects and Projects for Tribals (besides 2 All-India Coordinated Projects for Tribals, Scheduled Castes and Other Backward Communities and schemes for their upliftment).

NATIONAL AGRICULTURAL RESEARCH SYSTEM

	Crop Science	Horti-culture	Animal Science	Fish-eries	Agricultural Education
National Institute	1		2	1	
Central Research Institute	8	8	6	5	1*
National Bureau	1		1	1	
National Research Centre	7	10	7	1	
Project Directorate	5	1	2		
All-India Coordinated Research Project	26	17	16		

	Soil, Agronomy & Agroforestry	Agricultural Engineering
Central Research Institute	8	5
National Bureau	1	
National Research Centre	3	
Project Directorate	2	
All-India Coordinated Research Project	15	10

GENERAL

- Indian Agricultural Statistical Research Institute, New Delhi
- National Centre of Agricultural Economics & Policy Research, New Delhi
- Twenty-nine state agricultural universities.

*National Academy of Agricultural Research Management.

With the assistance of the ICAR, 29 state agricultural universities (SAUs) have been established in the country including the Central Agricultural University at Imphal, for the north-east region of the country.

A BIG EMPLOYER

On the pay-roll of the ICAR are 30,000 personnel in different categories. Nearly 7,000 are engaged in active research and its management, and in clearing of information generated in the National Agricultural Research System. They are all postgraduates in agriculture and allied sciences.

The state agricultural universities employ scientists for teaching, research and extension-education assignments.

INTERNATIONAL LINKAGES

Research and resources cut across nations. The developed and developing nations do not appear as donors and recipients but as members of a family which seeks to organize its resources, its output and its consumption, so as to become a balanced harmonious community.

The ICAR has been a partner in International Cooperation over a hundred years. The Imperial Bacteriological Laboratory established in 1889, at present the Indian Veterinary Research Institute, first evolved the goat-adapted Rinderpest vaccine in 1927 that is in use the world over. The vaccine against the Ranikhet disease developed in 1939 is also being produced on a large scale the world over.

ANNUAL CONTRIBUTIONS TO

CGIAR	US $	750,000
CABI	£	57,859
NACA	US $	60,000
APAARI	US $	6,000
CGPRT	US $	5,000

Our vast network of agricultural universities is a replica of the Land-Grant Colleges of the USA. These universities together with the CRIs of the ICAR have earned a reputation for the quality of education and training comparable to that in the West, which they impart at a lesser cost. Our contribution to the development of human resources of many developing nations is a matter of national pride.

International Cooperation — exchange of ideas, know-how and material — in rice, wheat, maize and millets brought about the Green Revolution in the country in the late sixties. It is perhaps the most-quoted success in agriculture.

Director-General, ICAR, Dr R.S. Paroda and Secretary, ICAR, Mr G.S. Sahni, IAS, discuss the ICAR-IRRI Work Plan with Dr K.S. Fischer, DDG (Research), IRRI.

IRRI-India Day 1996 is proposed for later this year to focus on: Rainfed Rice System; Rice-Wheat System; Hybrid Rice and Biotechnology in the Rice Crop

The recently launched, World Bank-assisted, Agricultural Human Resource Development Project is of greater significance to the country. The operational details are being discussed by Director-General, ICAR, Dr R.S. Paroda and Dr Peter Rosenegger, FAO representative in India

The continuous multilateral cooperative programmes with the United Nations Development Programme (UNDP), United Nations Educational, Scientific and Cultural Organization (UNESCO), Food and Agriculture Organization (FAO), Swedish Agency for Research Cooperation with Developing Countries (SAREC), Consultative Group on International Agricultural Research (CGIAR) and the Centre for Agriculture and Biosciences International (CABI) have helped in the exchange of information on both research and education, exchange of experts and ideas, and in equipping of our laboratories with the latest equipment.

At present there are more than 120 projects in operation with collaborations off-shore; majority of them with the USA, UK, Canada, the Netherlands, Australia and the EEC. The National Agricultural Research Project (NARP), the National Seeds Project (NSP) in operation, and the just begun Agricultural Human Resource Development Project are financed by the World Bank through credit assistance.

As a pioneer donor member of the CGIAR, the ICAR has cooperative agreements with most centres of the CGIAR. Our research programmes have benefited substantially from the interactions.

Memorandas of Understanding (MOUs) and Agreements/Work Plans have been signed with various countries (Brazil, Bulgaria, China, Cuba, Iran, Israel, Mauritius, Mongolia, the Philippines, Russia, USA, and Vietnam) and private organizations of world status (the Rockefeller Foundation and Ford Foundation of the United States of America). Work Plans are being finalized with Bangladesh, Nepal and Pakistan.

With the Rockefeller Foundation, the ICAR has signed a Work Plan to promote the development of rice biotechnology. The participating institutions, with a separate participating role are: the Biotechnology Centre, IARI, New Delhi; Central Rice Research Institute, Cuttack; Directorate of Rice Research, Hyderabad; ICAR Research Centre for NEH Region, Shillong; CCS Haryana Agricultural University, Hisar; Punjab Agricultural University, Ludhiana; Tamil Nadu Agricultural University, Coimbatore and the Orissa University of Agriculture and Technology, Bhubaneswar.

All negotiations between foreign governments and multilateral agencies are carried out with the ICAR through the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India.

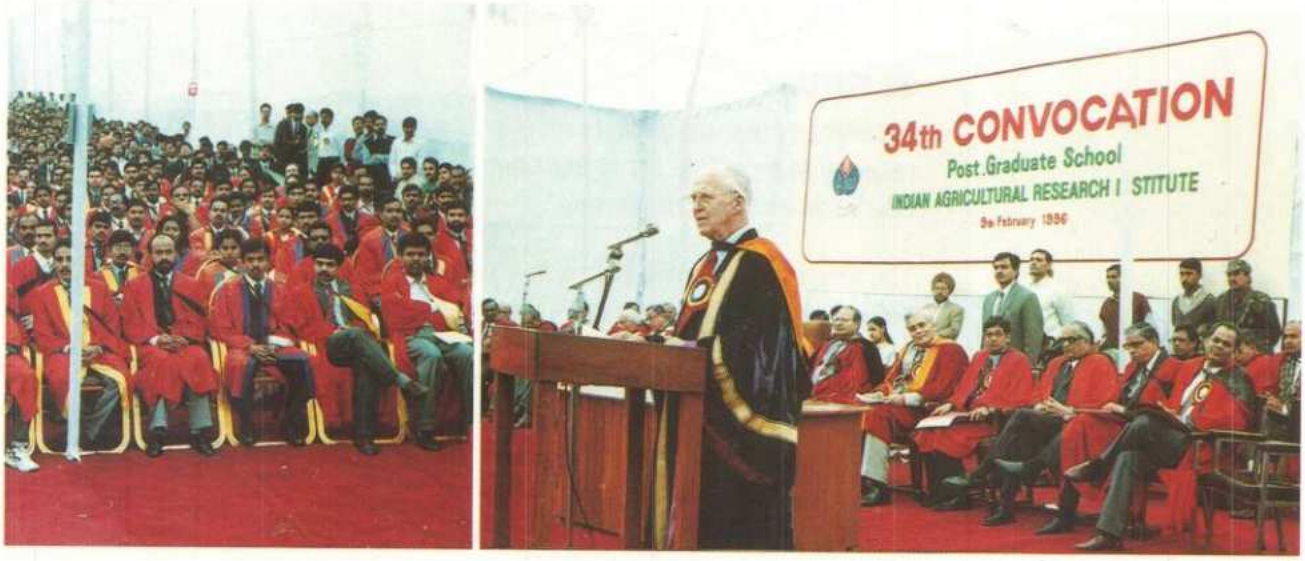
agricultural education

The goals of increased production can only be achieved through application of science and technology to agriculture for which trained personnel is a "requirement". While the Indian Agricultural Research Institute, New Delhi, and the Indian Veterinary Research Institute, Mukhteswar, were forerunners of the Land-Grant College System in 1958, the Govind Ballabh Pant University of Agriculture and Technology is the first state agricultural university to have been established at Pantnagar, Uttar Pradesh, in 1960. By 1968, there were 8 agricultural universities and their number has swelled to 29 that includes one Central Agricultural University for the North-East Hills Region. In addition, there are 4 deemed universities within the ICAR system: IARI (New Delhi), IVRI (Izatnagar), NDRI (Karnal) and CIFE (Bombay) and 3 central universities each with a separate agriculture faculty: AMU (Aligarh), Vishwa Bharati (Shantiniketan) and BHU (Varanasi).

These institutions provide for undergraduate education in 11 fields of specialization with 168 constituent colleges capable of absorbing 10,000 students in the postgraduate programme. Degrees are awarded in veterinary science, agricultural engineering, forestry, home science, agricultural science, horticulture, food science, dairy technology, fisheries, sericulture and marketing/banking, and cooperation. There are 55 disciplines in which specialization at the postgraduate level is available.

The ICAR recognizes professional excellence, utilizes professional resources and provides incentives for manpower development in agricultural education and research.

Convocation at the IARI, New Delhi. Dr Norman E. Borlaug addressing the postgraduates



The education programme is reviewed at the Vice-Chancellor's Conference held annually. Former honourable Minister of Agriculture, Mr Jagan Nath Misra speaking on the Inaugural.

It appoints National Professors and National Fellows and awards the Best Teacher.

To utilize professional resources, the ICAR has launched the Emeritus Scientists Scheme; organizes Summer Institutes and Short Courses and prepares university-level textbooks.

Fellowships and scholarships are also awarded to postgraduate students.

In essence, the Division of Education set up at the ICAR headquarters in 1965, aids, promotes, monitors and coordinates agricultural education at the national level.

IN FUTURE . . .

Excellence means improvement over the existing. An Accreditation Board has recently been set up for laying norms for various components of agricultural education and their monitoring.

The long-term goal however is to cater to emerging demands and challenges before agricultural education in a world of changing economic policies.

The newly begun Agricultural Human Resource Development Project with credit assistance from the World Bank is expected to improve the quality and relevance of agricultural education in the country.

NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT

Successful organizations need to train and tone up their management with up-to-date skills. In 1976, the ICAR established the state-of-the-art National Academy of Agricultural Research Management (NAARM) at Hyderabad.

It is mandatory for all scientists entering the Agricultural Research Service to undergo a training at the NAARM in project management techniques, inter-disciplinary project formulation, organizational behaviour, interpersonnel relationships, effective communication, and computer use.

The NAARM regularly organizes on-campus advanced courses and visits of overseas delegates and offers tailor-made programmes off-shore. The course-fee is modest.

The NAARM also collaborates with the UNDP, FAO, IMF, ADB, USAID, Ford Foundation, IDRC, ODA, SAARC, ISNAR, ICRISAT, SEARCA, UNESCO and several universities in the USA, UK and Australia to bring together agricultural scientists and policy-makers for exchange of ideas at conferences, seminars and training programmes.

An Advanced Centre on Agricultural Education and Research Management has been set up in 1987 at the NAARM with assistance from the UNDP, FAO and UNESCO, to assist the deemed universities, and CRIs of the ICAR and the SAUs in order to bring about constant improvements in education and research.

In the Video Console Laboratory, the scientists are taught production of scientific and educational programmes

agricultural extension

Agriculture must continually move forward for which adoption of newer methods of farming become imperative. The formation of the "Tonnage Club" in the Fourth Plan has been a step in that direction.

The ICAR has a Division of Agricultural Extension that helps in the assessment and refinement of technologies in all disciplines of research conducted in the system.

The Lab-to-Land gaps are plugged before a technology is adopted widely.

LAB-TO-LAND

Step 1. The latest technology is demonstrated to the farmers and extension workers.

Step 2. The technology is tested and refined in the bio-physical and socio-economic conditions of the farmers adopting it.

Step 3. The technical know-how of the extension personnel is upgraded.

Step 4. Vocational courses are organized in order to instil a spirit of "Learning by doing". The trainee may then raise institutional finance for self-employment.

Technology selling or shopping?

The farmer must be convinced.

The extension-education activity is conducted through 261 Krishi Vigyan Kendras (KVKs or Farm Science Centres) and 8 Trainers' Training Centres located in various parts of the country.

The KVKs are district-level institutions run by the SAUs, CRIs and select non-government organizations. Each year 2,500–3,000 farmers, farm women, rural youth and school dropouts are trained at the Krishi Vigyan Kendras in crop husbandry, horticulture, animal husbandry and dairying, fisheries and vocations leading to self-employment.

The Trainers' Training Centres (TTCs) are subject-specific training institutions for providing what's new in dryland agriculture, horticulture, farm machinery, inland fisheries, marine fisheries, hill agriculture, dairying and home science.

National Research Centre for Women in Agriculture, Bhubaneswar, Orissa, is devoted to women-specific research and extension-education programmes in the country.

The farmers plant rice by DAPOG METHOD during summer. They also earn more

Non-traditional crop groundnut, performs beyond expectation. The area under the crop is expanding

"AGRICULTURE IS NO MORE A WAY OF LIFE"

- **Varieties get replaced in no time**

Onion ARKA BINDU is a fine example of replacing its counterparts even though it was a state-level release.

The red-skinned ARKA BINDU developed exclusively for export in fresh form has been extensively grown in Karnataka ever since its performance was demonstrated to the farmers by the extension scientists of the ICAR. The onion is being regularly exported to Malaysia, Singapore, Sri Lanka, the Gulf countries and European markets since 1991.

- **A conventionally grown crop too goes out . . .**

The water-guzzler sugarcane has been replaced in south Arcot, Tamil Nadu, with the less-water demanding hybrids of sunflower whose performance was demonstrated in 5 hectares of land in 1991–92. At present the hybrids KBSH 1, MSFH 8 and MSFH 17 cover 10,000 hectares.

FRONT-LINE EXTENSION SERVICES OF THE ICAR REACH EVEN REMOTE AND INHOSPITABLE TERRAINS

- **Red lateritic fallow lands in western Midnapore, West Bengal, are now blossoming orchards**

Rainfed orchards of mango, jackfruit, litchi, sapota, ber, cashew, sweet orange, lime and lemon, guava and pomegranate are spread over the once abandoned red lateritic fallow lands of western Midnapore. Seva Bharathi Krishi Vigyan Kendra, Kapgari, has assisted the farmers in adopting the Progeny Orchard and Nursery Development Programme. Each farmer has now an orchard in 2 hectares and nursery in one hectare of this fallow land. The nurseries supply 'true-to-type' and 'true-to-variety' saplings.

- **Vocational training in animal husbandry**

In one of the least developed districts of India, Hazaribagh, Bihar, Holy Cross VTI KVK has been training the rural youth in para veterinary skills since 1986. The TRYSEM programme equips these youngsters in three months with adequate knowledge on poultry, goattery, piggery, fodder production and on treating common diseases of livestock through "learning by doing".

Once trained, the para veterinary doctors are given tool kits and basic medicines, while the banks provide loans for a working capital. The "Bare Foot Doctors" now take care of the livestock in the thickly covered forests of Hazaribagh, their home.

publications and information

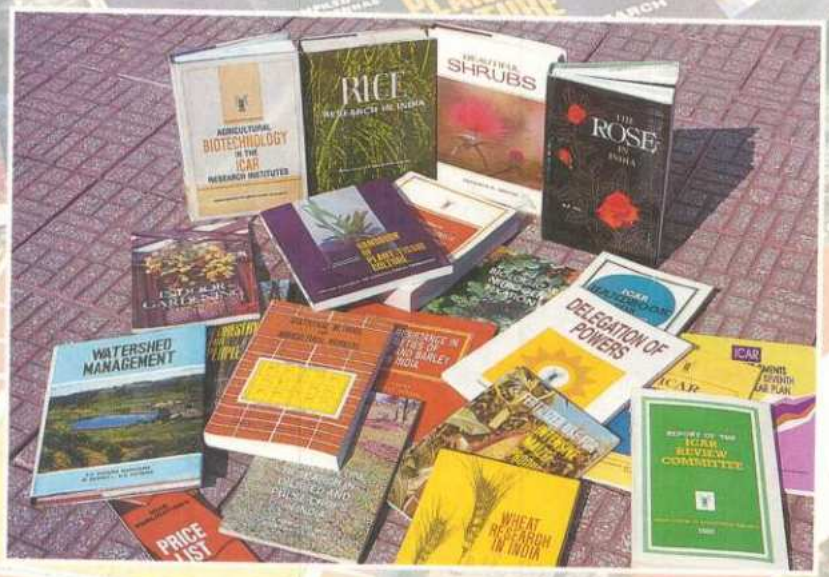
The reach of science and technology must penetrate masses. The world today has been closely linked than ever before only because of quick effective dissemination of information.

PUBLICATIONS

While research has been one objective of the ICAR, clearing of information the other, right from its inception.

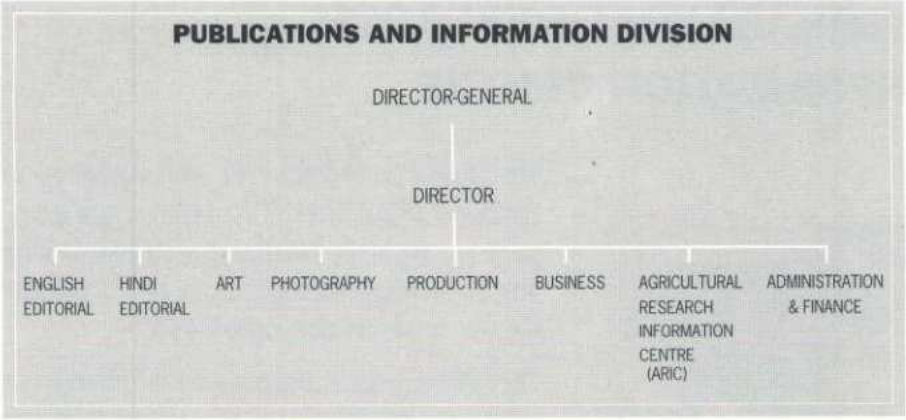
The publications and information programme comprises books, bulletins, journals, releases to the press and instructional films. It is a vehicle for announcing the results of numerous agricultural researches for increased production and for building up valuable scientific knowledge in the country.

The publications programme of the ICAR is under periodic review of the Publications Committee. The Director-General, ICAR, who is also the Chairman of the Publications Committee, identifies from time-to-time the titles of publications of topical importance.



The largest publisher of information on agriculture, the ICAR publishes 50 titles a year on an average.

These interface publications are much sought after



Semi-technical *Indian Farming* and *Indian Horticulture* are abstracted by leading bibliography services. *Indian Horticulture* enjoys a tremendous popularity. On the domestic scene it has proved "the pen is mightier" in moulding public opnion and reforming policy

Cross-discipline research journals, *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, are on the rating of the ISI, Philadelphia

Publications in Hindi are popular in substance

Books published in English may be monographs, technical books, textbooks, reference books or popular books; those published in Hindi are essentially popular in nature. The Handbook of ICAR on Agriculture and on Animal Husbandry, both in English, are very popular among students.

Research conducted in the ICAR is published in English in 2 technical journals and 2 semi-technical journals of the ICAR. **The Indian Journal of Agricultural Sciences** and **The Indian Journal of Animal Sciences** are monthly in periodicity. The semi-technical journal **Indian Farming** is a monthly and the **Indian Horticulture**, a quarterly. All of them are indexed and abstracted internationally. **Kheti**, a monthly, and **Phal Phool** and **Krishi Chayanika**, quarterlies, are published in Hindi.

The **ICAR News**, a science and technology newsletter, and **ICAR Reporter**, a house journal, are brought out every three months to keep the ICAR well-knit at home and abroad.

The books and semi-technical journals are beautifully designed and illustrated. They conform to the guidelines laid down by the UN Code of Conduct for Science Writers and Editors and the International Conference of Biology Editors. The publications are nominally priced, at no profit no loss. The journals have enrolled subscribers, and the books are well-read.

AGRICULTURAL RESEARCH INFORMATION CENTRE

Information Services of the ICAR

The Research Project Files Unit patterned on Current Research Information System (CRIS) of the USDA had been started in 1967. In 1975 the Council began participating in the FAO-sponsored International Information System for Science and Technology (AGRIS). From 1977, the Unit has been renamed Agricultural Research Information Centre (ARIC).

The ARIC maintains and provides information on agricultural scientists in the ICAR institutes and agricultural universities. It also works as a National Input Centre for AGRIS and annually contributes more than 4,000 inputs (abstracts of research papers) of Indian origin to the AGRIS. In return the computerized AGRIS Database is available to the Centre for operating Selective Dissemination of Information (SDI), a service for the benefit of ICAR scientists and those in agricultural universities.

The ARIC also brings out Directories of Agricultural Personnel, Conferences, Research Schemes on Agriculture and Animal Sciences and Research Workers in India.

The ARIC provides training in information management to FAO nominees from the developing countries.

PUBLICITY AND PUBLIC RELATIONS

Green Revolution has two vital inputs — research and mass awareness. The Publicity and Public Relations Unit had been added to the Publications and Information Division in 1969 to ensure its complete impact. The Unit has acquired independent status of late.

This unit is responsible for dissemination of information about major research findings of the Council through mass media, press releases to the newspapers, organization of press conferences, press visits, supplement and feature articles in newspapers.

BESIDES . . .

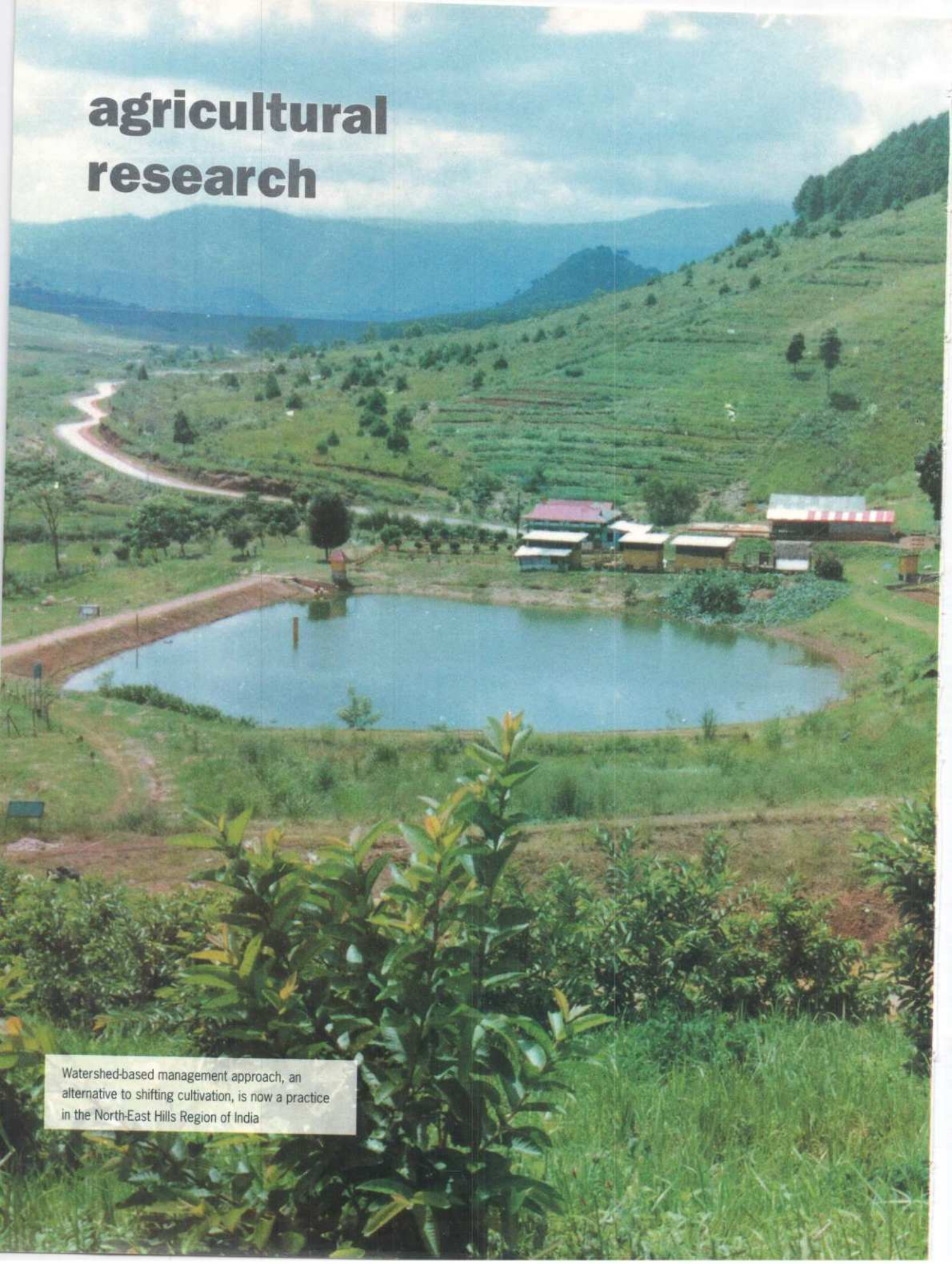
- Periodical broadcasts and telecasts are arranged on subjects of importance.
- National and international exhibitions are organized on special occasions.
- For the rural masses, documentaries and films are produced.

Research Accomplishments

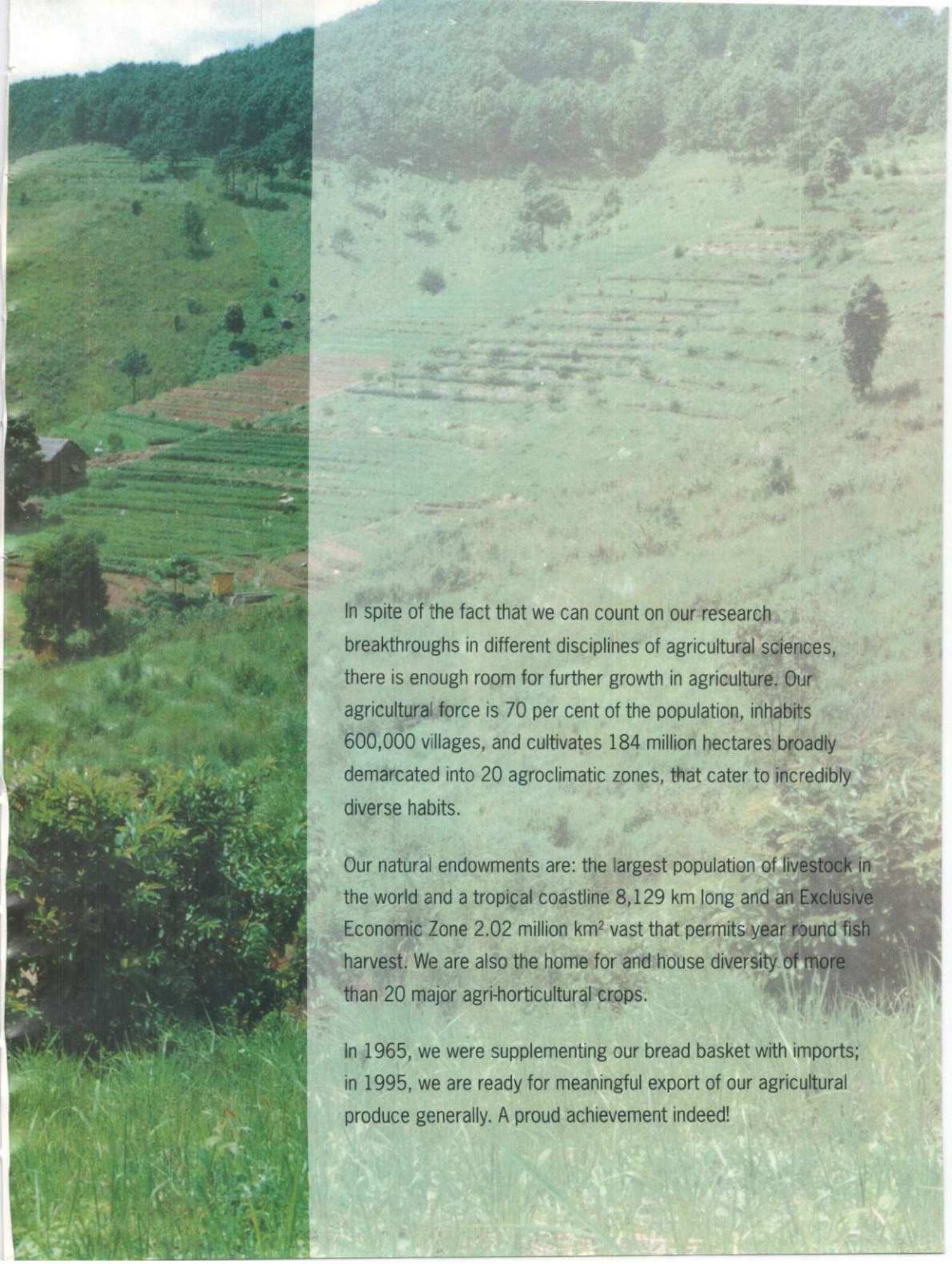
A village in Kerala

“Our wide diversity of flora, fauna, edaphos and climate — is both a blessing and a challenge. It opens as many vistas and requires as many solutions. It teaches us the essence of sustainability. Indian agriculture is an outstanding example.”

agricultural research



Watershed-based management approach, an alternative to shifting cultivation, is now a practice in the North-East Hills Region of India



In spite of the fact that we can count on our research breakthroughs in different disciplines of agricultural sciences, there is enough room for further growth in agriculture. Our agricultural force is 70 per cent of the population, inhabits 600,000 villages, and cultivates 184 million hectares broadly demarcated into 20 agroclimatic zones, that cater to incredibly diverse habits.

Our natural endowments are: the largest population of livestock in the world and a tropical coastline 8,129 km long and an Exclusive Economic Zone 2.02 million km^2 vast that permits year round fish harvest. We are also the home for and house diversity of more than 20 major agri-horticultural crops.

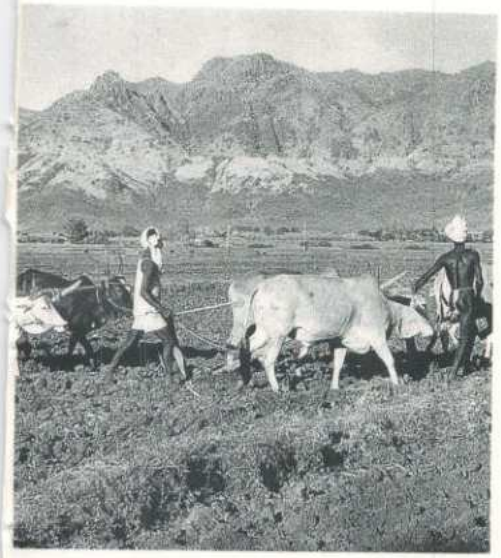
In 1965, we were supplementing our bread basket with imports; in 1995, we are ready for meaningful export of our agricultural produce generally. A proud achievement indeed!

oft-quoted success . . .

"GREEN REVOLUTION" OF INDIA

The "Grow More Food Campaign" of the early forties refused to pay off. But the sublime imagination of Mr Lal Bahadur Shastri and Mrs Indira Gandhi, our late Prime Ministers, C. Subramanium and B. Sivaraman, outstanding bureaucrats, and late Dr B.P. Pal at first and later Dr M.S. Swaminathan, his successor at the ICAR, did prove the right mix of policy and research in boosting foodgrains production in the country.

The introduction of improved varieties, for which we owe much to Dr Norman E. Borlaug, the steadfast application of ICAR scientists in the field and in the laboratory and above all the acceptance of the new varieties by the farmers and their toil helped India declare "Self-sufficiency" in foodgrains nearly two decades ago. The trend has only extended to other commodities ever since. For this Green Revolution, the ICAR has earned the King Baudouin International Development Prize in December 1988.

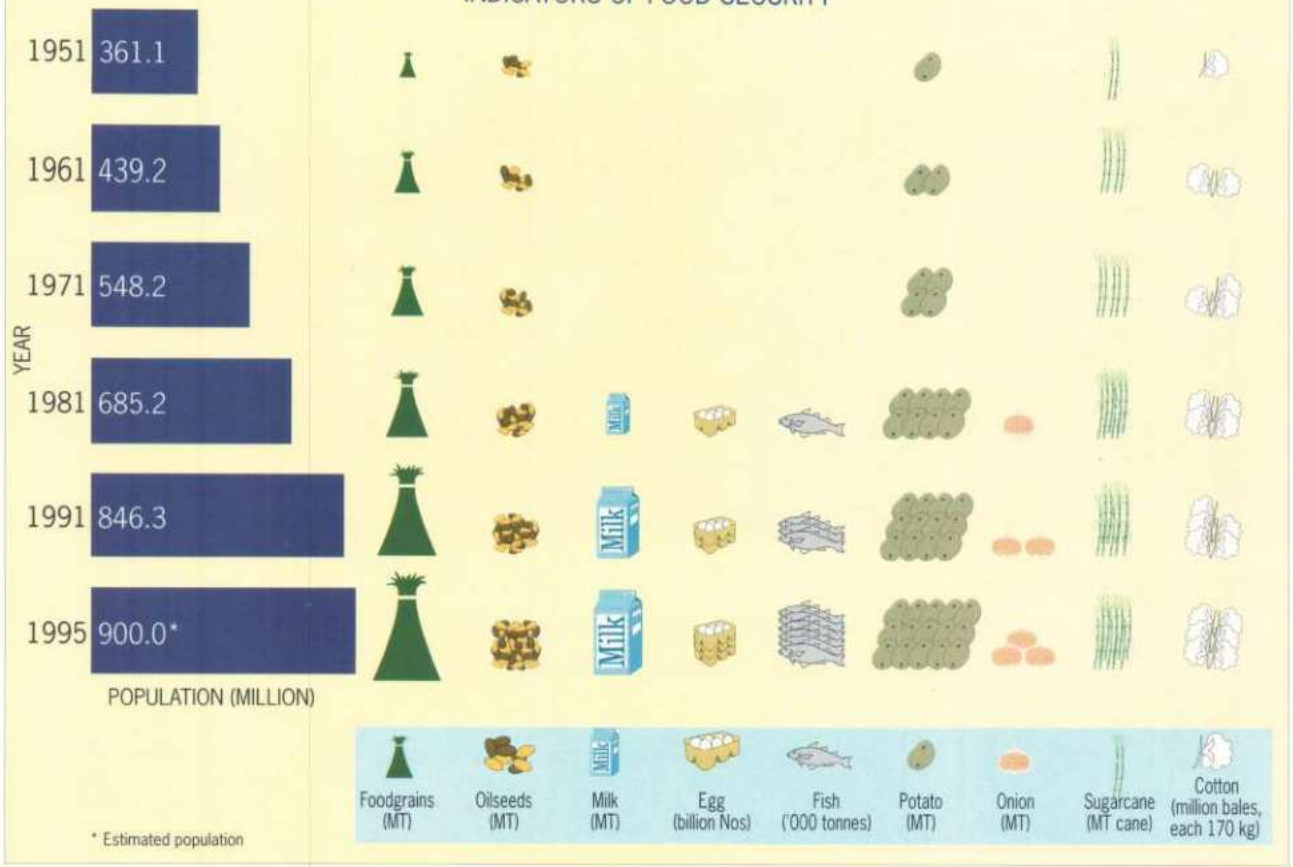


GREEN REVOLUTION that began with the wheat and rice crops extended to other commodities as well . . .

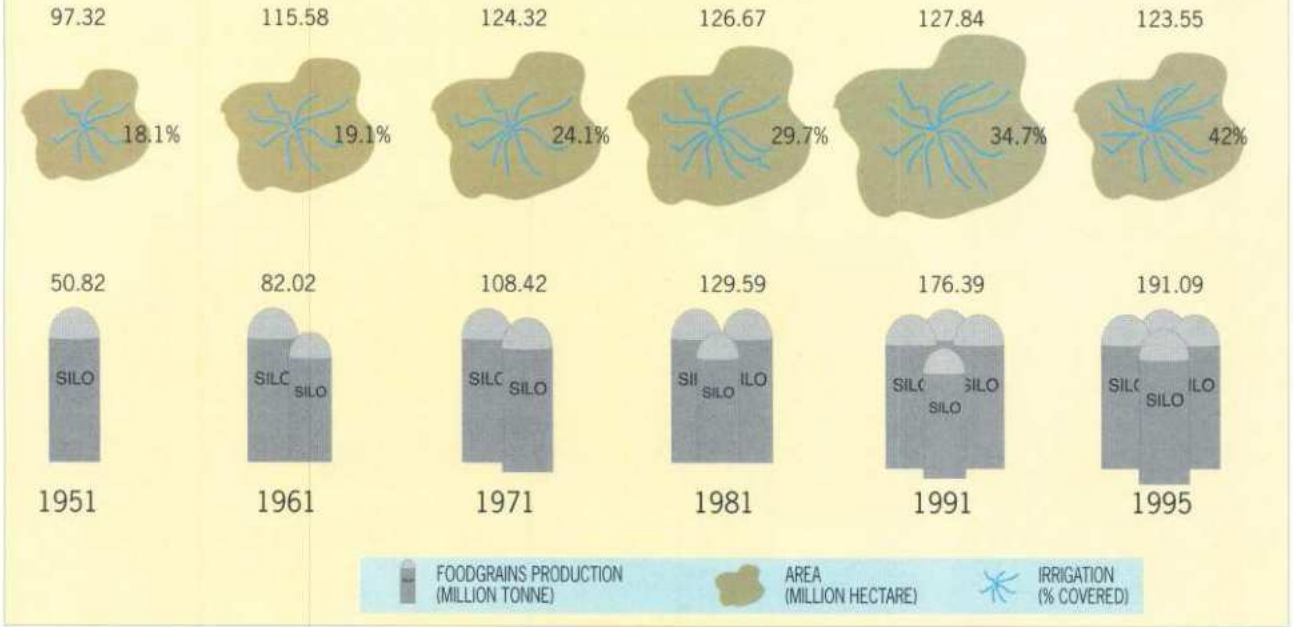
Year	Population	Food-grains (MT)	Oilseeds (MT)	Milk (MT)	Egg (billion nos)	Fish (000' tonnes)	Potato (MT)	Onion (MT)	Sugarcane (MT cane)	Cotton (million bales, each 170 kg)
1951	361.1	50.82	5.16	-	-	-	1.66	-	57.05	3.04
1961	439.2	82.02	6.98	-	-	-	2.72	-	110.0	5.60
1971	548.2	108.42	9.63	-	-	-	4.81	-	126.37	4.76
1981	685.2	129.59	9.37	31.6	10.60	2444	9.67	2.50	154.25	7.01
1991	846.3	176.39	18.61	53.9	21.10	3836	15.21	3.23	241.05	9.84
1995	900.0*	191.09	21.42	63.1	24.55	4786	17.94	4.06	271.23	12.11

*Estimated population

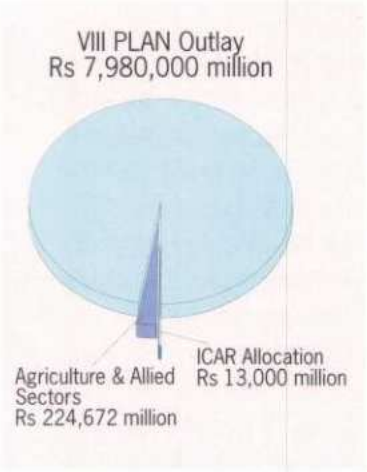
INDICATORS OF FOOD SECURITY

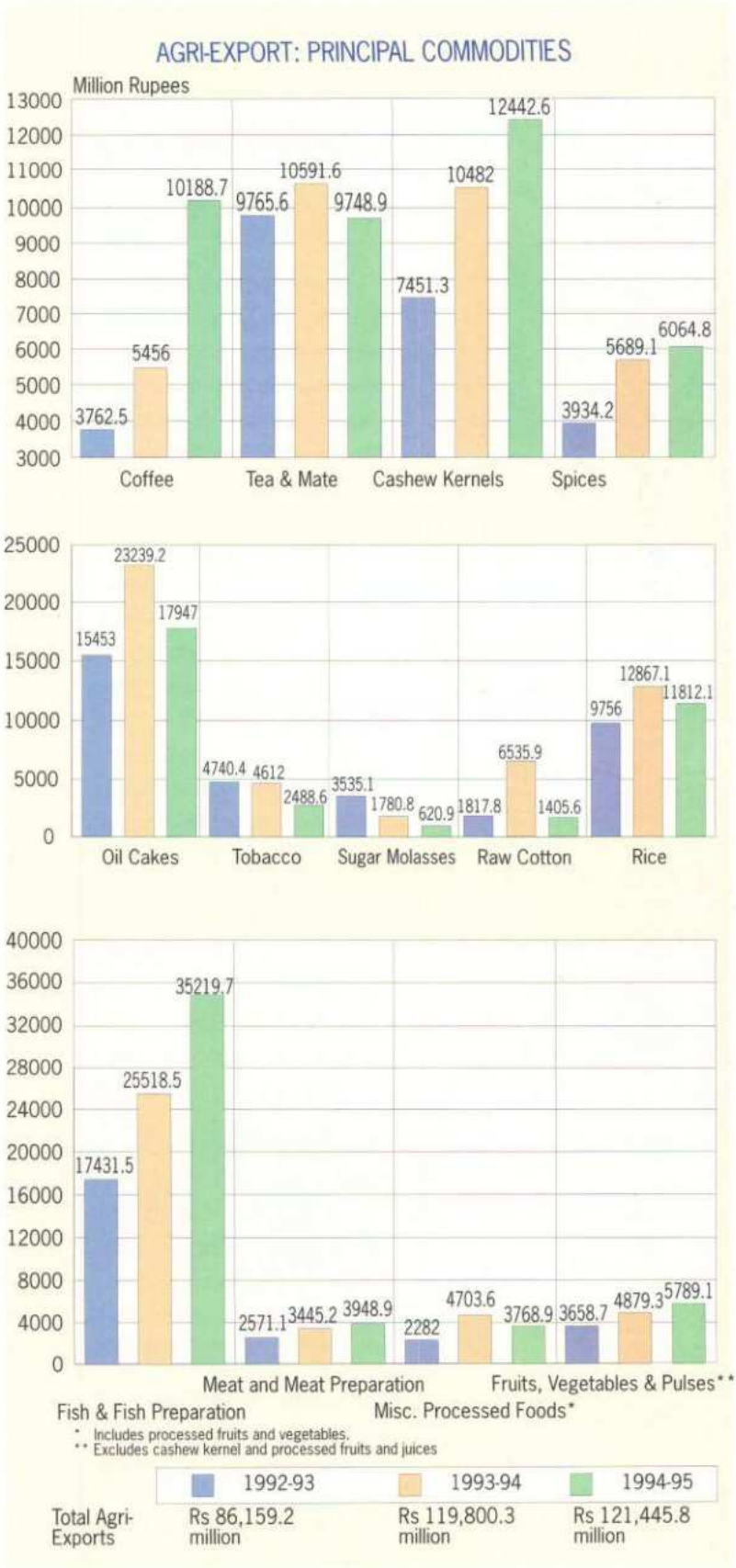


MECHANICS OF FOOD SECURITY



The share of the ICAR in the total budget of Rs 7,980,000 million for 1992–97 is around 0.16%. Agri-exports in just three years, 1992–95, have returned Rs 327,405.3 million in foreign exchange.





a paradigm . . .

