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Project final report

project

Better crop germplasm and management for improved production of wheat, barley and pulse and forage legumes in Iraq

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2 Executive summary

Redevelopment of the agricultural sector is a high priority in Iraq, providing 8% of GDP, employment for 20% of the population and sustenance for 7 million people in the rural areas. Over 50% of the cultivated area annually is sown to barley, wheat and pulse legumes (chickpea, lentil) in northern rainfed areas but production is poor by international standards due to lack of modern varieties and poor crop management. The project aimed to improve the productivity, profitability and sustainability of these cropping systems in Ninevah Governorate through objectives to: 1) identify, promote and widely disseminate amongst farmers “best-bet” improved varieties and crop management systems; 2) introduce, evaluate and select improved germplasm; 3) identify, evaluate and select improved cropping system management options; 4) enhance the capacity of Iraqi research and extension programs. The project was coordinated by ICARDA, implemented in Iraq by the Ministry of Agriculture (State Board of Agricultural Research, Directorate of Agriculture) and the University of Mosul, and supported by the University of Adelaide, Western Australian Department of Agriculture and the University of Western Australia.

Implementation was difficult because Iraq has been a hostile environment disabling to scientific R & D. ICARDA and Australian scientists cannot visit to evaluate/discuss collaborative work with Iraqi partners. A severe drought also caused crop failure in the third year. Despite the difficulties, the project has made good progress against all objectives. Australian, Iraq and ICARDA collaborators met annually at ICARDA to develop workplans and report results. The proximity of ICARDA has facilitated the attendance of 83 Iraqi scientists at six major technical meetings and 62 scientists at 14 training courses. Four senior Iraqi scientists visited Australia to study modern approaches to crop research and development. Capital equipment (ZT seeders, chisel ploughs, subsoil cultivators, seed cleaners) was supplied to enhance Iraqi capacity for conservation cropping R & D.

Well-chosen 'best bet' varieties and conservation cropping technologies were demonstrated and promoted over three years with cooperating farmers in 12 locations across three rainfall areas in Ninevah. Research tested hundreds of new crop lines and evaluated the newly-introduced zero-till (ZT) system for crop establishment. Some new lines of wheat, barley, chickpea and lentil and the ZT system performed well and were of great interest to farmers, with several growing good crops using locally-made ZT seeders on their own cropping areas, which has given the impetus for early adoption and impact.

In linked research at a secure site at ICARDA in Syria, ZT technology, local ZT seeder manufacture and the potential of oats, peas and oilseeds to diversify crop rotations were evaluated and developed in more depth. There were spill-overs in Syria, where machinery manufacturers and farmers have been developing and testing ZT systems and seeders.

The significant success of the project to date has been the introduction of ZT as a soil and crop management option for Iraq and Syria. This management system has been shown for the first time to be well suited to low rainfall areas, where it offers at least equivalent yields with lower production costs than conventional tillage, while improving soil quality and protecting it from wind and water erosion. Economic advantages have special attraction to Iraqi farmers now faced with greatly increased fuel costs. The nature of the project, based on the introduction of new cropping technology, precludes other than preliminary or predicted impacts after just three years. But given that farmers are already beginning to adopt the technology and machinery manufacturers are fabricating local, affordable ZT seeders, great impact seems assured given the rapid expansion of ZT technology over 100 Mha worldwide during the last two decades.

More work is needed to refine ZT technology, adapt machinery, select better crop cultivars, promote new rotations, monitor pest and disease dynamics and manage stubbles. This will be possible over the next three years with the development and approval of a follow-on project on to develop and promote conservation cropping in Iraq.

3 Background

At the time of project conception in 2004, redevelopment of the Iraqi agricultural sector was a high priority in the National Development Strategy (2005-2007), recognising its contribution of 8% to GDP, 20% to overall employment and sustenance to 7 million people in rural areas. The main prioritized actions to be taken included increasing production and productivity through providing improved seeds, fertilizers and “scientific” exploitation of them; expanding the scope of development and research programs; rehabilitating infrastructure; and building technical and administrative capacity through training and rehabilitation. Arable land is estimated at 11.5 million hectares, approximately 20-30 percent of the country's total area. The Food and Agriculture Organization estimates only 8 million hectares are used for agriculture and less than half are cultivated annually. Seventy-five percent of the cultivated area is located in the central and southern regions. Production of wheat, the staple food crop, and barley, an important livestock feed crop, is concentrated in the north.

Agricultural production has actually declined by about 1.1% per annum over the past 15-20 years, with five-year average production estimates of 860,000 MT for wheat and 720,000 MT for barley providing less than 50 percent of demand. Production of major crops in 2002/03 was 50 percent of 1990/91 levels, exacerbated by three years of drought from 1999-2001. Significant area and yield declines have resulted from shortages of inputs (seeds, fertilizers, pesticides) and machinery, irrigation related problems (soil salinity, lack of drainage, reduced irrigation water, deteriorating irrigation infrastructures), poor crop rotations, and limits to aerial spraying to control pests. An effort was made in the early 1990's to counter economic sanctions and increase domestic food production by raising areas and yields. However, any gains made appear to have been short-lived.

Whilst some Iraqi problems, like input subsidies, are largely political, solutions to major cropping constraints can be provided through application of existing technologies, on-going research to develop and promote new technologies, and increased institutional capacity to bring immediate benefits not only for crop production but also for animal production through reduced fallowing and increased stubble retention and use of legume forages.

Introduction of improved varieties and improved crop management technologies was expected to significantly increase resource use efficiency, reduce costs and enable higher crop productivity. Traditional production systems have been based on deep cultivation and crop management systems which have changed little over decades. Crop varieties currently used in research and commercial production were sourced from the Ministry of Agriculture (MOA), ICARDA or Australia and other countries in the early 1980s.

The MOA and others have already evaluated improved varieties and crop management practices and identified some promising lines and technologies that are available for dissemination. However, under the economic environment of the time there was little incentive for farmer use them. The proposed government strategy is to shift to a market-driven agricultural system, which is intended to induce producers to change their production systems to become more competitive. This will require the development and dissemination of integrated packages of practices, appropriate for specific agroclimatic conditions, that farmers can adopt to maximize their returns from rainfed crop production.

There are similarities in the major constraints for dryland cereal and pulse cropping in northern Iraq and southern Australia including drought and heat tolerance, B tolerance, grain quality issues, and cereal and pulse pests and diseases. These are all priorities for wheat, barley and pulse production in southern Australia, and are the subject of major industry funded projects being undertaken by universities and agriculture departments in southern and western Australia, with an overlap of research interests between Australian institutions and ICARDA relevant to the success of the project.

The Australian Government responded to the priority to increase agricultural production in various ways through plans to assist with the redevelopment of infrastructure, refurbishment of Ministry of Agriculture facilities, support for significant short-term technical training, support for the development of a research-extension program, and support for longer-term research initiatives.

Given this background, it was decided to focus the project on research, development and capacity building to improve production, profitability and sustainability of dryland cropping systems in the northern areas of Iraq, with initial interventions in Ninevah Governorate through the Ministry of Agriculture (Directorate of Agriculture; State Board of Agricultural Research) and the College of Agriculture and Forestry, University of Mosul.

The project aimed to achieve immediate benefits by developing and promoting currently-known "best bet" technologies and longer-term benefits through developing new technologies and improving capability through four major objectives:

1) to identify, promote and widely disseminate amongst farmers in the rainfed cropping regions of northern Iraq “best-bet” improved varieties and crop management systems for wheat, barley and pulse and forage legumes;

2) to introduce, evaluate and select improved germplasm of wheat, barley and pulse and forage legumes for adaptation to rainfed farming systems in northern Iraq;

3) to identify, evaluate and select improved cropping system management options suited to rainfed farming systems in northern Iraq;

4) to enhance the capacity of Iraqi research and extension program to identify and evaluate potentially valuable germplasm and better crop/soil management technologies and promote their adoption by farmers.

ICARDA and collaborating institutions in Australia (University of Adelaide, Western Australian Department of Agriculture, Centre for Legumes in Mediterranean Agriculture), have excellent scientific expertise and experience to assist in these areas. They have worked extensively in the region including in northern Iraq. ICARDA proximity and scientific connections to Iraq were seen as a particular strength.

The expected outcomes were:

- available “best bet” technologies identified and prioritized
- acceptable technology packages promoted and disseminated
- efficient production systems established fro seed for research and demonstration
- new crop management options identified, tested and evaluated with farmers
- enhanced capabilities of Iraqi research program through joint research and specialized training programs
- enhanced capabilities in evaluating adoption and impact of improved technologies
- effective international collaborative networks between Iraqi, ICARDA and Australian institutions and scientists.

Meeting this challenge was given a high chance of technical success. Soils in the region are considered to be fertile and productive, certainly by Australian standards. Average seasonal rainfall totals are around 100-300mm during the growing season although, like in Australia, these can be variable; for example, three years of drought from 1999-2001 significantly reduced production. Current average yields of 0.73 t/ha for wheat and 0.62 t/ha for barley are less than half those expected under such conditions. The target was to at least double yields is based on current levels of production, which was considered feasible based on productivity improvements achieved from a combination of improved crop husbandry and cultivars elsewhere in the world, and particularly in Australia where

regions with similar winter rainfall have averaged an annual 2.5% productivity gain over the past 20 years.

Significant economic and social benefits were expected from the project in the targeted areas. Profitability was expected to increase through higher crop yields and lower costs. The transition by farmers from a subsidized input system to a free market system should be facilitated by the expected improvement in crop yields and increased international competitiveness. Positive environmental impacts in terms of sustainability of the cropping systems, water savings and reductions in soil erosion were also foreseen as a result of better crop/soil management technologies

4 Objectives

The aim of this project was to contribute to the redevelopment of the dryland cropping sector in northern Iraq through the testing, promotion and dissemination of improved crop cultivars and crop management practices.

The objectives were:

1. To identify, promote and widely disseminate amongst farmers in the rainfed cropping regions of northern Iraq “best-bet” improved varieties and crop management systems for wheat, barley and pulse and forage legumes.
2. To introduce, evaluate and select improved germplasm of wheat, barley and pulse and forage legumes for adaptation to rainfed farming systems in northern Iraq.
3. To identify, evaluate and select improved cropping system management options suited to rainfed farming systems in northern Iraq.
4. To enhance the capacity of Iraqi research and extension program to identify and evaluate potentially valuable germplasm and better crop/soil management technologies and promote their adoption by farmers.

5 Methodology

The project was located geographically in the northern Governorate of Nineveh, the main wheat and barley producing region in Iraq, with activities focussed on the three main agro-climatic zones (high rainfall areas (HRA) with rainfall >450mm, moderate rainfall areas (MRA) with rainfall 350-450mm, and low rainfall areas (LRA) with rainfall <200-350mm). The methodology entailed analysing farmers' practices and current production constraints, and identifying potential technology options; identifying currently available and tested improved varieties and 'best bet' crop management practices that could be immediately be demonstrated in farmers' fields in each agro-climatic zone; selecting the sites and the participating host farmers and farmer groups for on-farm demonstrations; establishing on-farm demonstrations; evaluating germplasm from Iraq, ICARDA, Australia, and other sources on-station and in farmers' fields; identifying and prioritizing constraints/limitations in crop production systems to identify improved crop management practices; identifying possible elements of improved crop and soil fertility management and matching tillage components; conducting on-station research on crop management options; implementing on-station and farmer-managed on-farm research trials and demonstrations of potential options. The training component included training courses, workshops, on-the-job training and visits to ICARDA and/or Australian partners. It was expected that the demonstrations, field days and publications would communicate project results and activities to a wide range of beneficiaries. The farmer participatory approach being adopted was considered a sound strategy for facilitating uptake of successful technology.

Demonstration and research activities were implemented by DOA, SBAR and UniMosul field teams in all three agroecological zones. Funds were provided to assist research station rehabilitation through the purchase of some essential farm and small-plot equipment, lab and office equipment and building rehabilitation at one of the three research stations of Rabia, Tel Afer and Rashidiya. Most research trials were expected to be conducted on-station with some conducted or replicated in farmers' fields.

All activities in Iraq were implemented by Iraqi staff based on detailed work plans developed together with ICARDA and Australian partners. ICARDA and Australian scientists were not permitted to travel to Iraq because of insecurity and insurgence in rural areas. MOA personnel included extension staff, agronomists, breeders, soil scientists, plant protection scientists and socio-economists in each agro-ecological zone and research station. The results were reviewed in detail at annual coordination and planning meetings. MOA staff were supported by training in specific aspects within the project.

The project commenced with an analysis of farmers' practices and current production constraints, and the identification, from existing information, of potential technology options that are already available and can be demonstrated to farmers.

A baseline survey was carried out by the Iraqi team based on a survey and survey nethodology developed with ICARDA socio-economists. Iraqi research and extension teams in each agroclimatic zone undertook the survey.

The survey collected information on constraints and limitations in production in the three agro-climatic zones of Nineveh Province and assessed potential marketing and policy constraints to adoption of improved technology options. Information was collected on seed production and storage systems and the capacity of the farmers to take up technologies developed by the project. The survey included a study of the availability of inputs and the 2005 harvest and subsequent crop marketing. This baseline analysis included information for each of the main cropping systems on management practices, machinery specifications (e.g. availability and size of tractors, type of tillage implements and planting equipment, use of fertilizer spreaders and sprayers, etc.), the current type and amount of inputs being used (fertilisers, pesticides) and associated constraints (nutrition, weeds, diseases, pests), and marketing information on both inputs and outputs

(availability, prices, market access, etc). The data was disaggregated to provide information on the different gender roles that may have implications for village extension programs. The information from the survey served as a baseline for adoption and impact assessments.

Demonstrations of "best-bet" technologies

Existing information on potential available technology options, which have already been tested in Iraq, including registered Iraqi varieties of target crops and crop and pest management options, were compiled and reviewed. A meeting of all partners, including Iraqi research and extension personnel and representative farmers, was held at ICARDA in Syria in July 2005 to identify germplasm to be considered for demonstrations in the first year, taking account of information on prior testing and material available from the international collections and from Australia. The discussion group discussed the quality and agronomic characteristics required of improved varieties and agreed on the conditions and methodology of evaluation including best-bet management practices for the region.

The first Annual Project Coordination Meeting involving scientists from all project partners was held at ICARDA in September 2005 to decide the best bet technology options for germplasm and crop management in each agro-climatic zone and prepare the workplan for the 2005/06 cropping season.

Based on the work plan, Iraqi extension and research scientists selected representative sites and participating host farmers and farmer groups for on-farm demonstrations. Four demonstrations were established in each of the three agro-climatic zones (12 demonstrations total). Working closely with farmers/farmer groups, the project established the on-farm demonstrations in the selected areas. Introduced lines were compared to locally used varieties under several crop establishment/management options (farmer tillage, improved tillage and, in years 2 and 3 zero-tillage). Data was collected on establishment, phenology, seed weight and numbers, and crop yield. A research, extension, and farmer group monitored demonstrations and jointly evaluated options to identify preferences and potential constraints to adoption. Farmer participation was encouraged and field days were organised at all locations with invitations to MOA and other government policy makers, the media and other stakeholders to attend.

The potential adoption and impact of technologies based on information from baseline surveys and results from demonstrations was assessed and potential changes made for improvement.

Germplasm research

The first Annual Coordination meeting identified improved germplasm of wheat, barley and pulse and forage legumes with possible adaptation which had not been tested widely in Iraq, for evaluation first in on-station trials and then in farmers' fields. Germplasm from Iraq, ICARDA's international nurseries and Australia was supplied, evaluated and increased on-station during each growing season of the project. Introduced lines were compared to locally used varieties. Data collected included establishment, disease resistance, phenology, seed weight and numbers and crop yield. The data from individual sites was analysed for identification of best entries in different agro-climatic conditions.

In subsequent annual project reporting and planning meetings the results of the previous year's evaluation were presented, reviewed, discussed, and the best entries for evaluation in the next season identified. It was planned in the project document that selected entries each year would be evaluated in research stations (3 trials) and in replicated trials on farmers' fields in 3 sites in each agro climatic zone (3x3 = 9 trials). However, with 5 focus crops (bread wheat, durum wheat, barley, chickpea, lentil) and 2 non-functioning research stations, this was not practical and had to modified. Trials (50 planned and 27 conducted in 2005/06; 37 planned and 14 conducted in 2006/07; 26 planned and 6 conducted in 2007/08) were conducted at Rashidaya Research Station in Mosul and in selected demonstration sites and, in the last year, at the University of Mosul. Where possible,

entries were jointly evaluated with farmer groups, resulting in identification of elite lines suitable for different agro-climatic zones.

It was planned that the best lines on the basis of three-year evaluation would be identified, their morpho-agronomic traits compiled and submitted to the variety registration committee for registration and eventual release for general cultivation, and breeder and nucleus seed production of the lines entering registration simultaneously produced at Rabia research station for research and demonstrations. This did not occur because of inadequate evaluation, drought, non-functioning research stations and institutional capabilities and, in retrospect, was too ambitious considering the situation of Iraq.

Crop management research

Based on collective knowledge and the results from the baseline survey of production constraints, the July2005 meeting identified and prioritized constraints/limitations in crop production systems which are not addressed by readily available technologies and need further research to identify improved crop management practices. Potential research areas identified with Iraqi colleagues were tillage and sowing systems, pest and weed management, and new crop rotations.

