International Center
for Agricultural Research
in the Dry Areas

ICARDA

Research to Action 2

Conservation agriculture:

opportunities for intensified farming and environmental conservation in dry areas

A synthesis of research and trials with smallholder farmers in drylands systems; benefits and constraints to adoption.

Farmer experiences and potential for uptake in Iraq, Syria, Morocco and Tunisia.

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Research to Action reports are published by ICARDA to provide a synthesis of research evidence that is put in context for decision makers in low-income countries and for development professionals working with countries. The series offers practical approaches to improve the productivity of agriculture for smallholder farmers, in the world's dry areas.

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Feedback

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Conservation agriculture - Key Messages

1. Conservation agriculture is a proven approach to food production that is now widespread in several of the world's high-income countries and makes possible benefits to smallholder farmers, consumers, and rural and national economies in Asia and Africa, especially in dry regions.

2. The innovation of conservation agriculture is to avoid plowing of the soil, which saves time, energy and labor while conserving water and nutrients in the soil to support crop production. Research evidence illustrates that conservation agriculture gives at least the same yields as conventional tillage, often more, with less time and energy input and better environmental sustainability.

3. Common perceptions in low income-countries with marginal farming areas are that soil tillage is essential for intensification and production. These views inhibit the adoption of conservation tillage. But policy makers and development partners can create policies that illustrate the benefits and evidence of conservation agriculture from high-income regions, through education and demonstration, so that the practice sells itself to farmers.

4. Proscriptive approaches to conservation agriculture that dictate strict practices should be discouraged. Rather, the spirit of conservation agriculture should be advocated. Farmers and policy makers should be encouraged to adapt the general concept to meet their specific situations.

5. The limited availability of appropriate and affordable seeding machinery is an immediate obstacle to adoption. Promoters can overcome this by initially providing machinery free of charge to illustrate the benefits, and guiding and encouraging local manufacture. Over time, farmer demand will encourage and support local entrepreneurs to manufacture seeders or adaptor kits for existing seeders that are affordable, effective and easy to repair with locally-available parts and mechanical knowhow.

Conservation agriculture puts aside the plow to break new ground

Conservation agriculture balances yields, resource conservation and increased efficiency for smallholder farmers.

This report presents examples, approaches and evidence on conservation agriculture and its potential for use in low-income countries. It is designed to help policy makers and development partners appreciate the issues and evaluate how conservation agriculture can contribute to rural development and food security goals, paving the way for its adoption as a national agricultural strategy.[1]

Conservation agriculture – the practice of not plowing farmlands and leaving crop residue in the field for improved soil fertility and water conservation – is used by a majority of farmers in Australia, Brazil and by many in North America and other middle and high-income countries. Research and testing of the approach since the 1960s has confirmed to these countries that conservation agriculture brings optimal production at the best cost.

In the world's drylands agro-ecosystems and the marginal farming areas of low-income countries, conservation agriculture can bring direct benefits to smallholder farmers. The practice has the potential to benefit food security in many drylands agro-ecosystems in Central and West Asia, the Middle East and in North and sub-Saharan Africa.

For low-income countries, today's paradox for conservation agriculture is that it can benefit their smallholder farmers at minimal additional cost; but this thinking has so far not been recognized by their food security planners and policy makers. Likewise, donors and development partners active in rural development have yet to embrace the practice as a viable approach to improve livelihoods in low-income countries – even as this is how much of their agriculture is managed at home.

The two factors needed for the successful adoption of conservation agriculture for drylands farming are appropriate technologies and a favorable policy environment. Locally-made low-cost seeders are needed and require a local market for repair and technical services to farmers. These markets are taking shape today, and are expected to mature in the medium term.

But probably the most critical factor needed to encourage the uptake of conservation agriculture is a change in perception among decision makers in low-income countries. For conservation agriculture to spread, ministry officials, extension services and influential large-scale farmers in these regions need to be engaged and informed of the benefits. ICARDA's work over the past five years in Syria and Iraq, has shown that as a small number of farmers try the approach, news of the results can rapidly travel to neighboring villages and towns. This report contains examples, thinking and evidence. Its goal is to help policy makers and development partners better appreciate how conservation agriculture works, so they can formulate programs to evaluate how it can contribute to their rural development and food security goals, paving the way for its adoption in a national agricultural strategy.

[1] The Iraq examples profiled in this report are from the ongoing Iraq-ICARDA conservation agriculture project - supported by AusAid and the Australian Centre for International Agricultural Research (ACIAR).

1. Conservation agriculture: opportunities for farmers in dry areas

Zero tillage adoption worldwide
(countries with > 100.000 ha)

Country	Area under No-tillage (ha) 2007/2008
USA[1]	26.500.000
Argentina[2]	25.785.000
Brazil[3]	25.502.000
Australia[4]	17.000.000
Canada[5]	13.481.000
Paraguay[6]	2.400.000
China[7]	1.330.000
Kazakhstan[8]	1.300.000
Bolivia[9]	706.000
Uruguay[10]	655.000
Spain[11]	650.000
South Africa[12]	368.000
Venezuela[13]	300.000
France[14]	200.000
Finland[15]	200.000
Chile[16]	180.000
New Zealand[17]	162.000
Colombia[18]	102.000
Ukraine[19]	100.000
Total	**116.921.000**

Source: Derpsch, R. and Friedrich, T., 2010.

Area under zero tillage by continent

Continent	Area (hectares)	Percent of total
South America	55.630.000	47.6
North America	39.981.000	34.1
Australia & New Zealand	17.162.000	14.7
Asia	2.630.000	2.2
Europe	1.150.000	1.0
Africa	368.000	0.3
World total	**116.921.000**	**100%**

The Green Revolution of the late 1960s and 1970s is considered incomplete by some as it concentrated on improving yields without a focus on environmental sustainability.

Conservation agriculture is a slower-evolving agricultural revolution that began at the same time as the Green Revolution, gradually transforming agriculture in much of North and South America and Australia. The time has come for Asia and Africa to enjoy the economic and environmental benefits of this resource-conserving approach to food production.

Four central principles of conservation tillage

- Minimal soil disturbance over the long term
- Maintaining permanent organic soil cover by leaving the previous year's residue on the field
- Crop rotation and/or 'intercropping' to improve soil fertility and control pests and diseases
- Conservation agriculture requires specially built or adapted seeding machines but it does not require new crop varieties.

The economic benefits of not plowing include savings in expenditures on fuel, labor and seed, and higher yields from improved water use efficiency creating better moisture absorption in soils with good structure and reduced evaporation from soil protected by residues from the previous crop. The environmental benefits include better soil health, reduced greenhouse gas emissions and water use, and cleaner air and surface waters. Indirect benefits to social equity and development derive from direct economic and environmental benefits.

The many benefits of conservation agriculture for farmers, consumers, and the rural and national economy are what have fuelled its adoption in middle and high-income countries. The fact that conservation agriculture has been slow to spread in the low-income countries of Asia the Middle East and Africa reveals a missed opportunity. As climate change threatens worsening desertification and more frequent and severe drought, extending conservation agriculture for dryland agriculture to these regions is a high priority.

Constraints to adoption of conservation tillage

- The mistaken perception that soil cultivation (plowing) is essential for high crop production.
- The limited availability of affordable, appropriate seeding machinery that is locally produced and maintained.
- Limited knowledge and experience of how to adopt these practices.
- Perceptions of worsening of weed, pest and disease infestation.
- Unwelcoming policy and extension environments.

Experience has found, though, that conservation agriculture sells itself when given a chance by a well-formulated national policy to encourage adoption.

As the Green Revolution swept across Asia and Latin America in the late 1960s and 1970s, the next agricultural revolution incubated quietly in the advanced experimental fields of North America and Australia. Conservation agriculture has since proved its value in these two continents, and in South America, where it is applied in 70% of the agricultural area of some countries. Now conservation agriculture is poised to do the same in Asia and Africa, beginning in their most water-constrained environments.

