HSAD Iraq
Harmonized Support for Agriculture Developme

Principles of Conservation Agriculture in Northern Iraq

Building a participatory basis to understand local and regional capacity based on international experience

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Introduction

Conservation agriculture (CA) is a platform that is built on a package of technical information relating to zero-tillage (ZT), crop residue and mulch management, and crop rotations. Adoption of CA has started in northern Iraq, especially in Ninevah where about 15,000 ha of crop is planted using ZT. As has been the case in many areas around the world where CA has been widely adopted, the use of participatory extension and management approaches should also be regarded as a key component of the CA package to address local needs for adaptation of the technology.

The focus of this work is on rainfed, dryland systems where modest levels of supplementary irrigation, in some areas, and the integration of livestock add further elements of complexity and opportunity.

These systems will have objectives that address economic, environmental and social benefits for farmers and other stakeholders.

It is for these reasons that either part or all of the CA approach have attracted farmers and other stakeholders with an interest in sustainable and profitable agriculture. Over the past 40—50 years CA has been widely adapted by farmers on tens of millions of hectares of land throughout the world providing strong evidence that CA is successful in most situations.

The HSAD and ICARDA activities in Iraq and Kurdistan have aimed at gathering global experience and technologies for CA. These have been explored and adapted to meet regional needs with local researchers, extension agents, machinery manufacturers and farmers working cooperatively to understand the value of CA in the region. See background to HSAD in Appendix 3.

This discussion has an emphasis on ZT for cropping as a central component of CA. This is not to diminish the importance of the whole package, but rather to reflect the importance of ZT and machinery options for farmers and other key stakeholders such as local machinery dealers and maintenance providers.

It also respects the local knowledge and decisions of farmers with regard to crop rotations, residue management and livestock integration.

Importantly, it reminds us of the need for participatory planning to ensure that the capture of local farmer knowledge and their engagement

at the earliest stage of development of a new technology or process is essential to underpin adoption.
The aim of this publication is an introduction to CA for farmers, extension specialists and researchers, based on experiences in the HSAD project in northern Iraq and other projects within the region and around the globe. Those interested in learning more about CA, how to test it and promote its adoption will find this publication particularly useful.

What is CA?

Conservation agriculture (CA) is a production system aimed at reducing the effort and cost of farming in a way that protects and improves agricultural soils. It is based on three key elements:

1) Minimizing disturbance of the soil
2) Maintaining soil cover
3) Crop rotation

CA has been widely adopted around the world especially in the USA, Brazil, Argentina, Australia, and Canada. CA holds tremendous potential for all farms from small to large and all agro-ecological systems. But its adoption is perhaps most urgently required by smallholder farmers, especially those in dry areas facing declining yields and acute labor shortages.

Zero-tillage

The first, key step in CA is to minimize the disturbance of the soil—no plowing or harrowing is necessary. Seed is planted directly into undisturbed soil along with fertilizer using specialised zero-tillage (ZT) seeders. This eliminates the fuel and labor costs associated with plowing, and reduces emissions of greenhouse gases. Most importantly, by not plowing, crops can be sown immediately after (or before the first autumn rains) which boosts yields. By not disturbing the soil so much, ZT improves soil fertility (organic matter content, physical structure, and water infiltration and storage) and the rates of seed sown can also be reduced, resulting in yet another saving.

Soil Cover

Maintaining stubble and other crop residues from the previous harvest on the soil surface and leaving the soil undisturbed protects farmland from wind and water erosion and from the extremes of heat. The occurrence of dust storms is reduced significantly. It also helps increases infiltration of rainfall, reduces runoff, cracking in clay soils, and reduces evaporation of moisture from the soil surface.

The stubble and crop residues accumulate in the soil, increasing soil organic matter, improving the soil's structure and sequestering carbon. This boosts the soil's ability to hold water and make it available to plants. Removal or grazing of crop residues from the field is discouraged as this often leaves the soil bare and unprotected. Likewise, burning crop residues makes the soil prone to erosion and valuable nutrients are lost from the system.

Crop rotation

It is well known that a lack of crop rotation, or monoculture, leads to a build-up of weeds, diseases and insect pests, and declining yields. Relying on one crop can also be economically risky. The inclusion of legumes in rotations is especially valuable because they boost soil nitrogen levels. Conventional thinking says that plowing and burning crop residues help control weeds, pests, and diseases, but the same or better results can be achieved using crop rotations and judicial use of pesticides. Switching crops each season interrupts the cycle of pests and diseases that build up when the same crop is grown repeatedly, providing the foundation for integrated pest management.

When farmers initially switch to conservation farming, they may need some help from chemicals, especially with weed control, but this is part of learning to manage weeds, pests, and diseases in an integrated way. Continuously growing cereals can lead to high populations of grass weeds, whereas these can easily be controlled in broad-leafed crops like legumes with selective herbicides. Likewise, broad-leafed weeds can be controlled in cereals.

Flexible CA Approaches

Research and farmer experiences in northern Iraq and nearby in Syria show that ZT is the most important principle of CA. Farmers can reap immediate benefits of CA if they adopt ZT alone (Fig 1), especially as this allows them to sow crops earlier. The maintenance of soil cover and crop rotation, while desirable, are less important than ZT for this region. Crop residues are highly valued as feed for livestock in the Middle East and North Africa (MENA), and provide useful incomes to crop producers who rent their land for grazing. Also the production of cereals is favoured by government subsidies and lower production costs compared to food legumes. So farmers rely heavily on wheat and barley which are considered more reliable and profitable than other crops.

Water-use efficiency

All Mediterranean-type environments in MENA, southern Australia and elsewhere share cool wet winters and hot dry summers. In rainfed situations crop yields are largely determined by the amount of rainfall and the crop's efficiency in converting rainfall to grain and/or straw, also known as water-use efficiency.

While the exact pattern of rainfall will vary across individual locations resulting in a variable length of growing season, the challenge is to optimise the water use efficiency of any crop. The key feature is to maximise the use of any rainfall from the "break of season" (or the first effective autumn rains) for the growth of the crop. In all cases this requires adjusting the sowing time to utilise the earliest rainfall and minimise evaporative and other losses of soil moisture.

Sowing crops three to four weeks earlier than normal, also means the crop establishes itself vigorously under warmer autumn temperatures, and flowers and fills its grain earlier under cooler conditions in early spring. These factors combine to increase water-use efficiency and boost crop yields in most (but not all) seasons.

Using CA in dry environments

In Australia and elsewhere ZT or direct seeding has proven a key technology to achieve the goal of early sowing to maximize water-use efficiency. By simply reducing the time spent plowing a farmer has the opportunity to immediately sow crops with the onset of rain.
Experience has also shown that in some environments farmers can also sow into dry soil before the first rains. This is when sowing occurs based on an expectation of the first rains of the new season occurring within a week or two of sowing. Provided seeding depth is optimum, crops sown into dry soil germinate and establish rapidly after the first effective rains.
It should be noted that the use of long-term rainfall records for particular locations can be a very valuable part of crop planning. They will also help define actual calendar dates for time of sowing (e.g. early compared to conventional) so that length of growing season can be compared across different locations and years.

Farm Management

Farm businesses are a mix of resources, management, family aspirations, knowledge, skills and labour. Extended interactions may occur through banks and other financial institutions, markets and often with government or NGO's with an interest in enhancing opportunities. All farm management systems will be based on concepts such as profitability, return on investment and sustainability so that the impacts of change and market variation can be measured.
The adoptions of CA in many developing systems introduced the need for a clearer pathway for farmers to record and manage information. Inputs will increasingly involve financial exchanges and access to finance such as the developing markets in microfinance.
Additionally, technical information such as machinery calibration, the understanding of agrichemicals, the recording of plant development, and the understanding of energy requirements of grazing animals are all part of the ongoing quantification of agricultural activities.
Therefore, any change process towards CA will require recognition of the need for parallel education in crop farm management. In this way

farmers will be empowered to make decisions that are consistent with their personal and family goals.

Appendix 1 contains a simple check list or discussion points for analysing and understanding existing crop management systems.

Conservation cropping package

The conservation cropping package outlined in Table 1 was developed based on field experiments conducted in Syria and Iraq over eight years. Of the 11 practices for conservation cropping, five are dependent on a good knowledge of ZT machinery and its capacity to deliver results. This topic is expanded in the next section.

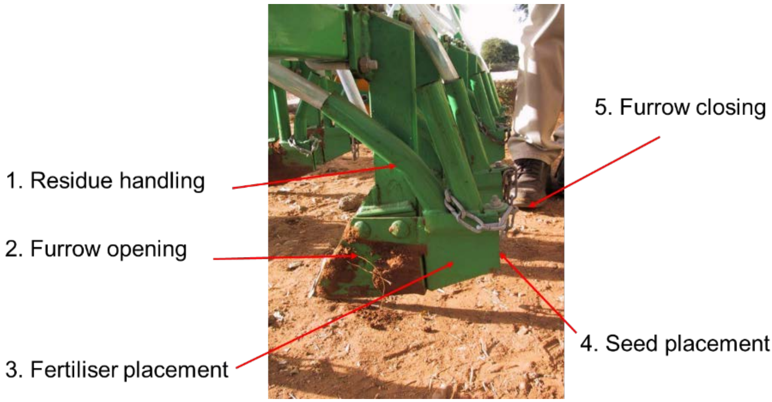
Table 1: Based on the recommended 'conservation cropping package' derived from field experiments conducted in Syria and Iraq from 2005-2012 (Loss et al, *in press*)

Practice	**Skills needed**
1. stop plowing	Machinery
2. use ZT seeders for all crops	Machinery
3. reduce seed rates (50-100kg/ha cereals; 100-150kg/ha pulses)	Machinery with seed/fertilizer metering
4. sow consistently at optimum depth (4-6cm)	Machinery with depth control (& consolidation with press wheels)
5. plant early (late October/early November)	Machinery – zero till enables speed and timely operations
6. if needed, kill weeds at sowing with glyphosate	Agronomy
7. keep as much stubble as possible - don't burn	Residue management
8. allow stubble grazing if needed - doesn't cancel ZT benefits	Residue management
9. use good quality seed of best adapted varieties	Good agronomy
10. use best fertility & weed/disease/pest management	Good agronomy
11. include non-cereals in rotation if possible	Good agronomy / rotations

Zero-tillage seeding machinery

A seeder is a series of many ‘seeding systems’ that plant a row of crop, and each system has five main functions (Fig 1). To achieve these functions, global manufacturers, local engineers and farmers have all contributed to many different variations in seeder design and modifications to suit their local conditions.

Figure 1: Functional elements of a ‘seeding systems’



In addition to the design elements of the seeder, the number of rows and seeder width will be determined by the farm and field size, and the power of the tractor available. Additional factors such as hydraulics, 3-point linkages or towing system will also influence ease of turning and depth control.

While these factors are essential in considering an individual machine set-up, the work done by ICARDA since 2005 has tested many seeders of different manufacturing origins, size and extent of modifications. In doing this they achieved comparable results in ZT trials with a range of solutions when set-up and calibrated appropriately (Fig 2).

What is most important is consideration of cost, local maintenance and capital available to a farmer. International experience such as in Australia has shown many farmers choose cheap modifications of their existing seeders to ZT while they gain experience with the new technology before proceeding to invest in larger, more refined and expensive new seeders. A range of modern machinery is available in local and international markets but such equipment might only be available to large farmers with capital resources, contractors who can meet the costs with many farmers, or local cooperative activities where costs might be shared by farmers and perhaps government.

Fig 2: Evaluation of various seeders in Syria

Types of modifications

In all countries where zero-tillage has been adopted farmers and local engineering companies have contributed to a wide range of machinery modifications and developments. The accumulation of such modifications is shown in Fig 3. This machine is basically a 30-40 year old design with a number of separate modifications that contribute to successful zero-tillage.

Fig 3: Machinery modified and adapted for zero-tillage in Iraq

Make of Seeder

Rama and John Shearer seeders are easy to convert for zero-tillage sowing. Where low levels of crop residue are expected, all that may be required is removal of all tines that are only cultivating (i.e. those not planting), replacement of the conventional high disturbance points (or soil openers) with narrow 'knife' points, and increasing the 'break out' force of the tines. Press wheels or a seed covering device may also be beneficial. Other conventional seeders, especially disc seeders are more difficult to convert.

Points

The soil openers shown in Fig 4 are narrow 'knife' points manufactured in Mosul Iraq. The key feature of modern ZT points is that they are designed to cut the soil in a narrow slot with minimal soil disturbance. Consequently, the tractor power required is less than with wide traditional points (e.g. high disturbance sweep type points), but this is usually offset by the fact that the soil was not cultivated previously.

Fig 4: Knife point openers for minimising soil disturbance

Tine configuration and row spacing

Depending on the size of previous crop and the extent of animal grazing, crop residues (or stubble) can cause blockages of the seed and fertiliser tubes or the accumulation of large clumps of residues under the seeder which causes problems at sowing and may prevent plant emergence. If crop residues are minimal due to grazing, then the conventional tine configurations may not require modification. By increasing the spacing between rows to about 20-25 cm and redistributing tines on three rather than two tool bars or ranks (Fig 5) residue flow under the seeder can be improved dramatically.

In some cases the wider row spacing can also reduce the incidence of leaf diseases in the crop and result in increased yields in cereals and some crop legumes.

Fig 5: Spacing of tines in a 3-row (or rank) configuration to improve crop residue flow under the seeder.

Tine strength

With direct drilling into uncultivated soil, the density and strength of the soil is likely to be much greater than if the field had been cultivated recently as in conventional tillage. As can be seen in Fig 5, tines need to be robust and provide adequate resistance, but also have the capacity to 'break out' or lift over a large stone or other obstacle in the soil, otherwise it will be easily damaged. It is important that the 'break out' settings on the springs are increased (Fig 6), and are sufficient to ensure an even depth of sowing into undisturbed soil.

Fig 6: The tine 'break-out' can be increased by tightening the adjusting nut.

Seed and fertilizer placement

Part of the success of zero-tillage has involved placement of seed and fertilizer at a precise depth. If the sowing tines are spread out over two tool bars (or ranks) then the existing seed and fertiliser box will probably work efficiently. But if the sowing tines are changed and spread out over three tool bars, the seed and fertilizer box needs to be mounted in an elevated position so that there is a sufficient angle of the tubes to ensure that the flow to the seeding boot is unimpeded. In Fig 7 the seed and fertilizer box of this seeder was raised 430mm to ensure the tubes connecting to the sowing boots on a third rank at the back were at a sufficient angle to allow good flow of seed and fertilizer.

Fig 7: The seed and fertilizer box was raised on this converted ZT seeder because the seeding tines were spread over three ranks

Seed cover and press wheels

While press wheels (see Fig 3) can be an optimum solution for soil cover and soil-seed contact, they can be costly to purchase and maintain, and add extra weight to the seeder. A variety of simple 'snake chains' devices attached to each sowing tine can improve seed cover without the need for press wheels (Fig 8).

Fig 8: A typical 'snake chain' device to help cover the seed

Operating speed

In general, zero-till seeding machinery will operate better and with reduced risk of damage and component wear, if operating speeds are reduced compared to those often used in fully cultivated seed beds, especially if soils are still relatively dry or hard setting. The additional time required for crop establishment due to the slower operating speed will still be much less than for conventional cultivation systems.

Maintenance

Every seeder should have regular maintenance and repairs. Obviously if you are going to the effort of converting a seeder to ZT, it will be wise to first ensure it is maintained well and operating effectively before you start.

A Participatory Approach

Our knowledge of CA and ZT has now developed in mnay countries over several decades with inputs from researchers, extension workers, farmers, machinery manufacturers and input suppliers. It is important to note therefore, that these countries generally have:

1. Highly mechanized and large farms
2. Extensive experience with weed, pest and disease management and emerging issues;
3. A wide array of modern media and communications systems and extension services (public and private);
4. Farmers with access to banking and other forms of support finance;
5. Bio-economic modelling of systems to enable broad scenario planning.

Much of this experience provides an idea of the potential challenges in new locations, particularly in parts of the world undergoing change and development. However, it will only be through engagement with all stakeholders in the agricultural industry in Iraq that we can understand how the proposed changes can address the needs and opportunities.

The HSAD project aimed to use 40-50 years of CA experience to reflect the knowledge that has developed, not to presume a particular CA solution or recipe for Iraqi farmers. We suggest that improvements in regions not familiar with CA can achieve faster gains by having a high level of awareness of other global developments and experiences with CA. ICARDA experience with CA in Syria and Iraq since 2005 has shown clearly that once an effort is put into raising awareness, that there is a significant drive and interest by farmers to learn more.

The easiest way to raise awareness is to work closely with farmers and other potential stakeholders from the beginning of the process to harness their interest and knowledge. In this participatory method local knowledge will contribute to problem identification, identification of research needs and local priorities, discussion of results in the community, and general problem solving. All of these factors can contribute to faster and higher adoption rates.

CA in new environments

This section provides some insights into why the unique aspects of each environment need to be considered when building a vision for the application of CA in new areas.

It is complex

CA includes elements of cultivation, mechanisation, residue management, weed and pest management, nutrient management, crop rotations, agricultural systems, environmental management, and learning and capacity building for a range of stakeholders. From an agronomic and farm business perspective, it will also involve impacts and management decisions over a range of time scales (e.g. this crop, next year's crop, long-term investment in machinery). So while it is complex, CA can be rewarding and motivating, and we know from global and regional experience that it delivers successful and sustainable cropping outcomes.

Community demographics, knowledge and attitudes

CA has been adopted in many countries around the world and the people involved in this process vary widely in their practical and technical knowledge, size of farms, attitudes to risk (especially for the farm household), and communications networks. As CA is a whole systems approach, a strong understanding of local farmers and their needs and resources will always be essential in designing programs to facilitate change. Size of individual land holdings will influence scale of machinery, use of contracting services and attitudes to risk when considering modernisation.

Stakeholders differ

CA has a wide array of stakeholders in all of the environments where it has been extensively adopted. In some cases the inputs are technical (crop agronomy, weed and pest management, mechanisation), in some cases they are about group participation (on-farm trials, field days, farmer field schools) and in others about services (public and private advisors, financial institutions, machinery services). In all cases where adoption has been rapid and widespread, an array of important stakeholders can be readily identified. For the MENA region, access to local expertise with machinery maintenance and adaption is especially important.