The first Annual Coordination meeting identified possible improved technologies for improved crop and soil management and matching tillage machinery, taking account of experience with similar farming systems experience in ICARDA and Australia. As with germplasm research, it was planned in the project document that crop management would be conducted in research stations (3 trials) and in replicated trials on farmers' fields in 3 sites in each agro climatic zone (3x3 = 9 trials). Again, this was not practical or possible. In 2005/06, three long-term zero-till trials were planned (1 in each rainfall zone) but these were not carried out because of agronomic resources and capacity, security concerns, land disputes, lack of ZT machinery, transport shortages and some confusion about agreed treatments/available seed/plot sizes.

In subsequent annual project reporting and planning meetings, one zero-till trial and two deep tillage trials were proposed in 2006/07, with the ZT trial being conducted, and 2 zero-till and one deep tillage trial in 2007/08, which were not possible because of drought.

It was planned that input-output data be collected from some of these experiments for cost-benefit analysis to allow better understanding and selection of some of the management options. The joint evaluation of options with farmer groups were planned to collect information on farmer preferences and constraints encountered in adoption of improved cultivars and crop management technologies, with a view to identifying where assistance is needed in mitigating constraints to adoption. However, given that only one trial was conducted, this was not done in Iraq.

Given weaknesses in crop management capability in Iraq, a linked agronomy research and development program was developed at ICARDA, focussing on conservation cropping (zero-tillage, stubble retention, crop diversification options). eighteen rials were conducted comparing ZT and CC and evaluating adaptation of oats, peas and brassica oilseeds. Data collected included establishment, vegetative growth, crop yield, yield parameters and soil physical and nutrient factors. This was used for technology development and verification and also as a training facility for visiting Iraqis and other groups.

With the success of ZT evaluations, a small local ZT seeder component was added into the research programs in both Iraq and ICARDA. ZT concepts were demonstrated and discussed with several local machinery manufacturers and farmers, and prototype ZT seeders were constructed and, in Iraq, were tested.

Training and capacity building

A detailed training program was developed at each Annual Project Reporting and Planning Meeting for short term training courses, workshops, individual training and visits

at ICARDA and for longer-term study visits to Australian partners. The Ministry of Agriculture nominated staff for training.

Training was planned to include: short-term training courses in germplasm evaluation, crop management, seed production and quality control, integrated pest/disease/weed management, and extension methods for 20 Iraqi staff per year; individual training for MOA staff in economic analysis, adoption and impact assessment; and visits of senior Iraqi scientists (one per year) to one Australian research institute (6-8 weeks). The project also planned to support based on requests the participation of Iraqi personnel in regional or international workshops and conferences of relevance to the project. The MOA, in nominating staff for training, and ICARDA, in the design of training content, planned to encourage training of staff in a position, on their return to Iraq, to benefit from their experience and consolidate and implement their training.

6 Achievements against activities and outputs/milestones

Objective 1 : To identify, promote and widely disseminate among farmers in the rainfed cropping regions of northern Iraq "best-bet" improved varieties and crop management systems for wheat, barley and pulse and forage legumes.

no.	outputs	milestones	completion date	comments
1.1	Constraints and limitations in rainfed crop production identified through diagnostic study of farmers' existing practices	Review completed – gaps in information identified Survey completed. Major production constraints identified in each zone	Yr 1 May Yr 1 Jun-Jul	A baseline survey was conducted with 260 farmers in July/August 2005 by MOA, University of Mosul and ICARDA socio-economists characterized the dryland environments and farming systems in Ninevah and identified constraints. This provides a base for later impact assessment. Preliminary results helped guide Sept 2005 selection of crop varieties and technologies for testing/promotion. The summary report (Shideed et. al. 2007) presented at the annual meeting in Oct 2006 identified major issues/constraints as declining production, low crop yields, cereal monocultures, heavy fallowing, excessive cultivation, highly variable and low rainfall, poor research and extension services, poor availability and increasing prices of inputs, and low prices and marketing difficulties for outputs.

1.2	Available “best bet” technologies identified and prioritized based on existing knowledge	Analysis of potential available technology options completed Agreed list of best-bet technology options to be demonstrated in each agro-climatic zone	Yr 1 Jun-Jul Yr 1 Sep	Best bet varieties/lines and technologies were discussed at ICARDA meetings in June 05 with ICARDA scientists, July 05 with ICARDA and Iraq scientists, and September 05 with ICARDA, Iraqi and Australian scientists. Discussion was based on previous experience by collaborators in Iraq and in similar environments in north-east Syria. Discussion in July 05 was stimulated by presentations from Iraqi scientists on: - agricultural extension in Iraq: Dr Awad Abbas, MOA Baghdad - agricultural research in Iraq: Dr Saleh Mahdi, MOA Baghdad - seed production in Iraq: Dr Nakd Khamis, MOA Baghdad - agriculture in Ninevah: Dr Abdul-Satar Alrajbu, DOA Ninevah - agricultural research in Ninevah: Dr Adnan Adary, SBAR Ninevah - agricultural extension in Ninevah: Dr Faod Abdullah, DOA Ninevah Dr Adnan Adary also presented a review of the crop R&D situation in Ninevah in Sept 05 Agreed best bet varieties and technologies were incorporated into the 2005/06 workplan, with necessary seed supplied from ICARDA and Australia. Following Sept 2005 discussions, Dr. Kasim Khalil Kasim of SBAR Ninevah prepared a review of experiences and literature on rotations and sowing dates/rates in Ninevah/Iraq. This provided direction for crop management R&D in the Oct 06 reporting/planning meeting.
		Annual research and training plan for next year	Yr 1, 2, 3 Sept	Developed and agreed at reporting and planning meetings at ICARDA in Sept 05, Oct 06, Sept 07
		Annual reports	Yr 2, 3 Sept	Produced for Yrs 1, 2, 3

1.3	On-farm demonstrations established	Sites, host farmers and participating farmer groups identified On-farm demonstrations established at each site Methods (protocols) for monitoring and farmer evaluation developed	Yr 1 Sept-Oct Yr 1, 2, 3 Nov-Jun Yr 1, 2, 3 Nov-Jun	Cooperating farm families were identified and on-farm variety x establishment method demonstrations were conducted in 2005/06 in 12 locations under high (Al Shikhan, Rabeea, Al Qush), medium (Al Hamdania, Tel Kief, Baashiqa) and low rainfall (Tel Abta, Al Hatra, Al Mahalabya) and SI (Rabeea-HRA, Al Nimrud-MRA, Hummaidat-LRA). Establishment treatments were farmer practice (tillage and broadcasting seed) and improved tillage (tine cultivation and sowing seed) in 2005/06. Some introduced lines performed better than local varieties and were of interest to farmers. With the arrival of the new zero-till seeders from India, a ZT comparison was added to the tillage treatments for all crops. The agreed workplan for the demonstration program in 2006/07 was carried out at the 12 locations with a target of 35 demonstrations (24 cereal, 9 legume, 2 forage). The season was good and crops grew well; some introduced lines performed well and ZT yields were similar or better than CC or farmer practice. The 2007/08 workplan proposed 34 demonstrations (24 cereal, 6 legume, 4 forage) but low rainfall (< 100mm) meant crops failed at all sites except Al Namroud under SI, where durum and bread wheat performed best under ZT. There was great enthusiasm about the potential of zero-tillage, which reportedly had never been tried before in Iraq, encouraged by the dramatic increase in the price of diesel (200 litre drum) from $2 a few years ago, to $125 in 2006, and to $250 in 2007. Some planned crop management demonstrations on tillage, fertilizers and weed control were not conducted in some years because of heavy rain, security concerns, land disputes, lack of machinery, transport shortages and drought. Baseline soil analyses were undertaken. Crops were regularly observed, managed, and harvested with seed saved for subsequent years. In 2005/06, demonstrations were monitored by the Ninevah Implementation Committee (NIC) which met 18 times from July 05 to May 06 to monitor, direct and report on the demonstration program. Meeting minutes were circulated. In other years, it was too dangerous for the NIC to meet regularly and demonstrations were managed and observed with site visits.

