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IN RESEARCH FOR DEVELOPMENT

The dryland agriculture REVOLUTION

PROFITABILITY • SUSTAINABILITY • DIVERSIFICATION

Rethinking soil management

One of the enduring images of agriculture is a plough running through soil, carving large furrows in the earth. For millennia land was tilled by hoes or ploughs pulled by animals. Only in the past two centuries has mechanisation redrawn the iconic imagery of land under cultivation.

Ploughing soils began in rich, fertile farmlands, such as the Nile Delta, and in the cradle of agriculture in the Tigris and Euphrates river systems of Iraq. The renewal of these soils, such as by the annual inundation in the Nile Delta, helped ensure these lands remained productive.

The process of tilling soils in dry countries such as Australia proved less successful. Declining fertility was a by-product of continual disturbance of soils. Nutrients, micro-organisms, moisture and trace elements, all essential to maintaining productive cropping, were lost as soil structures broke down. A consequence of this breakdown was reduced resilience against pests and diseases. A new approach to soil management was needed.

An increasing awareness of the fragility of the environment also prompted a rethink of how soils were managed. Agricultural science was able to maintain and reverse declines in soil productivity in the short-term through a focus on managing environmental stresses in combination with new varieties.

What became increasingly clear was that a better way was needed to deliver long-term sustainability by nurturing soils through trying to restore and maintain a natural balance within soils.

A feature of ACIAR's program to extend conservation agriculture is found in knowledge-sharing, notably in a recent partnership linking African nations to Indian and Australian expertise.

The solution was found in a new approach—conservation agriculture (CA).

CA is centred on the principles of minimising soil disturbance to maintain and restore fertility; adopting permanent groundcover through the use of stubble and straw, and seeding via specialised equipment to minimise soil disturbance; and diversifying cropping rotations to improve fertility and enhance pest and disease control.

While there remains debate in scientific circles about the full benefits of CA, tailored approaches to local conditions have consistently been proven to lift yields among smallholder farmers.

This issue of *Partners* tells the story of ACIAR's program to extend CA to parts of the developing world in South Asia, Africa and China. A feature of ACIAR's program to extend CA is found in knowledge-sharing, notably in a recent partnership linking African nations to Indian and Australian expertise.

Several themes also run through CA projects: reducing manual labour, both through practical approaches to CA and through the introduction of mechanisation; adapting CA to local environments and constraints; the importance of appropriate policy settings to support CA; and the ability of CA approaches to reduce water use.

The revolution in CA in India and Pakistan is reported, including developments of the Happy Seeder and other technologies. From this base, ACIAR has worked to further CA in Bangladesh (page 14), Iraq (page 20) and Africa (page 16).

Today, Australia has a higher percentage of land under CA than any other country. ACIAR is working to share the Australian experience and the benefits with the dryland areas of the developing world. ■

This issue…

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IN RESEARCH FOR DEVELOPMENT

Partners in Research for Development is the flagship publication of the Australian Centre for International Agricultural Research (ACIAR). *Partners* presents articles that summarise results from ACIAR-sponsored research projects and puts ACIAR research initiatives into perspective. Technical inquiries will be passed on to the appropriate researchers for reply. Reprinting of articles, either whole or in part, is welcomed, provided that the source is acknowledged.

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YIELD GROWTH the weak link in the food security chain

The world once again faces the need to quickly increase the yield potential of staple cereals to meet rapid growth in global demand. With Green Revolution solutions to yield gains no longer viable options, the challenge is creating the need for a new package of farming innovations.

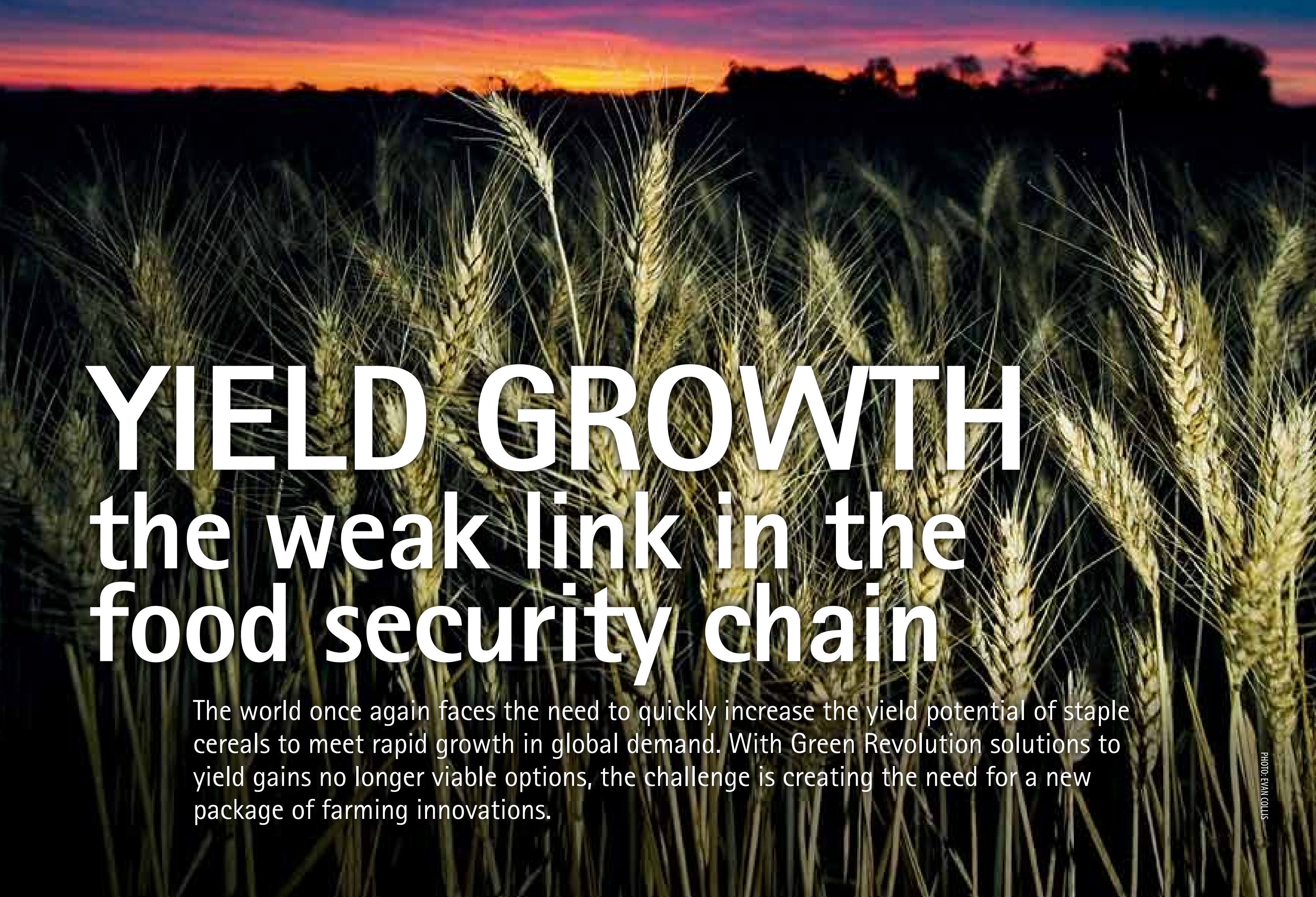


PHOTO: EVAN COLLIS

KEY POINTS:

- **The increase in cereal yields needed to meet food security demands to 2050 poses complex new challenges for farmers and agricultural science.**
- **New R&D programs are getting underway worldwide to tap unexplored opportunities to accelerate gains in grain yield potential.**
- **Questions remain whether the necessary gain is achievable within the required time frame.**

BY GIO BRAIDOTTI

No sooner had pre-breeders made impressive progress solving cereal's sensitivity to environmental stresses, such as salinity in wheat or flooding in rice, than a familiar challenge resurfaced with renewed urgency. The issue is yield. The problem is projections that show demand growing faster than current growth in yield potential.

Adding urgency is a decline in global grain stocks, which together with food and fertiliser price spikes, declining water resources and climate-related crop losses, has served to further focus global attention on food security.

As a result, yield is back on the agenda for innovation by concerned pre-breeders and agronomists worldwide. Helping to frame the nature of the challenge are projections that predict demand for agricultural production to peak in 2050, when the planet's population is expected to level out at about nine billion people.

Australian scientists have been quick to perceive and respond to the problem. Already projects—which can be massive in scale and ambition—are being launched, often structured as collaborative partnerships with public, philanthropic and private sector organisations including ACIAR, the Grains Research and Development Corporation (GRDC), CSIRO Plant Industry, the Australian National University, the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and the Bill and Melinda Gates Foundation.

THE SCALE OF THE PROBLEM

Professor Antonio Hall from the University of Buenos Aires in Argentina and CSIRO Plant Industry researcher Dr Richard Richards recently analysed the scale of the projected yield shortfall. In a review published in 2013, they quantified the rate at which yields of wheat, maize and rice need to increase to prevent food insecurity and famine and its associated human, social and environmental tragedies.

"We found that to meet expected demand for food and feed by 2050 requires yield gains to grow at annual compound rates of 1.16% given a low biofuel requirement and 1.31% for high biofuel requirements," Dr Richards says. "However, we found that existing rates of yield improvement fall well short of these benchmarks.

"For wheat there is evidence for rates of yield gain between 0.3–0.76%. In a worrying number of countries and regions there is strong evidence of yield plateaus."

The most comprehensive datasets analysed for wheat come from the UK. There, the results from rainfed trials are good approximations of a variety's true yield potential given generally adequate rainfall, mild seasons and complete pest and disease protection, which are built into the annual trials.

"Data from such trials shows consistent upward trends in wheat yields and since 1982 at least 88% of improvements in yields could be attributed to genetic improvement," Dr Richards says. "From 1948 to 2007 the rate of yield increase was linear and amounted to about 69 kilograms per hectare. But that translates into a relative rate of just 0.76% annually in 2007."

Other studies of yield potential follow a similar pattern, including gains of:

- 0.3% annually in irrigated spring wheat, based on experiments in the Yaqui Valley in Mexico in 2005 (although the rate halves in Mexico's warmer Tlaltizapán and showed little tendency to increase in cultivars released after 1966); and
- 0.68–0.75% annually in irrigated winter wheats, based on historic set studies from different periods in the main winter wheat regions in China.

"The hard truth emerging is that the vast majority of data points to relative rates of yield progress that fall below the necessary exponential rate required to meet projected demand to 2050," Dr Richards says.

The world faced a similar situation in the 1960s, with famine averted by the agricultural innovations of the Green Revolution. However, today's researchers note that key factors in past gains—dwarf varieties, nitrogen fertilisers, irrigation (particularly using groundwater) and expanding the land area being cropped—can contribute only a small proportion of the required increases in food production. This places key limits on how extra gains can be made, especially in light of diminishing water resources.

THE WATER LINK

According to a Stockholm International Water Institute report, *Feeding a Thirsty World*, the dependence of the world's large breadbasket regions on irrigation is becoming a problem. Groundwater depletion in the past 50 years has doubled to about 300 cubic kilometres per year, which has raised concerns for three large groundwater aquifers: the Ogallala Aquifer in the US, the North China Plain and Gujarat in north-west India. The report states:

> **"The conditions that challenge agriculture today are very different from those of the 1960s. From a water perspective, rivers are drying up, groundwater is being depleted, and 'water crisis' is now a commonly used term. Agriculture now consumes 70–80% of all human water withdrawals, with severe consequences for many ecosystems and the related services on which we all depend. We now know that we can no longer view water as an inexhaustible and free input to a global food production system."**

For Dr Richards, such issues serve to inextricably link yield with breeding for greater water use efficiency (WUE). Australia has a good track record in this area. But even given this expertise, rates of genetic progress made by breeders in wheat were estimated at close to 0.54% per year based on side-by-side trial data published in 2009.

"The important message emerging is that opportunities to increase WUE have been realised through selection for yield in rainfed multi-environment trials run within specific target environments," Dr Richards says.

"But studies of past gains all point to the fact that gains are often fairly small in absolute terms—except under extreme drought—and relative rates of advance are not likely to be high."

PULLING TOGETHER

From Dr Richards' perspective, the yield crisis coincides with the emergence of new pre-breeding biotechnologies such as phenomics (high-throughput selection of physical and physiological plant traits) and opportunities for greater adoption of a water-wise agronomic technology, namely, conservation agriculture.

The technical arsenal now available to accelerate genetic gains in yield potential in both unstressed environments and water-limited dryland environments includes:

- genomics, phenomics and marker-assisted selection incorporating high-throughput technology
- improved hybrid technologies, such as have occurred in rice
- genetic engineering and plant transformation technologies
- better crop-simulation models, long-term climatic records and soil information
- more efficient data capture.

Projects are already underway that exploit these technologies. These include massive international projects to convert the low-efficiency carbon dioxide capture and sugar-conversion rates of wheat and rice so that they gain the efficiency of crops such as maize. The Wheat Yield Consortium is coordinated by CIMMYT and much of it is funded by Mexico. The C4 Rice Project is led by the International Rice Research Institute and funded by the Bill and Melinda Gates Foundation.

ACIAR, in conjunction with the Indian Council of Agricultural Research, has implemented an initiative, led by CSIRO Plant Industry, to better adapt wheat roots to drier soils.

Also in Australia, the GRDC has made progress with a public–private initiative targeting the production of hybrid wheat.

The bottom line for these ventures is the time frame for delivery of farmer-ready varieties, Dr Richards says. With Professor Hall, he has estimated that going from initial idea to the release of new cultivars takes about 20 years for complex traits and 10 years for simple traits.

Demand for grain could outgrow the yield potential of staple cereals by 2050, creating massive challenges for agricultural science today.

"However, in the challenge to progress yield enough to meet projected demand for affordable cereals by 2050, the time scales that have emerged are not a good basis for optimism," Dr Richards says.

"While this is obviously speculative, it needs to be noted that so too is the optimistic alternative."

AGRONOMY

While breeding contends with its problematic time frames, agronomy has viable technology ready for roll-out. Widely adopted already in Australia and the Americas, conservation agriculture (CA) is proving it can do to yields from dryland farming what the Green Revolution did for irrigated fields, but with one difference.

Research has shown that CA can build the short-term productivity and sustainability of soil and water resources in ways that improve long-term farming productivity and environmental sustainability.

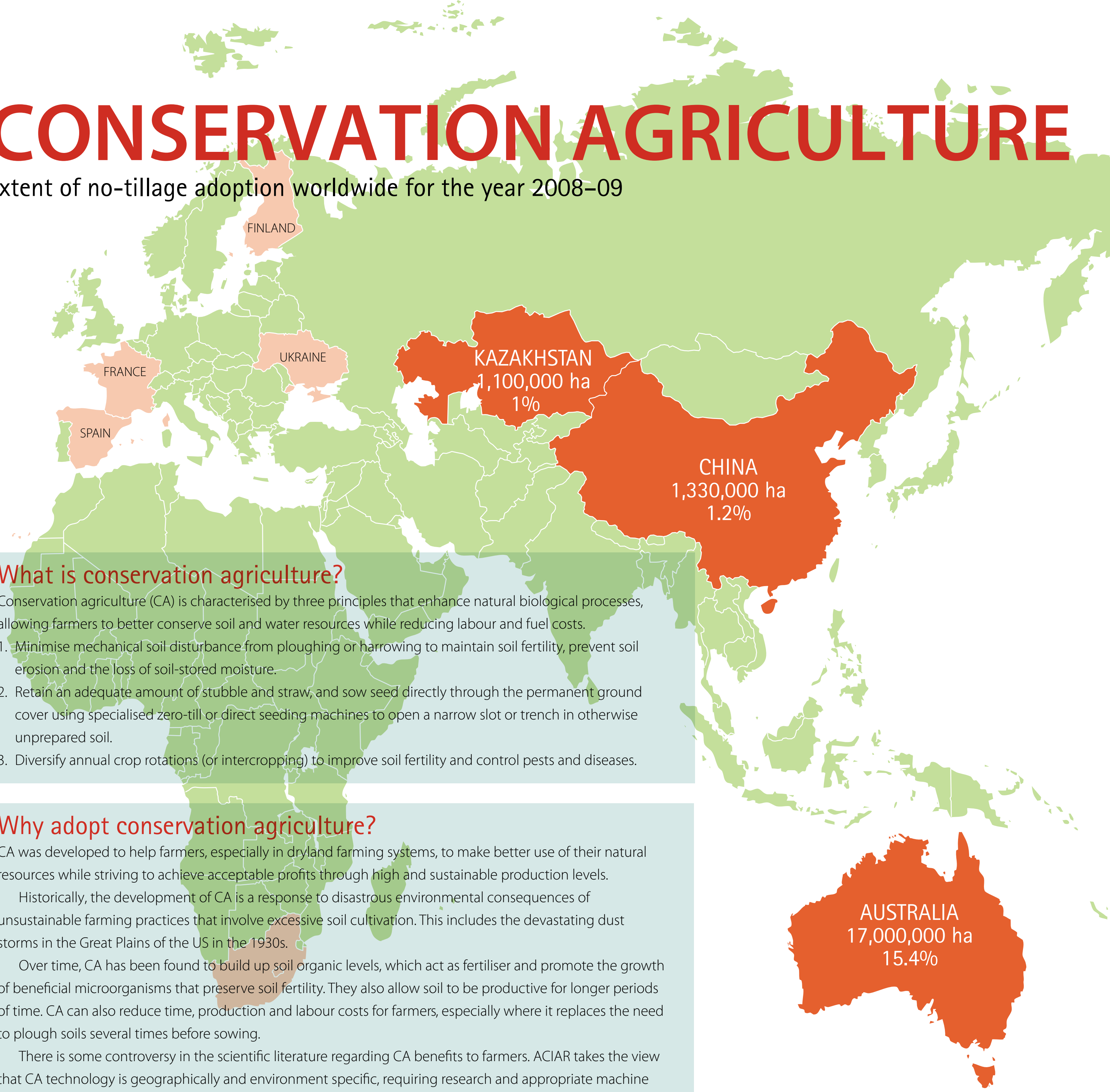
With many of the world's farmers—especially poorer smallholders—yet to trial this technology, CA's adoption provides one ready route to both immediate yield gains and to reversing the over-exploitation of soil and water resources.

