DRYLAND FARMING

Science with a human face

Dryland agriculture can emerge as a market-oriented, commercially viable, and ecologically sustainable means of producing food, fibre and raw materials to benefit the small farmer through a multi-pronged strategy, say **Dr. William. D. Dar**, Director General and **Ms. Cynthia Bantilan**, Global Theme Leader for Markets, Policy and Impacts, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh.

DRYLAND FARMING in India has survived natural vagaries, external trading competition and population growth to provide sustenance and employment to millions over the last decades. Its risky, less remunerative and subsistence-oriented nature is exacerbated by constraints such as persistent poverty, water scarcity, climate change, land degradation, nutrition and health threats and migration.

The first Green Revolution signalled the power of modern technology in enhancing agricultural productivity. While improved varieties, agronomic practices, soil and water conservation techniques and improved tools and implements developed by research institutions were adopted by farmers, its benefits did not percolate as much to the dry and marginal rural farmlands.

The adoption indices in the dryland areas have been far lower than those in the predominantly irrigated areas because of the harsh and risky production environment, lack of complementary support policies and deficient infrastructure, market uncertainties and investment capacities of the dryland farmers.

Investment in the drylands requires an entirely different approach than the standard 'high yield-irrigation-fertilizer green revolution approach' that has been developed for high-potential irrigated areas.

A farmer along with his son passing by the parched land near Kandi of Murshidabad district of West Bengal. A major part of the state is facing low rainfall, leading to a huge crop loss and drought in the current season. — Photo: Arunangsu Roy Chowdhury.

The importance of dry land agriculture was aptly described recently by the Indian Prime Minister Dr. Manmohan Singh during the Indian Science Congress, and we quote, "The technologies we develop must be economically affordable and relevant to small and marginal farmers, especially in drought-prone regions. We must ensure that the Second Green Revolution technologies have a special focus on dryland agriculture and do benefit small and marginal farmers."

The semi-arid tropics (SAT), where the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) conducts its research, supports over 1.4 billion people, of whom 560 million are classified as poor. Of these, 70 per cent live in rural areas. In India, where about 60 per cent of the labour force is dependent on agriculture, the non-agricultural sectors are in no state to cross-subsidise agriculture.

Input subsidies

A good portion of the available resources are diverted towards input subsidies on fertilizer, irrigation water, power, credit and the like, which have reduced the costs of production of farmers with irrigation facilities, but failed to cover farmers who grow crops under rainfed conditions.

Dryland farmers have been thus driven to cropping patterns favouring cash crops or high value agricultural products that have a market demand but are not best suited to the prevalent soil and water moisture regimes (like cotton, soybean, castor and sunflower).

ICRISAT's vision encompasses the challenges persisting in dryland agriculture — water scarcity, market linkages, crop-livestock integration in farming systems, commodity Vs systems approach, rural livelihoods, institutional innovations, postharvest technology, biotechnology impacts, feminisation of agriculture, AIDS and policy.

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Special emphasis

ICRISAT lays special emphasis on five dryland crops — sorghum, pearl millet, groundnut, chickpea and pigeonpea. Its goal is to harness the power of technology for development, food security, poverty alleviation and environmental protection targeted at poor rural families in general, and at women and children in particular.

'Science with a human face' is the credo that ICRISAT swears by. At ICRISAT, participatory and interdisciplinary research has evolved towards the development of an integrated genetic and natural resource management (IGNRM) approach. This approach takes advantage of an integrated strategy using core competencies to enhance productivity gains with equitable benefits through genetic enhancement and biotechnology, crop breeding, soil and water management, food safety and social science perspectives.

Given the persistent problems of drought and water scarcity in the drylands, ICRISAT's research addresses water scarcity on two fronts — by utilising natural resource management principles and techniques to improve moisture content, fertility, soil depth, organic matter, rainwater utilisation through watersheds and water conservation and by employing plant breeding and biotechnology research to improve water-use efficiency and/drought tolerance in crop genotypes.

Participatory and knowledge-based watershed development programs led by ICRISAT in Andhra Pradesh, Madhya Pradesh, Rajasthan and Gujarat have shown that farmer and public investment can provide attractive social returns leading to poverty reduction.

The success of the Adarsha Watershed in Kothapally in Andhra Pradesh has attracted farmers, policymakers and development investors.

Significant evidence of tangible and non-tangible benefits has been generated in the form of reduced runoff and soil loss, improved groundwater levels, improved land cover and vegetation, increased productivity and changes in cropping patterns.

Income-generating options for the landless and women at Kothapally and other benchmark watersheds have included the setting up of village seed banks through self-help groups, value addition through seed material, product processing such as dhal making, grading and marketability, poultry rearing for egg and meat production and vermicomposting.

The ICRISAT-led watershed consortium has scaled up the above integrated watershed development model to 218 villages in India. Its successful technologies have been included in India's Employment Guarantee Scheme.

New scientific tools are increasingly being used to enhance the precision and pace of genetic enhancement of dryland crops.

Molecular markers

Molecular markers associated with shoot fly and stem borer resistance and tolerance to terminal drought in sorghum and resistance to downy mildew and tolerance to drought in pearl millet are being developed.

The success of our marker-assisted selection led to the development of the downy mildew-resistant version of the early-maturing hybrid HHB 67 in collaboration with the Haryana Agricultural University (HAU), which was released in Haryana in 2005 as HHB 67 Improved.

It is the first product of public-sector marker-assisted selection to reach farmers in India. Among other achievements are the extra-short duration chickpea variety ICCV 2 and pigeonpea hybrid ICPH 8 that escape terminal drought. ICRISAT is also harnessing biotechnology to develop new varieties that are drought tolerant.

ICRISAT has made a good beginning in identifying salinity-tolerant and micronutrient dense parental lines in sorghum and pearl millet. This is meant to extend their cultivation to harsh and saline areas and to combat malnutrition (due to micronutrient deficiency), particularly in pregnant women and children.

Chickpea productivity

One of ICRISAT's significant contributions has been the development of early-maturing fusarium wilt-resistant varieties of both desi and kabuli chickpea.

For example, in Andhra Pradesh their adoption led to a five-fold increase in area and a 13-fold increase in production during 1993 to 2002.

More significantly, chickpea productivity has increased from less than 500 kg ha-1 in 1993 to about 1300 kg ha-1, the highest in the country and 40 per cent higher than the average national productivity (865 kg ha -1).

The extra short-duration pigeonpea cultivar ICPL 88039 with greater grain yield potential than the local cultivar UPAS 120 was found best suited for rotation with wheat in the Northwestern plains of India. Farmers in Uttar Pradesh (Gaziabad, Meerut, and Bulandshar) were highly impressed with it and by the end of the 2004 rainy season, approximately 1700 hectares were under ICPL 88039, almost replacing UPAS 120.

ICRISAT's discovery of the causal agent of the devastating Sterility Mosaic Disease (SMD) in pigeonpea in the Indian subcontinent has paved the way for the formulation of effective disease control strategies and the identification of durable SMD-resistant sources like ICP 7035, that have been released for cultivation in Southern India.

Integrated pest management (IPM) is the coordinated use of pest and environmental information to design and implement pest control measures that are economically, environmentally and socially sound.

Indigenous methods

Indigenous methods like shaking pod borers from pigeonpea (dislodging 97 per cent of the caterpillars) and using them for pest management, using pest-tolerant varieties, and biocontrol measures using Helicoverpa nuclear polyhedrosis virus (HNPV) are part of the Institute's method of optimising crop productivity in watershed interventions.

Studies have shown that 65 per cent of the 17 farmers' field trials in Kothapally achieved increased crop yields (3.47 t ha-1) over farmers' practice (2.33 t ha-1). Another study in southern and western India showed that IPM led to a 6-100 per cent reduction in pesticide usage.

The objective of diversification is to encourage farmers to grow a mix of diverse crops in order to reduce various types of risks.

Crop diversification through the introduction of legumes into rice/wheat fallows pursued in the Indo-Gangetic plains of South Asia, growing medicinal and aromatic plants in partnership with private sector companies and systems diversification through mixed crop-livestock systems have served as coping strategies against risk and also enhanced incomes.

