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1 Acknowledgments

We would like to acknowledge the exceptional efforts of our many collaborators in Iraq and Syria (researchers, extension workers, university teachers, students, machinery manufacturers and farmers), most of whom are not individually mentioned in this report. Against the troubling backdrop of escalating violence in their cities, towns and villages during 2011-2014, these people showed much dedication and passion for this project while they tried to go about their work and lives as their circumstances permitted, often at great personal risk. In Iraq this culminated in the take-over of Ramadi, Mosul, Tikrit, and Kirkuk by the radical extremist group Islamic State in Iraq and Syria (ISIS) during the first half of 2014. In Syria, it involved take-over initially by Free Syrian Army, local rebels, fundamentalist groups, and later by the Islamic State in Iraq and Syria (ISIS) across much of northern Syria, including the ICARDA headquarters where the project had been based since 2005. Many project collaborators lost family and friends during the conflict, in addition to their homes and most of their personal possessions, and as the fabric of their lives unravelled they showed much determination and resilience.

2 Executive summary

Between 2005 and 2014 ACIAR and AusAID supported a project with the overall goal of improving the productivity and sustainability of crop production in the drylands of northern Iraq, funded in three phases. The third phase of the project discussed in this report was designed to build upon two previous phases, to specifically develop and promote conservation agriculture (CA) in Iraq. This project consolidated and expanded research conducted in Ninevah and Aleppo Syria during the first two phases, and promoted conservation cropping practices (mainly zero-tillage and early sowing) to wider areas within Ninevah, and the new governorates of Kirkuk, Salahaddin and Anbar in Iraq. The project was a partnership led by the International Center for Agricultural Research in Dry Areas (ICARDA) involving the Ministry of Agriculture and Directorate of Agriculture in the governorate of Ninevah, (and later in Anbar, Salahaddin, Kirkuk, and Erbil), The University of Mosul and various other Iraqi universities, and The University of Western Australia, The University of Adelaide and The University of South Australia.

The lessons learned from the project are both numerous and substantial. The Iraqi project participants demonstrated through their commitment, dynamism and ingenuity that even in the challenging circumstances caused by civil unrest, agricultural research and development can lead to innovation for the benefit of farmers and the country. Through experiments on research stations and in farmers' fields at multiple locations in northern Iraq, Syria and Jordan, it was demonstrated that the elimination of plowing plus direct sowing with zero-tillage (ZT) seeders provided significant benefits to the dryland cropping systems of the Middle-East. The research unambiguously established that zero-tillage and other CA technologies resulted in cost savings, increases in grain yield production, reduced environmental degradation, and improved soil quality. In particular, CA reduces the risk of crop failure due to dry conditions and the effects of climate change. Zero-tillage alone, without the other two pillars of CA (i.e. soil cover and diverse crop rotations), produces cost savings and often results in yield increases, especially as this allows farmers to sow their crops early, which increases water use efficiency. These findings are consistent with the Australian experience of CA technologies developed over the past three decades. The project was also a catalyst in commercial release of superior wheat, barley and field pea varieties, some originating from ICARDA and Australia. The project is an example of successfully adapting and applying Australian knowledge and skills for the benefit of partner countries.

In the early stages of the project it was identified that a lack of affordable, small and simple ZT seeders was a major impediment to widespread adoption of CA in the Middle East. Consequently, machinery experts from Australia worked closely with local workshops and project partners to enhance their knowledge and skills, and produce inexpensive kits that allowed farmers to convert their conventional seeders to ZT. In the last two years two workshops in Ninevah and one in Amman Jordan produced prototypes of ZT seeders which are expected to be sold at about $US 8,000, less than half the cost of similar seeders imported from Europe or South America.

Throughout the project, the Iraq team led by Associate Prof Abdulsattar Al Rijabo from the University of Mosul and involving researchers and extension specialists from the University of Mosul, Directorates of Agriculture and State Board of Agricultural Research, plus leading farmers and machinery manufacturers, conducted numerous on-farm demonstrations of ZT seeder technology. These were well-publicized through field days often involving national television coverage, and they created much interest among farmers in CA. As a result of these activities, it is estimated that hundreds of farmers had adopted ZT over about 15,000 ha in 2014 from a zero base in 2007. Based on the farmer demonstrations and an initial analysis of the 2014 Ninevah farmer survey, the average yield increase with of ZT and early sowing was 160 kg/ha, and the estimated economic benefit was around $US 100/ha. If 80% of wheat and barley farmers in Iraq (the typical

levels of adoption in many parts of Australia) converted to ZT this would produce an extra 410,000 tonnes of grain and boost farm incomes by a total of $US 256 million per year.

The project also had significant spill-over effects in Syria, where ICARDA was based during the first two phases of the project. Syrian research and extension agencies, seeder manufacturers and farmers quickly saw the potential benefits of ZT and early sowing, and were keen to expand the adoption, with minimal input from the project. In 2012 there were seven workshops producing low-cost ZT seeders, 14 farmer demonstration groups were highly active, and about 30,000 hectares of commercial crops were grown using ZT and early sowing. Surveys of 820 Syrian wheat farmers showed those that adopted ZT reduced their costs of production by 38%, produced 465 kg/ha kg/ha (31%) extra yield and earned an additional $US 187/ha on average (25% increase). If 80% of wheat farmers in Syria used ZT the project predicts this would produce an extra 630,000 tonnes of wheat worth about $US 254 million per year. In addition, other crops will also benefit from ZT.

Since the start of the project in 2005, the project has supported the training of more than 700 Iraqi scientists, extension specialists, machinery suppliers and farmers, in a range of disciplines and at various levels, thereby providing a foundation of staff for the future research, extension and dissemination of CA in Iraq. These capacity development activities included seminars, short-term courses, six month research fellowships, on the job training, study tours and conferences, and five students completed postgraduate studies at the University of Adelaide and The University of Western Australia. In 2013 the University of Mosul established a Research Center for Conservation Agriculture in Dry Areas to undertake research, extension and training specifically on CA, and in the final phase of the project, the University of Mosul led a number of courses and workshops on CA for Iraqi collaborators, including those from Kirkuk, Salahaddin and Anbar.

Unfortunately, civil unrest in Iraq and Syria disrupted project activities and made management and implementation problematic, especially after 2011. For example, it was unsafe for the Project Leaders to travel to the main target areas in Iraq throughout the three phases of the project. During the third phase, conditions deteriorated to such an extent that researcher, extension specialists, manufacturers and farmers were not able to go about their work in many parts of Iraq and Syria. When peace returns to the region, these countries will have a major opportunity to exploit the benefits of this successful project by utilizing the enhanced expertise developed by the project to extend and disseminate the results widely. There are many places in Iraq and Syria where ZT technology developed and promoted by the project has become deeply embedded with farmers, researchers, extension officers and machinery manufacturers. All participants at the final project meeting conducted in Amman in October 2014 Jordan agreed to recommend that the Iraqi Ministry of Agriculture initiate a national program to develop and promote CA in all dryland areas and they believe CA technologies could also be beneficial for the irrigated areas of central and southern Iraq. This will result in cost savings, increases in grain production and greater incomes for farmers, and provide them with greater resilience to the effects of dry conditions and climate change. It will also increase food security and in the medium to long term will improve soil quality and reduce environmental degradation.

3 Background

The project discussed in this report was designed to build upon two consecutive projects which were funded by ACIAR and AusAID with the overall goal of improving the productivity and sustainability of crop production in the drylands of northern Iraq. This goal matched Iraq's National Development Plan 2010 and the United Nations Development Assistance Framework 2010, which both stressed the importance of agriculture as a pillar for broad-based economic development and acknowledged problems caused by the historical mismanagement and neglect of agriculture within the country. For many years Iraq has imported a high proportion of its food requirements, and in 2009 the Ministry of Agriculture set a long term target of achieving sustainable food self-sufficiency through the expansion of cropped areas and livestock numbers, and improved productivity. The projects' overall goal was also in accordance with AusAID's Iraq Agriculture Strategy which recognised agriculture as particularly important when addressing rural poverty through its capacity to provide opportunities for rural employment and its long and complex value chains with great economic multiplier effects and cross-sector linkages.

Large areas of southern Australia and the Middle East experience analogous agro-ecologies – both have Mediterranean-type environments; there are areas of alkaline red clay soils which are similar; and almost all of the crops grown in Australia originated from the Fertile Crescent. This led scientists to believe that many of the crop management technologies that boosted the productivity of Australian farmers over the previous three or four decades, may also benefit production in the Middle East. Among the most important cropping innovations in Australia was the elimination of ploughing, the development of ZT seeders capable sowing into undisturbed soil, and the use of herbicides to manage weeds – these enabled early sowing which improved water-use efficiency and crop productivity.

The first ACIAR funded project (CIM/2004/024: *Better crop germplasm and management for improved production of wheat, barley and pulse and forage legumes in Iraq)* ran from July 2005 to June 2008, and the second project (CIM/2008/027: *Development of conservation cropping systems in the drylands of northern Iraq)* ran from July 2008 to June 2012. Dr Colin Piggin from the International Center for Agricultural Research in the Dry Areas (ICARDA) led the development and management of both projects based in Aleppo Syria. In the aftermath of the second Gulf War, it was too dangerous for ICARDA staff to visit Iraq, so the projects were implemented on the ground by the University of Mosul (UniMosul) in the Ninevah governorate, the Ministry of Agriculture (MOA) Baghdad, the Ninevah Directorate of Agriculture (DOA), and the State Board of Agricultural Research (SBAR) in both Baghdad and Ninevah. The implementation of the projects in Iraq was led by Prof Abdulsattar Alrijabo, UniMosul. The WA Department of Agriculture, (AgWA), University of Western Australia (UniWA), University of Adelaide (UniAdelaide) and the Department of Agriculture and Food Western Australia (DAFWA) were the Australian partners. The activities in Iraq were concentrated in Ninevah, which is the largest governorate producing wheat and barley under rainfed conditions, and the closest to Aleppo which facilitated easy travel for meetings, visits and training courses.

The first two projects conducted highly successful field experiments which proved that productivity and profitability of crops in the Middle East can be increased substantially by the application of conservation agriculture (CA) technologies involving zero-tillage (ZT), stubble mulching, and crop rotation, along with other aspects of good crop management such as early sowing, reduced seed rates, and the use of improved crop cultivars. A range of better adapted cultivars of wheat, barley, chickpea and lentil, and new crop species (field pea, and oats) were introduced and evaluated in Ninevah, and seed of the most promising genotypes multiplied for commercial release. As in Australia, ZT and early sowing were the most valuable in terms of boosting productivity and profitability. Apart from savings in fuel and labour, ZT made early sowing possible, and in turn this improved crop growth and yields. Additional long-term benefits of CA included improved soil organic

matter, enhanced soil structure and water infiltration, and reduced soil erosion. Farmers inspecting the large-scale experiments in Ninevah and Aleppo were impressed with the field performance of crops sown with the ZT technology and were keen to test it on their farms, but suitable seeders were not commercially available in the Middle East.

The leaders of the project recognized that earlier work had successfully demonstrated similar benefits of CA in other countries (e.g. Morocco in the 1980s), but few farmers had embraced the technology, mainly because the scientists had used imported, large and expensive ZT seeders (mostly complicated disc-types from Europe or South America) that were unsuitable for small to medium farmers. In the second ACIAR Iraq project, project staff and engineering experts from the University of South Australia (UniSA) worked with local workshops to develop small and simple, tine-type, ZT seeders, and by late 2011 seven Syrian workshops were manufacturing ZT seeders, some of which were exported to Iraq, Morocco and Jordan. These cost between half and a third of the imported seeders. The manufacturing sector in Iraq was less advanced than Syria, so manufacturing efforts were initially concentrated in Syria, while project staff worked with keen farmers in Iraq to convert their existing conventional seeders to be suitable for ZT planting.

With the first supply of Syrian and converted ZT seeders, participatory farmer extension groups were then established in Ninevah to encourage widespread testing and refining of a CA package. The package was centred around ZT and early sowing, as farmers were reluctant to include legumes and other crops in their rotations and crop residues are a valuable source of animal feed. As a result of the demonstration program, adoption of ZT in Iraq increased from a zero base in 2005 to about 6,000 hectares at the end of the second project in mid 2011. The projects also had considerable impact in Syria where much of the adaptive research was conducted, ZT seeders were manufactured, and government research and extension agencies established their own participatory extension groups (14 by 2011) with minimal support from the project. The net result was about 15,000 hectares of adoption in Syria by mid 2011, again from a zero base in 2005.

Both projects conducted sizeable capacity development programs for Iraqi scientists, farmers and machinery manufacturers, including short-term training courses on a variety of subjects, study tours to Australia, and, towards the end of the second project six Iraqi postgraduates commenced English training at the UniWA and UniAdelaide in order to undertake M.Sc. and PhD studies.

This third project phase discussed in this report was an extension of the previous CIM/2008/027 project following a one year bridging phase and was designed to run from July 2012 to June 2015. However, it was terminated nine months early because of the Australian government's decision to reduce the budget available for development assistance to the Middle East, and most project activities ceased by September 30, 2014. This only allowed two growing seasons, not three as originally planned. Project work plans and budgets were revised in April 2014 so the project could meet the new end date. DAFWA withdrew as a collaborator for the third phase.

In early to mid 2012, ICARDA international staff left Aleppo because the escalating civil unrest in Syria, and relocated mainly to Amman Jordan, Beirut Lebanon, and Rabat Morocco. By the end of 2012, rebel forces had occupied regions across northern Syria, as well as the ICARDA headquarters where the project had been refining, promoting and training ZT technology. Later ISIS took over much of the northern and eastern regions - Idlib, Aleppo, Ain Al Arab, Raqqa and Deir Al Zour. During 2013 and 2014, sectarian violence similarly escalated in northern and central Iraq, hampering project activities. Extremist groups swept through Ramadi in late 2013, and when they rapidly took over Mosul, Tikrit, and Kirkuk in June 2014 forming the Islamic State in Iraq and Syria (ISIS), all project activities were halted and many collaborators fled from their home towns seeking refuge in areas under Kurdish control or in Turkey. The conflict certainly disrupted project progress but, as will be elaborated in this report, there are many places in Iraq and Syria where ZT technology developed and promoted by the project has become deeply embedded with farmers, researchers, extension officers and machinery manufacturers.

4 Objectives

The goal of the the third phase of the project was to consolidate the research and development conducted in Syria and Ninevah over seven years by the previous two phases, and promote wider adoption of conservation cropping practices by farmers in a wider area of northern Iraq (see Fig. 1). Extension and research staff from the DOA in surrounding governorates (Kirkuk, Salahahdin, Anbar,) were engaged to develop experience and expertise, and promote uptake of conservation cropping. In addition to the training of the six postgraduates who commenced their studies in January 2011 and Iraqi study visits to Australia, UniWA and UniAdelaide would undertake research in Australia and contribute conservation cropping knowledge, experience and expertise to Iraqi collaborators through participation in project reporting/planning meetings.

The five specific aims of the third phase of the project were to:

1. Promote ZT technology widely in Ninevah and also into surrounding governorates (Kirkuk, Salahaddin, Anbar) where dryland crops are prominent, through demonstrations, extension, research and training. It was expected that this would require support for local capacities to produce and market ZT seeders.
2. Develop an in-depth research program on conservation cropping, with collaborative, multi-site research in Ninevah, ICARDA, South Australia and Western Australia. Research themes linked to the change from cultivated to ZT systems were planned on the following: agronomy, rotations, residues, crop-livestock interaction, pest-disease-weed dynamics and control, and soil fertility-structure-biology dynamics and management. This program was expected to support the development of Ninevah as a centre of excellence in conservation cropping.
3. Develop and promote efficient and sustainable farmer-based seed production. Together with development of formal variety release systems, the objective was to increase farmer access to and uptake of well-adapted crop varieties.
4. Evaluate adoption and impact of project technologies (especially ZT and early sowing) through socio-economic surveys and evaluation.
5. Provide capacity development and training of Iraqi scientists in Mosul, ICARDA and Australia, including on-going support for six postgraduate trainees at UniWA and UniAdelaide so they are able to complete their degrees.

5 Methodology

Following the return of Dr Colin Piggin to Australia, a new project leader (Dr Stephen Loss) was appointed by ICARDA based in Amman Jordan at the start of the third phase of the project in mid 2012. A project instigation meeting was conducted in Amman in September 2012 during which previous project progress was reviewed, objectives discussed, and a comprehensive work plan developed. A Project Steering Committee was also established and the first meeting conducted.

In addition to the overall project coordination within Iraq by Dr Abdulsattar Alrijabo from UniMosul, project focal points from DOA were appointed for each governorate – Mr Ziyad Tareq Qasem (Ninevah), Mr Fadel Ahmad Amin (Salahdin), Mr Mahdi Zein Al Abdeen (Kirkuk) and Mr Salam Ismaiel Ibrahim (Anbar).

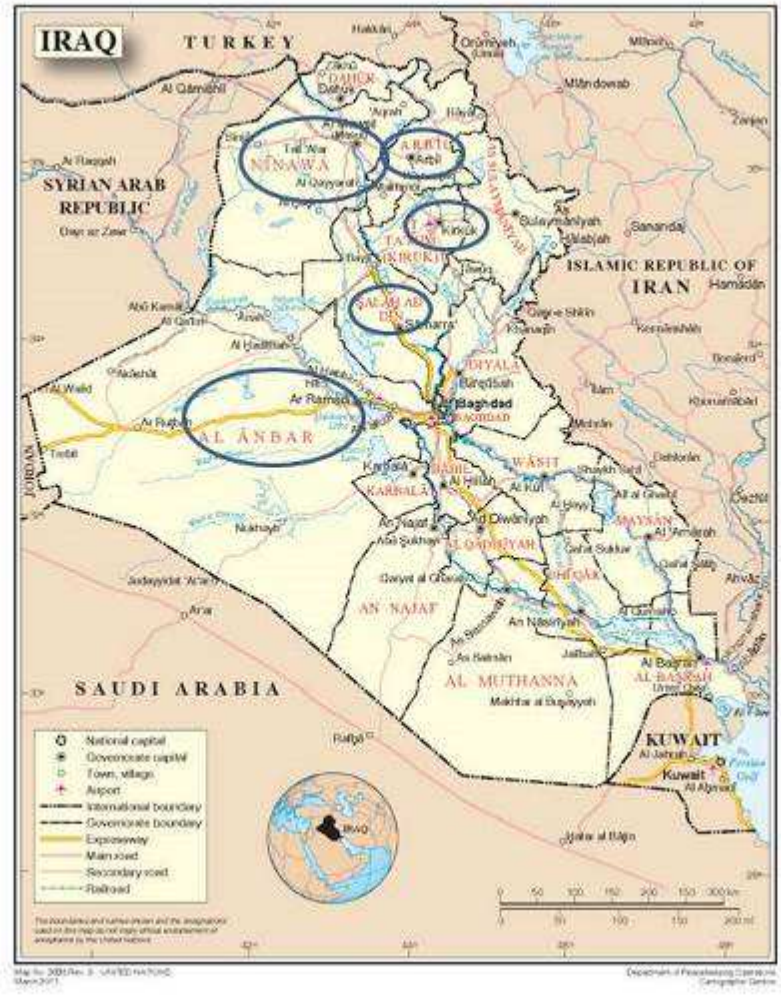

Fig. 1: Iraqi governorates where project activities were conducted during 2012-2014.

5.1 Demonstration and Promotion of Conservation Cropping

As in previous phase of the project, large-scale demonstration plots were established in farmers' fields across a range of rainfall zones, and used for field day and other extension activities in Ninevah (29 in 2012/13, and 35 in 2013/14). Two or three similar demonstrations were sown in each of the new governorates in 2012/13, which was increased to four or five each in the following season. The demonstrations and extension activities were coordinated by the DOA focal points in each governorate.

From the beginning of this third project phase, it was identified that a shortage of suitable ZT seeders was going to impair the expansion of the demonstration and extension program and wider farmer adoption in Iraq. The 2012/13 demonstrations were partly sown by ZT seeders introduced from Syria in the previous project phase, but most of the Syrian manufacturers were unable to operate because of the increasing civil conflict in their country. To address this shortage, project staff led by Dr Jacky Desbiolles (UniSA) worked with manufacturers in Mosul, Jordan and Iran to develop and improve ZT seeders produced within the region. In Iraq kits continued to be developed to convert conventional farmer seeders to ZT, and later newly manufactured ZT seeders were produced.

5.2 Adaptive Research

As in previous phases of the project, field research led by the team from UniMosul and SBAR was conducted at experimental stations in Ninevah. Large-scale replicated experiments were also conducted in farmers' fields by UniMosul and DoA, which were also used widely for field days and wider promotion. A small number of experiments were also instigated in Anbar governorate by Mr Salam Ismaiel. Evaluation and multiplication of improved genotypes and crops was ongoing by SBAR and UniMosul in Ninevah.

Because of the civil unrest in Syria and limited access to experiments at ICARDA headquarters at Tel Hadya near Aleppo, a substitute location for experiments and training was needed. Project staff were able to travel safely to Erbil in the Iraq Kurdistan Region (IKR), where they established links with Mr Sardar Sami, Director General of Research and Extension, at the Ministry of Agriculture and Water Resources. It was agreed that field experiments were to be established in late 2012 at the Ankawa Research Centre where there was a field that not been cultivated for two years, and training courses conducted in Ankawa. Similarly, links were established with the National Centre for Agricultural Research and Extension in Jordan, and field experiments were also established in late 2012 at the Maru Research Station, north of Amman, where a demonstration site had not been cultivated for three seasons.

In addition to sites at Ankawa and Maru, three long-term, large-scale, field experiments at Tel Hadya were able to be maintained in both 2012/13 and 2013/14 by skeleton staff left in Syria, led by Mr Zakarya Al-Motair. Tillage treatments were conducted according to the experimental designs, but there was some rationalisation of other treatments because of security issues e.g. sowing was not possible until early spring in 2013. Also, the project offered minor support for ongoing field research by a Syrian collaborator Mrs. Rehab Khateeb, General Commission for Scientific Agricultural Research, in Salamiyah Syria.

In early 2013, Research Associates Ms. Cara Allan and Dr Yi Zhou, were appointed at UniWA and UniAdelaide respectively. Under the supervision of Dr Ken Flower and Prof Kadambot Siddique, Ms. Allan monitored levels of insects and diseases, and crop residue decomposition in a long-term field experiment at Cunderdin, and collaborated in field experiments measuring the impact of stubble grazing on following crop performance at a number of sites in three seasons. Under supervision from Dr Matthew Denton, Dr Zhou established two new tillage x stubble x nitrogen experiments at Roseworthy and Karoonda over two seasons, and coordinated soil surveys in Australia, Jordan and Iraq comparing the effects of cropping and tillage on soil biology. The South Australian team also

investigated plant emergence through tough conditions, and root growth in glasshouse experiments.

5.3 Improved Seed Production

As part of the capacity development component, ICARDA staff led Dr Abdoul Aziz Niane trained Iraqi scientists and farmer seed producers to enhance the seed production systems in Ninevah. For the first time in Iraq, ministerial approval was granted for the multiplication of pioneer seed by private farmers in 2012, and this program was managed by Mr Qahtan S. Ibrahim from the State Board for Seed Testing and Certification, Ninevah. The elite lines of wheat and barley were included in demonstration program.

5.4 Socio-economics

The socioeconomics team led by Dr Yigezu Yigezu (ICARDA), Assistant Prof Amin Mugera (UniWA), and Dr Saad Hatem (SBAR Baghdad) developed a comprehensive survey of farmer households in all four governorates to evaluate the impact of the adoption of CA on productivity and rural livelihoods. Enumerators from all governorates were trained in Mosul in November 2013, but the survey could only be completed satisfactorily in Ninevah, as civil unrest was restricting staff travel during early 2014. The 2014 survey was planned to complement a survey in Ninevah conducted in 2011, as part of the previous project. Data from a Syrian survey conducted in 2011 was also re-examined using a range of analytical methods. Also Mr David Boussios, a PhD student from Purdue University, worked with the team in Amman to produce a bio-economic model based on the APSIM model for the Middle East to determine the impact of CA on productivity, income and risk to climate change.

5.5 Capacity Development

A program of training courses lasting 3-10 days, study tours, and longer in-service training covering a wide range of topics was developed for Iraqi scientists, machinery manufacturers and farmers. Courses led by ICARDA staff and Australian collaborators were conducted by the project in Erbil, Amman, Ankara Turkey, and Rabat Morocco during 2012 - 2014, and study tours to Turkey and Australia were also completed in 2014. The enhancement of skills and knowledge of machinery manufacturers, engineers and farmers, headed by Dr Jacky Desbiolles (UniSA) was critical in ZT seeder developments. In Iraq, the project team led by UniMosul also conducted training and workshops to demonstrate and explain ZT technology to scientists and farmers from the three new governorates, as well as many courses for local scientists and farmers, in addition to training for undergraduate and postgraduate students. Twenty-five young extension specialists from DOA Ninevah were given specific training in aspects of CA at UniMosul during mid 2013. This was backed-up by two 10 day courses on participatory approaches for promoting CA led by Dr Jim Fortune (Australia) during October 2013 in Erbil, and in April 2014 in Amman after some field experience. Extension workers from other governorates including the Kurdish region were also part of this training. Five of the six postgraduate trainees at UniWA and UniAdelaide completed their studies during 2014, and project collaborators were supported to attend various conferences and workshops.

6 Achievements against activities and outputs/milestones

The outputs for the five project objectives are presented in the following tables. In some cases, the planned outputs were not completed because of the increasing civil unrest in Iraq during late 2013 and 2014, and the termination of the project nine months earlier than planned which meant that there was no project activity in the final cropping season (October 2014 to May 2015).

Objective 1: *Promote wide adoption of conservation cropping (CC; zero-tillage plus early sowing) in Ninevah and surrounding governorates where dryland crops are prominent (Kirkuk, Salahaddin, Anbar).*

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Demonstrate and promote uptake of ZT cropping widely in Ninevah districts.	1.11 ZT interest groups: - 10 new districts, 12 existing districts, field days conducted. 1.12 Demos established in 10 new districts, information extended. 1.13 Verification trials conducted on ZT technologies in existing districts & information available to new growers	Jul 2013/14 Jul 2013/14 Jul 2013/14	**Exceeded.** Total of 29 demos were conducted in Ninevah in 2012/13, and 35 in 2013/14. Some sites included replication (output 1.13 & Obj 2) and included improved varieties (Obj 3). All sites had one or more field days, some involving TV & press. Trials were harvested each June/July and results extended.
1.2	Develop awareness and experience and encourage evaluation and uptake of ZT cropping in surrounding governorates.	1.21 Establish linkages and working relationship with active stakeholders especially farmers. 1.22 Study tour of active stakeholders to Ninevah and ICARDA (Jordan/Erbil). 1.23 Establish 2 ZT interest groups in each governorate. 1.24 Establish ZT demos in the 3 governorates - each with 2 districts in Yr 1 & 4 districts in Yr2. 1.25 Field walks and field days conducted with interest groups.	Jul 2013/14 Jul 2013/14 Jul 2013/14 Jul 2013/14 Jul 2013/14	**Achieved.** Good progress was made in establishing links with stakeholders in all three governorates. Formal interest groups & study tours to Ninevah were conducted in 2012/13 but not 2013/14 because of security issues. Trips to ICARDA were not possible because of security and timely establishment of trials in Jordan & Erbil. 2-3 demos were conducted in 2012/13 and 3-5 in 2013/14. Field walks and days conducted at each demo, some involving press and TV coverage.
1.3	Facilitate farmer access to locally fabricated or modified ZT seeders for testing and evaluation in Iraq and Syria.	1.31 Increased availability of ZT machinery to all interest groups through technical and financial support for ZT modification of conventional seeders and fabrication of ZT seeders. 1.32 Increased local and regional expertise and capacity to manufacture ZT machinery. 1.33 Wide testing, uptake and adoption of ZT by farmers	Jul 2013/14 Jul 2013/14 Jul 2013/14	**1.32 achieved.** **1.31 & 1.33 partially achieved.** Prototype ZT seeders completed by two workshops in Mosul, & 16 new seeders planned for 2014/15. 12 Rama seeders (Jordan) provided, but quality poor - upgrades planned when security improves. Kits to convert 40 farmer seeders to ZT were under construction. Four Iranian ZT seeders evaluated. Area of ZT adoption increased to 15,000 ha (mainly Ninevah) – Fig. 2.

Objective 2: *Evaluate and adapt technologies to optimise production and sustainability of cropping systems through research across collaborator sites in Ninevah, ICARDA, South Australia and Western Australia on better crop establishment and management and improved germplasm. CC = conservation cropping.*

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Investigate, verify and adapt conservation cropping technologies including agronomic practices, rotations, residues, crop-livestock interaction, pest-disease-weed dynamics and control, soil fertility-structure-biology dynamics and management and germplasm adaptation.	2.11 Agronomic CA research trials conducted at 12 existing demonstration sites in Ninevah • One long term trial site including +/- tillage & +/- stubble established and maintained for 3-5 yrs. • One IPM trial site in each of H, M, LRA including cereals and legumes with supplemental irrigation treatments. • Post-graduate survey/studies of crop establishment, growth, yield weeds, diseases & pests in trials and demonstrations (Obj 1). • Continuation of "replicated demo" sites (Obj 1). • Advice on CC practices provided by Uni Mosul • Other governorates may be included in later years.	Jul 2013/14	**Achieved**. Trials (incl. replicated demos) conducted in Ninevah according to plans except the establishment of long-term trials. 15 experiments conducted in agronomy & weed control in Ninevah. Several trials also conducted in Anbar. 8 MSc. And 2 PhD studies in CA completed at Uni Mosul. Farmer surveys of weeds and insect completed. Results summarised, reported at project meetings and extended.
		2.12 Evaluation of germplasm to support release of improved varieties for Ninevah • On-going evaluation of germplasm at many sites. • At least one elite line of wheat, barley, lentil, chickpea and oat nominated to the Variety Release Committee for release and certification (2015). • Foundation seed provided for seed production (Obj 3), extension, & adoption (Obj 1). • Other governorates may be included in later years.	Jul 2013/14	**Achieved**. Trials established according to plans. Results were summarised, reported at the project meetings and extended. Nine elite varieties (4 wheats, 2 barleys, 3 legumes) registered for release, and foundation seed multiplied and certified by collaborating seed producers in both years.
		2.13 Establishment of conservation cropping trials at Erbil • SL & team members visit and evaluate potential • Establish an experiment including tillage x TOS x seed rate, and demonstration blocks of zero & conventional tillage. • Expand trials to facilitate more detailed research questions including more intensive soil, weed and disease measurements eg. tillage x disease x variety . • These sites will be used for training (Obj. 5).	Oct 2012 Nov/Dec 2012 2014 2013-14	**Achieved**. Trials completed according to plans – 4 trials in 2012/13 and 2013/14. Trials used for training purposes and a field day for local farmers conducted in 2013. Results summarised, reported and extended.

		2.14 Iraqi agronomist visits to Erbil for conservation cropping agronomy research training • Four Iraqis visit for 1 month during seeding and spring for on-the-job training in ZT research and CC management (Obj 5). • These will become ZT agronomy 'champions' and pass on expertise gained to others in Iraq (Obj 1).	Jul 2013 2014	**Not achieved.** On-the-job training not conducted because collaborators from other parts of Iraq could not travel to Erbil for extended periods in 2013/14. Staff at Ankawa Research Centre (Erbil) benefited from agronomy trial experience. Trials used for training courses conducted in 2012/13.
		2.15 Establishment of conservation cropping research trials near Irbid, Jordan (Maru) • Establish an experiment including tillage x TOS & disease.	Nov/Dec 2012	**Achieved**. Three trials conducted according to plans in 2012/13 and 2013/14. Results summarised, reported and extended.
		2.16 Continuation of long term conservation cropping trials at Tel Hadya, Syria • Continue long-term sites including tillage, TOS, rotations, residue and seed rate treatments. • May involve seeding & harvest in 2012/13 depending upon situation in Syria. • More intensive measurements and trials may be possible if Syrian situation improves.	Jul 2013/14 2014/15	**Achieved**. Despite serious security issues, basic integrity of the trials maintained in 2012/13 and 2014/15. Tillage and other selected treatments conducted in both years. Results summarised, reported and extended.
		2.17 Investigation of grazing effects on weed, disease and pests in conservation cropping systems in Western Australia • Appoint Research Associate • Use existing long term trials and new trials to determine effects of crop residues on weeds, diseases and pests, and impacts of livestock grazing on soil fertility, soil moisture and farm profitability	2013/14	**Achieved**. Research associate appointed and studies commenced as planned. Observations on insects & diseases completed in two seasons, and data on effects of grazing stubble on crop performance analysed. Stubble decomposition study instigated. All results summarized and reported.
		2.18 Investigation of soil biology and fertility in conservation cropping systems in South Australia • Appointment of post-doctoral researcher • Conduct surveys of long-term ZT fields in south-east Australia, Iraq (& Syria) to provide understand key soil biology processes. • Use existing CC sites to investigate N and C cycling, soil moisture retention, and soil biology.	2013/14/15	**Achieved**. Post-doctoral researcher appointed. Two new field trials instigated at Roseworthy and Karoonda in 2013. Soil survey of sites in Australia, Iraq & Jordan conducted and analysed. Root distortion and crop emergence studies completed. All results summarized and reported.

		2.19 Research results used to evaluate and improve conservation cropping systems at all locations • Outputs from 2.11-2.18 reviewed at annual meetings to evaluate and modify approaches and select appropriate technologies to improve CC systems in all locations. • Produce technical and scientific papers - all drafts to be approved by SL for quality control and documentation before submission/ publishing.	2013/14/15	**Achieved.** All results reviewed at project meetings and used to improve CC systems. One paper on long-term Syrian trial submitted, and others to follow. Two book chapters on CC agronomy and economics in press. Four conference papers produced – see publications.
2.2	Fabricate, modify, evaluate and improve locally-made ZT seeders in conjunction with manufacturers and farmers	2.21 Machinery study visits undertaken from Ninevah to South Australia • Select two machinery experts (young research engineers) as in-country leaders that meet criteria supplied by JD. • Annual study visits (3 wks) to Uni SA to coincide with seeding time to provide practical knowledge of ZT seeders (Obj 5).	Jul 2013/14	**Achieved.** Machinery experts appointed and active in seeder testing and development. 14 day study visit to SA & WA conducted in Aug 2014, but 2013 tour was cancelled due to visa issues.
		2.22 Evaluation and improvement of ZT seeders in Iraq, Syria, Jordan and South Australia • On-going field and lab evaluations of seeders with feedback from extensionists, farmers, et al. • Seeder performance discussed informally during year and key improvements prioritised at annual meetings. • Formal evaluations of seeder improvements during Uni studies (post grads) and training courses involving key manufacturer/farmer groups (Obj 5). • Feedback on improvements to manufacturers and farmers.	Jul 2013/14	**Achieved.** Prototypes from Rama (Jordan) and two Mosul workshops completed and tested in Jordan, Erbil and Mosul. Several meetings held with machinery team in Erbil, Amman and Adelaide. Ongoing seeder improvements for Rama and Mosul prototypes implemented.

Objective 3: *Develop and promote efficient and sustainable farmer-based seed production and supply systems.*

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Provide promising new crop varieties/lines from ICARDA in Iraq for research, extension and seed production.	3.11 Foundation seed of elite lines/ varieties of wheat, barley, oats, chickpea, lentil, field pea, safflower, vetch, Lathyrus supplied (10–100 kg) • Iraqis to look at what is available for purification by SBAR and MU and further multiplication by VBSEs • 5 kg of what is available at ICARDA with preliminary description for variety registration purposes • Establish a back-up site for multiplication out of Iraq. Cost to be covered from the project to undertake the above activity by ICARDA in (Jordan/ Turkey/Erbil) • Provision of 100 MT of quality seed for new VBSEs to start with	July 2013/14	**Partially achieved.** Variety maintenance and foundation seed production of 4 improved wheats & 2 barleys from previous projects carried out at Rashidia (Ninevah) by SBAR. Pioneer farmers were provided with quality seed for demonstration, production and marketing. Back-up production site not implemented. No request for additional foundation seed were made by SBAR.
3.2	Develop a functional seed unit within the agricultural research system at Rashidiya RS and UniMosul to provide seed for research, demonstration and further multiplication.	3.21 Identification and supply of small equipment needs for two seed units • list of equipment prepared according the project document by SBAR and UniMosul staff with possibilities of some modification. ICARDA can advise if needed. • Equipment purchased and supplied to seed units	May 2014	**Achieved.** List provided and equipment purchased. Equipment delivered to Basra port in May 2014, just before Mosul takeover. Equipment will be transported to Baghdad, until safe to take to Mosul.
		3.22 Provision of training on breeder and foundation seed production at ICARDA (Obj 5) • Nomination of participants to be completed. An additional resource person may be required to assist in the training. • 1-2 weeks course on breeder and foundation seed production in Jordan/Turkey for up to 25 participants.	June 2013, Ankara May 2014, Rabat	**Achieved.** Variety identification and maintenance & seed enterprise courses conducted in Ankara Turkey and Rabat Morocco.
		3.23 Provision of sufficient seed of germplasm and varieties for trials and demos in Ninevah and adjacent provinces • Special nurseries of interest to SBAR and MU can be requested through the IN program coordinator • Available seed from previously supplied germplasm to be provided by SBAR and University of Mosul	November 2012/2013	**Achieved.** Seed provided by SBAR and UniMosul in both seasons in the target project areas in Ninevah. Pioneer farmers planted seed for demonstration and seed production in both seasons. Seed harvested in 2014 but quantities unknown.

3.3	Develop sustainable farmer/village-based seed production systems	3.31 Consolidation of existing individual seed producers (18) involved in local seed production and marketing under provincial seed producers association • select/confirm VBSE program coordinator (VPC) • establish VBSE coordination committee representatives of SBAR, Ninevah Agriculture directorate, SBSTC, Mosul Uni., Extension , pioneer famers and entrepreneurs • identification of common issues such as technical (production, equipment, storage) and business operation (planning, management, marketing, etc) for improvement (Mosul Uni and SBSTC) • contact, motivate and empower potential VBSE members to start seed business • organize farmers consensus meetings to establish VBSEs • provision of seed of best bet varieties, input equipment and basic training on technical and managerial aspects for farmer groups • formal registration and establishment of linkages with relevant research, seed, extension and credit facilities • provide advice on business planning, book keeping and seed marketing issues	November 2012	**Achieved.** Four pioneer farmers provided with 400kg nucleus seed in total for quality seed production and marketing in conjunction with SBAR and UniMosul in 2012. Formal approval from MOA of private seed producers for the 1st time in Iraq. VBSE program coordinator (Mr Qahtan Saed) was appointed in October 2013.
		3.32 Establishment of three additional seed production and marketing networks in the new governorates • based on needs assessment and linked to the Nineveh network	Not completed	**Not achieved.** Project terminated before this activity was instigated.
		3.33 Training undertaken for farmers, extension services and other stakeholders (see Obj 5) • organize one week train-the-trainers course on technical and managerial aspects for seed and extension officers on informal seed production and marketing for 10-12 participants (Jordan/Turkey/Erbil)	October 2013, Amman May 2014, Rabat	**Achieved.** Training courses completed.
		3.34 Monitoring and evaluation of technical and economic performance of VBSEs • seed demand survey, business plans, profitability assessment) completed and used to improve performance (Obj 4)	Not completed	**Not achieved.** Not possible due to civil conflict and early project termination.

Objective 4: *Monitor and evaluate adoption and impact of conservation cropping (CC) and identify constraints and enabling policy options for uptake by farmers.*

No.	Activity	Outputs/ Milestones	Completion date	Comments
4.1	Analyse improved technology option performance, profitability, WUE, and acceptance by farmers.	4.11 Farm level analysis of the effects of ZT technology on (a) benefit & costs and (b) production and resource use efficiency • modification of data collection formats for the demo farms • compilation of available datasets (surveys, demos and long term trials in both Iraq and Syria - including irrigation water measurement) • literature review on CA technology evaluations • develop methods • theory (economic, environmental, livestock, input and resource use-efficiency) • data analysis • publications - drafts approved by SL for quality control and documentation before submission/ publishing • policy brief	Sep 2013 Dec 2012 Jan 2013 Jan 2014 Dec 2014 Feb 2014 Dec 2014 Feb 2014	**Achieved.** 2011 Syria survey data analysed and publications submitted. 2011 Ninevah survey data analysed. Two publications produced and others planned.
4.2	Assess effectiveness of improved management options on adaptive capacity of local communities to climatic variability.	4.21 Better understanding of conservation cropping effects on farmers' resilience to risks • compilation of data • explore using crop simulation models for generating data for different states of nature • literature review • theory and methods • collection of missing data • data analysis • publications • policy briefs	June 2014 Sept 2014	**Partially achieved.** Data collected and bio-economic simulation model almost completed. Work ongoing in collaboration with other projects.
4.3	Monitor adoption of improved technologies and identify constraints and provide possible solutions	4.31 Understanding and documentation of diffusion of ZT technology & farmers' perceptions • literature review (theory and methods) • data to be collated in 4.1 & 4.2 for Syria • data collection for Iraq • analysis to determine adoption drivers and constraints and provide recommendations and solutions	Oct 2013 Dec 2012 Sep 2013 Dec 2014	**Achieved.** Literature review completed. Analysis of 2011 Syrian data (adoption and impacts of CA) completed. Iraqi data collected in Ninevah and analysis underway. Surveys in other governorates interrupted by civil conflict.
4.4	Assess the impacts of conservation cropping.	4.41 Understanding, quantification and documentation of economic impacts of ZT technology • use data from 4.1-4.3 for analysis	Oct 2014	**Achieved.** Completed for Syria data and two publications finalized. Iraq data still being analyzed.

4.5	Identify enabling policy and institutional options	4.5 Policies and strategies for the promotion of ZT technologies developed and communicated to policy-decision makers • document current agricultural policies • analyze their effect on CA • policy recommendations to enhance adoption of the CA technologies • publications	Not completed	**Not achieved.** Not conducted in any detail due to early project termination.
4.6	Evaluate and promote sustainability of and lessons learned from conservation cropping projects in Iraq (and Syria)	4.6 Conduct socio-economic training • socio-economic data collection: 25 persons from DoA and 2 persons from new provinces for 5d • socio-economic evaluations for 10 persons for 14d each year • hands-on training for 1 researcher for 6 mths in Australia	May 2014	**Achieved.** Survey formulated, enumerators trained, and survey completed in Ninevah. Baseline surveys in the new governorates were not completed due to civil conflict. Hands-on training for Dr Saad Hatem was modified to a 2 wk visit to UniWA.
4.7	Analyze economics of seed and machinery production in Iraq and Syria	4.7 Analyze the economics, market and marketing conditions of seed/machinery production • Review demand for seed and seed producers businesses • Review machinery manufacturer businesses • Feed key outcomes back to Obj 1 and 3.	Not completed	**Not achieved.** Not conducted due to civil conflict and early project termination.

Objective 5: *Enhance capacity of Iraqi research and extension institutions to develop and promote conservation cropping.*

No.	Activity	Outputs/milestones	Completion date	Comments
5.1	Raise awareness and provide training in Ninevah for Iraqis (managers, scientists, extension officers, farmers).	5.1 Increased awareness and understanding of CC in 10 new Ninevah districts and three new governorates especially for the 25 DoA extension specialists, other staff from the new governorates and farmers (20 persons x 7 days per visit) of: • Introduction to conservation cropping systems • ZT systems - entrepreneur farmers need to be identified & linked with objective 5.2 • ZT seeders - technical inputs important – ZT seeders/seed production – Obj 3. • seed production • spring field day – ZT v CT for farmers / technicians • media visit - 'Drumming' public relations / exposure	Jul 2013/14/15	**Achieved.** These activities increased the level of CA awareness and knowledge significantly among managers, scientists, extension officers, and farmers in Iraq. Outputs produced in Ninevah and new governorates although the civil conflict reduced activities during 2014. Also see Obj 1.1, 1.2 & 1.3.
5.2	Provide short- and medium-term training and joint data analysis at ICARDA presented by Australian and ICARDA scientists.	5.2 Courses conducted with field visits (if relevant) in: • scientific & report writing (10p x 7d x 2 visits) • participatory extension (18p x 14d x 2 visits) • ZT seeder design/performance (16p x 14d x 4 visits) – Obj. 5.1 • statistical analysis (10p x 14d x 2 visits) • ZT agronomy research (2p x 28d x 4 visits) - Obj 2.14 • spring farmer visit (20p x 7 x 3 visits) • seed production (10p x 14d x 2 visits) - Obj.3.2 • seed enterprise management (10px 14d x 3 visits) • socio-economic data collection: (20p x 7d) – Obj 4.6 • socio-economic evaluations (10p x 14d x 3 visits) – Obj. 4.6 • socio-economic students (3p x 2 mths x 3 visits) - Obj. 4.6	April 2013 (16p) May 2013 (11p) A field day at Erbil May 2013	**Achieved.** Training activities completed as planned except second statistical analysis, agronomy research & farmer visits, and socio-economic students, due to project termination and timeliness of Erbil/Jordan trials. Socio-economic data collection course conducted in Mosul by Dr Saad Hatem (not Erbil as planned) due to security issues.

5.3	Continue long-term training/joint research and MSc/PhD graduate research at Australian partner universities.	5.3 Conduct visits and postgrad training on CC in Australia • 2 visits x 6 mths to UWA for agronomist & socio-economist • 2 visits to Uni SA/Uni Ad for machinery counterparts, 3 wks Obj. 5.1 & 2.21 • 4 MSc and one PhD student (commenced Jan 2011) • 1 MSc graduate UWA (to commence 2012)	Nov. 2014	**Achieved.** 6 mth agronomist visit to UniWA will be completed by Dec 2014. 6 mth socio-economist visit was changed to 2 weeks in Aug 2014. One machinery visit to Uni SA/Uni Adel completed in Aug 2014. Also one visit to Konya for Iraqi and project staff in May 2014. Two postgraduate students from UniWA completed their study, and one from Uni Adel withdrew due to health problems. The other three students expected to complete by Dec. 2014.
5.4	Support Iraqi collaborators to attend workshops/ conferences.	5.4 Support for collaborators to attend conference or workshops • overseas trips for 2p per year	Nov, Dec 2012 Mar Nov 2013, May, Jun 2014	**Achieved.** Mohammed Altaweel, Mohamed Jabbar Abdulradh, Mujahid Hamdam and Stephen Loss attended 4 conferences in 2013/14. Project delegation attended CA workshop in Konya Turkey. Stephen Loss & other project staff attended the World CA Congress in Jun 2014.

7 Key results and discussion

7.1 Promotion and Adoption of Zero-tillage

The favourable results with ZT in the adaptive research program in Syria and Iraq were replicated in the participatory demonstration and extension program during 2012 to 2014 in Iraq, even in the absence of significant levels of residue retention or diversified crop rotation. In most cases crop yields with ZT, early sowing and reduced seed rates were equal to or greater than the conventional crop management methods, and the estimated income was usually greater because of reduced input costs. Farmer field days were conducted at each site, often at sowing, after crop establishment, and in late spring. The demonstration program was largely conducted in a participatory approach where leading farmers had a direct and positive impact on adoption by other farmers in Iraq. During the 2013/14 season the area of adoption had reached about 15,000 ha, by about 100 large farmers who converted the existing conventional seeders to ZT (Fig. 2). This mainly occurred in Ninevah where the level of awareness was higher than the new governorates because of previous project activities. In 2013 some farmers planted early into dry soil with ZT seeders and many others took advantage of rains in October to plant their crops much earlier than usual. Almost all farmers who tested/adopted ZT were either directly involved in the demonstration program or those that had attended a project field day.

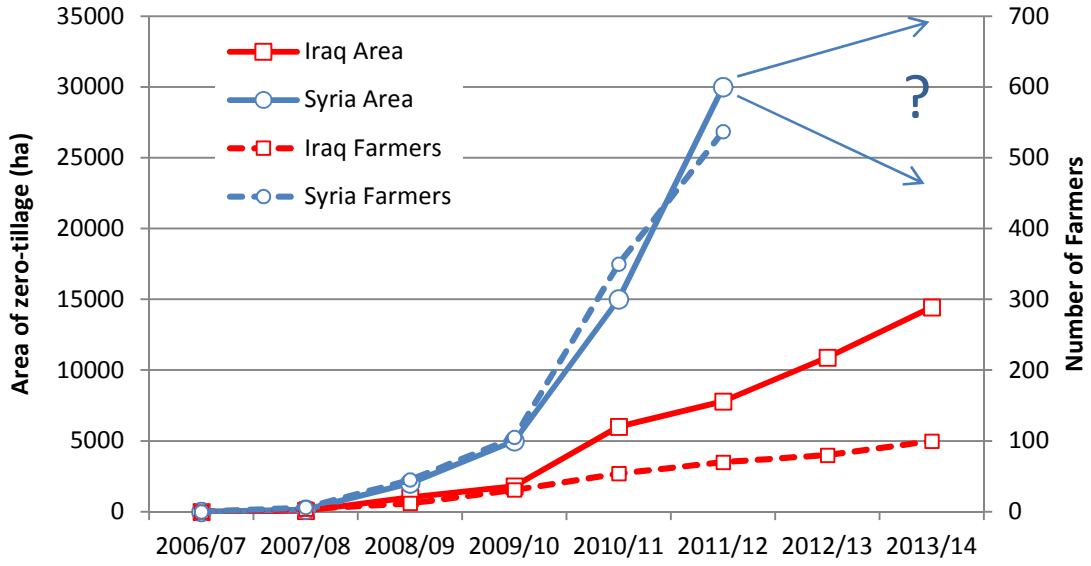

Fig. 2: Area and numbers of farmers adopting ZT technology in Iraq (red) and Syria (blue) since the first phase of the project. Accurate figures were not available for Syria since 2011/12.

The 25 DOA extension specialists from Ninevah and extensionists from other governorates (all trained by the project in 2013/14) were actively using the demonstrations to boost awareness of CA, and many farmers expressed interest in testing the technology in the coming 2014/15 season. For example, one DOA collaborator Mr Marwan Mahmood spoke of 50 farmers being keen to test ZT technology following the first ZT demonstrations in the Garmiyan region. Also in Ninevah, after a successful demonstration activity in Awainat village, all farmers from the village indicated their eagerness to use the ZT planting method in the next season, potentially an area more than 5,000 ha. It was encouraging to see female extensionists initiating awareness raising activities in Iraq, following their attendance in the participatory extension training program. One example

was Dr Asma Zuhair Younes Al-Hafdh from the University of Mosul who undertook a program to speak to school students in rural areas about the concepts and practices of CA (Fig. 3).

Fig. 3: Dr Asma Zuhair Younes Al-Hafdh (University of Mosul) raising awareness of CA among school students in rural areas in 2013.

Before the outbreak of widespread civil conflict in Syria in 2012, the area of adoption had reached 30,000 ha in 2011/12 and was increasing rapidly. Seven workshops were producing cost-effective ZT seeders and 14 participatory extension groups were operating throughout the country, which were largely an initiative of the government research and extension agencies and farmers, with minimal support from the project. From 2008/09 to 2010/11 many farmers recorded the yields of their crops sown with the new technology and nearby field managed conventionally. Given this was the first time that many of the farmers had used the technology, it was surprising that ZT produced similar or significantly greater yields than conventionally managed fields - the conventionally managed fields out-yielded ZT in only a handful of cases. On average over all three seasons the grain yield increases with ZT compared to CT were 0.26 t/ha (15%) for barley, 0.33 t/ha (19%) for wheat and 0.24t/ha (21%) for lentil (Table 1). By 2011/12 the message of the yield benefits and cost savings with ZT and early sowing were spreading spontaneously by word of mouth from village to village, and in some areas in the north east group leaders stopped recording the numbers of farmers adopting the technology because it was difficult to find farmers that were still using conventional tillage.

Table 1. Summary of Syrian farmer yields comparing ZT plus early sowing with conventional tillage (CT) in nearby fields from 2008/09 to 2010/11 for the most common crops (Loss et al. 2014).

Crop	No fields	Mean yield ZT t/ha	Mean yield CT t/ha	Difference t/ha
Barley	278	1.99	1.73	0.26
Wheat	264	2.07	1.74	0.33
Lentil	88	1.36	1.12	0.24

After the start of Syrian conflict it was not possible to get accurate adoption figures because of communication and travel restrictions, and the relocation of many staff. Fuel became in short supply and farmers were keen to reduce their personal risk by minimizing field activities (like ploughing) and transport of tillage and other equipment on public roads. ZT helped address these issues. One farmer from Qamishley, Mr Ali Alewi said that he was able to sow four times the area of crop because of the fuel savings with his ZT seeder in 2012. Some unconfirmed estimates of adoption in 2012/13 were as high as 50,000 ha (Haddad et al. 2014). However, within a year or two of the outbreak of the conflict, all but one of the workshops manufacturing ZT seeders had closed because of poor supplies of raw materials and electricity, and a lack of ZT seeders prevented any further adoption. In many areas farmers also reported the theft of agricultural produce and equipment, and farming generally became much more difficult to conduct. According to FAO, after two years of conflict the area of wheat and barley production in Syria in the 2012/13 season was less than half normal levels due to lack of inputs, damage to infrastructure (e.g. irrigation channels), displacement of farmers, and general security concerns (http://www.fao.org/news/story/en/item/168676/icode/). So it is possible that the area of ZT in Syrian is currently declining.

Nonetheless, project collaborators in some areas continued with their work in Syria. Of particular note is Mrs. Rehab Khateeb, from the General Commission for Scientific Agricultural Research, who has continued her research trials, extension activities and working with farmers and a local machinery workshop to convert seeders to ZT over the past two years in Salamiyah, despite severe conflict in this area. In collaboration with project staff and a local machinery workshop, she was instrumental in the recent development of a small ZT seeder to be used in experimental/demonstration trials among olive and fruit orchards at Lattakia. Mrs. Khateeb was also able to travel to Erbil Iraq in October 2013 and helped deliver training on participatory extension to Iraqi collaborators.

7.2 Machinery Developments

Given the successful promotion activities in Ninevah and other governorates, it was apparent to project staff that the largest constraint to farmer adoption in Iraq was a lack of commercially available ZT seeders. In fact, a lack of seeders was also limiting the number of demonstrations. Project staff, led by Dr Jacky Desbiolles from UniSA and in collaboration with two machinery counterparts based in Mosul (Mr Waad Ahmed and Mr Nawaf Jasm) worked with two workshops based in Mosul to produce ZT seeders that were cost-effective, 3-point linkage, and suited to the size of tractors owned by small to medium sized farmers in northern Iraq. With strong farmer input the first workshop in Bashiqah produced the first nine-tined ZT seeder with presswheels in November 2012, named *Ras Alrumh* meaning ‘spear head’ (Fig. 4). This was evaluated by the machinery team in Erbil and more broadly in Ninevah, while recommendations for improvements were implemented during the 2012/13 season. With financial support from the project higher quality and more cost-effective parts were sourced from Turkey and Australia, and a batch of four improved seeders was completed during 2014. Plans to manufacture a batch of 14 *Ras Alrumh* seeders for the 2014/15 season were underway. The second manufacturer in Mosul (named *Al Hafidha, meaning ‘conservation’*) produced its first 10-tine ZT seeder including presswheels in late 2013 (Fig. 5) with significant input from UniMosul. Several design deficiencies were also identified by the machinery team in Mosul and plans for the construction of a second prototype were being finalized. In addition to the newly manufactured seeders, a work plan involving the two Mosul workshops was underway to produce kits for the conversion of 40 conventional seeders to ZT for interested farmer in the 2014/15 season funded by the project. Unfortunately, all ZT seeder developments came to a halt when Mosul was invaded by ISIS in June 2014.

From the start of this phase of the project in 2012, project staff also worked with a machinery manufacturer based in Amman Jordan (Rama Agricultural Equipment Manufacturing, (www.ramajordan.com) to produce an initial 3.6m trailed prototype ZT

seeder (consisting of 16 tines with presswheels supplied from Mosul) which was tested and used to sow trials at Maru Research Station in Jordan. The machinery team also successfully converted a John Shearer 2.4m pasture seeder owned by the Ministry of Agriculture and Water Resources in Erbil to ZT including the addition of presswheels in November 2012, and this was used to sow experiments at Ankawa Research Center. Almost a year later, a conventional 3.6m trailed Rama seeder was also converted to ZT including low cost 'snake chains' rather than presswheels. These ZT conversions became examples for modifications applicable to a large number of existing seeders in Iraq (Rama, John Shearer and Nardi). Continuing collaboration with Rama resulted in the development of a smaller, 10-tined, 2.3m, 3 point linkage prototype in mid-2013, and they were subsequently contracted to supply 12 such seeders into Iraq for the 2013/14 demonstration program. Unfortunately, there was a delay in the order and manufacturing was rushed, and by the time the seeders arrived in Iraq during December 2013, all governorates had received good rain and completed sowing their demonstration programs. It was evident from limited testing in Iraq that the quality of manufacture was poor and some critical parts (e.g. the gear boxes) were not functioning effectively. A review of these issues guided Rama to correct these deficiencies under warranty although recent conditions in Iraq have not allowed this to occur. Specifications for an improved 10-tined ZT seeder (Rama II) were developed and this second generation prototype was tested in the field under heavy residue levels in Jordan in September 2014 with promising results (Fig. 6). Four such Rama II ZT seeders were produced for various research projects in Jordan and Palestine. Specifications for the next prototype (Rama III) have been compiled with the aim of producing a reliable, low cost (around US$7 K) ZT seeder which may find a market throughout the Middle East and North Africa.

In addition to the locally manufactured Iraqi and Rama seeders, two brands of ZT seeders from Iran were also introduced and successfully tested in Erbil and Kirkuk as part of the project. So by the middle of 2014, there were more than five brands of low cost ZT seeders (US$5-10 K) originating from three countries, potentially available in northern Iraq. These are in addition to the Syrian suppliers who were not manufacturing in 2013/14.

The final machinery development activity was the design and construction of two ZT plot seeders, manufactured by Agribits Pty. Ltd. (www.agribits.com.au) in South Australia. In October 2014 both seeders were shipped to ICARDA Jordan, and one will be sent from Jordan to UniMosul when the conditions in northern Iraq will permit its safe use. These custom-made experimental seeders were co-developed with Dr Jacky Desbiolles from UniSA and are highly flexible in terms of row spacing, rank spacing and height, lateral seed spread and opener options, and plot length. They include up to eight rows and combine cone seeder and drill box technology suitable for small experimental plot and larger block sowing, and will be vital for future ZT machinery research in Iraq and Jordan.

Fig. 4: The second Ras Alrumh seeder prototype being tested in Mosul in 2014.

Fig. 5: The first Al Hafidha seeder prototype produced in Mosul in late 2013.

Fig. 6: Field testing of the Rama II ZT seeder produced in Jordan in September 2014.

7.3 Adaptive Research Program

7.3.1 Iraq and Jordan

The adaptive research experiments conducted by ICARDA in Ankawa Research Centre, Iraq and Maru Research Station, Jordan during 2012/13 and 2013/14 generally confirmed results of trials conducted previously in Aleppo Syria. On average over a number of contrasting seasonal conditions, yields with ZT were similar to, or slightly greater than, conventional tillage (CT) for the common crops grown in the region. Although there were individual exceptions, in most experiments crops sown soon after the first autumn rains out-yielded crops where sowing was delayed by about four weeks, under both ZT and CT, except chickpea which suffered from greater disease and poor pot set with early sowing. As had been found in many parts of Australia, ZT allows crops to be sown 4-6 weeks earlier than CT crops because there was no need to wait for weeds to germinate after the first autumn rains, and this boosts yields and water-use efficiency significantly. When ZT was combined with early sowing this boosted yields in almost every experiment conducted in Syria, Iraq and Jordan. In a long term trial in Syria over four seasons, yields of wheat, chickpea, barley and lentil yields were increased by 18, 20, 12 and 15% respectively with ZT and early sowing compared to the traditional farmer practice of tillage followed by delayed planting (Fig. 7). Using data from the same experiment, it was estimated that savings in reduced fuel and machinery use in the ZT treatments amounted to $37/ha and that the gross margins of production (net income) were increased by $161, $140, $88, and $173/ ha for wheat, chickpea, barley and lentil, respectively, with the change from CT to ZT sown early (Piggin et al. in press).

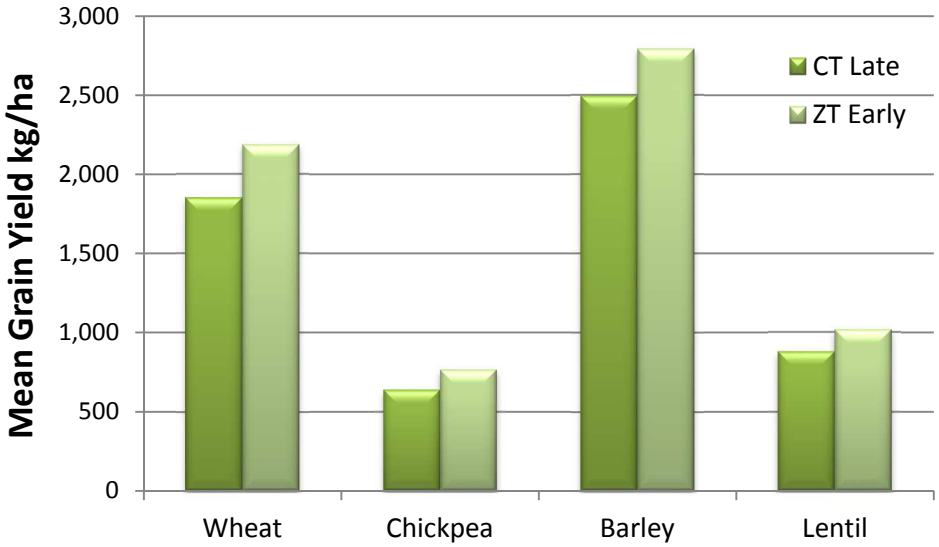

Fig. 7: Mean grain yields of crops sown with the traditional farmer practice (conventional tillage and at a delayed time; CT late) and ZT sown soon after the first autumn rains (ZT early) at Tel Hadya Syria during four seasons 2008/09 to 2011/12 (Piggin et al. submitted).

Crop establishment methods in Iraq and Syria are sometimes basic and farmers often use large seed rates (around 150-250 kg/ha for cereals) to compensate for this. Several experiments across sites and seasons in Iraq, Syria and Jordan highlighted that if crops are sown with good quality seed using an appropriate and well-operated seeder, much lower seeding rates produce similar or greater yields. For example, with wheat at Ankawa in 2012/13, although the lowest seeding rates (40-80 kg/ha) produced the lowest plant density (117-196 plants/m^2) it also produced the highest yields, about 1.0 t/ha more yield than the traditional practice of spreading seed at 160 kg/ha and ploughing it in (Fig. 8). In

this case, the reduced seed rate could represent a saving of about $56-84/ha in addition to the extra grain production.

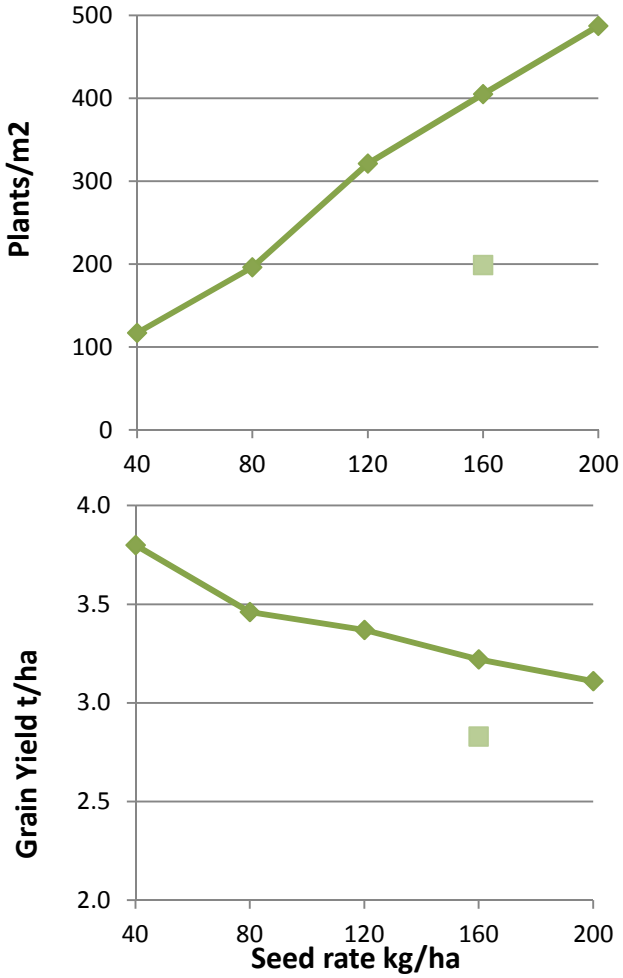

Fig. 8: Mean plant density and grain yields for wheat sown at various seed rates using a ZT seeder, and the traditional practice of spreading seed and ploughing (pale green square) at Ankawa Iraq in 2012/13 (unpublished data).

About 90 research experiments were conducted at UniMosul and SBAR during the course of the project. These included agronomy, machinery innovations, breeding, weed control and integrated insect pest management, and were in addition to 10 postgraduate studies.

7.3.2 Western Australia

Field research measurements conducted by UniWA over three years in a long term CA trial at Cunderdin, Western Australia, showed no change in the disease and insect species present among various rotations and residue levels under CA. Pest, insect and disease levels were consistently higher in the continuous cereal and wheat treatments, compared to other rotations and crops, but had no significant impact on yields which were largely determined by seasonal factors, such as rainfall and temperature. Over time with strategic pesticide applications, a level of equilibrium was reached between insect pests and beneficial populations, even under high levels of crop residue. The implementation of CA helped improve integrated pest and disease management, and reduced the reliance on chemical applications. Pesticides were only required for Ascochyta Blight in chickpea and one application for aphids and mites in pasture treatments when numbers reach threshold levels in spring. However, disease and pest levels were generally low at this site during the course of this study, and changes in stubble and pest management practices

may be required in other situations where pressures are greater e.g. in higher rainfall areas or seasons.

In a separate study over four years and multiple sites, light grazing of crop residues by sheep for several weeks over summer had little effect on percentage ground cover and amount of stubble, and hence there was little increase in the risk of erosion. Light summer grazing, leaving more than 50% ground cover (average 1.8t/ha), had no effect on the yield of following crops. Heavy grazing of crop residues during summer and winter reduced the yields of following crops by 40% at one site in 2012. Canola was most susceptible to yield loss after heavy grazing with up to 30% yield reduction at several sites. Grazing had little effect on soil organic carbon and soil chemical components over four years. However, grazing of pasture paddocks on heavy-textured soils over winter and summer increased soil bulk density, reduced rainfall infiltration and reduced yields due to a degradation of the soil physical structure caused by the sheep. In a third ongoing study which started in 2014 the rate of wheat stubble decomposition and changes in nutrient status will be determined in a long-term trial with continuous wheat and a diverse rotation to understand the effects of management history on residue decomposition.

7.3.3 South Australia

Field trials were conducted by UniAdelaide to evaluate the effects of tillage, stubble and targeted N application in 2013 and 2014. The research focussed on crop physiological responses including canopy development, water extraction capacity and photosynthetic capacity, and their impact yield and yield components. For example, higher yield from the ZT system than conventional tillage was explained by more soil water storage in the early wet period due to higher soil water infiltration and greater water extraction in the late dry period due to higher leaf area index. Yield increases from delayed N application resulted from higher photochemical efficiency, including maximum PSII quantum efficiency, PSII operating efficiency, and photosynthetic electron transport capacity.

On the same trials, root architecture was analysed, using a novel method to quantitatively describe root distortion, which was defined as a change in root direction from the original trajectory due to physical impediment. It was found that ZT and high N application on the structured soil produced a higher root distortion rate. More importantly, root distortion rate was positively correlated with soil pores and water uptake. The results indicated that ZT system not only increased soil water infiltration but also crop water uptake from more distorted roots in soil pores.

Paired soil samples from cropped land and its neighbour uncropped land were collected from 15 locations across South Australia, Western Australia, Jordan and Iraq. Soil DNA is being sequenced to study the metagenomics and function of soil microbial communities under different cropping history and environment. Taxonomic analysis of the Australian samples has been completed and over 600 bacterial species were identified by matching to databases. The richness of soil microbial community under cropped land was higher than uncropped in low rainfall regions (<400 mm) but lower under medium rainfall regions (>400 mm).

7.4 Seed Production

From the start of the project UniMosul and SBAR screened introduced germplasm and identified many lines with superior performance to local varieties. Elite lines of wheat and barley were included in demonstration program each year. Following five years of testing, nine new crop varieties were accepted and released by the national seed committee within the MoA in 2013 - these included bread wheats (Cham-8 and Bohouth-4), durum wheats (Doma-1 and ACSAD-65), and two varieties of barley (Zanbaka and Furat) and three Australian varieties of field peas (Helena, Dunwa and Kaspa). A society for seed production (named *Sanabil Alkhair*) was developed in Mosul and is the first private seed

production community in Iraq. The project helped the launch and support of this society through Mr Qahtan S. Ibrahim and some of the community members who attended the valuable ICARDA training courses in 2013 and 2014.

7.5 Socioeconomics

The socio-economics team from MOA, ICARDA and UWA along with the bio-physical scientists analysed the survey data collected in Syria during 2011. The analysis focused on factors which affect the decision, intensity and speed of adoption and the impact of ZT on productive efficiency, household income and grain consumption. By comparing wheat farmers that adopted ZT and early sowing, with similar non-adopters, the analysis showed that the technology:

- increased wheat yields by 31% (465 kg/ha), or enabled farmers to achieve their current output levels with 22% less inputs.
- boosted income by 25% (US$187/ha),
- increased consumption of grain by 34% (26.4 kg per capita) and
- reduced income risk, lifting 57% of the adopters out of poverty.

Also the results showed that participation in field days and hosting on-farm demonstration trials were very important in enhancing adoption, which is a clear indication of the effectiveness of the extension efforts in Syria.

Meanwhile, effective implementation of the socio-economics studies in Ninevah necessitated the use of data from both the baseline (2011) and follow-up survey in 2014. While some analysis was conducted on the baseline data, the cleaning of 2014 data was delayed because of the conflict in Iraq, and we hope analysis will be completed by the end of October 2014. An initial analysis of the survey and farmer demonstration data suggests at least a 60% reduction in fuel consumption and at least 160 kg/ha extra yield resulting in an additional income of $US 100/ha (under the subsidized price scheme operating in Iraq). If 80% of wheat and barley farmers in Iraq (the typical levels of adoption in many parts of Australia) converted to ZT this would produce an extra 410,000 tonnes of grain and boost farm incomes by a total of $US 256 million per year.

The project also contributed to work conducted by a PhD student from Purdue University (US), Mr David Boussios, in collaboration with the team in Amman, who produced a bio-economic model based on the APSIM model for the Middle East. He is currently assembling all the data required to run the model and will determine the impact of CA on productivity, income and risk to climate change.

The policy implications of these results are that ZT is one of few technologies which can have sizeable impacts on economic and food security outcomes, in addition to the environmental benefits documented in earlier studies and existing literature. ZT and early sowing are relatively simple technologies that can be adopted by most farmers in Syria and Iraq, and policies to promote the spread of ZT seeders could benefit production and food security, boost farm incomes, and help alleviate rural poverty significantly. Education and extension that encourage farmers to participate in field days and host demonstration trials on their own farms are important in promoting ZT technology.