In this issue of *Partners* we look at the role ACIAR is playing to facilitate the adaptation and adoption of CA by smallholder farmers in North Africa, the Middle East, Eastern Africa and Southern Asia. ■

More information: Dr Richard Richards, richard.richards@csiro.au

CONSERVATION AGRICULTURE

Extent of no-tillage adoption worldwide for the year 2008–09



What is conservation agriculture?

Conservation agriculture (CA) is characterised by three principles that enhance natural biological processes, allowing farmers to better conserve soil and water resources while reducing labour and fuel costs.

1. Minimise mechanical soil disturbance from ploughing or harrowing to maintain soil fertility, prevent soil erosion and the loss of soil-stored moisture.
2. Retain an adequate amount of stubble and straw, and sow seed directly through the permanent ground cover using specialised zero-till or direct seeding machines to open a narrow slot or trench in otherwise unprepared soil.
3. Diversify annual crop rotations (or intercropping) to improve soil fertility and control pests and diseases.

Why adopt conservation agriculture?

CA was developed to help farmers, especially in dryland farming systems, to make better use of their natural resources while striving to achieve acceptable profits through high and sustainable production levels.

Historically, the development of CA is a response to disastrous environmental consequences of unsustainable farming practices that involve excessive soil cultivation. This includes the devastating dust storms in the Great Plains of the US in the 1930s.

Over time, CA has been found to build up soil organic levels, which act as fertiliser and promote the growth of beneficial microorganisms that preserve soil fertility. They also allow soil to be productive for longer periods of time. CA can also reduce time, production and labour costs for farmers, especially where it replaces the need to plough soils several times before sowing.

There is some controversy in the scientific literature regarding CA benefits to farmers. ACIAR takes the view that CA technology is geographically and environment specific, requiring research and appropriate machine seeders to properly adapt the technology to different farming systems and sites. Due consideration is also needed when there are competing uses for the retained straw, particularly as feed for livestock.

PHOTO: BRAD COLLIS

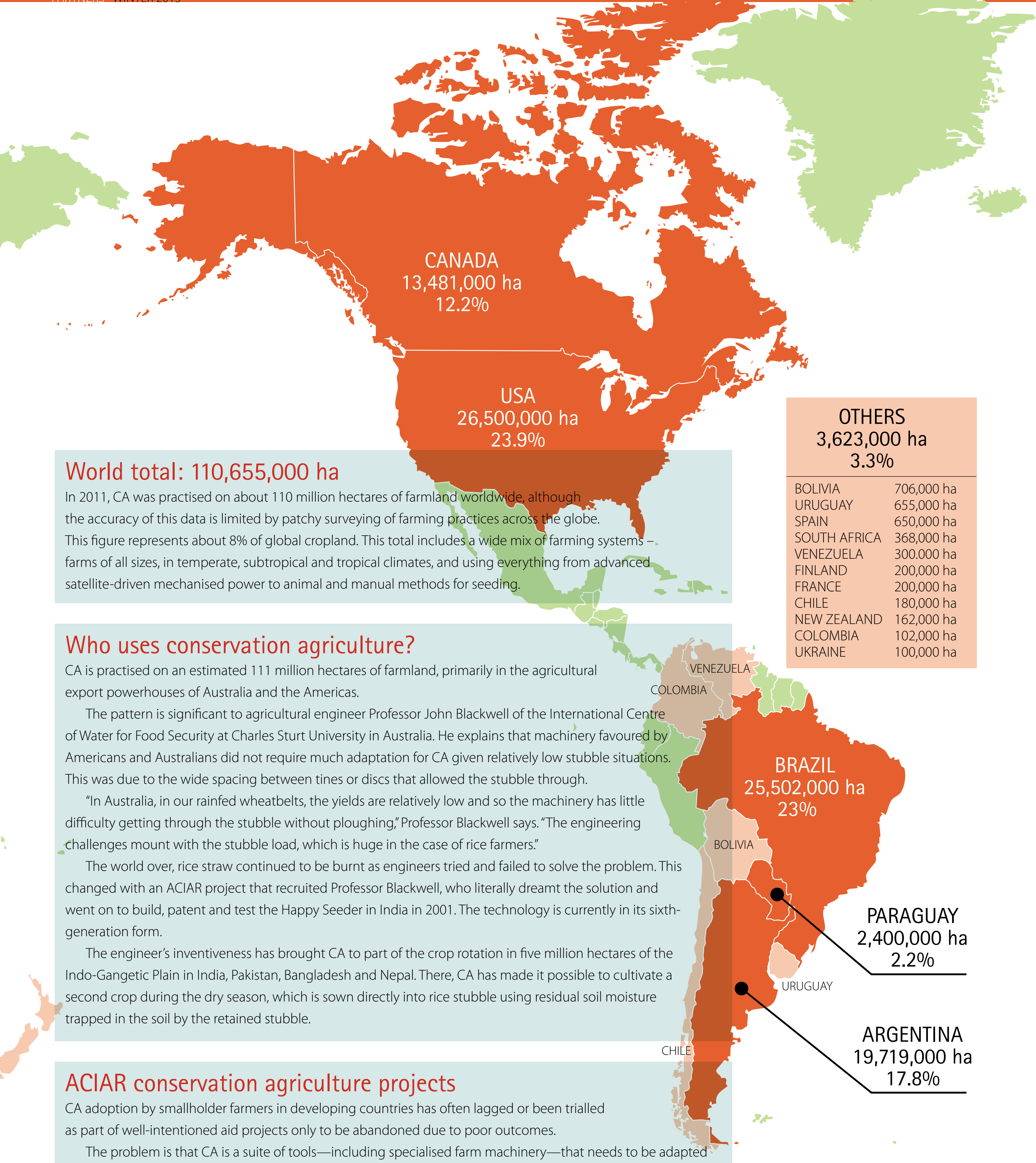
Retain stubble from previous crop as ground cover.

PHOTO: MELISSA MARINO

Replace the plough with specialised zero-till seeders.

PHOTO: BRAD COLLIS

Sow crop into undisturbed stubble.



Data compiled from Derpsch et al. (2010), mainly based on estimates made by farmer organisations and agro-industry.

World total: 110,655,000 ha

In 2011, CA was practised on about 110 million hectares of farmland worldwide, although the accuracy of this data is limited by patchy surveying of farming practices across the globe. This figure represents about 8% of global cropland. This total includes a wide mix of farming systems – farms of all sizes, in temperate, subtropical and tropical climates, and using everything from advanced satellite-driven mechanised power to animal and manual methods for seeding.

Who uses conservation agriculture?

CA is practised on an estimated 111 million hectares of farmland, primarily in the agricultural export powerhouses of Australia and the Americas.

The pattern is significant to agricultural engineer Professor John Blackwell of the International Centre of Water for Food Security at Charles Sturt University in Australia. He explains that machinery favoured by Americans and Australians did not require much adaptation for CA given relatively low stubble situations. This was due to the wide spacing between tines or discs that allowed the stubble through.

"In Australia, in our rainfed wheatbelts, the yields are relatively low and so the machinery has little difficulty getting through the stubble without ploughing," Professor Blackwell says. "The engineering challenges mount with the stubble load, which is huge in the case of rice farmers."

The world over, rice straw continued to be burnt as engineers tried and failed to solve the problem. This changed with an ACIAR project that recruited Professor Blackwell, who literally dreamt the solution and went on to build, patent and test the Happy Seeder in India in 2001. The technology is currently in its sixth-generation form.

The engineer's inventiveness has brought CA to part of the crop rotation in five million hectares of the Indo-Gangetic Plain in India, Pakistan, Bangladesh and Nepal. There, CA has made it possible to cultivate a second crop during the dry season, which is sown directly into rice stubble using residual soil moisture trapped in the soil by the retained stubble.

ACIAR conservation agriculture projects

CA adoption by smallholder farmers in developing countries has often lagged or been trialled as part of well-intentioned aid projects only to be abandoned due to poor outcomes.

The problem is that CA is a suite of tools—including specialised farm machinery—that needs to be adapted to local growing conditions, farming systems and evolving constraints. Adapting CA to local needs, in turn, requires relatively sophisticated RD&E capacity.

As an early adopter with advanced research capacity, Australia possesses both expertise and experience with dryland CA that is especially suited to help developing-world farmers avoid some of the looming yield and environmental crunches, including catastrophic soil erosion and creeping desertification.

ACIAR has tapped this expertise in its well-received series of CA projects located throughout the world's diverse farming systems. In this issue of *Partners* we look at CA projects underway in:

* the Middle East—Iraq and Syria
* the Maghreb region of Northern Africa—Morocco, Tunisia, Algeria, Libya, Sudan and Eritrea
* the Indo-Gangetic Plain—India, Pakistan and Bangladesh
* eastern and southern Africa—Ethiopia, Kenya, Tanzania and Zimbabwe.

DRILLING INTO A REVOLUTION

Four 'revolutions' in conservation agriculture in India in which ACIAR partners are helping ensure the region's food bowl continues to meet an accelerating demand for grain.

KEY POINTS:

- **Conservation agriculture in India is well and truly underway, with the technology spreading east across the Indo-Gangetic Plain.**
- **Innovations include the development of zero-till rice, double-till wheat-rice cropping and the design of specialised no-till machinery and its manufacture in India.**

BY MELISSA MARINO

In modern-day India, the economy is growing fast. It is expected that within a decade the country's 1.24 billion people will have, on average, nearly double their current disposable income. And with growing affluence comes an increased demand for food, particularly as the very poor climb out of poverty.

That demand, especially for grain, is serviced by the region's food bowl: the Indo-Gangetic Plain, which runs across India's north (and part of Nepal), stretching from Pakistan to Bangladesh. But under current production rates—and if productivity growth falters—the food bowl will struggle to keep pace with demand.

ACIAR principal regional coordinator for South and West Asia and Africa Dr John Dixon says if India has to import grain it will create ripples around the world, pushing up food prices and ultimately causing more poverty. "It's really important that we stabilise and boost productivity growth," he says.

And so ACIAR is moving to help ensure demand will be met—while also alleviating poverty. This continues a long tradition of partnership with India to introduce key advances in conservation agriculture (CA) to help stabilise productivity growth and build yields.

At the request of the Indian Government, ACIAR is now helping government agencies and universities take CA from the north-west, where it was established, to the country's east, which is home to more than half the world's poor.

In a new project under development with four Australian universities, the Australian Agency for International Development (AusAID) and the International Maize and

A HAPPY COLLABORATION SEEDS PROGRESS

BY MELISSA MARINO

The Happy Seeder represented a breakthrough for farmers across India's north-west rice-wheat cropping zone both in terms of conservation agriculture (CA) benefits and other benefits directly to farmers.

Developed initially to reduce the amount of suffocating smoke that blanketed the Punjab after rice stubbles were burnt to sow wheat, the Happy Seeder allowed farmers to direct-drill wheat into full, thick, combine-harvested rice residues for the first time. This eliminated any need to burn rice stubbles.

"It enables the sowing of any seed into any stubble," says inventor Professor John Blackwell, who led the ACIAR-funded project. This meant that not only was the amount of hazardous smoke reduced, but that growers could also engage completely in zero-till farming year-round. And a double no-till system of wheat and rice is a prime example of CA in practice: soils are improved, less water is required and greater profits are made.

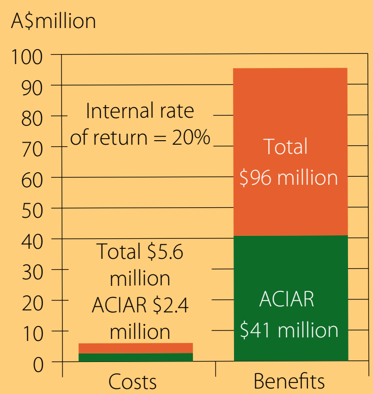
But the development of the Happy Seeder also provided a rare example of scientific and agricultural cooperation across the volatile political border between India and Pakistan.

With the Happy Seeder being developed in India, and a Pakistani version—the Rocket Seeder—underway at the same time in companion projects, ACIAR organised for a study tour of farmers and engineers from both countries to visit their respective agronomic and manufacturing sites.

It was a formidable challenge of logistics but worth the effort, says former ACIAR land and water resources research program manager Dr Christian Roth, who organised the tours. "There was a competition, of course, between the two sides and that was one of the reasons I did this exchange, so they could learn from each other and cross-fertilise ideas."

Dr Roth says each country had its advantages. The Indian project, thanks to a cooperative and committed working relationship between the engineers and the manufacturers, skipped ahead and had a commercial product ready

Figure 1 Cost-benefit analysis of three Happy Seeder projects.



The Happy Seeder facilitates direct seeding of wheat into rice stubble, a conservation agriculture practice with both environmental and economic benefits. For more information download volume 77 in ACIAR's Impact Assessment Series (IAS77).

Farmer Malkeet Singh with his Happy Seeder in northern India.

Wheat Improvement Center, CA principles and practices will be brought to the Indo-Gangetic Plain in India's east as well as Nepal and Bangladesh. Dr Dixon says the project has great potential to increase productivity because this area has the lowest irrigated crop yields in the country.

Extending the reach of CA, he says, would be the latest 'breakthrough' in the Indo-Gangetic Plain wheat-rice cropping systems, following three other ACIAR-led CA advances: no-till wheat, the Happy Seeder (see side story) and, most recently, direct-seeded rice (DSR). Much of this work has been in partnership with researchers from the University of Adelaide and Charles Sturt University in Australia, and the international Rice-Wheat Consortium, CCS Haryana Agricultural University and Punjab Agricultural University in India.

"The fourth revolution in CA would be to spread it out from the north-west of India, which has been the cradle of the innovations that have already led to major gains in South Asian food security," Dr Dixon says.

In fact, some of this spread has already begun. In an ACIAR project led by the University of Adelaide's Dr Gurjeet Gill, researchers and extension officers from the east of India are attending training workshops to learn about DSR.

Dr Gill, whose extension work follows his five-year project to establish DSR in the north-west, says the system is already showing clear advantages. "The general experience of growers is very positive and its uptake is increasing exponentially because there are environmental and economic benefits," he says.

15 YEARS OF CA ADVANCES

Dr Gill has been working in India for 15 years, since ACIAR-funded CA research began, when the north-west rice-wheat cropping systems faltered on the back of a lowering watertable and an intensive herbicide-resistant weed problem.

The first CA breakthrough—zero-till wheat—began almost by accident, he says, as a by-product of his research project into controlling *Phalaris minor*—a herbicide-resistant weed growing so rife that cropping had become unprofitable.

The researchers identified two new effective

quickly. But the first version of the Happy Seeder was big, heavy and required a lot of horsepower.

Meanwhile, although commercialisation was further away in Pakistan, the engineers, led by Shabbir Kalwal, had come up with a design that offered an important clue to reducing horsepower.

Professor Blackwell, from Charles Sturt University, who led both projects, says it was in the Rocket Seeder that he first saw the tine arrangement using straight knife blades that has since been incorporated into the Happy Seeder. By using four straight blades diametrically opposed on a rotor closely sweeping the straight tine to keep it free from straw and weed, more plant matter could be cut and less power used than with the original tine blade configuration, he says.

After several iterations, the Turbo Happy Seeder, compatible with lower-horsepower tractors common across India, has proved popular, he says. More than 600 have come off the production lines of eight separate manufacturers in north-west India, many of which have developed their own intellectual property.

An independent impact assessment of ACIAR Happy Seeder projects has found barriers to adoption include its cost, the risk aversion of farmers and herbicide and electricity subsidies. As a result, subsidies have also been made available for the Happy Seeder and Punjab Government extension programs have been introduced. The seeder is also being heavily promoted in the region through the Cereal Systems Initiative for South Asia project supported by the Bill and Melinda Gates Foundation and the US Agency for International Development.