Not a CA recipe

Modern CA has clearly demonstrated that while there are many common principles for success, there is no one simple blue-print or recipe that works in all circumstances. This underpins the need to develop a deep understanding of local systems and its unique issues, so that these can be addressed based on the broader international experience, and guided by the prevailing environment. Often this will mean consideration of a stepwise adoption of the key components such as zero-tillage, before examining crop residue and grazing management, and gaining experience with crop rotations.

Appendix 1 contains a MAKAT log frame aimed at measuring all issues that contribute to successful CA adoption - motivation, attitude, knowledge, abilities and skills and technology and tools of stakeholders.

Local innovation

Any agricultural system that makes simultaneous demands on plant, soil, water and livestock interactions will have to evolve slowly to meet local challenges and resources. The adoption of CA will need to be tested and adapted to meet local conditions so that farmers can fully understand changes that can occur and how to identify and manage local risk. Time of sowing is a key factor that will influence CA outcomes and needs to be understood in terms of the challenges relating to the onset and pattern of seasonal rainfall, frost risk and average timing of ripening.

Economic, social and environmental success

The success of CA can be measured in different ways with potential economic, social and environmental outcomes. In some cases the primary driver for conservation farming has been reduced soil erosion, but the value it has delivered in many environments comes quite directly from improved crop economic returns or profitability (see Fig. 9 of Iraq data from many trials).

a) **Early + yield** = yield advantage of early sowing enabled by the elimination of plowing and use of a single-pass sowing operation with onset of autumn/winter rains which enables the crop to make maximum use of the rainfall
b) **Seed rate** = significant reduction in seed; traditional sowing methods in the region have essentially been to broadcast seed (by hand or machine) at high rates or with conventional seeders (>200 kg/ha for wheat) whereas zero-till machines are proving successful at much lower seeding rates (90-120 kg/ha for wheat)
c) **No Plow** = fuel and labor savings; traditional cultivation often requires 2 or 3 plow operations before sowing whereas zero-tillage eliminates these with a resultant savings in fuel and time or labor
d) **Herb** = knockdown herbicide cost; in some cases where weeds are present at sowing it may be necessary to use a herbicide spray

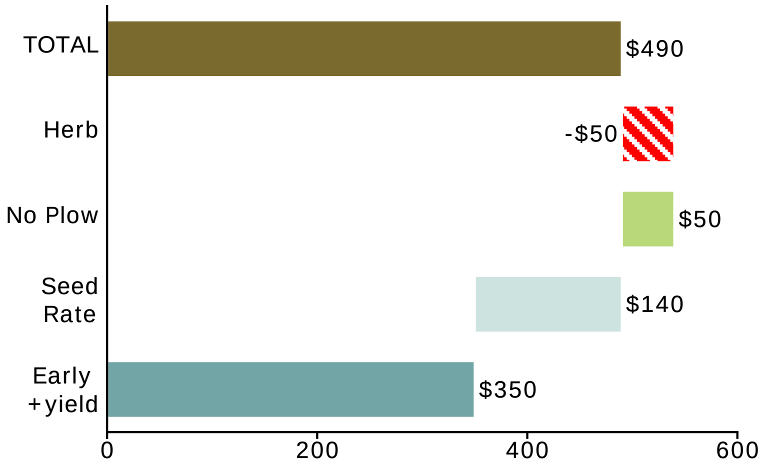


Fig 9: Factors contributing to the economic success ($/ha) of zero-tillage from trials in Iraq (Loss & Piggin 2013)

On-farm CA trials

On-farm trials are an excellent way to demonstrate CA, engage farmers and other stakeholders, generate discussion and encourage farmer to farmer learning. They were used very effectively to promote adoption of zero-tillage in Syria.

Ideally the trial planning should involve the farmer (and his/her neighbours) right from the start. Operations should be conducted by the farmer using his/her own seed, fertilizer, tractor and other equipment, in this way he/she will take greater ownership of the trial. If the trial is conducted totally by scientists using their own equipment, the farmer is only learning by watching. He/she will learn much more if they are actually doing the operations themselves.

The first steps are to ask

- What is the question that I want to answer? And, what do I want to test? Then design a trial to answer that question. For example, the most common question is how does zero-tillage and early sowing compare to conventional crop establishment practices.

Several points need to be kept in mind to get the best out of your trials:

- What sort of treatment(s), do you wish to investigate and the possible effects. It is best to keep things simple, with two or three different treatments – zero-tillage plus early sowing compared to conventional.
- Pick your test site/field carefully so it is as uniform as possible and representative of wider areas in the district. Eliminate all other factors which might cause false differences between the treatments. If possible, it is best to impose the treatments within a field that has been managed uniformly, rather than having one field with one treatment compared to another field with the second treatment because of possible difference in previous crop management, soil types, etc.