The Green Revolution is justly celebrated for arresting widespread famine, as runaway population growth and environmental degradation squeezed traditional agriculture in a vise of growing demand and hardening constraints on supply. The Green Revolution broke that grip with a potent package of mineral fertilizers, greatly expanded irrigation, semi-dwarf grain varieties with stiff stems able to bear the weight of optimally nourished panicles, and pesticides formulated to ward off the insects and diseases drawn to them.

Miraculous as rising grain harvests were, particularly in Asia, critics of the Green Revolution proved to be correct in questioning their sustainability. Today, it is clear that high yield cannot be the sole virtue of modern agriculture. People who are environmentally aware refuse to accept that runoff from fields be permitted to foul waterways with carelessly applied fertilizer and pesticides.

They no longer bow to the inevitability of water and wind erosion, reducing agriculture's natural capital, degrading priceless soil into clogging silt and smothering dust. The fact that water for agriculture is becoming scarce and expensive across the globe makes sharply improved water use efficiency an urgent priority for agriculture – all the more so as climate change threatens vast areas with droughts that are increasingly frequent and severe.

Today, agricultural approaches must be judged according to a balance of yield, costs, environmental and economic sustainability, and social equity. This is the paradigm that has seen conservation agriculture spread across innovative and advanced regions of the world's high-income regions over the past four decades. Conservation agriculture is practiced from the Arctic Circle through the tropics to 50° south, from sea level to 3,000 meters, and in extremely rainy areas with 2,500 millimeters a year to dry areas with only a tenth as much rain. Given these facts, conservation agriculture can no longer be dismissed as a niche technique or passing fad. It is a proven technique with diverse application: while two-thirds of fields under conservation agriculture in South America are never deeply plowed, most in North America are plowed from time to time.

Conservation agriculture in drylands – the Australian example

For policy makers, agricultural planners and development partners in the drylands agro-ecosystems and drought-prone parts of Central Asia, South Asia, the Middle East, North and sub-Saharan Africa, Australia is an illuminating model. The smallest continent's thin, ancient soils and tenuous water supplies create a particular need for resource-conserving agriculture.

Area under zero tillage in Brazil

Year	Area (million hectares)
1993/94	3.0
1995/96	5.5
1997/98	11.3
1999/00	14.3
2001/02	18.7
2003/04	21.8
2005/06	25.5

Source: (FEBRAPDP, 2009)

Area under zero tillage in the United States

Year	Area (million hectares)
1994	15.7
1996	17.3
1998	19.3
2000	21.1
2002	22.4
2004	25.3
2007	26.5

Source: (CTIC, 2005/07)

Area under zero tillage in Argentina

Year	Area (million hectares)
1993/94	1.81
1995/96	2.97
1997/98	5.00
1999/00	9.25
2001/02	15.10
2003/04	18.26
2005/06	19.72
2006/07	22.71
2007/08	25.78

Source: (AAPRESID, 2010)

Late in the 19th century, soil nutrient deficiency drove Australian wheat yields down to less than half a ton per hectare. At the turn of the century, the introduction of fallow, phosphorus fertilizer and improved varieties – the Australian foreshadowing of the Green Revolution – restored yields to 1 ton per hectare, where they stabilized until World War II. From 1945 to 1990, herbicides, additional improved varieties, nitrogen fixation using legumes, and mechanization doubled yields to almost 2 tons. From 1990 to 2010, nitrogen fertilizer, canola, lupin legumes and conservation agriculture boosted yields to 3 tons in 2010.

Today, conservation agriculture is the majority practice among grain growers across Australia, used in some areas by 90% of farmers. While adoption in Australia seems to plateau at this rate, 10% short of universal, it is notable that almost no adopting farmers revert to conventional tillage. Experts estimate that improved crop management is responsible for 70% of recent Australian yield gains, with principles of conservation agriculture – minimized soil disturbance, stubble retention, early sowing and wide cereal-legume-oilseed rotations – receiving much of the credit.

National agricultural systems in Asia and Africa find themselves today where Australia was before World War II – at best. Many are experiencing soil exhaustion and declining yields as in Australia before the turn of the century. Policy makers and development partners in Asia and Africa can formulate strong national agricultural strategies informed by lessons learned in Australia – and closer to home in forward-looking Asian and African communities that have begun to adopt conservation tillage. This report aims to show how such a strategy may come about.

Guiding principles for productive and sustainable cropping with conservation tillage

- **Do not cultivate fields, a**s plowing is unnecessary, takes time and money, and robs soil of moisture and structure.
- **Do not burn stubble from the previous crop,** but retain as much of it and other residue as possible on surface of the soil.
- **Allow livestock to graze on stubble.** This does not negate the many benefits of conservation tillage. Many countries have successfully integrated livestock into the system.
- **Sow seed and fertilizer using a conservation agriculture seeder,** that allows planting through surface residue into narrow slits in the soil.
- **Farmers can sow early as no plowing is needed.** Planting can start as soon as soil conditions are favorable and rains have resumed.
- **When the rains are late, consider early dry-sowing,** which is successful in many countries. Use optimal sowing rates of 50-100 kilograms per hectare for temperate cereals and small seeded pulses and of 100-150 kg/ha for large-seeded pulses.
- **Control weeds before sowing** with a glyphosate-based herbicide, but remember that this is often unnecessary where there is little summer rain.
- **New approaches may be needed to manage soil fertility and control pests, diseases and weeds,** that are different ways than in conventional systems.
- **Manage major soil problems according to best practice to optimize yields,** for problems such as hard pan, acidity and salinity.
- **Use diverse crop rotations to break the cycle of cereal pests and diseases.** Effective rotations are cereals with legumes, brassicas, other crops and forages.

2. How conservation agriculture works

Most of the benefits that materialize immediately or very soon after adopting conservation agriculture are economic. Most of its longer-term benefits are environmental.

Conservation agriculture benefits farmers by reducing the cost of achieving a crop's yield. Experience shows that these yields are at least as high as those achieved through conventional tillage – and often higher.

Conservation agriculture benefits:

- Consumers by providing affordable food more sustainably than does conventional tillage.
- The rural economy by building agriculture on a firm foundation, creating conditions to allow families who choose to tie their future to continued agricultural development to stay on the land, and creates opportunities for local manufacturers of new seeding machinery.
- The national economy by strengthening food security and contributing to building a more resilient rural economy. And it can be argued that conservation agriculture will benefit the credibility of government officials who are seen to facilitate its adoption.

From 1999 to 2008, the global area of farmland under conservation agriculture grew from 45 million ha to 117 million ha. Some of the biggest adopters are in South America, where 55.6 million ha is under conservation tillage, mostly in Argentina (25.8 million ha), Brazil (25.5 million ha) and Paraguay (2.4 million ha). North America follows with 40.0 million ha, two-thirds in the United States (26.5 million ha) and one-third in Canada (13.5 million ha).
Australia ranks fourth worldwide, with 17.0 million ha. Considering its size, Asia lags with 2.6 million ha, half in China and half in Kazakhstan. Europe has only 1.2 million ha under conservation tillage, slightly more than half of it in Spain. Modern conservation agriculture in Africa is all but restricted to South Africa (368,000 ha).[2]

This regional comparison shows that conservation agriculture has proven most successful so far in countries with extensive areas of semi-arid farmland, which reflects the particular benefits that the practice confers on these agricultural environments. It has also prospered in relatively advanced countries, as farmers lucky enough to have many options available to them have rapidly adopted this one.

That conservation agriculture has been slow to spread in the lower income countries reveals a missed opportunity. As climate change threatens worsening desertification and more frequent and severe drought, affecting in particular the Indian subcontinent and sub-Saharan Africa, extending conservation agriculture and its benefits for dryland agriculture to these regions is a high priority.

[2] Derpsch R, Friedrich T. 2010. *Sustainable crop production intensification: the adoption of conservation agriculture worldwide*. Presented at the 16th International Soil Conservation Organization Congress, 8-12 November 2010 in Santiago, Chile. pp 5-6.

2.1 Economic advantages

The economic advantages of conservation agriculture for the farmer begin with far fewer inputs being required before planting. Greatly reduced plowing saves farmers energy, labor and time.