THE INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI

Dr Norman E. Borlaug and Dr R. B. Singh, Director, IARI, being felicitated at the village Auchandi adopted by the IARI. Dr Norman E. Borlaug's contribution in bringing about Green Revolution in India has been placed on record. A noted agriculturist, and an accomplished academician, Dr Borlaug has earned several distinguished honours internationally, the greatest being the Nobel Prize in 1970.

Dr R. B. Singh, Director, IARI, is a breeder of several famous cotton and wheat varieties being cultivated extensively in the country and abroad. Dr Singh has contributed significantly to basic and strategic research. He has spent a-decade-and-a-half with the FAO

National Facility for Blue-Green Algal Collections at the IARI holds 560 strains of Cyanobacteria that include: nitrogen-fixing strains, halotolerant strains, species rich in natural colours, toxic substances and excess biopolymer-producing strains. The rice-growers are increasingly using Cyanobacteria as a biofertilizer on the recommendations of this Centre

Generally, a variety released from the IARI carries the epithet "PUSA". These varieties are spread through the pages of this publication.

Boasting of the most modern facilities for research and spread in 500 hectares of sylvan environ, the Indian Agricultural Research Institute, better known as the IARI, New Delhi, has been as much the researcher's haven as the student's delight ever since it acquired the status of a deemed university in 1958. Internationally tall agriculturists — in **Crop Improvement:** Drs B. P. Pal (Wheat Breeding), M.S. Swaminathan (Plant Breeding and Genetics), A.B. Joshi (Applied Genetics), H.K. Jain (Basic Genetics), V.L. Chopra (Biotechnology), Har Bhajan Singh (Plant Introduction), V.S. Mathur (Wheat Breeding), M.V. Rao (Wheat Breeding), N.G.P. Rao (Sorghum Breeding), R.S. Paroda (Fodder Crop Breeding) and E.A. Siddiq (Rice Breeding); **Horticulture:** Drs G.S. Randhawa (Horticulture), K.L. Chadha (Pomology), R.N. Singh (Mango Breeding), B.K. Majumdar (Mango Breeding), P.K. Mukherji (Horticulture); **Physiology and Biochemistry:** Drs R.D. Asana (Physiology), S.K. Sinha (Stress Physiology), N.B. Das (Biochemistry); **Crop Production:** Drs N.G. Dastne (Irrigation Agronomy), S.S. Bains (Cropping System), S.P. Raychowdhury (Soils), P.C. Raheja (Agronomy), N.P. Dutta (Soils), A.M. Michael (Irrigation Engineering); **Crop Protection:** Drs S. Pradhan (IPM), K.C. Gulati (Agricultural Chemicals), B.B. Mundkur (Plant Pathology), R.S. Vasudeva (Plant Pathology) and D.N. Srivastava (Bacteriology) have all been alumni of this Institute. It is owing to their steadfastness that agriculture in India witnessed a spectacular turn-around. . . . . developing modern varieties to meet the veritable needs of enhanced productivity, disease and pest resistance, quality and cropping intensity — the ingredients that spelt "Green Revolution". Nearly 14 million hectares, 55% of the area covered by the wheat crop, is sown with varieties developed by the IARI. Wheat HD 2329 has been a rare phenomenon. Released a decade ago, it still covers 4 million hectares.

The IARI has 9 regional stations giving it additional research support: Amartara Cottage, Shimla, Himachal Pradesh (Horticultural Technology); Indore, Madhya Pradesh (Wheat Breeding); Kalimpong, West Bengal (Virus Research); Karnal, Haryana (Seed Research and Production); Katrain, Himachal Pradesh (Vegetable Research and Production); Pune, Maharashtra (Virus Research); Pusa, Bihar (Wheat, Pulse and Fruit Research); Tutikandi, Shimla (Wheat and Barley Breeding) and Wellington, Tamil Nadu (Wheat Breeding).

The National Facility/Centre at the IARI exists independently for Maize, Water Technology, Nuclear Research, Blue-Green Algae, Integrated Pest Management, Plant Biotechnology and Phytotron.

The Institute awards postgraduation in 21 disciplines and Doctorate in 19 disciplines. More than 5,000 scholars have earned these honours.

LEADERSHIP OFFSHORE

- First biometer developed in the mid-50's that triggered the concept of IPM.
- Neem as a botanical pesticide and efficacy of its active principle azadirachtin in IPM.
- High quality triple dwarf wheats for bread-making and baking.
- Application of NMR for non-destructive screening of genotypes for oil content in oilseeds.
- Nitrification inhibitors—use of neem-coated urea and calcium carbide.
- Hybrids of mango, MALLIKA and AMRAPALI, also regular in bearing.
- Seed Plot Technique of potato for the tropics and semi-tropics.
- Crop introduction and germplasm conservation in Asia.
- Scientific basis of plant disease management and deployment of veritable resistant genes for stable disease management.
- Composite varieties of maize — VIJAY, KISAN, JAWAHAR and VIKRAM.

Mango AMRAPALI

HALLMARKS

- Modern varieties of wheat developed by the IARI have been the basis of Green Revolution. They occupy more than 50% of the area sown with the wheat crop in the country. Because of a substantial improvement in productivity in these varieties, land saving has been 20 million ha of the forest land and that belonging to other crops, and 40 million ha of additional land that would have been required to meet the present national demand. IARI varieties of wheat have contributed very significantly to the wheat baskets of Nepal, Bangladesh, Lebanon and Sudan.
- 45% of the area sown with pearlmillet hybrids is seeded with the hybrids developed by the IARI.
- The world's first high-yielding aromatic basmati rice PUSA BASMATI; first amber-coloured commercial *Triticale* variety DT 46; the first composite maize varieties VIJAY, KISAN, JAWAHAR and VIKRAM; the first fodder hybrid of sorghum CSH 106; the world famous castor hybrid ARUNA, and the first ever hybrids of mango AMRAPALI and MALLIKA, also regular in bearing, have all been developed at the IARI.
- Chickpea varieties of the IARI account for nearly 50% of the breeder-and-certified seed produced in the country.
- Grapes PUSA SEEDLESS and BEAUTY SEEDLESS have revolutionized the cultivation of grapes in northern India. While tomato PUSA SHEETAL, a thermo-insensitive variety, has helped in bringing ripe tomatoes a month in advance to the market. Thermo-tolerant cauliflower, off-season onion and radish varieties evolved by the IARI are widely grown by the farmers.
- More than 100 varieties of the rose, and a few good hybrids of Gladiolus, marigold, Bougainvillaea developed at the IARI are suited for commercial cultivation.

Wheat HD 2329

LAL BAHADUR SHASTRI CENTRE, IARI, NEW DELHI, HOUSES THE CENTRES OF EXCELLENCE

AGRICULTURAL CHEMICALS

Nearly 3 decades old, the Division of Agricultural Chemicals came into existence on 14 November 1966 to develop:

- eco-friendly pesticides, allied agrochemicals and formulations
- technologies for safe use of pesticides and lessening their load on the environment
- human resource.

While several plant-based and synthetic protectants recommended by the IARI are being manufactured commercially, those that have earned the Indian Patent Number 113193 for production of terpene alcohols from turpentine oil; 115716 for terpenyl esters from turpentine oil and its components; 119536 for methylene dioxyphenyl derivatives; 128129 for dillapiole and its components; 121303 for preparation of barium polysulphide and tobacco alkaloids; 133090 for the preparation of 2, 2, 2 trichloro-1, 1, di-(chlorophenyl)-ethanol; 141551 for emulsion concentrate; 153987 for anti-resistant insecticidal formulation and 4622315 for additives for improved photostability are revolutionary.

PLANT BIOTECHNOLOGY

A Centre of Excellence, the NRC on Plant Biotechnology, is assisting the plant breeders to overcome yield barriers in commodity crops in order to propel crop productivity.

The biotechnologists are currently involved in developing CMS systems and in their characterization at the molecular level. Significantly 3 CMS systems have been developed in *Brassica juncea*—*B. juncea* + *Trachystoma balli* (2n = 52, TTAABB); *B. juncea* + *Diplotaxis catholica* (2n = 56, DcDc AABB) and *B. juncea* + *Moricandia arvensis* (2n = 64, MMAABB). A preliminary map of *B. juncea* is already available.

Plant transformation through cry 1AB, a synthetic gene, obtained through ICAR–IRRI–ICRISAT consortium from Plantech Research Institute, Japan, is being extensively used for a higher degree of expression in brinjal, cabbage, cauliflower, tomato and tobacco.

The doubled haploid population of rice developed through anther culture standardized at the Centre is being used for molecular tagging of cooking quality traits in rice to provide reliable selections for breeding high-yielding aromatic rices.

NATIONAL FACILITY/CENTRE

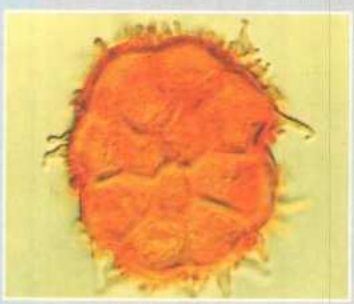
NUCLEAR RESEARCH LABORATORY

The Nuclear Research Laboratory, established in 1969, is mandated to research and promote peaceful uses of nuclear energy for agricultural development. Using isotope radiation-induced mutations and deploying nuclear techniques, the laboratory has developed practices in collaboration with FAO-IAEA for optimizing the use and increasing efficiency of fertilizers, water and pesticides and is assisting in developing integrated plant, soil, water and nutrient management practices. Techniques for nondestructive determination of oil in oilseeds, characterization of quality of foodgrains, drought tolerance in wheat and patho-physiology of mycoplasmal diseases have been widely used for developing new varieties and management practices.

Accomplishment . . .

- Development of safe gamma irradiation technologies for insect disinfestation of rice and pulses, and for storage life extension of fruits and vegetables such as tomato, button mushroom, onion and mango.

CENTRE OF BIOSYSTEMATICS FOR RESEARCH ON BIODIVERSITY OF AGRICULTURALLY IMPORTANT MICRO-ORGANISMS, NEMATODES AND INSECTS



The country's oldest herbarium, the *Herbarium Cryptogamae Indiae Orientalis* (HCIO) of fungi established in 1905 houses 42,000 collections; the National Pusa Insect Collection (NPIC) 440,000 collections; the Indian Type Culture Collection (ITCC) 4,000 fungal specimens and the National Nematode Collection of India (NNCI) 4,000 wet specimens.

The Centre provides quick identification service for characterization of fungi, insects, nematodes, bacteria and viruses. It is accredited with reporting of 120 genera of fungi, insects and nematodes; several hundred new species, and with developing synoptic keys and monographs for quick identification. Fungi of glassfibre yarn — a new recipe for avoiding fungi has earned the Indian Patent Number 27167.

Fungi of India, an authentic referral source, has been updated in 1992. The Centre has also generated an electronic database.

PHYTOTRON CENTRE, A NATIONAL FACILITY

To tackle the many problems posed by the environment and to accelerate the pace of research, the National Facility of Phytotron is being established at the IARI that becomes the select few institutes the world over to study life responses in controlled environment simulated in closed chambers. In all, there will be 22 Environment Controlled Plant Growth Chambers and 10 greenhouses permitting more than 250 permutations and combinations of photoperiod, temperature, lighting, humidity and carbon dioxide concentration.

The objectives defined are: plant and varietal response to multiple stress; controlling gene expression; regulating host-parasite/host-symbiotic relationship; synchronizing flowering; acclimatization of *in vitro* produced plants and response of crops to elevated CO_2 concentration, temperature, and available water, their interaction and incidence of disease and pest.

WATER TECHNOLOGY CENTRE

Almost the same time the inter-disciplinary approach to water management gained recognition globally, late Dr B.P. Pal set up the Water Technology Centre (WTC) at the IARI, New Delhi, in 1970 with partial financial assistance from the Ford Foundation and technical collaboration with the University of California, Davis, USA that housed the first ever such facility internationally. The WTC, IARI, has over the years evolved into a unique institution conducting research and imparting postgraduate education, training and extension services.

The Centre has designed appropriate structures for farm irrigation, water conveyance and has computerized techniques for use of saline water for irrigation and calculation of water balance at and within the crop root zone. It has also contributed towards understanding the physiological basis of drought resistance and crop and irrigation management. Studies conducted at the WTC in collaboration with the Space Application Centre, Ahmedabad, have guided in fixing frequencies of radiometers in the Indian Remote Sensing Satellite IRS1.

Genetic Diversity in *Hordeum vulgare* Linn. (barley), maintained at the Issapur Farms of the NBPGR, New Delhi

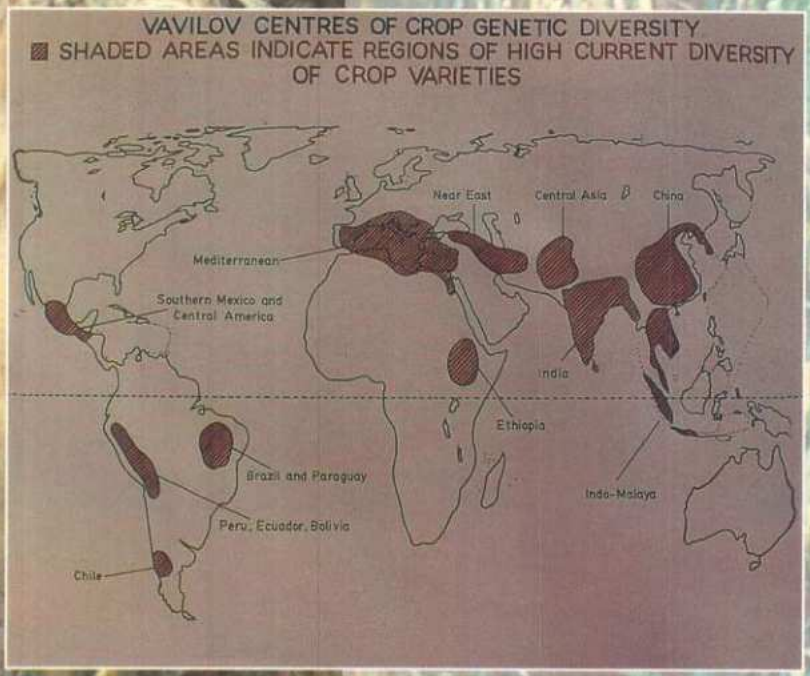
plant genetic resources

The Indian subcontinent is an important centre of origin and diversity for more than 20 major agri-horticultural crop species and their wild relatives — rice, beans, sugarcane, cotton, pigeonpea, citrus, mango, banana, yams, several vegetables, spices, condiments (turmeric and ginger) and a variety of medicinal and aromatic plants.

Nearly 160 domesticated species of economic importance, more than 350 species of their wild relatives, and above 800 species of ethnobotanical interest are natives to this region. They constitute an invaluable reservoir of genes needed by plant breeders for the development of superior crop varieties.

For collecting, conserving and utilizing plant genetic resources, a systematic effort was initiated in 1945 in the erstwhile Botany Division of the Indian Agricultural Research Institute, New Delhi.

The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, has come into existence in 1976, as a nodal office, to cater to a wider mandate — to plan and execute exploration, collection and evaluation of germplasm; to facilitate import-export of germplasm and plant quarantine, and also for safe conservation of both indigenous; and introduced genetic variability in crop plants and their wild relatives.



The NBPGR has spread itself into 12 regional stations and base centres that provide access into representative agri-ecological situations of the country. The Bureau also has a 40-hectare experimental farm at Issapur, 45 km west of Delhi.

The Bureau is interlinked nationally with leading crop-based institutes, national research centres, all-India coordinated crop improvement projects and the state agricultural universities.

Internationally, the Bureau collaborates with several international institutes and organizations. While, the NBPGR makes available the needed genetic material for crop improvement programmes, it conserves valuable genetic diversity *ex situ* for the future.

Shortly to be, the Indian National Gene Bank and Headquarters of the NBPGR, New Delhi.

The Indian National Gene Bank will house more than a million samples of seeds and propagules

INDIAN NATIONAL GENE BANK

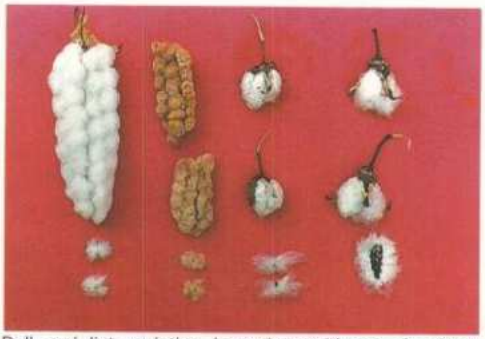
The Indian National Gene Bank has been established by the NBPGR to conserve national heritage of germplasm collections in the form of seeds, vegetative propagules, tissue or cell cultures, embryos and gametes.

Four modules (two units of 100 m^3 and two of 176 m^3 capacity) have been installed for long-term storage of seeds of orthodox species kept in laminated aluminium foils at –20°C after drying them to 5% moisture content. Vegetatively propagated clonal materials and recalcitrant species are being maintained in the field. The Bureau has a strong programme for *in vitro* conservation and cryopreservation of a large number of species.

At present, the facility comprises a seed repository holding nearly 145,000 accessions and a tissue culture repository maintaining over 800 accessions. Around 1,000 samples are also cryopreserved in liquid nitrogen. The Gene Bank facility is being expanded for safe storage of more than one million accessions and, when complete, it will be comparable to the largest facility of its kind in the world.

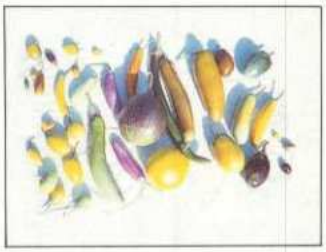
Jojoba EC 33198, an introduction from the USA

Soybean EC 309539, an introduction from Brazil



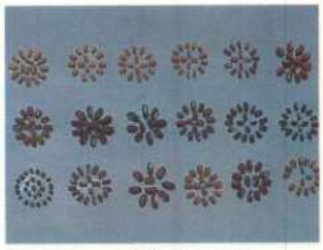
Ball and lint variation in native cultivars of cotton collected from eastern India

A deep purple pigmented land race of rice, AGNISAR (also called SIGNAL BABA) has been collected from the Chaibasa region of Bihar. It is adapted to heavy metal soils

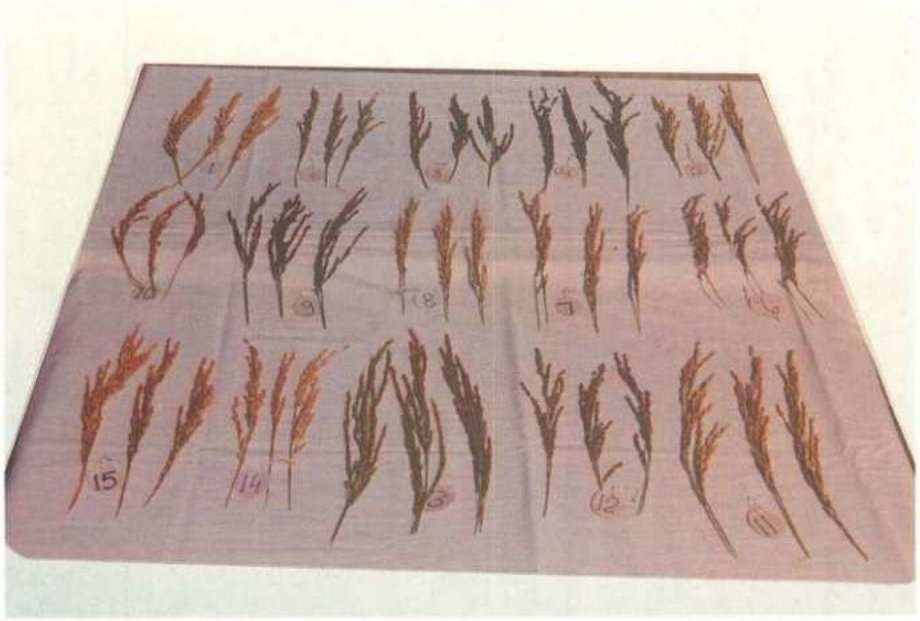


Fruit variability in egg plant

Variability in maize cob collected from north-eastern India



Rice-bean: variation in grain



Land races of rice in Chotanagpur, Bihar

NEW ROLE . . .

Under the new seed policy, the NBPGR has the authority to issue an import permit, phytosanitary certificate and conduct plant quarantine inspection of plant germplasm introduced into the country for research. It is also responsible for the long-term conservation of global base collections of several crops.

DT46 is the first *Triticale* variety to be released in India

crop science

Research in crop science has transformed a chronically food-deficit nation until the mid-sixties into a self-reliant nation since the beginning of the eighties with an adequate buffer stock. All major and minor cereals are a staple diet of a sizeable population, which is perpetually on the rise. In general there has been a marked increase in production of each one of them because of the development and wide adoption of genetically improved varieties and management technologies.

RICE

VIKRAMARYA is the world's first tungro-virus resistant rice

Rice LUNISHREE

Rice GAYATRI

Rice SNEHA

Rice NDRH 2, a hybrid

Hybrid rice production. The tribal *(banjara)* women in Andhra Pradesh are generally engaged in the activity

The all-season rice crop is in cultivation in the Indo-Gangetic plains for over 7,000 years. The crop has thus undergone tremendous selection pressure, natural and manmade.

The crop is grown below sea-level in Kerala, near sea-level in most rice-growing areas and at elevations of 2,500 m in Kashmir. The crop duration is between 70 days and 7 months.

Of the 80,000 botanical rice varieties identified in the world, nearly 40,000 are found in India, predominantly in the north-eastern parts located on the periphery of the centre of origin of the crop. The ARC accessions used worldwide are from this region.

Sensitive to day-length and temperature, with restricted adaptation to different agro-ecologies, the yield potential of these varieties varies from 0.2 to 2.0 tonnes per hectare.

Scientific breeding of the rice crop through pureline selection and hybridization, that commenced in the early twenties in the country has produced the world-famous qualitatively superior GEB 24, BCP 1, T 140, NP 130; the highly prized aromatic Amritsari BASMATI 370 and Dehraduni TYPE 3; disease-pest resistant TKM 6, ESWAROKARA and PATTAMBI strains PTB 10, PTB 18, PTB 21; saline-tolerant SR 26B and those adapted to floods FR 13A, FR 43B and MADHUKAR and for the deep water ecologies, BR 14, JALMAGNA and JAISURIA.

The massive *indica-japonica* hybridization programme of the fifties, an effort at

Analysing soil samples for heavy metal contents, CRRI, Cuttack

Germplasm Garden at the DRR, Hyderabad, houses a working collection of the rice plant diversity

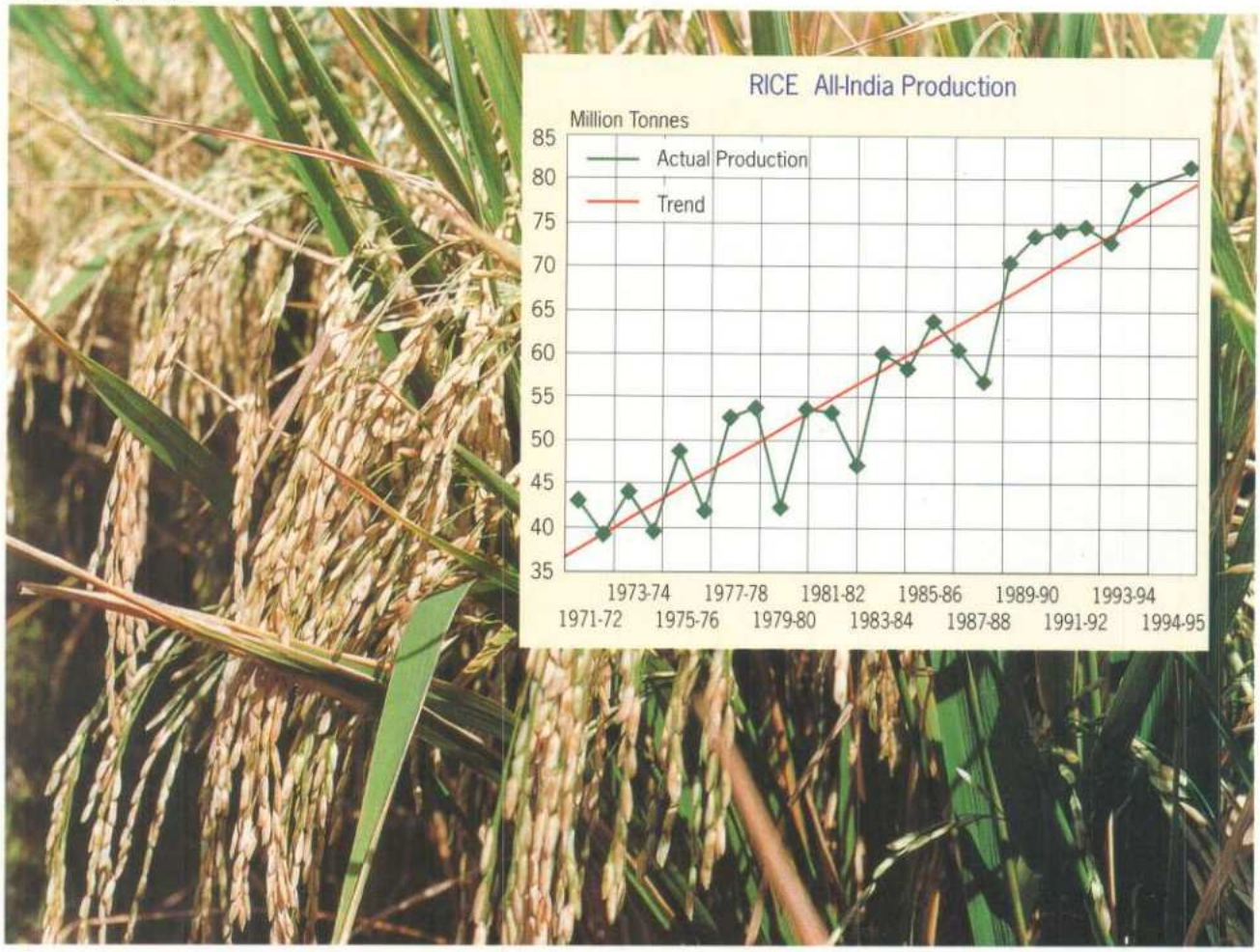
combining the quality characters of the *indica* with the high-fertilizer responsiveness of the *japonica* rices, though proved disappointing is a milestone in our approach at improving the crop. ADT 27, the only outstanding outcome in pre-dwarf era is early maturing, non-sensitive to light, and capable of yielding 4 tonnes/ha.

Unique of its kind in the world, the Central Rice Research Institute at Cuttack (Orissa) set up in 1945, addresses to all problems of the rice plant.

The All-India Coordinated Rice Improvement Project instituted in 1965 facilitates rapid generation and identification of high-yielding varieties for different ecologies through multidisciplinary research-based multilocation testing.

The yield barrier in our tropical rice has been crossed over with "Dee-Gee-Wu-Gen" dwarfing gene sourced from the semi-dwarf short-durationed, day-neutral, fertilizer-responsive variety TAICHUNG NATIVE 1 introduced from Taiwan. The yield has been stepped up from 3 tonnes/ha to 7 tonnes/ha.

CORH 1, a hybrid rice



Rice PUSA HYBRID 1

Seed production in hybrid rice, an experimental plot

There is now a wide choice of high-yielding varieties for irrigated and rainfed ecologies: miracle yielder JAYA; world's first rice-tungro-virus resistant VIKRAMARYA; bacterial-blight resistant AJAYA; gall-midge resistant PHALGUNA; several brown-planthopper resistant varieties; world's first high-yielding dwarf export-quality aromatic rice PUSA BASMATI 1; for rainfed lowlands SAVITHRI, VAIDEHI, RANJIT, JAYSHREE, DHARITRI, SULIVAHANA, LAKSHMI; for uplands PRASANNA, KALINGA III, HIRA, TULSI, ANNADA, ADITYA and for the saline-alkaline conditions LUNISREE and CSBH 10.

Development of hybrid rice is the turning point. India is the second country after China to have commercialized the hybrid technology. Hybrid rice APHR 1, APHR 2, KRH 1, MGR 1, CRH 1 and PHB 71 yield 1.0–1.5 tonnes/ha more than the best ruling variety in Andhra Pradesh, Karnataka and Tamil Nadu.

IN FUTURE . . .

Rice is 42 per cent of the total foodgrains (190 million tonnes) produced at present in the country. By AD 2000, 95 million tonnes of rice, and then on 25–30 million tonnes additionally every decade is our projected requirement. The focus of research will shift to:

- consolidation of yield levels in irrigated ecology
- maximization of yield in diverse rainfed and critical ecologies
- raising of the genetic yield ceiling through physiologically more productive plant types and intensification of the hybrid rice technology.

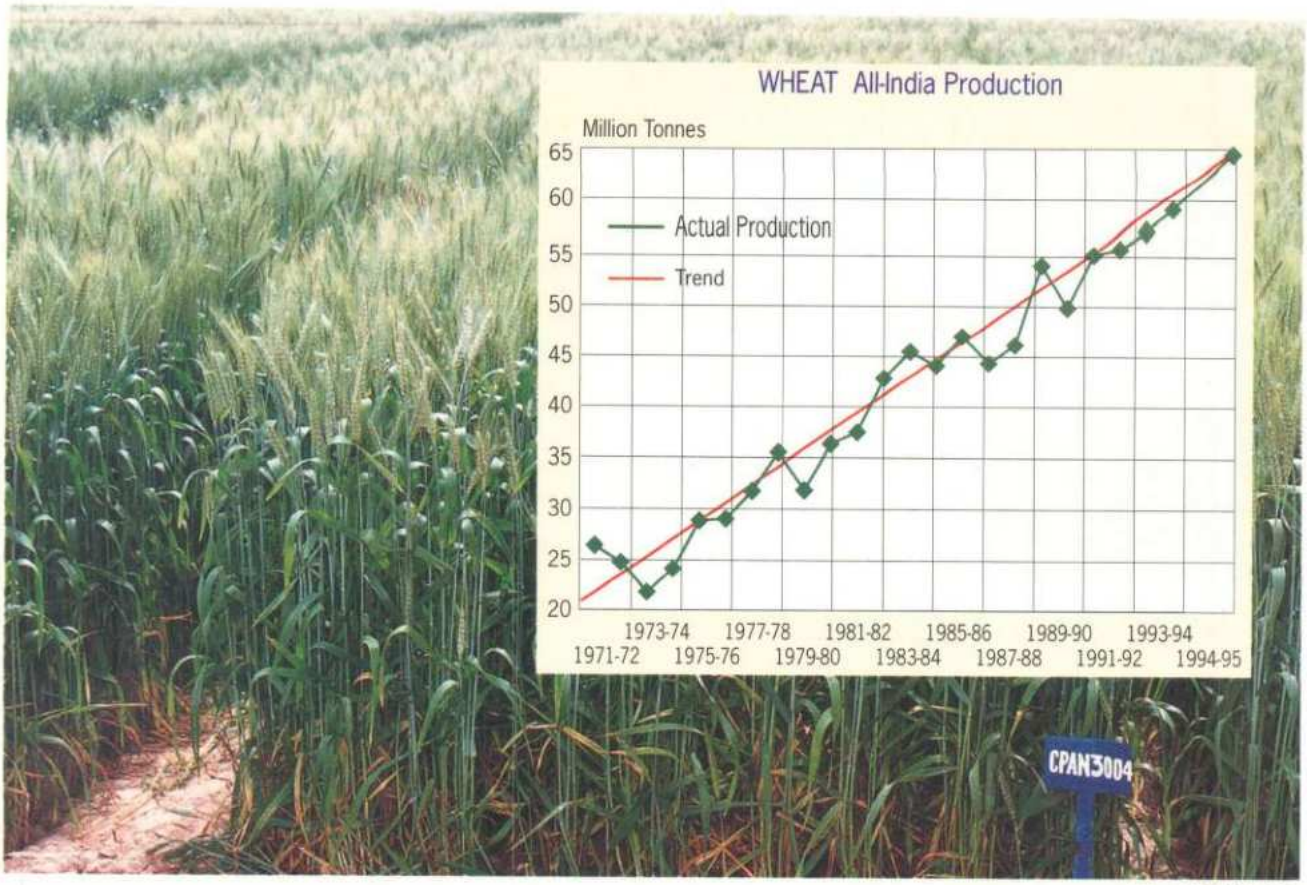
The ICAR is on its way to developing super-yielders with built-in resistance to all stresses.

WHEAT

Wheat NP 4, widely used as donor source for quality improvement

Disease resistance and grain quality have been identified with the varieties of wheat evolved from 1905 to the mid-sixties. Many of them are still used the world over as donor sources for improvement of quality and disease resistance; predominant are HINDI 62, HD 2160, NP 4 and NP 52 for quality, NP 770, NP 809 and NP 829 for resistance to rust. They all are poor yielding. NP 809 is the first variety to have manifested substantial resistance against the three rusts.

Incorporation of 'Norin 10' dwarfing gene from the semi-dwarf varieties introduced from CIMMYT in the sixties conspicuously improved our wheat yields. LERMO ROJO, SONORA 64, direct introductions, and KALYAN SONA and SONALIKA, selections from advanced breeding material S 227 and S 308, also supplied by



Wheat CPAN 3004

Wheat HD 2285

Wheat HD 2329

CIMMYT, are the first batch of high-yielding varieties to be planted in India. The production level of the wheat crop has thus risen from 10.4 million tonnes in 1965–66 to 63 million tonnes in 1994–95; productivity to 2,323 kg/ha from 827 kg/ha.

Systematic research on the wheat crop began in 1905 at the Agricultural Research Institute, Pusa, Bihar, which moved to New Delhi after 1936. Directorate of Wheat Research, starting off as the All-India Coordinated Wheat Improvement Project in 1965, has helped in accelerating breeding research. It is the national centre for research on the wheat crop.

Ninety per cent of the 24.5 million hectares cultivated with the wheat crop is sown with 40–50 high-yielding varieties. The more popular being the irrigated HD 2285, WH 542, UP 2338, PBW 343 for North-West Plains Zone; K 8804, K 9006, HP 1633 for North-East Plains Zone; HI 1077, GW 190 for Central Zone and SUJATA, C 306 and K 8027 for the rainfed regions. HD 2329 and HD 2285, released a decade ago, are still grown in 4 million hectares of irrigated land.

Durum wheat PBW 343 and PDW 215 developed for export have excellent grain characteristics.

Wheat HD 2009 is being grown by countries in our neighbourhood

Wheat HD 2172 has paved way for self-sufficiency in foodgrain in Sudan

Irrigated wheat PBW 343 for North-West Plains Zone

The Indian wheat varieties SONALIKA, WL 711, HD 2009 and HD 2172 are being cultivated in Bangladesh, Pakistan, Nepal, Bhutan, Afghanistan, Sudan and Syria. Sown in 90 per cent of wheat area, HD 2172 has paved way for self-sufficiency in foodgrains in Sudan.

Wheat breeders have developed in all 200 varieties irrigated and rainfed for sowing on time or late in the north-west plains, north-east plains, central India, peninsular India and the northern hills; in salt-affected soils and as durum wheat for export. They have also contributed in the development of varieties resistant to Karnal Bunt, being now used as donor sources elsewhere.

Varieties breaking down in their level of resistance are being replaced. The newer resistant and higher yielding WH 542, UP 2338, PBW 343 have replaced HD 2329 while HP 1631 has replaced SONALIKA.

IN FUTURE . . .

The wheat crop is mostly irrigated. With land and water, both to be scarcer in days ahead, researchers will concentrate on:

- development and propagation of location- and problem-specific varieties
- replacement of varieties in quick succession to safeguard against rust pathogens
- still higher-yielding varieties for salt-affected soils and crop intensification
- raising the genetic yield level under favourable climate.

MAIZE

Multicob SIKKIM PRIMITIVE, a valuable source of germplasm collected from the north-eastern hills of India.

Research in maize is as old as the ICAR. It began at the Indian (Imperial) Agricultural Research Institute in 1930. We reap 10.20 million tonnes from 6 million hectares at present. The productivity has increased 2.5 times, from 627 kg/ha in 1949 to 1,694 kg/ha in 1993.

Improvement in yield has been possible due to rapid generation and identification of productive hybrids and composites since 1960 through collective efforts and multilocation testing in the All-India Coordinated Maize Improvement Project. Historically, the Project is the first to have been started off in 1957.

The hybrids and composites evolved are: GANGA 1, GANGA 101, RANJIT, JAWAHAR, VIKRAM, VIJAY and GANGA 5. Of them in commercial cultivation are SHAKTI, RATTAN and PROTIMA, the high-protein composites carrying the donor-for-quality Opaque-2 gene.

The performance of this recently developed baby corn variety has been much appreciated

The early maturing *kharif* hybrid, as yet in testing, has produced 3.5 tonnes of cob per hectare in 75-80 days

The latest release of hybrid maize GANGA 11 by the Project Directorate Maize, IARI. The Directorate spearheads the country's high-yielding composite and hybrid, yellow-and-white type, maize programme for *kharif* and *rabi* growing. The earlier releases in the series for the Indo-Gangetic belt have been GANGA SAFED, GANGA 2, 5 and 9

North-East India, endowed with rich biodiversity, is considered to be the secondary centre of origin of the maize. SIKKIM PRIMITIVE, recognized as a living fossil, is much used in breeding programmes for increasing the number of cobs on a plant.

Sweet- and pop-corn composites developed in the late sixties are MADHURI SWEET CORN, AMBER POP and VL AMBER POP. A fodder composite AFRICAN TALL has been released in 1980.

The *rabi* crop of maize yields abundantly. Research on this aspect has dominated in the mid-seventies in the south and in the early eighties in the north. HI-STARCH, DECCAN 103, DECCAN 105, and TRISHULATA have been developed for *rabi* cultivation.

Shift in emphasis of late on single-cross hybrids with very high-yield levels has led to several hybrids in the pipeline; PARAS being a recent release.

IN FUTURE . . .

To ensure a steep increase in yield, maize researchers will devote to:

- development of higher-yielding hybrids for high-productive areas and composites for the less-productive areas
- development of single-cross hybrids
- widening the choice of *rabi* hybrids/varieties
- tailoring varieties for varied industrial use.

SORGHUM

Hybrid CSH 9 for *kharif*. Together with CSH 5, also a hybrid, sorghum cultivation in India has experienced a breakthrough in production

Dual-purpose sorghum CSH 13R

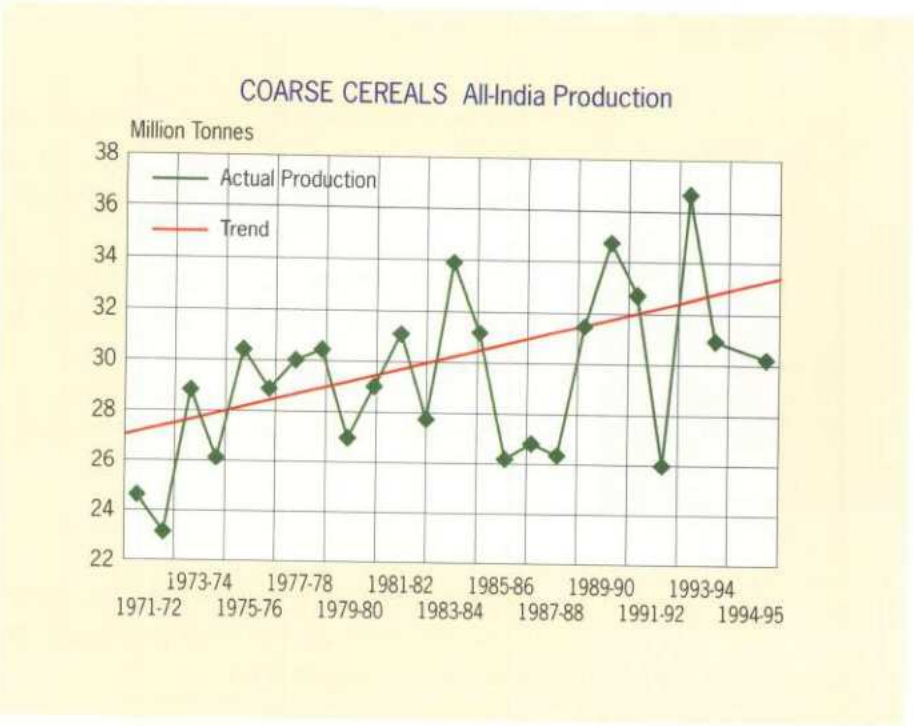
Kharif sorghum SPV 946 has now been released as CSV 15 for growing in *rabi* as well

Sorghum had been a traditional self-pollinated crop until the ICAR started exploring the possibilities of hybrid technology in 1960 and followed with the All-India Coordinated Sorghum Improvement Project in 1969. Sorghum is cultivated in 13–14 million hectares, assuming importance after the rice and wheat. Most of it is rainfed. CSH 1, the first hybrid of sorghum, produced 3 tonnes per hectare even when rainfed. Over years the hybrids released have in general given 3–4 tonnes per hectare in the rainy season *(kharif)* and 4–5 tonnes per hectare in the winter season *(rabi)*. Hybrids CSH 1, CSH 5, CSH 6, CSH 9, CSH 10, CSH 11 and varieties CSV 10, CSV 14, SPV 462, CSV 8R and SWATI are for *kharif* growing, while CSH 13R and CSH 15R are for *rabi* growing. Major yield constraint in *kharif* sorghum is the grain mould; much of the produce therefore finds use in the beverage industry. *Rabi* sorghum, consumed largely as foodgrain, is affected by the shoot-fly.

IN FUTURE . . .

Even though the land planted with sorghum has declined from 18 million hectares to 13 million hectares, the adoption of superior hybrids and varieties have sustained the production level. Further work will lead to:

- development of dual purpose — grain and fodder — *rabi* sorghum hybrids. Combining superior grain quality and resistance to shoot-fly
- development of hybrids and varieties for *kharif* that will combine resistance to grain mould
- development of varieties for diverse industrial use.



PEARLMILLET

India is the first to develop and use hybrids in pearlmillet. Though the possibilities of hybrid technology have been demonstrated long before the discovery and development of cytoplasmic male sterile lines in the sixties, development and commercial cultivation of hybrid HB 1 has been a stimulant. Many more hybrids and composites have followed with an ability to yield 2.0–2.5 tonnes/ha. They have raised the total production to 8.72 million tonnes that was less than a-third, 2.84 million tonnes in 1950. The corresponding average productivity of these hybrids and composites is 824 kg/ha and 306 kg/ha.

The recently released hybrids are HHB 67, PUSA 322, GHB 15, VBH 4, RHRBH 8609, EK-NATH 301, MLBH 104, GHB 235 and HHB 68. PUSA SAFED, ICMV 155, RAJ 171, and ICMV 221 are the composites.


Pearlmillet PUSA 322, a hybrid

IN FUTURE . . .

Pearlmillet is predominantly cultivated in areas receiving a very low rainfall. Forty per cent of the early-maturing crop of pearlmillet is raised in the drought-prone Rajasthan. The crop is also susceptible to downy mildew, the killer disease. With the availability of several parental lines tolerant to downy mildew and moisture stress, the research goal is:

- development of extra early heterotic mildew-resistant hybrids and composites.

SMALL MILLETS

The rainfed baryard millet VL 21 suited for the plains and hills of Uttar Pradesh yields 2.5 tonnes/ha in 80-100 days

The eco-friendly small millets — finger-millet, foxtail millet, kodo millet, little millet, prosomillet and barnyard millet — occupy 5 million hectares of the rainfed fragile habitat. Finger-millet alone is sown in nearly half the total area.

They have remained as crops of regional importance confined to Tamil Nadu, Andhra Pradesh, Karnataka, Uttar Pradesh and Bihar. The improved varieties in cultivation are: VL 149, VL 124, A 404 in finger-millet; GPUK 3 in kodo millet; S 114, AK 130-1 in foxtail millet; S 114, L 5224, L 1387, BHAWNA in prosomillet; KE 12, VL 21, VL 29 in barnyard millet and BIRSA GUNDLI in little millet.

IN FUTURE . . .

The significance of small millets has been realized only lately. An All-India Coordinated Small Millets Improvement Project has been started in 1986. The impetus of research is on:

- development of genetically high-yielding varieties
- adaptation of the crop into inter-and-mixed cropping systems, and
- value addition.

SUGARCANE

The ICAR claims global leadership in "Noble" canes developed by Sir T.S. Venkatraman in the forties at the Sugarcane Breeding Institute, Coimbatore, that started off as the Sugarcane Breeding Substation in 1912. It came up as an Institute in 1924.

For producing disease-free healthy seed of the sugarcane and for crop husbandry, the Indian Institute of Sugarcane Research has been set up at Lucknow in 1952. The All-India Coordinated Research Project on Sugarcane has been established in 1971 to provide boost to multidisciplinary research.


Bamboo germplasm is maintained at SBI, Coimbatore, for performing intergeneric crosses in sugarcane

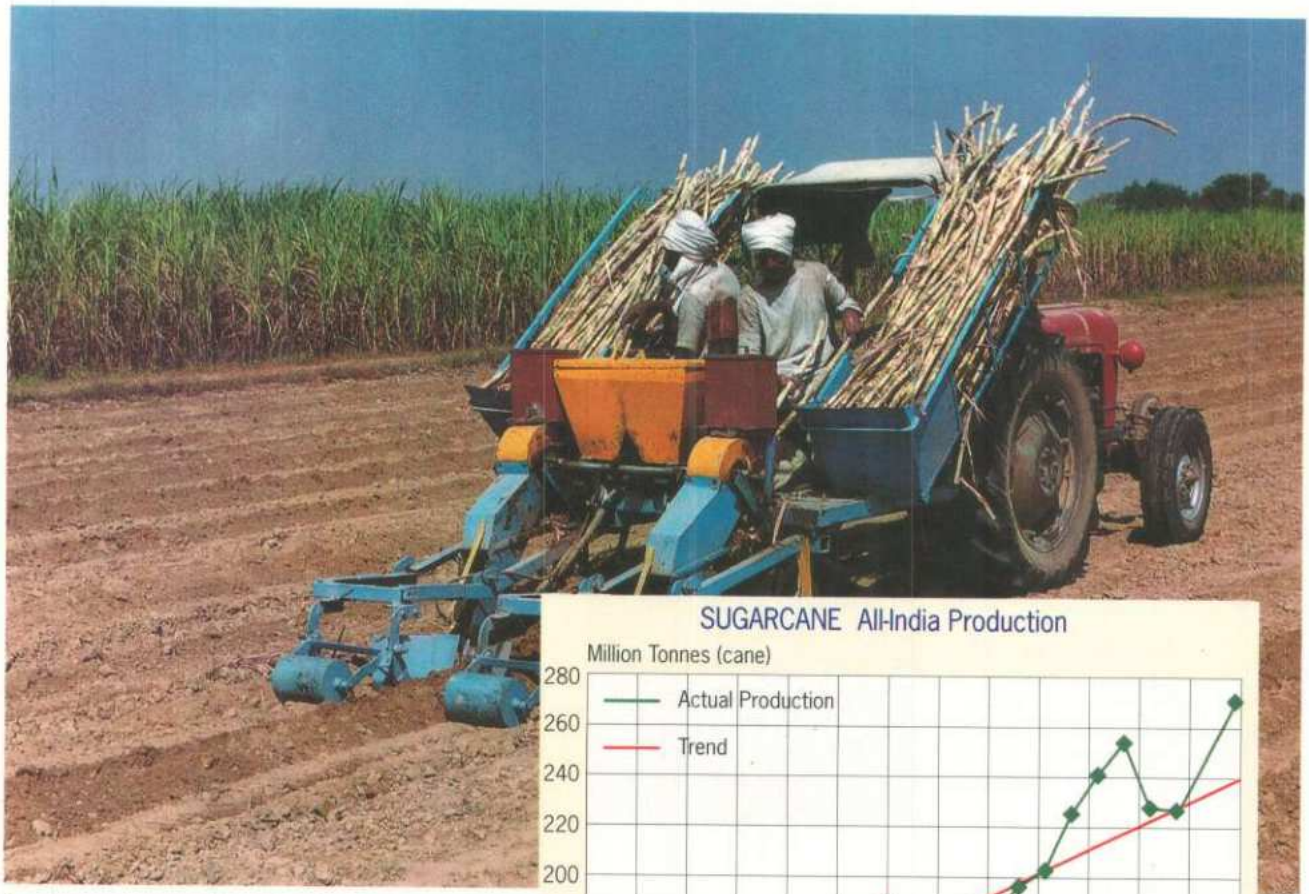
Improvement in yield, quality and adaptation of the sugarcane crop to varied ecologies has been brought about by crossing the cultivated species with the wild species. Acclaimed as revolutionary achievements in artificial plant hybridization, the first ever intergeneric crosses in the crop have been performed with bamboo, sorghum and maize by Sir Venkatraman.

Sugarcane Co 8021

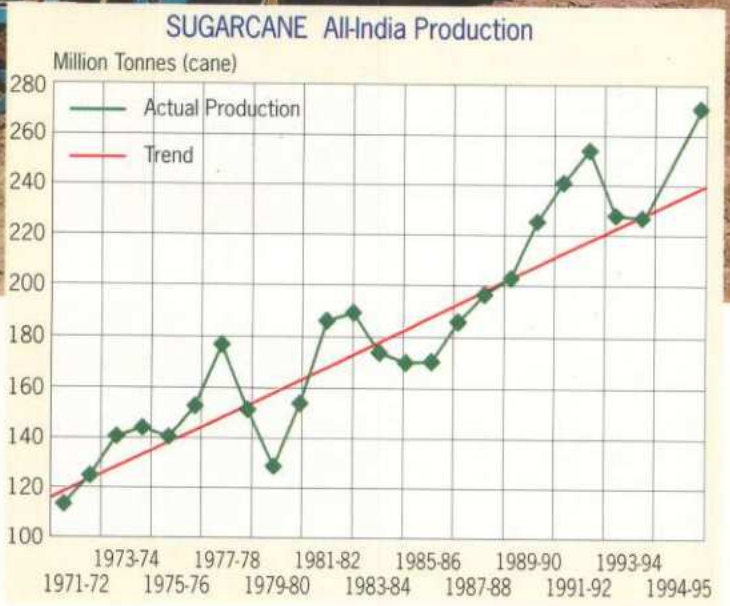
Sugarcane Co 1148

Sugarcane CoC 671

The tropical cane varieties Co 6304, Co 8362, Co 7314, CoC 671, Co 6907, Co 8021 and the subtropical Co 1148, Co 7717, Co 87268 and Co 87277 have ushered in a "Sugar Revolution" in India — producing 13.4 million tonnes of sugar from 3.84 million hectares. Quality of seed, hitherto a problem



Sugarcane cutter-cum-planter developed at the CIAE, Bhopal, is widely used by the farmers in the sugarcane belt of India



Sugarcane germplasm at Cannanore Centre of SBI, Coimbatore

Maintaining fluff for breeding, SBI, Coimbatore

Response to *Azospirillum* and *Azotobacter*, and control (*Left to Right*), Experimental Field, SBI, Coimbatore

. . . MILESTONES IN SUGARCANE RESEARCH

- While area under the sugarcane crop has only doubled (from 1.5 million hectares to 3.6 million hectares), our production has risen 4 times (from 50 million tonnes to 230 million tonnes). We have been able to step up the average productivity 2 times — from 34 tonnes/ha to 63 tonnes/ha, peak productivity being 100 tonnes/ha. And, therefore, we are the largest producer of sugar in the world — 13.4 million tonnes.
- The Sugarcane Breeding Institute (SBI), Coimbatore, holds the largest germplasm collection of the crop in the world — 3,500 accessions.
- The fluff supplied by the SBI, Coimbatore, has led to the development of outstanding varieties — Co J 64, Co C 671, Co LK 8001, Co LK 8102, Co S 767 and Co PANT 84211.
- Integrated Pest Management to control *Pyrilla*; eradication of red-rot in several parts of the country; ratoon management; intercropping and crop physiology in relation to drought are core research achievements in the crop.

Sugarcane CoLK 8102

Meristem of sugarcane is micropropagated commercially for multiplying the seed material by some sugar factories. The protocol has been standaridized at the SBI, Coimbatore

MICROPROPAGATION IN SUGARCANE . . .

In less than five-and-a-half months, 77,760 plantlets of sugarcane may be produced from a single ex plant *in vitro*. The technique has been standardized at the Indian Institute of Sugarcane Research, Lucknow. The cost of a plantlet works out to Re 1.45.

Wonder cane Co 419

because of a very low multiplication ratio (1:8), has been overcome with the sugarcane lending itself to micropropagation.

The wonder cane Co 419 and canes Co 527, and Co 6806 are very popular in African countries Sudan, Kenya, Mozambique, South Africa and the East Asian countries Vietnam and Koreas. The Indian bred Co 419, Co 997, Co 775, Co 312 and Co 740 are widely used as parents in breeding programmes in many countries including Australia and Thailand.

IN FUTURE . . .

The sugarcane yields up to 90 tonnes/ha in the tropics, ideally 120 tonnes/ha in Peninsular India, but 50–60 tonnes/ha in the subtropics and the sugar content normally fluctuates between 17.5 and 19 per cent in the different varieties.

A sugarcane crop is assured of irrigation in the tropics; in the subtropics, it is raised on protected irrigation 2–3 times in summer, excepting Punjab, where the crop is an irrigated one.

Also, the high-sugared varieties are attacked by the red-rot and wilt. Borers also inflict the crop in menacing proportions. Researchers are thus looking for solutions and concentrating on:

- developing high-yielding high-sugar varieties tolerant to red-rot for the subtropics.

OILSEEDS

Niger IGP 76

A male-sterile line of niger

Self-sufficiency in oilseeds is an example of an ideal mix of research policy and research *per se*. Improving the production to 22 million tonnes in 1992 from 8 million tonnes in 1986 has at present generated space for exports. Until 1990, we had been importing edible oils.

Research in oilseeds has been going on since 1947. The Oilseeds Development Council has replaced the Indian Central Oilseeds Committee in 1966 while the All-India Coordinated Research Project added in 1967 has been upgraded to Directorate of Oilseeds Research in 1977.

Our traditional oilseed crops have been: groundnut, rapeseed-mustard, sesame, linseed and castor. Together they yielded 5.16 million tonnes in 1951. With research input, the production has been improved by 13 million tonnes in 4 decades.

THE OIL CROP THAT HAS MADE ALL THE DIFFERENCE : SOYBEAN

The nation has witnessed a turnaround in edible oil scenario. The oil crop that has made all the difference is soybean:

Year	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
1980–81	608	442	728
1993–94	4,320	4,365	1,050
% increase	610	887	39

The crop was introduced into India in AD 1000. Its resurrection as an oil crop of consequence has been due to the research and development efforts put in by the ICAR during the last decade making the country the fifth largest producer of the soybean internationally.

Although the All-India Coordinated Research Project on Soybean came up in 1967, the National Research Centre (NRC) for Soybean has been set up much later, in 1987 at Indore, Madhya Pradesh. Madhya Pradesh has since come to be known as the "soybean state", where the soybean crop is primarily rainfed.

The NRC maintains 2,500 accessions of the crop. Fifty improved varieties suited to different agroclimates are now available to the farmers across the country, with NRC 2, JS 80-21, JS 335 and PB 1 capable of producing adequate plant population for higher yields.

Poor seed longevity in soybean is an inherent problem in the tropics. The scientists have taken care of the anamoly in their breeding programme. Pod shattering, a post-harvest problem, has also been countered genetically by the researchers.

The ongoing priorities revolve on build-up of the soybean germplasm collection, maintenance and evaluation, breeding of varieties with an extended juvenile period, prolonged life of seed and resistance to pod-shattering, insect pests and diseases.

Future research efforts in soybean are: evolving soybean-based cropping systems; development of varieties minus the anti-nutritional factors and beany flavour constituents in order to widen its consumption as high-quality protein food; to groom the indigenous soya industry; to diversify and add to the present-day forex earning of Rs 14,735 million from soybean meal alone.

Early maturing soybean JS 7105

Soybean intercropped with chickpea

Soybean intercropped with wheat. The cropping system is preferred by the farmers

A few good lines of safflower are in testing, such as this one

Castor 48-1 in testing

We are Plentiful in Oilseeds inside 10 years
"an ideal mix of research policy and research"

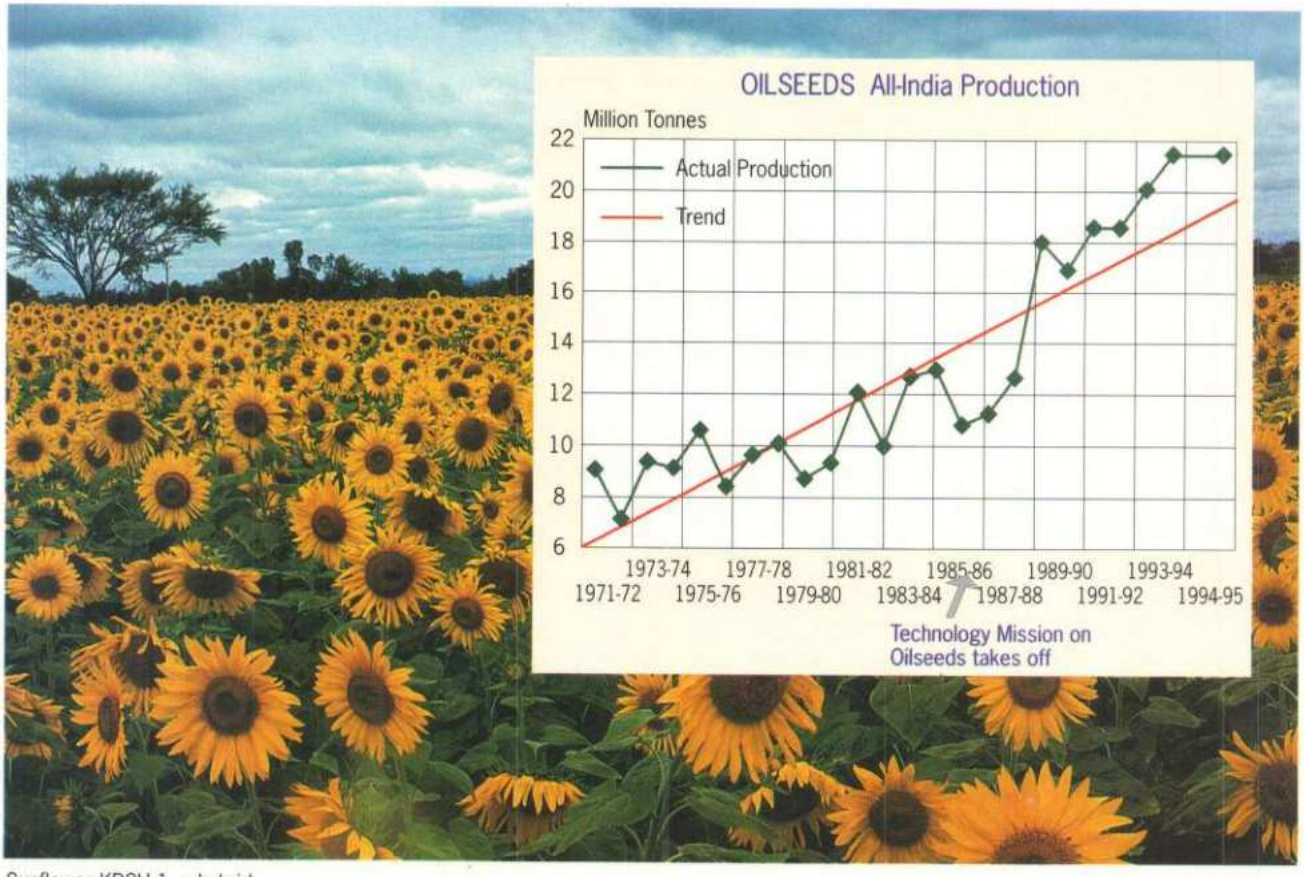
The Technology Mission on Oilseeds framed time-bound programmes with objectives in 1986 to help the nation become plentiful in less than 10 years. The approach has been holistic.

MICROMISSION I : Research and technology development in oilseed crops becomes the responsibility of the Indian Council of Agricultural Research (ICAR)

MICROMISSION II : Processing technology for industrial uses of oilseeds is entrusted to the Council of Scientific and Industrial Research (CSIR)

MICROMISSION III : Transfer-of-technology and extending oilseeds cultivation to non-traditional areas is left to the Ministry of Agriculture, Government of India

MICROMISSION IV : Market intervention for fair price spread is the mandate of the Ministry of Commerce, Government of India.



Sunflower KBSH 1, a hybrid

To avert a drain in foreign exchange reserves because of continuous imports of vegetable oil, the Technology Mission on Oilseeds (TMO) has been set up in 1986. The TMO has introduced new crops soybean and sunflower, and has extended the cultivation of the oilseed crops to non-traditional areas.

During the last 10 years, 176 improved varieties and hybrids have been developed that have paved the way for meeting the nation's oilseeds requirement. The noteworthy varieties are: groundnut TMV 2, JL 24; rapeseed-mustard PGSH 17; soybean JS 80-21, NRC 2 and sunflower KBSH 1, MSFH 8, MSFH 10, MSFH 17 and MSFH 67.

IN FUTURE . . .

The genetic base in groundnut is narrow. In twenty years, the yield has not altered very much in the new varieties. The same holds true for other traditional oilseed crops. Research, therefore would be intensive on the traditional and newly introduced crops that have the potential. In particular it would be for:

- improving the quality of oil to double zero or the canola type (low erucic acid and low glucosinolate)
- developing varieties in sunflower resistant to downy mildew and *Alternaria* blight, and hybrids with more per-hectare oil and yield
- developing non-shattering viable seed varieties in soybean
- improving upon the confectionery grade HPS groundnut varieties for export.

PULSE CROPS

We are predominantly a vegetarian population, meeting the intake of dietary proteins through pulses. The low-yielding pulse crops are grown rainfed.

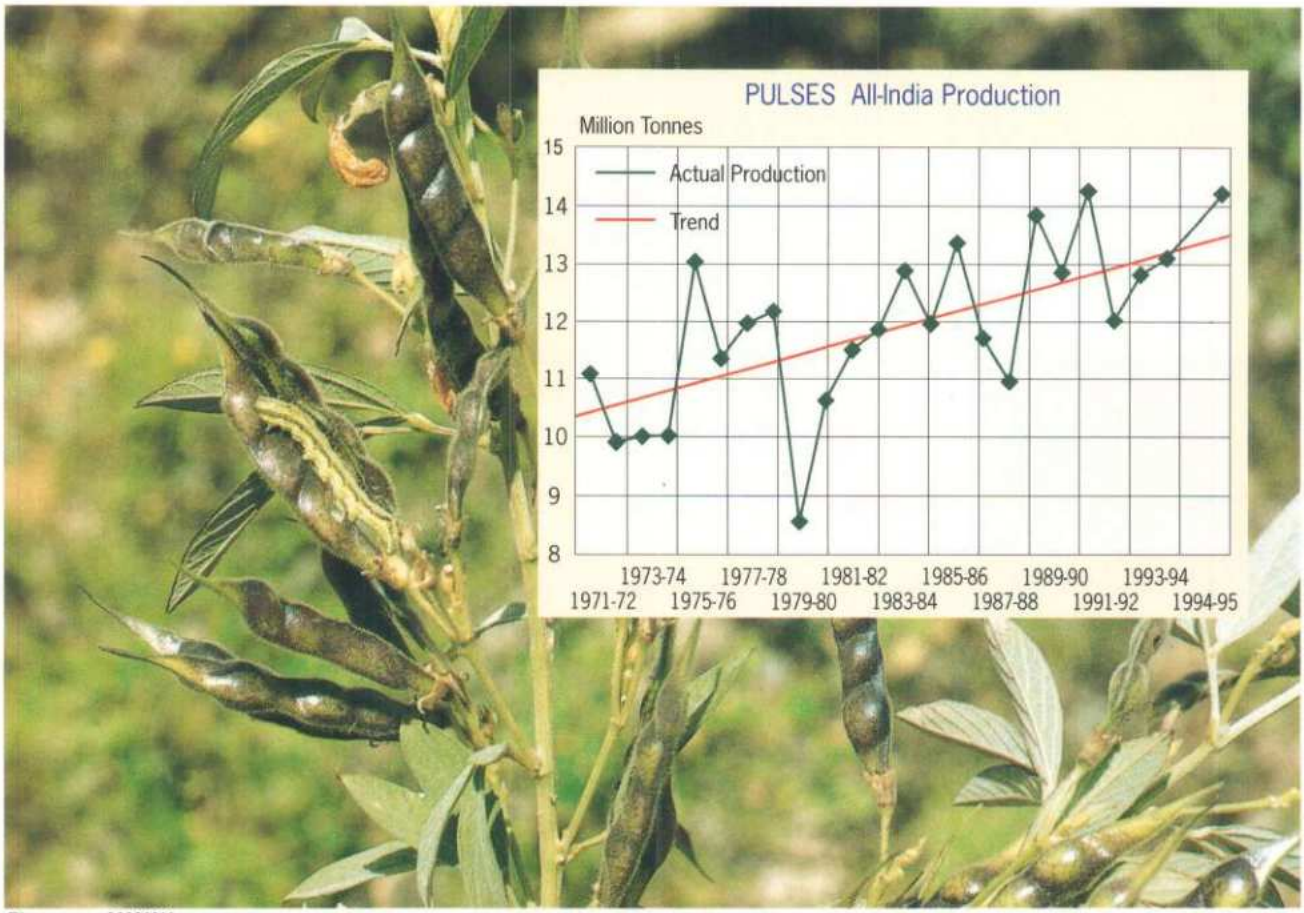
Research on the pulse crops began rather late, in 1966, when an All-India Coordinated Research Project on Pulses was set up. It has been upgraded to a Project Directorate in 1978. The Directorate has acquired a status equal to that of an institute in the Eighth Plan with three All-India Coordinated Research Projects — on chickpea, pigeonpea and MULLARP — also in operation.

The production in pulses has been static for the last 40 years. To repeat the success achieved in oilseeds, the pulse crops have been incorporated into the "Technology Mission" in 1990. A number of improved varieties suited to different agroclimates have been released in the past decade.

TECHNOLOGY MISSION 1990
BOOSTS
PULSE PRODUCTION

Five major pulse crops — chickpea, pigeonpea, moongbean, urdbean and lentil — have been included in the Technology Mission that has directed the success of oilseed crops. The activities related to pulses are:

- Enhancement of genetic resources and genetic improvement of pulse crops
- Development of proper production and protection technologies
- Development of suitable farm machinery and other agricultural equipment
- Production of appropriate quantities of breeders' seed
- Transfer-of-Technology to farmers.



Pigeonpea MANAK

IN FUTURE . . .

To ensure the gains of "Technology Mission", research in pulse crops will intensify on:

- hybrid breeding in pigeonpea
- development of high-yielding varieties resistant to biotic and abiotic stresses
- early maturity for extending crop productivity
- development and wide adoption of integrated pest management against major pests and diseases.

TOBACCO

Nearly 5 million people are engaged in the cultivation and processing of the tobacco in the country. The crop grown in 0.45 million hectare yields 0.50 million tonne; average national productivity being 1.39 tonnes/ha.

The tobacco contributes the highest excise revenue among agricultural commodities in India besides earning a forex equivalent of Rs 5,000 million. All major tobacco types grown in the world are being cultivated in India.

GTH 1, the first non-FCV tobacco hybrid released in India. It is resistant to the root-knot nematode

Planned research on the crop began at the Central Tobacco Research Institute set up in 1947 at Rajahmundry by the Central Tobacco Committee. The ICAR took over the Institute in 1965.

Till then in cultivation were a few FCV tobacco introductions — HARRISON SPECIAL, CHATHAN, DELCREST, VIRGINIA GOLD, with DELCREST outproducing them all (0.9–1.15 tonnes/ha). The addition of the All-India Coordinated Research Project in 1970 assisted the CTRI in evolving KANAKAPRABHA, JAYASRI, HEMA, SWARNA, GAUTHAMI and L 1158, all yielding between 1.5 and 1.8 tonnes/ha.

These high-yielding varieties possessed attributes suitable for cigarette (FCV), chewing, cheroot, cigar-wrapper and hookah. JAYASRI (MR) is resistant to the Tobacco-Mosaic Virus, MC NAIR 12 to black-shank, SWARNA to powdery mildew, BHAVYA to black-shank and root-knot nematodes. Natu tobacco LANKA SPECIAL carries resistance to powdery mildew.

Virginia tobacco L 1158

The CTRI caters to the production of foundation seed of all the scientifically-bred varieties in different tobacco-growing regions. Of tobacco FCV, 10,000 kilos of seed, and of LANKA SPECIAL, 1,200 kilos are distributed each year to cover the entire tobacco-growing area in the country.

Agrotechniques — plant population, fertilizer application, summer ploughing, transplanting time, topping and sucker control, fumigation of nursery beds — have been perfected for the crop. Ideal management of the white-fly and the leaf-eating caterpillar through IPM is now in practice.

Alternative uses of the tobacco crop to produce solanesol, cirtic acid, malic acid, nicotine sulphate and edible protein are being intensively researched upon.

In *bidi*-tobacco, the yield has been increased with the application of fertilizer prior to transplanting. Improved varieties ANAND 2 and ANAND 119 have replaced S 20 in Nipani. NPN 90 and PL 5 are the newer releases. In Gujarat, GT 4, drought-tolerant, and GT 5, the first variety to possess a shy-suckering habit and resistance to root-knot nematode but high nicotine content, have been preferred by the farmers.

IN FUTURE . . .

Since alternative uses of tobacco are gaining ground, future research will emphasize on:

- increasing productivity of the crop
- developing safer-leaf varieties.

COTTON

Cotton, an important industrial crop, accounts for 85 per cent of the raw material fed to the 900 textile mills with an installed capacity of 21.08 million spindles.

Improvement of Indian cottons has commenced in the 1920s with the establishment of the Indian Central Cotton Committee (ICCC). Since 1966, the ICCC has been abolished and the ICAR has taken over research on the crop.

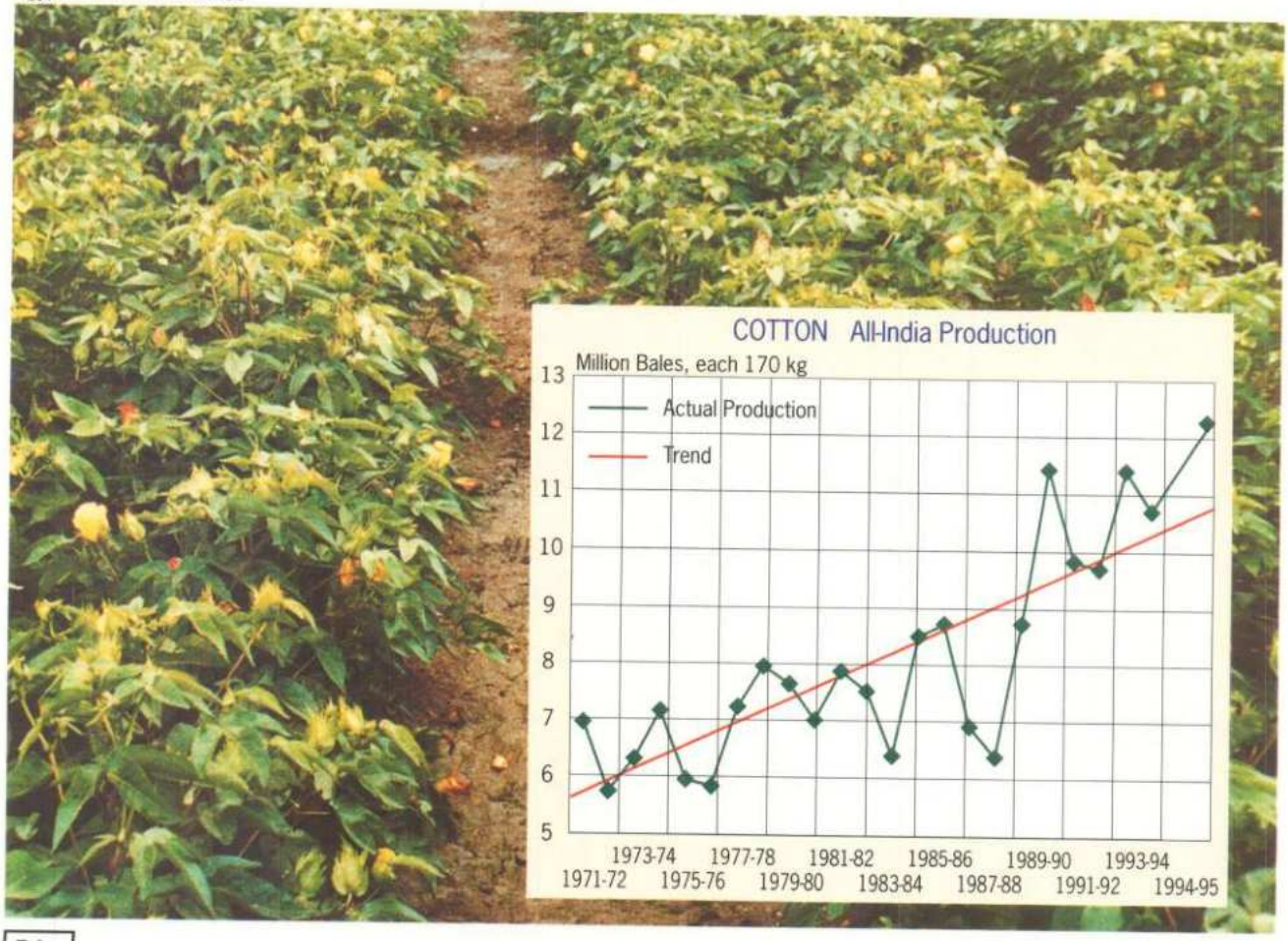
In 1967 an All-India Coordinated Cotton Improvement Project has been launched with headquarters at Coimbatore, and over years, centres have been set up at different cotton-growing states.

The Central Institute for Cotton Research (CICR) set up at Nagpur in 1976 has its regional stations at Coimbatore and Sirsa.

Although increase in production during the fifties has been largely due to area expansion, the uptrend in production in the past two decades has been due to increase in productivity alone — from 100 kg lint/ha in 1954–55 to 261 kg lint/ha in 1992–93.

In fact the area covered by the crop has stabilized at 7.5 million hectares during this period. Total production in the country has risen from 2.75 million bales to 11.58 million bales of cotton of all staple lengths.

Cotton SUVIN in flowering. It is comparable with GIZA 45, the best Egyptian cotton worldwide



More than 100 varieties and 20 hybrids belonging to four staple lengths have been developed by the ICAR. Of them LAXMI, SUVIN, BIKANERI NERMA, H 777, F 414, MCU 5, LRA 5166, SRT 1, G COT 11, V 797, JAYDHAR and hybrids HYBRID 4, VARALAXMI, H 6, DCH 32, G COT HYBRID 7 have added to the total yield significantly.

HYBRID 4 is the first hybrid of cotton to be released in the world

India is the only country to have developed and grown hybrid cotton commercially—both, the long-staple premier hybrid cotton H 4 and the extra-long staple interspecific VARALAXMI and DCH 32. SUVIN gives the finest-quality cotton with spinning performance of 120s counts. It is comparable with GIZA 45, the best Egyptian cotton.

The latest additions are early-maturing hybrids FATEH, DHANLAXMI and RAJHANS for Punjab, Haryana and Rajasthan, the north-west region. Production- and plant-protection technologies for the crop are near perfect.

Interspecific hybrid VARALAXMI

. . . HYBRIDS IN COTTON

India is the only country in the world to have produced and commercialized hybrids in cotton.

H 4 and VARALAXMI are the earliest hybrids developed in 1970 and 1972. To follow are: FATEH, DHANLAXMI and RAJHANS for north-west India. They are early-maturing, intra-*hirsutum* hybrids. LDH 11, an intraspecific hybrid (bengalense x cernuum), is an *arboreum* cotton.

In pipeline are: CHH 107, LHH 121, LHH 144, CSHA 29, CSH 33, PUNJAB HB 354 and PUSA HB 322.

Ten years ago we were importing a million bales of cotton; at present we are exporting a million bales of cotton and textiles worth Rs 250,000 million, 33% of the total forex earned by the country.

IN FUTURE . . .

To produce 18 million bales by the turn of the century and to remain competitive in the international market, our research strategies are:

- development of more heterotic hybrids of medium-and-long staple length and sowing more cotton area with them
- development of high-yielding varieties and hybrids for rainfed and critical environment
- stabilization of yield through development and adoption of integrated management approach against pests and diseases.

JUTE & ALLIED FIBRES

Jute is predominantly a crop of eastern India. Jute production had been 1.6 million bales and productivity 1.13 tonnes/ha in 1947. With the combined efforts of the Indian Central Jute Committee until 1966 and the ICAR subsequently, the area, production and productivity of the jute and mesta have increased across the country.

The area under the jute crop has now stabilized at 0.8 million hectares and that for mesta at 0.35 million hectares. India produces about 7.3 million bales of the jute fibre and 2.0 million bales of the mesta fibre. However, there has been an increase in productivity from 1.1 tonnes/ha to 1.9 tonnes/ha in jute and from 0.8 to 1.1 tonnes/ha in mesta. Tossa jute yields have been raised up to 2.5 tonnes/ha under ideal conditions.

The Indian Central Jute Committee set up in 1936 has been re-established as Jute Agricultural Research Institute near Barrackpore, West Bengal, in 1953. The Jute Technological Research Laboratory is located in Calcutta, while the coordinated research centres are operating in most jute-growing states since 1967. Together they provide a strong infrastructure for research on the fibre crops.

Replacement of varieties and management techniques have been progressively contributing to improvement in yield of both jute and mesta. Poor-yielding traditional varieties like CHINSURAH GREEN (*olitorius*) and D 154 (*capsularis*), cultivated widely in the fifties, have been replaced with the high-yielding JRO 632 (*olitorius*) for mid-April sowing, JRC 212 (*capsularis*) for mid-March sowing in the mid- and -high lands and JRC 321 for the lowlands.

Between 1961 and 1970, JRO 878 replaced JRO 632 and new high-yielding mesta varieties HC 583 (*cannabinus*) and HS 4288 (*sabdariffa*) came into cultivation. For improving extraction of the sisal and ramie fibres, a decorticator has been developed.

Several advances in the fibre crops have been achieved during 1971–80 — the non-premature flowering *olitorius* JRO 7835 and JRO 524, *capsularis* JRC 7447 (responsive to high-fertilizer doses) and JRC 4444 for Orissa, and a non-bristle mesta HS 7910. The germplasm pool for both crops has been built up with 765 collections of jute and 121 collections of mesta. The Central Nucleus Jute Seed Multiplication Farm, Bud Bud, Burdwan, is supplying the breeders' seed regularly.

Ideal cropping systems — jute–paddy–wheat for alluvial tracts and jute–paddy–potato for sandy loam soils — have also come into practice.

The boost in yield of ramie varieties R 1411, R 1412, R 1449 and R 1452 has been largely through agronomic practices. Besides, a ribbon-type decorticator has been developed for jute, mesta and sunnhemp.

The subsequent advance in yield has come with the release of JRO 3690 (*capsularis*), HYBRID C (*sisal* hybrid), and ramie R 67-34. The germplasm collection has been augmented to 3,000 in jute and 506 in mesta. For paper pulp, MT 150, a mesta variety has been developed. In addition, UPO 94 (*capsularis*) and TJ 40 (*olitorius*) from the Jute Research Station, Baharaich and Bhabha Atomic Research Centre, Trombay, have been released through the All-India Coordinated Research Project on Jute and Allied Fibres. Mesta AMC 108 (*cannabinus*) and AS OP-3 (*sabdariffa*) developed at Mesta Research Station, Amadalavalasa, are also in cultivation.

IN FUTURE . . .

Value-added products from jute — fine yarn, blended yarn, speciality fabric and non-woven jute waste materials— are gaining acceptance. Raw jute requirement by AD 2000 is expected to be 10.5 million bales. Therefore,

- development of still higher-yielding varieties will be one approach, improvement in retting practices the other.

UNDER-UTILIZED CROPS

Over dependence on select crops must stop. Instead, alternative crop plants more familiar with habitats, less demanding on natural resources and inputs — commodities becoming scarcer each passing day — must find use.

To identify the more suitable alternatives, the ICAR has begun research on the under-utilized and under-exploited plants nation-wide in 1984. Currently, 22 centres located in different agro-ecological zones are operating.

The programme embraces on potential indigenous and exotic crops of food, fodder, energy and industrial value. More than 7,100 accessions of select under-utilized crops have been built up over years.