The impact assessment has estimated that the project will deliver gross benefits of about A$96 million, of which A$41 million can be attributed to ACIAR on the basis of its funding (A$5.6 million) of three Happy Seeder-related projects.

The Happy Seeder research has generated significant social benefits in improved health and air quality, and has also provided the potential for substantial economic gains. By eliminating the need for burning and cultivating, soil quality improves and leads to better water retention, nutrient cycling and possibly higher yields. Also, by reducing the number of field preparations between crops, farmers save time and money on labour, herbicides and fuel.

Dr Roth says the Happy Seeder development in India is an example of how to get things done. "All the ducks were lined up," he says. "We had engineers who hammered it out and a manufacturer who was engaged and involved from day one."

In Pakistan, however, progress moved more slowly and despite some significant engineering and manufacturing progress, extension work was not possible by the time the projects ended, due in part to heavy rains, personnel changes and political upheaval.

Professor Blackwell says that in India there is much genuine interest in the Happy Seeder and usage is spreading. "Farmers who have capacity are contract hiring and it's looking really good," he says. "But it's a slow process."

herbicides, but they were expensive. Research undertaken by the project showed that the growers could buy the new herbicides with savings arising from abandoning a lengthy and expensive cultivation process that involved at least six separate tillage operations. High yields of wheat could be achieved without any pre-sowing tillage by sowing the crop directly in the field after the rice crop, where loose residues were partially burnt or removed.

This zero-till approach not only saved time and money that could be spent on the new herbicides, but also led to improved soil structure and, rather neatly, fewer weeds, as a result of more ground cover and less soil disturbance.

"The driver was to save money on planting costs that could be spent on the new herbicide but one of the key outputs was zero-till wheat," Dr Gill says. "And now it has taken off."

NEW MACHINERY FOR NEW SYSTEMS

Aiding the uptake of zero-till wheat was the development of a revolutionary piece of machinery that not only made sowing into total rice residue possible, but also addressed the problem of burning rice straw.

With many rice crop residues left standing about one-metre tall and too thick to sow directly into with conventional seeders, farmers across the north-west were burning rice straw, leading to a pall of smoke haze sitting over the region.

"The reality is that this creates a terrible health problem and a terrible soil problem, so we had to find some machinery that would plant into rice straw," Dr Dixon says.

That machinery came in the form of the Happy Seeder, invented by engineer Professor John Blackwell from Charles Sturt University with Indian collaborator Dr Harminder Singh Sidhu and Dasmesh Mechanical Works.

The Happy Seeder enables direct seeding into complete combine-harvested rice residue by keeping the sowing tines clear of residue, thus preventing the blockages that make conventional zero-till drills useless in these conditions. It has been embraced by farmers across the north-west and is now being manufactured by eight local companies in the Punjab, with 600 machines produced to date.

The Happy Seeder can also be used for DSR, which is the latest development in CA in India. DSR, Dr Dixon says, is a "fantastic breakthrough" made in a project also led by Dr Gill and which has allowed for double no-till systems of wheat and rice to be established in the north-west.

"After our success with wheat, the next challenge was to get the whole system under conservation agriculture, so we continued on to rice," Dr Gill says.

The challenge was considerable as DSR represents a major departure from the way rice has been traditionally sown. That is, in a 'puddling' system where rice seedlings are transplanted by hand into a slurry above a compacted clay base.

While it is challenging for growers to change well-worn practices, it is, Dr Gill says, a natural continuation of the successful no-till wheat system that preceded it and which is now in place across more than a million hectares in the north-west.

The environmental benefits of DSR over puddling are evident. Soil structure is improved, providing better conditions for root growth of crops such as wheat grown in rotation with rice. And paddocks no longer have to be permanently flooded, meaning far less irrigation is required, easing pressure on the depleted groundwater aquifers.

Importantly, the technology also provides some clear-cut economic benefits. Farmers save money by spending less on expensive diesel to run water pumps and are also less reliant on hired help.

"Even if growers are getting an equal yield to puddling, their profit is greater because the input costs both from labour and water are much lower," Dr Gill says.

GROWER PROFILES

BY DR KUHU CHATTERJEE AND MELISSA MARINO

SAHAB SINGH

Sahab Singh grows cereal crops, wheat and rice, as well as sorghum and maize, in sandy loam soils across a 42-hectare, family-owned, irrigated farm near Karnal, Haryana, in India's north.

Mr Singh first experimented with zero-tillage technology in 1999 and by 2001, with guidance from scientists from Karnal's Directorate of Wheat Research and CCS Haryana Agricultural University, he had purchased two zero-tillage machines, which both fertilise and sow crops. He now also owns a laser land leveller.

Before adopting zero-tillage, Mr Singh ploughed his fields eight to 10 times, using large quantities of diesel. Burning also caused a lot of pollution. Today, he does not burn crop residue and his environment is not polluted.

Zero-tillage has also brought savings in water and herbicide use as well as labour, which is an emerging issue across north-west India as workers leave for other industries. Mr Singh only uses herbicides once every three years to control *Phalaris minor*, in comparison with other growers who must apply it anually. Better moisture retention has also helped the crops handle sudden rises in temperature. During 2012–13, Mr Singh's average wheat yield was 5.5 tonnes/ha, whereas the average yield on his neighbours' farm was less than 4.8 t/ha.

Handling crop residues with his existing zero-tillage machines remains a challenge for Mr Singh. While he has tried the Happy Seeder, he found it only suitable for a narrow window of time as it was difficult to operate in the early hours of the day due to wet residue.

Sahab Singh

Labour costs have skyrocketed in India over recent years as farmers compete with fast-developing industry for workers. The lure of higher-paying factory jobs has also meant workers have been harder to find at planting time.

"Farmers not only had to pay a lot of money but they also often had to wait a long time for labour to become available, which meant planting was delayed and yields went down," Dr Gill says. "So that is one of the reasons that we thought the opportunity and the timing was right to go with mechanisation."

Dr Gill reports there has been rapid uptake of DSR since the concept was recently proven in extensive on-farm and scientific trials in partnership with local agricultural researchers and growers. These trials helped determine optimum sowing times, seeding rates and weed and nutrient management, as well as the recommendation for field laser levelling.

Adoption of DSR has increased from nothing five years ago to more than 10,000 hectares in 2012, he says, representing up to 5% of the area planted to rice in some villages. While this is dwarfed by no-till wheat rates, he expects to see a major expansion of the DSR technology in coming years as growers seek to obtain the benefits of CA year-round through a double no-till system of wheat and rice.

SPREADING THE WORD

Now in the project's important adoption–extension phase, DSR workshops are being held across the north-west to demonstrate the system in action. Representatives from eastern India are also learning about the technology at the workshops.

Although the expansion east is in its early days, Dr Gill foresees that some changes may be needed for the concept to work in regions where farmers are poorer. For example, the machinery required for no-till systems may need to be modified for growers with fewer resources.

ACIAR hopes to address this and other adoption issues through future research both with the DSR project and others. The new project with AusAID, as well as collaboration within the Bill and Melinda Gates Foundation-backed Cereal System Initiative South Asia project, will also assist the spread of CA in the east, Dr Dixon says.

"One of the greatest places for Australian aid to have an impact for every dollar spent is on the alluvial plains of eastern India, which, despite strong and promising growth in India, is home to 300 million people living in poverty," Dr Gill says.

The region also faces a strong climate threat that could destabilise food security through increased rainfall variability and severity of coastal storms. These are reasons why the Indian government asked ACIAR to shift its geographic focus east.

Dr Dixon says ACIAR has been able to achieve a tangible impact with CA in India to date because regional managers in the area over the past 15 years have shared a similar vision and forged strong local partnerships.

"These things don't happen by accident," Dr Dixon says. "It needs continuity and a strategic approach. Our dollar investment is tiny compared with others, but our strength is that we partner with people who can see the big picture and position ourselves at key points of intervention." ■

PARTNER COUNTRY
INDIA

PROJECTS: CSE/2006/124: Fine-tuning the Happy Seeder technology for adoption in northwest India 2007–11
CSE/2004/033: Zero-tillage rice establishment and crop–weed dynamics in rice and wheat cropping systems in India and Australia
CONTACT: Professor John Blackwell, jblackwell@csu.edu.au, 02 6933 4937, 0427 225 355
Dr Gurjeet Gill, gurjeet.gill@adelaide.edu.au, 08 8313 7744

VIKAS CHAUDHARY

Vikas Chaudhary only began farming in 1996, but by 1999 had already adopted zero-tillage technology on his 14-hectare farm, north of Karnal in Haryana, where he grows mostly rice and wheat. It was a short-lived experiment, but then in 2010 he began using a Happy Seeder, which, he says, has been effective in managing residues. Retaining crop residues conserves soil moisture, reduces weeds, moderates soil temperature, aids water infiltration, saves time and energy, and increases organic matter in the soil, he says.

Two Happy Seeders have also been purchased by the Society for Conservation of Natural Resources and Empowering Rural Youth—a group Mr Chaudhary registered in 2010, which now has 20 young farmers as members. The seeders, as well as other machinery including a laser leveller, are being used on farms around the area through the society's extension work. The society, which partners with a range of research organisations, is also providing training to hundreds of farmers and information on various technologies is being distributed.

Challenges relating to zero-tillage machinery have been the high cost of purchase and slow progress on the field, due to the seeder's difficulties operating in wet residues, he says.

Mr Chaudhary has also taken-up direct-seeded rice (DSR), which he says is alleviating many of the problems associated with traditional puddling, including intensive labour, water requirements and soil damage. DSR has helped save time he says, and 20–30% of irrigation water compared with transplanted rice. In its first year, DSR yields were slightly down compared with transplanted rice. But due to better quality, DSR sold for a higher price and provided significant savings in labour costs.


Vikas Chaudhary

Raised beds prove their worth

The versatility of conservation agriculture was demonstrated in Pakistan, where trials were found to vastly decrease hardships for wheat–maize croppers. But no progress is ever truly possible without a broader social coalition willing to drive it.

BY MELISSA MARINO

Conservation agriculture (CA) is not a 'one-size-fits-all' approach. While its key principles of minimal soil disturbance, permanent soil cover and crop rotations remain consistent, the methods used to realise them can vary.

In Pakistan, ACIAR-funded CA research has centred on the use of permanent raised beds. This is largely through 10 years of work in the north-west, near Peshawar, led by Western Australian soil physicist Greg Hamilton.

In this part of Pakistan, maize–wheat crop rotation systems are common, as distinct from the rice–wheat and cotton–wheat systems found throughout the Punjab region, which covers Pakistan's centre and south, as well as the north of India. As the work concentrated on maize–wheat, most of the results and the best outcomes are from this system.

Mr Hamilton says results from two trial sites and several hundred hectares of farmer adoption in Mardan, north-east of Peshawar—where permanent raised beds using furrow irrigation are used to replace flooding irrigation—found many advantages. These led not only to an improved environment but also a greater overall profit.

From 1999 to 2010, through two ACIAR projects interspersed with Pakistani government funding over 24 cropping seasons, farmers across the Mardan district achieved an average increase in gross margin profits of 23–25%, Mr Hamilton says. This is due to several factors.

First, a raised-bed system requires less seedbed preparation compared with flood irrigation, replacing three or four separate field operations with one or two. This provides significant cost savings in labour, fuel and herbicides. Labour and herbicide use were also reduced because the system aids weed suppression. Raised beds have 30–50% fewer weeds than traditional systems, he says.

Water savings too were significant, with 30–50% less water used. And deeper and improved root zones, created by a deep-blade loosening and furrow making, led to increased yields. There was a 10–20% yield increase in wheat and maize yields grew by 30–50%, Mr Hamilton says.

Dr Christian Roth, who was ACIAR research program manager for land and water resources at the time of the project, says the raised beds worked well for maize–wheat crop rotations, bringing the dual benefit of major water savings and improved soil structure.

Mr Hamilton says healthier soils improve water usage. "Over three or four years, soils developed that were much more stable to wetting and irrigation efficiency improved dramatically," he says.

Soils in Pakistan's north-west have been degraded over centuries due to over-cultivation and flood irrigation. "Excessive cultivation removes all the root material and soil organisms that feed off the root material, making the soil less physically stable and fertile," he says. "Soils in this condition fall apart when irrigation water is applied and the water is far less able to penetrate the soil."

Improved farming systems are urgently needed because Pakistan is one of the most water-insecure countries in the world and highly dependent on irrigated systems for food. Over time, cultivated land has suffered substantial productivity declines, which have been estimated to be as high as 25% of gross production.

Mr Hamilton's project replaced flood irrigation with raised beds and furrow irrigation. The system uses two machines: a no-till disc seeder; and a bed-former deep-blade loosener that creates a bed in which the crop is grown and excavates two furrows that align with tractor wheels, creating a controlled-traffic environment.

This machinery applied CA principles, ensuring there was minimal soil disturbance and maximum root retention. But the precise nature of the machinery is also one of the key reasons that, despite the success of the trials, the system has not been more broadly adopted.

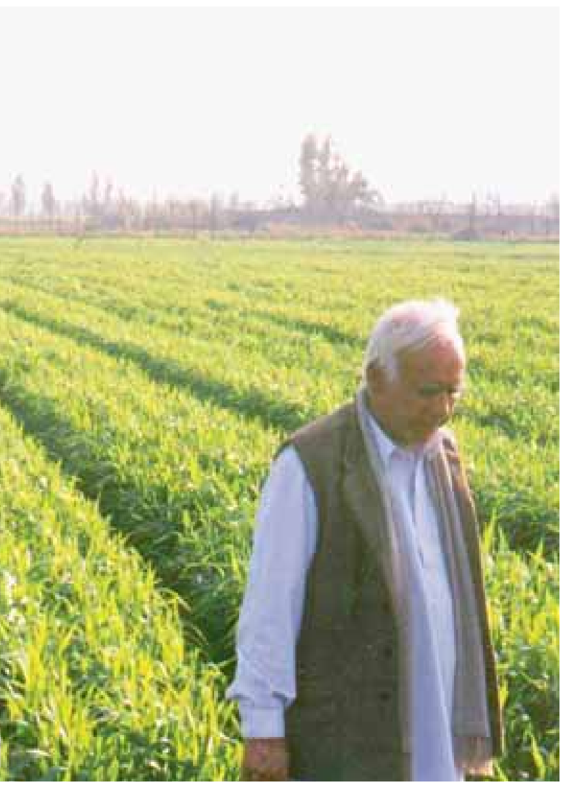
While it is not complex, the machinery is specific, Mr Hamilton says, and therefore has to be specially manufactured. Australia provided three sets of machinery for the trials and ongoing use, but manufacturing and selling the machines in Pakistan has proven problematic.

The machines, by local standards, were expensive to produce and parts hard to source. Attempts to adapt the machinery using cheaper, more readily available materials

Maize crop grown on permanent beds using the conservation agriculture and furrow irrigation practices of the ACIAR-sponsored technology in Mardan, Pakistan.

An Australian machine in Mardan, Pakistan, renovates beds on which maize was grown. The undisturbed stalks of the previous crop and seeds on the bed surface illustrate the retention of root systems and lack of soil inversion.

A Pakistan-made copy of the Australian no-till seeder is tested in a field near Faisalabad, Pakistan.



Conservation agriculture trials also impact wheat crops in maize–wheat farming systems in Mardan, Pakistan.

was difficult within the project's parameters and time frame, so development languished. While some prototypes were produced it is not known whether further production continued after the project ended in 2010.

"When you are trying a new technology with different and comparatively expensive machinery you've got yourself an adoption barrier," Mr Hamilton says.

"First, you've got a psychological barrier of a farmer having to change his ways; and second, at the same he is required to buy new, more expensive machinery, so adopting the new technology can quickly fall into the 'too-hard basket'."

Efforts to break through this barrier were complicated by another obstacle entrenched in the Pakistani farming system: irrigation land is generally owned by wealthy landlords who lease smaller plots to tenant farmers.

"The motivation for landlords to change systems and invest is often just not there because they are financially comfortable," Mr Hamilton says.

"Advances in agriculture come from farmers who are sufficiently motivated to push the envelope or live on the edge."

Other institutional challenges to adoption came in the form of autonomous governments at provincial and national levels resulting in changing personnel and a lack of continuity, and travel restrictions in Pakistan making coordinated research and extension more difficult.

But with baseline research in place and some committed local partners, Mr Hamilton hopes the groundwork has been done from which adoption programs can be launched should the impetus arise.

"Water conservation and productivity increases mean this is a very impactful technology with many benefits," he says. "I would hope the follow-up could be institutionalised in Pakistan so support and promotion services are in place to aid broader adoption." ■

PARTNER COUNTRY
PAKISTAN

PROJECT: LWR/2002/034: Refinement and adoption of permanent raised-bed technology for the irrigated maize-wheat cropping system in Pakistan 2004–10

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New technologies ease the burden

Properly adapted conservation agriculture technology delivered alongside sweeping agronomic, environmental and productivity innovations are helping Bangladeshi rural communities escape poverty.

Dr Enamul Haque from International Development Enterprise discusses lentil planting with the versatile multi-crop planter with farmers at Alipur, Rajshahi, Bangladesh.