Energy and labor savings. The benefits of lower costs for fuel and/or draft animals and hired labor are straightforward. Farmers who use tractors to plow are able to reduce their fuel use for plowing by two-thirds. Enhanced soil structure (*see Environmental Advantages, below*) makes soil more easily trafficked by farm machinery for the remaining operations, further reducing fuel costs, as well as equipment wear and tear. Labor savings mean more time for members of the farm family to pursue other livelihood options, interests and investments such as education, and a smaller portion of farm household income paid out to hired labor.

Time savings. Time savings allow farmers to plant earlier, perhaps by weeks. Depending on the agricultural environment, this can improve the odds that the crop will mature and be ready to harvest before the onset of late-season drought. It may allow farmers to squeeze in a third cropping per year in what had been a system producing only two crops per year, adding perhaps a crop of high-value vegetables or another cash crop.

Rotation to heighten cropping diversity is integral to successful conservation agriculture. Planting legumes fixes nitrogen in the soil to replenish this vital crop nutrient. It also helps break crop disease cycles, subjecting diseases like wheat rust to a man-made famine as wheat disappears for a while from fields. Probably of most immediate interest to most farmers, diversified cropping offers expanded crop sales and mitigates risk as farmers become less dependent on their main crop, the selling price of which may sag as farmers bring their crops to market.

Optimal seeding rate. Alongside earlier planting, the optimal seeding rate is an approach that complements conservation tillage. Conservation agriculture requires specially designed or adapted seeding machines (drill seeders) that help farmers optimize their seeding rate. This generally means reducing current seeding practices by as much as two-thirds, where many farmers in many areas are using 'broadcast seeding' on the soil surface. Optimizing the seeding rate at 100 kg/ha or less for wheat – a significant advance in regional terms – improves yields, reduces seed usage and costs. Researchers at the International Center for Agricultural Research in the Dry Areas (ICARDA) working on conservation agriculture trials estimate that reduced seeding achieved through drill seeders built for conservation agriculture has saved participating farmers in Iraq $84,000 and their counterparts in Syria $1.2 million.

Water conservation. Improved water use efficiency is yet another immediate benefit of conservation tillage, achieved through better soil structure for improved water infiltration and storage and reduced water loss by evaporation. In dry areas, all water loss constrains yield, and a small amount of moisture can have a big effect. In an area that receives 300 millimeters (mm) of rainfall per cropping season, plowing can contribute to the evaporation of a third of that water, slashing the effective rainfall for production to 200 mm. The most productive farmers can harvest perhaps 2-3 tons/ha of wheat from rainfed land under conditions like these. More often a farmer will harvest one ton/ ha.[3]

Refraining from plowing can reduce evaporation loss by the equivalent of 20-30 mm, or between a fifth and a third. This additional moisture can boost wheat yield by 0.3-0.5 tons/ha. The difference a little moisture makes mounts as aridity worsens. In 2010, Syria's Salamiyia Province was very dry because of rains that did not materialize. Many farmers saw their crops fail.
But farmers participating in ICARDA-led conservation agriculture trials were able to harvest wheat from fields where they had tried zero tillage.[4]

The bottom line. In these trials, researchers at ICARDA calculated savings and increased earnings in trial areas of Syria and Iraq. In Syria, a ton of wheat sells for $400, so a higher yield of 20%, or an additional 250 kg/ha, increases earnings per hectare by $100. Savings from two fewer plowings are $40/ha. Reducing the seeding rate from 300 kg/ha to 100 kg/ha saves $80/ha. Conservation agriculture thus improves farmer profitability in Syria by $220, or more than 50% of the take from a hectare yielding 1 ton. In Iraq, where wheat sells for $700/ton, higher yield brings in an additional $175/ha, and optimal seeding saves $140/ha. Factor in the same savings from reduced plowing, and conservation agriculture improves profitability by $355.

As Syria had more than 15,000 ha under conservation agriculture in 2010/11, its net economic benefit from the practice may have exceeded $3.3 million. Similarly, as Iraq recorded more than 6,000 ha, its net benefit may have exceeded $2.1 million. Such benefits would multiply with higher yields, larger areas and higher-value crops such as pulses.[5] Syria's 15,000 ha of conservation agriculture is a tiny fraction of its 3 million ha under cereal cultivation. If half of that area were converted to conservation agriculture and experienced the 20% yield increase that ICARDA researchers have found to be routine upon conversion, the national cereal harvest would grow by 10%, significantly bolstering national food security and economic activity.

With the environmental benefits of widespread adoption described below, economic planners can anticipate more stable production and yields, further strengthening food and economic security. And, because conservation agriculture is much more environmentally friendly than modern conventional farming, marginal areas such as highlands where conventional farming is too destructive to be contemplated may be brought carefully into production that is profitable and sustainable over the long term.

2.2 Environmental advantages

While the economic advantages of conservation agriculture are often realized with the first cropping, the environmental advantages emerge more slowly. Further, while a pioneering individual adopter can enjoy the full range of economic benefits regardless of whether neighboring farms follow suit, most environmental advantages require majority adoption in a community, subsequently maintained year after year, to avoid being negated by environmental pollution flowing from conventional farms. The environmental advantages are, however, at least as significant as the economic advantages over the long run.

[3] Sadras & Angus.

[4] ICARDA Conservation Agriculture project technical report for Iraq and Syria.

[5] Piggin C. 2011. Development of conservation cropping systems in the dry lands of northern Iraq. Annual report prepared for the Australian Centre for International Agricultural Research. International Center for Agricultural Research in the Dry Areas (ICARDA): Aleppo, Syria. p 21.

Soil health. A core benefit is that soil that is little disturbed, rather than completely turned over several times a year, is able to develop better soil structure. Healthier soil absorbs and retains water for crops more effectively than does disturbed soil. Nutrients drawn from stubble and other residues from the previous crop enable better nutrient cycling. Crop residues physically protect soil to reduce the wind and water erosion that inevitably diminishes soils left bare by plowing. Conservation agriculture can reduce soil erosion by up to 96%.[6] Biological activity continues uninterrupted in largely undisturbed soil, and nutrient-rich organic matter is left to accumulate there, rather than become depleted as it is by plowing. All these factors contribute to long-term increases in yield and productivity.

Reduced greenhouse gas emissions and water use. Conservation agriculture sharply reduces greenhouse gas emissions by several avenues. Less plowing requires tractors to burn smaller quantities of fossil fuels, reducing carbon dioxide emissions. Soil with better structure is more easily trafficked with farm machinery for the operations that remain, further reducing emissions. Soil with higher organic matter content sequesters more carbon than does depleted soil. Reduced need for mineral nitrogen fertilizer also reduces emissions. Where irrigation is available, better soil-water dynamics and moisture retention means fields need less irrigation, cutting fuel use for pumping water, with consequent reduced carbon dioxide emissions, and avoiding the overexploitation of groundwater resources that, if left unchecked, can drive the water table down beyond the reach of all but the deepest wells.

Cleaner air. A rising problem across regions is rural air pollution caused by farmers burning crop stubble and other residues. If conservation agriculture becomes prevalent enough in a farm area, leaving most residues in the field for soil protection, fires and the haze they cause can become a thing of the past. Undisturbed soil is less prone to rise as dust, which is another rural health hazard when plowed soil is left bare between crops.

Cleaner surface water. Improved water infiltration into healthy soil and reduced water erosion of bare plowed soils not only keep water, soil and agricultural inputs such as fertilizer, herbicides and pesticides in the field where they are needed and desired. They also reduce the nuisance and threats to public and environmental health that occur when agricultural runoff causes excessive silting of rivers, reservoirs, lakes and micro catchments.
As conservation agriculture all but eliminates soil erosion and greatly reduces runoff, widespread adoption in a farm area can be expected to enhance the cleanliness and biodiversity of surface water bodies, protecting their value as fisheries, sources of drinking water and venues for recreation. Sharply curtailed erosion can alleviate the problem with reservoir sedimentation that bedevils many hydroelectric power plants. Roads crews can expect to have less mud to shovel up after heavy showers. Governments and society as a whole can look forward to spending fewer of their limited financial resources coping with the off-farm effects of soil erosion.