Germplasm collection of Amaranth

Headway in acquisition of germplasm evaluation, documentation, utilization, conservation, varietal development and standardization of cultivation practices has been made. Select examples are:

***AMARANTH* SP.**

A grain, vegetable and fodder crop, the amaranth has high protein with high

Standardization of agrotechniques in Amaranth

Amaranth hypochondrian x *A. tricolor*

Amaranth intercropped with maize, Shimla

Rice-bean RBL 1 for cultivation in Punjab

Amaranth ANNAPURNA yields 1.8-2.5 tonnes/ha

lysine content, a good balance of essential amino acids and a very wide adaptability.

Amaranth ANNAPURNA and ORA 8801 have been released for the hills and GA 1 and SUVARNA for the plains. They yield 1.8–2.5 tonnes/ha.

FAGOPYRUM SP.

Apart from edible value as grain and vegetable, *Fagopyrum* has medicinal importance because of the presence of a glucoside "rutin". It is suitable for cultivation in the Himalayan region and the south Indian hills. It is amenable to poor and acidic soils.

The buckwheat HIMPRIYA has been released for higher altitudes, and VL 7 for the mid-hills of Uttar Pradesh. They yield 1.0–1.5 tonnes/ha.

VIGNA UMBELLATA

The rice-bean can be grown in the hills where moongbean and urdbean fail to grow. The crop has a fair degree of resistance to the foliar diseases. It is edible. It is also useful as a green manure and cover crop.

Rice-bean adapts well in the humid sub-tropical and warmer climates. Rice-bean RBL 1 is cultivated in Punjab, RBL 6 in the north-east and north-west and PRR 8801 in the north-west hills.

Faba bean cultivation is picking up in India

Winged bean AKWB 1 has been released for the humid subtropics

VICIA FABA

Of very high nutritive value, the faba bean is regarded a substitute for meat and skimmed milk. Faba bean may be eaten fresh or canned.

It is being cultivated in the European countries on a large scale. UHC 82-1 gives a grain yield of 4.2 tonnes/ha.

PSOPHOCARPUS TETRAGONOLOBUS

The multipurpose crop is rich in protein and oil. It is capable of very efficient nitrogen fixation.

Winged-bean AKWB 1 may be grown in the humid subtropics of the north-east Bengal, Bihar and Western and Eastern Ghats.

SIMMONDSIA CHINENSIS

The exotic jojoba is a hardy shrub native to Mexico and the south-west USA. The oil from the seeds is a substitute of whale-sperm oil. It may be used as a lubricant and diesel when mixed with alcohol, and in pharmaceuticals and cosmetics.

Jojoba grows well on arid and coasted wastelands. Valuable germplasm from the USA has been collected. EC 33198 is a promising jojoba introduction.

CITRULLUS COLOCYNTHIS

The perennial drought-hardy creeper grows on sandy, undulating plains and sand dunes. The pale yellow oil from the seeds contains an alkaloid, a glucoside and saponin.

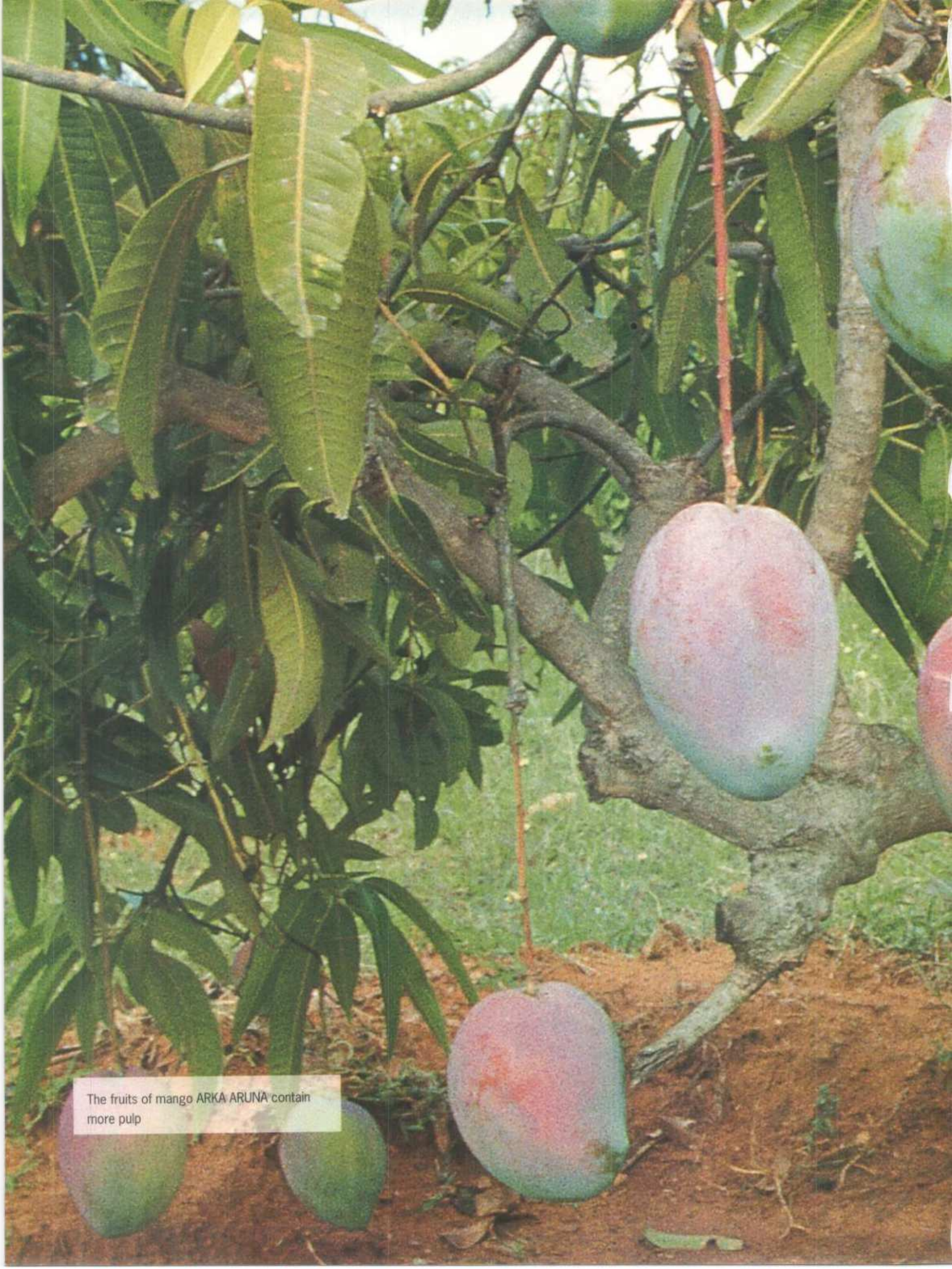
The dried pulp of the unripe fruits freed from the rind constitutes the dry 'Colocynth'. The roots too have medicinal uses.

SALICORNEA

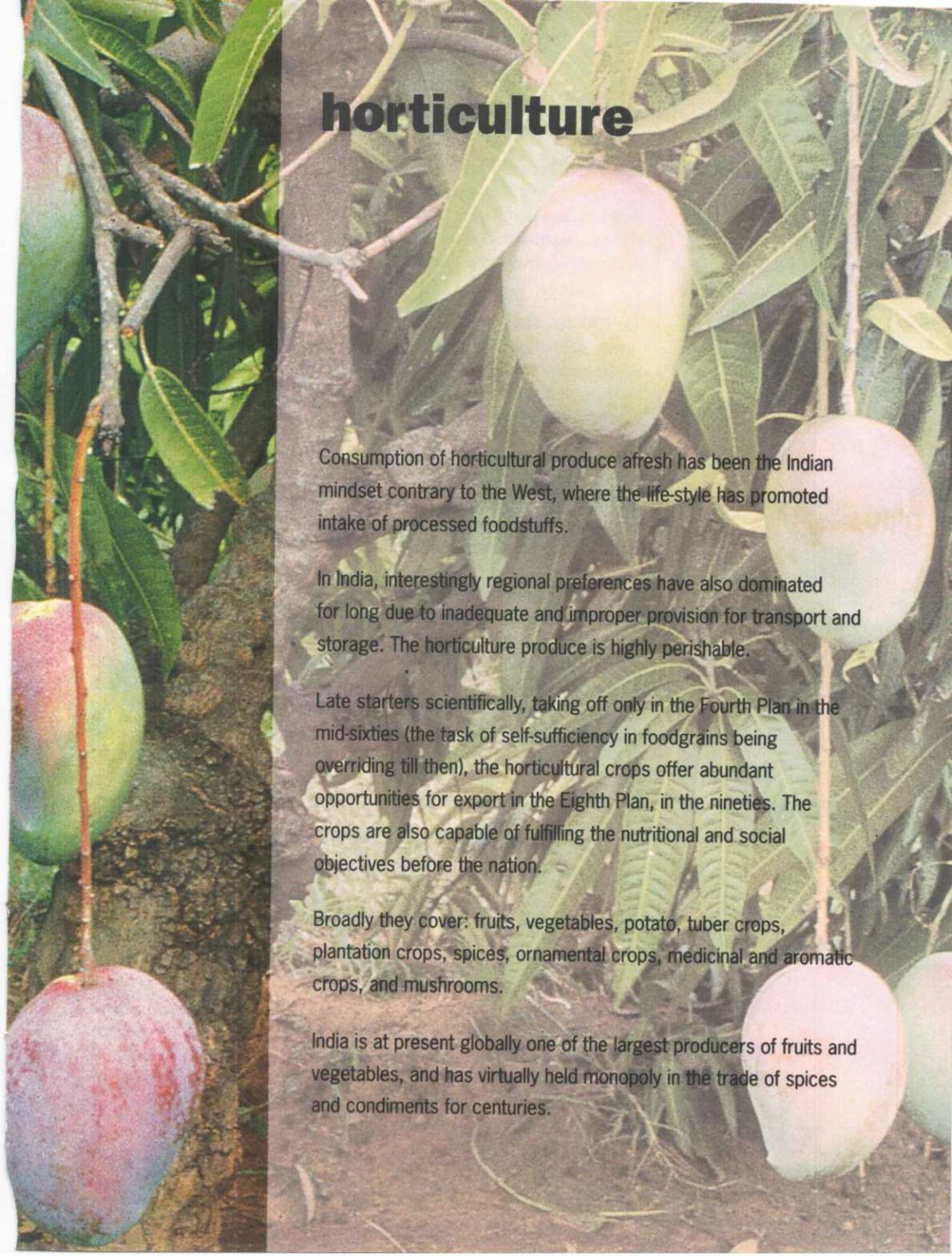
The halophyte is cultivated as a food crop in southern France and the UK. However, the seeds contain an oil akin to that produced from safflower and protein content comparable with that of soybean de-oiled cake.

IN FUTURE . . .

While identification of more crops will continue, introduction of alternative crops into the existing cropping systems and land-use systems would be a priority.



The fruits of mango ARKA ARUNA contain more pulp



horticulture

Consumption of horticultural produce afresh has been the Indian mindset contrary to the West, where the life-style has promoted intake of processed foodstuffs.

In India, interestingly regional preferences have also dominated for long due to inadequate and improper provision for transport and storage. The horticulture produce is highly perishable.

Late starters scientifically, taking off only in the Fourth Plan in the mid-sixties (the task of self-sufficiency in foodgrains being overriding till then), the horticultural crops offer abundant opportunities for export in the Eighth Plan, in the nineties. The crops are also capable of fulfilling the nutritional and social objectives before the nation.

Broadly they cover: fruits, vegetables, potato, tuber crops, plantation crops, spices, ornamental crops, medicinal and aromatic crops, and mushrooms.

India is at present globally one of the largest producers of fruits and vegetables, and has virtually held monopoly in the trade of spices and condiments for centuries.

INFRASTRUCTURE

Central Potato Research Institute, Shimla, has contributed to the tremendous success of the potato crop in India

Before the Second Plan, only *ad-hoc* schemes for horticulture had been operating. During the Second Plan, the latter half of the fifties, 8 regional horticultural research stations and 12 horticultural substations had been set up in various agroclimatic zones of the country. There has been, however, a rapid expansion of infrastructure during the Seventh and Eighth Plans.

The ICAR has at present 8 CRIs, 1 PD, 10 NRCs and 17 AICRPs engaged in research on horticultural crops. The coordinated projects are being implemented in 210 centres located at the state agricultural universities and central research institutes. In addition, more than 90 projects are also in operation with financial support of the AP Cess.

The first full-fledged institute to work on fruits, vegetables, ornamentals and medicinal and aromatic plants, and postharvest management of horticultural produce, the Indian Institute of Horticultural Research (IIHR) has been established in 1968 at Hessaraghatta, Bangalore, Karnataka. Although, the Central Potato Research Institute (CPRI), Shimla, has come up in 1949 and the Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, in 1963. Research on coconut has been continuing since 1916 at Kasaragod, but the Central Plantation Crops Research Institute (CPCRI), Kasaragod, has come up only in 1970. The other institutes devoted to research on horticultural crops are: the Central Institute of Subtropical Horticulture (since 1984); ICAR Research Complex for Goa (since 1989); Central Institute of Temperate Horticulture (since 1994); and the Indian Institute of Spices Research, Calicut (since 1995). The Indian Institute of Spices Research started off as National Research Centre for Spices in 1985.

RESEARCH

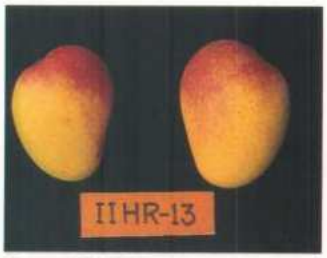
On most horticultural crops (except potato, tuber crops, coconut, arecanut and some spices) systematic research is nearly two decades old.

FRUIT CROPS

Regular bearing in mango — genetic and paclobutrazol-induced; high-density planting in mango, banana and pineapple; hardy rootstock in citrus; use of gibberellic acid to improve berry-size and quality of grape; commercialization of arid fruit crops ber, aonla and pomegranate; introduction and expansion of KINNOW mandarin in Punjab, Haryana, Rajasthan and Himachal Pradesh and standardization of softwood grafting in mango, cashew and sapota have led to marked improvements in production and productivity of the fruit crops.

Mango ARKA ANMOL

Mango ARKA ARUNA



Mango ARKA PUNEET

NEWER HYBRIDS OF MANGO . . .

Dwarf, regular bearing, free-from-spongy-tissue hybrids of mango have been developed at the Indian Institute of Horticultural Research (IIHR), Bangalore.

ARKA ARUNA (BANGANAPALLI x ALPHONSO). Suitable for high-density planting (400 plants/ha). Average fruit weight 400 g; TSS 20° Brix. Yield 20–24 tonnes/ha.

ARKA PUNEET (ALPHONSO x BANGANAPALLI). Average fruit weight 225 g; flesh firm, good flavoured; pulp fibreless, deep orange in colour. Yield 10–12 tonnes/ha.

ARKA ANMOL (ALPHONSO x JANARDHAN PASAND). Average fruit weight 300 g. Pulp fibreless; excellent sugar-acid blend. Yield 11–12 tonnes/ha.

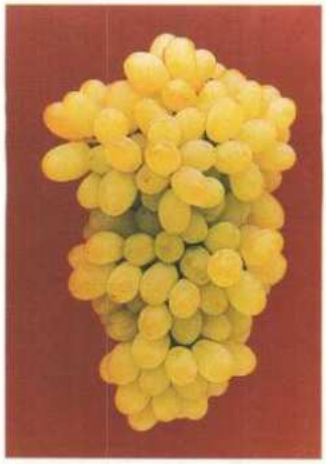
While several varieties have been identified in apple for commercial growing, many high-yielding varieties have been developed in mango (MALLIKA, AMRAPALI, ARKA ANMOL, RATNA, SINDHU); banana (Co 1, H 1, H 2); grape (ARKAVATI, ARKA NEELMANI, TAS-E-GANESH, DILKUSH); citrus (PRAMALINI, VIKRAM, PKM 1

Paclobutrazol-fed mango trees in bearing. These mango trees have no off-season

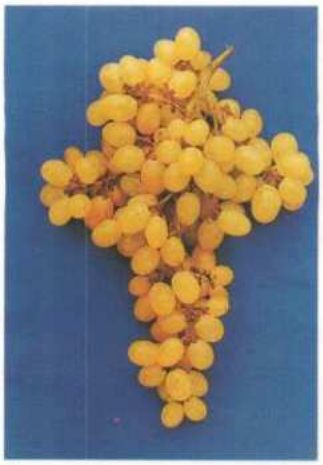
ONGOING BASIC RESEARCH ON MANGO. . .

- Though regular flowering has been induced at the IIHR, Bangalore, by spraying the trees five times with 200 ppm ethrel and 0.1% urea commencing mid-September, the trees become devitalized. Suitable alternatives are being looked for.
- Soil drenching of Paclobutrazol @ 5 g/tree promotes flowering and fruit-set during the off-years. Residual effect of the chemical in soil continues for 2–3 years and irregular bearing is offset; instead early and higher yields encouraged. Long-term effects of continued use of Paclobutrazol remain to be assessed.
- In mango ALPHONSO, the gene for spongy tissue is homozygous and recessive. It has been established by crossing ALPHONSO with BANGANPALLI, KALAPADY and JANARDHAN PASAND; susceptibility to spongy tissue has proved to be a recessive character.
- Mango malformation may be partially controlled by spraying Mangiferin -Zn 2 and Mangiferin -Cu 2+ chelates OR by pruning the diseased portions and following up with a spray of Bavistin (0.1%) or Captaf (0.2%).

BREEDERS CONCENTRATE ON HYBRIDS OF GRAPE . . .

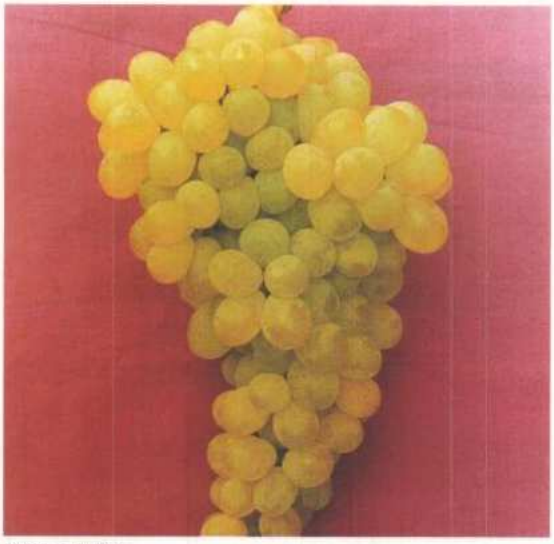


THOMPSON SEEDLESS, an introduction



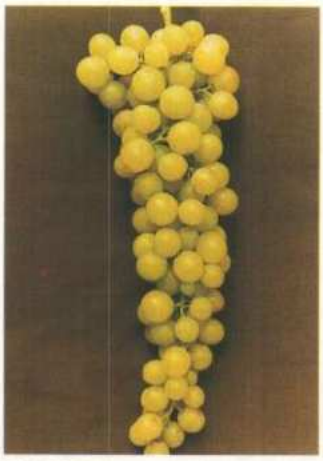
ARKA KANCHAN

ARKA NEELMANI



ARKA SHWET

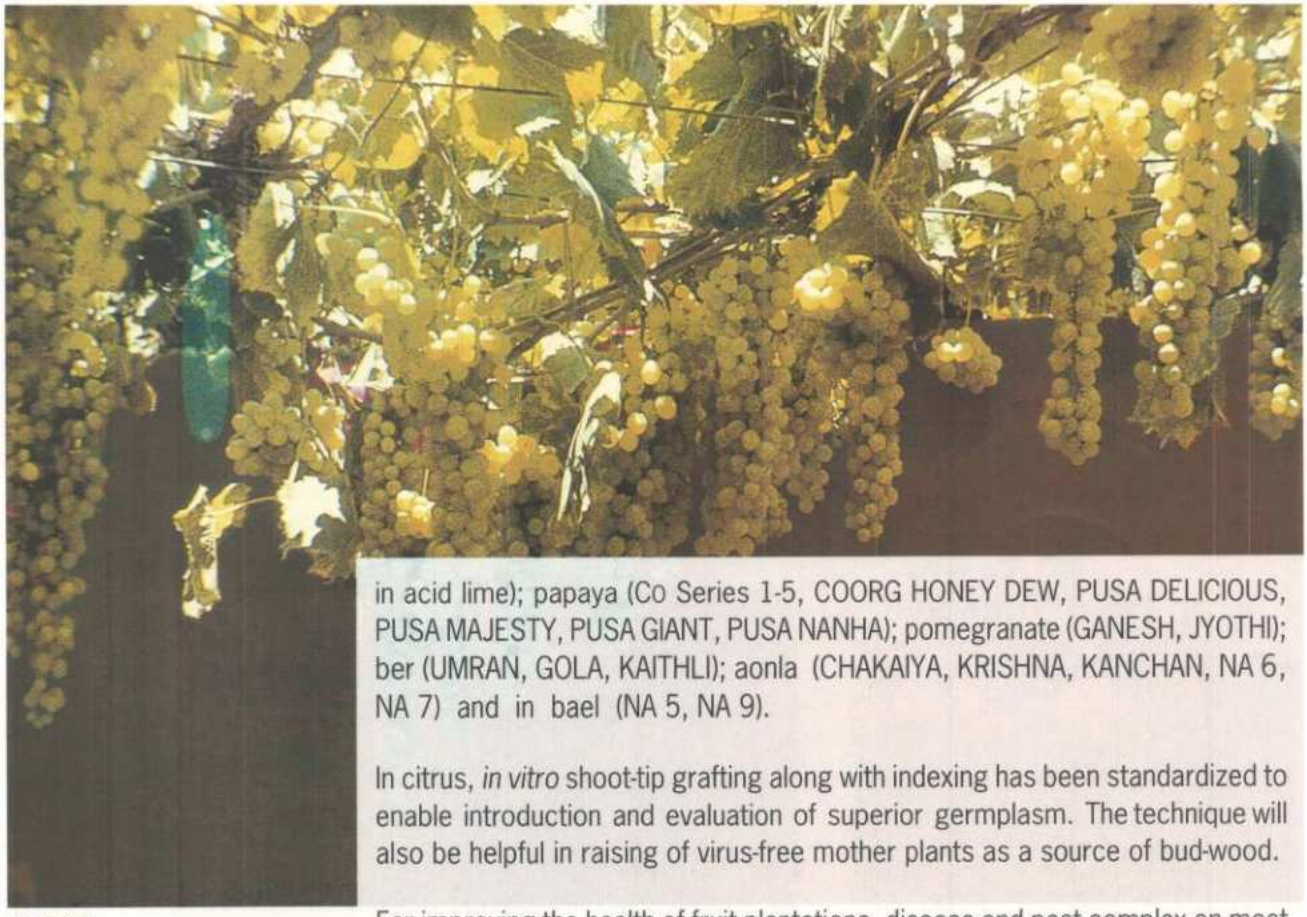
ARKA SONAKA



ARKA SOMA

Improvements in grape have been aimed at developing hybrids resistant to diseases and for table consumption, raisin-, juice- or wine-making. More than 13,000 hybrid seedlings have been evaluated at the IIHR, Bangalore, for releasing grape hybrids ARKA KANCHAN, ARKA NEELMANI, ARKA SHWET, ARKA SONAKA, ARKA SOMA and ARKAVATI.

The IIHR, Bangalore, maintains a germplasm collection of 606 species of the grape and allied genera.



ARKAVATI

in acid lime); papaya (Co Series 1-5, COORG HONEY DEW, PUSA DELICIOUS, PUSA MAJESTY, PUSA GIANT, PUSA NANHA); pomegranate (GANESH, JYOTHI); ber (UMRAN, GOLA, KAITHLI); aonla (CHAKAIYA, KRISHNA, KANCHAN, NA 6, NA 7) and in bael (NA 5, NA 9).

In citrus, *in vitro* shoot-tip grafting along with indexing has been standardized to enable introduction and evaluation of superior germplasm. The technique will also be helpful in raising of virus-free mother plants as a source of bud-wood.

For improving the health of fruit plantations, disease and pest complex on most of them has been identified. Integrated Pest Management or protective sprays, conscious of pesticide-residue levels, are now a practice with the growers.

Prescribed use of grape guard prolongs the shelf-life of the fruits up to 12 weeks (*right*)

The postharvest problems are: a limited shelf-life, the task of transporting the produce across extremely varying climate regimes, and the existing lack of facility for ideal storage to enable better price spread to the grower.

Research on postharvest has produced some solutions which have been adopted commercially. They are:

- A crop of NAGPUR MANDARIN may now be handled with negligible losses until it is sold. The technique takes care of the harvest from pre-cooling to increasing its shelf-life.
- In grapes, use of card fibre-board cartons, grape guard, pre-cooling at 2°– 4°C and 94 per cent relative humidity have prolonged the storage life of the fruit. The shipped consignment reaching its European destinations is absolutely healthy.
- The technology for converting grapes into raisin is being used on a commercial scale.

Mango, IIHR, Bangalore

Citrus, NRC Citrus, Nagpur

Custard-apple, IIHR, Bangalore

Papaya, IIHR, Bangalore

Guava, IIHR, Bangalore

OUR GERMPLASM GARDENS OF FRUITS SAFEGUARD CONSIDERABLE DIVERSITY

Papaya COORG HONEY DEW

Papaya PUSA NANHA

Aonla NEELAM

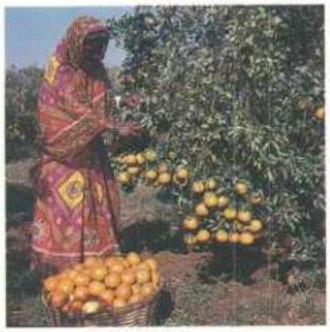
Tissue culture in banana

Pomegranate GANESH

GROWERS' PREFERENCE

Bael NARENDRA BAEL 5

Guava SARDAR



Mandarin KINNOW

Peach CHAKLI BIG, an indigenous selection

NATIONAL RESEARCH CENTRE FOR CITRUS, NAGPUR

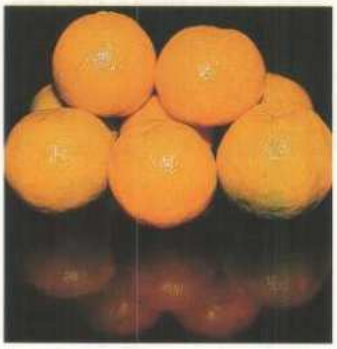
"Still Young, but making Rapid Strides"

Situated in the NAGPUR MANDARIN belt, the NRC for Citrus, has vouched to solve the problems of the growers and offer them better varieties of the mandarin. The crop has tremendous scope for export.

Dr H.C. Dass, Director, interacting with the growers

An experimental orchard at the NRC Citrus, Nagpur

Monitoring the postharvest performance of NAGPUR MANDARIN in storage chambers at the NRC, Citrus, Nagpur



NAGPUR MANDARIN N_2 (*far left*) and N_5 (*left*) are new selections

Packing line operations standardized at the NRC Citrus, Nagpur. The NAGPUR MANDARIN has now several destinations offshore. . .

IN NAGPUR MANDARIN . . .

'the pre- to post-harvest schedule for maintaining the health of fruits during transport'

- Apply 3 sprays of Bavistin or Benlate or Topsin M @ 1 g/litre spacing each 15 days apart. At ambient temperature, up to 3 weeks, postharvest diseases are no cause of worry
- Precool the fruit with forced air at 6° – 7° C
- The National Research Centre for Citrus, Nagpur, has mechanized all operations for bulk handling, sorting, washing, waxing, sizing and packing of fruits. Waxing of the fruit is done using high-shine wax (2.5%) in combination with Bavistin (4000 ppm). Adopt the packing line
- For short-term storage (20–25 days), a chamber has been developed on the principle of evaporative cooling. The chamber is cost-effective and each structure can store up to 1.5 tonnes of the produce
- Telescopic vented corrugated fibre-board boxes (50 cm x 30 cm x 30 cm) have proved better for forced-air precooling. They have come to replace the wooden boxes used in distant transportation traditionally.

Sorting

Washing

Fungicidal wax-coating

Size-grading

In packing

Vented telescopic containers

VEGETABLE CROPS

Quantitative preference is edging out flavour in breeding of improved varieties in vegetable crops, the fact cultivation of vegetable crops is expensive. A typical example is the tomato, where the acid-flavoured low-yielding PUSA RUBY has been fast replaced with hybrids for shear bulk harvests and shelf-life. Importantly the nutritional value is not at stake.

In all, more than 150 varieties have been released in 20 vegetable crops. Of the 26 F_1 hybrids released, 9 have been recommended by the Central Variety Release Committee.

Varieties that have brought about a revolution in vegetable cultivation are: bottlegourd PUSA SUMMER PROLIFIC LONG and PUSA SUMMER PROLIFIC ROUND (IARI); hybrid brinjal ARKA NAVNEET (IIHR); Indian cauliflower PUSA DEEPALI, EARLY SYNTHETIC and PUSA HYBRID 2 (IARI); cabbage PUSA MUKTA (IARI); tomato ARKA VIKAS; ARKA ALOK and ARKA ABHA (IIHR), PUNJAB CHHUARA (PAU), BT 1 (OUAT), LE 79 (KAU); capsicum ARKA MOHINI and ARKA GAURAV (IIHR); chilli PANT C 1 (GBPUAT); peas ARKA AJIT (IIHR); watermelon ARKA MANIK and ARKA JYOTI (IIHR); muskmelon PUNJAB HYBRID (PAU); okra ARKA ANAMIKA, ARKA ABHAY (IIHR); PARBHANI KRANTI (MAU); onion N 53 (MPAU); ARKA NIKETAN, ARKA KALYAN, ARKA PITAMBER and ARKA BINDU (IIHR); pumpkin ARKA CHANDAN (IIHR) and Dolichos bean ARKA JAY and ARKA VIJAY (IIHR).

Onion ARKA KALYAN

Onion PUSA MADHVI

The Diamond-back moth severely damages the tropical cole crops. For which, an integrated pest management schedule has been standardized.

Development of *kharif* onions LIGHT RED, N 53, ARKA KALYAN and AGRI-FOUND have expanded the availability of the crop, particularly in northern India.

Onion ARKA BINDU

Chilli PUSA SADABAHAR

Chilli PUSA JWALA

Chilli ARKA LOHIT

CONSUMED FRESH AND PROCESSED

Tomato BRH 1

Tomato PUSA HYBRID 1

Tomato RAINFED SELECTION 1

Tomato ARKA ALOK

Brinjal BWR 12

Brinjal ARKA KESHAV

Brinjal ARKA NAVNEET

Brinjal ARKA NEELKANTH

UP-MARKET VEGETABLES

Capsicum ARKA GAURAV

Capsicum ARKA MOHINI

Cauliflower PUSA SYNTHETIC

Cabbage PUSA MUKTA

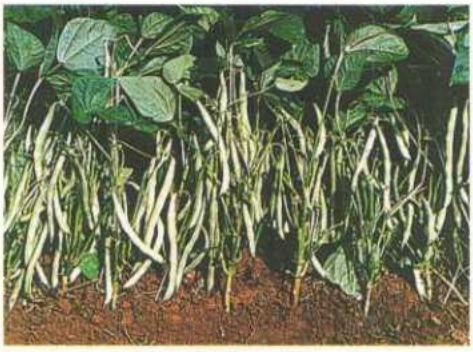
Cauliflower PUSA HYBRID 2

Cauliflower PUSA EARLY SYNTHETIC

Cabbage GOLDEN ACRE

Dolichos bean ARKA JAY

Cowpea ARKA GARIMA



French-bean IIHR SELECTION 909

Carrot PUSA MEGHALI

Carrot PUSA YAMDAGINI

Amaranth PUSA KIRTI

Radish ARKA NISHANT

IMPROVEMENT IN OKRA . . .

In India, the okra (*Hibiscus esculentus* Linn.) occupies 369,684 hectares next only to chillies (738,000 hectares), the largest cultivated vegetable crop. Uttar Pradesh, Orissa, Bihar and West Bengal lead in its cultivation.

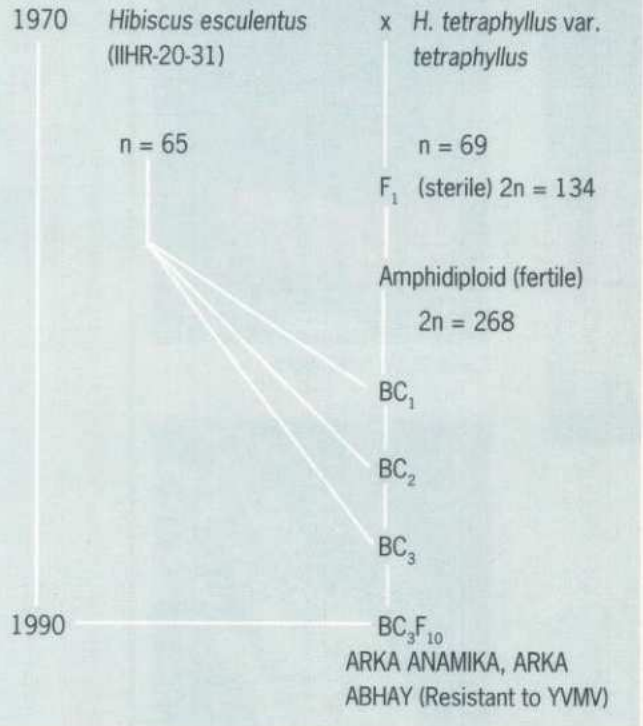
The immature tender green fruits of the tropical vegetable, rich in calcium (90 mg/100 g of fresh weight) are eaten fresh, dehydrated, frozen or canned. It is exported chiefly to the Middle-East, Gulf and western Europe.

Yellow-vein mosaic virus (YVMV) can devastate up to 93.3 per cent of the crop. Fusarium and low temperature stresses are the other limiting factors.

RESEARCH HAS FOUND SOLUTIONS FROM TIME TO TIME

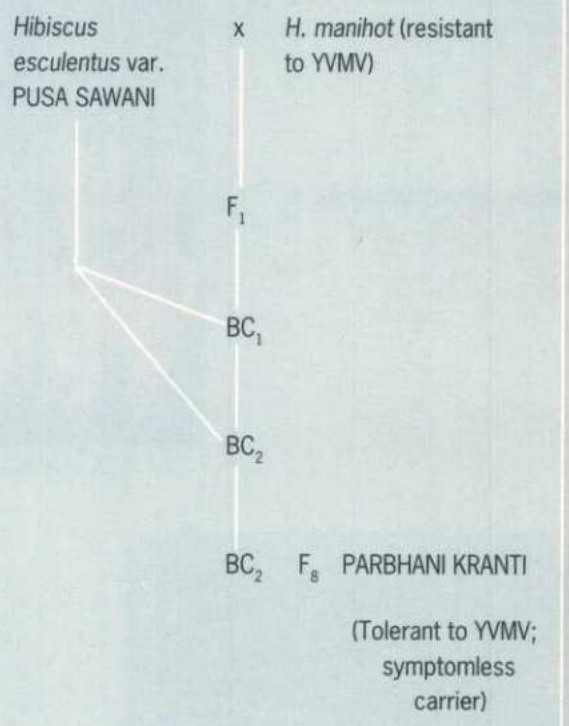
1950	No improved variety
1955	Okra PUSA MAKHMALI — qualitatively superior but susceptible to YVMV
1960	Okra PUSA SAWANI — tolerant to YVMV grown throughout the country
Late Sixties	YVMV resistance breaks down in PUSA SAWANI. No replacement available
1985	Okra PARBHANI KRANTI and P 7 both tolerant to YVMV released by the Maharashtra Agricultural University, Parbhani, and the Punjab Agricultural University, Ludhiana
1990	Okra ARKA ANAMIKA and ARKA ABHAY also resistant to the YVMV released by the Indian Institute of Horticultural Research, Bangalore
At present	ARKA ANAMIKA and PARBHANI KRANTI very popular with the growers.

PEDIGREE OF ARKA ANAMIKA and ARKA ABHAY



ARKA ANAMIKA and ARKA ABHAY yield 17.5–25 tonnes/ha in 130 days depending upon the season. The fruits are long, remain tender even up to 20 cm length, are lush green in colour and borne in two flushes. Both possess very good cooking-and-keeping qualities.

PEDIGREE OF PARBHANI KRANTI



PARBHANI KRANTI yields 8.5–11.5 tonnes/ha in 120 days depending upon the season. The fruits are medium long, green and tender at marketable stage. It has good cooking-and-keeping qualities.

"IT TOOK US NEARLY TWO DECADES TO TACKLE YELLOW-VEIN-MOSAIC VIRUS IN OKRA"

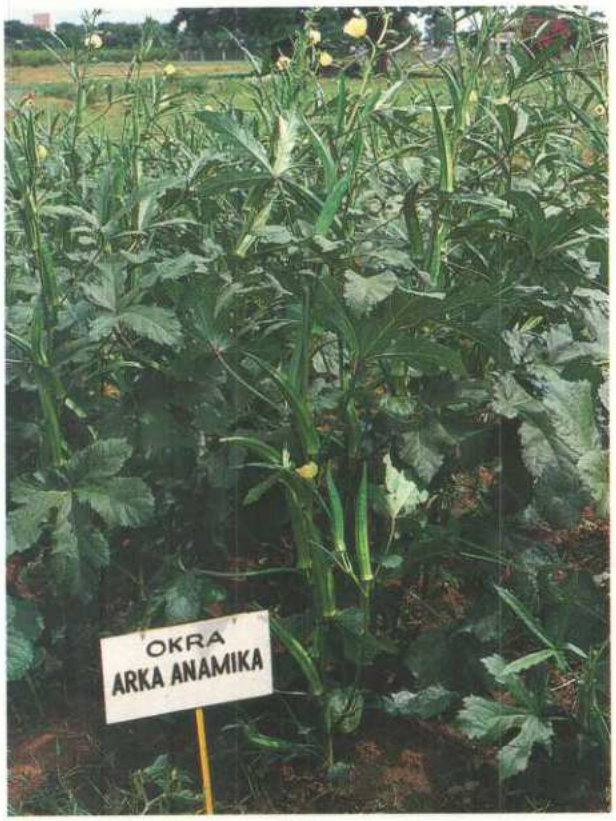
Yellow-vein susceptible okra

Wild source

Experimental plants of ARKA ANAMIKA. Dr O.P. Dutta, the breeder in conversation with physiologist Dr N.K. Srinivasa Rao

Branching and cluster-bearing pattern in ARKA ANAMIKA

Fruit-bearing habit, *close-up*



ARKA ANAMIKA in the farmers' fields

The tender pods, very uniform in size of the yellow-vein-mosaic-virus- resistant okra ARKA ANAMIKA

OKRA

- **Domestic consumption is high**
- **Demand for export, rising**

DISEASE-RESISTANT VARIETIES COME HANDY, WHEN FARMERS CAN ILL-AFFORD HYBRIDS

Triple disease-resistant : Watermelon ARKA MANIK

Anthracnose, Fusarium-wilt, powdery-and-downy mildew and watermelon bud-necrosis afflict the watermelon crop (*Citrullus lanatus)* grown throughout India. Anthracnose is particularly serious in the southern and eastern India. SUGAR BABY, CHARLSTON GREY and ASAHI YAMATO though popular are susceptible to Anthracnose.

DEVELOPMENT OF ARKA MANIK

Project launched at IIHR, Bangalore	1969
Source of resistance to Anthracnose	Watermelon CRIMSON SWEET (IIHR 4)
to powdery-and-downy mildew	Local collection IIHR 21 from Rajasthan

1969 IIHR 21 X IIHR 4

F_1

BC_1

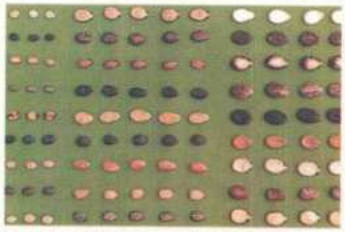
BC_2

BC_2F_5

1976 ARKA MANIK
(triple resistance, to Anthracnose, downy- and powdery-mildew

Watermelon ARKA MANIK in farmers' fields

In multilocation trial	During 1976–1980
Released in	1980
Notified at national level	1990
Yield	60 tonnes/ha in 110 days
Average fruit weight	6 kg (but fruits weighing 12–15 kg not uncommon)
TSS	12–13%
Colour of flesh	Crimson
Keeping quality	Very good



Seed variability in watermelon

Bittergourd PRIYA

Bittergourd PUSA HYBRID 1

Bittergourd PUSA DO MAUSAMI

Bottlegourd PUSA NAVEEN

Bottlegourd ARKA BAHAR

Roundgourd ARKA TINDA

REGIONAL PREFERENCES DOMINATE . . . RESEARCH FACES MANY CHALLENGES

Muskmelon ARKA JEET

Muskmelon PUSA RASRAJ

Turnip PUSA SWETI

Pumpkin ARKA CHANDAN

POTATO

We consume potato as a vegetable. Research on the crop began in 1935 at the newly established potato-breeding substation of the Indian Agricultural Research Institute, acquiring the status of a full-fledged Institute, Central Potato Research Institute, Shimla, in 1949.

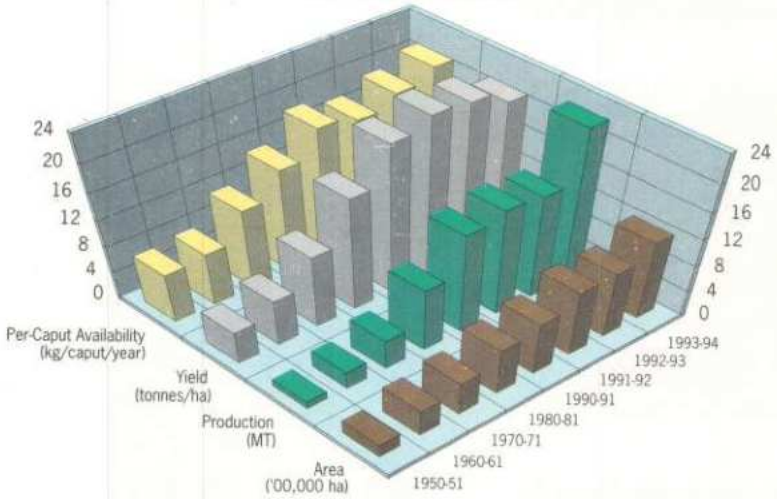
Early collections of the potato varieties and species had been built up at this station especially with the cooperation of the Commonwealth potato expeditions. The germplasm has been used to breed 25 improved potatoes of which KUFRI JYOTI, KUFRI LALIMA, KUFRI SINDHURI, KUFRI CHANDERMUKHI,KUFRI BAHAR, KUFRI BADSHAH, KUFRI LAUVKAR and KUFRI SWARNA are grown commercially.

The Institute has also developed the seed plot technique, which makes use of low-aphid periods for growing disease-free seed stocks of potato in the plains of northern India. The technique has been widely adopted by the farmers.

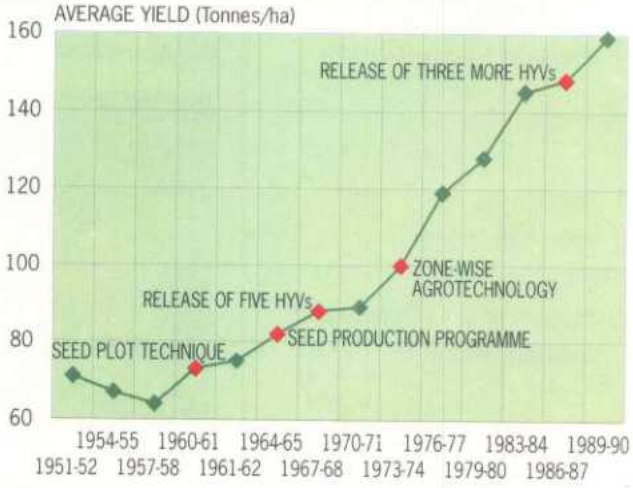
The cost involved in transportation of the potato seed is often exhorbitant and its availability to remote growers untimely. True Potato Seed (TPS) has proved to be an alternative therefore. TPS populations TPS C_3 and HPS 1/13 are in commercial cultivation since 1992 and yield 30 tonnes/ha.

Central Potato Research Station, Kufri

POTATO
AREA, PRODUCTION, YIELD AND PER-CAPUT AVAILABILITY IN INDIA



POTATO YIELD IN INDIA
"UPTREND"



Interculture operations are mechanized

Potato-based cropping systems in study

Potato grader empties the four grades of potatoes into different bags

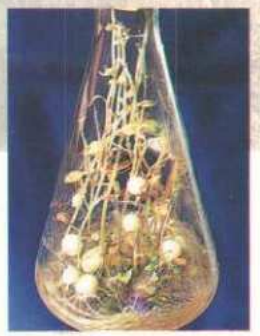
Potato intercropped with barley

POTATO DEVELOPMENT HAS HAD A SOUND RESEARCH BACKING

The potato has been introduced into India in the late sixteenth or early seventeenth century. Research and development in the crop began in the first quarter of the nineteenth century. The crop is short-durationed in India (70–90 days) unlike Europe, where the crop is grown under temperate long-day conditions (150–180 days).

It is grown in summer in the hills, in spring in the mid-hills, during winter in the north-western plains and through the year in the Nilgiris and the eastern low hills. Suitable varieties and agrotechniques have been evolved for all ecologies.

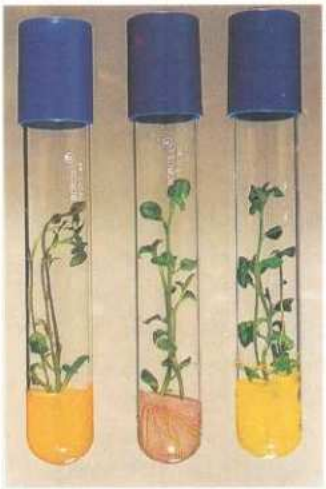
In Gujarat, potato yields surpass those obtained in the Netherlands. The crop is raised in the riverbeds where the water table is very high, 30–60 cm in the root zone, and the crop is photosynthesizing actively the whole day. The yield is 65 tonnes/ha; in the Netherlands, it is 40 tonnes/ha.



Micropropagation in potato

True potato seed

Raising potatoes in a glasshouse



In-vitro conservation of potato germplasm

Minitubers

TUBER CROPS

Germplasm of *Pachyrrhizus*

Dioscorea rotundata hybrid

Cassava H 1687

Cassava SREE PRAKASH

Cassava *en route* a starch factory in Kerala

The tuber crops have been lesser attended to by the researchers the world over being considered inferior foodstuffs.

Research has countered the myth both biologically and nutritionally. The group of crops are the most efficient producers of carbohydrates per unit area per unit time with sweet potato being the most-efficient energy producer in the plant kingdom.

Nutritionally, energy released from consumption of the cassava starch is comparable to that from cereals, and the β-cartone in orange-fleshed tubers of sweet potato is on a par with that of carrot.

From 1963, when systematic research on tuber crops began, 33 varieties have been released — 8 of cassava, 14 of sweet potato, 3 of colocasia, 6 of yams and one each of *Amorphophallus* and *Pachyrrhizus*. In India, cassava and sweet potato can become alternative starch supplement for animal feed. Many products like *sago*, alcohol, dextrin and liquid glucose can be manufactured from tuber crops. The starch is both food-grade and industrial-grade.

Cassava Chipping Machine and the technology for ethanol production have earned a patent.

Cassava is also being raised as an intercrop in coconut gardens

INDUSTRIAL SUCCESS OF CASSAVA IN TAMIL NADU

The phenomenal growth of the cassava in the much-harsher semi-arid environment of Tamil Nadu is owing to its utilization by the cottage-scale starch-based industry. Cultivation of high-yielding varieties with good management practices, including supplementary irrigation has been responsible for increased productivity — from 10 tonnes/ha in the beginning of seventies, to 22 tonnes/ha by the middle, to 31 tonnes/ha at present. Sample survey conducted by the CTCRI reveals that more than 60% of the cassava area in Tamil Nadu is now covered with the high-yielding hybrids H 226 and H 165. During 1993–94, the annual turnover of the cassava-based starch-and-sago industry of Tamil Nadu has been Rs 1,000 million approximately.

MUSHROOMS

The last decade has witnessed a great success in mushroom cultivation. The domestic market has grown rapidly and the opportunities for export have been equally encouraging. Behind it all is the commercial success of the crop demonstrated by the ICAR scientists of the National Centre of Mushroom Research and Training, Solan; Indian Institute of Horticultural Research, Bangalore and centres of the All-India Coordinated Mushroom Improvement Project.

While technology for cultivation of two species of the white button mushroom and oyster mushroom has gone commercial, temperature-tolerant strains of the white button species *Agaricus bitorquis* have also been released.

NCMRT, Solan, is researching on all edible species of the mushroom

IIHR, Bangalore, is concentrating on the mushrooms *Pleurotus* sp. and *Calocybe indica*. The Mushroom Laboratory has proposed newer alternatives as substrates

Auricularia polytricha

Agaricus bitorquis

FAST-EXPANDING FOCUS OF RESEARCH . . .

- **Newer alternatives as substrates are being proposed by scientists. The exercise is another dimension in recycling of horticultural and agricultural waste.**
- **Recently a sporeless mutant of *Pleurotus* and a low-spored hybrid of *Pleurotus* have been released by the IIHR.**

Lentinus edodes on artificial saw-dust logs

Pleurotus sajor-caju on wheat-straw

Sparassis sp.

Calocybe indica

MEDICINAL AND AROMATIC PLANTS

India's traditional medical systems — Ayurvedic, Sidha and Unani have been time-honoured and time-tested for over 3,000 years.

Commiphora mukul or the Indian bdellium tree is ready for tapping. It is one of the 12 native species of medicinal plants domesticated

Our local communities use over 7,000 species of plants. In fact 20% of the flowering plants in the country — 2,000 species with curative properties and 1,300 species with aroma and flavour are known at large.

The ICAR through the All-India Coordinated Research Project on Medicinal and Aromatic Plants (begun in 1972) is carrying out an integrated multidisciplinary research at 9 centres on chosen crops that include 12 mandatory crops: psyllium, senna, opium poppy, periwinkle, liquorice, asgandh, jasmine, palmarosa, lemon grass, vetiver, rose, geranium and patchouli; 10 introduced crops (of exotic origin): *Solanum viarum*, henbane, *Chamomilla*, sage, basil, lavender, Rosemery, lemon-mint, *Nelis* and anise; and 12 native species for domestication: Swertia, *safed musli*, aloe, *babchi*, Mucuna, *pipalamul*, *satavari*, Valerian, Indian bdellium and Galangal.

MEDICINAL PLANTS

Psyllium *(Plantago ovata)*	GUJARAT ISABGOL 1, GUJARAT ISABGOL 2	Henbane *(Hyoscyamus niger)*	IC 66
Opium poppy *(Papaver somniferum)*	JAWAHAR APHIM 16 (JA 16), TRISHNA, CHETAK APHIM, KIRTIMAN	*(Hyoscyamus muticus)*	EC 93928
		Senna *(Cassia angustifolia)*	ALFT 2
Sarpagandha (Rauvolfia serpentina)	RS 1	Periwinkle *(Catharanthus roseus)*	EC 120837, IC 49581
Steroidal yams *(Dioscorea floribunda)*	PB (C) 1, ARKA UPKAR	*Pipalamul (Piper longum)*	CHEEMATHIPPALI
Khasi-Kateri (Solanum viarum)	ARKA SANJEEVANI	Asgandh *(Withania somnifera)*	WS 20
Kangaroo-Kateri *(Solanum laciniatum)*	EC 113465	Liquorice *(Glycyrrhiza glabra)*	EC 114304

AROMATIC PLANTS

Japanese mint *(Mentha arvensis)* var. *piperascens)*	EC 41911 SIWALIK	Lemon grass *(Cymbopogon flexuosus)*	OD 19, PRAGATI
		Vetiver	HYBRID 8, NC 66403, NC 66416
Spear mint *(Mentha spicata)*	PBV PBY	Sacred basil *(Ocimum sanctum)*	IC 75730
Palmarosa oilgrass *(Cymbopogon martini* var. *motia)*	IW 31245	Basil	EC 174526, EC 174527 EC 291415
		Jasmine *(Jasminum grandiflorum)*	PITCHI (CO 1)

In the last two decades a large number of varieties have been developed — 21 in medicinal plants and 27 in aromatic plants.

Management technologies have been standardized for all the varieties. Cropping systems involving vetiver, palmarosa, opium poppy, psyllium, senna and Rauvolfia have been recommended. Patchouli has been accepted as an intercrop in coconut gardens.

Principal chemical compounds using HPLC, and aroma chemicals using gas chromatography, have also been estimated.

A National Research Centre for Medicinal and Aromatic Plants has been very recently set up at Boriavi Farms, Anand, Gujarat.

PLANTATION AND SPICE CROPS

Planting or replanting with improved varieties, grafting of existing trees, inter-, mixed-, multiple-, and multi-storeyed cropping systems coupled with the practice of crop husbandry in plantation and spice crops has led to fulfilling of the ever-increasing demand for these crops and in sustaining domination in their export.

Many of them are committed to the land for decades and they have prolonged juvenile phase. Research results are therefore slow.

Improved varieties have been released in cashew (30), arecanut (4), black pepper (9), small cardamom (5), ginger (3), turmeric (14), seed spices (27), and betelvine (1). In coconut, however, apart from 5 varieties, 11 hybrids have been provided to the growers.

Using soft-wood and flush-grafting, techniques standardized at the NRC for Cashew, 1.5 million cashew grafts are produced a year. Cashew development has witnessed a spectacular change as a result. In cocoa, soft-wood grafting and patch-budding are replacing seed propagation.

Pepper may now be multiplied rapidly through the split-bamboo or PVC-pipe technique developed at the IISR, Calicut. Epicotyl grafting is suitable for generating planting material in nutmeg, wherein sexuality is a problem. While approach-grafting is preferred in clove, layering has been advised in cinnamon. Both techniques have been standardized at the IISR, Calicut.

In the coconut and arecanut gardens, the farmers have increased their total income, and spread it round-the-year by accommodating suitable inter-, mixed-, multiple- and multi-storeyed cropping systems. The farmers are also raising milch animals and poultry in these gardens.

Productivity of black pepper (up to 1,000 kg dry pepper/ha) and cardamom (up to 770 kg dry capsules/ha) has risen remarkably because of superior high-production technologies.

Bush pepper

Scientists have recommended the release of *Trichoderma* sp. to check *Ganoderma* and Thanjavur-wilt in coconut. Leaf-eating caterpillars and *Oryctes rhinoceros* may also be managed by releasing predators.

Shortly, it would be possible to biocontrol the red-palm weevil and mites in the coconut gardens.

Appropriate management practices have been demonstrated for various pests and diseases in plantation and spice crops — *Ganoderma* and root-wilt in coconut; spindle-bug in arecanut; tea-mosquito, stem -and root-borer in cashew; *Phytophthora* foot-rot; *pollu*-beetle and top shoot-borer in black pepper; *katte* virus in small cardamom; seedling-rot, leaf-spot, leaf-rust, leaf-blight and

INDIAN INSTITUTE OF SPICES RESEARCH, CALICUT, SPEARHEADS THE TASK OF ENSURING INDIAN DOMINATION IN SPICE TRADE PROGRESSIVELY THROUGH RESEARCH . . . AND MORE RESEARCH . . .

For supra-optimal production in difficult areas
PACKAGE OF PRACTICES

FOR BLACK PEPPER

In Phytophthora-affected gardens adopt phytosanitary guidelines to curb disease incidence; replant gardens with higher-yielding varieties; apply balanced fertilizers; incorporate 5 kg farmyard manure and 1 kg neem cake per standard/vine annually and ensure appropriate plant protection.

RESULT: 1,000 kilos of dry pepper per hectare, 4 times the average national yield.

FOR CARDAMOM

In *katte*-affected gardens: plant with improved varieties, regulate shade, soil moisture and drainage and practice plant protection.

RESULT: 770 kg of dry cardamom capsules per hectare.

Bush peppers SUBHAKARA *(top)*, and AIMPIRIAN, renamed PANCHAMI *(above)* have been released exclusively for export

Cardamom NKE 34 is a recent release

Our germplasm collection in black pepper includes 1,956 indigenous, 7 exotic and 930 wild samples at the Indian Institute for Spices Research, Calicut.

National Conservatory of Black Pepper Germplasm, IISR, Calicut

Variability in Allepy turmeric

Turmeric SUDARSHANA is tolerant to rhizome-rot

Approach grafting is recommended for propagating the clove vegetatively

Propagation of cinnamon by layering is widely accepted

In vitro rhizome formation in ginger, IISR, Calicut

Somatic embryogenesis in cotyledon callus of Cocoa, IISR, Calicut

India holds near complete monopoly in the nutmeg trade

COCONUT-BASED CROPPING SYSTEMS

Since coconut-based cropping systems buffer extreme variations in climate, improve organic matter content, fertility status and microbial activity of the soil, increase yield of the coconut and total production and productivity from coconut land, recycle the self-generated organic wastes and provide better employment opportunities to the otherwise under-employed family labour, they have come to be widely adopted.

Coconut LO X GB, a hybrid

RESEARCH RECOMMENDATIONS MUCH IN VOGUE . . .

- Arecanut-based cropping systems involve black pepper, Cocoa, pineapple, banana and tree spices
- Indigenous *tenera* hybrids of oil palm developed at the Regional Station of the Central Plantation Crops Research Institute, Palode, cultivated in the rainfed West Coast yield 4.6 tonnes of oil per hectare per year
- Mass multiplication of quality planting material in small cardamom, black pepper, ginger and turmeric through micropropagation is a commercial activity
- Black pepper and cardamom are conserved *in vitro*.

In cashew, somatic embryos have been obtained from immature cotyledon segments cultured on MS medium supplemented with 2, 4 D and BAP

Variation in cashew apple

Planting cashew in wastelands or wasted lands! Cashew is performing very successfully in these new habitats

Export-grade cashew PRIYANKA (WI 80) has a nut weight of 10 g and more

capsule-rot in large cardamom; shoot-borer and rhizome-rot in ginger; shoot-borer in turmeric and powdery mildew and grain-mould in coriander. Disease-free palms have been identified in the hot-spot areas of root-wilt-affected coconut gardens for resistance breeding.

In betelvine, a combination of organic and inorganic treatments (neem cake, Carbofuran plus NPK) have proved to be effective in checking the nematodes. Resistant and tolerant cultivars have also been identified against *Phytophthora* and powdery mildew of betelvine.

At the CPCRI, Kasaragod, copra driers, electronic copra moisture meter, coconut dehusker, bunch supporter and the tree-climbing device have been developed.

The low-cost drier developed by the CPCRI, Kasaragod, ensures uniform drying, keeping the natural colour, aroma and the essential oil content intact.

For oil palm processing, a cottage-scale unit of 1 tonne/hr has been developed by the ICAR in collaboration with the Council of Scientific and Industrial Research (CSIR).

Keeping quality of the betel leaves may now be enhanced by removing the petioles from the leaves and transporting them in bamboo baskets lined with straw or banana leaves.

Small-scale palm oil extraction unit developed by the CPCRI, Kasaragod

FLORICULTURE

Rose SADABAHAR

Rose DR G.S. RANDHAWA

Research on the floricultural crops is rather recent. The efforts have been at collection, maintenance, assessment and cataloguing of germplasm; development of improved varieties; standardization of agrotechniques, improvements in propagation techniques; identification and control of pests and diseases and postharvest technology.

BREEDING

Late Dr B.P. Pal, a famous wheat breeder and the first scientist Vice-President of the ICAR, began intensive work on rose breeding in 1960 as a hobby at the IARI, New Delhi. Dr Pal evolved 105 rose varieties of the 570 bred so far. Among them are Floribundas DELHI PRINCESS, BANJARAN, CHITCHOR, MADHURA and SURYAKIRAN; and Hybrid Teas DR HOMI BHABHA, SIR C.V. RAMAN, DR M.S. RANDHAWA, MRS K B SHARMA and UMA RAO. The other very popular roses are MRINALINI, JAWAHAR, DR B.P. PAL, PRIYADARSHINI, MOHINI (Hybrid Teas) and HIMAGINI, PREMA, SADABAHAR, KIRAN, DR G.S. RANDHAWA (Floribundas). Hybrid Teas RAKTAGANDHA and ARJUN are preferred for export owing to their longer stalks.

Chinese Hibiscus SMT INDIRA GANDHI

In Gladiolus, through hybridization and gamma-irradiation several improved varieties have been developed at the IIHR and IARI. The mildly fragrant Gladiolus 82-11-90 is resistant to Fusarium wilt.

Both, the IIHR, Bangalore, and the PAU, Ludhiana, have improved the Chrysanthemum considerably. INDIRA, RAKHEE, RED GOLD (from IIHR), and SHANTI, VASANTI and BAGGI (from PAU) are in commercial cultivation.

Bougainvillaea DR H.B. SINGH

New Bougainvillaeas have been developed through seedling selection and hybridization. They number 150. The more popular are DR H.B. SINGH, SONNET, SPRING FESTIVAL, SUMMER TIME, WAJID ALI SHAH, BEGUM SIKANDER, MARY PALMER SPECIAL and CHITRA.

Tuberose SUHASINI

Interspecific hybrids of orchids *Vanda* IIHR 164 and Dendrobium IIHR 38 have been bred at the IIHR, Bangalore. A few good varieties have also been released in *Hibiscus*, jasmine, Amaryllis and tuberose, and in annuals — hollyhock, marigold, China aster, Verbena, Amaranthus, Antirrhinum and Zinnia.

Paphiopedilum spicerianum

Orchidarium at the IIHR, Bangalore

Chrysanthemum RED GOLD

Gladiolus APSARA

A FEW OF THE RESULTS IN FLORICULTURE

- **ROSE.** Rootstocks *Rosa indica* var. *odorata* up North is better; a thornless one gives 100% budding success down South.

  For producing quality blooms, application of 600 kg N, 200 kg each of P and K per hectare are recommendations from the BCKVV, Kalyani.

  In close-density planting under plastic cover during November–February, 120,000 exportable cut roses have been grown by the PAU, Ludhiana.

  In the trials of the All-India Coordinated Floriculture Improvement Project, Sulfex (0.2%), Karathane (0.05%) and Bavistin (0.1%) have proved an effective combination for controlling powdery mildew.

- **ORCHID.** Modified Vacin and Went medium supplemented with coconut water and banana pulp is best for transflasking of the orchid species.

  In *Rhynchostylis gigantica*, a fortnightly spray each of N, P_2O_5 and K_2O (500 ppm) increases the number of flowers and length of the stalk.

  Fungal disease in orchids may be controlled by spraying of Captan, Dithane, Agrosan and Cerasan.

- **CHRYSANTHEMUM.** A closer spacing, 30 cm x 20 cm and 30 cm x 30 cm, and optimum nutrition, 40 g N, 20 g each of P and K to a m^2, greatly improves the number of flowers. Cycocel (50 ppm) and 8 HQC (200 ppm) prolong the vase life of flowers.

  Septoria leaf-spot may be controlled by monthly sprays of Bavistin (0.1%), Difolatan (0.3%) and Dalonil (0.2%).

- **GLADIOLUS.** For greater number of flower spikes, corms and cormels, feeding recommendations in Gladiolus are: 50 g N, 20 g each of P and K.

  Cobalt at 300 ppm and thiosulphate at 0.25 ppm increase the vase life of the Gladiolus spikes. Treat freshly harvested corms with 500 ppm of Ethrel, the shoots emerge early.

  Guidelines for early shoot emergence for stored corms are: keep corms at 20°C for 2 weeks; follow with 2 weeks at 5°C and revert to 25°C for another 2 weeks before planting.

  To control Fusarium wilt, spray Captan (0.3%); Emisan (0.2%) and Bavistin (0.2%).

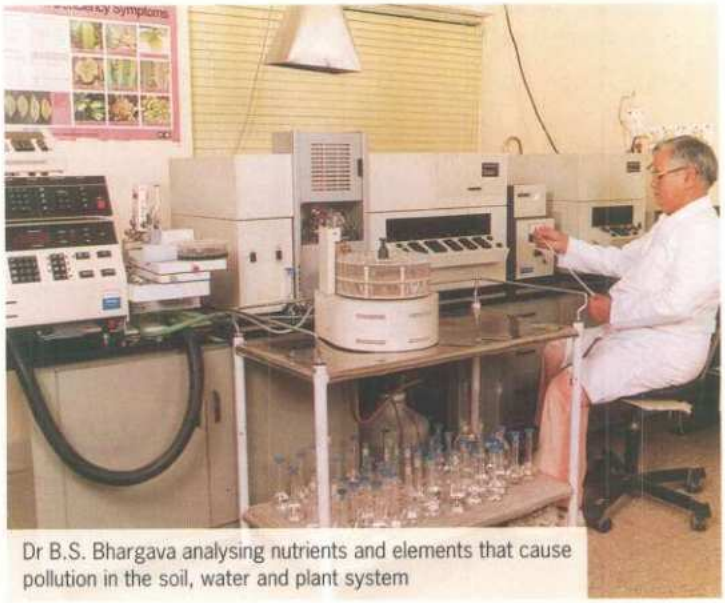
MICROPROPAGATION

Protocols for micropropagation of most ornamental crops of commercial value have been standardized.

These unseen scientists, each well-known for their individual contributions or as a group, conduct basic research at the Indian Institute of Horticultural Research, Bangalore

Dr G.S.R. Murthi analysing plant hormones

Dr Sukhda Mohandas has recently earned an award for isolating efficient nitrogen-fixing strains from non-legume vegetables. Her contribution in biofertilizers is acknowledged



Dr B.S. Bhargava analysing nutrients and elements that cause pollution in the soil, water and plant system

The Pesticide Residue Laboratory recommends the waiting period for a crop to be harvested

Checking on the performance of stored fruits in controlled atmosphere is Mr K.P. Gopalakrishna Rao

Dr S.J. Singh, plant pathologist, is associated with the development of several outstanding disease-resistant varieties

Dr S.C. Kotur at the Liquid Scintillation Counter

Drs Shantha Krishnamurthy and Sudhakara Rao examining the shrink-wrapped fruits

Mr P.R. Ramachander, IIHR, Bangalore, has developed these softwares on different aspects of horticulture in collaboration with a large number of specialists

IN FUTURE . . .

The demands on research on the horticultural crops have increased a great deal owing to a rise in domestic consumption and quality expectations, and their fast-improving export status. For an overall development, the horticulturists have thus embarked on the following charter:

- with cultivable area penetrating into wastelands, apart from breeding of improved cultivars of the arid crops, conservation and management of soil water through well-tested micro-irrigation systems and moisture-conservation techniques have to be evolved concomitantly
- widening the existing choice of horticulture-based cropping/farming systems for different agroclimates
- conducting need-specific research on protected cultivation of export-oriented vegetables and flowers
- tackling disease problems of national importance — mango malformation, guava-wilt, citrus decline, spongy tissue in mango, bunchy top in banana, root-wilt in coconut, citrus and pepper, Phytophthora and mycoplasma diseases of horticultural crops
- standardization of appropriate biotechniques for genetic manipulation — introduction of desirable traits for yield, quality and stress tolerance — and, micropropagation through tissue culture in crops of importance for mass production of quality planting material
- development of integrated pest management systems to reduce the cost of inputs, lessen environmental pollution and to avoid problems of pesticide residues
- strengthening of research on the tropical oil palm and the temperate olive in order to improve the contribution of horticultural crops to the total edible oil produced in the country
- advancing in hybrid technology, particularly for the vegetable crops.

plant protection

The Project Directorate of Biological Control, Bangalore, houses the largest collection of parasitoids and predators and their host insects in the country.
The Project Directorate of Biological Control, Bangalore, is also the nodal agency for import of exotic natural enemies. They have all been colonized

An in-built component of crop improvement research and its various disciplines, plant-protection research is both a part of crop research institutes and the All-India Coordinated Crop Improvement Projects of the ICAR.

The emphasis is increasingly on an integrated approach: manipulation of the variety for built-in resistance; modification of agronomic practices to evade or reduce pest incidence; safe and efficient methods of pest control through pest survey and monitoring and biological control through pest's natural enemies — parasitoids, predators and pathogens.

The target-specific all-India coordinated research projects in operation are:

- Biological control of crop pests and weeds
- Nematode pests and their management
- Rodent control
- White-grub management
- Seed-borne diseases (as part of the National Seeds Project)
- Agricultural ornithology
- Honeybee research and training
- Agricultural acarology
- Pesticide residues

The inexpensive moth collection assembly has made the task of moth collection rather easy and quick. It has also spared the collector from inhaling scales

Dr S.P. Singh and his colleagues from the Project Directorate of Biological Control attending to the farmers' problems, who are increasingly opting for IPM

In the computerized environmental chambers, Mr S.K. Jalali, scientist, is experimenting on the ability of *Cheilomenes sexmaculata* to suppress the aphids from attacking the cotton plant

The free-floating *Eichhornia crassipes*, water hyacinth, has spread across the globe to at least 50 countries. Within the country more than 150,000 adults of weevils *Neochetina eichhorniae, N. bruchi* and mite *Orthogalumna terebrantis* have been released into 15 states. The biological control is very effective, yet safe for the cultivated plants

The Mexican beetle *Zygogramma bicolorata*, imported in 1983, has been dispersed over Karnataka, Tamil Nadu and Andhra Pradesh to control the *Parthenium* weed-infested fields, pastures and wastelands. The beetle is safe, since it cannot complete its development on any cultivated plant in the country

The ICAR has a National Centre for Integrated Pest Management at the IARI, New Delhi, for evolving environmentally sound pest-management strategies to counter the pest-and-disease problem in major crops. The Project Directorate of Biological Control, Bangalore, is, however, exclusive in its approach.

The major pests of rice, cotton, pulses and sugarcane may now be managed through integrated pest-management (IPM). *Pyrilla* and top-borer of sugarcane, mealy bug of citrus, grape, guava and coffee, lepidopterous pests of cotton, tobacco, coconut and sugarcane may be managed through release of bio-control agents.

Mass-rearing technology for biotic agents *Trichogramma* spp, *Chrysoperla* spp. and nuclear polyhedrosis virus (NPV) of *Helicoverpa* and *Spodoptera* has been widely adopted by the farmers. Aquatic weeds, *Eichhornia crassipes* (water-hyacinth) and *Salvinia molesta* (water-fern) may also be managed through biological control.

African marigold distracts the fruit-borer *Helicoverpa armigera* from attacking the tomato. Instead the resistant and immigrant fruit-borer moths lay creamy white eggs on the tight flower buds and petals of the fully opened marigold flowers. The borer is known to depress yield up to 50%

Important species of rodents associated with different crops have been identified. Their population in wheat and rice crops can be kept in safe limits with anti-coagulent rodenticides.

Definite schedules for controlling nematode pests in wheat, rice, pulse and oilseed crops, plantation crops and fruit and vegetable crops have been prescribed.

Depredatory birds may now be kept off by the use of reflecting tapes. Most seed-borne diseases may now be prevented by sowing/planting of disease-free material or by coating it with fungal or bacterial antagonists. There are stringent certification standards. Disease forecasting leads to timely application of fungicides in protecting the apple orchards from apple-scab.

SUCCESSFUL IPM PROGRAMMES

Crop/Pest Problem	Management Tactics
RICE: Brown planthopper, stem-borer, gall-midge	Resistant varieties, pest monitoring, conservation and mass release of biotic agents, cultural methods
SUGARCANE: Tissue-borers, Pyrilla, scale-insect	Resistant varieties, augmentation and release of parasitoid (*Trichogramma, Epiricania, Strumiopsis inferens, Isotima javensis* and GV), need-based pesticides
COTTON: Bollworm, jassid, white-fly	Mass release of biotic agents (NPV, *Chrysoperla, Trichogramma* spp., *Bracon* spp.), need-based pesticides
GROUNDNUT: White-grub	Cultural and mechanical means, seed treatment with safe pesticides
CRUCIFEROUS VEGETABLES: Diamond-back moth, other Lepidoptera	Biotic agents, trap-crops, need-based use of safe chemicals, neem, B.t.
MANGO: Leaf-hopper, mealybug	Tree banding, entmofungal pathogens
CITRUS, GRAPES, GUAVA: mealy-bug	Mass release of *Cryptolaemus montrouzieri* and *Laptomastix dactylopii*
COCONUT: *Rhinocerous* beetle	Use of baculovirus
AQUATIC WEEDS: Water-fern and water-hyacinth	Introduction and mass release of exotic weevils, *Cyrtobagous salvinae* (for water-fern) and *Neochetina* spp. (for water-hyacinth).

Larvae, 2–3-day-old, of the lace-wing fly *Chrysoperla carnea* being released on the cotton plant. 50,000 larvae/ha released twice suppress the pest population very effectively. *Chrysoperla carnea* predates on aphids, bollworm eggs and other soft-bodied insects on the cotton and sunflower plants

The third instar larvae of the lace-wing feeding on the cotton aphid

Trichogramma brasiliensis parasitizing on the eggs of *Helicoverpa armigera* on the tomato. The egg parasitoid, *Trichogramma* spp., attacks the Lepidoptera hosts in the egg state

Released early, 500 Coccinellid beetles per hectare are enough to gobble up the aphids on groundnut. The adults live long; for more than 45 days

Mass breeding of *Cryptolaemus montrouzieri* on the mealybug-infested pumpkins

More than 30 species of the mealybug known to occur in India attack the grape, citrus, guava, pineapple, mango, pomegranate, ber, jackfruit, custard-apple and the *phalsa*. The AICRP on Biological Control and the Division of Entomology and Nematology, IIHR, Bangalore, over the last decade have although identified local natural enemies of the mealybug, but the introduced parasitoids and predators have proved more effective. The techniques for mass production of these exotic natural enemies *Laptomastix dactylopii, Cryptolaemus montrouzieri* and *Planococcus citri* have been commercialized by Drs S. P. Singh, M. Mani and A. Krishnamoorthy.

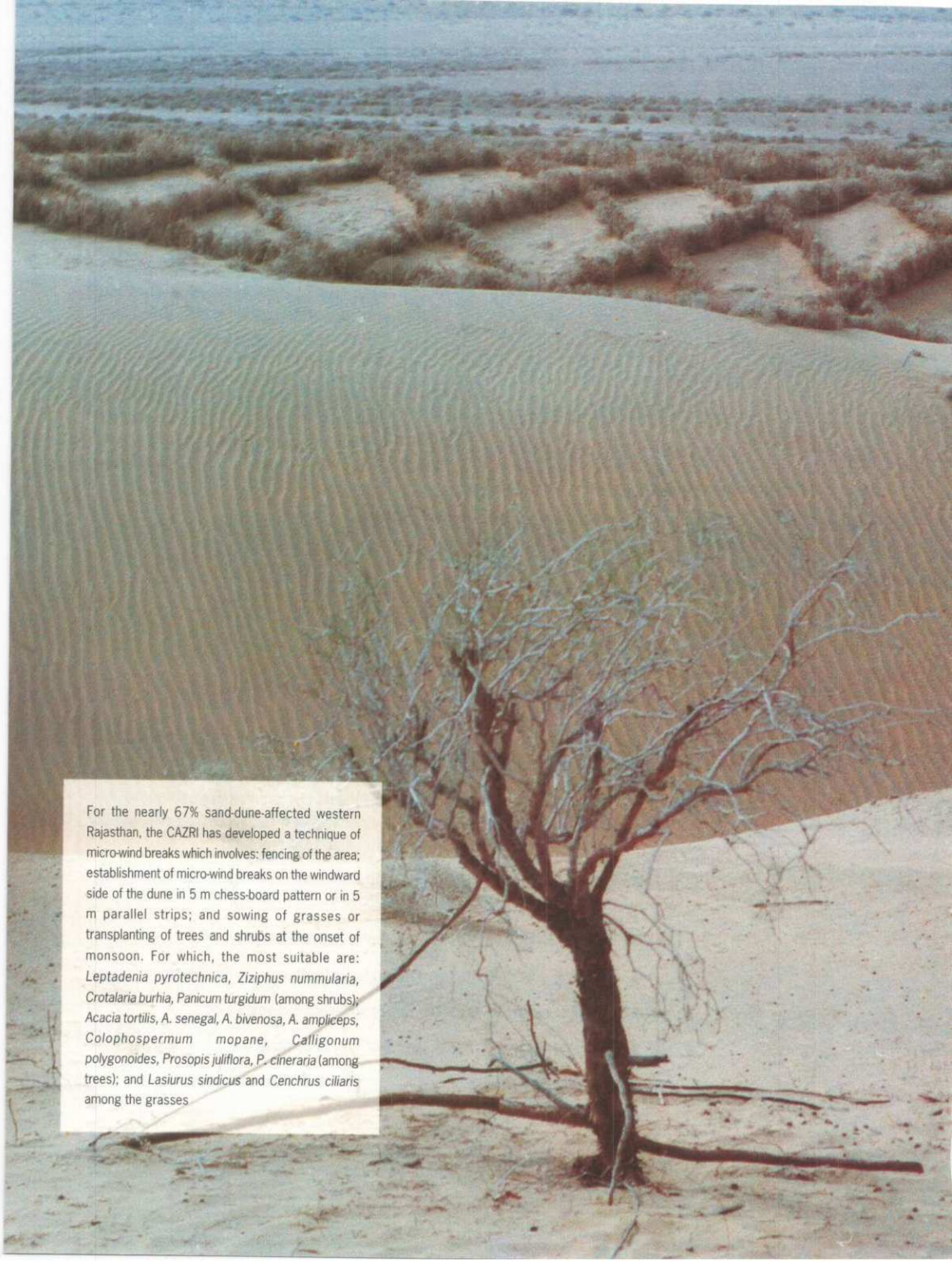
Mealybug-infested mango fruits

Acid-limes infested with the mealybug

Cryptolaemus montrouzieri predates on the mealybugs on coffee, citrus, grape and guava

ICAR continues to ensure the well-being of crops through an Integrated Pest Management approach. That recommends . . .

- Adopt biological control to keep off insect pests and plant pathogens by mass multiplication of predators, parasites and pathogens; application of insect-growth regulators, pheromones and kairomones.
- Survey, surveillance and monitor the pest population build-up for forecasting and forewarning the farmer to prepare against the damage
- Screen germplasm through a national support system
- Exchange clean germplasm through application of biotechnology
- Conduct research on pesticides, particularly biopesticides
- Carefully monitor the pest resistance to pesticides
- Maintain biodiversity by strengthening research on biosystemics, conservation and biotic agents.



For the nearly 67% sand-dune-affected western Rajasthan, the CAZRI has developed a technique of micro-wind breaks which involves: fencing of the area; establishment of micro-wind breaks on the windward side of the dune in 5 m chess-board pattern or in 5 m parallel strips; and sowing of grasses or transplanting of trees and shrubs at the onset of monsoon. For which, the most suitable are: *Leptadenia pyrotechnica, Ziziphus nummularia, Crotalaria burhia, Panicum turgidum* (among shrubs); *Acacia tortilis, A. senegal, A. bivenosa, A. ampliceps, Colophospermum mopane, Calligonum polygonoides, Prosopis juliflora, P. cineraria* (among trees); and *Lasiurus sindicus* and *Cenchrus ciliaris* among the grasses

soil, agronomy and agroforestry

Soil resources are finite. The per-caput availability of the arable land is declining gradually. In India, it was 0.48 ha in 1950; it is 0.15 ha at present. Our inelastic net cultivated area of 141 million hectares has a cropping intensity of 1.29. The production base of agriculture — the soil — is often beset with physical, chemical and microbiological constraints. Soil degradation occurs chiefly due to erosion, nutrient depletion, waterlogging, salinity and alkalinity. About 0.8% of the agricultural land is annually usurped for urbanization. Nearly 5,334 million tonnes of the soil are annually lost due to erosion. Of which, 29% is permanently lost to the sea, 10% deposits in reservoirs reducing their storage capacity by 1–2% and 61% gets shifted to other places.

Management of resource base — soil and water — is vital for ensuring optimal production. So far, increase in production has largely been through mobilization of production inputs and expansion of arable land.

The possibility of continued expansion has little future. We are therefore currently placing far greater emphasis on soil-resource inventory and on development of agricultural technologies that integrate efficient management of land, water, nutrients and other production inputs.

INFRASTRUCTURE

The importance of soil and climate in agriculture has been recognized as early as 1905 when the provinces were divided into a suitable number of 'Circles' and each housed an experimental farm representing a definite soil and climate. In the early forties, it had been realized that agricultural development could be achieved only if two objectives were kept in mind: abolition of poverty of the cultivator and the abolition of poverty of the soil. The concern for water management gained acceptance also the same time. An All-India Coordinated Research Project for Investigations in Soil Science was launched in 1965–66.

In 1968, there was a Project Directorate on Dryland Agriculture. The All-India Coordinated Research Project only highlighted the compulsion of undertaking problem-oriented applied research and testing the technology/knowledge in different agroclimates. At the ICAR, therefore in 1965, a Deputy Director-General was appointed for Soils, Agronomy, Irrigation and Agricultural Engineering. Agricultural Engineering, however, grew into an independent division in 1976. The Central Soil Salinity Research Institute, Karnal, Haryana, has been the first institute to come up in the discipline in 1969. To follow in quick succession have been: the Central Soil and Water Conservation Research and Training Institute, Dehra Dun (1974), and the National Bureau of Soil Survey and Land-Use Planning, Nagpur (1976).

At present, the programmes in production agriculture and resource management are carried out at 8 central research institutes, 2 project directorates, 3 national research centres and 15 all-India coordinated research projects with a wide network of cooperating centres located at the ICAR institutes and state agricultural universities spread over different agro-ecological regions of the country.

RESEARCH

Our major research programmes in the discipline are:

- Resource Inventory
- Cropping Systems Research
- Nutrient Management
- Water Management
- Soil Management
- Agroforestry

RESOURCE INVENTORY

The extent and distribution of different soils for planning rational land-use, availability of water to match the crop needs and precise information on weather parameters to determine the growing season are important for preparing land-use plans and for developing location-specific agricultural technologies.