An operator modifying the multi-crop planter before seeding.

KEY POINTS:

- **Conservation agriculture (CA) practices provide poverty-reduction opportunities for smallholder farmers in Bangladesh's poorest region.**
- **CA requires new ways of approaching aspects of crop agronomy, including mechanisation and crop diversification.**

BY SARAH CLARRY

Trundling behind a two-wheeled tractor (2WT) in fields located in one of the poorest regions of Bangladesh is a machine that is reconfiguring the potential productivity, profitability and sustainability of crop farming for poor smallholder farmers.

The machine is a sign that conservation agriculture (CA) specialists have researched the local rice-based farming systems and, with the assistance of a broader coalition of research partners, have come to understand the potential for CA to better the farmers' social, economic and environmental realities.

Leading the way in this CA revolution is the north-western region of Bangladesh, where an alluvial farming system centres around an annual monsoon. Sustained efforts to diversify cropping beyond a single rice harvest in the past 30 years have succeeded and despite the tiny size of most farms (about 0.6 hectares), they are highly productive, regularly growing three crops a year and their scarce resources are carefully managed.

The region, however, frequently faces food shortages. A preference for cereal cultivation at the expense of protein-rich pulses is one aspect of the problem. The other is the labour, fuel, water and time-intensive methods used to cultivate these patches of land.

From ACIAR's perspective, the lower labour and operating costs (from minimising soil disturbance) and more profitable rotations inherent to the CA philosophy represented a holistic solution to the problems faced by marginalised Bangladeshi rural communities.

Currently engaged in the region on behalf of ACIAR is Australian soil fertility specialist Professor Richard Bell of Murdoch University's School of Veterinary and Life Sciences. He is leading a project that is overcoming both the agronomic and mechanisation constraints to CA adoption in Bangladesh.

Professor Bell explains that generally, CA adoption has been hampered in rice-based cropping systems in contrast to other cereals, such as wheat. One issue is the practice of transplanting seedlings into 'puddled' soil—near-saturated soil that has been cultivated into soft, structureless mud.

Puddling compacts soils for subsequent crops, creating the need for intense tilling with a plough to aerate soils so that additional crops such as wheat, maize and pulses can be planted. As a result, smallholder farmers are required to till the soil repeatedly, sometimes up to eight times.

An important first step in reducing the labour, fuel and environmental effects of so much ploughing was achieved in an earlier ACIAR project (LWR-2005-001). The first crucial innovation, led by Dr Enamul Haque from international development enterprise iDE, was the development of an unpuddled rice seedling transplanting system that required just one pass of the till.

"Unpuddled conditions could be established by several different kinds of 'single-pass' minimum-tillage operations—the methods tested were strip tillage, single-pass shallow tillage and bed formation," Dr Haque says.

"Studies found the single-pass tillage methods had no detrimental effects on rice yields across three seasons when compared with the traditional puddled transplanting. But in contrast to those traditional methods, the limited soil disturbance with single-pass tillage reduced the cost of production and increased the gross margin of rice relative to full puddling and transplanting."

As with direct seeding in previous studies, unpuddled transplanting was found to reduce the time taken for land preparation and crop establishment, and decreased the number of irrigation events required to wet up the soil.

Under a current ACIAR project (LWR-2010-080) the concept of unpuddled rice establishment was demonstrated as beneficial to farmers in different agro-ecological zones, soil types, cropping systems and seasons in Bangladesh. Professor Bell says his project aims to accelerate the implementation of CA as a way to boost local food security, sustain land and water resources, and increase the productivity and profitability of smallholder farms in ways that lift the broader potential of rural communities.

To achieve all that, Professor Bell and Murdoch University have the benefit of well-thought-out partnerships established by ACIAR. On board are the Bangladesh Agricultural University, the Bangladesh Agricultural Research Council, the Bangladesh Rice Research Institute (BRRI), the Bangladesh Agricultural Research Institute, the Department of Agriculture and Food, Western Australia (DAFWA), the UN's Food and Agriculture Organization, the Peoples' Resource Oriented Voluntary Association and iDE.

Essential to the uptake of CA is access to the specialised machines needed to avoid disturbing the soil's structure and moisture content as little as possible.

Part of that jigsaw puzzle was solved by the pre-existence in Bangladesh of about half a million 2WTs. ACIAR then identified an opportunity to develop planters suited to minimum-tillage practices that would work with the existing 2WTs. The resulting CA planters are now undergoing testing, commercial manufacture and roll out.

"With the minimum tillage we are endorsing, each field has only one pass and it is done in a single day, saving the farmer time," Professor Bell says. "The impact on yield is minimal and in dry areas, yield increases have been seen due to the ability of the soil to better retain moisture."

Marketing is a key focus for ACIAR and the team is working with iDE to make the machine planters available to farmers. iDE is a not-for-profit corporation with extensive experience bringing new technology to markets in marginalised rural communities, both in Bangladesh and other developing countries.

iDE's past expertise lies in facilitating the local manufacture of affordable and scalable micro-irrigation and other low-cost water recovery systems and in distribution methods—through local supply chains—where the technology is available to farmers at an affordable cost that can be repaid in one growing season.

Professor Bell says the iDE partnership has been valuable because for many researchers, marketing is an area outside their comfort zone.

"It has involved some learning and challenges because the private sector operates in a way that is different to the research sector," he says. "That's what iDE is assisting with—helping us to understand the impediments to getting into the market and ensuring the people who want to buy have access to funds."

The target group for the planters is not necessarily the farmers themselves, but rather small business or service providers. These providers then hire the equipment out on a fee-for-service basis.

The cost of the planters is about A$600–900. Annual per capita income in Bangladesh is about A$400–600, and a small business operating one of these planters can earn about A$1,000–1,500 per year. Cost-benefit analysis has shown that within two to three years, the operator can pay back their loan and start making a profit from their business.

CROPPING OPTIONS EXPANDED

While CA can lead to savings in fuel, labour, time and operational costs and can boost productivity, it does require substantial modifications to traditional crop agronomy.

Since conventional tillage is effective for controlling weeds, the new CA-based approach requires the use of herbicides and attention to seeding rates, row spacing and varieties. Not much is known about herbicides among Bangladeshi farmers, so learning what is effective is a high priority.

Dr Abul Hashem, a weeds specialist from DAFWA, is teaching local farmers about weed management and herbicide use.

"Dr Hashem was born in Bangladesh so he is a great asset to the team," Professor Bell says. "He can communicate in the local language and is highly respected."

CA also emphasises the agronomic benefits derived from crop rotation, so crop diversification is encouraged.

"Bangladeshi farmers are very responsive to markets and will adjust the mix of crops accordingly," Professor Bell says. "Minimum tillage helps with crop diversification because a crop can be planted in one day. This gives farmers the flexibility to respond to the markets and to plant at the ideal time for higher productivity."

Through the ACIAR project 'Sustainable intensification of rice–maize production systems in Bangladesh', CA is being used to support farmers' efforts to diversify their production to meet changing demand patterns, without compromising yields. The project is led by Dr Mahesh Gathala from the International Maize and Wheat Improvement Center and Dr Roland Buresh from the International Rice Research Institute.

In Bangladesh there are three cropping seasons a year to consider: aman, boro and aus. Aman is the wet season from around June–July to October–November and only rice is typically grown during this time. Boro is the dry season that follows when rainfall is limited and considerable electricity and fuel are used to pump water for irrigating rice.

Growth of boro rice is critical for the production of sufficient food, but maize uses less irrigation water than rice. Maize grown in this season is referred to as rabi maize. Rabi maize, like boro rice, can achieve high yields at this time of the year with high solar radiation. Pre-wet season maize is referred to a kharif-1 maize.

Demand for maize has been increasing both as feed for the poultry industry and for human consumption. Alongside the increase in demand for maize is the importance of growing maize in rotation with rice to ensure effective use of limited arable land.

As part of the rice–maize intensification project, the yield gap for both rice and maize has been addressed through a range of interventions that include resource-conserving technologies such as the minimum-tillage planters and web-based information and communication technology (ICT) for delivery of agronomic information to farmers and service providers.

The ICT component of Dr Buresh's project supports the changing agronomic practices with information delivery to farmers, particularly in the context of fertiliser recommendations.

Maize and rice farmers require use of fertiliser to achieve target yield and profitability. However, Bangladesh is diverse in soil type and topography, and these, along with other factors, influence the amount of fertiliser required.

The ICT tool developed by the team is called Nutrient Manager for Rice (Bangladesh). It has been endorsed and released for use on computers and smartphones by the BRRI (http://webapps.irri.org/nm/bd).

A similar app for rabi and kharif maize is undergoing field testing prior to its release.

While the development and release of the rice app has been a major success, Dr Buresh acknowledges that it does not replace effective extension.

"Getting technologies to farmers through ICT still takes personal contact with farmers," Dr Buresh says. "An ICT tool such as Nutrient Manager facilitates the work of extension, but we have learnt that it does not reduce the importance of personal contact with the farmer."

In addition to rice and maize, potato can also achieve high yields and it has become an important crop. Potato is typically harvested in February, giving farmers the opportunity to grow a crop of maize prior to aman rice in the next wet season. ■

PARTNER COUNTRY
BANGLADESH
PROJECT: **CIM/2007/122: Sustainable intensification of rice–maize production systems in Bangladesh 2008–2013**
CONTACT: Dr Eric Huttner, eric.huttner@aciar.gov.au, 02 6217 0527
PROJECT: **LWR/2010/080: Overcoming agronomic and mechanisation constraints to development and adoption of conservation agriculture in diversified rice-based cropping in Bangladesh 2012–2016**
CONTACT: **Dr Evan Christen, evan.christen@aciar.gov.au, 02 6217 0561**

MUSCLE TO MACHINES: CUTTING LABOUR DRUDGERY IN AFRICA

Drawing lessons from Australia, Bangladesh and India, a new ACIAR/AIFSC-funded project in Africa will help mechanise conservation agriculture and relieve women of exhausting manual labour.

KEY POINTS:

- **A new project will evaluate and demonstrate the best two-wheel tractor (2WT)-based technology for conservation agriculture across four African countries. The tractors and equipment will be selected from Australia, Asia and Africa.**
- **It will test commercial systems to deliver 2WTs to African smallholders.**
- **The mechanisation is expected to benefit families on more than 35,000 farms, create jobs and relieve labour drudgery.**

A CIMMYT-led project to promote rapid adoption of two-wheel tractor technology in eastern and southern Africa will help mechanise conservation agriculture.

BY LINDA VERGNANI

While smallholder farmers in countries such as India and Bangladesh rely increasingly on mechanised equipment, including two-wheel tractors (2WTs), in Africa many impoverished farmers are caught in a time warp and still rely solely on human muscle power.

"When you look at the production means and when you look at the farm power available, the difference is really shocking between Africa and other regions," says Dr Frédéric Baudron, cropping system agronomist at the International Maize and Wheat Improvement Center (CIMMYT) in Addis Ababa, Ethiopia. "Yet Africa is meant to compete in a global market."

While some people have a "very bucolic idea" of traditional African farming, Dr Baudron says in reality hand ploughing, weeding and threshing, and tasks such as pounding grain in wooden stampers involve backbreaking work.

This drudgery often falls to women or children, who may be kept out of school to work in the fields.

In Sub-Saharan Africa most government-run tractor hire schemes have collapsed and many draught animals have died from drought or disease. "Shockingly, the number of tractors in Sub-Saharan Africa has declined from 235,000 in 1970 to 222,000 in 2000," Dr Baudron says.

Although African farmers—many of whom are women or elderly people—still rely on muscle power, labour is getting scarce and expensive. This follows the deaths of millions of able-bodied people in the AIDS pandemic, as well as increasing migration to the cities.

Now Dr Baudron is leading a CIMMYT project that aims to promote rapid adoption of 2WT technology for conservation agriculture (CA) in eastern and southern Africa.

"Our entry point is to mechanise conservation agriculture," Dr Baudron says. "We also want to look at other tasks we should mechanise as a priority so that we can release some of this labour for more productive, more rewarding use."

The four-year project will identify and demonstrate the best imported and local 2WT-driven technology for CA in eight sites in Tanzania, Kenya, Ethiopia and Zimbabwe.

Among the goals of the Farm mechanization and conservation agriculture for sustainable intensification (FACASI) project is to test commercial models for delivering 2WT technology to African smallholders. It received A$3.9 million of funding from the new Australian International Food Security Centre (AIFSC) within ACIAR.

More than 35,000 farms will benefit from the project, according to a report on FACASI by Dr Baudron and Dr Bruno Gérard, director of the Global Conservation Agricultural Program of CIMMYT.

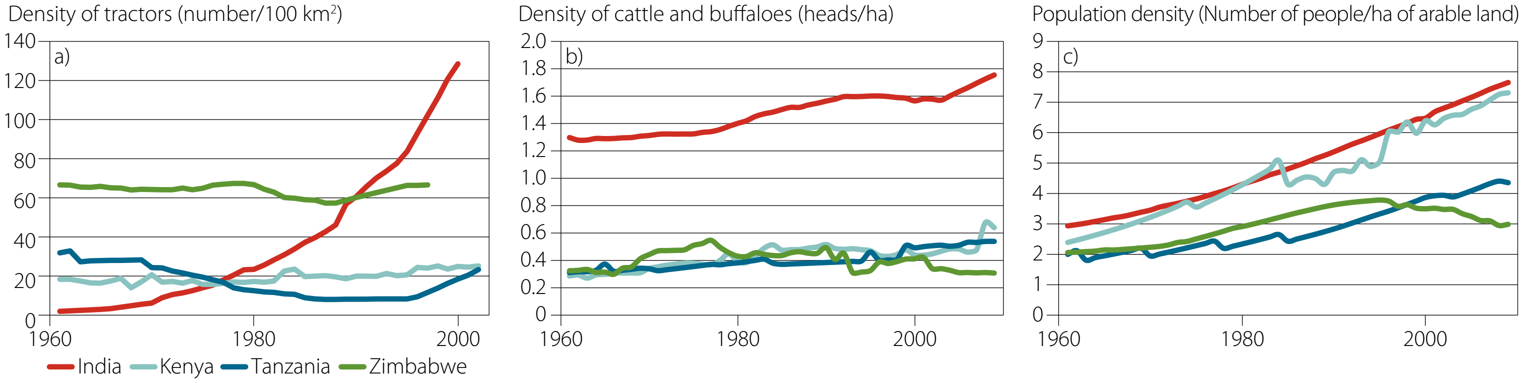
Smallholder farmers using 2WT-based CA are expected to increase their incomes by 50% and those adopting the equipment for transport, threshing and shelling to increase their incomes by 20%.

The project will also create jobs for about 360 rural service providers, who are likely to double their incomes. By the end of the project, the cumulative value of adopting 2WT technology will translate into an A$18.5 million economic boost.

The mechanisation project will focus on communities already involved in CA through SIMLESA (Sustainable intensification of maize-legume cropping systems for food security in eastern and southern Africa) or ZimCLIFS (Integrating crops and livestock for improved security and livelihoods in rural Zimbabwe).

Local importers, tractor manufacturers and dealers will be trained in 2WT-based CA, including machine maintenance, agronomy and

Figure 1 African decline in farm mechanisation



Farm mechanisation in Sub-Saharan Africa has declined from 235,000 tractors in 1970 to 222,000 in 2000 (graph a). This is in contrast to other regions, where the number of tractors increased linearly (such as Latin America and the Caribbean) or exponentially (as in Asia). During the same period, the number of draught animals on the African continent declined sharply in many areas due to biomass shortage, droughts and diseases (graph b). The decline occurred even though population density (graph c) increased in the comparison countries.

mulch management. They will in turn train rural service providers. National policy workshops will target bottlenecks and opportunities for wider delivery of the technology, especially to poor and women farmers.

Dr Baudron says using cheaper, low-energy 2WT mechanisation for CA is "smart mechanisation". It should avoid the problems agronomists observed in the 1980s when large-scale mechanisation using four-wheel tractors led to consolidation of farms, displacement of small farmers and job losses, as well as land degradation and erosion.

The project ties in with current government policies, programs or plans in Kenya, Ethiopia, Tanzania and Zimbabwe to give smallholders greater access to machinery. For example, in Tanzania following the 2009 and 2010 drought in which half the cattle and draught oxen died, the government imported more 2WTs from China and gave an 80% subsidy to smallholders to buy the vehicles.