Fig 10. Sowing of a ZT demonstration trial at Kalar/Garmiyan

Make it a true test

You have to ensure that the results you get accurately reflect the treatments you applied, rather than some other source of variation. To get valid comparisons between your treatments it is important to:

- Ensure the treatment areas have the same soil type ideally in the same field (and avoid corners of the field that may have had double sowing);
- Use the same varieties and source of seed;
- Use the same fertiliser at the same rate;
- Use the same herbicides;
- Because the use of zero-tillage enables farmers to sow early, it is useful to combine the two factors in one treatment, unless you want to specifically want to investigate the effect of planting date.

Measurements

Before you start you should decide what needs to be recorded and measured, and how. Again it is best to keep things simple to start with. Just plant density after establishment and grain yield at harvest may be sufficient, but you might also consider assessing early crop vigour, weed and pest densities, biomass, and tiller numbers. Because your on-farm trials will be conducted with the assistance of farmers and in their fields, it is essential that in the planning process they understand the needs especially for correct timing of activities. This is especially important if the site is to be used for shared discussions, field days and the like where there will be a strong reliance of visual assessment.

Appendix 1 - Crop management

The following questions form a simple check list for analysing and understanding existing crop management systems. They also provide prompts for consideration of matters that are often the basis for farmer discussion, experimentation and application in a wide range of environments.

Choice of site

Soil type	*Soil texture and stoniness; while zero-tillage has proven itself in a wide range of soils, soils with a high mechanical resistance can be challenging to some machinery. Slower speeds always help in such difficult conditions.*
Slope / contour	*Influence access, and need to avoid erosion by avoiding sowing down slopes.*
Ease of access for machinery	*Machinery needs to turn & not damage other areas – especially where fields are small.*

History of the site

Has it been cultivated?	*Information about soil surface and potential compaction; past cultivation may have left a very uneven surface.*
Is there crop residue?	*Heavy crop residues can present challenges to machinery but are valuable for soil protection and nutrient cycling.*
What was the last crop?	*Disease risk, nutrient interactions and crop residue management.*
Is there a crop rotation practiced or monoculture?	*Crop rotations, especially cereal and legume crops can improve sustainability through disease and nutrient management.*

Cultivation methods & Machinery

Mechanisation	*Grower understanding of demands of mechanisation & skills needed*
Maintenance	*Local sources of spare parts, modifications and repairs to seeders.*
What machinery is available and is that likely to be shared?	*Machinery is expensive and its value depends on the scale of usage which may require cooperative activities by farmers.*
What type of procedure is used to measure quantities of seed and fertiliser and to calibrate sowing machinery?	*Measurement is central to understanding crop performance and it commences with the precise calibration of seeds and fertiliser through machine.*

Place of animals

Is the crop land directly grazed by animals?	*While animal manure can be valuable, animal treading can cause other soil interactions and also reduce crop residues.*
Is the crop land always cropped or can it used for forage or pasture ley phases?	*Mixed farming and land-use can be profitable but may present different challenges in terms of timing for optimum management.*

Crop residues

Are crop residues collected?	*The complete removal of residues can create erosion risks during the non-crop phase.*
Are crop residues burned?	*Burning of residues can cause both nutrient and carbon loss.*

Timeliness and break of season

Is the environment strongly seasonal?	*Considerable success has been gained through the early sowing opportunity that comes with zero-tillage. This is especially important in benefitting from early season rain*
Do weeds have to be managed at or about sowing?	*In many environments, the use of knock-down herbicides is a critical element of zero-tillage where there are weeds present at or about the onset of sowing (for some or all of the cropping program).*

Sowing

What crop will be sown?	*The choice of crop will influence time of sowing and flexibility of sowing date. It will also influence style of planting (precision planting versus general metering).*
Is there flexibility with varieties depending on anticipated length of growing season?	*For the area to be sown, will the varieties change as the sowing program progresses (longer to shorter season varieties)? It is important to take this into consideration if earlier sowing puts crops at a greater risk from frost or disease.*
Are different crops sown?	*What is the sequence for growing different species and under what conditions is it anticipated sowing will occur? (Changing crops will require recalibration of machinery)*

Seed and fertiliser placement

Is seed and fertiliser distributed at the same time	*Modern seeding equipment offers quite precise placement of seed and fertiliser but this may be new technology, especially for calibration.*
Is seed sown or broadcast into prepared ground?	*This is perhaps a description of current practice and is inconsistent with maximising the use of valuable seed.*

Fertiliser

What types of fertilisers are normally used?	*In most cropping environments there will be an economic advantage from the use of fertiliser and therefore understanding choice and cost will be important. Being able to sow fertiliser in close proximity to seed can improve efficiency.*

Protecting the crop

What crop protection methods are used – pre-emergent, post-emergent (early and late)?	*In most areas where weeds are an important issue, zero-tillage will be tightly linked with the use of herbicides, and thus understanding potential use patterns is an important part of the system*
Does the farmer have experience with preparing and delivering agrichemicals?	*The use of agri-chemicals demands a level of knowledge to ensure safe handling and effective usage.*

Appendix 2 - MAKAT: issues that contribute to adoption

(Motivation (**M**), Attitude (**A**), Knowledge (**K**), Abilities and Skills (**A**) and technology and tools (**T**))

The following table represents the equivalent of a log-frame in considering the combination of change and drive by people and technology details leading to the potential adoption of CA.

