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Challenges and opportunities for conservation tillage-direct drilling in CWANA region: ICARDA/NARS's experience

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SUMMARY – The past several decades have witnessed a change from traditional to more intensive agriculture in dryland farming systems of West Asia and North Africa (WANA) and also in the transitional period of Central Asia and Caucasus (CAC). These two areas can be combined in which is called the Central and West Asia and North Africa (CWANA) region. This region is a major area of the world where drought invariably limits crop production in about 1.7 million ha arable land. Agriculture is primarily based on rainfed cropping during the relatively cooler late fall to early spring as rainfall ranges generally between 200 to 600 mm per year. Dryland crops are mainly wheat, food legumes such as lentil, chickpea, faba beans, and forage legumes such as vetch, medics, and lathyrus. Increasing human and livestock population has led desertification and soil degradation in the region. This has led also ICARDA to an assessment of tillage systems for efficiency, enhanced productivity and sustainability of the various farming system changes through a series of long-term trials in the mid 1980's at ICARDA headquarter as well as in the NARS (National Agricultural Research Services) in close collaboration. Results at ICARDA and the region support a preference for the conservation tillage system (minimum tillage) over deep tillage systems on the grounds of both energy-use efficiency and increased net revenue as direct benefits to livelihood of the rural population. However, whenever available and tested and adopted by farmers with their participatory evaluation as in Central Asia, no-till direct drilling would increase soil organic matter from about 0.9 % to 1.3% at 0-10 cm top soil and sustain the systems productivity in the long-run on the basis of the initial research results throughout the CWANA region.

Keywords: Zero tillage, no-tillage, conservation tillage, conventional tillage, organic matter, sustainability.

RESUME – “Défis et atouts pour le labour de conservation - semis direct dans la région CWANA : l'expérience de l'ICARDA/NARS”. Les dernières décennies ont vu l'évolution d'une agriculture traditionnelle vers une agriculture plus intensive dans les systèmes agricoles des zones arides de l'Asie de l'Ouest et l'Afrique du Nord (WANA) et une période de transition a également eu lieu en Asie Centrale et dans le Caucase (CAC), régions qui, combinées, sont désignées sous le sigle CWANA (Asie Centrale et Occidentale et Afrique du Nord). Il s'agit d'une vaste région du monde où la sécheresse limite invariablement la production des cultures sur quelque 1,7 million d'ha de terres agricoles. L'agriculture est fondée en premier lieu sur des cultures pluviales pendant la période relativement fraîche allant de la fin d'automne au début de printemps, avec une pluviométrie qui est généralement de 200 à 600 mm par an. Les cultures des terres arides sont principalement constituées par le blé, les légumes secs tels que les lentilles, les pois chiches, les fèves, et les légumineuses fourragères telles que la vesce, la luzerne, et la gesse. L'augmentation de la population humaine et du bétail a entraîné une désertification et une dégradation du sol dans la région. Ceci a amené l'ICARDA à réaliser une évaluation des systèmes de labour pour étudier l'efficacité, la meilleure productivité et la durabilité des différents changements des systèmes d'agriculture à travers une série d'essais à long terme vers le milieu des années 80 au siège de l'ICARDA ainsi qu'au NARS en étroite collaboration. Les résultats à l'ICARDA et dans la région seraient en faveur du système de labour de conservation (labour minimum) par rapport aux systèmes de labour profond en raison de l'efficacité d'utilisation de l'énergie et d'un meilleur revenu net comme bénéfices directs pour l'existence des populations rurales. Cependant, lorsqu'il a été disponible, testé et adopté par les agriculteurs dans le cadre de cette évaluation participative, comme en Asie Centrale, le système de non labour et semis direct semble augmenter le carbone organique du sol d'environ 0,9 à 1,3% et favoriser la productivité des systèmes à long terme, au vu des résultats préliminaires des recherches menées dans la région CWANA.

Mots-clés : