

## Can crops be climate-proofed?

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T.V. Padma

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Africa's Sahel region will produce fewer crops as a result of climate change (Flickr/Ametxa)

### **Climate change threatens food crops across the world. Now scientists are re-focusing their efforts on crop resilience, rather than yields.**

Among the most worrying aspects of climate change is its effects on the world's food supply. The worst-case scenario is stark: Africa's Sahel region will produce fewer cereals, rice cultivation in Asia will be under threat, there will be fewer vegetables — with potatoes and beans potentially wiped out — and livestock and fisheries will be severely stressed.

Climate change is making crop scientists review their research agenda. Until now, their main focus was on improving yields. But with successive International Panel on Climate Change (IPCC) reports warning that increased droughts and floods will shift crop systems, 'climate-proofing' of crops has become crucial. The Consultative Group on International Agricultural Research (CGIAR) institutes are now investigating how to make crops' more resilient to environment stresses.

### **Working blind**

But efforts are hampered because few climate models predict changes for individual regions, making it difficult to predict how climate change will affect growth and yields of specific crops in each region.

"A partnership between climatologists and crop scientists will be valuable in developing regional analogues," says Martin Parry, IPCC co-chair and a scientist at the UK-based Hadley Centre for Climate Prediction and Research.

And the need is urgent. At a meeting of CGIAR institutes in Hyderabad, India, in November 2007, Parry said that the estimated window for implementing mitigation and adaptation programmes has shrunk from 30–40 years to 15.

He advised CGIAR scientists to put climate change at the heart of research programmes.

Others agree. As Kwesi Atta-Krah, deputy director-general of the Italy-based research organisation Bioversity International says, "Plant breeders now need to focus on the future as well as the present, and use the vast genetic resources in gene banks and in the wild that hold potential for adaptation of major crops to a changing climate."

### **Rice crops most vulnerable**

Rice crops are most vulnerable to global warming. Studies worldwide show that rising carbon dioxide levels may initially increase growth, but the benefit is temporary. Rising temperatures make rice spikelets — the slender branches containing rice flowers — sterile, and grain yields will fall.



Rice crops are the most vulnerable to global warming

Credit: Flickr/shop boy

Asia and sub-Saharan Africa will be amongst the most severely affected by climate change. About 90 per cent of the world's rice is grown and consumed in Asia (where 70 per cent of the world's poor live), and sub-Saharan Africa is the world's fastest growing rice consumer. The most vulnerable agricultural systems are the rain-fed uplands and lowlands that form almost 80 per cent of total rice land in Africa.

Reiner Wassman, coordinator of the Rice and Climate Change Consortium at the International Rice Research Institute (IRRI) in the Philippines, says IRRI strategies should include breeding rice that can survive climate change. He wants to see plants that can tolerate higher temperatures and/or flooding, that flower in the mornings before temperatures rise, and that transpire (lose water through evaporation from leaves) more efficiently to cool the air around them.

His hopes are buoyed by IRRI's latest research into the rice line 'sub1', which survived submersion for 17 days (see Scientists create flood-resistant rice). The line could provide genes for flood tolerance.

In Africa, the Africa Rice Centre (WARDA) is focusing on its NERICA (New Rice for Africa) varieties. These combine traits of Africa's *Oryza glaberrima* — such as drought and local disease tolerance — with the high yields of Asia's *Oryza sativa*.

### Looming disaster for wheat?

Drought is also a big concern for the International Maize and Wheat Improvement Centre (CIMMYT) in El Batán, Mexico. The IPCC's predictions of increasing droughts spell disaster for half of the developing world's wheat growing areas.

The problem is particularly acute in central and west Africa, where the poor depend on wheat but get an annual rainfall of less than 350 mm, says CIMMYT scientist Rodomiro Ortiz.

CIMMYT has launched a hunt for drought tolerance in wild wheats and 'landraces' — traditional crops that have adapted to local conditions over centuries. The centre is also teaming up with the Japan International Research Centre for Agricultural Sciences to map drought-tolerant genes in wheat and maize.

CIMMYT is using its findings in both traditional breeding and genetic engineering programmes. For example, researchers are working on genetically engineered wheat containing the DREB gene of *Arabidopsis thaliana* — a relative of mustard plants — that may confer tolerance to drought, saline soils and low temperatures. CIMMYT is testing yields of genetically engineered plants with the DREB gene under varying water stress.