7.6 Capacity Development

Since the start of first phase of the project in 2005, more than 600 Iraqi scientists, extension officers, machinery suppliers and farmers have received training in a range of disciplines and at various levels, thereby providing a foundation of staff for the future extension and dissemination of CA in Iraq. In this third phase of the project, 14 short-term training courses covering a wide range of CA and general topics were conducted in the

Middle East and North Africa which were attended by 219 trainees (Table 2). Most of these courses were enhanced greatly by the translation and contributions of Mr Atef Haddad, Mr Yaseen Khalil and Mr Zardasht Taha. Led by UniMosul, the team in Iraq also conducted many courses for local scientists and farmers, including workshops in the new governorates. Twenty-five young extension specialists from DOA Ninevah were identified to specialise in the promotion of CA and given specific training in aspects of CA at UniMosul during mid 2013, followed up by two courses on participatory extension led by Dr Jim Fortune (Fig. 6). Successful training programs on ZT seeder technology, and variety maintenance and seed production were led by Dr Jacky Desbiolles and Dr Abdoul Aziz Niane, respectively. Also eight MSc and two PhD students completed their degrees in CA at UniMosul.

A two week agricultural machinery study tour to South and West Australia was conducted in August 2014 after the ISIS invasion of Mosul. The machinery delegation from Iraq consisted of Mr Nawaf Jasim (UniMosul), Mr Waad Ahmed (farmer and machinery manufacturer from Mosul), Mr Sarmad Khalil (DOA, Kirkuk) and Mr Zardasht Taha (ICARDA, Erbil). In South Australia they visited various agricultural manufacturers, University of SA, and attended the Mallee Machinery Field Day in Speed Victoria. In Western Australia they visited UniWA and two local manufacturers of ZT machinery and parts. The delegation learned more about Australian ZT systems and the machinery innovations to suit these. The knowledge they gained will help them develop further the manufacture of local ZT seeders which will benefit greatly the adoption of CA in Iraq. A five day study tour to Konya Turkey was attended by five UniMosul staff and two machinery manufacturers in May 2014. The participants attended the Konya machinery fair, a national CA workshop organized by the Turkish Ministry of Agriculture, and inspected ZT agronomy and extension work.

Various Iraqi collaborators attended several conferences with support from the project which increased their knowledge of CA and networks among researchers worldwide. In November 2012 the project supported Dr Mohammed Altaweel (UniMosul) to attend the International Agronomy Conference in New Delhi, and in December Mr Mohammed Jabbar (MoA Ninevah) attended the 3rd International Conference on CA in Southeast Asia, in Hanoi and delivered a paper on his MSc work into CA adoption in Ninevah. Dr Mujahid Hamdan MoA attended the Interdrought Conference, September 2-8 in Perth and the Drought Masterclass during August 27-31, 2013.

The six Iraqi post-grads in Australia all passed the required English training and most completed their courses as planned, apart from Mr Jamal Abdufattah Yousuf who had to return to Iraq after an extended illness affected his studies (Table 3). In addition to these post-graduate students, Dr Moyasser Aziz from UniMosul travelled to UniWA in July 2014 (after the ISIS invasion of Mosul) to spend six months as a post-doctoral fellow. He is researching three topics: 1) rotation, residue management and pest/diseases dynamics under CA; 2) use of an anti-transpirant to improve drought tolerance in wheat, and 3) the effect of breeding on wheat rooting patterns. Dr Saad Hatem (MoA) spent 10 days in Perth during August 2014 working with Dr Amin Mugera (UniWA) and Dr Yigezu Yigezu (ICARDA) to clean the 2014 Iraqi survey data, and analyse the 2011 Syrian survey. Also Mr Yaseen Khalil who worked for four years on the project as an ICARDA Research Associate, was awarded an ACIAR John Allwright Fellowship, and he commenced his English and PhD studies at UniWA in 2014, under the supervision of Dr Ken Flower, Prof Kadambot Siddique, Dr Phil Ward, Dr Stephen Loss and Dr Colin Piggin.

The project budget included a significant investment in capital equipment to enhance local capacity of Iraqi researchers. An order of small manual and self-propelled seeders for breeding and seed production intended for UniMosul and SBAR Mosul arrived in Basra in mid 2014. Because of the ISIS take over of Mosul, this shipment will be transported to SBAR Basra for storage until it can be taken safely to Mosul. The Australian-made ZT cone-seeder for agronomic and breeding field experiments at UniMosul is currently being

shipped to ICARDA Amman for safe keeping. An order for a plot harvester for UniMosul was not finalized following the ISIS take-over of Mosul.

Table 2. Summary of the short term training courses conducted by the project.

Title	**Dates**	**Location**	**# Trainees**	**Leader**
Zero tillage seeder conversion and operation	Nov, 2012	Ankawa Res. Center, Erbil, Iraq	12	Jack Desbiolles, UniSA
Zero tillage seeder conversion and operation	31 Mar - 04 Apr 2013	Ankawa Res. Center, Erbil, Iraq	18	Jack Desbiolles, UniSA
CA agronomy, machinery and extension.	15 May 2013	NCARE, Amman Jordan	20	Stephen Loss & Colin Piggin, ICARDA/ACIAR
Experimental design, data management & analysis	26 - 30 May 2013	Amman Jordan	11	Jens Berger, CSIRO/UWA
Scientific communication and writing	9-12 Jun 2013	Erbil Iraq	15	Richard Sanders, ICARDA
Variety identification and maintenance	24 Jun – 5 Jul 2013	Ankara, Turkey	11	Adoul Aziz Niane, ICARDA
Zero tillage seeder conversion and operation	15-18 Sep 2013	Ankawa Res. Center, Erbil, Iraq	7	Jack Desbiolles, UniSA
Participatory extension of CA (module 1)	30 Sept - 10 Oct 2013	Erbil Iraq	38 for 2 days 23 for 10 d	Jim Fortune, South Australia
Small-scale seed enterprise development and management	20-31 Oct. 2013	Amman Jordan	9	Adoul Aziz Niane, & T. Srinivas ICARDA
Scientific communication and writing	18-20 Mar 2014	Amman Jordan	15	Stephen Loss ICARDA
Participatory extension of CA (module 2)	April 5 - 14, 2013	Amman Jordan	23	Jim Fortune, South Australia
Variety maintenance and quality seed production	21-26 Apr 2014	Rabat, Morocco	4	Adoul Aziz Niane, ICARDA
Community-based seed production and marketing	28 Apr- 2 May 2014	Rabat, Morocco	7	Adoul Aziz Niane & Chilot Yirga ICARDA
Zero-tillage seeder review workshop	Mar 31-Apr 3 2014	Ankawa Res. Center, Erbil, Iraq	6	Jack Desbiolles, UniSA

Fig. 6: The trainees and instructors at the participatory extension training course conducted during October 2013 in Erbil. The course was led by Dr Jim Fortune (centre front), and included presentations from Mrs. Rehab Khateeb and Mr Elias Khouli on the success of their extension programs in Syria.

Table 3: List of Iraqi postgraduate students from UniWA and UniAdelaide and their topics.

Trainee	Degree	University	Topic	Comments
Ayman Taher Mohsen Al Hobaity	Grad. Dip in agronomy	UniWA	Does potassium reduce the effect of drought in wheat and barley?	Completed Dec 2013.
Mahmoud Ahmed Hassan Al Ardeny	MSc in GIS/RS	UniWA/Curtin University	Locating suitable water harvest sites using GIS and remote sensing in West Nineveh, Iraq.	Completed Jul 2014.
Araz Sedqi Abdullah	MSc in agronomy	UniWA	Improving drought tolerance in wheat with the application of an anti-transpirant	Will complete Dec. 2014
Alaa Fakher Kadham Al-Hameedawi	MSc global food & agribusiness	UniAdelaide		Will complete Dec. 2014
Mahdi Salih Khudhur	MSc plant biotech, breeding	UniAdelaide		Will complete Dec. 2014
Jamal Abdulfattah Yousuf	MSc plant biotech, breeding	UniAdelaide		Did not complete due to illness. Returned to Iraq in Dec 2013.

8 Impacts

The project's impacts are discussed below as of early 2014, before the escalation of civil conflict and the ISIS take-over of Mosul and other areas of Iraq. It is difficult to speculate on the impact of the project over the next five years as this will largely depend on the cessation of violence, and the levels of political and social cohesion within Iraq. If peace is established in Iraq over the next few months, then the adoption of ZT would be expected to continue to increase after the end of the project. Awareness of CA, particularly ZT, among researchers, extension specialists, manufacturers, farmers, and the general community is now reasonably widespread (although not to the extent of Syria) and this will drive further developments by the two ZT seeder manufacturers in Mosul, and the commercial importation of ZT seeders from Jordan and Iran is also likely. In 2013/14, the MOA in Baghdad was working on plans to out-scale ZT to the irrigated regions central and southern Iraq, an indication of their acceptance of the benefits of technology. At the final project meeting in October 2014, a list of recommendations was collated to encourage the MOA to formally launch a CA program to further develop and promote CA technologies throughout Iraq. These recommendations along with a summary of the projects achievements will be communicated from ICARDA to the Iraqi Minister of Agriculture.

The opening of the Conservation Agriculture Research Center for Dry Areas at UniMosul (see Fig. 9) in late 2013 will help ensure the principles of CA are taught at undergraduate and postgraduate levels and will act as a focal point for CA research and extension in Iraq for many decades to come. This center, which includes a gene-bank and crop improvement facilities, was funded by UniMosul based on the success of the project. In another encouraging development, some groups of farmers proud of their achievements and keen to spread the benefits of ZT technology had independently organized and funded their own field days and UniMosul and MOA are working closely with these groups.

Fig. 9. The Conservation Agriculture Research Center for Dry Areas was opened in late 2013 at UniMosul.

Sadly, it is unlikely that the conflict in Iraq will end in the next few months, and violence and civil unrest could persist many years. However, this region has practiced agriculture for more than 8,000 years and seen many violent conflicts come and go over the millennia. Most project collaborators (farmers, extension workers and researchers) appear to be reacting calmly to the situation, adopting a 'wait and see' approach. A core group of

leading farmers in Ninevah are convinced of the benefits of ZT and early sowing, and they will continue to use these technologies when they are able to. Based on anecdotal evidence from the conflict zones of Syria, it is possible that the area of ZT in Iraq may actually increase in the short-term even if the civil unrest continues, provided farmers can go about their jobs without major disruption to inputs and personal safety, and there is a mechanism to sell their products. As is the case in Syria, seeder manufacturing activities in Ninevah have ceased at the moment due to the insecurity and problems with importing parts and materials.

Since ZT and early sowing are relatively simple technologies which can be adopted by most farmers to significantly increase grain production and food security, while helping to alleviate rural poverty was not lost on the Syrian government. During 2013 they announced a program to support the production and distribution of 200 ZT seeders. However, because of the expanding impact of the civil conflict on workshops, this initiative was not implemented. If peace is restored in Syria within the next 4-5 years, it is likely the expansion of ZT will re-commence relatively quickly, as the area in 2011/12 had established a large critical mass of farmers convinced of the value of the technology and as many as seven companies were producing ZT seeders. By contrast, the area of adoption in Iraq is about half the area in Syria, and the two workshops near Mosul are less advanced than those in Syria, so there is considerable doubt whether adoption of ZT will resume rapidly over a widespread area if the current conflict persists over a 4-5 year period.

Once peace returns to Iraq and Syria, CA, particularly ZT and early sowing, will be needed more than ever to boost agricultural production, food security and rural livelihoods.

8.1 Scientific impacts

The research component of the project produced several scientific papers and book chapters, either published, submitted or still being finalised, and results were also presented at various conferences and workshops (see the list of project publications in 10.1). These results increased the level of knowledge of CA in the Middle East, especially the fact that farmers in the region can derive significant benefits from ZT when combined with early sowing of crops, even in the absence of diverse rotations and retention of crop residues. Results of investigations in Western and South Australia also add to the body of knowledge on CA in Australia, much of which is applicable to other areas that experience a Mediterranean-type environment. The Australian research provided a fundamental understanding of plant and crop physiology, and farming systems that could be extended within Iraq or the region. The Australian trials and research were showed to visting Iarqi trainees during their visits to Western Australia and South Australia.

8.2 Capacity impacts

The project's capacity development program resulted in significant increases in the knowledge, skills and abilities of Iraqi researchers, extension specialists, machinery manufacturers, seed producers and farmers, not only regarding CA but other generic topics such as extension methodology, experimental design and analysis, scientific communication, and field trial management. The trainees will continue to use their enhanced capacities throughout their careers, long after the end of the project. It was rewarding to see most trainees engaging keenly in the training activities and then to return to their workplace and utilize the lessons learnt, although sometimes their institutions and/or a lack of resources did not allow them to pursue these aims. Project staff tried to target young upcoming trainees, but given the complicated approval processes in Iraq, this was not always possible.

8.3 Community impacts

8.3.1 Economic impacts

The farmer household surveys and socioeconomic studies in Iraq and Syria show clear biological and economic benefits of the adoption of ZT and early sowing. In the 2011 Syrian survey the estimated the extra income was US$187/ha. In most states of Australia, adoption of ZT and early sowing is about 80%. If 80% of the area of wheat in Syria (total 1.7 million ha before the war) was converted to ZT and early sowing, then this could boost production by about 630,000 tonnes p.a. and increase farmers' incomes by US$254 million across the country. In addition, similar increases might be expected with other crops. Based on the farmer demonstrations and an initial analysis of the Ninevah farmer survey, the estimated economic benefit of ZT and early sowing in Iraq was around $US 100/ha. If 80% of wheat and barley farmers in Iraq (total 3.2 million ha) converted to ZT this would produce an extra 410,000 tonnes of grain worth about $US 256 million per year.

The machinery development activities of the project greatly enhanced the technical capacities of the manufacturers and created new business opportunities in Syria, Iraq and Jordan. In particular, the collaborative work with Rama Agricultural Equipment Manufacturing in Jordan improved their understanding of the interaction between seeder performance and crop establishment and growth. Prior to the project, no Rama staff had actually seen a seeder working in the field. In addition to creating a new product for Rama and potentially growing their market, the collaboration prompted them to examine and improve quality issues throughout their production processes.

