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Special report: Scientists Race to Avoid Climate Change Harvest

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Special report: Scientists Race to Avoid Climate Change Harvest Combines harvest soybeans at a farm in Tangara da Serra, Mato Grosso state in western Brazil, March 5, 2009. REUTERS/Paulo Whitaker Image:

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By David Fogarty

CANBERRA (Reuters) - Charlie Bragg gazes across his lush fields where fat lambs are grazing, his reservoirs filled with water, and issues a sigh of relief. Things are normal this year and that's a bit unusual of late.

His 7,000-acre farm near the Australian town of Cootamundra is testament to the plight facing farmers around the globe: increasingly wilder weather is making food production more unpredictable. It's the new normal they must prepare for.

Bragg's farm in New South Wales state has been in the family for generations and has weather records for the area stretching back 110 years. After seven years of costly drought, the weather switched last year to unseasonably wet with flooding rains.

"It's screaming to me that things are getting hotter and drier at different times of the year," said the 40-year-old Bragg during a recent visit to his property, about two hours drive to the west of Canberra, the Australian capital.

"Our summers are getting wetter and if this trend continues, then we will have to find different means of farming," he said.

Across the globe, rising temperatures and more intense droughts, floods and storms are forcing a rethink in how to grow food, from breeding hardier crop varieties and changing planting times to complete genetic overhauls of plants.

Growing populations, changing diets and insatiable demand for grains, meat and vegetables is putting pressure on global food production and prices like never before.

Soaring food prices, civil unrest and worries about weather have spurred a global race to create more productive crops that can thrive in a warmer -- and more prosperous -- world.

The World Bank estimates 925 million people are hungry in the world today. The figure has been rising since 1995-97 due to rising food prices, a succession of economic crises, and a neglect of agricultural innovation, especially relevant to the poor.

It is going to get much worse for the hungry because global food prices will more than double within 20 years, aid agency Oxfam International said in a June 1 report. Flat-lining yields, a scramble for fertile land and water, and environmental crises are reversing decades of progress against hunger, it said.

The challenge is to speed up the creation of new crops more adaptable to climate change and capable of much greater yields. A laboratory in the leafy heart of Canberra could hold some of the answers.

Inside, hundreds of seedlings on a conveyor belt file through a high-tech chamber, each plant bar-coded and scanned for signs of genetic superiority. A selection process that took months in the past, now takes a fraction of the time.

"I call this digital agriculture," said plant scientist Bob Furbank of Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO). The 3-meter high PlantScan chamber uses 3D laser radar and other devices to measure size, growth and water use.

"It's like the plant Olympics. We have to rapidly pick the best of the best," Furbank, scientific director of CSIRO's Plant Phenomics center in Canberra, said on a recent visit to the laboratory brimming with high-tech equipment after a multi-million dollar refit.

The center is part of renewed global efforts to create a new generation of crops that will dramatically boost yields, particularly for wheat and rice.

Investment into creating a new generation of staple crops, especially wheat and rice, has lagged since the Green Revolution of the 1960s, which led to years of bumper harvests, easing worries about lack of food.

The new green revolutionaries must find ways of doubling yields as the global population, set to hit 7 billion later this year, heads for 9 billion by 2050, with greater affluence changing diets and triggering ever greater demand.

THE HEAT IS ON

To feed 2 billion more mouths by 2050, food production will have to increase by 70 percent, the U.N.'s Food and Agriculture Organization (FAO) says.

Climate change is perhaps the greatest threat to meeting the target as rising temperatures and droughts dry out farmlands or more intense floods and storms inundate them.

"What we expect in the future is there will be much more unexpected events, much more extreme climate change," said Concepcion Calpe, a senior economist with the FAO in Rome.

Boosting yields has become almost an obsession with governments, seed companies such as Syngenta and Monsanto, and scientific bodies such as Australia's CSIRO.

Global yield growth of wheat and rice has stagnated at 0.6 percent to 0.7 percent annually over the past 10 years -- about half the production growth rate of 1.2 to 1.4 percent annually needed from now to 2050, the FAO says.

Scientists say they are running out of time to boost yields.

With greenhouse gas emissions rising quickly, the world is already on track to exceed a 2 degrees Celsius threshold that scientists say risks triggering dangerous climate change. The planet has already warmed about 0.8 degrees Celsius on average since 1900.