Issue: The need to increase the adoption of CA principles and practices in Northern Iraq to achieve more profitable and sustainable farming systems **Background:** The principles of CA have been tested at research level in Syria and Iraq, and have been shown to be a viable method to reduce land degradation and improve farmer profitability and resilience in dryland cropping. **Outcomes:** More profitable and sustainable farm businesses through the adoption of CA practices More sustainable land uses with lower potential for land degradation **Desired change in practices:** Establishment of crops and pastures using minimal soil disturbance techniques. The adoption of best practice agronomy (including using suitable diverse rotations) to maximise productivity and profitability. Increased retention of crop and pasture residues to provide soil protection as well as other benefits to crop productivity.

Measure	Where are we now?	What will encourage changing practices?
Motivation	*What is motivating farmers now?* Fear of the unknown- not sure how the new technologies fit on their farm Current farming system has worked for many generations Satisfied with present level of profitability - staying within comfort zone Are not that concerned about land degradation levels Want to retain present benefits from cheap grazing of fallow lands Simplicity is a strong motivator/low risk (cf. break crops and use of expensive herbicides) Unreliability with break crops Personal preferences for enterprise types	*What will motivate change?* Better understanding of the benefits of CA- case studies of changed farmers? Options which are simple and have low risk Peer pressure Financial incentives
Attitude	*How do we/ farmers feel about this issue?* Farmers are aware of CA practices Farmers believe that break crops are agronomically desirable but are too risky and too difficult to manage (including marketability)	*What are the feelings/attitudes/values that embrace change?* Educating the full benefits of CA and the solutions to weaknesses Increased belief in the value of long term sustainable

Measure	Where are we now?	What will encourage changing practices?
	Farmers want to retain present stock numbers for risk management and liquidity Alternative crops are too difficult to grow and high risk	farming systems Identifying with other farmers success in CA
Knowledge	*What do growers/scientists know?* Poor understanding of range of weed control options, both knock down and in crop Unaware of the cost to crop yield of high weed burdens, retained to benefit stock in the following weedy fallow Inadequate analysis of cereal and break options has led to poor comparisons of their relative profitability Unaware of the cost of disease to cereal crop yields of high incidence of cereals in the rotation Quality of pastures need to be improved so they are better breaks for cereals	*What do we need to know?* Understand the effect weed and disease burdens are having on crop yield Improved understanding of benefits of break crops and their profitability Recognise the improved nutritional value of improved pasture and forage options over traditional weedy fallow Least cost options for establishing fodder beak crops

Measure	Where are we now?	What will encourage changing practices?
Abilities/ skills	*What are we able to do?* Poor operational skills in herbicide application Poor understanding of correct settings for direct seeding equipment	*What skills & abilities do we need in future to encourage change?* Skill in operating suitable ZT machinery Skill in understanding calibration of crop sprayers and application aspects
Technologi-es/ tools	*What tool/technologies do we have?* Poor availability of appropriate ZT drills and crop sprayers Inadequate harvesting equipment for handling break crops efficiently Little use of monitoring soil resources (e.g. N and water)	*What tool/ technologies are needed?* More access to ZT seeders Widespread use of in crop monitoring tools to understand crop constraints Improved forage and break crop species
What do we need to do? **Suggested R, D & E activities**	Need to fully quantify the benefits of CA through the use of case studies, and whole farm analysis (for crop, and crop-livestock options) Refine agronomic packages to improve returns from all crop options so their potential can be more fully realised	

Measure	Where are we now?	What will encourage changing practices?
	Increase farmer skills in machinery operation and herbicide usage and application Improving the farm business capacity of farmers to assess options more realistically/thoroughly Develop simple crop monitoring options for farmer use Inform farmers of the improvements in performance of current crop varieties and crop options Indicators for success or minimum criteria of break options	

Appendix 3 - Background to HSAD

The HSAD project funded by USAID worked to improve the competitiveness of agricultural value chains and raise the incomes of farmers and agri-businesses in Iraq. Improved skills and professional capacity were key to achieving this positive change. Capacity building activities with the Ministry of Agriculture equipped officials with the skills to deliver training, accurately assess technology and policy constraints, and promote self-reliance. This strengthened national ownership and ultimately reduced the need for external support – a key priority of the program. HSAD's international partners supported the Iraqi Ministry of Agriculture, the lead organization.