The machinery activities of this project also produced some economic benefits for Australia. Overall, this project, together with the ACIAR-funded CA in North Africa project, facilitated constructive interactions between leading farmers and researchers in-country and many ZT seeding equipment manufacturers in Australia - i.e. 8 small and medium size Australian companies have supplied ZT technologies for in-country evaluation over the last three years and had first-hand discussions with the local stakeholders through visits organised in Australia. In terms of outcomes for Australian industry, as a result of the project collaboration with ICARDA and the University of SA:

1) John Shearer Ltd. is now upgrading some of their small seeder lines to improve suitability to these markets and is developing corresponding brochures in Arabic and Kurdish to support renewed access to these former markets.
2) AgriBits Pty. Ltd. has now manufactured two specialised ZT plots seeders at a much reduced cost compared to international alternatives, which will represent an attractive new technology to enable in-country CA research both on agronomy aspects of CA systems but also on ZT seeding system suitability. Over the last 12 months, three additional models have already been ordered by Australian research teams, with a strong interest expected internationally once the company's related website page becomes available.
3) Agpoint Australia and Primary Sales Australia have supplied more than 1,000 tungsten protected narrow points to both project regions with the potential to create an on-going commercial linkage in the supply of quality ZT furrow openers for the two project regions (Iraq/Syria/Jordan and North Africa).

The initiation of private seed production in Ninevah, the first of its kind in Iraq, also created new business opportunities for farmers.

8.3.2 Social impacts

The socioeconomic studies also showed that if ZT is widely adopted, improvements in rural livelihoods will help reduce poverty and hunger, and hopefully produce more

prosperous civil societies. The Syrian survey showed that the technology boosted production and increased consumption of grain by 34% (26.4 kg per capita) while reducing income risk, lifting 57% of the adopters out of poverty. Feedback from the participatory farmer groups in Iraq and Syria included the fact that the elimination of ploughing frees up time for other income generating or social activities.

The extension programs were a catalyst for improved farmer cooperation and greater interaction between researchers, extension specialists, manufacturers, input suppliers, NGOs and other parts of rural communities in Iraq and Syria. An important development was the formation of the Mosul Society of Conservative Agriculture, a group of farmers and scientists who encouraged and supported CA development and education in Ninevah. This group was led by Mr Sinan Jalili an outstanding farmer with qualifications as an engineer, and one of the driving forces behind the *Ras Alrumh* seeder. Mr Jalili commented that prior to the project, most farmers in Iraq were not used to sharing technical information and personal experiences outside their own immediate family group or village, and that the formation of the farmer society fostered a more cooperative approach among a wide network of farmers which helped strengthen agricultural communities.

It was good to see the involvement of several women in the research and participatory extension training programs – several examples were highlighted earlier in this report. But the overall gender balance of project activities was heavily weighted to men. The opportunities for women to be involved in research, development and extension projects in the Middle East are often limited, especially in conservative areas of Iraq and Syria where religious and cultural values, beliefs, attitudes, rules and practices restrict the participation of women. These will change slowly as education and awareness of gender imbalances is increased.

For many collaborators, the project provided a stimulating and useful distraction from the increasing civil unrest in Iraq and Syria. The project team was amazed to see the way staff in Iraq and Syria went about their work and studies when it seemed their society was falling apart, even when this involved considerable personal risk. People in conflict zones often try to go about their personal and work lives as best they can because this helps relieve their psychological stresses and worries.

8.3.3 Environmental impacts

Studies of the changes in soil fertility among the long-term CA trials near Aleppo were conducted in the second phase of the project and analysed and published recently (Sommer et al. 2014). They considered that increases in crop yield under ZT with crop residue retention could be linked to improvements in a range of soil fertility and quality indicators including higher soil organic matter and microbial biomass contents, increased levels of extractable phosphate, higher amounts of larger water-stable soil aggregates, increased water infiltration capacity and soil water retention. The build-up of soil organic matter and associated carbon sequestration was in the range of a modest 0.29 Mg C/ha/yr. High amounts of surface residues delayed the desiccation of the topsoil during the summer fallow period, but could not diminish the overall longer-term drying of the topsoil. It was concluded that the observed positive changes in soil quality over six years were relatively small, but nevertheless, in combination with the economic savings that ZT offers, provide an attractive option for farmers, from the standpoints of economy and ecological efficiency, especially in the long term.

There is considerable previously published information showing that when ZT is adopted along with the retention of crop residues, the risk of wind and water soil erosion is minimized. Consequently, the loss of fertile top-soil and the incidence of dust storms should also be reduced as ZT adoption spreads.

8.3.4 Regional impacts

This project and its predecessors have had considerable impact throughout the Middle East, North Africa and Central Asia. The success of this project have inspired the development of projects and other initiatives to promote the adoption of CA in Morocco, Algeria, Tunisia, Egypt, Sudan, Palestine, Turkey, Iran and Tajikistan, where the key lessons learnt in Iraq and Syria are being applied. The manufacturers in Iraq, Syria, Jordan and Iran, have the potential to supply ZT seeders to the region.

8.3.5 Communication and dissemination activities

Monthly (or bi-monthly) activity reports were produced for project collaborators to document progress and issues during the project implementation. Annual project meetings were conducted in Amman where Iraqi, ICARDA and Australian colleagues interacted closely while reviewing results and progress, revising work plans, and arranging upcoming activities.

The project was well represented at World Congress on Conservation Agriculture in Winnipeg Canada, with three poster and three oral presentations (see publications). Results from the baseline Ninevah survey in 2011 were also presented at the 3rd International Conference on CA in Southeast Asia (Hanoi Dec. 2012). Dr Stephen Loss presented project progress and outcomes at the International Conference on Development of Drylands, (Beijing, Mar. 2013), the American Society of Agronomy, (Tampa, Nov. 2013), 7th Conservation Tillage and Direct Drilling Workshop, (Konya May 2014), and various other smaller workshops and meetings.

Each year several blog articles on project activities were posted on the ACIAR website, and the project was also featured in several ICARDA and ACIAR annual reports. Project staff collated information on a range of topics for ICARDA's CA webpage (http://www.icarda.org/conservation-agriculture/teaser) which also contains several machinery fact sheets.

A full list of scientific publications arising from the project is presented in section 10.1. Of particular importance is the chapter by Loss et al. on the "Evolution and Adoption of Conservation Agriculture in the Middle East" for the book 'Conservation Agriculture' edited by Farooq & Siddique (Springer Science Nov. 2014) which provides a comprehensive summary of the project justification, methods, results, outcomes and implications for the region. In the same book there is also a chapter in the impact of ZT in Syria by Yigezu et al. Because of the early termination of the project, numerous papers are currently in preparation and can be expected to be published in the next year or so.

9 Conclusions and recommendations

9.1 Conclusions

The project was successful in increasing knowledge, awareness and adoption of CA in Iraq, Syria and elsewhere, although progress was severely interrupted by escalating civil conflict in both countries.

This was achieved largely by the development of:

1) adaptive research programs which calibrated what was already known about CA in Mediterranean and other environments from around the world to local conditions and farming systems;
2) flexible crop production packages that emphasised ZT as the most important principle of CA because it produces an immediate cost saving while enabling early sowing, which boosts crop growth, water use efficiency, and grain yield;
3) ZT seeders that are tine-type, simple, cost effective, and ideally locally manufactured; and
4) participatory extension groups where farmers and other stakeholders tested ZT on-farm using the farmer's inputs, labour and equipment, with little or no financial or other incentives, other than free access to a ZT seeder.

The research experiments and subsequent farmer adoption clearly showed that ZT when combined with early sowing is one of few technologies which can have sizeable impacts on crop production, farm income and food security outcomes, even when other principles of CA (i.e. soil cover or crop residue retention, and crop rotation) are not adopted.

By comparing Syrian wheat farmers that adopted ZT and early sowing, with similar non-adopters, an analysis showed that the technology:

- increased wheat yields by 31% (465 kg/ha), or enabled farmers to achieve their current output levels with 22% less inputs.
- boosted income by 25% (US$187/ha),
- increased consumption of grain by 34% (26.4 kg per capita) and
- reduced income risk, lifting 57% of the adopters out of poverty.

The socio-economic anlaysis of the Iraq data is still being finalised, but the estimated yield increase is about 160 kg/ha, while income is boosted by $US 100/ha. Environmental outcomes and resilience to climate change are also enhanced when soil cover and rotation are also employed, but these are more difficult for farmers to adopt. However, once farmers experience the benefit of ZT and early sowing, many are keen to explore the other CA principles.

The machinery team were successful in expanding the availability of ZT seeders in the Middle East and North Africa. At the end of project there were more than five brands of low cost ZT seeders (US$6-10 K) originating from Iraq, Jordan and Iran, potentially available in northern Iraq. Replicating success of earlier project phases in Syria, the team assisted two workshops in Mosul and one in Jordan to produce locally constructed ZT seeders suitable for small to medium farmers in the region.

Efforts in Syria and Iraq showed that education and extension strategies that encourage farmers to participate in field days and host demonstration trials on their own farms are important in promoting ZT technology, especially when conducted in a participatory approach.

The capacity enhancement program successfully conducted 14 short-term training courses, various study tours and work experience programs, and six Iraqi students

undertook postgraduate study in Australia. This program is expected to provide long term benefits to Iraq's capacity to undertake agricultural research and extension, and promote CA in the future.

Conducting research and development projects in conflict zones is unpredictable and risky. Project staff from ICARDA and Australia were unable to travel to the target areas in Iraq (Ninevah, Anbar, Kirkuk and Salahaddin) because of security concerns, and this restricted their input. However, successful annual review and planning meetings in Amman, and other implementation meetings and training courses were conducted in Erbil. We were amazed to see the dedication of most staff in Iraq and Syria to the project, and their efforts to pursue their work and studies when this involved considerable personal risk. People in conflict zones often try to go about their personal and work lives as best they can because this is important for their psychological well-being.

9.2 Recommendations

1) Conservation agriculture technologies, especially ZT and early sowing of crops, will be important practices to boost sustainable agricultural production, food security and rural livelihoods in Iraq and Syria, when the current civil conflict in these countries ends. Once peace returns, adoption of ZT will probably recommence of its own accord in Syria, however in Iraq this could be enhanced greatly with in the revitalization of the MoA extension service, especially using participatory extension approaches and on-farm testing and demonstrations.
2) ZT and early sowing are relatively simple technologies that can be adopted by most farmers in Syria and Iraq, and policies to promote the manufacture and spread of ZT seeders could benefit production and food security, boost farm incomes, create local employment, and help alleviate rural poverty significantly.
3) There is a need to promote the adoption of crop rotation (especially legumes) to boost the sustainability of cropping systems in the Middle East and North Africa. Before this is attempted, an analysis of the constraints to adoption would be helpful, especially the impact of government subsidies on wheat price (promoting wheat production at the expense of other crops) and bread price (favouring consumption of wheat) on food security, and alternatives investigated. Ways to lift legume productivity and reduce costs of production (weed management and mechanical harvest) should be further explored.
4) While most farmers in Iraq and Syria were able to derive significant benefits from the adoption of ZT and early sowing without retaining crop residues, the long-term trade-offs between the retention of crop residues for soil fertility plus the productivity of following crops, and their use as a stockfeed are not well understood in the region. Crop residues are a highly valued stockfeed in the Middle East and North Africa, and most farmers believe they can derive greater income from grazing their crop stubbles than protecting them for soil conservation purposes. This deserves greater research and alternative stockfeeds need greater exploration to enhance the sustainability of farming systems in the region.
5) We recommend that ICARDA maintain the tillage treatments in the three long-term trials at Tel Hadya (one commenced in 2000), if security is sufficient for staff. These trials are an important resource for future studies into the long-term benefits CA in the Middle East. ICARDA should also maintain its expertise in CA and crop agronomy.
6) Collaborators should complete the data analysis and numerous scientific papers arising from the project as soon as possible.

7) At the final project meeting, a recommendation was formulated that the MOA instigate a national program to develop and promote conservation agriculture throughout Iraq. The activities of the program could include:

- Increase the availability of ZT seeders through local conversion, manufacture &/or import from Jordan, Iran or elsewhere. The option of government subsidies could be examined.
- Establish CA unit or branch in each governorate.
- Provide training (led by Uni Mosul) in CA & participatory extension for CA extension specialists.
- Form CA testing groups involving all stakeholders - provide ZT seeders and training on calibration, operation & maintenance free (but no other incentives).
- Conduct field days, group meetings, workshops, etc. to collect, collate and share information.
- Instigate an CA research programs to investigate:
- Agronomy (time of sowing, row spacing, seed rate, residues management, etc.)
- Weed, disease & pest management
- Nutrient management
- Machinery innovations (in collaboration with manufacturers)
- Socio economics – constraints to adoption, policy recommendations
- Develop a CA manual & website (in Arabic) for researchers, extensionists, and leading farmers.
- Maintain a network with Australian and other CA scientists.
- Conduct an annual national CA workshop including all stakeholders.
- Provide funding of Iraq postgraduate students to investigate CA systems at Australian universities (could be part of existing programs).

This final recommendation along with the main project outcomes will be communicated to the Iraqi Minister of Agriculture shortly after the end of the project.

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Zhou et al. Soil metagenomics in soils of contrasting agricultural histories

11 Appendixes

11.1 Appendix 1: List of the main project collaborators 2005-2014

ICARDA - Dr Colin Piggin (Project Leader 2005-2011) and Dr Stephen Loss (Project Leader 2012-2014), Dr Kamel Shideed, Dr Nasri Haddad, Atef Haddad, Yaseen Khalil, Dr Yigezu Yigezu, Tamer El-Shater, Dr Zewdie Bishaw, Abdoul Aziz Niane, Dr Rolf Sommer, Dr David Feindel, Nabil Trabulsi, Majd Jamal, Betty Abrilian, Shukri Ismail, Zardasht Taha, Zakarya Al-Motair, Zilal Al-Qadur

University of Western Australia - Prof Kadambot Siddique, Dr Ken Flower, Dr Amin Mugera, Ms Cara Allan, Dr Jens Berger; Postgraduate students - Ayman Taher Al Hobaity, Mahmoud Ahmed Al Ardeny and Araz Sedqi Abdullah

University of Adelaide - Dr Matthew Denton, Dr David Coventry, Dr Yi Zhou, Postgraduate students - Alaa Fakher Al Hameedawi, Mahdi Salih Khudur, Jamal Abdufattah Yousuf

University of South Australia – Dr Jacky Desbiolles

Rural Solutions, South Australia: Dr Jay Cummins, Dr Jim Fortune

Department of Agriculture & Food Western Australia – Dr Wal Anderson, Dr Reg Lance and Dr Doug Abrecht

University of Mosul – Prof Abdulsattar Al-Rijabo (Iraq Project Coordinator), Dr Nahil Mohammed Ali, Dr Ahmad Sultan, Dr Abdul Jabbar Samir, Dr Mohammed Yousef Hameed, Dr Mohammed Al-Taweel, , Dr Salim H. Antar, Dr Moyasser Mohammad Aziz, Dr Salim Younis Al-Niaamy, Dr Emad Yousif Ismael Abdullah, Nawaf Jasem Mohamed, Dr Suaad Irdeny Abdullah, Dr Hesham Hassan, Dr Asma Zuhair Al-Hafiz, Dr Roa Mohammed Hamid, Mahmood Awad Husein

Ministry of Agriculture – Dr Saleh Mohsin Bader, Dr Kasim Ahmed Saliem, Dr Saad H. Mohamed.