[6] Derpsch R, Friedrich T. 2010. *Sustainable crop production intensification: the adoption of conservation agriculture worldwide*. Presented at he 16th International Soil Conservation Organization Congress, 8-12 November 2010 in Santiago, Chile. p 21.

Why till soil in the first place?

Tillage facilitates sowing a crop by loosening and aerating the soil and mixing residue from the previous harvest, soil organic matter, and other nutrients such as manure and chemical fertilizers evenly throughout the upper layers of the soil within the root zone of the coming crop. Tillage destroys weeds, dries the soil before seeding and creates a smooth, uniform soil surface that facilitates planting.

After planting, farmers use tillage periodically to kill and remove weeds that appear between crop plants. Tillage is so ingrained in the concept of agriculture that one meaning of cultivation has come to be mean *agriculture or growing plants*, expanding from its narrower sense of *soil tillage*. Soil tillage began 10-12 millennia ago in the Middle East, where early farmers used a digging stick to loosen the soil before planting seeds. The tool evolved into spade and then a triangular blade, its material evolving from wood to stone and finally metal. The first wooden plows were likely pulled by farmers themselves, with animals beginning to pull plows around 3,000 years ago in Mesopotamia.

Through most of history, tillage had more in common with current conservation agriculture than with modern plowing practices. Cultivation is hard work, even with draft animals. A smallholder farmer plowing a field with animal traction typically has to walk 30-40 kilometers per hectare, and the constant need to keep the animal and plow in line makes this no easy task. Not surprisingly, farmers chose to plow as little as was necessary to produce a good crop.

Then came Jethro Tull (1674-1741), the English agriculturalist who revolutionized horse-drawn farm machinery and plowed the soil to release its nutrients, thinking this minimized the need to apply manure and the many weed seeds it contained. Plows became increasingly sophisticated through the 17th and 18th century, by the end of which German, Dutch and British improvements brought into being moldboards that turned the soil 135° and controlled weeds very efficiently.

European colonial powers took the modern plow to North and South America, Asia, Australia and Africa, where it became a primary tool for developing newly cultivated land. With the advent of tractors, operators no longer walked behind their plows but sat in front of them. Many farmers and agricultural experts started to believe that the more they tilled, the higher the yield they got. Powerful plows became icons of human conquest of nature.

Some perceptive farmers and experts began to discover that heavy plowing, the same technique that brought bounteous harvests and wealth to Europe and other farming areas in cooler temperate climates, condemned farmlands in warmer climates to soil erosion and degradation. In the late 1940s, the introduction of plant growth regulators developed during World War II made possible the development of modern conservation tillage.

Source: Derpsch R. 2004. History of Crop Production With & Without Tillage. Leading Edge, the Journal of No-Till Agriculture 3(1):150-154.

3. Adoption - constraints and opportunities

For all its benefits, and despite its burgeoning popularity among well-resourced farmers in the higher income countries and some of the more progressive developing and emerging markets, conservation agriculture faces some daunting constraints to adoption. First among these constraints is the perception that cropping absolutely requires soil cultivation. Researchers and farmer advocates work to dispel this notion, which is not as old as most people assume but deeply engrained nevertheless (see the box Why Till Soil in the First Place?). Success is almost surely just a matter of time, but the urgent need in Asia and Africa for agricultural reform toward conservation agriculture leaves unanswered whether success will be timely.

Another constraint is the limited availability in most developing countries of seeding machines that are affordable and suitable for conservation tillage. ICARDA and its partners have demonstrated that locally manufactured or adapted seeders can do the job, so overcoming this constraint is mostly a matter or refining designs and scaling up.

Other constraints include the lack of knowledge in developing countries about (1) conservation agriculture and how to develop and promote it, (2) herbicides and their use to replace cultivation in weed control, and (3) how an enabling policy environment can advance conservation agriculture beyond the status of a promising idea and make it the paradigm for a new agriculture that is profitable, socially equitable, ecologically sustainable, resilient in the face of climate change.

3.1 The perception problem – a need for policies, information and sharing of practices

Shifting to conservation agriculture is not an intuitive step for many academic experts on agriculture, successful farmers and agricultural extension personnel. Many of these potential change agents do not believe that there can be any alternative to heavy plowing, if only because it is the only system they know.

Understandably, many smallholder farmers, made cautious by their vulnerability, also resist change that they poorly understand and that contradicts what they believe to be the wisdom of the ages, handed down from parent to child. When ICARDA started farmer field trials in Iraq and Syria, many younger farmers reported that their fathers had forbidden them to try conservation tillage, seeing no hope of anything good coming from what they saw as madness.[7]

Yet, other farmers have been willing to try conservation tillage, most notably better off, well-educated farmers of drylands in wealthier countries. Once farmers try conservation tillage, almost none revert to conventional tillage.

[7] ICARDA Conservation Agriculture project technical report for Iraq and Syria.

Addressing unwelcoming policy environments

Even the most effective agriculture innovation can die on the shelf for lack of a policy environment that enables it to take root and grow. Conservation agriculture may minimize soil disturbance, but its widespread adoption among smallholder farmers in developing countries is unlikely unless the national research and extension system prepares the ground for it.

Approaches to creating a policy environment that is enabling include: providing education and information to overcome, first, unfavorable perceptions; sharing knowledge and practice of other countries, with examples of how to proceed adoption; encouraging public-private partnerships to develop and deliver the mechanical seeders and other inputs needed for conservation agriculture to succeed.

Politicians, public administrators, farmers, researchers, extension agents and university professors can work together to formulate forward-looking and effective policy encouraging conservation tillage. With adequate policies in place, it will be possible to obtain the 'triple bottom line' of economic, social and environmental sustainability, while at the same time improving soil health and boosting production.

3.2 The need for seeders – low-cost and locally made

Special seeders are required to practice conservation tillage. Commercially available seeders are made mostly in wealthier countries with extensive areas of conservation tillage, such as the United States and Brazil. They typically cost $50,000-60,000 or more, which places them out of reach of smallholders in developing countries.

As a part of the research partnerships in Syria and Iraq (2007-2009), ICARDA, local equipment producers and farmers compared conservation with conventional tillage, and developed prototypes of low-cost seeders that can be profitably manufactured and sold for $2,000-6,000. Smaller models measure 2.3 meters across, larger ones 4 meters. Seeders manufactured locally in Syria cost $1,500 for 2.3-meter models and $4,500 for the 4-meter models. Seeder modification cost $1,250 in Iraq. In Iraq, farmers developed modification kits to adapt local 3.6-meter John Shearer-type seeders for conservation tillage. This farmer-led effort to develop, test, demonstrate and promote modified seeders was a surprise success and a major outcome of the project.

In 2008, ICARDA compared the performance of imported seeders with three seeders locally manufactured in Syria. They were tested for early sowing (mid-November 2008) and late sowing (mid-December) at its research campus in Aleppo, Syria. It found crop establishment and yields of wheat, barley, lentil and chickpea to be similar. All seeders worked well on both sowing dates. Yields for barley, wheat and chickpea were higher when sown early. As an illustration of emerging interest to adopt conservation tillage, from 2008 to 2011, 21 Iraqi farmers and five Syrian farmers had seeders modified for conservation tillage, and 14 Syrian farmers and 9 institutions and non-governmental organizations purchased zero-tillage seeders from Syrian manufacturers.[8]

[8] Piggin C, Haddad A, Khalil Y. 2011. Development and promotion of zero tillage in Iraq and Syria. Presented at the 5th World Congress of Conservation Agriculture, incorporating the 3rd Farming Systems Design Conference in September 2011 in Brisbane, Australia. www.wcca2011.org

This experience shows that affordable and effective seeders for conservation agriculture can be built locally, potentially removing a significant and commonly reported constraint to the adoption of conservation tillage.

In Syria, three new seeder manufacturers were added to the group of collaborating machinery manufacturers in 2010, with each producing excellent seeders. In 2010/11, Syrian seeder manufacturers sold two zero-tillage seeders to ICARDA, 26 to farmers, 14 to US-funded Provincial Reconstruction Team Projects in Nineveh, Iraq, and 10 to the Institut National de la Recherche Agronomique of Morocco.

Aside from lower initial costs, an advantage of locally produced machinery is that it is easy to repair locally, using locally available spare parts and mechanical skills.

ICARDA has lent seeders to collaborating farmers and other partners for test runs. To expand the reach of this locally appropriate technology, countries need to formulate plans and policies that encourage the local production of seeders and establish market mechanisms to create, distribute and maintain them.

3.3 Other constraints

Lack of local knowledge and extension expertise. Overcoming the perception constraint mentioned above is only part of the challenge of mustering global knowledge of conservation agriculture and its techniques and packaging it effectively for dissemination in the developing world agricultural economies where it can do the most good. Australia has been especially active in sending its agricultural academics and farmers who practice conservation agriculture on missions abroad to spread the word, but much remains to be done.

Chemical weed control. Conservation agriculture became possible with the advent of modern herbicides. In research and trials, ICARDA has found weeds to be of little consequence in conservation agriculture trials in Syria and Iraq, especially as the dry Mediterranean summer means that few weeds emerge, and a pre-sowing glyphosate application is only occasionally needed. Post-sowing crop management is similar under conservation and conventional agriculture.

Pests and diseases. Leaving the previous crop's stubble and other residues raises the risk of plant pests and diseases surviving into the following crop, rather than succumbing to the famine that plowing between crops creates for them. Conservation agriculture addresses the problem of pests and diseases by integrating crop rotation, which breaks the cycles that perpetuate crop diseases such as wheat rust and pest infestations. The practice also promotes biological pest control as the first option to try.

Imported conservation agriculture seeders

Imported seeders - price $40-60,000

Syria: locally made conservation agriculture seeders 2008

Local seeders - price $2000-5000

4. The way forward

In its work with partners in the Middle East and Central Asia, ICARDA has found that introducing conservation agriculture, where there is little awareness of the technology, best begins with a program of research and development over 3-5 years.

The main tasks of such a program are to (1) verify and adapt the system to local conditions through agronomic research; (2) develop local capacity to fabricate and maintain effective and affordable conservation agriculture seeders; (3) facilitate extensive participatory collaboration among researchers, extension personnel, non-governmental organizations, private industry and farmers to raise awareness of the system, share lessons learned, and guide the adoption of conservation agriculture to local conditions.

The first step of implementation is to discuss the approach with local stakeholders and demonstrate its application. After one cropping season, researchers and their local counterparts should conduct trials that directly compare the results in fields managed with conservation agriculture with those in fields using existing practices. The lessons learned in these trials are good starting points to see how to adapt conservation agriculture to local conditions, develop locally appropriate recommendations of best practice, and generate local capacity to support the new seeding technology.

Maintaining flexibility. Like other revolutionary concepts conservation agriculture is prone to an overlay of dogma. This ill-serves the spread of the technology into developing agricultural markets. Researchers and practitioners should keep an open mind to avoid steering the local evolution of conservation agriculture away from its optimal form. Individual countries and agricultural regions within them do not need a list of prescriptions, to which they must adhere without fail, on exactly how much to plow or not plow or on what percentage of stubble to leave in the field. Rather, they need to appreciate the concept and adapt it to their specific situations.

A sensible approach is not to promote fixed technologies, but to demonstrate options and let farmers decide. Introducing conservation agriculture requires fundamentally changing the perceptions of farmers, policymakers and planners, but it does not necessarily mean immediate and fundamental changes in farmer practice.

Probably the most effective way to promote conservation agriculture is to demonstrate it through the experiences of successful adopters. Policymakers, extension personnel and farmers can benefit from the lessons learned by their counterparts abroad, ideally in neighboring countries with similar agricultural environments and economies. Two such countries that have been learning from each other about conservation agriculture in a structured way are Iraq and Syria, where ICARDA has led trials of the approach since 2005.

Steps to encourage farmers to adopt conservation tillage

If given the chance, conservation agriculture can sell itself. The task for policy makers and development partners is to give this innovative approach to agriculture a chance with farmers whose practical experience makes them skeptical that crops can grow on land that has not been prepared with heavy plowing. The following can lead to the widespread adoption of conservation tillage:

- **Raise awareness.** Education is the first need toward achieving understanding and acceptance of conservation agriculture in principle from farmers and the national agricultural research and extension systems upon which they depend. Education consists mainly of presenting to these potential change agents learning from the experience of others. This is how success with conservation tillage In Australia has begun to be transplanted to Iraq and Syria.
- **Local verification and modification of technology.** Participatory research and demonstration needs to leave behind any dogma that may have attached itself to the fine points of conservation tillage. Instead, it needs to take a flexible approach to testing and verifying local modification of the amount and nature of stubble and other residues to be left in the field, the time of sowing, soil fertility management, weed control, and integrated pest management.
- **Provide appropriate and affordable seeders.** As a practical matter, participating farmers must have access to appropriate seeders beginning with participatory research and demonstration. To help overcome their natural skepticism, farmers should enjoy the use of seeders at no cost and bear no liability for seeder breakdown. Once farmers' interest in continuing to use conservation tillage creates local demand for affordable seeders, policymakers and development partners need to help local entrepreneurs acquire the capacity to manufacture new seeders and kits for adopting seeders that are already available locally.
- **Organize participatory research and demonstrations.** Once farmers and extension personnel understand conservation agriculture in principle, they need to see it in practice. This requires participatory research and demonstration enlisting the collaboration of scientists, extension officers, economists, policymakers and farmers. Farmers may require concessions that allow them to participate without taking personal responsibility for crop failure.

5. Adoption scenarios and recent examples

The widespread adoption of conservation agriculture is a fact in North and South America and Australia, in particular in drier areas of these continents. It has also been adopted, to a much lesser extent, in Europe, most notably in relatively arid Spain.

This section, considers progress in extending conservation agriculture to drylands in Central and West Asia, sub-Saharan Africa and the Sahel. In these poorer regions, conservation agriculture has the potential to raise crop productivity and, through reduced costs, profitability, helping to make the rural economy a stronger contributor to national economic growth and development. At the same time, and perhaps as importantly, conservation agriculture can reverse decades or centuries of damage caused by unsustainable agricultural practice, restoring natural fertility and productivity while strengthening national and regional resilience in the face of climate change.

5.1 Iraq and Syria - collaborative research and adoption in West Asia

In 2006/07, Syria had only three farmers testing conservation agriculture on a combined area of 15 ha. The following year, both the number of farmers and the area doubled – to a grand total of six farmers working 30 ha. In 2009/10, 119 Syrian farmers practiced conservation agriculture on 4,918 ha. Both of those numbers are thought to have roughly tripled in 2010/11, to about 350 farmers working about 15,000 ha. Some 70% of this area was actual adoption by farmers using their own, rented or borrowed seeders.

Cost of field operations - cereal/legume rain-fed rotation under conservation agriculture and Conventional cultivation
Syria (2008-09)

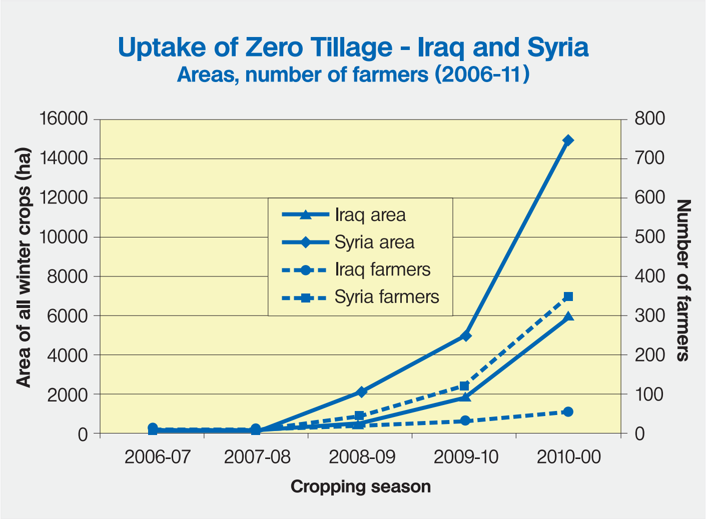
Crop	Operation	Conventional tillage		Conservation agriculture	
		Implement	Cost SL/ha	Implement	Cost SL/ha
Cereals	*Cultivation*	*Duck-foot*	*1000*		
	Seeding	*Cereal drill*	*800*	*ZT planter*	*800*
	Weed control	*Pre-planting*		*Glyphosate***	*(750)*
		Post-em	*1600*	*Post-em*	*1600*
	Total cereals		**3400**		**2400**
Lentil	*Plough*	*MB or Disc*	*2500*		
	Cultivation	*Duck-foot*	*1000*		
	Seeding	*Cereal drill*	*800*	*ZT planter*	*800*
	Weed control	*Pre-planting*		*Glyphosate***	*(750)*
		Post-em	*3100*	*Post-em*	*3100*
	Harvesting	*20 l/day/ha*	*3500*	*22 l/day/ha*	*3850*
	Total lentil		**10900**		**7750**
Total system			**14300**		**10150**