Unless emissions growth is slammed into hard reverse, the world could be 2 to 3 degrees warmer on average by 2050, and much more by 2100.

Computer climate models show large areas of Australia, Africa, the United States, eastern Brazil and southern Europe drying out in the coming decades. But Russia, Canada and Indochina would become wetter, potentially benefiting crop production or allowing new crops to be grown in previously cooler climes.

Overall, for many major cereal crop-growing regions, the future will hinge on drought and heat-tolerant varieties, better weather forecasts and a likely shift in cropping to new areas.

A U.S. study published last month in the journal *Science* found climate change was already exerting a considerable drag on the yield growth of crops.

The authors used crop yield models with and without changes in temperature and rainfall to show global falls in wheat output of 5.5 percent and 3.8 percent for corn as a result of climate change from 1980-2008.

That was equivalent to the entire annual corn crop of Mexico, or the wheat crop of France, the European Union's biggest producer, it said.

SEEDS OF CHANGE

The global forecast is for increasingly bad weather, amid spiraling demand from an expanding global middle class.

"2.5 billion people entering the world's middle class is a lot more important than climate change," said Jeffrey Currie, global head of commodities for Goldman Sachs in London.

The World Bank's food price index, which measures global prices, jumped 36 percent in April from a year ago to near its 2008 peak, before dropping again.

"While it might not be the primary cause, it definitely is an underlying cause for some of the instability you're seeing in North Africa and the Middle East right now," said Rick Leach, chief executive of the World Food Program USA. "The very poor can spend up to 80 percent of their income on food," he said, adding: "We're now moving into a period of extreme worry in terms of the implications of food price increases."

More than 680 million people in Asia and the Pacific region live on less than US\$1.25 a day, the International Fund for Agricultural Development, a U.N. agency, says. More than 70 per cent of these are in South Asia -- Bangladesh, India, Nepal and Pakistan -- making the region among the most vulnerable to food price inflation and climate change.

The World Bank in February said rising food prices had pushed an estimated 44 million more people into extreme poverty over the course of eight months, triggering unrest.

That is putting ever mounting pressure on governments, agronomists and the farm industry to come up with ways of growing more food on less land and under harsher conditions.

"Everything we do in terms of developing our technology, bringing that to growers worldwide, is really about addressing the need to grow more from less," said Davor Pisk, chief operating officer for Syngenta, the world's largest agrochemicals firm.

The Swiss firm's seeds business has flourished, growing to \$2.8 billion in 2010, out of total sales of \$11.6 billion, in large part for demand for Genetically Modified (GM) seeds to meet soaring demand in the United States for corn ethanol and for soyoil and soymeal in China.

Corn and soy, major elements of animal feed and biofuels, have attracted significant investment for new GM food varieties that have substantially boosted yields. Corn and soybean are also much simpler genetically than wheat and rice.

Syngenta has developed corn and soy varieties that repel pests, fungi and are tolerant to a range of chemicals that kill weeds -- all threats expected to get worse during climate change. It has also just released a hybrid called Agrisure Artesian that has resistance to drought.

"What we're confident of being able to demonstrate is that we can achieve a 15 percent decline in percentage of losses due to drought. So if you like, we get 15 percent yield preservation," Pisk said. The next generation of varieties would aim for 25 percent.

GM is just one part of a suite of technologies growers need to meet demand and fight the impact of climate change, he said.

The problem is knowing just what sort of future lies ahead for farmers and exactly what varieties were needed for different growing areas.

Computer climate models have become quite good at showing how temperatures will change across the globe, but are less precise on how rainfall and storm patterns will change, particularly at local levels.

SEARCH FOR BETTER YIELDS

If you can't predict the weather then you can try to beat it -- with new genetic strains of grain plants that will boost yields.

But crop yields would have to rise a lot faster than they have been. Scientists say yields will have to increase by around 1.5 percent a year to match the growth in the world's population of around 1 percent a year. That may sound small, but the current pace of yield growth is well below that.

Overall, rice yields have more than doubled over the past half-century from 1.85 metric tones per hectare in 1960 to 4.29 metric tones in 2011/12, USDA data shows.

But the International Rice Research Institute (IRRI) in the Philippines says rice yields will have to rise another 11 percent to about 4.8 metric tones per ha by 2018/19 just to keep rice prices steady.