State Board of Agricultural Research – Muthana Akidi, Ali Jasm, Dr Kasim Khalil Kasim, Dr Mujahid Hamdan, Younis Hamdoun Kassem, Raad Ahmed Hameed, Husham Abdulrahman Ahmed

Directorate of Agriculture Ninevah - Muhanna Al-Tak, Ziyad Tareq Qasem, Jaafar S. Saied, Hazem Aziz Saleh, Abdul Al-Moniem Mahmoud, Emad Shakir Hermiz, Sami Ibrahim Mustafa, Haji Mohammad Yakub, Hayder Nasser Bahgat, Mohammed Jabar Abdulradh, Talal Taha Ali, Salah Eddin Abdul Kader, Abdl Al-Kareem Jouli Abo, Amjed Thanon Khalil, Yazen Tawfiq Hamed

State Board for Seed testing and Certification, Ninevah - Qahtan S. Ibrahim Eesam Y. Saied

Directorate of Agriculture Kirkuk - Mahdi Mubarak Hameed, Mardan Hameed Mardan, Sarmad Kareem Khalil, Amer Saleh Helal, Fadel A. Jasim

University of Kirkuk - Dalshad R. Azeez, Zakariya M. Mohamad, Hassan Habib Hassan

Directorate of Agriculture, Salahaddin - Zead Abood Saeed, Fadhel Ahmed Ameen, Ameer Saaod Alwan, Naseem Abdulhameed Hassan, Abdulkareem Shab Taresh, Omar Sarhan, Hadi A. Abdullah, Ghazi Fesel Sharif

University of Tikrit - Dr Dalshad R. Azeez, Dr Jasem Mohamad Azeez, Dr Niama Darweesh

Directorate of Agriculture Anbar - Adel Murshed Mutlak, Salam Ismaeel Ibraheem , Arkan Ali Mohammed, Hisham Mohammed Ali

University of Anbar – Dr Karkaz M Thalij

Ministry of Agriculture & Water Resources, IKR – Sadar Sami, Azos Zrari, Khasro Mamand, Maqsood Khalid, Rauf Hussin Ali, Mohsin Marzany, Serbast Mohammad, Osman Hamdamin, Marwan Shuker Mahmoud

Farmers –Waad Ahmed, Sinan Al-Jalili, Fathi Ali Najim, Yasser A. Saleem, Khalid Alnujaify, Ghazi Fathi, Mohammed Al-Ghulami, Munther Kashmoula, Nawzad Younis

11.2 Appendix 2: Report on Palestine activities – November 2014 to June 2015. Development of conservation cropping systems in the drylands of northern Iraq

Report on Palestine Activities - November 2014 to June 2015

ACIAR/AusAID Project CIM/2008/027

Development of conservation cropping systems in the drylands of northern Iraq

Mr Atef Haddad and Dr Abdallah Alimari

International Center for Agricultural Research in the Dry Areas (ICARDA)

Amman Jordan and Jenin Palestine

1. Project objectives and agreement

On 13 November 2014 ICARDA and ACIAR agreed that unspent ACIAR funding for the project CIM/2008/027 **(**Development of conservation cropping systems in the drylands of northern Iraq) be used to support pilot activities to introduce conservation agriculture (CA) to the Palestinian Territories. The amount allocated to these extra activities was up to AUD$200,000 and the completion date was 30 June 2015.

The initial objectives of the work were two-fold:

- To increase the CA knowledge of research and extension staff and provide experience in the calibration, operation and maintenance of a zero-tillage (ZT) seeder.
- To quantify, demonstrate and promote conservation technology packages (especially ZT) for field crops and forage legumes in orchards in Palestine.

During the implementation of the work plan, it was evident that the Palestinians were keen to foster local manufacturing of ZT seeders. So support for the development of a ZT seeder prototype was also provided.

Ongoing CA experiments in Jordan instigated under the main project were also continued for the 2014/15 season. In this report we also briefly describe ongoing activities conducted by collaborators in Iraq and Syria, although no project funds were spent in these countries during the project extension.

2. CA awareness, knowledge and skills

Although the duration and funds for this project extension were limited, several highly effective courses, seminars and other activities were conducted in Jordan and Palestine to enhance the awareness, knowledge and skills of research and extension staff, machinery manufacturers and farmers in Palestine.

2.1 Jordan

A couple of training activities were conducted at Mushagar Station near Amman on CA and specifically ZT machinery.

A ZT seeder training course was conducted during 3-7 November 2014, involving 16 researchers and extensionists, 10 from Palestine and 6 from Jordan (Figure 1). The course was delivered by Dr. Jack Desbiolles (University of South Australia), Dr. Stephen Loss, and Mr. Atef Haddad, and included a theoretical component concerning CA principles and approaches in Australia, Iraq and Syria, and practical sessions involving ZT seeder calibration and field operation. Factsheets, videos and other CA relevant material were also distributed to trainees.

Fig. 1: ZT machinery training activities, Mushagar November 2014.

Given the enthusiasm for local ZT seeder manufacturing, a Palestinian manufacturer, Mr. Nour Eddin Zakarneh, was contracted to fabricate and assemble a ZT seeder prototype. He visited Amman on three occasions (1-3 days each) in December 2014, and March and May 2015, during which discussions were conducted with ICARDA staff, Mr. Atef Haddad and Mr. Shukri Ismail, at Mushagar Station. Station machinery and crop establishment were inspected, and a visit to the Rama Manufacturing Company workshop was conducted where discussions included fabrication principles and material sourcing.

2.2 Palestine

Several effective educational activities were conducted at different locations in Palestine. In October 2014 Dr Stephen Loss (ICARDA) met with DFAT and the National Agricultural Research Centre (NARC) staff in Ramallah to discuss the project work plan and implementation. This was followed by a public lecture attended by about 45 people and meetings with several NGOs.

Following the training course in Jordan in November 2014, Dr Jack Desbiolles and Dr Stephen Loss visited Ramallah and met with Joel Thorpe DFAT, and then travelled to Jenin to plant some ZT demonstration areas on Beit Qad Research Station. They also gave a seminar at the station and visited farmer field sites near Tubas.

Another visit by the same pair occurred in mid-February including lectures and field days, and an inspection of the low input cropping systems in Hebron, which were assessed as suitable for the introduction of CA. A field day at Beit Qad on February 17 was attended by 52 people, involving inspection of machinery and visits to nearby farmer demonstrations. Two Brazilian ZT 'jab planters' were provided to local researchers to evaluate with horticultural crops, which are common in Palestine.

As part of the ZT seeder demonstration program, four spring field days were delivered by NARC staff for Palestinian farmers in late April and early May.

Fig. 2: ZT training and field days in Palestine, 2014-2015.

3. ZT demonstration and farmer promotion

3.1 Palestine

A relatively low-cost ZT seeder (2.3 m wide) was made in Amman, Jordan by the Rama Manufacturing Company and imported into the Palestinian Territories in November 2014. The ZT seeder was effectively used to establish 20 simple 1.0 ha demonstrations (ZT vs CT) with various crops at different locations in Palestine. Dr Stephen Loss and Dr Jack Desbiolles joined the initial plantings, and a few informal field days were conducted during their seeding which generated much interest from local famers because of the potential savings and ease of planting.

Fig. 3: Wheat planting with the Rama Zt seeder in Tubas

Fig. 4: ZT planting of vetch between olive trees

The demonstrations were established around the centers of Tubas and Jenin to verify ZT technology with best agronomic management, including the application of glyphosate herbicide, and to compare this with farmer practice as shown in Figures 3 and 4. Details of number and area of the demonstrations are summarized in Table 1.

Table 1: The numbers and areas of ZT demonstration established in Palestine in the 2014-15 cropping season.

Location	**Tubas**		**Jenin**	
Crop	No. of Farmers	Area (ha)	No. of Farmers	Area (ha)
Barley	3	3	2	2
Wheat	3	3	4	4
Vetch	4	4	3	3
Chickpea			1	0.5

The full set of yields from these demonstrations was not available at the time of preparing this report. The three sites where yield data were obtained are summarized in Table 2. Although these treatments were not replicated, they indicated slightly better yields of wheat and barley grain and straw with ZT compared to the nearby farmer practice, and also improved vetch hay yields.

Table 2: Average yields of grain and straw in demonstrations under ZT vs CT, Palestine 2014-15

Crop	**Zero tillage** t/ha		**Farmer practice** t/ha	
	Grain	Straw	Grain	Straw
Durum wheat	3.7	3.4	2.5	2.2
Barley	2.9	2.7	2.3	2.2
Vetch for hay	-	2.5	-	1.9

3.2 Iraq

Despite the civil unrest in Iraq, CA activities were continued by farmers in Mosul and Anbar. Leading farmers who pioneered the conversion and manufacture of ZT seeders planted their fields and observed better performance under ZT compared to traditional planting methods (Figures 5 & 6). For the first time in many years there was an early break to the season during late April and early September in northern Iraq and significant weed growth was present at sowing time in October. Some farmers reported very good weed control with glyphosate applied immediately before sowing.

Fig. 5: Mr. Waad Al Ahmad in his ZT field.

Fig. 6: Pioneer farmer Sinan Jalili checking his ZT field.

3.4 Syria

Before the outbreak of conflict in Syria the rapid uptake of ZT was remarkable, and recent reports from several regions suggest it continues to expand. The main factor leading to ongoing expansion is the scarcity and high costs of fuel. Many farmers and operating extension units have kept reporting to ICARDA staff of the ongoing success with ZT plantings (Figures 7 & 8).

In 2013 the project approved a request from Mrs. Rehab Alkhateeb from the Agricultural Scientific Research Center in Salamiyeh Syria to contract a nearby workshop to construct a 1.8m wide ZT seeder. Due to the ongoing unrest in the area the seeder was only completed in April 2015 and ZT demonstrations between orchards are planned for the 2015/16 season. Mrs. Alkhateeb also continued her on-going CA research program on the Salamiyeh station.

Fig. 7: ZT lentil in Raqqa Syria, April 2015.

Fig. 8: Early sown ZT vs late CT barley in Raqqa Syria, April 2015.

4 ZT Seeder Development

4.1 Palestine

Following an assessment of local workshops by Dr Stephen Loss and Dr Jack Desbiolles, the project provided technical support to ZT seeder manufacturing in Palestine. In a short period of time, the enthusiastic Mr Nour Eddin Zakarneh and NARC project collaborators in Palestine produced a local ZT protoype (1.8m wide) partly from second hand materials. The seeder was designed to suit small-scale farming and orchards systems common in the Palestinian Territories. Mr Nour Eddin Zakarneh visited Amman three times to discuss design and technical issues with ICARDA staff and also received long-distant advice from Dr Jack Desbiolles. The first ZT seeder prototype manufactured in Palestine was completed and successfully tested in June (Figure 9).

Fig. 9: The prototyype compact ZT seeder developed in Jenin (Palestine), June 2015.

4.2 Jordan

The project continued to provide technical support to the Rama Manufacturing Company in Amman Jordan, who produced ZT seeders for Iraq, and recently to Palestine. The project supported improvements in ZT seeder design, quality control and performance, especially with regard to the gearbox and metering systems.

5 Ongoing research activities

Four ongoing research experiments were maintained at Mushagar Station near Amman Jordan and were used as a benchmark site and for training for the project (Figures 10 & 11). Yield and harvest component data were collected and will be published together with results from Erbil Iraq during the 2013/14 and 2014/15 seasons.

Fig. 10: Time of sowing trial at Mushagar.

Fig. 11: Barley/legume rotation trial at Mushagar.

6 Other Activities

A manual titled "The Practical Implementation of Conservation Agriculture in the Middle East" was collated and finalized. The comprehensive English version has 100 A5 pages with 62 illustrations, and printing will be completed in early July. A translation into Arabic has also been contracted. This manual will serve as a valuable guide for farmers, extension specialists, machinery manufacturers and farmers throughout the Middle East, North Africa and elsewhere. It collates all the lessons learned during the Iraq project since it started in 2005.

The project staff also contributed to development of the CA component for the AMENCA III, funded by the Australian government for Palestine.

7 Project outputs

- One Rama ZT seeder and two ZT jab planters were provided to NARC
- Manufacturing of a ZT prototype in Palestine was facilitated
- 20 ZT demonstrations in a range of crops were completed near Jenin and Tubas
- A four day ZT machinery training course was conducted in Jordan
- Several seminars, informal field walks and four field days were conducted in Palestine
- Ongoing CA trials at Mushagar Jordan were completed
- A CA manual for Middle East was finalized.

6 List of project stakeholders and participants

The project collaborated with several organizations in Palestine:

- National Agricultural Research Centre (NARC)
- Ministry of Agriculture (MoA)
- Cooperative for Assistance and Relief Everywhere, Inc (CARE), Dr Ayman Shuaibi Shuaibi@carewbg.org
- Palestinian Agriculture Relief Committee (PARC)
- Palestinian farmer associations

7 Financial statement

The project final acquittal for the November 2014 to June 2015 period will be finalized and sent to ACIAR by the end of July 2015. However, the allocated project funds for this period (AUD$ 200,000) are almost completely spent. Any remaining funds will be reimbursed to ACIAR following the submission of the acquittal.

8 Impact and recommendations

Despite the limited funds and period of this work, the project delivered two effective and affordable ZT seeders that were used successfully used for demonstrations in Palestine.

Farmers were impressed with the ease of ZT sowing, potential savings, good crop establishment and yields, and are keen to test ZT on their own farms in the coming seasons.

We believe there is great potential for ZT in the small-scale farming systems in Palestine around Jenin, Tubas and Hebron.

We strongly recommend continuing support for the support of further manufacturing of ZT seeders in Palestine and promotion of CA through the upcoming proposed AMENCA III project and others.