Syrian Lira/hectare.
Source: ICARDA conservation Agriculture project technical report for Iraq and Syria, supported by AusAid/ACIAR.

In neighboring Iraq, the spread of conservation agriculture has been only slightly less remarkable, with the number of farmer practitioners expanding fourfold, from 12 in 2006/07 to about 50 in 2010/11, and the area expanding by 115 times from 52 ha in 2006/07 to about 6,000 ha in 2010/11. Some 80% of this area was actual adoption.

Dryland cropping in West Asia traditionally employs heavy cultivation, late sowing, grazing on harvested land, and finally the burning of stubble. Cereal and legume yields are low because rainfall is limited and water use efficiency is poor. That farmers working similar agricultural environments in Australia have greatly improved their yields and profitability using conservation agriculture prompted the Australian government to fund research through the Australian Agency for International Development and the Australian

Centre for International Agricultural Research into extending this success to the drylands of West Asia.



Source: ICARDA Conservation Agriculture project technical report for Iraq and Syria, supported by AusAid/ACIAR.

Research and demonstrations to develop conservation agriculture cropping systems in the drylands of Ninevah Governorate in northern Iraq started in the 2005/2006 cropping season. Trials took place in a variety of rainfed areas: those with high rainfall exceeding 450 mm per year, those with moderate rainfall of 350-450 mm, and those with low rainfall of 200-350 mm or less. Initially, collaborators in Ninevah were skeptical, as conservation agriculture had never before been tried in Iraq. Many believed that it simply was not possible to grow crops without cultivation because the soil was too hard for roots to penetrate. They feared machinery breakdown and worsened infestations of weeds, pests and diseases, agreeing to participate only if research tested and verifies new possibilities and only if the farmers themselves bore no responsibility for crop or machine failure.

Comments from Iraq - adopting conservation agriculture in the Nenawa Farming System

In a recent article in the Iraqi press, Dr Abdul-Suttar Asmir Alp-Rajbo CEO Conservation Agriculture Program, College of Agriculture, Soil and Forestry, Al Mosul University, Iraq, gave background on conservation agriculture practices and their impact worldwide. He also summarized the recent trials done in the country on conservation agriculture and commented on the policy.

He equates the Nenawa project to a school which can 'broadcast information and benefits of the technique the across Iraq'.

Summarizing the role of the Ministry, he advises that it has:

- Assisted farmers who seek to modify their seeders to suit zero tillage by allocating a specific budget.
- Purchased not less than 20 seeders to be distributed to all units so that the are freely used by farmers.
- Focused on training and extension courses to develop the capacity of farmers and extension agents and accelerates the adoption of conservation farming approaches.

He further commented on the importance of seeders, saying that zero tillage practices have rendered the well-known 'duck-foot' cultivator economically unfeasible. Some farmers have replaced their old seeders with zero tillage ones and achieved impressive results. He calls for the creation of an agricultural association to encourage use of the conservation farming technique.
The extension program, a collaborative research effort with ICARDA, has provided huge benefits to the Iraqi farmers, in that a number of seeders have been imported; others have been rehabilitated to serve the new technique.

(see translation of the full article in Annex).

Linked research also started in the 2005/2006 cropping season with trials at ICARDA's research campus at Aleppo of wheat, chickpea, barley and lentil grown in rotation, comparing conservation agriculture and conventional tillage. Early sowing, which conservation agriculture facilitates, was the primary reason for improved yields of all crops. Especially eye-opening were costs reduced by nearly a third, from 14,300 Syrian pounds ($300)/ha to £10,150, as £4,500/ ha in saved plowing and cultivation costs were offset by only £1,500/ha for glyphosate herbicide applications (which is occasionally necessary) and 10% higher harvesting costs.

In Iraq and spillover participatory research across the border in Syria – research that combined the efforts of research and extension institutions, private industry and nongovernment organizations – conservation agriculture was first explained to farmers. Seeders were made available to interested farmers without charge or payment, and with farmers supplying tractors and other inputs. Comparisons with conventional tillage were made within individual farms and with neighbors. Farmers generally found yields to be better from conservation agriculture than from conventional management, even where fields had little stubble.

A survey in 2008/09 of 43 Syrian farmers using conservation agriculture found all responding that they had saved $30-40/ha in plowing costs, as well as time, seed and soil moisture, and had achieved good early germination. Because conservation agriculture produced better yields than conventionally managed fields on their own or neighbors' farms, all participating farmers were keen to continue conservation agriculture if given continued access to seeding machines, with some expressing interest in buying or modifying their own equipment. Researchers estimate that 70-80% of the area expansion under conservation agriculture in Iraq and Syria was enabled by farmers using seeding machines they purchased, adapted, borrowed or rented.

Yields using locally built or adopted machinery were as good as those using expensive imported seeding machines. Iraqi and Syrian farmers who were encouraged to try conservation agriculture were impressed by higher yields and lower cost. At the same time, collaborative research improved the technical capacity of agricultural extension agencies working in both countries. Researchers believe that adoption will continue to spread in Iraq and Syria.

Syria on-farm Zero Tillage testing
(2009-2010)

Survey of experiences/opinions of 180 farmers about zero tillage.

Questions:

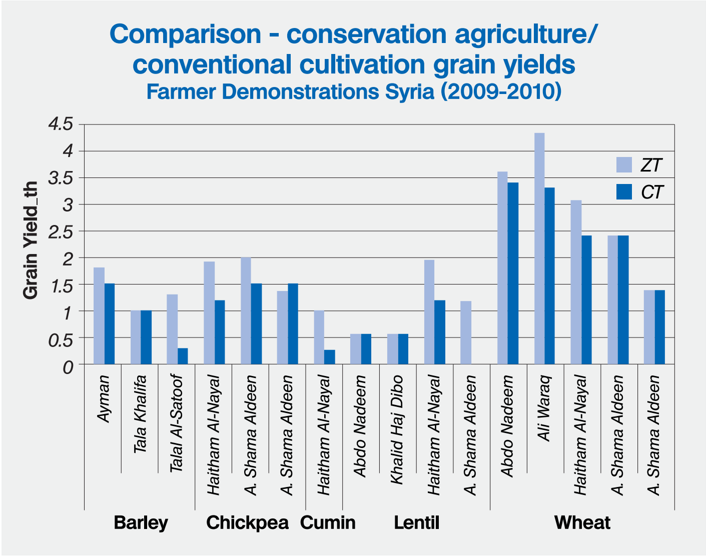
1. costs (SL/ha) for growing a crop with zero tillage or CT
2. advantages of zero tillage
3. comments on zero tillage
4. plans to try zero tillage next year
5. yield (t/ha) compared with CT neighbor

Responses:

1. 100 % of farmers saved 1500-2000 SL/ha using zero tillage instead of CC
2. 100 % of farmers saw many advantages of zero tillage such as:
   • saving time, seed, soil moisture and money
   • early and good germination.
   • increasing yield
3. 100 % of farmers will continue zero tillage with drill access and some may buy/modify a drill
4. 76 % of farmers who used zero tillage got a high yield compared with neighbor as a percentage increase (3.7-67 %).
5. 9.5 % of farmers who used zero tillage didn't harvest because drought.
6. 9.5 % of farmers who used zero tillage got an same yield compared with neighbor.
7. 4 % of farmers who used zero tillage got a low yield compared with neighbor as 4-10% decrease.