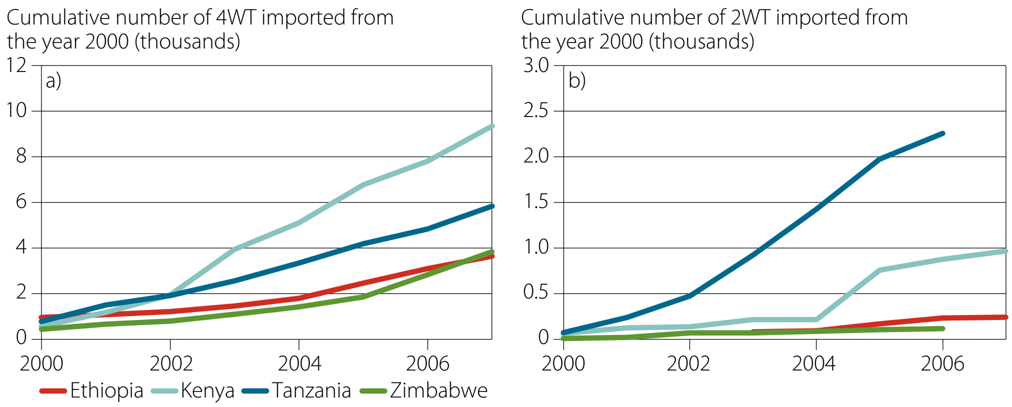
The import of the 2WTs generated business opportunities, with local mechanics repairing vehicles and Tanzanian manufacturers developing rippers and planters.

Dr Baudron quotes a farmer in Karangai in north Tanzania who told him: "A two-wheel tractor is easier to maintain than oxen. It leaves you free, because it is non-living." Another farmer commented that a person could work three to four acres of land a day using the small tractors compared with a quarter to half an acre using oxen.

Dr John Dixon, senior adviser for cropping system economics at ACIAR and for the FACASI project, says: "The timing is perfect for another round of support for mechanisation in Africa." It was tried 20 years ago by governments, but labour was still cheap and public-sector tractor schemes were poorly managed. "Now, with the support from many African governments to small-scale business, we believe that the environment is much better for using commercial models for small-scale mechanisation that will be within reach of the smallholders.

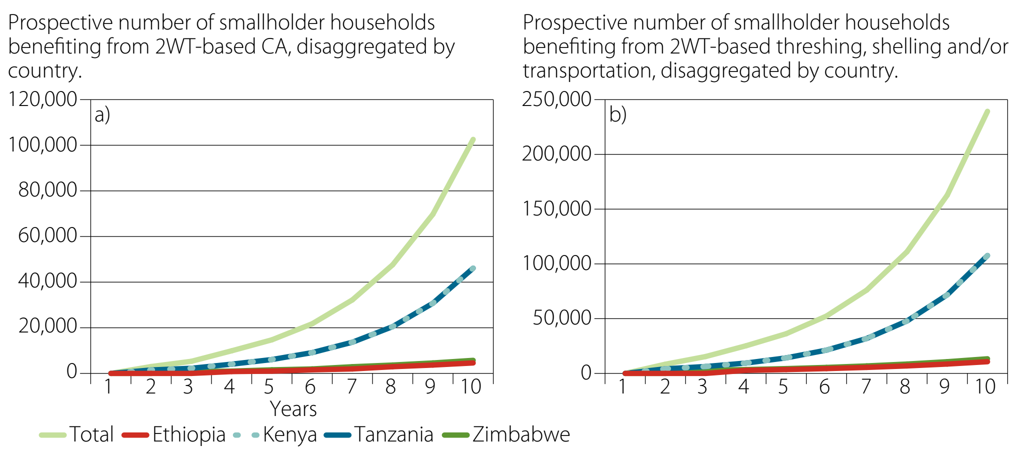
"What's quite intriguing about this project is it's not about promoting mechanisation as such. It's really about testing different

Figure 2 The forgotten resource—farm power



The need for sustainable intensification of farming in Sub-Saharan Africa is widely recognised. Although a lot of emphasis is being placed in current research for development work on increasing the efficiency with which land, water and nutrients are being used, farm power appears to be a 'forgotten resource'. Yet farm power is in decline due to the collapse of most tractor-hire schemes, the decline in draught animals, and the impact of urban migration and pandemics on human labour. The resulting high labour drudgery disproportionately affects women.

Figure 3 Projected growth in benefits to smallholder households from an ACIAR project to reverse the decline in farm mechanisation in eastern and southern Africa.



commercial models for the provision of small 2WTs and associated equipment for CA. And so the real focus is on small-scale business rather than on farmers or on factories."

According to Dr Dixon, FACASI will allow Africa to draw on the CA expertise of Australia, which leads the world in CA food production, and the small-scale mechanisation experience of South Asia.

The Indian Council of Agricultural Research recently hosted a small-scale mechanisation training workshop in Bhopal and Ludhiana for about 15 African businessmen, researchers and representatives of non-government organisations. "Later, African professionals will have a look at how Bangladesh has been so successful with 2WTs," Dr Dixon says.

"On top of that, China is very interested and China's 2WT companies have said that they will provide support for training in Africa as the sales of 2WTs begin to increase. So I think we've got an international hook-up orchestrated by Australia that should be of immense value to Africa."

Dr Dixon cites Bangladesh as the "stand-out example" of successful 2WT mechanisation. Following a policy shift that facilitated importing 2WTs from China 20 years ago, there was a revolution in small-scale agriculture in Bangladesh.

Dr Dixon says ACIAR's experience in Bangladesh shows that "it's small farmers, who pick up or purchase a 2WT and then become business providers by leasing or renting out those tractors with the equipment to their neighbours or even to farmers in other districts nearby."

The inaugural meeting of the mechanisation project, held in Arusha in Tanzania in March, was attended by about 60 researchers, business people, importers and manufacturers of 2WTs, representatives of finance and credit organisations and government officials.

Professor John Blackwell, professor of Innovative Agricultural Water Technologies at Charles Sturt University, who attended the meeting, says: "The project is about exploring clever ways to get the available machinery into the African market, through small businesses, importers, sellers and service providers."

The inventor of the Happy Seeder, which is widely used with four-wheel tractors for CA in India, Professor Blackwell is involved with evaluation and training for FACASI.

He says in Tanzania the group saw a few 2WTs, with trailers behind them, being used for transport rather than tilling or preparing land. "We want to introduce 2WTs and the required machinery, as an aid to CA that will save labour, preserve soil and preserve water.

"A lot of existing 2WT technology is not suitable for achieving conservation agriculture in African conditions," Professor Blackwell says.

"We will encourage African innovators, mechanics and engineers to modify the available machines and equipment to suit their conditions."

The 2WTs are usually equipped with a rotary cultivator, which is the driving force for their uptake in Bangladesh's rice-paddy-based agriculture. However, rotary hoeing and conventional ploughing are contrary to the minimum-tillage principle of CA. Professor Blackwell says modifying rotary hoes to strip-till will be "a step in the right direction".

For minimum disturbance, the 2WT can also pull two shallow-depth tines or disc coulters for direct seeding.

While many large farms in Zimbabwe and Kenya are fully mechanised, Professor Blackwell says the 2WT-based mechanisation is aimed at millions of smallholders living on the poverty line. "Perhaps this small-scale mechanisation approach can get them out of the poverty trap. It will be a beginning."

The Food and Agriculture Organization (FAO) is among groups partnering with CIMMYT to implement the mechanisation project.

Josef Kienzle, agricultural engineer at the Plant Production and Protection Division of the FAO, says: "Farm power is a critical input for sustainable crop production intensification in the region; it is a limiting and scarce factor that can be mitigated by the provision of farm power in the form of 2WTs."

Mellissa Wood, director of the AIFSC, believes the uptake of 2WTs could be even quicker in Africa because of labour shortages at critical times of the year. She notes: "Gender must be mainstreamed into all our research as the majority of smallholder farmers in south-east Africa are women. What we have found is women are quite able to handle these 2WTs. So we think that will fit very well with the current agenda for delivering gender responsive technologies." ■

PARTNER COUNTRIES
BANGLADESH, ETHIOPIA, INDIA, KENYA, TANZANIA, ZIMBABWE

PROJECT: FSC/2012/047 Farm mechanization and conservation agriculture for sustainable intensification (FACASI)

CONTACT: Dr John Dixon, senior adviser, Cropping Systems and Economics Research Program, john.dixon@aciar.gov.au

THE FAST TRACK

If African maize farmers could rapidly adopt sustainable agricultural practices that increase their yields, it would make them less vulnerable to climate change shocks, improve food security and reduce poverty in the region.

This is the rationale behind the new Adoption Pathways study of 3,600 farming households in five African countries: Ethiopia, Kenya, Tanzania, Malawi and Mozambique. Researchers will assess how quickly smallholders in 220 farming communities take up sustainable agricultural intensification (SAI) technologies.

Sustainable agriculture allows farmers to produce more on the same plot of land while reducing environmental harm. Repeat studies of the same households in 2013 and 2016 will identify socioeconomic factors that speed up or hold back uptake of the improved practices.

The project, which is being funded by the Australian International Food Security Centre and managed by ACIAR, will identify policies that could encourage faster uptake of sustainable agriculture. It is expected to benefit about 130,000 farmers over 10 years and help address food shortages in the region.

Dr John Dixon, senior adviser and manager of ACIAR's Cropping Systems and Economics Research Program, says: "Rapid adoption of sustainable agriculture is a critical challenge across many parts of Africa, from Cape Town to Casablanca. If we can understand more about what causes adoption and especially what accelerates it, then we could get farmers to take up the agronomy, the conservation agriculture, the market access and institutional innovations much more quickly, so the benefits will come sooner. We can reduce poverty more quickly and avert and avoid many deaths associated with hunger and malnutrition."

The project is being undertaken in partnership with the International Wheat and Maize Improvement Center (CIMMYT). Collaborating institutions include the University of Queensland in Australia, the Ethiopian Institute of Agricultural Research and universities in Tanzania, Kenya, Mozambique and Malawi.

Project leader Dr Menale Kassie, an agricultural economist in the Socioeconomics Program of CIMMYT, says: "This Adoption Pathway project is mainly focusing on the uptake of intensification technologies such as: agronomic practices; use of fertiliser and improved varieties; maize and legume intercropping or rotation; and zero or minimum-tillage. These are the complementary conservation agriculture practices and technologies promoted by SIMLESA [Sustainable intensification of maize–legume cropping systems for food security in Eastern and Southern Africa project]."

The two Adoption Pathways surveys will be done in more than 500 villages where SIMLESA has introduced improved farming methods. The researchers will visit the same households where SIMLESA baseline data was gathered in 2010 to find out what changes smallholders have made.

While previous studies concentrated on specific SAI technologies, such as the uptake of fertiliser, the new study takes a more holistic approach. "We are trying to look at the drivers of adoption such as policies, market access and institutions. We also want to look at the role of extension services in influencing adoption of new technologies," Dr Kassie says.

"We will collect the same information from the same households over time. Adoption is a process that takes a while and the benefits of technologies may not be seen in the short term, especially with conservation agriculture."

Dr Kassie adds that even with short-term technologies, such as using fertiliser and improved seed, farmers are observed adopting these and then tomorrow or in the near future they drop the same technology. "So why is this happening? Why is this adoption and dis-adoption taking place?"

Researchers will also examine what farming practices and technologies women farmers use compared with men. They will look at the role of gender in agricultural development to see if there is a difference with technology adoption or approach to food security between female and male farmers, as well as between a wife and husband in the same house.

For example, farmers who have planted improved maize or legume varieties will be asked if they or their spouse took the decision to plant the new varieties, how they found out about these varieties and who got the credit or cash to buy the seeds.

According to a report on the project, the findings will "facilitate the formulation of robust pro-poor and gender-equitable policies" that promote the spread of SAI technologies and improve food security. Dr Dixon says the lessons learnt from this project will be useful for other projects and governments across Africa.

PARTNER COUNTRIES
ETHIOPIA, KENYA, MALAWI, MOZAMBIQUE, TANZANIA

PROJECT: FSC/2012/024 Identifying socioeconomic constraints to and incentives for faster technology adoption: Pathways to sustainable intensification in eastern and southern Africa (Adoption Pathways)
CONTACT: Dr John Dixon, senior adviser, Cropping Systems and Economics Research Program, john.dixon@aciar.gov.au

Farm mechanisation

In Keni South, located in eastern Kenya's Embu district, farms are still ploughed mainly by hand. Asliphon Nyaga farms a small plot of land, growing maize and sometimes bananas. She is like many women across eastern Africa, tending small plots of land and raising a family.

Input costs are rising and with little spare money Mrs Nyaga has to make choices about crops, purchasing expensive fertilisers and how to market any surplus produce. Labour is becoming scarcer and therefore more expensive.

In doing the work herself, Mrs Nyaga is typical of many farmers in rural Africa. Unable to afford to buy or hire a small tractor, and having no draught animals, she must till, weed and harvest her crops by hand, and work out how to move any surpluses to market herself.

The possibility of intensifying production without external help is remote, both in terms of labour or power and access to new farming techniques and crop varieties. Yet it is farmers such as Mrs Nyaga who are expected to carry much of the load in meeting increasing demand and sustainably increasing production in Sub-Saharan Africa.

ACIAR's Sustainable intensification of maize–legume cropping systems for food security in eastern and southern Africa (SIMLESA) project is working with farmers, including Mrs Nyaga, to introduce new farming practices and crop varieties. Through support from the project, delivered by the Kenyan National Agricultural Research Institute, Mrs Nyaga has learnt about conservation agriculture (CA), introduced legume crops and now uses manure and fertiliser. The result is improved yields.

CA is central to SIMLESA, which is adapting this approach to the unique needs of smallholder farmers across five east African nations. The approach acknowledges the realities of farming systems in each nation and adapts the introduction of CA to those realities. For example, in Ethiopia, where livestock is common, use of crop residues differs to that in Kenya.

The aim is to introduce smart CA approaches to boost yields. This will provide a platform for the farm mechanisation work to build on, accelerating adoption. Smart CA is helping Mrs Nyaga and many other farmers to boost yields and earn more income. For Mrs Nyaga, the future may extend to accessing mechanised labour, introduced through ACIAR's farm mechanisation research.

Trilateral partnership a first

Conservation agriculture (CA) is well established in parts of India, so much so that the country is now hosting African researchers interested in farm mechanisation. The visit was organised as part of ACIAR's farm mechanisation research project and is the first trilateral partnership between ACIAR, the Indian Council of Agricultural Research (ICAR), and the International Maize and Wheat Improvement Center (CIMMYT).

The training tour also represents a first in cooperation between the African nations of Kenya, Tanzania, Ethiopia and Zimbabwe, and India and Australia in agricultural research.

The Director General of ICAR, Dr S Ayyapan, says the exchange represents a strengthening of south-south collaboration by encouraging mutual learning and growth between countries. Dr Ayyapan says that India and Africa have many similar challenges and such exchanges offer a good model to carry forward future activities to benefit all involved.

The visit was organised and coordinated by CIMMYT in partnership with ICAR and the Central Institute of Agricultural Engineering (CIAE) in Bhopal. Other host institutions were: the Central Farm Machinery Training and Testing Institute Budni; Borlaug Institute for South Asia; PACS-machinery hire bank/cooperative; Punjab Agricultural University; National Agro Industries; Jagatjit Agro Technology; Dashmesh Mechanical Engineering Works; Amar Agro Industries; All India Machinery Manufacturers Association; CIMMYT on-farm CA sites and farmer cooperatives; Central Soil Salinity Research Institute; and the Directorate of Wheat Research in Karnal.

The delegation was led by the Farm power and conservation agriculture for sustainable intensification (FACASI) project coordinator, Dr Frédéric Baudron, and engineer Saidi Mkomwa, executive secretary of the African Conservation Tillage Network, during the first and second week respectively.

A feature of the exchange was three days of hands-on-training on manual, animal traction, and two-wheel and four-wheel tractor machinery at the CIAE. Participants also welcomed the opportunities to share stories and build a network of CA practitioners across several countries.

One of the main outcomes of the tour was the identification of CA equipment to match FACASI mechanisation needs.

Technology returned to agriculture's cradle

Conservation agriculture as practised in Australia has proven to be a viable technology in war and drought-scarred Iraq, introduced within a package of assistance provided by Australia to help rebuild Iraq's agricultural sector.

The Iraqi-made 2-metre zero-till seeder undergoes testing in Ninevah, Iraq.

PHOTO: SINAN JALILI

BY DR GIO BRAIDOTTI

In Iraq's northern dryland areas—including the governorates of Ninevah, Anbar, Salahuddin and Kirkuk—crop yields are low as soil degradation and nutrient depletion push cropping systems into serious decline. Among the crops affected is wheat and with it, the social stability provided by reliable, affordable and adequate supplies of flour and bread.

Recognising the need to rehabilitate and rebuild its farming capacity, the Iraqi Government has worked with ACIAR in a project funded by Australian Government Overseas Aid Program (AusAID) to study the reasons for the decline, identify the means to reverse it and build the capacity to help farmers implement innovations.

Among the technology proven capable of restoring soils and raising crop productivity and profitability is a form of conservation agriculture (CA) that was specifically adapted to local growing conditions through an ACIAR project headed by the International Center for Agricultural Research in the Dry Areas (ICARDA).

The project commenced in 2005 at ICARDA headquarters near Aleppo, in northern Syria, where researchers established the value to farm productivity of zero tillage, no stubble burning and early planting. Benefits were found to include fuel savings and higher yields—as much as 20%—compared with conventional tillage and late planting. These benefits proved major incentives for adoption by Syrian farmers.