The new revolution to green the grey areas is not possible without modern tools of science such as biotechnology and information technology. ICRISAT has pioneered transformation technologies for all its mandate crops.

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The first transgenics from ICRISAT is the transgenic groundnut for resistance to the Indian peanut clump virus that employed the coat protein and replicase genes from the virus itself. Transgenics have been developed in pigeonpea and chickpea with resistance to *Helicoverpa armigera* by using the Bt Cry1Ab and cry1Ac genes derived from the bacterium *Bacillus thuringiensis*.

This material is currently undergoing contained field testing. Besides this, groundnut rosette virus (GRAV), peanut bud necrosis virus (PBNV) and peanut stem necrosis disease are being addressed through transgenic approaches.

Tolerance to drought

Work is also on to develop transgenics in groundnut and chickpea for tolerance to abiotic stresses such as drought and low temperatures where the transgenics carrying the transcription factors like DREB and proline-overproduction genes are currently being tested in greenhouse studies.

In cereals, transgenics have been developed for resistance to stem borer in sorghum and are currently under greenhouse testing.

The Agri-Science Park@ICRISAT comprising The Agri-Biotech Park (ABP), the Agri-Business Incubator (ABI), a Seeds Consortium and the SAT Eco-Venture, are a means to commercialise technology to help farmers in the semi-arid tropics.

The Agri-business Incubator helps novel agri-businesses realise their potential. It was jointly initiated by ICRISAT and the Government of India, with the former contributing its technologies and infrastructure and the latter pitching in with the corpus funding. Rusni Distilleries Pvt Ltd, the first incubatee, is collaborating to generate raw material to produce potable alcohol and fuel alcohol from sweet sorghum varieties developed by ICRISAT.

The second incubatee, Bioseed Research India, Pvt Ltd, is working on research projects related to the application of biotechnology for the development of superior cotton hybrids.

Public research goods

The strategic partnerships established by ICRISAT with stakeholders from both the public and private sectors are effectively addressing complex developmental issues through research in agriculture.

For example, the 33-member Hybrid Parents Research Consortium in sorghum, pearl millet and pigeonpea was formed to harness the energies and resources of private sector seed companies to produce public research goods and deliver improved technologies to farmers/seed producers.

It is now generating US$ 4,70,000 annually from membership contributions to support seed-based technology at ICRISAT.

The Biopesticides Research Consortium (BRC) with 11 biopesticide manufacturers as members, develops, promotes and commercialises the use of biopesticides by farmers. The partnership research will validate protocols for low-cost, commercial-scale production of microbial biopesticides developed at ICRISAT, and will promote agricultural practices that enable low-cost crop protection.

As an innovations and impact-driven organization, ICRISAT has established effective partnerships to tackle aflatoxin levels in food.

As part of a DFID-funded project, ICRISAT developed an inexpensive ELISA-based tool, reducing the cost of testing per sample to under US$ 1. ICRISAT has also developed an integrated approach to mitigate *A. flavus* infestation and aflatoxin contamination by combining host-plant resistance, soil amendments with lime, organic supplements and timely harvesting and post-harvesting drying methods.

Commercially viable

Dryland agriculture can emerge as a market-oriented, commercially viable, and ecologically sustainable means of producing food, fibre and raw materials to benefit the small farmer through a multi-pronged strategy.

The strategy involves reorienting policies (rationalizing subsidies on agricultural inputs and covering more crops under the minimum support price); higher public investment in technology, infrastructure, and markets; addressing chronic trade deficits in pulses and oilseeds; integration of labour markets; institutional innovations, partnerships and capacity building; higher inflow of institutional credit to dryland agriculture, coping with the challenges of globalization, and facilitating migration.

The new innovations developed for dryland agriculture and tested on farmers' fields for economic viability and feasibility have convincingly established their efficiency and demonstrated how a regular farm family can economically manage its farm, achieve good livelihoods, accumulate assets to reduce vulnerability and escape from poverty.