Source: ICARDA conservation Agriculture project technical report for Iraq and Syria, supported by AusAid/ACIAR.

“Seeding” the local production of seeding machinery. The availability of affordable and readily available seeders for conservation agriculture was highlighted as an important constraint to its adoption. Demonstration versions of seeders were provided and farmers were offered to rent the services of seeders. As the work has developed in Iraq and Syria, demand has grown, and number of local companies have started producing low-cost seeders. A market for manufacture and repair is likely to emerge as demand from farmers grows.



Source: ICARDA conservation Agriculture project technical report for Iraq and Syria, supported by AusAid/ACIAR.

Experience in Iraq and Syria illustrates that the constraint to adoption posed by the need for special machinery can be managed. Policymakers and/or development partners need to provide machinery initially at no cost or risk to farmers. Once successful cropping under conservation agriculture builds farmer demand for appropriate seeding machines, local entrepreneurs can, with initial assistance from policymakers and/or development partners, start to meet that demand with locally manufactured machinery and kits with which to adapt farmers’ existing machinery.

Existing crop varieties found suitable. An important finding of the research is that specially bred varieties would not be required before conversion to conservation agriculture. If a variety performs well under conventional management in a particular agricultural environment, it will perform well under conservation agriculture. The fact that farmers can use their favored varieties greatly simplifies the adoption of conservation agriculture. At ICARDA, breeders are currently evaluating hundreds of crop varieties for their best performance under conservation agriculture practices.

5.2 Promoting conservation agriculture for rain-fed crops in Morocco: issues, opportunities and constraints

Farming in rain-fed areas of North Africa is a high-risk activity for farmers. The situation is made more severe by the emergence of erratic rainfall and climate patterns. Conventional agriculture practices in the region have caused intensive natural resources mining and continuous degradation of soil fertility, causing a worsening threat to farm productivity and food security.

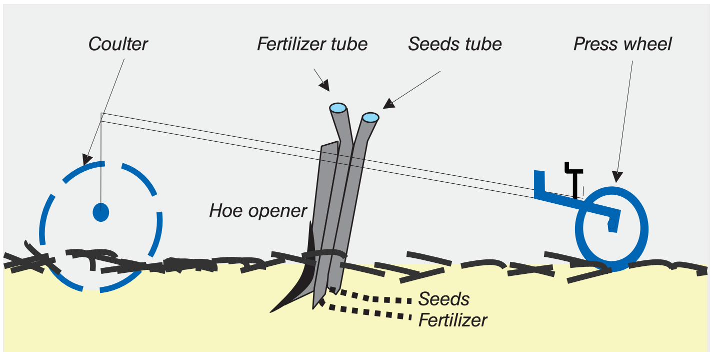
In Morocco, conservation agriculture – using the 'no till' approach of minimal ploughing of fields – has been tested and developed since 1984 at the experimental stations and taken to farmers in 1997, in an effort to keep cereal production systems sustainable for the coming years and to address the effects of climate change.

In 2011, the total area under conservation agriculture in Morocco reached 5,000 Ha. It is expected to grow to 7,000 ha in a small percentage of the total farming land in this region. The research team following the uptake of conservation practices and benefits to farmers feels that the results achieved since 1997, while initially slow, now constitute a strong case for the intensification of efforts to scale-up conservation agriculture in the country.

Morocco first introduced no-till practices to farmer fields in 1997, in the Chaouia area where 15% of the country's cereal is produced. This region is characterized as an intermediate to low rainfall zone. Deep clay vertisols and shallow calcixeroll and silt clay fertialitique are common soil types.

Savings in fuel and labor cost

The immediate benefits noted by farmers trying the conservation approach are savings in energy cost and reduced time spend in crop labor. They registered savings of up to 40 litres of fuel per hectare and reductions in labour and seeds expenses. These are the short-term motivations for farmers to take up conservation practices. The long-term incentives, which being significant benefits to agricultural regions and the country, are natural resource conservation, improved soil fertility and water productivity. To achieve true scaling-up these benefits need to be promoted to farmers and appreciated by them.



Key components of the Moroccan-developed seed drill.

In 2007-2008 a new no-till system development program was initiated with the Arab Authority for Agricultural Investment and Development (AAAID) and Morocco's National Institute for Agricultural Research - INRA-Settat. This involved the introduction of seed drills from Brazil to support this program and test their performance under Moroccan soil conditions. Some 1200 ha were planted using these machines and similar locally-manufactured drills.

Some 80 farmers subscribed to this program, which includes ongoing recommendations and guidance for farmers. Performance of both drills showed excellent results in the clay vertisol and calcixeroll soil types. But they could not offer necessary penetration in fields with a high percentage of surface stones, as seeding discs roll over the rocks leaving seeds uncovered. The program team also noted that the farmers need to take more care in operating the machines with conventional drills, regarding speed of soil surface preparation and maintenance of seeding equipment. Ongoing guidance is also needed for farmers for crop management, especially weed control, that need to be scheduled in a timely way and efficiently executed.

Effect of cereal rotation and tillage on wheat yield In experimental stations (tons/ha^{-1})

Sidi El Aïdi and Jemaa Shim. Bouzza, 1990 and Mrabet, 2000

	Sidi El Aydi [a]		Jemaa Shaim [b]	
Type of tillage	Wheat-wheat	Wheat-fallow	Wheat-wheat	Wheat-fallow
No-till	1.9	3.5	1.7	3.0
Minimum till	1.6	3.4	1.5	3.0
Conventionnal tillage	1.4	2.4	1.6	2.4

[a] Average grain yield 1983-1992 in clay soil Vertisol, average rainfall 370mm.

[b] Average grain yield 1983-1998 in caly soil, Vertisol, average rainfall 270 mm.

Perceived benefits – immediate and long-term

Current research on the progress of these conservation agriculture efforts in Morocco reveals that it brings slight improvements to soil fertility and water use efficiency. But over a number of years these small changes translate into significant yield improvements and production stability in the areas adopting conservation practices.

Crop residue build-up over a number of years and the corresponding changes in farmers' practices for residue management has illustrated that a long-term increase in soil quality in participating farmers' fields can be achieved.

Despite the adoption of conservation approaches in some areas of Morocco, and the improved soil fertility and stability of wheat yields that have been achieved, there has been a generally slow uptake of these practices across the country.

Scaling-up: constraints and strategies

The demonstration of these practices to farmers using participatory approaches has had a slow impact on their scaling-up and on the wider adoption of no-till farming.

Innovative development approaches are needed to inform and demonstrate the benefits of conservation agriculture to farmers. This can be achieved through activities such as:

- Intensive guidance of farmers to change the centuries-old conventional farming heritage.
- On-the-job training and creation of 'conservation agriculture services' for farmers in areas such as planting and weed control and for support around other practical issues for the adoption of conservation practices.
- Favouring of subsidies for conservation farm machinery and withdrawing of support for those allocated in conventional practices.

	Power (hp/m)	Time (h/ha)	Fuel consumption (l/ha)	Number of passes
Conventional tillage:	**100 to 140**	**6.5 to 8.5**	**31 to 45**	**4**
• Deep tillage	50 - 70	3.0 - 4.0	10 - 15	
• Secondary tillage	20 - 30	2.0 - 2.5	10 - 12	
• Seed bed preparation	15 - 25	1.0 - 1.5	6 - 8	
• Seeding	15	0.5	5	
Reduced tillage:	**50 to 70**	**3.5 to 5.0**	**21 to 25**	**3**
• Stubble plowing	20 - 30	2.0 - 3.0	10 - 12	
• Seed bed preparation	15 - 25	1.0 - 1.5	6 - 8	
• Seeding	15	0.5	5	
Minimum tillage:	**30 to 40**	**2.0 to 2.5**	**11 to 13**	**2**
• Disc harrowing	15 - 25	1.0 - 1.5	5 - 8	
• Seeding	15	0.5	5	
No-till	**25 to 35**	**0.6 to 1.0**	**5 to 7**	**1**

Capital investment is required to boost the cereals production chain toward natural resource conservation. The involvement of international and regional development programs (such as AAAID) is also needed.