Specific objectives supporting the main aims of the HSAD project included:

- **Delivering technologies to farmers:** proven interventions for crop, livestock, and natural resource management, including stress tolerant plant varieties, alternative feed sources, and supplemental irrigation [e.g. developing CA]
- **Developing reform action plans:** summarizing constraints, piloting enabling options, and recommending policy reforms [e.g. pilot activities for CA, especially zero-tillage with success supporting further regional and national development]
- **Strengthening and supporting the Iraqi extension system to increase its effectiveness in technology and services delivery:** shifting from 'top-down' extension models to participatory approaches involving farmers and rural communities [e.g. training in participatory methods and participatory actions in on-farm CA field trials]
- **Developing new policies, rules, and regulations:** a new informed policy framework based on the results of pilot programs and assessments [e.g. understanding and supporting investment needs at a farmer, regional and national level to facilitate adoption]

- **Developing an impact evaluation of new policy options, rules and regulations:** a persuasive and robust analysis of policy and regulation impacts approved and enacted by Iraqi authorities
[e.g. provide robust costs and benefits arising from the adoption of CA]
- **Training targeting farmers and agri-businesses:** helping beneficiaries to effectively navigate new services, policy rules, and regulations
[e.g. training to support continuous improvement and engagement of all stakeholders in CA]

Glossary

Conservation agriculture (CA)	**Aims to achieve sustainable and profitable agriculture and subsequently improves livelihoods of farmers through the application of the three CA principles: minimal soil disturbance, permanent soil cover and crop rotations. (http://www.fao.org/ag/ca/)**
Conservation tillage	Uses a number of practices in combination, which conserve soil, moisture, fertilizer, seeds, energy, time, and money. With conservation tillage, tillage is minimized when planting the crop but other simple techniques are also applied which protect the soil from the damaging effects of rain splash. These include reducing run off and making the best use of fertilizer and seeds.
Reduced tillage	Reducing tillage operations to the minimum required to plant a crop. For hoe and ox draft farmers it usually involves scratching or ploughing out the row where the crop is to be planted and leaving the rest of the land untouched until weeding is required. Alternatively, hoe farmers may just dig holes where the seed will be sown. (Source: Food and Agriculture Organization of the United Nations)
Zero-tillage	One pass operation which places seed and fertilizer into an undisturbed seedbed, packs the furrow and retains adequate surface residues to prevent soil erosion. (Source: Canada-Saskatchewan Agreement on Soil Conservation, Economics of Zero Tillage)
Break of the season	The first effective rainfall in autumn starting the growing season for crops
Knock down herbicide	Non-selective herbicide used for complete vegetation (weed) control ahead of sowing e.g. glyphosate
HSAD	Harmonized Support for Agricultural Development (also harvest in Arabic)
MENA region	Middle East and North Africa region
Water-use efficiency	The efficiency of crop in converting rainfall into grain and/or straw, usually measured as kg/mm rainfall or available moisture.

Useful Reading

The following documents can provide further detail of value for developments in the MENA region, with an international perspective.

Baker, C.J., Saxton, K.E., Ritchie, W.R., Chamen, W.C.T., Reicosky, D.C., Ribeiro, F., Justice S.E. and Hobbs, P.R. (2006). No Tillage Seeding in Conservation Agriculture. Second Edition (FAO CABI Publishing)

ICARDA (2011) Conservation agriculture: opportunities for intensifying farming and environmental conservation (A synthesis of research and trials with smallholder farmers in drylands systems; benefits and constraints to adoption. Farmer experiences and potential for uptake in Iraq, Syria,

orocco and Tunisia). Research to Action No. 2. (English and Arabic versions)

Loss, S., Haddad, A., Khalil, Y., Alrijabo, A., Feindel, D., and Piggin, C. (2014) Evolution and Adoption of Conservation Agriculture in the Middle East, Chapter 9 In 'Conservation Agriculture' Eds. Farooq M, Siddique KHM. Springer Science (in press).

Swanson, B.E. and R. Rajalahti. (2010) Strengthening Agricultural Extension and Advisory Systems. World Bank, Washington, DC, USA.

Derpsh, R *et al*., (2014) Why do we need to standardize no-tillage research? Soil and Tillage Research, 137, 16-22.

Journals with CA and zero-tillage coverage

Soil & Tillage Research
Agriculture, Ecosystems and Environment
Field Crops Research
Also see the ICARDA CA webpage which contains useful ZT seeder fact sheets in English and Arabic:
http://www.icarda.org/conservation-agriculture/teaser

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