OBJECTIVES

- Refining agro-ecological zones based on climate, landscape and soil-related criteria
- Inventory of soil resources at national, state and agri-ecozone level
- Preparation of thematic maps for land evaluation and land-use planning
- Soil degradation assessment
- Developing long-term climatic database
- Database on surface and groundwater resources

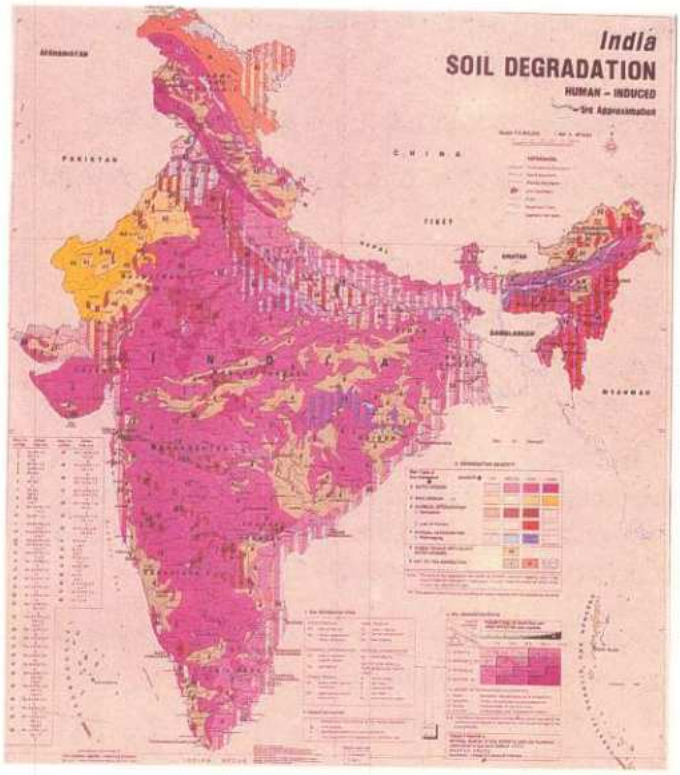
ACHIEVEMENTS

A map of the country delineating 20 agro-ecological regions (AER) and 60 sub-regions based on physiography, soil and period of crop growth has been prepared in 1992. The soil resource maps of different states in 1:250,000 scale and country map in 1:5 m scale have been recently completed.

So far the soil resource maps of 12 states and 2 union territories have been released. Thematic maps on various soil parameters for West Bengal, Gujarat and Pondicherry have also been brought out.

India : Agro-Ecological Regions

Soil map, West Bengal



The status of land degradation — degree and distribution of different kinds of degradation — has been evaluated and depicted cartographically.

IN FUTURE . . .

- Evolving a strategy for land-use planning using soil-based information
- Preparing problem-specific thematic maps of areas for restoring productivity or for their rehabilitation
- Developing soil-quality indices
- Monitoring of soil health periodically.

CROPPING SYSTEMS RESEARCH

In our land of great diversity, the farmers grow a wide range of crops in spatial and temporal arrangement depending on the natural resource endowments and socio-economic conditions.

Cropping Systems Research has not only to focus increasingly on parameters affecting productivity of these diverse crops, but on year-round production as well without deteriorating the soil health. Suitable crop combinations have therefore to be developed for specific regions.

OBJECTIVES

- Developing efficient and high-intensity cropping systems and compatible agrotechniques suited to different agro-ecological regions across the country
- Understanding crop-weather relationships that serve as a basis for preparing crop-weather production models and for disease and pest forecasting
- Diversification of cropping systems by inclusion of high-value crops for higher returns
- Promoting farming systems approach for enhancing biomass production and increasing income and employment while ensuring minimum risk in rainfed agriculture

ACHIEVEMENTS

Cropping systems research has resulted in the development of sustainable multiple cropping systems — rice–rice; rice–wheat–greengram; pearlmillet–wheat — capable of producing 10–12 tonnes to a hectare a year from irrigated areas.

Physics Laboratory, CRIDA

Physiology Laboratory, CRIDA

Microbiology Laboratory, CRIDA

Central Laboratory, CRIDA

GIS Laboratory, CRIDA

The multipurpose gooseberry (*Emblica officinalis*) has been identified for regions experiencing spatial and temporal variability in rainfall and soil resource

Sorghum–pigeonpea are recommended as intercrops

The neem tree, known for its biopesticide value, has been proposed for growing interspersed in arable crops

. . . DRYLANDS CONSTITUTE TWO-THIRDS THE ARABLE LAND

Though the rainfed arable land is two-thirds at present, food produced from it is 40%. Predominantly cultivated in the rainfed or drylands (largely Alfisols), are coarse cereals (91%), pulses (91%), oilseeds (80%) and cotton (65%).

Research on dryland agriculture is carried out by 43 scientists at the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad; 23 cooperating centres of the All-India Coordinated Research Project for Dryland Agriculture (AICRPDA) and 12 cooperating centres of the All-India Coordinated Research Project on Agrometeorology (AICRPAM) on Resource Characterization, Rainfed Water Management, Crop and Cropping Systems, Soils and Nutrient Management, Alternate Land-Use Systems, Energy Management, and on Socio-Economic Aspects. Specialists, extension workers, farmers and farm women are also trained by the CRIDA.

Various pulse and oilseed combinations — sorghum + pigeonpea; cereals; pigeonpea + groundnut; mustard + chickpea; soybean + maize; sorghum + cluster bean have been recommended as rainfed intercrops. They provide higher returns per unit area.

- For the rainfed areas, a low-cost seed-cum-fertilizer drill that ensures uniform and desired placement of seed and fertilizer has been developed.
- Integrated weed control management has been recommended for major cropping systems.
- Alternative farming has replaced *jhum* farming in the North-East Hills region.
- Crop-weather relationship models have been developed for the different agri-ecosystems based on the agrometeorological data generated over the last 60 years.

IN FUTURE . . .

- Introduction of appropriate crops and cultivars, and crop-establishment techniques for increasing crop intensity
- Improving system productivity by still better management of production inputs
- Developing farming systems for the various agro-ecological regions.

NUTRIENT MANAGEMENT

Crops remove large quantities of nutrient elements from the soils. Unless these are replenished from time to time and in adequate quantities, crop yields are adversely affected. Nutrient management research thus advocates suitable remedies to keep the soil health intact.

OBJECTIVES

- Increasing the efficiency of fertilizer for higher crop response
- Promoting the utilization of indigenous resources
- Evolving integrated-nutrient-management strategies for different cropping systems.

ACHIEVEMENTS

- Optimum fertilizer schedules for the crop and cropping systems have been worked out to ensure balanced nutrition. They are also based on the soil tests carried out.

Integrated nutrient management studies have established nutrient turnover values for organic manures and biofertilizers

Optimum requirements of N, P and K fertilizers for different crops depending upon rainfall and soil-moisture-holding capacities for various crops/cropping systems have been analysed

- Deficiencies of micro- and secondary nutrients have been delineated and corrective measures evolved.
- Techniques for recycling of organic wastes as manure have also been developed.

IN FUTURE . . .

- Increasing the fertilizer-use efficiency
- Enriching organic sources
- Increasing nutrient-supplying capacities of indigenous phosphatic resources
- Monitoring the emerging nutrient-related problems
- Promoting integrated nutrient management
- Developing and refining inoculation technologies.

WATER MANAGEMENT

Water is a key input for improving crop production. Since independence, a huge investment has been made for creating irrigation potential using both surface and groundwater. Though about 64 million ha may now be irrigated, efficient utilization of water to overcome waterlogging, soil salinization and low crop productivity remain a key concern.

OBJECTIVES

- Improving use-efficiency of available water resources
- Integrated water management
- Conjunctive utilization of surface and groundwater resources in canal commands
- Putting to use poor quality groundwater, drainage effluents and sewerage for irrigation.

Completely degraded watershed due to mining

Mined watershed treated mechanically and vegetatively

Clear water now flows longer from the low peaks of the watersheds that had been spoilt due to mining

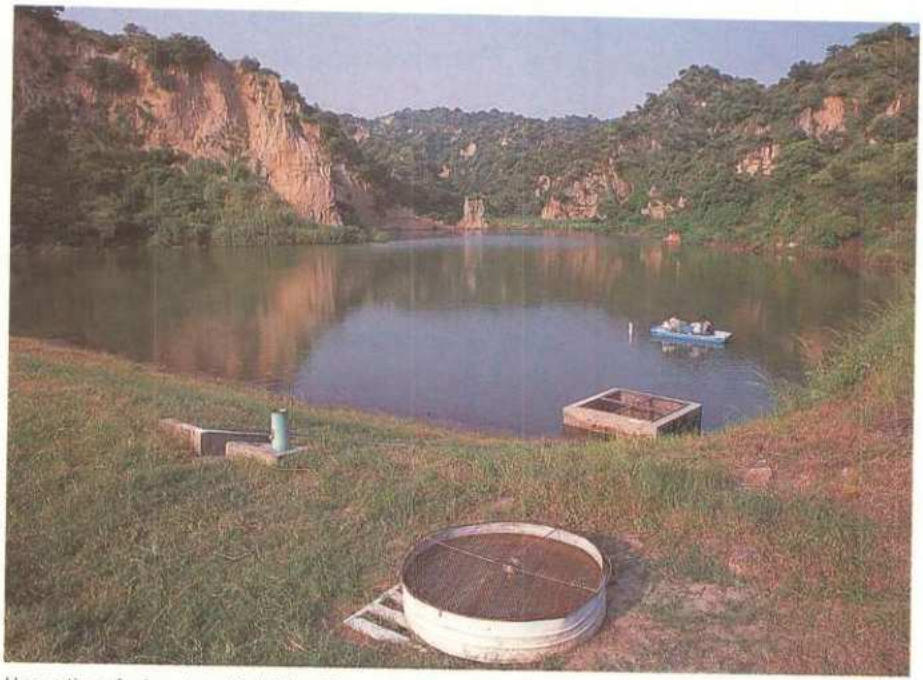
Clean water harvested into a pond from the Shiwalik watershed

Grasses and trees provide an effective vegetation cover to the Shiwalik watershed

Horti-pastures raised on drip irrigation in degraded sandy soils

SUCCESS AT WATER HARVESTING, CSWCRTI, DEHRA DUN

Multipurpose water reservoir with earthen embankments



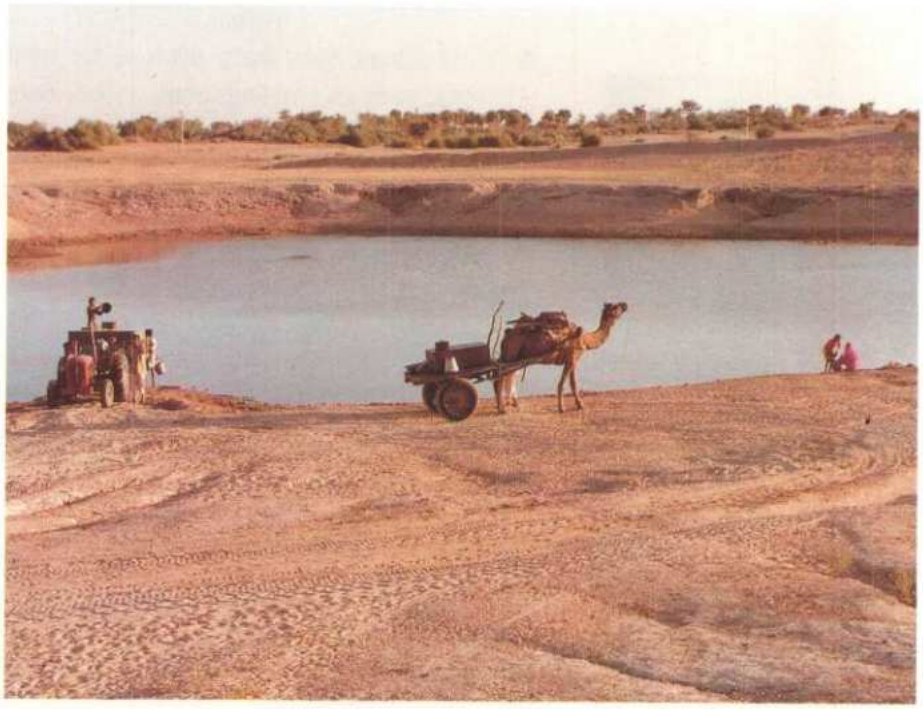
Harvesting of rainwater at Rel Majra, Ropar, Punjab, with the help of the scientists of the CSWCRTI, Dehra Dun, has led to the transformation of the degraded rainfed hilly terrain into a community-managed highly productive land

ACHIEVEMENTS

- Water requirements of crops have been determined and irrigation schedules for crops and cropping systems in different agro-ecological situations advised.
- Methods for water economy have been evaluated for field adoption.
- Surface and sub-surface drainage designing criteria have been enforced.
- Technologies have been developed for rainwater harvesting and recycling.
- Water quality standards for irrigation have been tested.

Affordable drip system developed by the CAZRI, Jodhpur, for irrigating the high-value crops

Excess rainfall in rice fields is measured by this device developed by the Water Technology Centre for Eastern Region, Bhubaneswar, Orissa



Nadi, an indigenous structure for harvesting water in the Thar desert of Rajasthan

IN FUTURE . . .

- Developing water production functions
- Enhancing water- and nutrient-use efficiency by adopting efficient irrigation schedules, and resorting to micro-irrigation for fertigation
- Conjunctive utilization of water from various sources and of varying quality
- Developing water management models by optimizing water demands and augmenting water supplies
- Developing technologies for recharging groundwater and computing regional salt and water balances.

SOIL MANAGEMENT

Soil-related constraints often limit the ability to attain desired crop productivity. For combating, suitable techniques have been evolved.

OBJECTIVES

- Diagnosing soil-related problems and developing area-specific technologies for amelioration
- Developing strategies for integrated watershed management.

ACHIEVEMENTS

- Integrated watershed management models have been developed for different agro-ecological regions.
- Techniques have been evolved for management of physical problems of soils, such as crusting, compaction, deep percolation or low permeability and for reclaiming salt-affected soils.
- Techniques for stabilization of sand dunes have been evolved.
- Strategies for reclamation of ravine lands have been developed.

Assessing mineral content in soils on X-ray defraction machine, NBSSLUP, Nagpur

Computer-guided Atomic Absorption Spectrophotometer, IISS, Bhopal

Vegetative barriers are as good as mechanical bunds in conserving soil and rainwater. *Cenchrus ciliaris, Cymbopogon flexuosus, Pennisetum hohenackeri* and *Leucaena latisiliqua* are used as vegetative barriers across several locations in the country

Acacia tortilis, an introduction, has established exceedingly well in the sand-dune affected areas

IN FUTURE . . .

- Refining soil reclamation technologies for greater efficiency and cost effectiveness
- Evolving preventive measures against various forms of soil degradation and desertification
- Developing farmers' participation models for integrated watershed management.

AGROFORESTRY

Agri-silvi combination of *Acacia nilotica*, wheat and chickpea is recommended for the marginal and drylands

Agroforestry systems are not new to us. They are really old and traditional. *Taungya*, growing of tea and coffee in the shade of trees; intercropping in coconut, multistoreyed home gardens; *khejra* and agricultural crop combinations in hot arid regions; *Alnus nepalensis* in the hills of Nagaland and Manipur; growing of trees on field bunds, their sporadic distribution in fields of ginger, turmeric and large cardamom have been all too familiar to Indian agriculture.

Agroforestry through the ages has been a production technique or method that combines agriculture and forestry, horticulture or animal husbandry on the same piece of land in order to fully utilize the natural resources — sunlight, water and nutrition.

OBJECTIVES

- Identification of multipurpose tree species
- Development of agroforestry system for different agro-ecological regions
- Sustainable productivity of wastelands through agroforestry interventions.

ACHIEVEMENTS

Prosopis cineraria and pearlmillet combinations are now a practice in sandy areas of Rajasthan

- Ideal multipurpose tree species of fodder, fuel, timber have been identified and evaluated for agroforestry. The recommended ones are: alder for the lower Himalayas; *Albizia lebbek*, *Acacia nilotica* for the Indo-Gangetic plains; *Azadirachta indica*, *Casuarina* for the tropics, *Prosopis cineraria* (*khejra*), *Tecomella undulata*, *Hardwickia bipinata*, *Dalbergia sissoo*, *Leucaena latisiliqua* for the arid and semi-arids; *Butea monosperma*, *Acacia auriculiformis* and *Albizia procera* for the humid and sub-humid regions.
- Agroforestry systems such as agri-horti-silvi-pastoral, silvi-pastoral, agri-silvi-pastoral and agri-horticulture have been developed for different agro-ecological regions.

IN FUTURE . . .

Research will continue on:

- Evaluation of 'plus' trees
- Agroforestry interventions for rice–wheat cropping systems, waterlogged conditions and problem soils
- Utilization of vesicular-arbuscular mycorrhizal fungi in the establishment of nitrogen-fixing trees.

Crossbred FRIESWAL cows yield 4000 litres of milk in mature lactation (300 days) at the Germplasm Unit of the Project Directorate of Cattle, Military Farm, Meerut

animal science

India has a large population of livestock : 200 million cattle, 76 million buffaloes, 46 million sheep, 110 million goats, 11 million pigs, 1.9 million equines, 1 million camel and 310 million poultry. Extreme agroclimatic and socio-economic diversity has resulted into unique evolution of these animal species.

Nature's own perfect food, milk, despite odds has witnessed uptrend in production over the years. From 17 million tonnes in 1950, milk production has surpassed 64 million tonnes in 1995.

Egg and broiler production has also increased from 5 million to 27,500 million eggs at present and from 1 million to 300 million broilers over the past 3 decades.

Sustainable animal husbandry over the years has been a part of man-animal-plant-soil relationship where the animal has been an important integrating link sustaining animal agriculture. Our agricultural operations have been traditionally much dependent on the animal draught power and would continue to be the mainstay of Indian agriculture.

A large animal population in relation to available feed and fodder resources coupled with inadequate reach of transfer-of-technology programmes especially in the hinterlands has been the main constraint in animal production.

INFRASTRUCTURE

Research on animal health is the first to have started off in the country. For which the Imperial Bacteriological Laboratory was set up in 1889 at Pune, transferred to Mukteswar in 1893, and named as the Indian Veterinary Research Institute (IVRI) in 1947. The headquarters of the IVRI are located at Izatnagar, at Mukteswar, Bangalore and Bhopal, its campuses.

The National Dairy Research Institute (NDRI), Karnal, has come up in 1955 though dairying activities in India began in 1923 at the Imperial Dairy Institute, Bangalore, at present the Southern Regional Station of the NDRI. In 1962, the Central Sheep and Wool Research Institute began independent research on sheep, wool and its products.

On date, there are 6 CRIs, 2 national institutes, conducting research on livestock (buffalo, sheep, goat and poultry), 1 National Bureau of Animal Genetic Resources and 7 NRCs on Equine (Hisar), Camel (Bikaner), Yak (Arunachal Pradesh), Mithun (Nagaland) and Meat (Izatnagar) and 2 Project Directorates one each on Cattle (Meerut) and Poultry (Hyderabad).

There are 16 all-India coordinated and network projects operating: in Cattle (3), Buffalo (1), Sheep (1), Goat (1), Poultry Production and Improvement (3), Pig Breeding (1), Embryo Transfer Technology (1), Micro-nutrients in Animal Production (1), Crop-based Production Systems (1), Epidemiological studies on foot-and-mouth disease (1), Blood Profista (1) and Animal Disease Monitoring and Surveillance (1).

ANIMAL BREEDING

Producing outstanding bulls : In a collaborative programme between the ICAR and Military Farms, Meerut, 3/8 elite crossbred cows are impregnated with imported frozen semen of HOLSTEIN FRIESIAN with a sire index of 10,000 litres for producing outstanding bulls. The bulls after progeny test are used in genetic improvement of cattle nation-wide

Selection of animals for higher productivity has been practised from the days of *Matsya Purana*, which educates on the criteria for selection of a bull. Such a long and historical association with the art of breeding and raising of animals in widely varying agro-ecologies has resulted in the origin and development of several species and breed types leading to a vast diversity in our livestock and poultry genetic resources over the years.

INDIGENOUS ANIMAL GENETIC RESOURCES

Our country has the world's best breeds of dairy buffaloes MURRAH, NILI RAVI, SURTI, JAFFARABADI and BHADAWARI; draught cattle ONGOLE, HARIANA, KANKREJ, KANGAYAM, NAGORI; carpet-wool sheep MAGRA, CHOKLA, and goats JAMUNAPARI and BEETAL.

Better adapted to adverse tropical conditions of heat and humidity, our livestock is resistant to many tropical diseases compared with livestock of the temperate climate. The country has also a number of rare species of Yak, Mithun, pigmy hog and wild buffaloes, including *arni*, the ancestor of the modern-day buffaloes.

Buffalo MEHSANA

Buffalo MURRAH

Buffalo NILI RAVI

Buffalo NAGPURI

Buffalo JAFFARABADI

Buffalo SURTI

INDIGENOUS BREEDS . . .

Draught cattle ONGOLE

Draught cattle HALLIKAR

Draught cattle DANGI

Cattle RED SINDHI

Cattle THARPARKAR

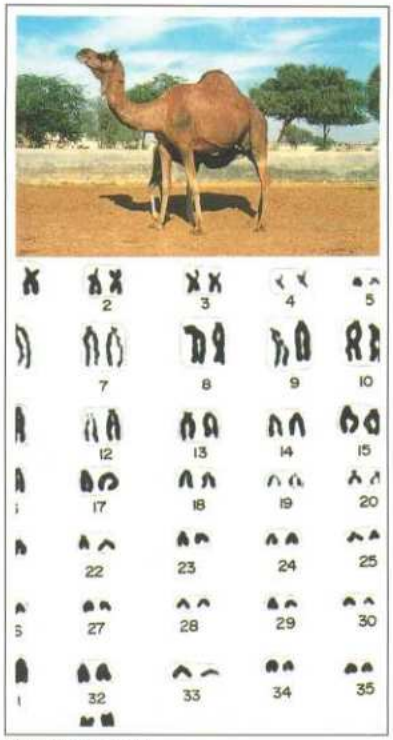
Cattle GIR

Cattle RATHI

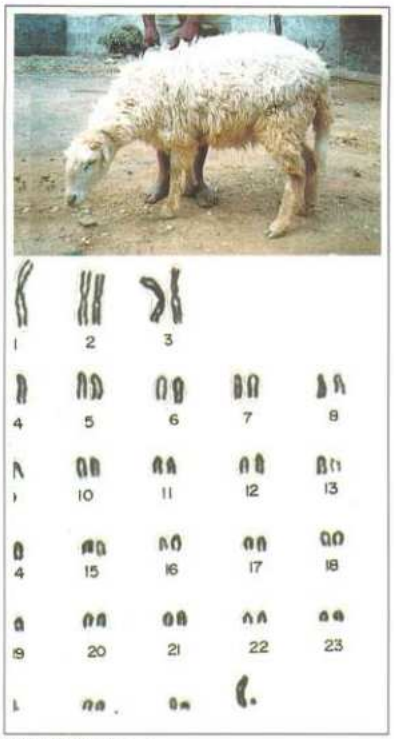
Very recently, the indigenous black prickly-haired species of the pig has been crossed with pig LANDRACE *(right)* for breeding a new strain at the IVRI, Izatnagar

To maintain our biodiversity, steps have been taken to evaluate genetic resources and to develop programmes for their conservation, management, documentation and improvement. The National Bureau of Animal Genetic Resources in collaboration with respective institutes, state animal husbandry departments and the SAUs has developed programmes for their evaluation, characterization, conservation and improvement.

Work on evaluation and characterization of cattle HARIANA and RATHI, buffalo BHADAWARI; sheep MALPURA and CHOKLA; Yak and Mithun is in progress. A number of data bases have been developed and linked for inflow of information.



BIKANERI camel

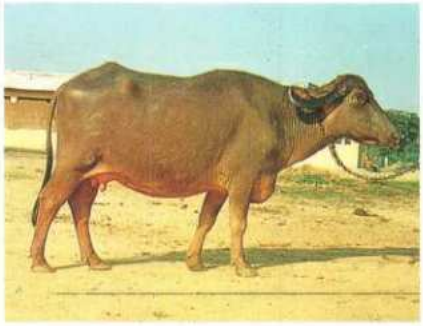


MALPURA sheep

HARIANA cattle

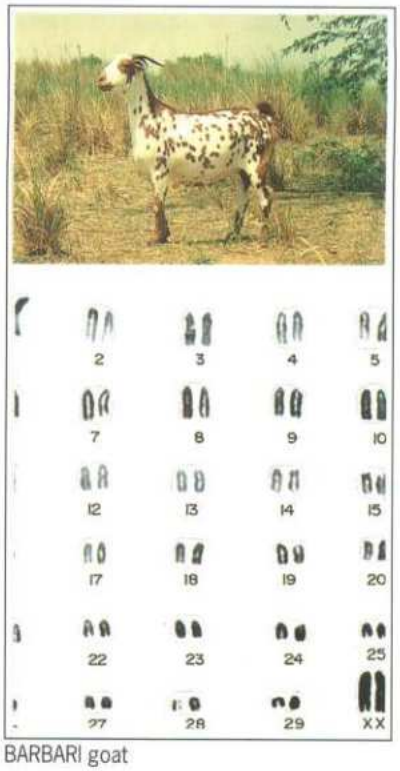
at the National Bureau of Animal Genetic Resources . . .

- Establishing cytogenetic profiles of native livestock for breed conservation.
- Recording descriptions of species of livestock in data-banks.



BHADAWARI buffalo

SONADI sheep



BARBARI goat

CHROMOSOMAL PROFILE OF INDIAN DOMESTIC LIVESTOCK

Species	Scientific name	Diploid count	Morphology of chromosomes	
			Autosomes	Sex chromosomes
Cattle (Zebu)	*Bos indicus*	60	All autosomes are acrocentric	X is submetacentric Y is acrocentric
Buffalo	*Bubalus bubalis*	50	5 pairs of submetacentric 19 pairs acrocentric	X is largest of the acrocentric chromosomes
Goat	*Capra hircus*	60	All autosomes are acrocentric	X is acrocentric Y is acrocentric/ submetacentric
Sheep	*Ovis aries*	54	3 pairs of autosomes are submetacentric 23 pairs acrocentric	X is large acrocentric Y is metacentric
Horse	*Equus domesticus*	64	3 pairs of metacentric/sub metacentric 18 pairs acrocentric	X is large submeta-centric Y is acrocentric
Donkey	*Equus asinus*	62	23 pairs of meta/ submetacentric 7 pairs acrocentric	X is submetacentric Y is acrocentric
Camel (single-humped)	*Camelus dromedarius*	74	5 pairs of submetacentric 31 pairs acrocentric	X is largest submetacentric Y is small acrocentric
Pig (domestic)	*Sus scrofa*	38	12 pairs of meta/ submetacentric 6 pairs acrocentric	X is submetacentric Y is smallest submetacentric
Yak	*Bos grunniens*	60	All autosomes are acrocentric	X is submetacentric Y is metacentric
Mithun	*Bos frontalis*	58	1 pair submetacentric 27 pairs acrocentric	X is submetacentric Y is metacentric


Yak


Mithun

Cattle KARAN FRIES

Cattle KARAN SWISS

Improvement programmes on important native breeds of cattle HARIANA, ONGOLE, THARPARKAR and GIR, and indigenous breeds CHOKLA, MAGRA and MALPURA of sheep, and JAMUNAPARI, BARBARI, SIROHI and BLACK BENGAL of goat through selection and progeny testing are in progress. More indigenous breeds are being included.

BREEDS AND STRAINS

Crossbreeding with improved exotic breeds has been adopted to improve the low-productivity of the Indian breeds. In cattle, new genotypes KARAN SWISS, KARAN FRIES and FRIESWAL have been evolved. They are continuously being improved upon through selection and progeny testing.

KARAN SWISS (BROWN SWISS x RED SINDHI or SAHIWAL) and KARAN FRIES (FRIESIAN x THARPARKAR) crossbreds at the NDRI, Karnal, are giving an annual lactation of 3,385 and 3,820 litres.

The first lactation yield of FRIESWAL (HOLSTEIN x SAHIWAL) has been 2,832 litres of milk, at the Military Farm, Meerut, which is around 4,000 litres in mature lactation.

At the Central Sheep and Wool Research Institute (CSWRI), AVIKALIN (RAMBOUILLET x MALPURA, 50%), producing 2 kg of superior carpet wool per annum; AVIVASTRA (RAMBOUILLET/MERINO x NALI/CHOKLA, >50% exotic) producing 2.5 kg of apparel wool per annum and BHARAT MERINO (RAMBOUILLET/MERINO x native, 75% exotic) yielding 2.9 kg greasy wool with 19 micron fibre diameter have been evolved. They are being improved through selection.

Mule breeding. At the NRC Equines, Hisar, liquid/frozen semen is used for production of quality mules and crossbred donkeys.

Young ones produced through artificial insemination : of mule *(above)* using French JACK semen; of donkey foal using French JENNY *(top)*

BHARAT MERINO, a fine wool synthetic, is as good as RAMBOUILLET/MERINO purebred both with regard to reproduction and wool yield, and in being well-adapted to tropical conditions. BHARAT MERINO is being used for improving carpet wool breeds MALPURA and CHOKLA.

MUTTON SYNTHETIC, AVIMANNS (DORSET/SUFFOLK x MALPURA/SONADI) are fed intensively and weigh more than 30 kg at six months of age.

Small ruminant, the rabbit has been bred successfully for meat and wool. Imported strains have been selected for the different ecologies. The broiler rabbit SOVIET CHINCHALLA, WHITE GIANT, GREY GIANT and NEW ZEALAND WHITE attain a body weight of 2 kilos at 12 weeks of age. They are being improved to attain 2.5 kg at 12 weeks.

The annual wool yield of the rabbit GERMAN ANGORA is 500–600 g. Rabbit-farming for wool and meat has been accepted by the farmers as a full-time occupation in several areas of the country especially in the hilly terrain of the Himalayas.

Pashmina goats CHEGHU, CHANGATHANGI and their crosses with local goats at 3/4 level produce on an average 125–210 grams of superior quality pashmina

BHARAT MERINO, crossbred of CHOKLA and NALI sheep with RAMBOUILLET and SOVIET MERINO and stabilized at 3/4 level through *inter se* mating and selection, has been evolved at the Central Sheep and Wool Research Institute, Avikanagar. It produces 2.9 kg greasy wool of 19 micron diameter with less than 2% medullation and a staple length of 9.0 cm *(right)*.

Natural colours, extracted from the bark of trees, flowers and leaves, used with metallic salts for dyeing the wool neither leach nor affect its tensile strength *(above)*

A strain of MOHAIR goat has been developed by crossing the exotic ANGORA with the local SANGAMNERI. It is capable of producing 1.5 kg mohair hair at 87.5% exotic inheritance level.

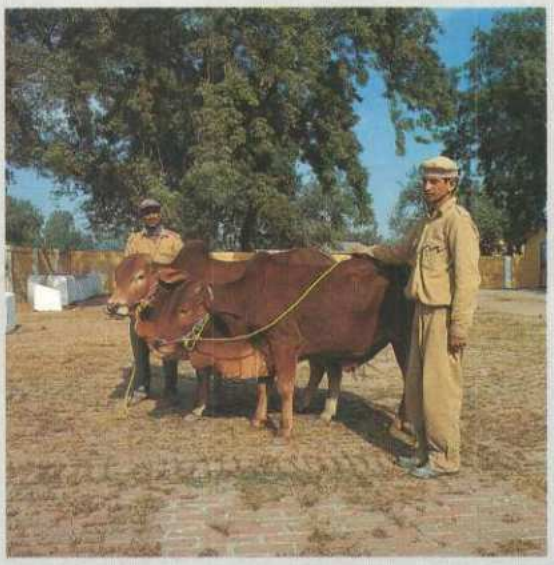
New strains of poultry for meat and egg are in commercial production. IBL 80 and IBB 83, the two hybrids of poultry broilers weigh 1,800 g at 8 weeks of age, while layers ILI 80, ILR 90 and ILM 90 produce more than 270 eggs per annum.

CONTRIBUTION OF INDIAN LIVESTOCK GERMPLASM RESOURCES TOWARDS DEVELOPMENT OF NEW BREEDS

Zebu cattle have relatively lower basal metabolic rate, better capacity for heat dissipation and resistance to diseases, especially the tick-borne diseases than the temperate Taurus cattle. Therefore Zebu cattle ONGOLE, KANKREJ, GIR, THARPARKAR and SAHIWAL have been used in South America and Australia for developing their own new beef-and-dairy breeds. Zebu is also raised as a pure breed in many of these countries.

MURRAH a high milk-yielding buffalo, has been invariably used as an improver breed for grading up of the non-descript low-milk-producing buffaloes in Europe, and SWAMP buffaloes in South-East Asia. The progeny raised from MURRAH x SWAMP buffaloes is performing well.

JAMUNAPARI and BEETAL goats have also been exported to a number of countries in the neighbouring South-East Asia for improvement of their native goats. JUNGLE FOWL breed of poultry is reported to have given rise to all the present-day breeds of poultry.



INDIGENOUS GERMPLASM. . .

Zebu cattle SAHIWAL has been used in South America and Australia for developing their own beef-and-dairy breeds.

It is also raised as a pure breed.

SAHIWAL cows are being maintained at the Military Farm, Meerut, for producing the crossbred strain, FRIESWAL.

NAKED NECK

FRIZZLE FOWL

KADAKNATH

ASEEL

GUINEA FOWL

ILI 80

IBI 91

CARI GOLD

BROODING OF CHICKS

QUAIL

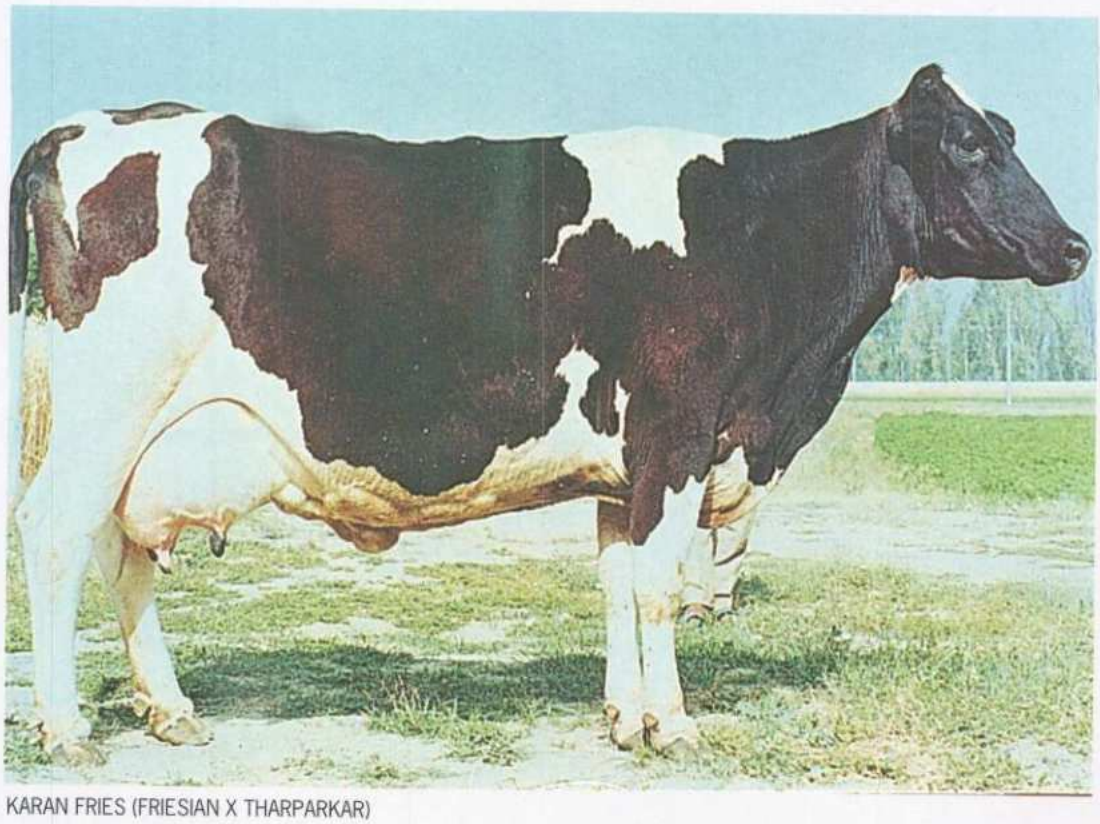
HYBRID BIRDS
transform poultry-rearing into a dynamic agri-business

Poultry production in India has advanced significantly over the last thirty-five years: 27,500 million eggs and 300 million broilers in 1994.

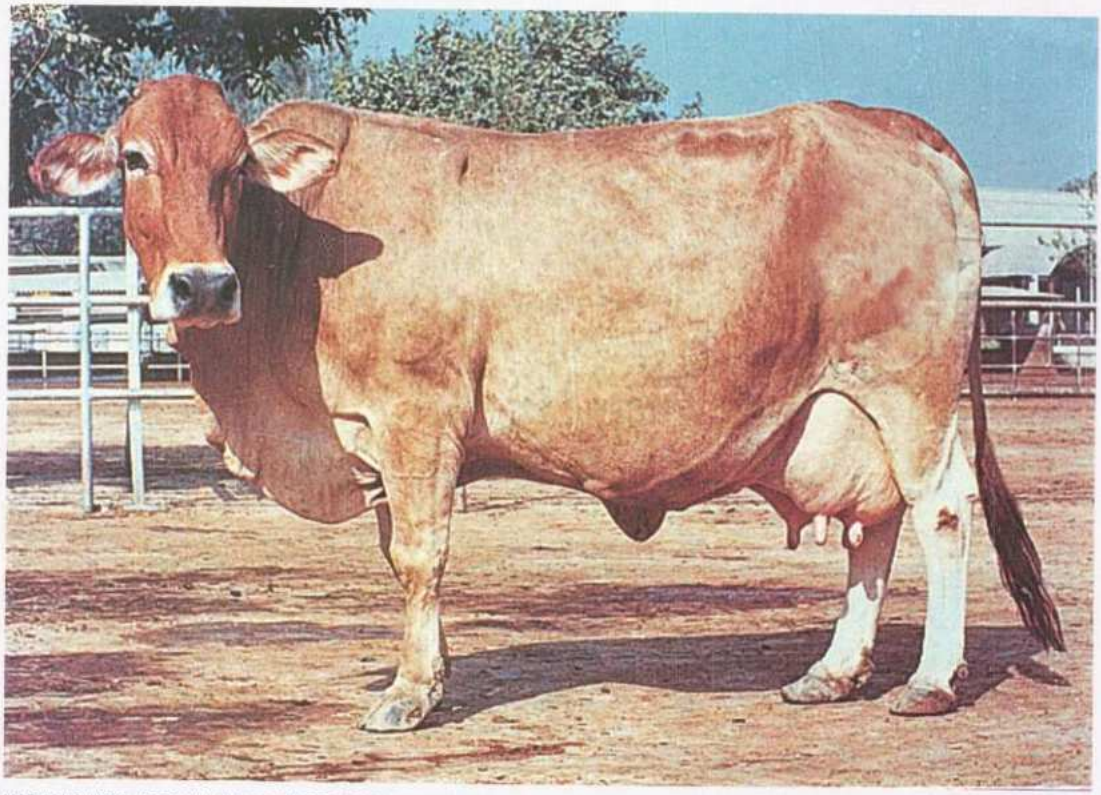
Central Avian Research Institute, Izatnagar; Project Directorate on Poultry, Hyderabad and associated All-India Coordinated Research Projects have led to this remarkable achievement through:

- commercial release of white-egg layers ILI 80, ILM 90, ILR 90 and brown-egg layer CARI GOLD
- commercial release of broilers B77, IBI 91, IBL 80 and IBB 83
- release of improved quail and guinea fowl germplasm
- feed formulations with optimal nutrients for the tropical climate for different classes and age groups of poultry
- evaluation of alternate energy and protein feeds for improving feeding standards in poultry
- illucidation of physiological mechanisms for functioning of stress hormones in chickens
- better health standards
- increasing the shelf-life of poultry egg and meat
- development of affordable and efficient thermo-plastic and laminated packaging for poultry products.

LEFT. COMMERCIAL BREEDS
FAR LEFT. NATIVE POULTRY GERMPLASM.



KARAN FRIES (FRIESIAN X THARPARKAR)



KARAN SWISS (BROWN SWISS X RED SINDHI/SAHIWAL)

. . . AS A CONSEQUENCE OF

animal improvement programmes, especially the crossbreeding and use of young and proven sires, milk production has gone up from 31.6 million tonnes in 1980 to 64 million tonnes in 1995.

MILK PRODUCTION IN INDIA

PER-CAPUT MILK CONSUMPTION IN INDIA

NATIONAL DAIRY RESEARCH INSTITUTE (NDRI) at Karnal and its Regional Station, Bangalore . . .

Imperial Dairy Institute established in 1923 at Bangalore turned into a regional station with headquarters shifting to Karnal in 1955 and came to be known as the National Dairy Research Institute (NDRI). The NDRI plays a very significant role in dairying in India — it conducts research, develops manpower, provides consultancy and extension services to the dairying sector. Value of output of dairying has been on the increase. It has been Rs 470,000 million in 1995, next only to rice.

- Increase in dairy production has been due to development of crossbred cattle KARAN SWISS and KARAN FRIES, and through improvements in feeds.
- Recent advances have been cryopreservation of buffalo semen, *in vitro* maturation and *in vitro* fertilization of buffalo oocyte and the embryo transfer technology.
- Dairy processing has advanced equally. The NDRI is a pioneer in processing of buffalo milk — LP system for preservation of milk in ambient conditions; thermal processing of UHT milk and processing buffalo milk into dairy products — butter, condensed milk, evaporated milk and dried milk products.
- Infant formula, cheese, soy-whey-based spray-dried weaning food, 'Tea and Coffee complete' and continuous *khoa*-and *ghee*-making machine are the other products developed by the Institute.
- Nearly 4,500 personnel trained at the Institute are placed as planners, managers, plant operators, private entrepreneurs, consultants and educationists.