Local manufacturing of no-till drills can also enhance private capital investments to play a major role in adoption of no-till system. Recently developed national strategies for Moroccan agriculture encourage the cooperation of small farmers around an aggregator in a production chain. Here a no-till system can play a major role in gathering farmers around a common interest.

Use of the drill has given a good result cereal crops and for lentils, vetch and chickpea. Broad bean is not suited to current drill sizes.

5.3 Collaborative research and adoption in Tunisia

Tunisia has 12 years' experience in adopting conservation agriculture practices. Earlier attempts at no or limited tillage were tried 25 years ago in agriculture and rural development research projects, but these activities ceased when the projects ended.

Conservation practices, are defined in Tunisia as: (1) no soil disturbance through the use of direct drilling as opposed to the traditional plowing, (2) establishing continuous vegetal cover (dry residues, green biomass) of the soil to maintain humidity and promote soil microbial activity (3) implementing agronomically relevant combinations of activities and sequences.

The current conservation agriculture introduction in Tunisia was done as a part of international agricultural research projects similar to earlier attempts. The program focused on understanding what was needed to increase the likelihood of its adoption by farmers.
Conservation agriculture in Tunisia today is limited to agro-ecologically fragile areas in the northwest of the country and to a number of large-scale farms. To date, an estimated 12,000 hectares use conservation practices and the trend is increasing. Some 90 farmers have experimented with the practice. Some 10% of the initial project partners who tried conservation agriculture have discontinued it, but the majority of the farmers involved continue conservation practices. The program focuses on highlighting the immediate advantages of the practice, such as energy cost savings and the freeing of some resources, such as labor, for other activities – as a way to inform farmers of the limited risks attached to considering conservation farming practices. Medium and long term repercussions of the practice on the farming and environmental aspects are explained in extension messages that are regularly provided to farmers. Another important feature of this extension work is to stress the role of the farmer in the demonstration efforts provided by and to farmers themselves.

Among the major constraints to adoption is the cost of the investment in the required specialized seeder drills. The program has mainly worked with large-scale farms and the team feels that the relatively high cost of these drills, will be a constraint for medium and small farms, which have not yet considered conservation agriculture. Other constraints are the national standard extension messages and programs which do not generally recognize the potential of this new approach. A low level of farm organization adds to the lack of information and is a further obstacle to encourage farmers and decision makers to consider trying or adopting conservation approaches.

To overcome these constraints, at least partially, significant research work on the required machinery equipment has attempted to develop affordable locally based drills. To address the extension bias against conservation farming, seminars, workshops, field days - all with farmer active participation - are frequently organized. A farmer's organization focusing on resource preservation has been created to facilitate adoption by farmers.

Evidence of the expansion of areas under conservation farming in Tunisia, and the spontaneous investment by farmers in seeder drills are interpreted as indications that farmers are responding to the perceived benefits of conservation practices. Interest by a growing number of farmers in participating in conservation-focused extension initiatives is another positive indicator.

Program leaders report that the main lesson learned so far is that adoption of new conservation ideas is a long-term endeavor and a slow process. Worldwide findings, confirmed by early Tunisian results, show that the major impacts of adopting conservation farming may not be immediate or statistically significant. But as more pillars of the conservation package are implemented, overall impacts will be more visible in terms of sustaining farm incomes over time and limiting resource degradation (soil erosion, soil fertility, soil moisture).

Program leaders hypothesize that impacts will be even more spectacular when these new farming practices can be seen to have a positive effect on stabilizing large-scale environments and public projects such as water runoff over sloped watersheds and reservoir sedimentation and other public infrastructure protection such as roads and railroads.

The program sees other challenges to face, related to uptake and impact among small and medium- scale farming, in the country's tree crop and pasture areas – particularly where common property resources are encountered. The group feels that more thought and experimentation are needed along these lines before more definite conclusions can be derived as to the universality of conservation agriculture practices in the Tunisian case.

READING LIST AND ADDITIONAL RESOURCES

Conservation Agriculture and adoption in Tunisia
Boubaker Thabet & Moncef Ben-Hammouda
Benhammouda.moncef@iresa.agrinet.tn INAT, Tunis 1002 , Tunisia

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Adoption of Zero Tillage Farming System in Nenawa, Iraq

Translation of article published in Arabic in the Iraqi press by Dr Abdul-Suttar Asmir Alp-Rajbo CEO Conservation Agriculture Program, College of Agriculture, Soil and Forestry, Al Mosul University, Iraq. August 2011

Background

Traditional tillage is a major reason for Severe soil loss. The FAO reported that while wind and water erosion cause some 40% of land loss around the world, traditional tillage causes an annual soil loss of some 150 t/ha. Sand became a major problem in parts of Latin America due to the recurrent land plowing to control jungles.

Zero tillage is modern scientific vision that looks back to an ancient practice. With the advancement of agricultural science and the eruption of industrial revolution, agricultural mechanization have developed accumulating technical problems as a result of frequent soil tillage. These came in conjunction with financial problems such as high costs of fuel, labor and inputs which turned the economic feasibility the most important factor to consider before embarking on any agricultural activity, especially in rainfed areas where the risk is at its highest rates. The global trend has, therefore, targeted reduction of production input costs so that they do not go over the production gains. Most countries have started adopting zero tillage technique on gradual or relative bases. Statistics of 1999 show a 60% increase in the number of farmers adopting this technique in west Australia.

Pros of Zero Tillage Practices

- Leaving the crop residues in the field on soil surface and regulation of grazing in conjunction with zero tillage have reduced/prevented soil erosion
- Giving high agronomic resilience through extending the seeding period
- Reducing the runoff water
- Increasing soil porosity, i.e. increased the soil water storage capacity and reduced evaporation
- Increasing rainwater harvesting
- Reducing the impact of high temperature on soil surface, i.e. prevented the negative impact of heat on seed germination
- Improving seedlings growth
- Reducing fuel and mechanization usage
- Applicability of this techniques in all types of soils as per the Australian experience
- Restoring the bio-life in soil surface, such as earth worm, arthropods, and other insects which increases the depth of root layer and improves the organic matter

Water use rationalization

In south Asia, the adoption of zero tillage approach in an area of 5 million hectares saved an amount of 5 billion cubic meters of water annually. Such an amount may fill a lake of 10 km long, 5 km wide and 100 m deep. What is more, the amount of saved diesel would be about half a billion liters annually.

This means an annual reduction of CO_2 emission of about 1.3 million tones.

A comparison between the traditional and zero tillage techniques shows that the zero tillage has been superior in a number of studied traits (7 traits) in various sites (12 sites). The ratio of superiority has been 28 (zero tillage) to 8 (traditional system).

Zero tillage has made the duck-foot cultivator economically infeasible. Some farmers replaced their old seeders with zero tillage ones and grew large areas gaining startling results. Now, there is a need to establish an agricultural association that encourages this new technique.

The extension program, in cooperation with ICARDA, has provided huge benefits to the Iraqi farmers, in that a number of seeders have been imported; others have been rehabilitated to match the new technique.

This pilot trial in Nenawa would be like a school that broadcasts the technique all over Iraq.

Role of province and Ministry

- Assisting farmers who seek to modify their seeders to suit zero tillage by allocating a specific budget
- Purchasing not less than 20 seeders to be distributed to all units so that they are freely used by farmers
- Focusing on training and extension courses. This develops the capacity of farmers and extension agents and accelerates the adoption of this modern technique.

About ICARDA and the CGIAR

ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

CGIAR

CGIAR is a global research partnership that unites organizations engaged in research for sustainable development. CGIAR research is dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources. It is carried out by the 15 centers who are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations, including national and regional research institutes, civil society organizations, academia, and the private sector. WWW.cgiar.org