1.4	Potential constraints to adoption identified	Input-output data collected and cost-benefit analyses of demonstrations completed Farmers' preferences recorded and potential constraints identified	Yr 1, 2, 3 Nov-Jun Yr 1, 2, 3 Nov-Jun	Completed for 2006/07 demonstrations and reported by Mohammed et. al (2008). Yields and net revenue from wheat, barley, pulses and forages in all demonstration locations were relatively good under both chisel and zero-tillage establishment. Low rainfall (< 100mm) meant crops failed at most sites and 2007/08 adoption/impact analysis could not be undertaken. Completed and reported under the baseline survey (Shideed et. al 2007). Major issues and constraints are listed under 1.1 above.
1.5	Acceptable technology packages promoted and disseminated	Field days for farmers and other stakeholders held each year (May) Extension material prepared and distributed Annual research and training plan for next year Annual reports	Yr 1, 2, 3 May	On-farm demonstrations involved farm families in operations with constant observation and interaction by farmers. Field days were conducted at all sites in 2005/06 and 2006/07. Many farmers were interested in improved varieties which performed better than local varieties and, in 06/07 and 07/08, were very enthusiastic about zero-tillage. Dissemination of better varieties was encouraged through distribution of seed from the demonstrations/trials and provision of information and advice to interested farmers. Developed at Sept 05, Oct 06, Sept 07 reporting/planning meetings at ICARDA Produced for Yr 1, 2, 3
1.6	Assessment of potential adoption and impact	Adoption and impact assessments completed	Yr 2, 3	2005 baseline data collected and analysed. Cost-benefits evaluated in 2006/07 but adoption/impact studies with farmers were not possible in 07/08 due to drought and failed crops

PC = partner country, A = Australia

Objective 2: To introduce, evaluate and select improved germplasm of wheat, barley and pulse and forage legumes for adaptation to rainfed farming systems in northern Iraq

no.	outputs	milestones	completion date	comments

2.1	Cultivars of these crops that produce higher yields and/or better satisfy local market requirements through better disease resistance, drought tolerance, bread quality characteristics, etc., identified and evaluated with farmers at research stations and in farmers' fields	List of potential lines for evaluation	Yr 1 May-Aug	New varieties/lines discussed as outlined under 1.2 above
		Agreed list of lines to be evaluated. Annual research and training plan for first year	Yr 1 Sept	Agreed lines and evaluation methodology included in first-year workplan developed at the Sept 05 planning meeting
		Methods (protocols) for monitoring and farmer evaluation developed	Yr 1-2 Nov-June	Trials monitored and evaluated according workplan methodology
		Annual research and training plan for next year	Yr 2, 3 Sept	Developed at reporting/planning meetings held at ICARDA in Oct 06 and Sept 07
		Annual reports		Produced for Yr 1, 2, 3
		Selection of best entries in each research station and in each farmer's field for further evaluation. Agreed list of selected lines for each agro-climatic zone	Yr 2, 3, 4 Nov-Jun	An ambitious total of 50 research trials evaluating better adapted lines/varieties was planned in 05/06 at ten locations: Rabiah (HRA), Al Kosh (HRA), Al Rashidya (MRA), Baashika (MRA), Tel Keyf (MRA), Al Namroud (MRA), Bartala (LRA), Al Hatra (LRA), Tel Abta (LRA), Tel Afar (LRA). However, it was only possible to conduct 27 trials, all at Rashidya Research Station, because of heavy rain, security concerns, land disputes and transport shortages. This included 6 on durum/bread wheat, 5 on barley, 14 on chickpea, 4 on lentil and 1 on faba bean.
		List of lines	Yr 4 July	A more realistic workplan in 06/07 proposed 34 nursery/yield trials (24 cereals, 7 food legumes, 3 forages). However, only 14 trials were undertaken at Rashidya Research Station, with 2 bread wheat, 3 durum wheat, 3 barley, 2 chickpea, 1 lentil, 2 faba bean, and 1vetch trial.
				In 07/08 it was planned to undertake 23 nursery/yield trials (14 cereals, 6 food legumes, 3 forages). Because of low rainfall (< 100mm) and irrigation failures, only 6 barley trials were planted. The only result was under SI at Mosul University, where Assala-04 and Rihane-03 gave the highest yields of 850kg/ha and five other lines gave >500kg/ha.

2.2	Efficient production systems of the seed needed in research and demonstrations established	Equipment purchased and seed quality control in place	Yr 1	ICARDA supplied 16 t of seed in Oct 05, 2 t in Dec 06, and 1.9 t in Dec 07. Most seed for yrs 2 and 3 was saved in Ninevah, indicating enhanced capacity to supply experimental seed. Three scientists from SBAR and State Board for Seed Inspection and Certification who attended a seed management course in ICARDA in Nov05 are assisting in development of seed production systems in Ninevah. At the request of MOA in 2005, capital funds were redirected from research station rehabilitation and allocated to purchase 10 mobile seed cleaners to support the development of efficient seed production systems for MOA and farmers in Ninevah. It took until 2008 to quote, order, supply and deliver the Syrian-made seed cleaners due to approval delays and border crossing insecurity. The cleaners will support future village-based and formal seed production.

PC = partner country, A = Australia

Objective 3: To identify, evaluate and select improved cropping system management options suited to rainfed farming systems in northern Iraq

no.	outputs	milestones	completion date	comments
3.1	Specific production constraints, identified under Output 1.1, for which there are no immediate available technologies are identified and prioritized	List of production constraints to be addressed in research trials	Yr 1 Sept	Crop management constraints and new technologies for inclusion in research were discussed as outlined under 1.2 above Tillage and sowing systems, new rotation options and pest/weed management were identified as priorities for research following 2004 visits by Iraqi scientists to Australia. These were incorporated into research programs in Iraq and ICARDA

3.2	New crop management options that solve these constraints identified, tested and evaluated with farmers	Annual research and training plans Annual reports Methods (protocols) for monitoring and farmer evaluation developed. Input-output data collected and cost-benefit analyses of trials. Farmers' preferences recorded and potential constraints identified List of identified options. Recommendations for measures to mitigate constraints to adoption.	Yr 1,2,3 Sept Yr 1, 2, 3 Sep Yr 1, 2, 3 Nov-June Yr 3	Discussed and developed at project reporting/work planning meetings held at ICARDA in Sept 05, Oct 06, Sept 07 Produced for Yr 1, 2, 3 On-station and researcher-managed trials were monitored and evaluated for treatment performance according to workplan methodology. Socio-economic analyses have not been undertaken for research trials but all operations are recorded and this should be possible for selected trials. Clearly, farmers in Iraq are very interested in ZT and alternative crops. Obvious constraints to adoption are knowledge, experience, availability of ZT seeders and seed. These can be addressed by participatory research and extension. In Iraq, research trials on conservation tillage (ZT vs CC, +/- stubble mulch) were planned after the supply of Indian zero-till seeders in 2006. Three trials were planned for 06/07. However, due to demands for ZT seeders in demonstrations and lack of untilled land in Mosul, these could not be undertaken in 06/07 or 07/08. In project linked research and development at ICARDA, to verify and adapt technologies under safe, controlled conditions, two demonstrations in 2005/06 (290 mm seasonal rainfall) compared conventional cultivation (CC) and zero-tillage (ZT), using a large, German Amazone ZT seeder, and showed higher yields and great promise with ZT. SIx further trials at ICARDA in 06/07 (315 mm) and 07/08 (222mm) comparing ZT vs CC and early vs late sowing of wheat, barley, oats, chickpea and lentil showed consistently higher production with ZT and early sowing. With the success of ZT, and the constraint of availability of ZT seeders, it was decided in Sept 2007 to commence a local ZT seeder fabrication component in the project. Work on ZT seeder fabrication was initiated in 2007 with 4 local machinery manufacturers in Syria - three affordable ($1500) prototypes which work well have been manufactured. Comparable work is underway with a machinery manufacturer and several farmers in Iraq fabricating wider seeders for larger farms - three successful prototypes have been built, one associated with a MSc at Mosul University. To promote crop rotation options, a range of oat, pea and oilseed brassica lines have been evaluated for adaptation and productivity over three seasons from 2005 to 2008. Several oat varieties (Possum, Carrolop, Euro, Brusher, Wintaroo, Mitika, Kangaroo) produced around 2t/ha of seed and 5 t/ha straw and pea varieties (Dunwa, Helena, Kaspa) around 1 t/ha seed and 3 t/ha straw. Seed better lines has been

PC = partner country, A = Australia

Objective 4: To enhance the capacity of Iraqi research and extension programs to identify and evaluate potentially valuable germplasm and better crop/soil management technologies and promote their adoption by farmers

no.	outputs	milestones	completion date	comments
4.1	Enhanced capabilities of Iraqi research program through joint research and specialized training programs	Annual report on previous years training (Yrs 2, 3). Agreed detailed training plan for next year 20 Iraqis complete training each year	Yr 1, 2, 3 Sept Yr 1, 2, 3	Discussed and developed at project reporting/work planning meetings held at ICARDA in Sept 05, Oct 06, Sept 07 62 Iraqis trained in 15 courses/study visits at ICARDA (26 in 6 courses in 2005/06, 36 in 8 courses in 2006/07)
4.2	Research and extension staff are better able to promote and disseminate new technologies in partnership with farmers	Annual report on previous years training (Yrs 2, 3). Agreed detailed training plan for next year 20 Iraqis complete training each year	Yr 1, 2, 3 Sept Yr 1, 2, 3	Training program discussed and developed at project reporting/work planning meetings held at ICARDA in Sept 05, Oct 06, Sept 07 It was planned and budgeted that 30 Iraqi scientists would attend planning, reporting and review meetings at ICARDA but in fact a total of 83 attended, greatly increasing capacity to plan, undertake and report crop development. These scientists also attended the 11 seminars by Australian collaborators, updating awareness and knowledge of international crop R&D. 8 farmers and 5 DOA scientists from Ninevah visited ICARDA on a study tour on 20-24 May 2007 to inspect and discuss research on crop improvement, management and zero-tillage
4.3	Enhanced capabilities in evaluating adoption and impact of improved technologies	2 Iraqi staff complete training and develop work plans for economic analysis, adoption and impact assessment	Yr 1	Four Iraqi socio-economists from the University of Mosul and MOA Baghdad collaborating in the baseline survey and adoption/impact studies have visited ICARDA regularly to plan, analyse, evaluate and report work. This has been excellent experience and training on baseline surveying, reporting and assessment of adoption and impact.

4.4	Effective international collaborative networks between Iraqi, ICARDA and Australian institutions and scientists	2 Iraqi scientists visit Australia each year Iraqi personnel interact with international research community.	Yr 1, 2, 3	It was planned and budgeted that 3 Iraqis (1 per year) would undertake a study tour to Australia. Nomination difficulties caused delays. Eventually, 4 Iraqi scientists (research director, agronomist, breeder, economist) had very successful and valuable visits to Canberra, South Australia and Western Australia in May/June 08 to study latest approaches to research management, crop R&D and farmer experiences with conservation cropping. Australian collaborators interacted closely with Iraqis through participation in planning and reporting meetings, contributing farming system knowledge, presenting 11 major seminars, provided research seed, and arranging Iraqi training visits in Australian One Iraqi scientist (Dr Suaad R Abdullah, entomologist, Mosul University) was supported to attend the 9th Arab Congress of Plant Protection, in Damascus in Nov 2006 The project re-established close contact between ICARDA and Iraqi scientists, with regular visits to plan and report on project work, participate in training courses and collaborate on research and development programs. Collaboration with Australian and ICARDA scientists increasingly evident in the two annual reports and planning, reporting and review meetings.

PC = partner country, A = Australia

7 Key results and discussion

CIM2004-024 is an unusual ACIAR-AusAID project with many constraints and difficulties to implementation. Firstly, Iraq has long been a hostile environment with the recent 1980-82 Iran-Iraq, 1990-91 Gulf and 2003-08 Iraq wars resulting in destruction of infrastructure, a bureaucracy constrained to function properly, international isolation and on-going violence and insecurity. This was and is a disabling environment for scientific research and development (and for life itself). Secondly, ICARDA and Australian scientists were unable to visit Iraq and inspect, evaluate and discuss collaborative work together. This has meant that Iraqi scientists implement and evaluate the research and demonstration activities within Iraq. Rainfall variability has also been a constraint, with crops being successfully grown only in the first two years in Iraq; the 2007-08 season was a failure with growing season rainfall of less than 100mm in most Ninevah locations.

Despite the difficulties, the project has made good progress against all objectives. Australian, Iraq and ICARDA collaborators gathered annually at ICARDA in September/October each year to develop technical workplans for the next year and report results of planned activities from the previous year. Under the circumstances, this has worked well with the proximity and similar environment of ICARDA facilitating the attendance of 83 Iraqi scientists at six major planning/reporting, review and technical exchange meetings and 62 Iraqi scientists taking part in 14 training courses and study visits.

Flexibility has enabled unusual obstacles to be overcome. In the project management group, when the Iraqi MOA project co-ordinator, Dr Awad Abbas, DG of the State Board of Agricultural Extension, was assassinated in Baghdad after returning from the September 2005 planning meeting at ICARDA, which was a severe setback, Dr Saleh Bader, DG of the State Board of Agricultural Research, was quickly assigned to fill the role. In the capital purchase program, the MOA requested in 2005 that funds be directed from research station rehabilitation to purchase of mobile seed cleaners; this was agreed to by AusAID, ACIAR and ICARDA and 10 Syrian-made were supplied to Mosul DOA to support important local production and distribution of better seed. When fund transfers from ICARDA to Iraq were delayed, the MOA was able to allocate bridging funds to allow work to proceed.

In the research program, two of the three Iraqi research stations where activity was planned were not functional due to land disputes and insurgency. To provide a secure site where research trials could be carefully managed and evaluated, a linked agronomy research program was undertaken at ICARDA focussing on development and evaluation of conservation cropping technologies, where Iraqi scientists, trainees and visitors could inspect and discuss the work together with ICARDA and Australian scientists. The University of Mosul was also introduced as a partner into the project, to provide an additional research group and station, with excellent scientific experience and expertise and access to students.

In the crop management program, as zero-tillage systems began to show potential in Iraq and Syria using small imported ZT seeders from India and a large, expensive imported ZT seeder from Germany, a component was added in both countries on local manufacture of effective and affordable zero-till seeders as experience elsewhere including Australia has shown seeder availability to be a major constraint to ZT adoption. This has turned out to be a very critical and successful program, with small village machinery engineering workshops and farmers in Iraq and Syria managing to modify and fabricate affordable local machines to incorporate zero-till features such as narrow points for minimal soil disturbance, wider tine spacing for stubble flow, and separate seed and fertilizer delivery. In a PhD study at Mosul University, a local seed broadcasting disc, commonly used for sowing crops in the northern dry areas of Ninevah, was modified for zero-tillage. The

expertise, enthusiasm and innovation of these manufacturers encourage confidence that these machines can be further developed and effective and affordable ZT seeders will not be a constraint to wide adoption.

In the research and development program, there was confidence that something could be done technically to increase crop productivity. Iraqi wheat production declined by 30% from 1990 to 2003 and average yields of wheat (0.73 t/ha) and barley (0.62 t/ha) were less than half of attainable yields (Sadras and Angus 2006). In contrast, average yields in similar environments in Australia have increased by 3% per annum over the last 100 years and now average around 2 t/ha. Anderson et al. (2005) have shown in a review of many studies around the world that 70% of such improvements come from better crop management and 30% from better crop varieties. The twin approach focussing on improved lines/varieties and improved crop management was logical and proved to be sound.

'Best bet' varieties and crop management technologies identified by Iraqi, Australian and ICARDA scientists and demonstrated and promoted with cooperating Iraqi farmers in 12 locations across the three rainfall areas of Ninevah were well chosen. The good performance of some introduced lines/varieties and the ZT system in participatory demonstrations has given the project impetus for early adoption and early impact.

Research was conducted on Rashidiya Research Station in Mosul and some demonstration locations to identify new adapted lines of the main target crops (wheat, barley, chickpea, lentil), to bulk up seed for subsequent inclusion in demonstrations and to evaluate improved crop management. Research plans were always too ambitious considering the conditions and the available research teams and support facilities. The project research team was reorganised in 2007-08 and Mosul University formally included as a partner with an expanded role beyond socio-economic support. A good workplan was developed with responsible scientists identified but, as noted above, the drought meant few trials and demonstrations were successful except under supplementary irrigation although there was good progress working with local machinery manufacturers and farmers to modify and develop local ZT seeders.

In ICARDA, linked research in 2005-08 evaluated and refined ZT technology and local ZT seeder manufacture and investigated the potential of oats, peas and oilseeds to diversify crop rotation options for Iraq. To date, this has shown in six trials that yields were similar or higher for ZT compared to CC, and higher for early than late sowing, for wheat, barley, lentil, chickpea and oats. In nine adaptation trials, several lines of oats and peas from Australia yielded well and showed potential as rotation crops - seed of these was shared with Iraq for evaluation. There were some spill-overs of this work in Syria, where some 10 local farmers and 4 local machinery manufacturers have been keenly involved in developing and testing ZT systems and seeders.

Some 150 Iraqi scientists visited ICARDA to participate in 14 formal training courses and 5 major reporting-planning-scientific exchange meetings, where Australian collaborators delivered 11 seminars on latest developments in crop R & D in Australia (Appendix 11.1). Four senior scientists went on study tour/training visits to Australia to learn more about modern approaches to research management, conservation cropping, plant breeding and socio-economics. Capital equipment supplied included ZT seeders, chisel ploughs, deep tillage subsoilers, and mobile seed cleaners.

In summary, the major achievements and outputs of the project in Iraq have been:

- evaluation of current cropping systems and identification of constraints through a major baseline survey and economic analysis to direct research efforts and evaluate project outcomes and impacts
- identification and uptake of more productive wheat and barley varieties

- demonstrations showing that crop establishment with chisel ploughing and drill seeding gave better yields than farmer methods involving several cultivations and broadcast seeding
- introduction of ZT technology into Iraq, for the first time according to Iraqi collaborators, with ZT-sown crops showing comparable or better yields than crops sown with conventional cultivation
- development of strong interest by farmers in ZT technology, which has been related to good yields and less cost at a time when diesel fuel prices are rising alarmingly due to the lifting of input subsidies (from $2 a few years ago, to $125 in 2006, and to $250 in 2007 for a 200 litre drum)
- identification and seed multiplication of some promising lines of alternative crops (oats, peas) to diversify rotations
- improved seed production capacity through training and the procurement of 10 Syrian-made mobile seed cleaners
- improved capacity of 150 Iraqi staff from MOA, DOA and University of Mosul through training delivered by ICARDA and Australian institutions in crop improvement, crop management, research methodology and socio-economic analysis
- production of annual progress and technical reports and the establishment of a project website to document and disseminate project results
- strengthening of MOA and Ninevah links with ICARDA and Australia
- opening access to new information and approaches through interaction and exchanges
- in linked agronomy at ICARDA to verify and demonstrate technology, there have been spillovers of ZT technology and alternative crops (oats, peas) into Syria stimulating strong interest by farmers, machinery manufacturers and processors.

External project review and Phase 2

This good progress and achievements were recognised in the external review, conducted at ICARDA on 13-17 April 2008 by Dr David Connor, University of Melbourne. The review was a major exercise for the project with two days of presentations addressing planned objectives and outputs by all project partners and a 1-day field visit north of Aleppo to inspect and discuss ZT cropping demonstrations in farmer fields and ZT seeder fabrication at local machinery manufacturer workshops.

The review was positive, recommending continuation into a Phase 2 to consolidate initial achievements and promote uptake of technologies with farmers and users. Connor (2008) recommended and commented on achievements and impacts (amongst other things) as follows:

"The significant success of the project to date has been the introduction of zero tillage (ZT) as a soil and crop management option for Iraq, and initially for Syrian farmers in the vicinity of ICARDA also. This management system now practiced over 100 Mha worldwide is well suited to low rainfall areas where it offers at least equivalent yields but at smaller production cost than conventional tillage, while improving soil quality and protecting it from wind and water erosion. These responses are evident in the results obtained so far and the economic advantages have special attraction to Iraqi farmers faced with greatly increased fuel costs now that they are outside a heavily subsidized agriculture. Much work remains in refining the adoption of ZT to the northern areas of Iraq. There remain issues of adaptation of machinery, selection of better crop cultivars, rotations, and management of stubbles. The latter is a major issue in a region where usually sparse stubbles are commonly completely grazed by sheep and goats that are an integral part of the production systems. Much benefit from zero tillage derives from soil

protection and increasing soil organic matter by stubble retention. In developing acceptable cropping systems, therefore, compromise must resolve the competition for stubble between grazing animals and soil conservation and quality. Part of the solution will be found in provision of alternative fodder supplies for grazing animals.

It is too early to claim major impacts of this project but significant advances are evident in all outcomes proposed for the project at the outset. The Iraqi counterparts are now once again linked into international level work on cultivar evaluation and crop management practices. Given the extraordinarily difficult situation in which they are working they have built a cohesive team, demonstrated commitment to the project, and made remarkable progress. The initial four objectives were sound in concept but probably overambitious in scale. Key demonstration sites were established in three rainfall zones as planned but cultivar evaluation was possible at only one and it was not possible to establish the planned research plots in Iraq. However enough of what was proposed has been achieved to claim success. In this it is important to acknowledge the major contribution of ICARDA in undertaking experimental and evaluation work to compensate for that not possible in Iraq, for its assistance generally in all aspects of the project, and the leadership it has provided to the project. The Australians have provided sound advice on 'best-bet' options that enabled rapid initial progress in the field, and in the provision of advice and training in research methodology and data analysis. . .

- ACIAR classify the project as highly successful and favourably consider a proposed extension ... based on the substantial progress that the project has made in all areas of the project and the determination of the Project Team to continue. While impact has been greatest in capacity building, the results of the demonstrations are already reaching farmers and machinery manufacturers. Given the response in comparable areas worldwide, a significant impact of ZT can be anticipated provided the adaptive research is carried out, and its value clearly presented through demonstrations and socio economic analyses. The value of the long-term trials that have been established will be obtained by continuation into the future

- ACIAR ensure that a continuing project focuses on the gains that have been achieved in the first phase. Overall, this implies a concentration of all aspects of work on the adaptability of zero tillage to production systems that include rotational crops and also alternative forage sources for sheep. This will require new work on nutrient management and IPM so that the production systems can reach water-limited productivity."

Proposal for project continuation (Phase 2)

The proposal for a second phase of the project, including project activities, work plan and implementation, was discussed and developed at a workshop attended by project review participants from all collaborating institutions, held at ICARDA on 16-17 April 2008, with four senior Iraqi scientists remaining at ICARDA until 1 May 2008 to assist with final proposal development.

A 3-year continuation was proposed focused around further developing and promoting conservation cropping, involving zero-tillage, stubble mulching, diversification of crop rotations, crop agronomy, better adapted crop varieties, crop-livestock interactions and expanded medium and long term postgraduate training in crop management and improvement. Areas for evaluation, research, promotion and training, building on what has already been established and achieved and opening up some new areas, were:

- conservation cropping - development of zero-till, stubble mulching, diverse rotation, crop-livestock interaction, nutrient management, IPM technologies
- socio-economic analysis - adoption and impact of new technologies
- ZT machinery - development of local and private-sector design/supply capacity
- seed - development of local and private-sector production/supply capacity

- GIS analysis - identification of constraint and recommendation domains
- variety selection - new approaches of evaluation through multi-site testing and multi-variate analysis (G x E); expand emphasis for salinity tolerance
- training - medium-term on-the-job training and MSc/PhD students linked to Australian Universities/ICARDA
- refurbishment of research stations

The draft proposal was submitted by ICARDA to ACIAR in May, with ACIAR arranging internal and external (Dr David Connor) reviews of the proposal. ACIAR submitted it to AusAID in June, with AusAID also arranging an external review (Dr David Swete-Kelly) and discussions between Drs Fox, Piggin, Swete-Kelly and Jonathan Ball of AusAID. Based on review comments, discussions and a visit by Drs Piggin to Adelaide and Perth to review/revise the proposal with Drs Coventry, Anderson and Siddique, the proposal was finalised in ACIAR by Drs Bailey, Fox and Piggin and Ms Tara Ali during June. (ACIAR and AusAID approved the proposal and signed an agreement to implement and fund the project in early August. ICARDA signed an agreement as the Commissioned Organisation to implement the project with ACIAR on 21/25 August 2008.)

That the follow-on proposal has been approved is indication of the good base and potential for conservation cropping built by this project and confidence that there can be wide adoption and impact for the technology.

8 Impacts

Given that the project is introducing, developing and promoting new cropping technologies in a difficult environment, major impacts were not expected in just three years. However, given the promising performance of zero-tillage in initial testing, its obvious wide applicability and initial farmer and machinery manufacturer interest, there are some preliminary and predicted impacts after just three years. Over the next few years, wide adoption and significant impacts seem assured given the wide uptake of ZT technology over 100 million hectares worldwide during the last two decades and its particular application to low-rainfall areas like northern Iraq.

8.1 Scientific impacts – now and in 5 years

For Iraq and Iraqi scientists, the project has re-established important direct contact with ICARDA and Australian scientists, provided access to their technologies and genetic resources and reintroduced Iraqi crop science to modern, world standard developments in plant improvement and crop management appropriate to the region.

Some 20 tonnes of experimental seed was introduced into Iraq over three years; some lines from these introductions will form the basis of breeding programs and new varieties over the next 5-10 years.

The project has introduced Iraq scientists, and many in ICARDA also, to the importance, concepts and potential of ZT as a means to increase yields, improve resource-use efficiencies, and conserve environmental resources. The technology would not have been introduced without the project and the involvement of Australian scientists with deep ZT knowledge and experience. Ninevah collaborators and farmers were sceptical about ZT after three small Indian ZT seeders were first introduced in 2006, because it had never tried in Iraq and it was considered crops cannot be grown without cultivation, soils are too hard to penetrate, ZT machines will break, and there will be increased weeds, pests and diseases. Following two years of testing and wider exposure on Australian study visits, in a remarkable but familiar turn-around, many are now evangelists for ZT. This change in mind-set, and the increased research and development it will bring, will contribute significantly to increased awareness, understanding and adoption of ZT over the next 5 years.

The project has also developed considerable knowledge and experience of conservation cropping technologies in ICARDA and Syria through in-depth research on zero-tillage, alternative crops and ZT seeder fabrication, which are little known and not used on farms in Syria.

Efforts will be made to publish one or two scientific papers from the project when the all the data have been compiled and analysed.

8.2 Capacity impacts – now and in 5 years

Some 150 Iraqi scientists visited ICARDA with 63 participating in 14 formal training courses and 83 participating in 5 major reporting-planning-scientific exchange meetings, where Australian collaborators delivered 11 seminars on latest developments in crop R & D in Australia (Appendix 11.1).