However, Ortiz cautions that the plant is still experimental. Most published studies simulated drought conditions in greenhouses more rapidly than would occur naturally. Ortiz wants more experiments under natural water stress conditions.

### Shrinking diversity

Scientists look for useful genes in plants grown only locally, and CIMMYT already has maize breeding programmes that work with local communities. But researchers fear many useful wild species could disappear.

"Climate change is leading to significant losses of genetic resources in several regions of the world," says Atta-Krah. He says diversity among crop species must be effectively conserved, managed, and used to improve crops and adapt to climate change.

One striking example of shrinking diversity is Latin America's beans. Peter Jones, a scientist at the International Centre for Tropical Agriculture (CIAT) in Colombia, says that of the 17 wild species of the *Arachis* genus — the pea family that includes the peanut — 12 will be extinct by 2055 due to climate change.

We must systematically map important bean species and ensure important collections have more than five live specimens, adds Jones.

The world's livestock are also in the danger zone. A 2006 assessment of global animal genetic resources by the UN Food and Agriculture Organization estimated that 70 per cent of the world's unique livestock are in developing countries. Many breeds already risk extinction. On average, one livestock breed is lost every month, mainly due to globalisation of livestock markets.

Climate change will strike further blows. According to the International Livestock Research Institute (ILRI) in Kenya, climate change will affect livestock by changing the yield and nutritional quality of their fodder, increasing disease and disease-spreading pests, reducing water availability, and making it difficult to survive in extreme environments.

"Climate change will have impacts at the ecosystem level that are poorly understood," says ILRI's deputy director-general for research, John McDermott. Effects will vary between the rain-fed highlands in the Great Lakes region of eastern Africa, the coastal regions of south, east and west Africa, and the forests of central Africa. The exact consequences for each ecosystem need to be analysed in detail.



ICRISAT is working to make crops such as sorghum better adapted to climate stresses

Credit: Flickr/cyanocorax

### **Water holds the key**

The common theme in all these changes is water availability. Already, one-third of the world's people live in river basins where they face water scarcity. But climate change will have other effects on agricultural irrigation.

The timing and size of river flows will change, affecting river water schemes, says Colin Chartres, director-general of the Sri-Lanka-based International Water Management Institute. He adds that receding glaciers mean less water will be available in spring, which could affect some 17 per cent of the world's population, including those irrigating the Indus basin. Changes in groundwater recharge could also affect irrigation in China, India, Mexico and the United States.

Chartes says scientists need to go beyond coarse global models, and develop specific river-basin and farm-scale models of how climate change will affect river water availability and lake levels. He also calls for more precise models of how climate change may affect fish productivity in oceans, seas and inland fisheries.

### **A tentative start**

As the problems become apparent, CGIAR centres are working on better understanding their implications.

The India-based International Centre for Research in Semi-Arid Tropics (ICRISAT) research strategy for 2007–2012 targets climate change issues in the short- and medium-to-longer term.

ICRISAT director-general, William Dar, says ICRISAT is working to make millets, sorghum, pigeon pea and groundnut better adapted to major climate stresses. The organisation has already developed varieties tolerant to heat, high soil temperatures, low and variable rainfall, and diseases.

What is needed now, says Dar, is a better knowledge of the physiology behind stress tolerance, wider gene pools, and more effective screening methods for useful genes.

CIAT is developing computer software to analyse future climate scenarios. Examples include 'MarkSim' to simulate daily weather for up to 100 years anywhere in the tropics, and 'Homologue' to compare climate and soil throughout the tropics.

The International Centre for Agricultural Research in the Dry Areas (ICARDA) has studied how areas in and around Egypt, Morocco and Sudan are coping with water scarcity in rainfed and irrigated grasslands, as well as traditional watershed management systems.

But the task ahead is tough. As Jones points out, historically the average time between scientists beginning to hunt for useful traits and a new stable variety growing in farmers' fields has been 46 years. "So that is how far ahead we should be looking at the start of every project," he says.

And as one participant at the Hyderabad conference commented, "You may put all those traits for tolerance to drought, salt and pests in a plant — and then find it has no yield!"