STATE-OF-THE-ART IN EMBRYO TRANSFER TECHNOLOGY

- Success at Embryo Transfer Technology (ETT) in cattle, buffalo, sheep and goat has been identified as a critical tool for increasing the productivity of these animals.
- Through superovulation, embryo collection and embryo transfer, a superior bovine female can now be made to produce 5 to 10 calves a year and up to 50 calves or more in its life-time.
- Ongoing emphasis is on the development of protocols for superovulation, and embryo transfer responses in buffaloes in order to cut down the cost and make the technology user-friendly.
- *In vitro* fertilization technology has been developed in buffalo.
- Endocrine profiles of normal and superovulated animals have been established with respect to ovarian and pituitary steroid protein hormones.

Through Embryo Transfer Technologies, 10 calves have been born in a year's time to an elite KARAN FRIES cow producing more than 6,000 litres of milk per lactation

PRATHAM, the world's first *in vitro* fertilized buffalo calf. A buffalo oocyte was aspirated from the donor mother ovary fertilized *in vitro*

ANIMAL NUTRITION

Feed resources are limited compared with the large population of our livestock. While improvement of the conventional feeds goes on, unconventional feed resources more nutritious and economical are being continually explored.

Poor-quality diet consisting of rouphage, straw or bagasse is now being supplemented with minerals and treated with urea. The ruminants have developed a palate for the nutrition-packed urea-molasses licks and blocks, and the steam-treated bagasse.

The non-conventional feed resources, often by-products of agriculture, industry and forests are: *Mesua ferrea (nahor)* seed; *karanj* cake; apple pomace; niger seed; tea, coffee, prawn and slaughter-house wastes and tree leaves. They are being used as ingredients of newer economic livestock rations. Compound livestock feed industries are using our research input for large-scale production. For removal of the toxic components from weeds, many studies are being conducted.

Avena sativa KENT gives up to 45 tonnes green/ha in 2 cuts

Zea mays AFRICAN TALL contains higher crude protein content in winter

Dactylis glomerata is fed as pasture and hay

Feed analyses are carried out in animal nutrition laboratories

Fattening trials on male buffalo calves for quality meat

Urea molasses blocks

Urea treatment of straw

VALUE ADDITION OF FEED

UREA TREATMENT OF WHEAT OR PADDY STRAW. About 1,000 million tonnes of crop residues are annually available in India, the major residues being the straw of wheat and paddy, poorly digestible and their voluntary intake very low.

The wheat straw is treated with urea (4 kg urea dissolved in 65 litres of water, sprayed or sprinkled on 100 kg of straw) and stored for 10 days. Its digestibility improves by 40–45% and the voluntary feed intake by 86–100%. Crude protein content increases from 3.5 to 7.5% and growth rate by 200–250 g a day. The growth rate otherwise is 100–120 g a day.

The approximate cost of treating straw is Rs 200–250 per tonne. The treated straw contains 55–57% TDN (total digestible nutrients) and 3–4% DCP (digestible crude protein).

STEAM TREATMENT OF SUGARCANE BAGASSE. Nearly 20 million tonnes of the sugarcane baggase is available in the country annually. On treatment with steam (pressure of 7 kg/cm^2 for 30 minutes), the voluntary feed intake and the digestibility improves by 56%.

NEWER FEED RESOURCES FOR LIVESTOCK AND POULTRY

By-product	Annual availability (tonnes)	Nutritive value (% DM basis) DCP	TDN	Level of feeding
Kenaf cake *(Hibiscus cannabinus)*	300	18.7	63.8	20% in CM of calves
Babul seeds *(Acacia nilotica)*	600	13.8	59.0	30% in CM of calves
Cocoa pods *(Theobroma cacao)*	300	6.6	63.5	20% in CM of calves
Coconut pith coir waste *(Cocos nucifera)*	2,000	0.0	62.0	20% in CM of calves
Damaged apple waste *(Malus pumila)*	200	2.0	70.0	30% in CM of calves and 12.5% in broiler mash

NEWER FEED RESOURCES FOR LIVESTOCK AND POULTRY *(Continued)*

Decaffeinated tea-waste *(Camellia sinensis)*	50	7.5	58.0	15% in CM of pig, 10% in broiler feed
Karanj-cake (solvent extract) *(Pongamia pinnata)*	1,300	25.5	62.0	15% in CM of calves and lactating cows
Kokam-cake *(Garcinia indica)*	150	9.3	80.0	15% in CM of calves
Lac-cake *(Schleichera oleosa)*	300	14.73	79.62	30% in CM of calves, 15% in broiler mash
Mango seed kernel *(Mangifera indica)*	10,000	6.1	70.00	10% in CM of milch cattle
Mahua seed-cake *(Madhuca indica)*	3,000	9.3	49.8	20% in CM of calves
Niger seed-cake *(Guizotia abyssinica)*	100	32.7	49.4	50% in CM of calves
Panewar seed *(Cassia tora)*	300	15.9	66.0	15% in CM of milch cattle
Rubber seed-cake *(Hevea brasiliensis)*	150	18.6	66.0	20% in CM of calves and milch cattle
Sal seed-cake *(Shorea robusta)*	70	0.1	57.8	10% in CM of milch cattle
Annatto-seed *(Bixa orellana)*	300	7.9	67.2	20% in CM of calves
Tapioca starch waste *(Manihot esculenta)*	400	1.8	64.0	25% in CM of calves
Tamarind seed (decorticated) *(Tamarindus indica)*	87,000	11.26	63.92	25% in calf starters
Tea-waste *(Camellia sinensis)*	150	9.7	43.3	20% in CM of calves
Mesquite pods *(Prosopis chilensis)*	10,000	7.0	75.0	20% in CM of calves and milch cattle
Proso millet *(Panicum miliaceum)*	200	4.5	57.4	20% in CM of calves and milch cattle

C M, Concentrate Mixture; DCP, Digestible Crude Protein; and TDN, Total Digestible Nutrients

ANIMAL NUTRITION STUDIES . . .

To bridge the gap between demand and supply of animal feed resources, an All-India Coordinated Research Project on the Utilization of Agricultural By-products and Industrial Waste Materials for Evolving Economic Rations for Livestock was started in 1967 at 4 centres. More centres have been added on over the years and the scope of the project has been widened. In 1995, a full-fledged institute, the National Institute of Animal Nutrition and Physiology, Bangalore, has gone functional.

While new varieties of conventional feeds continue to be evolved, newer and alternative feed resources are regularly being tapped and analysed to feed the massive livestock population of the country and the crossbreds that require superior nutrition to express their genetic potential.

ANIMAL PHYSIOLOGY AND REPRODUCTION

Semen Freezing Laboratory of the Project Directorate (cattle) checks the quality of each semen sample before it is frozen for transport and use elsewhere

To improve the performance, standardization has been attempted in relation to various production systems in their capacity to boost the production of milk, meat, egg and fibre and the draftability of animals in varying climates.

Progress in extending the viability of semen at room temperature and its preservation through deep-freezing under liquid nitrogen is spectacular. Semen is now transported when desired.

Basic researches conducted on reproduction and endocrinology of livestock, especially buffaloes, assist in monitoring the reproduction cycle, estrus induction and diagnosis of pregnancy and its confirmation in very early stages.

LIVESTOCK PRODUCTS TECHNOLOGY

At the NDRI, Karnal, the students are trained in packaging of milk

Pickled quail eggs

Milk products of the NDRI. The formulations are commercial-grade

Quantitative and qualitative improvements in animal products and their diversification through value-addition find application in: preservation of raw milk at ambient temperature; preparation of *khoa*, *kulfi*-mix, *gulab jamun*-mix, *rasogulla*-mix, *paneer* and *chhana*.

Starter cultures standardized by the NDRI are being used in making cheese, mozzarella, cheddar cheese, goat-milk cheddar cheese and fermented milk products, curd, butter-milk, butter-milk powder, yoghurt and *shrikhand*.

Formulations recommended by the NDRI for the preparation of infant foods, malted milk, and low-lactose milk are of international standards. They are being widely made use of by the industry.

Poultry meat nuggets, patties, steaks, meat sausages and quail egg pickles have a longer shelf-life using the technologies developed at the National Research Centre (Meat) and Livestock Products Technology, Divisions of the IVRI and CARI Izatnagar.

A lot of basic research is being conducted for improving the active span of starter cultures at the NDRI Regional Station, Bangalore. Dairy Microbiologist, Dr Jaganathan is engaged in explaining some exciting results to Dr M.K. Ramamoorthy

ANIMAL HEALTH

Research in animal health is more than a century old. The vaccine to control the highly virulent Rinderpest disease is in use ever since 1927.

Over the years, improved vaccines, diagnostic reagents, disease investigation methods, and disease monitoring and surveillance procedures have been boosting production quantitatively and qualitatively.

Swine Pox

The important vaccines developed much earlier still guard against: Anthrax, Haemorrhagic Septicaemia, Blackquarter, Fowl Cholera, Ranikhet Disease, Swine Fever and Rabies.

The newer ones are those that guard against the Foot-and-Mouth Disease, Sheep Pox, Goat Pox, Fowl Pox, Clostridial diseases in sheep, Theileriosis, Canine Distemper and Equine Influenza.

Deemed-to-be university, IVRI, Izatnagar

INDIAN VETERINARY RESEARCH INSTITUTE, IZATNAGAR

Imperial Bacteriological Laboratory, Pune, was the first research laboratory to be set up to investigate problems of livestock health conservation and development in India in 1889 but moved to Mukteswar in 1893 for reasons of safety, since cattle-plague or Rinderpest which was then being researched upon was very virulent. A lot of expansion took place and the Laboratory came to be known as the Imperial Institute of Veterinary Research in 1925. It is a forerunner of the Indian Veterinary Research Institute, Izatnagar, a deemed-to-be-university that conducts research on all disciplines of animal sciences and offers postgraduate education in 23 disciplines leading to Master's degree and in 21 disciplines leading to Doctoral degree. The IVRI also awards National Diplomas and conducts short-term courses. The IVRI has 3 campuses : at Bangalore, Mukteswar and Bhopal.

The Institute has developed effective diagnostic and prophylactic measures against important diseases of livestock and poultry. More than 44 immunobiologicals against bacterial, viral and parasitic diseases have been developed making the country self-sufficient in preventive veterinary medicine. The IVRI is a referral center for the diagnosis of almost all important animal diseases including wildlife at the national level.

A **High Security Animal Disease Laboratory** is being established with assistance of the UNDP and World Bank at the Indian Veterinary Research Institute, Bhopal, to:

- Diagnose, differentially diagnose and control exotic/emerging diseases
- Develop diagnostic tests against exotic diseases
- Create Data Bank for exotic disease situations in India and its neighbourhood and network dissemination of information
- Provide consultancy services and advise on procedures of diagnosis and containment of exotic animal disease problems
- Organize training facilities for diagnosis and control of exotic/emerging diseases.

To be, HSAD Laboratory, Bhopal

EXPERIMENTAL ANIMALS REARED AT THE IVRI FARM, BANGALORE

Rabbits

Albino guinea pigs

Coloured guinea pigs

Mice

P 3 LAB

Fermenter Control Panel

Evaluation of vaccine antigens

Serology Laboratory

Cold storage of vaccine

P 3 LAB

Among the contagious diseases of the cloven-footed animals, the Foot-and-Mouth Disease (FMD) is rampant in our country. Although mortality is low, morbidity is very high causing heavy economic losses due to reduced production of milk, meat and work capacity of the animal.

The P 3 level microbial containment facility for the production of FMD vaccine — inactivated saponified aluminium hydroxide gel-absorbed FMD vaccine in BHK 21 suspension cell culture system using fermenters — has been started at Bangalore in 1979. "The IAEA, Vienna, the nodal agency in the world for validation of Diagnostic Techniques in Animal Diseases has expressed its willingness to validate the techniques (protocols and reagents) for diagnosis of FMD standardized at the IVRI, Bangalore," says Dr C. Natarajan, Joint Director.

Dr V.V.S. Suryanarayana loading a sequencing gel for deciphering the nucleotide sequence of different FMDV strains. PNA Lab, IVRI, Bangalore

Is it the same VPI sequence or is it a variant? Dr V.V.S. Suryanarayana discussing with Dr T.J. Rasool over a DNA sequence autoradiograph

B.P. Sreenivasa, a Ph.D. Scholar is trying to establish the molecular identity of the Bovine herpesvirus (BHV 1). The virus is of particular significance for although the cattle survive, the virus continues to be present and is transmitted.

So far B.P. Sreenivasa has established the existence of two different varieties of BHV 1. He is currently trying to clone and express the major immunogenic genes in suitable vector system for developing antibody-based diagnostic kit

PROTEIN AND NUCLEIC ACID RESEARCH LABORATORY, IVRI, BANGALORE

The Protein and Nucleic Acid Research Laboratory at the IVRI, Bangalore, was established in 1991 to conduct basic and applied research on protein and nucleic acid components of the Foot-and-Mouth Disease Virus (FMDV). However, molecular aspects of the FMDV are being studied at this Campus since 1983 and cloning of FMDV Asia 1 genes reported in 1985.

The Laboratory has following well-defined objectives:

- Develop highly sensitive and cost-effective diagnostics
- Identify strain variations of viruses isolated from vaccine outbreaks using nucleotide sequencing
- Identify sequences responsible for virus virulence and persistence
- Production of efficacious immunogens using recombinant DNA technology
- Molecular basis of disease resistance

The achievements of this Lab have been . . .

- Antigen capture PCR
- Using the Sandwich Nucleic Acid Hybridization Technique as nucleic acid-based diagnostic
- Expression of immunoreactive proteins of FMDV types for using as protein-based diagnostic antigens and prospective immunogens
- Nucleotide sequencing techniques standardized at the laboratory are put to identify a number of field viruses at genome level
- The knowledge obtained from the basic studies on 5 untranslated regions have helped in identifying the regions responsible for the virus replication
- A technique has been standardized, based on PCR-RFLP, for MHC typing of farm animals
- A gene of the MHC complex of an Indian cattle breed HALLIKAR has been cloned
- MHC typing of the guinea pigs which may be used for potency testing of FMD vaccine

Dr S. Gopalakrishna in his Histo-pathology Lab

Dr Mukund Gajendragad carrying out ELISA for detecting viral antigens

The Computer and Communication Centre of the IVRI, Bangalore, is equipped with latest software packages—Windows, Multi Express, Modem, Linkage Programme and PC Gene Works for analysing gene sequences

CENTRE FOR ANIMAL DISEASE RESEARCH AND DIAGNOSIS UNIT, BANGALORE

. . . a referral laboratory for southern India

The CADRAD Unit, Bangalore, conducts Epidemiological studies on Rinderpest and Rinderpest-like diseases among small ruminants in the southern peninsular region.

The small ruminant population has been grouped into: Residential flocks, Migratory flocks and Semi-nomadic flocks. The flock structures of all have been studied. Epidemiology of twenty-nine outbreaks of morbill virus infection/disease has led to the identification of the causative agent, Rinderpest. In fact, the small ruminants are not just blind hosts for the morbill virus, but many a times alternative hosts too.

IN FUTURE . . .

Continued progress in animal sciences will be maintained through:

- Conservation, evaluation, and improvement of indigenous animal genetic resources.
- Further improvements in the newly developed strains of livestock for commercial viability.
- Development of transgenic animals for higher productivity.
- Basic studies on energy and protein metabolism, rumen microbiology and endocrinology for growth and reproduction.
- Standardization of newer reproduction technologies including transfer and cryopreservation of gametes and embryos.
- Research on molecular biology of pathogenic microbes to develop immunodiagnostics and prophylactics.
- Improving on disease forecasting, and monitoring to ensure strategic control and eradication.
- Processing technologies for indigenous dairy, meat, egg, wool and skin products and their value addition, packaging and storage.
- Continued search for non-conventional feed resources and development of combined feeds.

Mixed cropping (maize + cowpea) is advised for increasing herbage yield and improving forage quality. Many more combinations have also been recommended by the IGFRI

Pastures of *Pennisetum pedicellatum* var. BUNDEL DINANATH 1 and BUNDEL DINANATH 2 are very productive

This two-tier system of forage provides up to 5 tonnes/ha and up to 4 tonnes/ha of protein-rich *Leucaena latisiliqua* leaves

The "Protein Bank Cafetaria" serves lucerne to sheep. It is a rainfed degraded rangeland restored by the IGFRI

grassland and fodder research

India feeds 900 million people and 760 million livestock from 184 million hectares of cultivable land. Mixed farming systems have been a traditional practice. Better arable land is used more and more for food and cash crops. The grasslands and fodder crops not only receive a low priority in the quality of land available for cultivation but also in the use of fertilizer.

In India, scientific range management began with the setting up of the Indian Grassland and Fodder Research Institute (IGFRI) in 1962. Over years, the IGFRI has concentrated on: evolving improved varieties of pasture and fodder crops; developing soil-enriching forage crops in order to use neglected lands; providing quality seed to ensure sown pastures in the rangelands for the livestock to browse; bringing about adjustments of soil nutrients by matching biofertilizer affinities and by balancing management to integrate the growth cycle of the plant with animal requirements. Additionally, to improve productivity of such land, and to raise and diversify total production, complementary land-use systems have been suggested.

The IGFRI also evaluates the quality parameters of feeds, and conducts tests on the better suited feed/feed combination.

Protein-rich top feed alongside a watershed developed by the IGFRI

Fodder Crop Production
RECOMMENDED ROTATIONS

- Hybrid napier + cowpea – berseem +mustard (286 tonnes green/ha)
- Guinea grass + cowpea – berseem + mustard (200 tonnes green/ha)
- Maize + cowpea – MP Chari–berseem + mustard (197 tonnes green/ha)
- MP Chari – turnip – oat (192 tonnes green/ha)
- MP Chari + cowpea – berseem – sorghum + cowpea (168 tonnes/ha)
- Maize + cowpea – oat – maize + cowpea (168 tonnes/ha)

NEW VARIETIES DEVELOPED AT IGFRI

Cenchrus ciliaris

BUNDEL ANJAN

Pennisetum pedicellatum

BUNDEL DINANATH 1

BUNDEL DINANATH 2

Napier-bajra hybrids

IGFRI 6

IGFRI 7

IGFRI 10

SWETIKA

Berseem

WARDAN

JHB-ISB 86

JHB 146

Oat

BUNDEL JAI 822

BUNDEL SHEET JAI 810

BUNDEL SHEET JAI 829

BUNDEL JAI 851

Cowpea

BUNDEL LOBIA 1

BUNDEL LOBIA 2

Cluster bean

BUNDEL GUAR 1

BUNDEL GUAR 2

Dolichos bean

BUNDEL SEM 1

A somaclonal variant of marvel grass *Dichanthium annulatum*. Plant types with novel variation, from creeping, semi-erect and erect with broad and large leaves to small and curly leaves, have been developed for site-specific utilization

IGFRI has developed many varieties of *Trifolium alexandrinum*, berseem. The recent ones are: JHB-ISB-86 and JHB 146 for the South and Central North-West Zones

Berseem WARDAN is a single plant selection from the segregating polyploid material. It has been released in 1982 and is at present a National check variety

Pennisetum pedicellatum BUNDEL DINANATH 2 has been developed for marginal drylands

The protein-rich *Leucaena latisiliqua* is planted for browsing in most pastoral system. It helps the animal in gaining body weight quickly

Green chopped fodder is ensiled in *kachacha* or cemented pits in compacted layers, 25-30 cm thick, and covered with polythene and soil layer. The conserved fodder is fed to the livestock during lean period. Addition of 0.5% urea makes it more nutritive

To evaluate quality parameters of feeds and fodder, laboratory tests are conducted at the IGFRI, Jhansi

For developing multi-tier cropping system, the micro-environment variation in tree-crop interactions are studied

IGFRI TYRE-TYPE SEED PELLETING MACHINE can produce 20-25 kg of seed pellets in an hour

IGFRI POWER-OPERATED PELLETING MACHINE operating on a 5 kW electric motor makes 80 kg of feed pellets or 100 kg seed pellets in an hour

MACHINES DEVELOPED AT IGFRI

All forage seed produced is processed before it is distributed for wholesale or retail

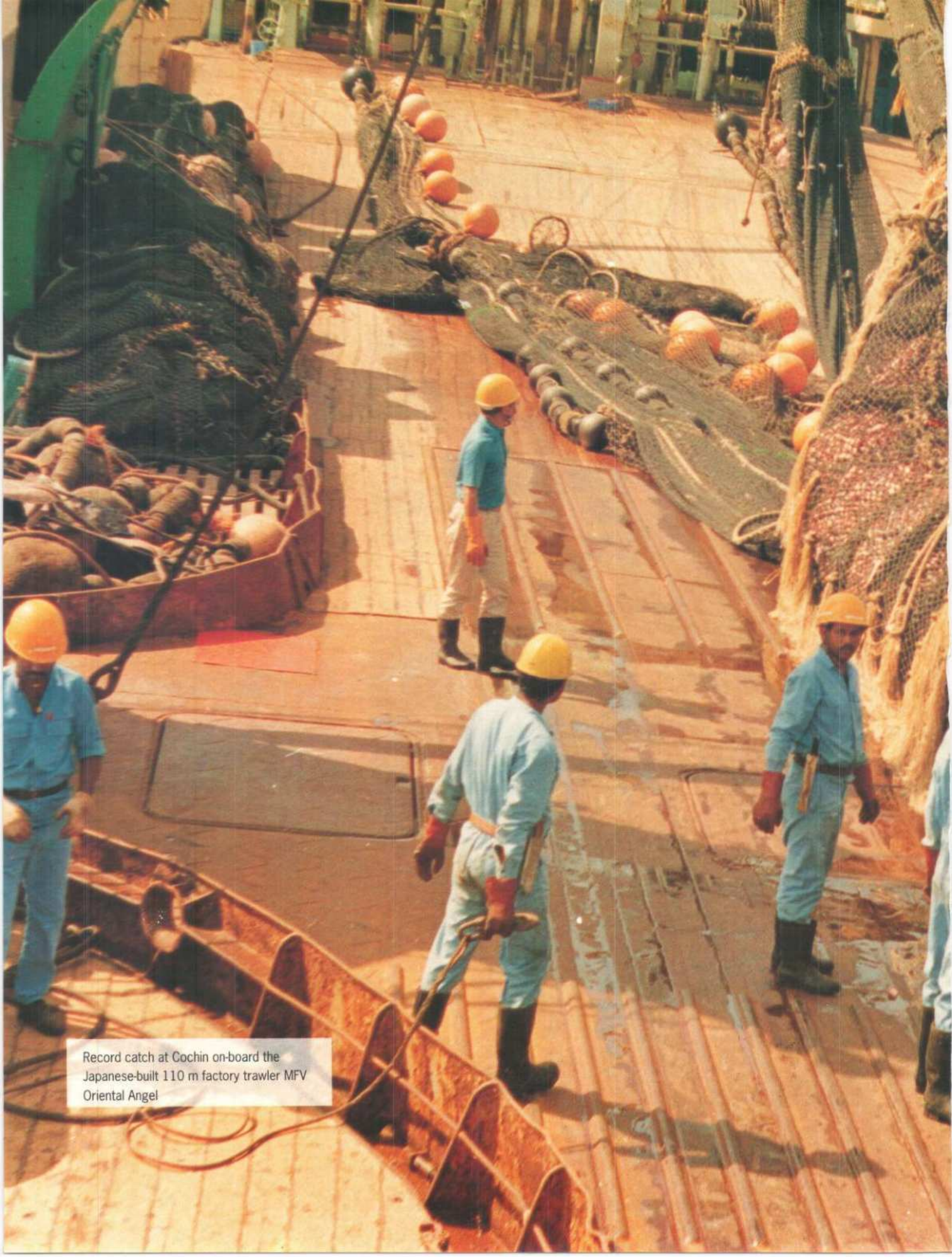
A Lysimeter has been developed to measure the specific requirement of water at various stages of crop growth

IGFRI ROTARY DISC MOWER has been designed for harvesting berseem and the oat crops. Its capacity is 0.22 hectare per hour and efficiency, 62%

IGFRI TRACTOR-MOUNTED IMPROVED GRASS SEED HARVESTER has been developed for harvesting mature grass seeds of *Cenchrus ciliaris*, *C. setigerus* and Dinanath grass at 50-170 cm height. The field capacity is 0.34 hectare/hr and seed collection up to 14 kg/hr

This simple machine helps in baling of grasses for convenient transportation

With the help of this device attached to a tractor, the surplus green fodder is heaped 1-1.5 m high for ensiling



Record catch at Cochin on-board the Japanese-built 110 m factory trawler MFV Oriental Angel

fisheries

Fish is a dynamic and renewable resource with considerable potential. It is also a very economical and rich source of animal protein.

Out of the 23% of India's total animal protein supply in the diet, the fish accounts for a mere 2.3% even when a wide variety of species contribute to the total production. Fish-eating population is generally restricted.

India ranks seventh in the world and first among Commonwealth countries in fish production. However, only 10% of the produce is exported. India is the second largest fish producer from inland sources after China.

Our coastline is 8,129 km long and the Exclusive Economic Zone (EEZ) 2.02 million km^2 vast. The tropical water permit year-round harvesting. Tropical fishstocks are generally fast-growing and short-lived.

INFRASTRUCTURE

A practical class in Aquaculture Engineering being conducted at the brackishwater fish farm of CIFE, Kakinada, Andhra Pradesh

In study, liver and kidney of fish *Rita rita* that had lived in its natural environment, CIFE, Bombay

Fisheries had largely been seen only as a source of revenue until the Fish Sub-Committee was set up in 1945 by the Government of India. The all-India approach in research came into practice with the establishment of the Central Inland Fisheries Research Institute (CIFRI) and the Central Marine Fisheries Research Institute (CMFRI) in 1947.

Establishment of the Central Institute of Fisheries Technology (CIFT) in 1957 for research on fishing craft and gear and fish processing was a singular effort towards laying the foundation for fish and fish products export.

Epizootic Ulcerative Syndrome (EUS) being investigated in *Etroplus suratensis*, Microbiology Lab, CIFT, Cochin

Significantly, the Central Institute of Fisheries Education (CIFE) has come up in 1961 at Bombay and the National Bureau of Fish Genetic Resources (NBFGR) at Lucknow in 1983.

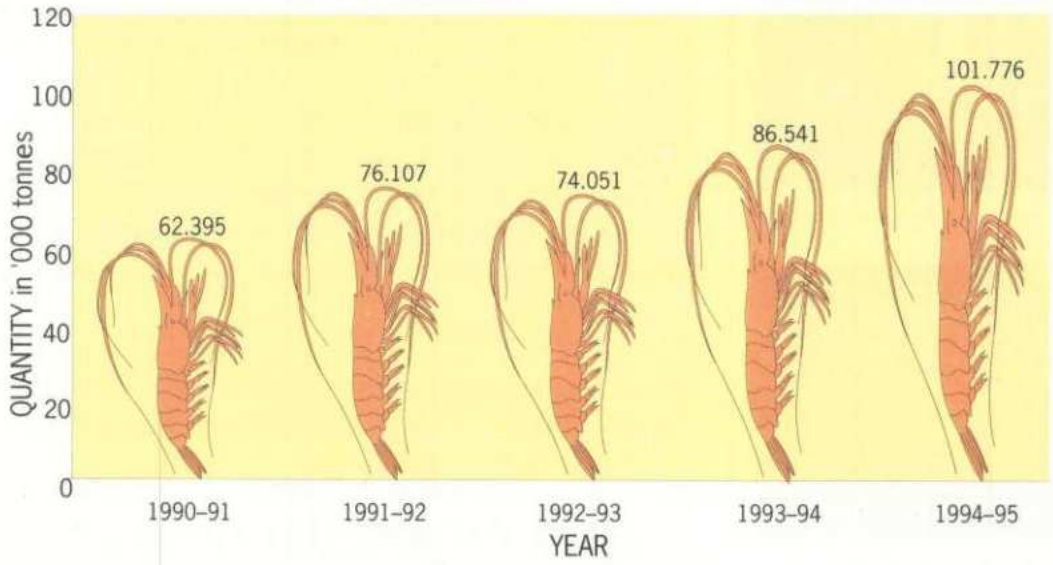
At present 7 resource-specific institutes conduct research on exploitation, survey, experimentation, management and conservation of various acquatic resources from freshwaters, brackishwaters, cold-waters, high altitude, neretic and open ocean ecosystems; on harvest and post-harvest technologies, and on genetic resources. They also include an exclusive deemed university on fisheries for the development of human resources and a National Research Centre.

MARINE FISHERIES

The Central Marine Fisheries Research Institute evolves models for stock assessment and population dynamics for multispecies, multigear fish resources in tropical waters. Our methodology for stratified multistage random sampling

Tagged *Penaeus indicus* juveniles ready for sea-ranching at Palk Bay, Bay of Bengal

EXPORT OF FROZEN SHRIMP FROM INDIA



for estimation of fish landings in space and time is being emulated internationally through the FAO. Nationally, their application has increased current marine fish production to 2.69 million tonnes from 0.53 million tonne during the early fifties.

The maximum annual sustainable yield (MSY) from the EEZ is estimated by the CMFRI at 3.92 million tonnes from depth regimes of: up to 50 m, 100 m, 200 m and beyond, with the near-shore zone (up to 50 m depth) providing a catch of 2.4 million tonnes. Fetching higher profits, the tuna, squid, cuttle fish, deep sea shark, shrimp and the lobster from offshore waters are harvested with deep sea fishing vessels.

A nutritious feed: the marine algae cultured on a coir net in Minicoy lagoon at Lakshadweep

The CMFRI is developing models for fishery forecasting, particularly in collaboration with the National Remote Sensing Agency (NRSA). Marine environment monitoring is a marked contribution of the CMFRI.

The CMFRI is sea-ranching the more important varieties — shrimp and sea-cucumber — to augment the wild stocks in nature. India is the second country in Asia to pursue this activity.

Marine fish haul at Cochin Fishing Harbour, Kerala

Of commercial importance are mariculture technologies for pearl oyster, edible oyster, clam, mussel, lobster and seaweeds. While domestic market for them is limited, the export market unlimited.

The CMFRI conducts all-India quinquennial census surveys on fisher-folk, their socio-economic status, health and educational standards, that regularly assist the marine sector across the country.

Round pearls cultured in *Lamellidens marginalis*

Pearls may also be cultured in desired images and shapes. This one is depicting Lord Ganesha

"PEARL CULTURE IS A COMMERCIAL SUCCESS IN INDIA AS WELL"

The ICAR has commercialized both the freshwater and marine water pearl cultures. The Central Institute of Freshwater Aquaculture (CIFA) has cultured pearls in the common freshwater mussel *Lamellidens marginalis*, *L. corrianus* and *Parreysia corrugata*. The Central Marine Fisheries Research Institute (CMFRI) has standardized culture of pearls in *Pinctada fucata*, the most important and abundant pearl oyster in India.

Suitable surgical grafting and culture procedures have been developed for different pearl products — irregular round pearls; irregular baroque pearls; half-round shell-attached pearls and pearl images.

CIFA is at present embarking on technology upgradation using *in vitro* cell culture. For which, the large oriental pearl mussel species *Hypriopsis schegcli* and *H. cumengi* have been introduced from Vietnam. The pearls produced are going to be bigger and more in number.

INLAND FISHERIES

Research at the Central Inland Capture Fisheries Research Institute (CIFRI) concentrates on maximizing fish production from both the perennial and seasonal open water bodies that abound in rural areas.

A haul of fish from the Aliyar Reservoir

Composite fish culture of the Indian and exotic carps has significantly improved the production from the smaller ponds. It involves stocking of compatible species of different feeding habits in order to utilize the food spectrum available in different ecological niches of the ponds and tanks. The technology (developed in the seventies) has raised the national average to over 2 tonnes/ha/yr from 50 kg/ha/yr. Though, a harvest of 15 tonnes/ha/yr has been demonstrated by the ICAR scientists.

The ability to induce breeding among a majority of Indian carps through pituitary hormone in confined waters is a breakthrough of the late fifties. Over the years this advancement has industrialized inland fisheries.

The environment monitoring programme has evaluated the commonly used pesticides and heavy metals for their toxic effects to fish and fish food organisms in the major river systems.

FRESHWATER AQUACULTURE

The biology and physiology of a number of commercially important fish species has been detailed at the CIFA for recommending a package of technologies for: composite culture of the carp, prolonging the breeding season and triggering multiple spawning; culture of the air-breathing fish, catfish and the freshwater prawn; production of freshwater pearl; culture of land snails and integration of aquaculture with crop and animal components of agriculture.

The indigenous breed of the giant land snail is being exported to the European Union since 1993

The giant land snail is being largely farmed for export, a cuisine delicacy in western Europe.

With intensive culture of carps in freshwater ponds, 15 tonnes/ha/yr of fish may now be harvested.

Five times as much spawn may be produced from catla by manipulation of gonadal maturity, breeding season, feed and environment. Nearly 10 million seed per hectare with 80% survival is reared commercially. As a result, the country is self-sufficient in the production of the fish seed.

Freshwater prawn cultured in pens

The technology for breeding hilsa and production of its seed on a large scale is reviving the depleting hilsa fishery in the river systems.

Scientific breeding, seed production and culture of the cold water fish, trout and masheer, in the uplands is improving the economy of the rural fishermen and tribals.

The endangered golden-masheer may now be reared in a flow-through hatchery fitted with an airlift system. Because of which, its population is now on the increase in the lakes of Kumaon Hills.

BRACKISHWATER AQUACULTURE

The Central Institute of Brackishwater Aquaculture (CIBA) has its parent in the CMFRI, which has pioneered shrimp farming in the sixties. Since 1987, the CIBA has been monitoring; developing technologies to augment the supply of healthy viable seed; developing stable nutritious feed from least-expensive indigenous raw materials, innovating backyard hatcheries for the low-income fish farmers and containing and combating pollution and diseases in brackishwaters. As a result there is now a gradual decline in indiscriminate collection of the wild shrimp seed; instead there is better maintenance of brood stock and monitoring of fish health through diagnostic, prognostic and therapeutic measures.

Demonstrations of brackishwater shrimp and fin-fish culture in saline soils of Haryana is opening newer ways of utilizing the aberrant saline soils.

HARVEST AND POST-HARVEST TECHNOLOGY

The redesigned curvatures of the blades have lent efficiency to the 4-blade propellers fitted on the existing medium-sized trawlers of 100 HP range operating off Kerala coast. While the fuel efficiency is 30% for the corresponding speed and pull, the load on the engine considerably less, CIFT, Cochin

The capacity to tap the pelagic and dimersal fishstocks has been increasing with improvements in the fuel-efficiency of craft and operation efficiency of gears. The Central Institute of Fisheries Technology (CIFT) has made some outstanding innovations in harvest technology: high-opening mid-water trawl; pelagic trawl; lobster-and-crab traps; designing, fabrication and commercialization of fuel-efficient, low-cost, resource-specific wooden, FRP and aluminium fishing craft for different types of fishing operations. Fabrication of the 4-blade propeller as a fuel-efficient device is a trend-setter.

Postharvest options — value addition, new products, processing-plant hygiene, quality control, longer shelf-life and improved transportation have transformed traditional fish processing in India into a blue-chip industry.

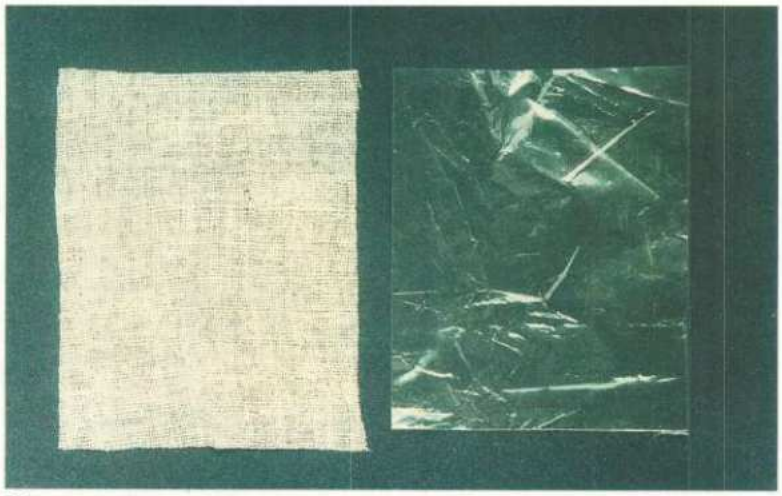
Ready to be packed for export, snail meat, a non-marine product

Prawn feed to be fed to a shrimp at different stages of growth, CIFT, Cochin

The CIFT is also developing technologies for the utilization of fish discards and discarded fish. In practice are: production of chitin or chitosan from crustacean waste for a variety of uses in pharmaceuticals, textile, cosmetic and paint industry and absorbable surgical sutures from fish gut.

APPLIED

RESEARCH . . .



Chitosan

CHITIN AND CHITOSAN. Chitin and Chitosan produced from prawn shell-waste have wide-ranging applications. The technology developed by the CIFT has been adopted by the industry. Chitin incorporated into poultry feed at a low level results in 10–12% weight gain.

Chitosan, a very effective haemostatic chemical, is much used in dental and neuro-surgery, skin-grafting, wound-healing and as an artificial kidney membrane. It's use in cosmetics is revolutionary.

Surgical sutures

SURGICAL SUTURES. Absorbent surgical sutures have been developed from gut collagen of fish by cross- and polymer-coating for eye and micro-surgery. They fulfil all clinical requirements and are particularly low-cost. Indigenously produced on large scale, the sutures are fast-substituting their imported counterparts.

Indian mackerel, *Rastrelliger kanagurta*, our major scombroid fish resource

Barracudas, a mid-water resource along south-east and south-west coasts

Green mullet *Perna virdis*

Mud crab, *Scilla serata*

Treadfin bream, the best resource at 100–200 m depth

Catfish, a demersal finfish demanding conservation

Mullets *Mugil tade*, found in the eastern coast of India, are being cultured in land-based ponds in the coastal areas

Lizard fish, a ground fish resource along the Indian shelf-waters

Bull's eye, a deep water bottom resource with vast potential

Oil sardine, *Sardinella longiceps*, the predominant clupeid fish

NATIONAL BUREAU OF FISH GENETIC RESOURCES

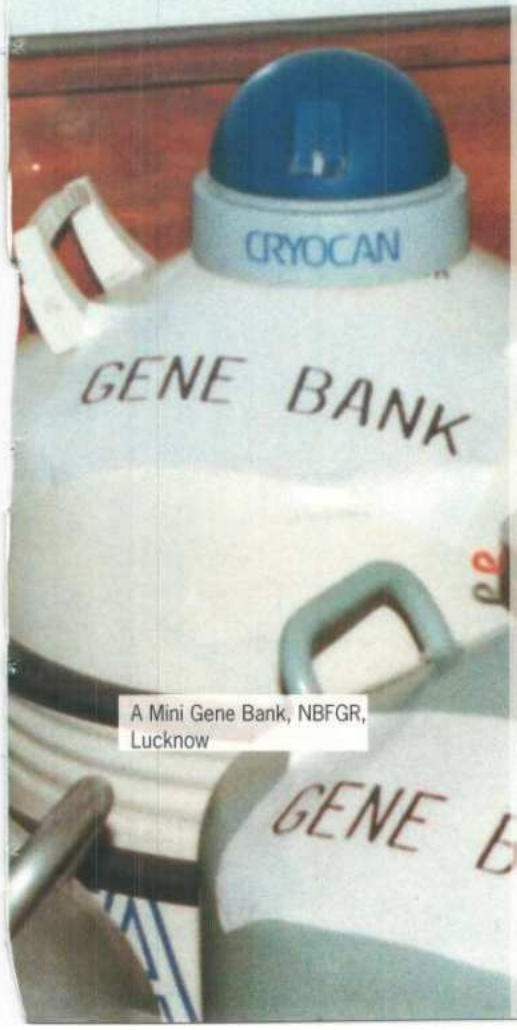
The National Bureau of Fish Genetic Resources (NBFGR), a recent addition, aims to introduce appropriate alternatives in gonadal sex manipulation, cryopreservation of gametes, potent hybrids, gynogenesis and polyploidy. To breed fast-growing hardy and high-yielding fish varieties, the pureline fish stocks are preserved and maintained.

At present the NBFGR has compiled genetic information on 2,200 indigenous fish species. The Bureau is also working on genetic taxonomy through DNA mapping of look-alike, closely related and interbreeding species.

IN FUTURE . . .

By AD 2000, the world production of fish is projected at 100 million tonnes and India envisages to produce 6 million tonnes of it. However, the domestic consumption at present 4.5 million tonnes is expected to be 12.5 million tonnes. With capture fisheries from seas and rivers having reached a plateau, the research strategy for the future is:

- diversification of aquaculture to include more candidate species concomitantly widening the culturable area for higher production
- sustaining production through culture technologies that safeguard the environment
- macro- and micro-survey of coastal areas through remote sensing for location of additional culture sites
- management of water-quality and health of stocked fish by diagnostic, prognostic and therapeutic measures
- optimal synergetic use of water and land resources for aquaculture
- survey and assessment of potential resources in the outer continental shelf and beyond our EEZ
- rational management and conservation of the already overfished coastal resources
- R&D on unconventional offshore resources, by-catches, fish-discards and discarded fish
- R&D in optimization of craft and gear designs for maximum harvest efficiency in offshore/oceanic operations
- upgradation of processing technology for prolonging shelf-life and preventing loss and spoilage during processing.



A Mini Gene Bank, NBFGR, Lucknow

Multicrop thresher

agricultural engineering

Indian agriculture has made rapid strides from subsistence farming to surplus and commercial farming. Improved agricultural machinery has played a significant role apart from good seed and use of fertilizer. Fortunately our industry has manufactured good modern machines from time to time.