The Iraqi scientists undertook formal training and increased their capacity for future work in the following areas: Seed enterprise development and management; Chemical and Physical Soil Analysis; Insect taxonomy, anatomy and biological control; Plant taxonomy/herbarium/seed bank management; Analysis of feed stuffs; and Experimental designs, data analysis, field plot techniques, scientific writing, and data presentation, Utilization of Expert Systems in Agricultural Research and Production; Automated Library

and Information Management;, Seed Health Testing; Weed Management; Crop Variety Management and Seed Quality; Integrated Crop and Livestock Production Systems Management; and Water Management.

Capability to plan and implement programs to identify, demonstrate and disseminate new technologies, especially related to conservation cropping, has been enhanced for 83 scientists through involvement in planning, conducting and reporting the research and demonstration activities. They have received good guidance from ICARDA and Australian scientists but, because of their isolated situation, have been completely responsible along with colleagues for implementation. This has encouraged experience and capacity in communication and innovation.

Eight collaborator farmers from Iraq visited ICARDA in 2006/07 to inspect and discuss crop improvement activities and conservation cropping systems including zero-till direct sowing, stubble retention and diverse rotations and discussed and enhanced their knowledge in these areas. Some have returned to Iraq and used ZT on their farms.

Four Iraqi socio-economists from the University of Mosul and MOA Baghdad have collaborated in analysis, evaluation and reporting of the baseline survey and adoption and impact analyses. This has enhanced their capacity to undertake socio-economic investigations.

The project has encouraged some institutional change and facilitated closer interaction and collaboration between Iraqi scientists from various institutions in Iraq (MOA, DOA, University of Mosul)

A significant capacity enhancement event was the study visit by four senior Iraqi scientists, including the Project Coordinator and Project Leader, to Australia. The participants listed below gained in-depth knowledge and experience which will enhance their capability in future work in their institutions and within the ACIAR project in listed areas:

- Dr Saleh Bader, DG Research, MOA Baghdad studied R&D management and conservation cropping at AusAID, ACIAR, GRDC, CSIRO, University of Adelaide, SARDI, PIRSA, UWA, DAFWA, Murdoch University, Muresk-Curtin Uni, and WANTFA on 1-18 May 08.
- Dr AbdulSattar AlRajibu, Agronomy lecturer, Uni Mosul studied conservation cropping at the University of Adelaide and SARDI on 1 May–12 June 08.
- Dr Sa'ad Mohamed, Socio-economist, MOA Baghdad studied conservation agriculture and socio-economics at UWA and DAFWA on 1 May–22 June 08.
- Mr Raad Hameed, Cereal breeder, MOA Ninevah studied conservation agriculture and plant breeding at DAFWA and UWA on 1 May-12 June 08.

ICARDA scientists and Syrian national scientists and farmers gained knowledge and experience with conservation cropping through involvement in research and demonstration activities. This will be valuable in developing and promoting conservation cropping, and particularly ZT, more widely in Syria.

Capacity of Iraqi institutions to undertake work has been enhanced with the supply and training in the use of 3 zero-till seeders, 4 chisel harrows, 2 sub-soilers (deep tillage machines), and 10 seed cleaning plants. These will enable conservation cropping and quality seed production to be part of future projects and development efforts.

8.3 Community impacts – now and in 5 years

The socio-economic survey identified that participating farmers at the 12 demonstration locations in Iraq have been impressed with the performance of some new varieties of tested crops and expressed interest in obtaining seed. Some may have obtained and

planted improved seed but this has not been quantified. Given the fact that introductions and testing of new lines has been severely curtailed in Iraq over the last 5+ years, the project introduction and testing program bringing literally hundreds of new lines (20 tonnes of seed over 3 years) into Iraq is very significant. It is highly likely that several of the better-performing lines will be adopted by farmers over the next five years.

Farmers were also very interested in zero-till sowing from the point of view of economics and timeliness of operations and believe it could improve the soil quality except under very hard soil conditions. Given its relevance and applicability in dry areas, it is very significant that the project has introduced ZT technology and seeders into Iraq and shown the potential of the technology to both scientists and farmers, for the first time according to Iraqi project collaborators. Already several farmers are modifying seeders and have grown significant areas of their crop under ZT.

Some of these farmers were amongst the eight collaborating farmers who visited ICARDA on 2006/07, accompanied by four scientists from DOA Ninevah, to enhance their knowledge of wheat, barley, chickpea, lentil and faba bean improvement, disease and insect management, and agronomic management of cropping systems including zero-till direct sowing. They discussed with ICARDA scientists potential best bet varieties and technologies and expressed keenness to undertake further testing of better varieties and zero-tillage in their fields.

Again, this has not been quantified because of the drought in 2007-08 and impossibility of conducting the planned adoption/impact study. There is no doubt that, with the impetus the project has provided and the wide adoption of the technology in similar environments around the world, there will be significant validation and adoption of ZT in the drylands of Northern Iraq over the next five years.

In Syria, some 20 farmers have collaborated with ICARDA in demonstrations of ZT with their crops over the last two years. Generally, farmers have been impressed with the simplicity, good yields and lower costs of the ZT system. From this base, it is likely that ZT will be adopted more widely in Syria, as fuel costs are escalating and an issue for farmers. Four machinery manufacturers involved in local development of ZT machines see the potential of the technology, as many are farmers, and are likely to increase their business when there is more demand and wide adoption of the technology. One manufacturer in Kamishley on the Iraqi border expects there may be some demand from Iraq as demand and adoption of ZT systems increase.

8.3.1 Economic impacts

The economic advantages of ZT that derive from lower costs and greater yields are evident in preliminary results from the research and demonstration work in both Iraq and Syria. Especially significant is the opportunity to sow crops early, which usually brings higher yields.

In preliminary cost-benefit studies of 2006/07 results (the only year ZT vs CC comparisons are available), it was shown for wheat and barley that ZT can often be more profitable given its comparable or increased productivity for different cultivars under different climatic zones, taking into account the absence of plowing costs. It was emphasised that no firm conclusions can be made based on results from one season, especially in very variable rainfed areas such as where the project is situated. Rainfall is the main factor affecting production and parameters such as quantities and distribution in different seasons and location should be measured in order to build solid functions describing the relationship between productivity and rainfall..

8.3.2 Social impacts

The reductions in cultivation and quicker sowing of crops possible with ZT will bring more time and leisure to farmers and more family opportunity for interaction and recreation. Human health may be enhanced with no requirement for stubble burning and

consequently less smoke pollution. These are predicted impacts which will be realised when ZT is widely adopted.

8.3.3 Environmental impacts

Environmental benefits to soils and water can be expected in future. From experience elsewhere, ZT brings better soil structure (OM), better soil-water dynamics (porosity), better nutrient recycling (NPK), improved trafficability, less erosion, and opportunity for increased soil OM and C sequestration. Pollution will also be less as stubbles are retained on the soil surface and burning is reduced. These benefits have not been quantified but are well known from other experiences and publications.

8.4 Communication and dissemination activities

Initial communication and dissemination activities on project technologies, and especially ZT, alternative crops and new varieties, has been through attendees at project meetings and training courses at ICARDA. This has reached some 150 Iraqi scientists, who did not know of ZT technology or the value of these alternative crops before the project started, and raised their awareness and knowledge and their applicability and benefits for Iraq. This is significant as these scientists will be the ones to pass on awareness and experience to others in Iraq.

In Iraq, annual field days at demonstration sites, which were in farmer fields, were used to demonstrate and promote awareness of new lines of crops and ZT technology. These were reportedly attended by 20-30 farmers in each of the 12 locations in 2005/06 and 2006/07. Perhaps 400 farmers have been reached and many expressed keenness to take up some new varieties and the ZT technology.

Several machinery manufacturers and farmers in Iraq collaborated to construct local ZT seeders, and three machines were produced and demonstrated and used in farmer fields. Several farmers sowed large areas (>50ha) using these seeders in 2007-08. This has introduced the technology into the private sector domain and has resulted in some initial uptake.

A farmer group from Iraq visited ICARDA for a week in 2006-07 to inspect and discuss ZT research. Several of these farmers were the ones who used ZT in Ninevah in 2007-08.

In Syria, ZT was tested by 3 farmers in 2006/07 and 6 farmers in 2007/08 using the ZT seeder from ICARDA. A large ICARDA field day was held on one farm in 2006/07, attended by around 100 farmers and Syrian GCSAR research and extension scientists. Four machinery manufacturers have been involved in fabricating local ZT seeders since late 2007 and have become familiar and enthusiastic with the technology. They are producing three prototypes for testing in 2008/09 and can see commercial opportunities in marketing ZT seeders at prices of around $1500, which is comparable to conventional seeders. This initial uptake and involvement of local seeder manufacturers is a good foundation for wider adoption and impact. In more opportunistic dissemination, ICARDA trials have been shown and discussed with some 8-10 visiting groups from various countries in the region (perhaps 100 scientists/students).