By comparison, corn yields have risen from 1.95 metric tones per ha in 1960 to 5.22 metric tones in 2011/12, propelled by soaring demand for animal feed and ethanol. Wheat yields have gained more modestly to 3 metric tones in 2011/12 from 1.15 metric tones in 1960.

The production of rice, the staple for more than half the world's population, has kept pace so far with consumption, thanks to advances made in the Green Revolution. But yields will have to keep rising and stocks kept at healthy levels to avoid the kind of panic purchases by governments and export restrictions that helped drive the food price crisis of 2008.

The danger is that climate change could cause yields to drop, in some cases dramatically so, according to a study by the International Food Policy Research Institute.

Its modeling of the impact of climate change on cereal crops showed yields in 2050 are likely to be lower than they were in 2000, with the most vulnerable being wheat.

But developing a new variety of higher-yielding wheat takes a minimum of seven to 10 years, mostly because it has highly complex genetics. It's one reason why wheat, and to a similar extent rice, have fallen behind in yield growth and investment.

"In breeding new varieties for use in 20 years' time, we need to have the necessary genes now. And I think that's going to be tricky," said Greg Rebetzke, a wheat breeder for CSIRO in Canberra. One trick is to boost the early growth of wheat plants. The dwarfing genes that triggered the Green Revolution cut the height of wheat plants and allowed the plant to focus on filling the grain head. But the shoot that emerges from the seed is too short, limiting planting depth and access to water deeper in the soil. Rebetzke said CSIRO has found "alternative dwarfing genes" with no negative effects on early growth, which are "a major thrust in our breeding effort."

FUTURE RICE PLANT

To the north of London, the world's oldest agricultural research station is working on ways to boost British wheat potential yields to 20 or even 25 tonnes in the long-term, far above the 8 tonnes produced there now.

The 1.6 ha Broadbalk field on Rothamsted farm dates back to 1843 when its founder, John Bennet Lawes, decided to test the power of artificial fertilisers. He had built the world's first fertilizer factory a year earlier.

Walking in the same field where those trials started, project team leader Martin Parry explained how his team at Rothamsted and in the United States were looking at ways to super-charge photosynthesis in wheat by doubling the amount of CO₂ inside the plant.

Parry, like many agronomists, believes a new global effort akin to what happened in the 1970s is needed to feed the world, beyond the promise of technology.

"We're going to have to do it much more effectively. We're going to have use our resources like fertilizer much more efficiently and we'll have to do it with less land," he said.

Developing countries will be a big focus in those efforts.

According to the USDA, yields for major crops, including corn, wheat, soybean and rice, are more than 40 percent lower in developing nations than rich nations, highlighting the paradox that production is lowest where demand is greatest.

The biggest breakthrough on the yields front could come in creating a new type of rice plant, the staple for many countries in the developing world.

"We expect the weather conditions and temperature to be more severe in the coming years," said IRRI Director-General Robert Zeigler during a recent open day at the institute, near Manila.

"That's why we need to develop more rice varieties that can tolerate flooding, drought, higher temperature, and can also tolerate salt water," he said as farmers chatted with scientists at the institute to learn about new varieties.

IRRI has already released commercial varieties that are drought and flood tolerant, limiting losses during bad weather.

Salt-water tolerance will also be crucial as seas rise and more powerful storms push seawater further into fertile river deltas, such as the Mekong Delta in Vietnam and large areas of coastal Bangladesh. Faster growing varieties can also help farmers get in a crop before the typhoon season starts.

IRRI, the CSIRO, as well as researchers in Britain and elsewhere are working on creating supercharged rice to try to double yields, by boosting the rate of photosynthesis.

The project, funded by the Bill and Melinda Gates Foundation, could take 20 years, said CSIRO's Furbank, but will also lead to new ways to ramp up wheat yields as well.

Crucial as well to bridging the yield gap is better agronomy, or farm management practices. Syngenta has developed a way to boost rice yields in India by an average of 30 percent as well as cutting labor. Its Tegra system uses seeds coated with an insecticide, mechanical planting of seedlings and training for farmers. That can make a huge difference in a country of 1.2 billion people where two-thirds of the population are employed by the farm sector and where a failed monsoon can send shockwaves through international markets. "It should be an agronomy revolution," Calpe, the FAO economist said. "This has been missing tremendously in a lot of countries."

(Additional reporting by Gerard Wynn in London, Erik Dela Cruz in Manila, and Naveen Thukral in Singapore; Editing by Bill Tarrant)

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