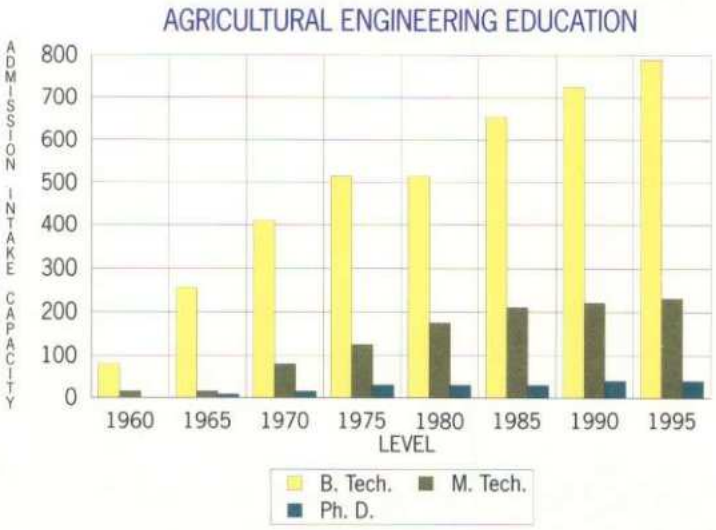
Agricultural engineering extends its role into efficient utilization of agricultural inputs to reduce human drudgery; increase productivity of a man-animal-machine system; improve agricultural productivity, and add value to produce by adopting appropriate processes and equipment.

Agricultural engineers at the ICAR are, thus, involved in the development of machinery for agricultural production, and postharvest operation, irrigation and drainage, energy and power management, lac, jute and cotton technology.

INFRASTRUCTURE

Mechanization of farms — tractors, irrigation equipment, efficient harvesting and threshing machinery — has become inevitable with the introduction of high-yielding varieties since the sixties. The ICAR therefore established the research training and testing centres (RTTC) in different states which compiled information on indigenous tools, implements and machinery used by the farmers to understand the limitations of the existing operations.

During the early seventies 5 zonal research centres (ZRC) had been established with a Coordinating centre at the IARI, New Delhi and replaced in the Sixth Plan with an All-India Coordinated Research Project (AICRP) on Farm Implements and Machinery and 10 centres. An independent AICRP on Post-Harvest Technology to reduce losses, and add value to the produce, has also been established the same time.



However, the first institute, the Central Institute of Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh, in 1976 has been set up for developing appropriate mechanization, energy management and agro-processing technologies. The AICRP on Farm Implements and Machinery and Post- Harvest Technology had also been moved to the CIAE.

At present, the activities relating to agricultural engineering are carried out at 6 institutes, 10 AICRPs and in a number of *ad-hoc* projects located nation-wide. At the Central Institute for Research on Cotton Technology (CIRCOT), Bombay, research is exclusively conducted on the quality of fibres including cotton waste, and, at the Jute Technological Research Institute (JTRL), Calcutta, on processing of jute and development of diversified jute products. The Indian Lac Research Institute (ILRI), Ranchi, is unique in the world for development of technology related to production and processing of lac.

To research on cottage-scale agro-processing, the Central Institute for Post-Harvest Engineering and Technology (CIPHET) has been set up in 1989 at Ludhiana. Another campus of CIPHET is being established at Abohar to concentrate on processing of fruits, vegetables and oilseeds.

FARM IMPLEMENTS AND MACHINERY

TILLAGE AND SOWING

Well-equipped laboratories develop functional prototypes and commercial-grade technology and liaise with industries for commercial manufacturing.

Tractor-drawn cultivator performing weeding in the soybean crop

Weeding of soybean crop using hand-hoe

Power-tiller-operated rice transplanter

Self-propelled vertical conveyor-reaper-harvester

Animal-drawn multipurpose tool carrier may be fitted with tillage, sowing or interculture equipment

COMMERCIALIZED FARM EQUIPMENT

OPERATION	MACHINE	CROP SUITABILITY
Tillage	Bullock drawn harrow-cum-puddler	Discing and puddling generally
Sowing and planting	Bullock drawn 3-row seed-cum-fertilizer drill	Wheat, chickpea, soybean, sorghum, safflower, sunflower
	CRIDA drill plough	Cereals, pulses
	Tractor-drawn cup-feed-type planter	Groundnut, sorghum, rice
	Manual transplanter	Rice
	Automatic potato planter	Potato
Weeding, inter-culture and plant protection	Manual wheel-hoe weeder	Row crop weeding in sorghum, maize, soybean
	Battery operated low-volume sprayer	All crops
Irrigation and drainage	Power-tiller-operated axial flow pump	Low-lift high-discharge pump
	Propeller pump	Low-lift high-discharge pump
	Energy-efficient foot valve	Improved pumping efficiency
Harvesting	Self-propelled reaper harvester	Wheat, rice, soybean, *ragi* rapeseed, mustard
	Tractor-drawn harvester	Soybean, chickpea, wheat
Threshing	Multicrop thresher	All major crops
	Soybean thresher	Soybean, chickpea, sorghum, wheat
	Pedal-operated *Phule* sunflower thresher	Sunflower

India is not importing any farm machinery. Hand tools for weeding, harvesting, decortication; bullock-drawn tillage implements for uplands and puddling; multipurpose bullock-drawn tool frame on which tillage and sowing equipment could be mounted; line sowing and planting equipment that may be operated with draught power or tractors, and paddy transplanters (manual, power-tiller operated or self-propelled) are a few examples.

Seed-cum-fertilizer drills (bullock- and tractor-operated) for line sowing and fertilizer application in dryland agriculture have led to considerable increase in productivity. Groundnut, maize, potato and the sugarcane require special planting machinery.

Smaller seeds — pearlmillet, rapeseed and mustard — also require specialized seed-metering mechanism (less than 4 kg/ha) for which seed-cum-fertilizer drills and planters have been developed. They are widely used.

HARVESTING AND THRESHING

Practice of modern agriculture has led to manifold increase in yields. Efficient harvesting and threshing machinery — improved sickles, combine harvesters (self-propelled and tractor-operated), power tillers, and tractor-operated reapers, hammer mill-type threshers — have reduced the turnaround time. Development of spiked-tooth and dummy threshers are revolutionary achievements of our engineers. Multicrop threshers have been developed for versatility and economy.

To avoid mishaps, the Dangerous Agricultural Machinery Act has been enforced.

IRRIGATION AND DRAINAGE

Irrigation of crops is not only essential for their survival but also for increasing productivity. About 76.3 million hectares of the cultivated land is assured of irrigation, expanding at 2.9% a year. The farmer has been provided incentive (credit or subsidy) for adoption of modern devices for efficient irrigation — centrifugal pump, drip, sprinkler and micro-irrigation systems. While the devices are continually improved for performance, the water-balance models are studied for appropriate use of ground- and-surface water. Use of drip for fertigation in fruits and vegetables is being studied.

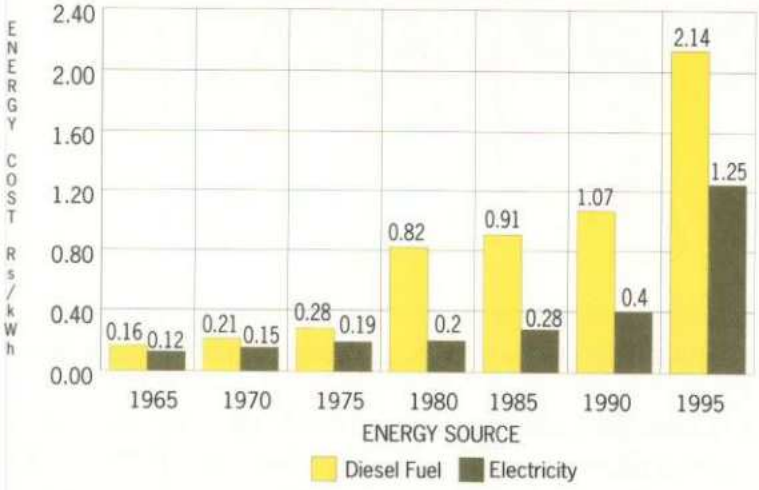
Drainage is equally essential, since high precipitation, over-irrigation and seepage from canals lead to a rise in water table affecting adversely the root growth and ultimately the crop yield.

Extra water beyond field capacity may be drained off through surface and sub-surface drainage techniques developed under the AICRP on Agricultural Drainage. The drainage experiments demonstrated on the farmers' fields in Madhya Pradesh, Andhra Pradesh, West Bengal and Kerala have improved the physical condition of the soil. The crop yield of rice, wheat, soybean and sugarcane has improved as a result.

ENERGY MANAGEMENT IN AGRICULTURE

Animal power still predominates in Indian agriculture, especially in the fragmented small holdings, hill agriculture, shifting cultivation, and low-lying water-logged soils (DIARA lands). The draught animals, 73 million in number, generate power equivalent to 18,250 MW and cultivate about 55% of the total area.

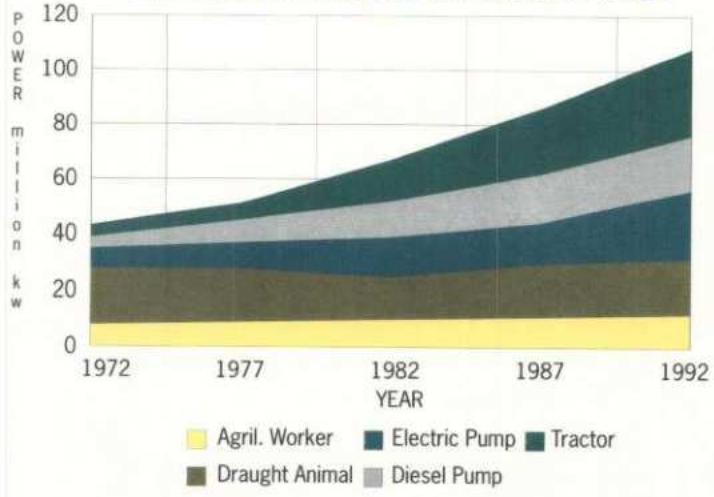
TRENDS IN ENERGY COST



Though the population of draught animals is declining, agriculture labour is increasing at a compound rate of 2.1% a year. They numbered 186 million in 1991.

Sowing, transplanting, weeding, harvesting and paddy threshing depend on human power. The agricultural engineers have developed efficient hand tools like wheel-hoe weeder, paddy transplanter, hand maize-sheller, manual groundnut decorticator, winnower and cleaner.

TRENDS IN ANIMATE AND MECHANICAL POWER



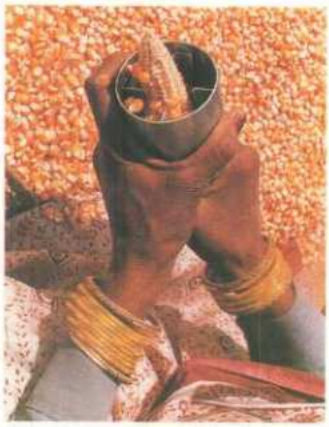
Mechanical power supports intensive agriculture and agro-processing. From 8,000 tractors being introduced a year in the fifties, 155,000 tractors are being introduced a year in the nineties. At present more than 1.5 million tractors are used in cultivation of nearly 17% of the cultivated area. Electricity, diesel- and engine-operated irrigation pumps are progressively improved upon for efficiency. Improved foot valves and pipes alone have brought in a saving of 30–40% energy.

RENEWABLE ENERGY SOURCES

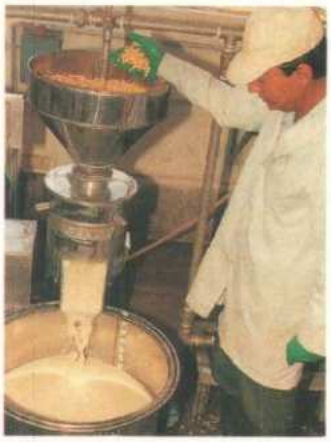
Solar, biogas, producer gas, and windmills are alternative or supplementary sources of energy. Solar dryers, water heaters, cookers, biogas for cooking, producer gas for thermal application have been developed for domestic use and cottage industries.

RENEWABLE ENERGY EQUIPMENT IN PROMOTION	
ENERGY FORM	MACHINE
Producer gas	Producer gas gasifiers using wastes and residues as feedstock : 5 kW, 10 kW and 20 kW
Animal energy	Harnessing animal power efficiently by using improved yokes and harness

AGRO-PROCESSING



Hand maize sheller, CIAE, Bhopal



Wet-grinding of soybean for tofu-making, CIAE, Bhopal. The technology is being widely used in the country

Post-Harvest Technology at appropriate threshold has a 3-fold objective : conservation of produce, its conversion into by-products, and value-addition.

Improvement through processing and product diversification are continuously researched upon in the ICAR. The outcome supports the agro-industries, both cottage-based and large-scale. The research recommendations in vogue at cottage level are: methods of sundrying, cleaning, winnowing, paddy-and-pulse milling using hand-grinding mills, oil extraction, wheat-milling, *gur-, khandsari, ghee-* and *khoya*-making.

POST-HARVEST TECHNOLOGY IN PROMOTION		
OPERATION	MACHINE	CROP SUITABILITY
Decortication/ shelling	• Manual maize sheller	Maize
	• Manual groundnut decorticator	Groundnut
Cleaning, grading	• Pedal-operated grain cleaner	Cereals, pulses, oilseeds
Milling	• Dal mill	Pigeonpea and chickpea
Food technology	• Soy products : flour, biscuit, paneer and soyflake	Soybean

Improved storage structures have replaced the existing ones to prevent huge losses. Grain protectants, non-chemical and of plant origin have been developed to reduce the damage occurring during storage because of insect infestation.

EQUIPMENT

Solar cabinet, *copra*, fruit and vegetable, spice, continuous and batch-type dryers to suit farm-holdings of different sizes; manual, pedal- and power-operated cleaning and grinding equipment for grain; grain and flour separator, maize sheller, groundnut decorticator and oil-expellers have gone commercial.

The green pea-peeling machine, mango peeler and the potato peeler are much in use at cottage scale.

VALUE-ADDED PRODUCTS

Dehydrated fruits and vegetables, full-fat soy-flour, extruded products, soy-paneer, soy-cookies, nuggets and cakes are gaining shelf space. Processing and packaging of *gur* during high humidity has been worked out for increasing the shelf-life.

JUTE TECHNOLOGY

Jute fibre is bio-degradable and eco-friendly. The declining trend in its usage is bound to reverse in time with the present-day awareness about the environment norms.

Improvement in quality of jute fibres that would be capable of blending with other fibres is a continuous programme with the Jute Technological Research Laboratory. Blanket, carpet, and curtain are woven with jute and jute-blended fibres.

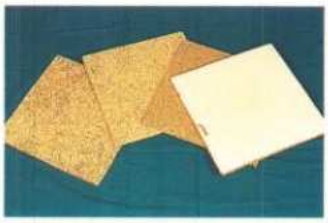
Non-woven jute has proved to be useful as geotextile in soil conservation and as a mulch. The utility of the jute plant and its fibre has been extended for making paper, packaging boxes and particle boards. When commercialized, the technology will desist deforestation.

COTTON TECHNOLOGY

The agri-engineers help plant breeders to evaluate the quality of cotton fibre when evolving new varieties. Using X-ray defractometer, transport of nutrients has been studied for improving the productivity of the cotton plant.

The cotton stalk has been used for manufacturing paper, packaging-material and particleboards.

COMMERCIALIZED JUTE, COTTON AND LAC PRODUCTS	
OPERATION	PRODUCT
Jute technology	Jute fibre products : caplon blanket, carpet, decorative fabrics, non-woven products, thermal insulation, particle board, paper
Cotton technology	Cotton-stalk residue products : paper, particle board, packaging box
Lac processing	Lac waste products : edible grade lac dye, aleuritic acid perfumery base



Particle boards manufactured from jute-and-cotton residues

Environment friendly dye-extracts from lac

Dry-lacquered handicrafts and toys

Brood lac (*close-up*)

Shellac, a product of the natural resin

Lac, the hardened secretion of a tiny insect called the lac insect, is a natural resin. India and Thailand are the major producers of the lac in the world. In 1993–94, India produced 20,000 tonnes of the resin and exported 75% of it to earn Rs 880 million in foreign exchange.

LAC TECHNOLOGY

Lac is a natural resin used in the production of decorative paint and sealing wax. It provides subsidiary income to about 4 million cultivators, mostly tribal. Of the total 20,000 tonnes of the natural resin produced, 75% is exported fetching Rs 880 million in foreign exchange.

Stick lac. Separation of the natural resin produced by the lac insect is in the women's domain

The new variant of KUSUMI lac insect evolved through screening produces superior resin pink in colour. The host plants KUSUMI and AKASHMANI promise higher lac productivity. *Palas* (*Butea monosperma*) evolved through air-layering for RANGEENI lac insect starts yielding lac when the plant is in the sixth or seventh year. The edible-grade lac dye, aleuritic acid (perfumery compound), juvenile hormone analogues, agro-chemicals besides insulation and varnish are a few lac-based products developed for industrial application. They also have export potential.

LIAISON WITH INDUSTRIES

Linkage has been established with industries for conversion of the researched prototypes into a commercial product and for its pilot marketing. This is achieved through entrepreneurial training, plant guidance and consultancy.

The equipment to test the animal draught power is very effective. It has been developed at the CIAE, Bhopal

The R&D workshops are equipped to fabricate prototypes for multilocation verification and pilot introduction. This also facilitates techno-economic evaluation and refinement in varying agroclimates. More than 35 items have been released by the National Implement Review

Developing jigs and fixtures for batch manufacturing, CIAE, Bhopal

Animal-drawn potato-cum-groundnut digger, CIAE, Bhopal

Pedal/power-operated cleaner-cum-grader, CIAE, Bhopal

Manual groundnut decorticator, the rocking-type, CIAE, Bhopal

SHARING OF EXPERTISE . . .

- Through the Regional Network for Agricultural Machinery (RNAM) of the Economic and Social Commission for Asia and the Pacific of the United Nations, prototype of seed drills, sugarcane planter, wheat thresher, groundnut decorticator and rice-husk furnace have been supplied to Bangladesh, Indonesia, Nepal, Pakistan, and the Philippines.
- With the cooperation of the Philippines-based International Rice Research Institute (IRRI), India has adopted the vertical conveyer-reaper-harvester, the axial-flow thresher and the rice transplanter.
- The Royal Institute of Technology, Sweden, has lent assistance in initiating projects for utilization of hydrogen fuel for the generation of electricity in rural India.

and Release Committee and they are into commercial production. The ILRI, Ranchi, provides testing facilities to the industry and exporters for evaluating the quality of lac.

IN FUTURE . . .

With agriculture turning hi-tech, generation, refinement and sophistication of technology will be a priority in all departments — crop production machinery (including irrigation and drainage machinery), postharvest technology and energy management. Of particular significance would be:

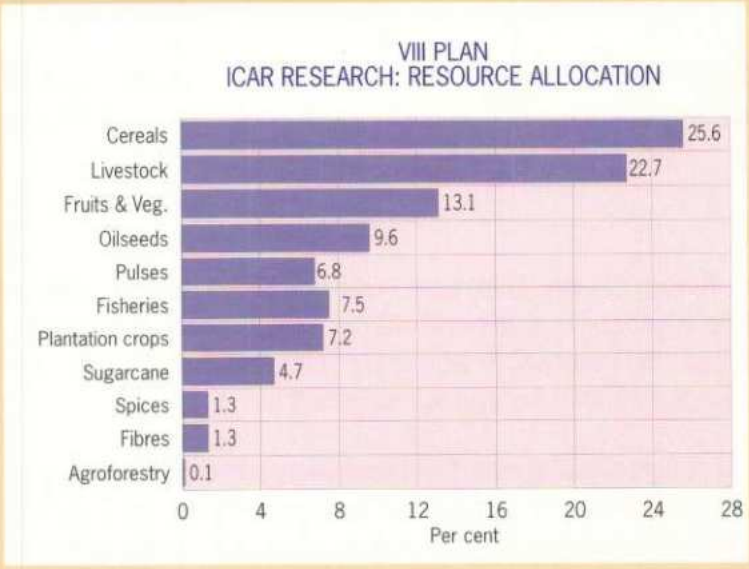
- development of high-capacity multi-functional energy-efficient machines for promotion of custom service; equipment for mechanization of cultivation of rice, sugarcane, cotton, horticulture and agroforestry, and hardware for controlled environment cultivation
- development of ready-to-use processes and equipment for clean,graded and processed grains, fruits, vegetables and their by-products
- development of controlled atmospheric storage systems for handling of perishables and semi-perishables
- energy-audit and management studies on crop production, agro-processing, rural industries and for home management using conventional and renewable energy sources
- biofuel production,its characterization and reforming for use in agriculture
- development of energy-efficient water-lifting-and-application hardware that uses conventional and renewable energy.

more about ICAR

AGRICULTURAL ECONOMICS AND STATISTICS

Economic analyses of prospective agro-biological technologies that result in technology transfer; impact ex-ante and ex-post of agricultural research; priority and resource allocation for research and, involvement in agricultural policy debates lend strength to a National Agricultural Research System.

ICAR has thus created the National Centre for Agricultural Economics and Policy Research (NCAP) in early 1991 at New Delhi.



Economic input in planning; designing and evaluation of agricultural research programmes and policy analyses are the objectives before the NCAP. The Centre also undertakes and sponsors research in agricultural economics to tackle problems of regional and national importance.

Since 1930, the Indian Agricultural Statistical Research Institute (IASRI), New Delhi, has been imparting education to postgraduates in theoretical and applied statistics, and training them to develop management information systems on all aspects of agricultural research. IASRI has a PENTIUM-90 SERVER and its computer laboratories are equipped with up-to-date software.

Centre of Advanced Studies in Agricultural Statistics and Computer Application, a centre of excellence, has been set up in 1983 with assistance from the United Nations Development Programme at the IASRI.

Research of greater significance from the IASRI includes: survey and estimation techniques in crop and livestock production; design for plant and animal breeding trials; development of scientific breeding plans for improvement of livestock; statistical packages for agricultural research data analyses; development of pre-harvest forecast models for various crops; assessment of impact of agricultural technologies on-farm and employment.

IASRI will broaden its horizon to conduct research on application of GIS and remote sensing, computer networking and in molecular biology.

NATIONAL RESEARCH CENTRE ON PLANT BIOTECHNOLOGY

Of late recombinant - DNA and cell culture techniques have lent a newer outlook to crop improvement programmes in the more advanced nations. India too is in the fray.

ICAR has established the National Research Centre on Plant Biotechnology (NRCPB) in 1985 at the IARI, New Delhi. The Department of Biotechnology, Government of India; the United Nations Development Programme; the Rockefeller Foundation and the World Bank have invested in the growth of NRCPB.

MUSTARD PUSA JAIKISAN . . .

Polygenic variations obtained through somaclones (somatic tissue culture) have been preferred in *Brassicia juncea* VARUNA. Selections BIO 902 and BIO-YSR were chosen and tested from 1990 to 93 in the All-India Coordinated Research Project on Oilseeds. BIO 902, distinctly superior has been released in 1994 as PUSA JAIKISAN for cultivation in Gujarat, Rajasthan and Maharashtra.

A team of competent scientists headed by Dr R. P. Sharma, and technical officers assisting them, train manpower and develop molecular tools and techniques for use in crop improvement at the NRCPB. Dr V. L. Chopra is a National Professor at the NRCPB.

Research programmes being pursued are: Evaluation and Utilization of Genetic Variation from *in vitro* cultures of Brassicas and *Basmati* Rice; Harnessing Genes of Economic importance from wild relatives of *Brassica*; Molecular Maps and Gene-tagging in *Brassica*, Rice and Chickpea; Genetic Transformation of Crop Plants — *Brassica*, Rice, Chickpea; Development and deployment of Bt Gene System for Insect-Pest Management; Molecular Approaches to improve Fungal Resistance in Chickpea and *Brassica*; Molecular Characterization of Gene for storage Proteins in Chickpea; Manipulating Biological Nitrogen Fixation in Chickpea, *Rhizobium* and *Azotobacter* and Micropropagation in Papaya and Potato.

NATIONAL RESEARCH CENTRE FOR DNA FINGERPRINTING

DNA fingerprinting techniques are coming handy in genotype identification, population genetics, taxonomy, plant and animal breeding, and in diagnostics and epidemiology of plant, animal, and human pathogens.

The Council has in early 1996 established the National Research Centre for DNA Fingerprinting at the NBPGR, New Delhi.

A 3-part strategy includes. . .

Short-term	DNA fingerprinting of all plant varieties and parental lines of the hybrids released; and of livestock including poultry and promising strains of different acquatic animals
Long-term	DNA fingerprinting of promising indigenous germplasm which includes land races and wild relatives of commercial significance
Subsequently	DNA fingerprinting of gene pools and cross-pollinated flora and fauna

NATIONAL AGRICULTURAL LIBRARY

National Agricultural Library at the Indian Agricultural Research Institute, New Delhi, is the primary and the richest library possessing the largest collection of agro-biological literature in South Asia. It fulfils the information needs of the scientists, teachers, students and extension workers in agriculture. The colossal collection comprises books, monographs, journals and research bulletins; PG thesis; pamphlets and micro-films. The library has been providing reference through bibliography, reprography and inter-library link services to about ten thousand scientists spread in the length and breadth of the country. Shortly the library will be linked to the information highway.

PROJECT ARIS

. . . QUICKENING THE PACE OF COMMUNICATION GLOBALLY

Project Agricultural Research Information System (ARIS) is in the process of providing for systematic access to research information amongst scientists

nationally and internationally. For which, state-of-the-art networking is in progress throughout the National Agricultural Research System (NARS). Both quality of research and management of projects will gain.

Thus, the NARS will have on-line connection with INTERNET through NICNET or ERNET.

ICAR MERITS TALENT

Consistently good research and extension in agricultural sciences by the ICAR has made the nation self-reliant in most agricultural commodities and has propelled exports. But to keep the spirit of competition alive and to merit talent, the ICAR has instituted various awards.

RAFI AHMED KIDWAI MEMORIAL PRIZE is being awarded every two years since 1956 for agriculture, animal husbandry and allied sciences.

FAKHRUDDIN ALI AHMED AWARD encourages 'Agricultural Research in Tribal Areas'. Since 1977, the award is being given once in two years essentially to promote more scientists to take to research in remote areas.

HARI OM ASHRAM TRUST AWARD, instituted in 1972, biannually recognizes published original research, fundamental or applied, in crop science, horticulture, resource management and animal science.

JAWAHARLAL NEHRU AWARD is distributed since 1969 among young scientists for excellence in Postgraduate Agricultural Research submitted for their doctorate degree in any discipline of agricultural science.

VASANTRAO NAIK AWARD has been started in 1994 for distribution annually based on published work of a scientist or an extension worker suggesting reforms in Water Conservation and Dryland Farming.

ICAR TEAM AWARD every three years merits multidisciplinary research in agriculture and allied sciences since 1995.

NEW AWARDS...

ICAR YOUNG SCIENTIST AWARD will be awarded every two years henceforth.

OUTSTANDING TEACHER AWARD will be bestowed on 8 teachers in alternate years.

OUTSTANDING WOMAN AGRICULTURAL SCIENTIST AWARD, an annual award, has been instituted in 1996 to encourage the woman scientists.

CAREER OPPORTUNITIES . . .

Upon graduating or postgraduating in a discipline of Agriculture and allied sciences, the options and opportunities of a career in teaching, research and transfer-of-technology streams in SAU, State Department of Agriculture, Non-Government Organization or Industry are many. Even banks advancing credit and loans for agri-based projects employ agricultural specialists in-house. The avenues are really multifacet depending entirely on competence.

AT THE ICAR . . .

The ICAR is one of the largest employers of scientific manpower in the country — more than 6,500 research scientists work directly in the Council's research establishments and about 5,000 scientists in the SAUs in projects funded directly by the Council. Recruitment to these positions are made each year by the Agricultural Scientists Recruitment Board (ASRB) in 61 disciplines through a nation-wide competitive examination followed by a personal interview. These 61 disciplines apart from agricultural sciences, animal sciences and fisheries sciences include Basic and Fundamental Sciences, Social Sciences, Home Science and Engineering.

Though the maximum qualification is a Master's degree in the subject, many of those writing the entrance examination have already earned their doctoral degree.

Scientific placements are classified into: Scientists, Scientists Selection Grade, Senior Scientists and Principal Scientists. Nearly 1,000 of them occupy management placements as Heads of Divisions, Project Coordinators, Project Directors, Directors of Institutes, Assistant Directors-General and Deputy Directors-General. Promotion from Scientist to the level of a Senior Scientist is through performance assessment of workdone and length of service in the previous grade. Subsequently, Principal Scientists and research management placements are filled through international advertizement and selection. Lateral entry into these positions is open to scientists from other organizations and the SAUs.

HUMAN RESOURCE DEVELOPMENT

The Indian National Agricultural Research System, the biggest in the world, offers graduation in Agriculture, Veterinary Science and Animal Husbandry, Horticulture, Agricultural Engineering, Fisheries, Forestry, Home Science, Dairy Technology, Food Science and Technology, Agricultural Marketing and Cooperation and Sericulture.

Postgraduation leading to a Master's or Doctoral degree may be obtained in a discipline of the curriculums broadly offered at the graduate level.

Human resource in agriculture is also being trained/skilled in emerging areas — Computer Science, Biotechnology and Environmental Sciences — to fulfil the demands of the changed agricultural scenario.

IN-SERVICE ADVANCEMENT . . .

ICAR enters into a large number of bilateral and collaborative arrangements with national and international institutions. Therefore, also while in service, there is ample opportunity for training, skill upgradation and active participation in research both within the country and abroad.

Opportunities are also available for obtaining advance degrees as in-service candidates with study-leave benefits.

TRAINING FOREIGN NATIONALS AT ICAR

Third world countries, particularly those in the Afro-Asian region, view the Indian Agricultural Research System as a model. For them, the ICAR organizes training courses in nearly all disciplines at the related institution of the ICAR. Director DARE, ICAR Headquarters, is the nodal officer.

Foreign nationals should either be directly sponsored by their governments or by the FAO, USAID, IDRC or international agencies.

At the CPCRI, Kasaragod, a week-long training is conducted on Integrated Nutrient Management for Palms (during October); Palm-based Farming Systems (during November) and Water Management of Palms (during December)

At the CPRI, Shimla, the SAARC trainees are being exposed to Potato Production Technology. A training is also conducted on Recent Advances in Detection and Management of Potato Virus

CORPORATIZATION

Indian Agriculture has grown step for step. Quantitative and qualitative improvements in produce have been backed up with year-round production and diversification.

ICAR research has withstood the test of many economic, social and political objectives.

ICAR is now prepared for corporatization in stages with a combination of commercial and non-commercial goals.

CONSULTANCY SERVICES

ICAR, the apex body for agricultural research, education and extension education in the country, is being increasingly looked up to for providing technical expertise in all disciplines of agricultural sciences. For which, a special consultancy/patent cell is being set up at the ICAR Headquarters, New Delhi.

The core group of specialists — scientists, technocrats and professionals — on the panel of the ICAR may shortly be engaged by institutions or individuals in an area of expertise of the institution/organization. The monetary benefit is intended to spread out between the Consultant(s) and the Institution with a part trickling towards the Staff Welfare Fund.

CONTRACT SERVICE/ RESEARCH

A two-way link between the NARS and industry, contract services will be rendered for soil analyses, testing of pesticides/insecticides and seed quality.

Contract research, however, will be commissioned to assist the fast-expanding agri-business industries.

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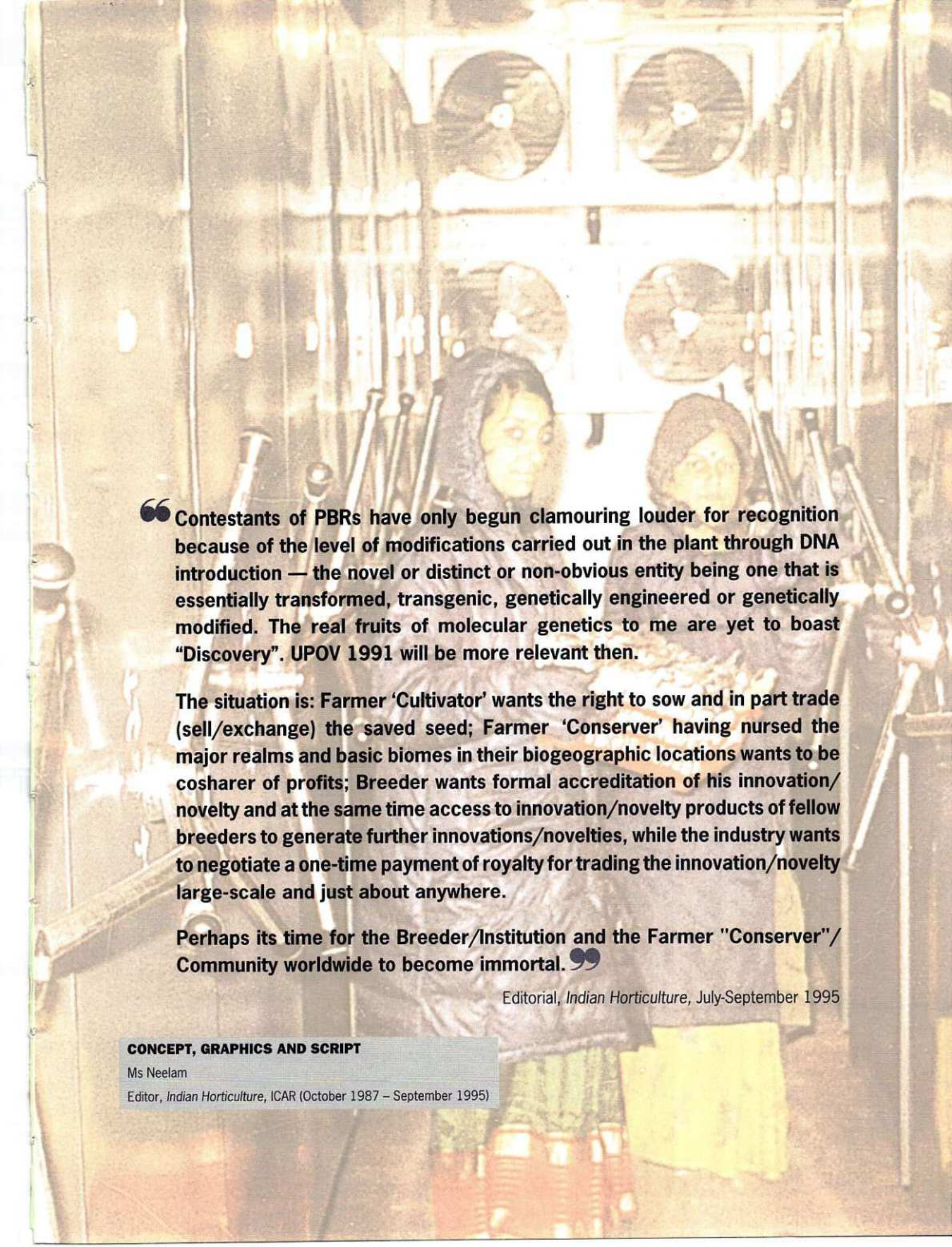
acronyms

ADB	Asian Development Bank
AHRD	Agricultural Human Resource Development Project
AICRP	All-India Coordinated Research Project
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ARIC	Agricultural Research Information Centre
BARC	Bhabha Atomic Research Centre
CABI	Centre for Agriculture and Biosciences International
CGIAR	Consultative Group on International Agricultural Research
CGPRT	Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Centre)
CRI	Central Research Institute
CSIR	Council of Scientific and Industrial Research
FAO	Food and Agriculture Organization of the United Nations
IAEA	International Atomic Energy Association
IDRC	International Development Research Centre
IMF	International Monetary Fund
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
NAARM	National Academy of Agricultural Research Management
NACA	Network of Aquaculture Centres in Asia
NARP	National Agricultural Research Project
ODA	Overseas Development Agency
PD	Project Directorate
SAARC	South Asian Association for Regional Cooperation
SAREC	Swedish Agency for Research Cooperation with Developing Countries
SAU	State Agricultural Universities
SDC	Swiss Development Cooperation
SDI	Selective Dissemination of Information
SEARCA	Southeast Asian Regional Centre for Graduate Study and Research in Agriculture
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USDA	United States Development Agency



“Contestants of PBRs have only begun clamouring louder for recognition because of the level of modifications carried out in the plant through DNA introduction — the novel or distinct or non-obvious entity being one that is essentially transformed, transgenic, genetically engineered or genetically modified. The real fruits of molecular genetics to me are yet to boast “Discovery”. UPOV 1991 will be more relevant then.

The situation is: Farmer ‘Cultivator’ wants the right to sow and in part trade (sell/exchange) the saved seed; Farmer ‘Conserver’ having nursed the major realms and basic biomes in their biogeographic locations wants to be cosharer of profits; Breeder wants formal accreditation of his innovation/ novelty and at the same time access to innovation/novelty products of fellow breeders to generate further innovations/novelties, while the industry wants to negotiate a one-time payment of royalty for trading the innovation/novelty large-scale and just about anywhere.

Perhaps its time for the Breeder/Institution and the Farmer "Conserver"/ Community worldwide to become immortal.”

Editorial, *Indian Horticulture*, July-September 1995

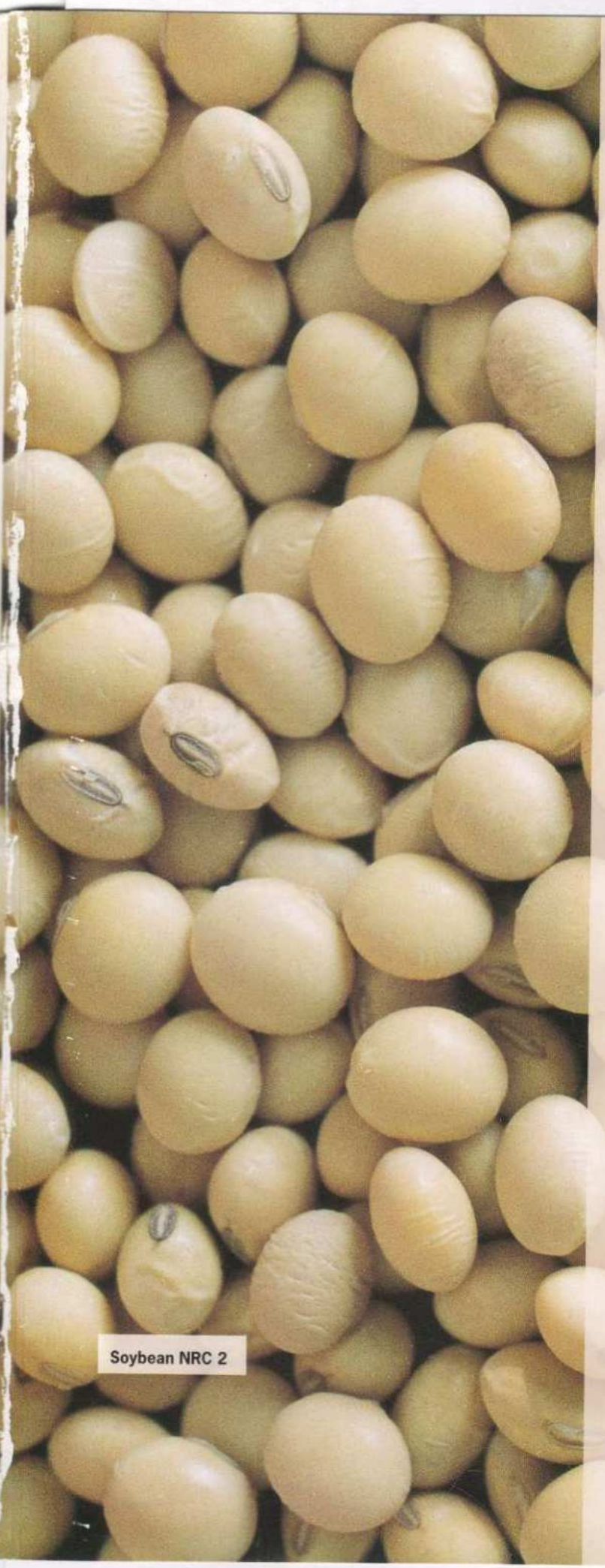
CONCEPT, GRAPHICS AND SCRIPT

Ms Neelam

Editor, *Indian Horticulture*, ICAR (October 1987 – September 1995)

“Mechanical power supports intensive agriculture and agro-processing. From 8,000 tractors being introduced a year in the fifties, 155,000 tractors are being introduced a year in the nineties. At present more than 1.5 million tractors are used in cultivation of nearly 17% of the cultivated area.”

Ms Neelam



Soybean NRC 2

colophon

The blue book ***ICAR, now and ahead . . .*** is a statement of fact based entirely on the pure and interface research investigated at the ICAR. The script is a product of numerous interactions with the subject-matter specialists spanning a year. I thank them all for their cooperation.

Most of the photographs have come from the source of information, others have been supplemented from the Photo Units of the ICAR and IARI.

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The information preserved in the ICAR Library has been of great help.

While the facts have been endorsed by the subject-matter specialists and every effort made at ensuring accuracy, bear with us, if otherwise.

I hope those acquainting themselves with the system and those building partnership find the information contained adequate.

Editor

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