In Australia visits of Iraqi scientists and the project activities were widely publicised through national radios, newspapers, websites and university publications.

9 Conclusions and recommendation

9.1 Conclusions

In an extremely difficult environment, the project has made good progress against all objectives and produced a range of broad-picture achievements which would not have been possible without the project. For Iraq, it has:

- strengthened MOA and Ninevah links with ICARDA and Australia
- opened access to new information and approaches through interaction and exchanges
- collected valuable baseline information and undertaken cost-benefit analyses to underpin adoption and impact assessments of project technologies in Ninevah
- introduced and evaluated the latest ICARDA germplasm widely in Ninevah
- introduced and evaluated conservation cropping widely in Ninevah
- stimulated great interest in zero-till technology and some uptake/modification by farmers and machinery manufacturers in Ninevah
- used the secure environment of ICARDA for scientific exchange, meetings and training, which has stimulated spillovers into Syria, especially with ZT

This has been possible because of the expertise and comparative advantage of the project partners and scientists. Iraqi collaborators have been solely responsible for in-country implementation and have undertaken the task with enthusiasm, industry, flexibility and dedication under very difficult circumstances.

ICARDA and Australian institutions have brought strong interest and support through deep experience and expertise in the main project components of improved lines/varieties and modern conservation cropping systems. ICARDA breeders have been able to select and provide much appropriate germplasm for evaluation and promotion. Australian scientists provided the essential outside influence to recognise the potential of ZT technology for Iraq and import the small Indian-made ZT seeders which enabled evaluation and promotion to begin. ICARDA proximity and climatic similarity to northern Iraq has also been critical in the success of the project, facilitating relatively easy access to a secure location for research, training and interaction amongst collaborators. This emphasises the importance of well-chosen partners and locations.

A lesson has been to retain flexibility within projects being implemented in difficult situations. This was especially important in supplementing the weak research program in Ninevah by the introduction into the project of the University of Mosul, with its broad agricultural research expertise, and the establishment of a research and development program on conservation cropping in the secure ICARDA station where technologies could be investigated in depth and inspected and discussed by project collaborators and by interested visiting scientists and farmers. It has been important in the initiation of a ZT seeder fabrication component with machinery manufacturers and farmers in both Iraq and Syria. It was also important when four rather than the planned three scientists were supported to participate in the major study visit to Australia, so that there could be high-level interactions with DFAT, AusAID and ACIAR on project implementation in Iraq and MOA commitment and focus for any project continuation. All of these modifications, not flagged in the original proposal, were critical to developing the understanding and awareness of zero-tillage technology necessary to underpin promotion and adoption.

9.2 Recommendations

Given the difficult environment in Iraq and the focus on promoting improved varieties and crop management, time is needed to develop, verify, and create awareness of technologies and promote adoption. The very promising performance of ZT, farmer enthusiasm for its applicability and initial farmer and machinery manufacturer interest in fabricating local ZT seeders all suggest that project continuation will encourage wide awareness and adoption in Iraq and, through spillovers, in Syria.

This was recognised in April 2008 by the project reviewer, Dr David Connor (Connor 2008), when he recommended "a continuing project focuses on the gains that have been achieved in the first phase ... (with) a concentration of all aspects of work on the adaptability of zero tillage to production systems that include rotational crops and also alternative forage sources for sheep. This will require new work on nutrient management and IPM so that the production systems can reach water-limited productivity."

A proposal for a second phase of the project was discussed and developed at a workshop held at ICARDA following the review, focused on further developing and promoting conservation cropping in Iraq and postgraduate training in Australia on crop management and improvement. The proposal was finalised and submitted to ACIAR and AusAID in June and approved in August 2008. This is an indication of the good base and potential for conservation cropping built by this project and confidence that there can be wide adoption and impact for the technology.

10 References

10.1 References cited in report

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Connor, D. (2008). External review report: ACIAR CIM/2004/024 Better crop germplasm and management for improved production of wheat, barley and pulse and forage legumes in Iraq, June 2008. ACIAR, Canberra, Australia.

Sadras, V.O., and Angus, J.F. 2006. Benchmarking water-use efficiency of rainfed wheat in dry environments. Aust. J. Agric. Res. 57, 847–856.

10.2 List of publications produced by project

Brief monthly reports to ACIAR/AusAID: May 2005-March 2008

Minutes of the ACIAR CIM/2004/024 Iraq Project Inception Meeting, 2 June 2005, ICARDA, Aleppo, Syria, 7pp.

Report of the Project Planning Meeting, 10-14 July 2005, ICARDA, Aleppo, Syria, 16pp.

Minutes and 2005/06 Workplan, Project Planning Meeting, 4-8 Sept 2005, ICARDA, Aleppo, Syria, 22pp.

Minutes and 2006/07 Workplan, Project Reporting and Planning Meeting, 1-5 Oct 2006, ICARDA, Aleppo, Syria, 28pp.

Minutes and 2007/08 Workplan, Project Reporting and Planning meeting, 2-6 September 2007, ICARDA, Aleppo, Syria, 33pp.

Annual Project Reports to ACIAR: First Year Report 2005-06 (12pp), Second Year Report 2006-07 (10pp), Final Report 2005-08

First Technical Report April 2005 - October 2006 (including Appendix 3 Details of crop management for all crops in alphabetical order of sites). ICARDA/DOA-MOA Iraq/University of Adelaide/University of WA-CLIMA, Agriculture WA. 100pp.

Second Technical Report November 2006 - September 2007: Technical results from information presented at the project reporting and planning meeting, 1-6 September 2007. ICARDA/DOA-MOA Iraq/University of Adelaide/University of WA-CLIMA, Agriculture WA. 139pp.

Kasim Khalil Kasim (2006). Review of background information on crop rotation under the rainfall conditions in North of Iraq, MOA/DOA Ninevah, Iraq. June 2006. 5pp.

Shideed, Kamel, Salem Younis Sultan, Sa'ad H. Mohamed, Watheq Abdul Kahar Al-Rawi, and Emad Yousif Ismael Abdullah (2007). Summary Report of the Baseline Socio-economic Survey Conducted in Ninevah Governorate, in July-August 2005. ICARDA/MOA-DOA Iraq. 7pp.

Pala, M., A. Haddad, and C. Piggin. 2007. Challenges and Opportunities for Conservation Cropping: ICARDA experience in dry areas. Presentation in International Workshop on 'Conservation Agriculture for Sustainable Land Management to Improve the Livelihood of People in Dry Areas' by ACSAD, GTZ and FAO, 7-9 May, 2007, Damascus, Syria. 16pp.

Mohammed, Saad H., Kamel Shideed, Watheq Abdul Kahar Al-Rawi, Salem Younis Sultan, and Emad Yousif Ismael Abdullah (2008) Socioeconomic Studies Report 2006-07, 7pp. MOA Baghdad, ICARDA, University of Mosul, March 2008.

Project web site (established 2007) - ACIAR-AusAID Iraq Project at www.icarda.org

11 Appendixes

11.1 Seminars by Australian scientist during project meetings at ICARDA

Project planning meeting, 4-8 September 2005

"A decade of research on cool season grain legumes in dryland environments of Australia: Lessons learned" Professor Kadambot Siddique, Director, CLIMA, University of Western Australia

"Cereal improvement in Australia" Dr Reg Lance, Barley Breeder, Department of Agriculture and Food Western Australia

"New horizons for farming systems suited to Southern Australia" Professor David Coventry, University of Adelaide

"The benefits and challenges of crop-pasture-livestock integration in Australian agriculture" Professor Kadambot Siddique, Director, CLIMA

Project reporting and planning meeting, 1-5 October 2006

"Dryland cropping in Iraq - the way forward" Dr Wal Anderson, Principal Research Agronomist, DAFWA, WA

"Chickpea collections: GxE responses and characterization of habitats" Dr. Jens Berger, Ecophysiologist, CSIRO Plant Industry and CLIMA, WA

"Farming System Changes in Southern Australia" Professor David Coventry, University of Adelaide, South Australia

"Agronomy as applied ecology-or why we shouldn't lose sight of the big picture when marking the white pegs. A chickpea example" Dr. Jens Berger, CSIRO and CLIMA.

Project reporting and planning meeting, 2-6 September 2007

"Wheat Breeding for Salt Tolerance" Mr Keith Alcock, Director Crop Research, Dept. of Agriculture and Food Western Australia (DAFWA)

"Recent advances in wheat improvement in the DAFWA Breeding Program" Mr Robin Wilson, Principal Wheat Breeder, DAFWA

"Some thoughts on starting new cropping industries based on experience with field pea in Western Australia" Mr Mark Seymour, Senior legume agronomist, DAFWA and University of Western Australia/CLIMA