From the outset the project had an unusual feature: ICARDA researchers are unable to enter Iraq due to ongoing security concerns. Instead, ICARDA has run the project remotely from Aleppo, where the environment and farming systems are similar to northern Iraq. This was achieved by using the Syrian trial sites—and the fields of early-adopting Syrian farmers—to provide experience and facilitate training in zero-tillage systems for visiting Iraqis.

Back in Iraq, the project relied on the extraordinary efforts of the commissioned team of Iraqi scientists, agronomists, extension officers and participating farmers to trial and implement the technology, initially in the Ninevah Governorate. The collaborating Iraqi institutions are the State Board for Agricultural Research, the Ministry of Agriculture, the Directorate of Agriculture and the University of Mosul.

Syria itself subsequently succumbed to civil unrest. As it escalated during 2011, ICARDA had no choice but to evacuate its international staff and decentralise its activities, distributing them among their network of regional facilities (see box). Since 2012, the Iraq project has been run from the Jordan office in Amman, one of the oldest continually inhabited cities in the world.

A key ICARDA figure in designing and running the project is an Australian agronomist, farmer and one-time ACIAR research program manager, Dr Colin Piggin. His experience with CA dates back decades, as he was involved when it was first being developed for Australian farmers. He says it has now proven an appropriate technology for northern Iraq and Syria, just as it was in Australia where 80–90% of grain growers now use it.

"Farmers in Iraq are getting the same benefits as farmers in Australia," Dr Piggin says.

"We are finding that once they try it and see the results, farmers do not go back to the traditional system as long as they have access to a zero-till seeder. Project activities are ensuring that the seeders are becoming more widely available."

CONSIGNING THE PLOUGH TO HISTORY

The uptake of CA is extraordinary considering how big a cultural change is involved in abandoning the plough and retaining stubble from the previous crop (see box). In the region, Dr Piggin estimates that farmers traditionally ploughed up to three times before sowing their crops, each tillage costing A$20–30 per hectare.

"To grow a crop without ploughing is a radical departure and must initially seem counterintuitive," he says. "As in Australia 40 years ago, everybody said you had to cultivate and get a fine seed bed before you could plant a crop. But it turns out that is just not the case. And if you don't have to do that—and yet get better yields—then of course farmers are very attracted to that technology."

Two features of the ACIAR project in particular have eased the way for successful adoption of CA in northern Iraq and Syria (the rate of adoption is shown in Figure 2).

The first was the methodical, paddock-centric, farmer-friendly project design. Scientists were careful to first verify what works in the target environment using R&D techniques that engage farmers. These included establishing on-farm trials, permanent demonstration sites and thinking about the farming system as a whole.

"In addition to emphasising zero-till technology we work with the broader agronomic opportunities that CA enables," Dr Piggin says. "This includes early planting, a practice that makes a tremendous difference to yields in this environment, as it does in Australia.

"Another example is the careful calibration of the seeders for seed rate. A lot of farmers in this region use seed rates that are much too high and exhaust soil moisture so that all the plants run out of moisture and none yield well. A lower seed rate allows the crop to survive until it has filled the grain."

The second factor was ensuring ready access to the specialised machinery needed to sow through stubble. Here, past Australian aid inadvertently provided a helping hand: an AusAID project in the 1980s imported numerous conventional seeders from Australian machine manufacturer John Shearer in a bid to mechanise crop production in northern Iraq.

"When we started our project in 2005 we discovered that a lot of these seeders were still operational," Dr Piggin says. "So, together with innovative farmers and machinery manufacturers, we developed local capacity to modify them into zero-till seeders. We also encouraged farmer groups to manufacture seeders that have the same sort of components [narrow openers, widely spaced tines] as the Shearer machines."

As a result, costs are minimised, with a 2-meter-wide seeder retailing for about A$1,500–2,000 and a 4-metre version for about twice that. These prices make them attractive to many farmers, especially those with a reasonable amount of land who can more quickly recoup costs through income from higher yields and money saved by not ploughing.

"Many of the farmers who own a seeder also get opportunities to earn additional income by contracting to sow crops for other farmers," Dr

ICARDA

The International Center for Agricultural Research in the Dry Areas (ICARDA) was established in 1977. Its origins lie in a 1973 study that highlighted the food security challenges faced by countries across the dry regions of the Near East and North Africa.

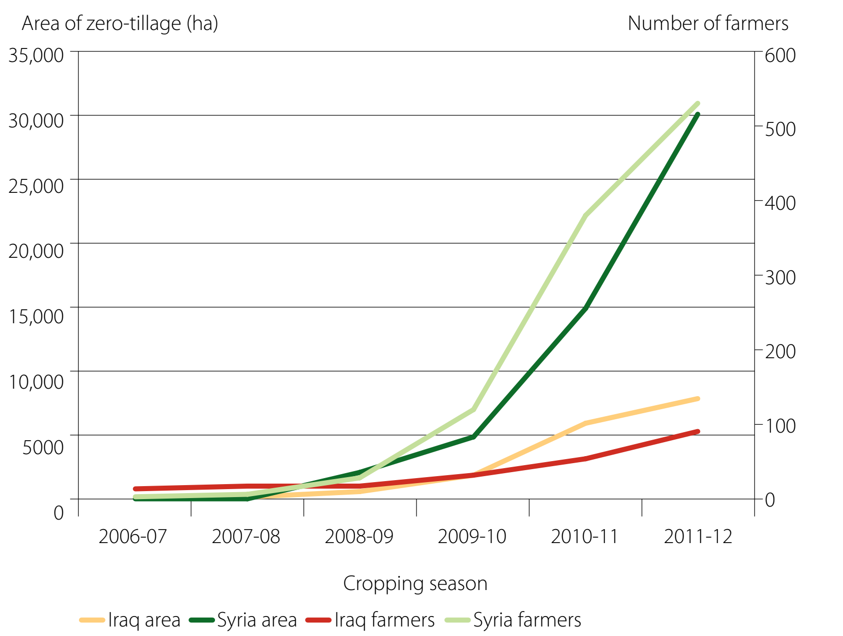
Besides its evacuated main premises in Aleppo, ICARDA has several regional offices and research stations in Jordan, Lebanon, Egypt, Morocco, Tunisia, Turkey and Ethiopia. It has research, development and capacity-building programs underway in more than 40 countries in collaboration with national initiatives.

In addition to research to increase legume and wheat crop yields in some of the world's driest areas, ICARDA is also working with governments in Africa to determine the best strategic crops and ensure food and water security.

The centre also works with war-torn countries in the region. As well as projects to rebuild agricultural systems in Iraq, Afghanistan and Sudan, it reactivated a program in November 2011 with Libya to upgrade the country's agricultural research potential following the death of Muammar Gaddafi.

Figure 1 Iraqi Governorates

Figure 2 Area under zero-tillage and number of farmers adopting zero-tillage in northern Iraq and Syria between 2006 and 2012



Piggin says. "To encourage uptake, NGOs and government extension services also provide locally made zero-tillage seeders on loan so that farmers can trial the technology on part of their land and compare the cost-benefits to traditionally cultivated fields."

In the current season in Ninevah, Iraq, there are nearly 100 farmers using zero-till technology on about 8,000 hectares, up from 52 ha in 2006. There are also several machinery manufacturing groups starting to build and market simple zero-till seeders. In Syria, too, uptake has consistently grown. In 2011–12 this amounted to more than 500 farmers who planted 30,000 ha using CA, in addition to five to six local manufacturers making and selling zero-till seeders.

ACIAR also made it possible to build capacity among Iraq and Syria's national agricultural, research and extension organisations. For instance, the project is supporting six Iraqi scientists to undertake master's degrees with project partners at the University of Adelaide and the University Western Australia. Capacity building, too, is paying dividends as highlighted by the Iraqi universities that now provide CA courses as part of their curriculum on crop management.

A FOOD SECURITY REVOLUTION

In all, a momentum has been generated that is establishing Ninevah as a centre for excellence in CA, a vital resource in a region where farmers increasingly struggle with parched and strained farmland.

"The Ninevah project has created a very good base for expanding the technology to more farmers," Dr Piggin says. "ACIAR is taking advantage, extending the Iraq project into a third term to assist rollout of the technology beyond Ninevah to three neighbouring governorates—Anbar, Salahuddin and Kirkuk."

Farmers and scientists from these additional governorates are being invited to visit Ninevah to learn about the technology before implementing research work and field demonstration sites of their own. These will provide a base for extension services to farmers to raise awareness and provide experience with the technology.

This extension process includes the purchase of eight zero-till seeders for the new participating governorates from the collaborating manufacturers in Syria (the purchase was made before Iraq achieved the capacity to provide this machinery). That means growing numbers of farmers are in a position to try the technology for themselves on their own farms.

Further afield, an ACIAR scoping study in the wider region identified additional opportunities for ICARDA to adapt and adopt CA in the wider Maghreb region of northern Africa—an area that includes Morocco, Tunisia, Algeria, Libya, Sudan and Eritrea.

A five-year project was launched in 2012

The environmental advantages

Conservation agriculture (CA) can increase yield and productivity in ways that also improve environmental health, especially of soil, water and air-quality resources.

- **Undisturbed soil is able to develop better structure that absorbs and retains water for crops more effectively.**
- **Nutrients drawn from stubble and other residues enable better nutrient cycling.**
- **Crop residues physically protect soil to reduce wind and water erosion by up to 96%.**
- **Biological activity continues uninterrupted and nutrient-rich organic matter is left to accumulate.**
- **There is better retention of water, soil and inputs such as fertiliser, herbicides and pesticides in the field.**
- **The effects of agricultural run-off such as silting and polluting of water bodies are reduced.**
- **Rural air pollution and haze caused by farmers burning crop stubble is eliminated.**
- **Fields are less prone to rise as dust or dust storms.**
- **Greenhouse gas emissions are reduced since less nitrogen fertiliser and fossil fuels are needed and the soil is better able to sequester carbon.**
- **Improved water-use efficiency helps to better conserve diminishing water resources such as groundwater.**

ICARDA'S TEMPORARY HOME

FROM DR COLIN PIGGIN AND VARIOUS ICARDA SOURCES

The general uprising of the Arab Spring spilled over into Syria in March nearly two years ago. Everybody at the International Center for Agricultural Research in the Dry Areas (ICARDA) was initially confident it would be resolved, but things just kept getting worse. The unrest and disruption is pretty extreme at the moment.

ICARDA kept operating as best it could until the unrest escalated in June 2012. I was there in Aleppo at the time and there was a lot of bombing, gunfire and uncertainty over who was manning the many road blocks. At ICARDA, the main research station was looted, the sheep unit facilities were damaged and the centre lost vehicles, farm machinery and computers.

When several ICARDA staff were kidnapped the situation became untenable. Despite their safe return after about a week, all international staff were evacuated to regional offices and research stations in Jordan, Lebanon, Egypt, Morocco, Tunisia, Turkey and Ethiopia.

A few months later, heavy fighting broke out in Aleppo and ICARDA's headquarters were occupied by anti-government forces.

Also evacuated safely was ICARDA's priceless gene bank. It holds more than 110,000 accessions selected for their genetic diversity that includes important variation in heat and drought tolerance in crops such as wheat and chickpeas. The collection was spared by looters and its importance has been recognised by the anti-government rebel forces.

The gene bank was duplicated by ICARDA in 2012 and seed was deposited in gene banks across its regional network. Curators from Aleppo have now relocated to offices in Tunisia and Morocco—nations that operate excellent national gene bank facilities. Seed was also sent to the Svalbard 'doomsday vault' in Norway for long-term safekeeping.

The decentralisation of ICARDA activities was further eased by the backup of all the research, financial and corporate data and documents outside of Syria.

As to ICARDA's Crop Management Group in charge of the Iraq project, it is now based in Amman, Jordan, where ICARDA has cultivated valuable links with Jordan's agricultural sector, especially the National Centre for Agricultural Research and Extension. This has enabled us to re-create the field demonstration sites we need to train visiting Iraqi scientists, just as we used to do in Syria's 1,000-hectare research station.

We have also linked up with a local machinery manufacturer that has supplied Iraq for the past 20 to 30 years. They are involved in converting their conventional machinery to zero tillage, for which they see a growing market in the region.

While the loss of the Aleppo facilities is a tragedy—and everyone hopes this is a temporary state of affairs—it is not the first time civil strife has overwhelmed a research centre from the Consultative Group on International Agricultural Research. With careful planning, flexibility and good use of its excellent regional network and facilities, ICARDA research for development activities continues unabated.

headed by ICARDA's Dr Mohammed El-Mourid who is based in Tunisia. The project targets rainfed, dual cereal–livestock farms (of less than 20 ha) and aims to use CA technology to reduce yield fluctuations, production costs and soil degradation.

It is noteworthy that these activities take place in a region frequently cited by archaeologists as the 'cradle' of both the domestication of wheat and the invention of tillage.

These were technological innovations that radically facilitated the evolution of human societies into city-states and ignited the spread of cereal cultivation around the world, including most recently to Australia. It is now Australia's opportunity to return the favour, giving back to the cradle of agriculture some important innovations that render farming more sustainable.

"A lot of people are talking about this technology in terms of a zero-tillage revolution," Dr Piggin says. "It is certainly a revolution in terms of the way in which farmers are growing their crops, the gains in productivity and the enthusiasm with which it is adopted."

Researchers at ICARDA used field trials in Syria and Iraq to calculate savings and increased earnings from the adoption of agronomic innovations developed for farmers in the CA project (Table 1). ■

PARTNER COUNTRY
IRAQ
PROJECT: CIM/2008/027: Development of conservation cropping systems in the drylands of northern Iraq 2008–2015
CONTACT: Dr Eric Huttner, ACIAR crop improvement and management, eric.huttner@aciar.gov.au

Table 1 The bottom line for farmers in Syria and Iraq

	SYRIA	IRAQ
Selling price of a tonne of wheat	$400	$700
Increased earnings from 20% yield gain	$100/ha	$175/ha
Savings from two fewer ploughings	$40/ha	$40/ha
Savings from reduced seed rate	$80/ha	$140/ha
CA improves farmer profitability by	$220/ha	$355/ha
Net economic benefit in 2010–11 from area under conservation agriculture	$6.6 million	$2.8 million

Wheat shortages write history

Some consider drought's impact on already-declining wheat harvests as a factor in the timing of the Arab Spring uprising. This would not be the first instance of crediting wheat shortages with shaping geopolitical history.

Drought on the heel of crop failures triggered by the Laki eruption in Iceland in 1783 are considered a trigger for the French Revolution (1788–89).

In Europe at the time, bread was essential to survival for most peasants and grain trade was highly regulated to ensure prices remained stable and affordable. King Louis XV of France even earned the nickname the 'Baker King' due to his keen interest in regulatory activity around bread.

French peasants existed at the subsistence level, growing just enough grain to pay their taxes and have some left over to eat and plant the following year.

It was a precarious food security situation, with extreme weather, war and disease capable of reducing peasants to penury. A few bad years in a row could cause widespread famine and death.

During 1789, bread riots were especially common in France. The unrest leading to the Fall of the Bastille on 14 July 1789, in the early stages of the French Revolution, actually began as a search for arms and grain.

THE 'INVENTION' OF WHEAT

BY GIO BRAIDOTTI

In 2010, wheat was grown on more land than any other commercial food—240 million hectares—and world trade in wheat was greater than for all other crops combined. World production totalled 651 million tonnes, second only to maize and roughly on par with rice (672 million tonnes).

It is an amazing success story. Wheat was one of the first cereals ever domesticated, originating in the eastern Mediterranean region spanning southern Turkey, north-western Iraq, Syria, Lebanon, Jordan, Israel, Palestine, Cyprus, the Sinai Peninsula and the Ethiopian Highlands.

Recent findings narrow the first domestication of wheat to a small region of south-eastern Turkey in about 9000 BCE (although exploitation of wild wheat dates back to 23,000 BCE). Domestication is considered a key factor in the emergence of city-based societies including those in the Nile Delta, and in the Babylonian and Assyrian empires.

With domestication came technological innovation, primarily to facilitate tillage as a way to loosen and aerate the soil, mix in nutrients and destroy weeds. Tillage, too, began in the eastern Mediterranean, first in the form of digging sticks 12,000 years ago and evolving into spades and then triangular blades. The first wooden ploughs were likely pulled by farmers, with animals recruited about 3,000 years ago in Mesopotamia (the area between the Tigris and Euphrates rivers in Iraq, north-eastern Syria and south-eastern Turkey).

Throughout early history, soil tillage had more in common with current conservation agriculture than with modern ploughing practices due to the intense labour involved. To plough one hectare with animal traction, a farmer typically has to walk 30–40 kilometres.

With the Industrial Revolution came the next wave of innovation, starting with Jethro Tull (1674–1741), who revolutionised horse-drawn farm machinery, and culminating in the replacement of animals with tractors. Many farmers and agricultural experts started to believe that the more they tilled, the higher the yield they achieved. Powerful ploughs became icons of human progress.

The combination of wheat and plough proved incredibly adaptable. Wheat is able to grow from near-Arctic regions to the equator, from sea level to the plains of Tibet at 4,000 metres above sea level. European colonial powers took wheat and the modern plough to North and South America, Asia, Australia and Africa, where it became a primary tool for developing newly cultivated land.

But the same techniques that brought bounteous harvests in cool, wet regions were gradually found to condemn farmland in warmer climates to soil erosion and degradation. The last landmasses to adopt the plough were also the first to abandon it in favour of conservation agriculture and zero-till seeders.

With Australian aid to the Middle East, the circle is completed, as the youngest among adopters of wheat return to the region of its origin with technology to sustain production into the future.

Life on the Mekong.

WATER-WISE RESILIENCE

Competing interests are degrading water resources worldwide. Overuse, pollution, water redirection, tidal surges and climate effects are threatening the world's most fertile deltas, the Mekong, Yellow River and Nile. Conservation agriculture offers solutions that concurrently lift the profitability of smallholder famers.

KEY POINTS:

- **Australia has the highest proportion of cereal production under conservation agriculture (CA) in the world.**
- **ACIAR has been a pioneer in promoting CA to the developing world in a bid to increase farming productivity and sustainability, and in turn, improve the outlook for smallholder farmers.**
- **ACIAR began supporting CA research in China back in 1990, about 20 years ago in India, about 10 years ago in Bangladesh and four years ago in Africa.**

BY WENDY HENDERSON

Agriculture is a risky business, and for the farmer, water is the main production risk. Without water, farming is not possible. Smallholder farmers in Africa, India, Bangladesh and elsewhere are facing similar challenges of feeding themselves and their families without consistent water supplies. Their crop yields are decreasing and costs increasing, due in no small part to poor water availability and soil degradation issues.

Famers tell of problems with crops drying-off, hard ground surfaces, soil diseases and the ever-increasing need for fertiliser to combat low soil-nutrient levels. The greater the variability in water supply, the less resilient the farm.

One means of lifting resilience is through conservation agriculture (CA), which allows farmers to better use existing water supplies.

Much of the water potentially available for agriculture is not productive, being lost through evaporation and run-off, such as in Sub-Saharan Africa where 75–85% is lost.

When CA practices are tailored appropriately to the specific farming situation, the result is significantly more efficient water use, in both irrigated and rainfed agriculture.

The CA approach significantly reduces water losses, particularly through zero tillage (no ploughing) and leaving crop residue on the ground as mulch. Both practices increase soil moisture, reducing the need for additional water to get the crop through to harvest time. Crop rotations, matched properly to water and soil requirements, can then be added to grow food more intensively, for longer periods and with more crop choices.

Mulching with crop residue not only reduces evaporation, it also helps rainwater enter the soil, further increasing soil moisture and preventing erosion. When rain hits the residue, instead of compacting the soil and running off, the leaves or straw dissipate the droplets and allow water to gently infiltrate the soil. In addition, as the residue decomposes into the ground, it increases the organic matter in the soil. This further improves the soil's capacity to

PHOTO: BRAD COLLIS

hold water and allows nutrients to build up in the soil.

The presence of soil organic matter significantly increases earthworm numbers and microbial activity, and helps bind and retain nutrients. This translates into healthier, more productive soils for the farmer. If the surface mulch is thick enough it can also suppress weeds. The catch with all this mulching magic is that the farmer needs to reach a trade-off between having a decent amount of ground cover and using the residue for other things, such as feed for livestock or fuel to burn.

Zero-tillage or minimal-tillage techniques involve planting seeds directly into the ground, either mechanically or by hand, rather than using ploughing. In irrigated rice-based systems, the traditional method involves ‘puddling’ the soil (churning the soil and adding water) and hand-transplanting rice seedlings into the mud. ACIAR research in northern India and Bangladesh has shown that the alternative CA methods use 30–50% less water than puddling methods without compromising rice yields. Water savings under direct seeding result from no longer needing the slurry and from reduced deep drainage, seepage and run-off. Considerable savings on labour and fuel are also made.

As an aside, research with non-rice crops (such as lentils and chickpeas) has also shown that direct seeding results in better seedling emergence (more seeds germinate and grow) compared with the traditional method of broadcasting seeds and digging them in.

In rainfed agriculture, particularly in areas where rainfall is low (or reducing due to climate change), increased soil moisture enables farmers to grow crops more consistently, with less dependence on rainfall. Reductions in yield variability build resilience, lowering the chances that a bad year can be the difference between hunger and opportunity.

In irrigated systems, farmers are encouraged to collect excess wetter-season rainfall in pits, trenches and small dams. This water harvesting permits supplementary watering in seasons when rainfall is reduced or more sporadic. And because of the existing soil moisture, relatively little extra water is needed to see the crop through.

The increased water efficiency means that two, three or even four crops can be grown in succession where previously only one or two were grown. This has been proven time and again. For example, in rice-based systems in India and Bangladesh, rice can be grown in the wettest season and wheat in the driest, but pulses or maize can be grown in the in-between seasons as well. This can translate to better nutrition, improved food security and even income opportunities for smallholder farmers.

The environment also scores a win. The main water-related benefit of CA is reduced demand for water resources. That means reduced harmful effects on river flows, aquifer and dam levels, and reduced salinity. Better soil management associated with CA also results in fewer run-off contaminants entering the water catchment (watershed).

Climate change is likely to shift rainfall patterns and change temperatures, making it harder for smallholder farmers, especially those living ‘on the edge’—in a geographical sense, pushed into marginal areas, or in a production sense, struggling to produce enough to feed their families. There is an urgent need for agriculture to adapt to enable farmers to cope with climate variability, especially in bad years when crops threaten to fail. CA clearly has a critical role to play.

The success of CA in dry environments such as north-west India and Bangladesh is now being extended into some of the driest arable lands in North Africa, including Algeria and Morocco. CA is allowing crops to be grown more intensively and with more diversity in places they could not have been grown productively before, particularly more water-hungry crops such as maize in place of sorghum.

The reduced labour and inputs—particularly water and fuel—needed for CA, along with the improved returns from better soil treatment, can make the CA system self-perpetuating once farmers have adopted it. However, getting smallholder farmers to change to CA practices has challenges, depending on the cultural and socioeconomic context. For instance, the practices of ploughing fields and puddling for rice are deeply embedded in some cultures. In some cases, once farmers see improvements in their neighbour’s field or at research demonstration sites, they are convinced to make changes.

Over the past 20 years about a million African farmers have changed their mind and are now practising CA. Understanding how farmers assess risks and make decisions is the topic of current ACIAR research aiming to increase the uptake of new technologies and practices.

Sustainable farming is the only viable direction to proceed in while trying to produce enough food for the world’s growing population. Many conventional farming practices using high tillage and inappropriate growing practices—such as suboptimal use of inputs, poor-yielding varieties or lack of crop rotation—are running down soils. They often hinder rather than help with issues of soil degradation, nutrient depletion, land erosion, and water quality and availability. CA offers a rare but viable option to reverse this trend, resulting in a win–win of more resilient and productive farmers and a healthier environment. ■

THEME

RELATED CA PROJECTS WITH WATER CONSERVATION IMPACTS

CSE/2004/033: Zero-tillage rice establishment and crop–weed dynamics in rice and wheat cropping systems in India and Australia

LWR/2010/080: Overcoming agronomic and mechanisation constraints to development and adoption of conservation agriculture in diversified rice-based cropping in Bangladesh

CSE/2011/025: Adapting conservation agriculture for rapid adoption by smallholder farmers in northern Africa

CIM/2008/027: Development of conservation cropping systems in the drylands of northern Iraq

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The scramble for natural resources: how science can help

Science now needs to find a way to increase food productivity by about 50% over the next four decades—without using more land or water.

BY DR FRANK RIJSBERMAN
Chief executive officer of the Consultative Group on International Agricultural Research

Today we are facing humanity's greatest challenge. The food price spikes that began in 2008, along with the ensuing scramble for natural resources that these sparked, have served as a massive wake-up call.

Declining agricultural yields, a drop in support for agricultural research, depleted natural resources and climatic changes are just some of the factors that have brought us to the brink of disaster. If we are to feed future populations without damaging the environment further, we are going to have to learn how to do much more with much less.

The United Nations Food and Agriculture Organization (FAO) tells us that our world population is likely to grow from seven billion to more than nine billion by 2050, requiring about a 70% increase in food production. Another FAO estimate indicates that at least 75% of that increase will have to come from land already being used for agricultural purposes.

Science now needs to find a way to increase food productivity by about 50% over the next four decades—without using more land or water. Such an increase is likely to come from the people who currently experience low yields: small-scale farmers in developing countries, the majority of whom are women. And science needs to help them achieve those increases in a climate-smart way.

So this is the focus and mandate of publicly funded agricultural research, and the largest group of researchers in that arena come from the Consultative Group on International Agricultural Research (CGIAR).

Is it possible?

Absolute yields of key cereals have increased steadily over the past five decades, but since these increases have to feed an ever-increasing population, the percentage increase has actually gone down from about 3% to slightly more than 1%. That is not enough to sustain future populations.

In addition, there is every indication that the yields for rice, wheat and maize are beginning to level off, posing a far greater challenge for us if we aim to build on and increase that productivity.

These relative decreases in productivity can be traced back to the Green Revolution in the 1960s and 1970s. By working with researchers from the International Maize and Wheat Improvement Center (CIMMYT), Dr Norman Borlaug helped develop semi-dwarf, high-yielding varieties of cereal grains that, together with increased fertiliser use and massive investment in irrigation, led to the doubling of yields and abundant supplies of cheap food in Asia, the Americas, the Near East and the Middle East. Billions of people escaped starvation, but the increased yields also led to complacency and neglect of, and a drop in support for, agriculture.

CLOSING YIELD GAPS

If we look at some of the results coming out of the International Water Management Institute (a CGIAR member centre) and the work it is undertaking with the CGIAR Challenge Program on Water and Food in a number of major river basins, we see that water productivity is very low in these areas. The current cereal productivity in almost all of these basins, which together are home to more than a billion people and more than 50% of the poorest people in the world, is between 0.2–0.5 kilograms against a potential of 1–2 kg per cubic metre of water used. As such, there is a huge potential to intensify agriculture in these areas.

CGIAR has the scientific know-how to close some of these yield gaps, and not just in terms of water. For example, the International Rice Research Institute (IRRI), another CGIAR member centre headquartered in the Philippines, has paddy fields on its extensive campus that have been producing three crops of rice a year, with each crop yielding about 7 tonnes, for a total of 21 t of rice per hectare from the same piece of land. Of course these crops are cultivated under ideal conditions—fertile soils and plenty of water, coupled with a meticulous crop-management strategy.

Outside the gates of IRRI, farmers get only two crops of about 4 t/ha per year, which means 8 t rather than 21 t.

In Africa, the smallholders who grow rice in rainfed upland valleys might get as little as one crop of 2 t/ha per year. However, such a situation does have potential.

Those farmers might have problem soils, no access to fertiliser, or no money to buy fertiliser. They might not have seed companies bringing them new seeds, or roads to take their produce to market. Their governments might not have extension policies that can help them be part of the value chain to enable them to process their rice. But there is a whole series of things that we can do to help, although none of them are necessarily easy.

Of course, just because the yields are only 2 t does not mean that we know how to increase them immediately. Many of the low yields in Africa are caused by disease. So we need to use science to help develop new crop varieties that are disease resistant. This will require a constant effort, but we take hope from knowing that there is a crop yield gap and that there is tremendous potential in science today to help us close it.

THE POTENTIAL

Two trends are having a big impact on science for tomorrow's agriculture.

First, there is the life science revolution that is being propelled by molecular biology, which has, over the past decade, changed the way our scientists do business, both in their CGIAR centres and with their partners.

Then there is the IT revolution, which is relevant even today, not only to Australian farmers, but also to smallholder farmers. For example, laser land levelling, which offers great potential for water savings and higher grain yields, is becoming increasingly popular with farmers everywhere. More and more farmers are also using mobile phones to access extension services and market information.

With the help of countries such as Australia, which is supporting publicly funded research in agriculture, CGIAR is ready to take advantage of these and other scientific opportunities. IRRI, for example, has received a large grant from ACIAR to build new labs and buy new equipment.

CGIAR does not have a separate program on genetic research, but genetics certainly cut across all of our programs. Molecular breeding forms the basis of much of the work carried out today by our 15 centres.

In almost all of the centres, the application of molecular breeding to understand the genetic diversity in our gene banks was just a dream 10 years ago, but today it is a reality. Centres such as IRRI are now not only breeding plants that have a higher productivity or are disease resistant, but they are also breeding plants that are resistant to abiotic stresses, which was not possible 10 years ago.

One of the key genes discovered by IRRI enables rice to be submergence tolerant. Almost all the hybrid rice varieties today have incorporated this gene and are available to farmers on a wide scale.

To date, CGIAR has developed more than 7,000 improved varieties and released them as public goods. Worldwide, 60% of all land planted with improved varieties includes varieties produced by CGIAR centres.

Australia, which ranks among the world's top 10 wheat-producing countries, devotes as much as 98% of the area sown to wheat in the country to varieties developed by CIMMYT.

CGIAR is also the custodian of very large collections of plant genetic material with the necessary diversity on which we can build.

We also need more holistic approaches that span from the microscope to the marketplace—approaches that not only integrate the latest science and technology to breed better varieties more quickly, but also use effective strategies to get those varieties to small-scale farmers.

CGIAR RESEARCH

CGIAR research puts real benefits into farmers' hands. And we are getting better at making sure that our innovations reach the farmers who need them.

We understand how to influence real people, and not just by increasing productivity. In recent years, for example, we have focused on growing more nutritious crops. Many of our impact stories can be found on the CGIAR website (www.cgiar.org).

Although the food price spikes in recent years have led to a scramble for natural resources, they have also put food security back at the top of the agenda. We certainly feel that science can help grow more food using less land and less water, thereby limiting our natural resources footprint.

CGIAR has a promising agenda that harnesses the potential of science. We are also pleased that out work benefits Australia and are very grateful that Australia is a strong supporter of international research and agriculture through ACIAR and the Australian Government Overseas Aid Program.

More information: Dr Frank Rijsberman, f.rijsberman@cgiar.org

About the author

Dr Frank Rijsberman served as director-general of the International Water Management Institute (IWMI), one of the 15 CGIAR Consortium Research Centers, from 2000 to 2007. At IWMI he initiated the Comprehensive Assessment of Water Management in Agriculture and he developed and led the Challenge Program on Water and Food. He then moved to Google to lead their philanthropic team. He has more than 30 years' experience as a researcher and consultant in natural resources management in developing, transition and developed economies. He has consulted for numerous international and bilateral organisations and co-founded Resource Analysis, a research and consulting firm in his native Holland. In 1997 he was appointed full professor at UNESCO-IHE, International Institute for Water Education. He obtained his bachelor's and master's degrees in civil engineering from Delft University of Technology in the Netherlands, and earned a multidisciplinary PhD in water resources planning and management and civil engineering from Colorado State University, US.

PHOTO: ISAGANI SERRANO

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SPILLOVER BENEFITS:
FERNANDO VERGARA, EL BATÁN, MEXICO

BY CATHERINE NORWOOD

When it comes to access to the latest agricultural research, Mexican farmer Fernando Vergara is undoubtedly well positioned. His farm is only a few kilometres from the International Maize and Wheat Improvement Center (CIMMYT) headquarters in El Batán.

As a well-respected member of the local farming community, he is participating in the Take it to the Farmer extension program, initiated in 2011 as part of the national MasAgro program to modernise agriculture and improve its sustainability.

MasAgro is a collaborative effort of more than 150 Mexican partner institutions, led by CIMMYT and supported by SAGARPA (the Mexican ministry of agriculture), which aims to increase maize production in rainfed areas by 85% and increase wheat production by 10%.

Mr Vergara has been involved with CIMMYT's conservation agriculture program for more than six years, committing part of his property to trial new varieties and farming systems. He and four other local farmers work with a CIMMYT-trained technician to implement farm trial plots and monitor the results, and their experiences provide a model for other local farmers.

Mr Vergara grows irrigated maize and has introduced conservation techniques such as stubble retention to conserve soil moisture. "If we get normal rain, then I only need to irrigate the crop three times," he says. "That's compared with six irrigations before adopting the new techniques."

He says the greatest benefits of conservation agriculture have been improved weed control and reduced water use. In conjunction with the use of new maize varieties he has almost tripled yields.

Maximum yields six years ago were 3–4 tonnes, using indigenous maize land races. By 2010, he was achieving yields of almost 12 t/ha using CIMMYT-bred hybrid maizes, with improved fertiliser and management.

"You do have to pay more to use the hybrid varieties, but you get much more in return," Mr Vergara says. He estimates that he has also halved his crop preparation costs by adopting conservation techniques.

Testing the weed-control benefits of stubble retention, Mr Vergara says he left less residue on one part of the trial area and weeds quickly established in greater numbers on the barer soil. In general, the conservation techniques have helped him to reduce his weed control sprays from three to two.

He has traditionally grown maize-on-maize, but his irrigation system is allowing him to introduce a winter crop into his rotation. His initial choice was a forage oat crop, but he is also considering faba beans to increase soil nitrogen. Mr Vergara also produces greenhouse tomatoes to complement his cereal production.

Dr Nele Verhulst is the strategic research coordinator for CIMMYT's Conservation Agriculture Program, and says the program is an essential part of Mexico's strategies to address the risks of climate change and increasingly variable rainfall.

The Take it to the Farmer program uses a network of regional hubs in different agronomic zones, with farmer groups such as the one Mr Vergara leads sharing knowledge about farming practices that can lift yields. The leading farmers work with qualified technicians and take part in once-a-month training sessions during the course of a year to improve their understanding of different systems and technologies, and assist with knowledge transfer to other farmers.

Dr Verhulst says conservation agriculture extension is "not a top-down approach". Farmer hubs test the recommended best practices in field conditions and their feedback is used to refine practices and to develop further research. ■

PHOTO: CATHERINE NORWOOD

Good ideas travel. In Mexico and Kazakhstan conservation agriculture is being spread by CIMMYT.

Fernando Vergara

Conservation agriculture beats drought

Kazakhstan's 2012 drought and high temperatures cut the country's wheat harvests by more than half from 2011 output, except under conservation agriculture (CA), where wheat produced up to 10 times more grain than conventionally cultivated crops.

Kazakhstan went from practically no land under CA in 2000 to two million hectares in 2012—13% of the country's wheat-growing area—with the support of the International Maize and Wheat Improvement Center, the International Center for Agricultural Research in the Dry Areas and international donors. This makes Kazakhstan one of the top 10 countries for CA and the world's sixth-largest wheat exporter.

However, more than 14 million of the country's 15 million hectares of wheat are rainfed, making yield susceptible to climate variability. In Kostanay—the country's main wheat-growing region—wheat fields went two months without rain after planting in 2012 and daily temperatures were several degrees above normal. But Kostanay is also where many farmers adopted CA and it protected them from the drought's worst effects. Under CA, farmers reported yields of 2 tonnes per hectare, while some farmers using conventional practices lost their entire crop.

Benefits to Kazakhstan farmers from CA include the capture of snow on the surface and improved water retention under heavy snowfall and sub-zero temperatures. Zero tillage also augments soil organic matter and cuts erosion by 75–100%. These benefits have helped to nearly double average wheat yields, from 1.4 to 2.6 t/ha, according to Valentin Dvurechenskii, director general of the Kostanay Agricultural Research Institute.

In December 2011, Mr Dvurechenskii was awarded the Gold Star medal and the rank Hero of Labor of Kazakhstan by the country's president, in recognition of his work to promote CA.

"If no-till practices had not been used in this period of drought, we would have gotten nothing," he says. "It would have been an absolute catastrophe."

DR KEVIN WILLIAMS: GENTLEMAN OF SCIENCE

ACIAR project leaders have many responsibilities, perhaps none more important than building capacity and skills among research staff in partner countries. The success and sustainability of ACIAR's projects are founded on partnerships that transfer skills, knowledge and expertise. Often this role extends beyond science.

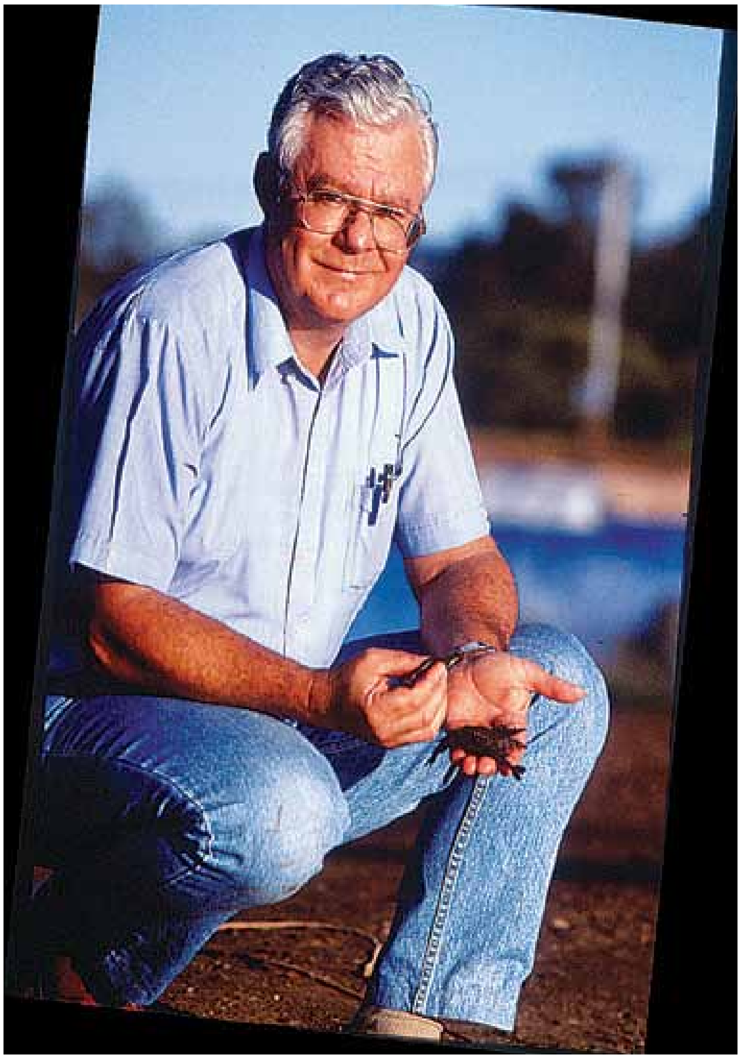
Dr Kevin Williams was a great example of how central capacity building is to ACIAR's partnership model. Kevin, who died recently, had a prestigious career in Australia as an animal nutritionist, first working with pigs and poultry, and later in the aquaculture industry, developing feed formulations for both crustaceans and fish. His diverse professional skills were highly regarded. His attention to detail in setting up laboratory and field experiments was exceptional. Kevin was a prolific writer and one who always drew his fellow workers into the reporting and subsequent authorships.

One of Kevin's outstanding attributes was his enthusiasm for mentoring young scientists, which was evident in the way he nurtured both skills and self-confidence. He questioned, listened to and valued the input of others. Whenever Kevin spoke, it was with carefully considered words of wisdom, often delivered as if they were the listener's own ideas.

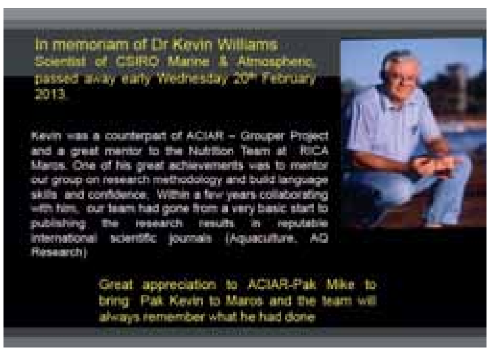
He brought these professional and personal skills to the international arena when he began working with ACIAR in 2000. His earliest work was on lobster nutrition in Vietnam and the scientific output of that project can be seen in the 20 papers Kevin edited and published in the manual *Spiny Lobster Aquaculture in the Asia–Pacific Region*. He moved on to other projects in Indonesia, Thailand and the Philippines, and he continued mentoring young scientists overseas up to, and indeed after, his retirement from CSIRO in 2009.

Kevin's role as a mentor, teacher and adviser was not unique. ACIAR's project leaders and collaborators all play a part in transferring skills, building capacity and creating lasting ties within projects. Kevin's example is emblematic of so many of ACIAR's project people.

Sadly, Kevin passed away on 20 February 2013 after a short battle with cancer. But his legacy endures. Recognition of his influence as a teacher and friend is shown by reactions of overseas colleagues on hearing of his passing. ■



Slide from a public presentation by nutritionist, Ibu Asda Laining, RICA, Maros, Indonesia



When we heard of Kevin's death, we were shocked and saddened. We stopped. We stopped our problem-solving … our concerns for the work getting done … our push toward all deadlines. Infinitely more important than such routine matters is dealing with the loss of one who had become almost like a family member to us at work.

Please tell Kevin's family that we would like to let them know about their husband and father in his dealings with us, his work friends. First of all, Kevin was a brilliant scientist. People from all over my country—colleagues, state agencies, lobster farmers, our students—have both written and called me to express condolences.

Their husband and father was not only a brilliant scientist, but also a good listener. Many of us remember hours sitting in Kevin's office, asking his advice on work and personal matters. Things could be big and small—like how to build up an experimental protocol as well as where to apply for a scholarship. He listened to our concerns and offered advice freely.

Their husband and father was loyal. When we were right, he stood up for us. When we were wrong, he helped us see the other side—often to our benefit.

I'm sure you, more than we at work, know this side of Kevin—his brilliance, his listening attitude, his loyalty. A reputation for only a few of these virtues is in itself a good fortune for his family.

But I wanted this group gathered together in his memory to know that we, his friends in Vietnam, also knew him as more than a dedicated professional. We loved a genuinely warm individual—one we will miss greatly.

– from Dr Le Anh Tuan of Nha Trang University, Nha Trang, Vietnam

round up
news and events
from around ACIAR

VALE, JULIE HART

It is with deep sadness that we advise of the passing of Julie Hart on 27 March 2013. Julie was ACIAR's program support officer for our Animal Health and Crop Improvement programs, having joined ACIAR on 19 September 2005.

During her time at ACIAR, Julie provided administrative support to several research program managers, helping to deliver a range of projects to improve the lives of smallholder farmers. Throughout her eight years at ACIAR she contributed to a range of other initiatives, offering her insights and knowledge about how ACIAR worked.

Julie also played a part in strengthening the partnership model that has made ACIAR so successful, from interacting with project teams to contributing to process improvements. She loved a chat, whether it was about her children, a recent social occasion or matters of work.

We will miss the laughter that punctuated those occasions. Her qualities contributed a great deal to the success of the administrative support within projects. She was fun to have around, was hardworking and respected by our staff and our partners.

ACIAR will miss Julie. We are grateful that we were able to share a part of our lives with Julie, and that through her work others will benefit.

The staff,
ACIAR


Julie Hart

NEW PROJECTS

ASEM/2011/075	Enhancing district delivery and management of agriculture extension in Lao PDR
FSC/2012/047	Farm mechanization and conservation agriculture for sustainable intensification
FST/2011/003	Effective implementation of payments for environmental services in Lao PDR
FST/2011/076	Enhancing livelihoods and food security from agroforestry and community forestry in Nepal
FST/2012/039	Development of timber and non-timber forest product production and market strategies for improvement of smallholders' livelihoods in Indonesia
FST/2012/040	Enhancing smallholder benefits from reduced emissions from deforestation and forest degradation in Indonesia
FST/2012/042	Enhancing management and processing systems for value-adding in plantation-grown whitewood in Vanuatu
FST/2012/043	Enhancing economic opportunities offered by community and smallholder forestry in Solomon Islands
HORT/2012/002	Heat stress alleviation in summer vegetables: enhancing the use of genetic diversity in central Punjab, Pakistan
HORT/2012/020	Integrated crop management to enhance vegetable profitability and food security in the southern Philippines and Australia
LWR/2010/082	Improving livelihoods with innovative cropping systems on the East India Plateau

ACIAR'S DISTRIBUTION POLICY

ACIAR provides complimentary copies of its publications to developing-country libraries, institutions, researchers and administrators with involvement in agriculture in developing countries in ACIAR's operating areas, and to scientists involved in ACIAR projects. For enquiries about complimentary copies, please contact ACIAR's Communications Unit, **comms@aciar.gov.au**.

For other customers, please use our online ordering facility at <**aciar.gov.au**> or direct enquiries to our distributors, Can Print Communications, PO Box 7472, Canberra BC, ACT 2610, Australia, phone +61 2 6295 4422, fax +61 2 6295 4473, aciar@infoservices.com.au.

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ROUNDUP

To keep up to date with the latest events, projects and happenings at ACIAR please visit our website (aciar.gov.au), our blog (aciarblog.blogspot.com.au) or on Twitter (twitter.com/ACIARAustralia). You can also subscribe to our RSS feed (aciar.gov.au/RSSfeeds) to get updates on the latest from ACIAR.

NEW PUBLICATIONS

CO-PUBLICATIONS

International Forestry Review, Vol. 14, No. 4, 2012

A.G. Bartlett, J.D. Nichols and J.K. Vanclay (eds), 2013, CoP024, 118pp.

Two ACIAR-funded forestry projects in Vanuatu have researched the growth and management of whitewood (*Endospermum medulosum*) and the improved availability of whitewood germplasm. Whitewood is a fast-growing hardwood species in the natural forest that is well suited to plantation and agroforestry situations, and is able to survive cyclones without major damage. Improved knowledge of whitewood silviculture should enhance the benefits for both the landowners who grow the trees and the processing industries that will use them. This special issue of *International Forestry Review* deals with a diverse series of insights derived from these ACIAR projects in Vanuatu, covering the constraints, establishment, silviculture, genetics and marketing opportunities.

CORPORATE PUBLICATIONS

Adoption of ACIAR project outputs: studies of projects completed in 2007–08

Amir Jilani, David Pearce and Debbie Templeton (eds), 2013, AS009, 88pp. $50 inc. GST (http://aciar.gov.au/publication/AS009)

Adoption studies are undertaken three to four years after a large project is completed to assess the level of uptake and the legacy of the project. They provide valuable insights into the uptake of project results and the impact on local communities. This adoption study looks at projects completed in 2007–08.

Independent review of the Australian Centre for International Agricultural Research (ACIAR)

Bill Farmer, Ron Duncan, Terry Enright and Wendy Jarvie, 2013, CP025, 100pp.

The Minister for Foreign Affairs commissioned a panel to conduct a review of ACIAR. The review was asked to address issues including: the appropriateness of ACIAR's goals and strategies in helping people overcome poverty; ACIAR's effectiveness in improving livelihoods through more productive and sustainable agriculture, and achieving knowledge-generation and capacity-building outcomes; and the efficiency of ACIAR's operations and arrangements for managing research programs and building capacity, including internal capability and systems, risk management, performance oversight and transparency.

IMPACT ASSESSMENT SERIES

Impact pathway analysis of ACIAR's investment in rodent control in Vietnam, Lao PDR and Cambodia

Florencia G. Palis, Zenaida M. Sumalde, Cleofe S. Torres, Antonio P. Contreras and Francisco A. Datar, 2013, IAS083, 59pp. $54 inc. GST

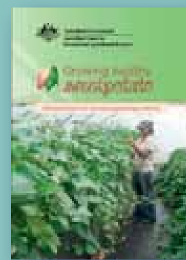
This impact assessment report analyses the extent to which ACIAR-funded research into rodent control has been taken up in Vietnam, Laos and Cambodia. The report identifies factors that favour and constrain adoption, and lays out a plan for future action.

MONOGRAPHS

A guide to upland cropping in Cambodia: soybean [Khmer]

Stephanie Belfield, Christine Brown and Robert Martin, 2012, MN146a, 174pp. (http://aciar.gov.au/publication/MN146a)

In response to the Royal Government of Cambodia's National Poverty Reduction Strategy (2003–05), ACIAR funded research to develop sustainable farming systems for crops, with a focus on maize, soybean, sesame, mungbeans, peanuts and cowpeas in upland areas of Kampong Cham and Battambang provinces. The aim was to help reduce poverty and contribute to food security at household and national levels through the development of technologies and opportunities for the production of non-rice upland crops. The research process involved discussion with farmers, validation of local knowledge, documentation of case studies and identifying priorities for field experimentation. This book is part of a series of publications produced by ACIAR in support of the ongoing rollout of on-farm demonstrations for upland crops in Cambodia.



Growing healthy sweetpotato: best practices for producing planting material

Sandra Dennien, Dorcas Homare, Michael Hughes, Jerry Lovatt, Eric Coleman and Grahame Jackson, 2013, MN153, 176pp. $65 inc. GST

Sweetpotato is a major food crop in Papua New Guinea (PNG), with about 2.9 million tonnes grown each year. But sweetpotato is prone to pests and diseases, particularly viruses, which can significantly reduce yields. Because there are no varieties known to be resistant to viruses, the next best solution is to produce planting material that is free from infection, and to make this readily available to growers. This manual is aimed at researchers and technicians, and describes how to test for sweetpotato viruses and to keep vines free from infection. The methods described should help locals in PNG and other Pacific nations produce disease-free planting material for sweetpotato and other root and tuber crops.

FINAL REPORTS

FR2013-01 to FR2013-08

ACIAR'S VISION

ACIAR looks to a world where poverty has been reduced and the livelihoods of many improved through more productive and sustainable agriculture emerging from collaborative international research.

PHOTO: TBA

The Australian Centre for International Agricultural Research (ACIAR) operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems for the benefit of developing countries and Australia. ACIAR commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

Back cover: Farmers in Bangladesh inspect lentil crops established by strip tillage with the Versatile Multi-crop Planter (VMP).

Front cover: Local farmer Malkeet Singh with his Happy Seeder in northern India.

ACIAR

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FRONT COVER PHOTO: MELISSA MARINO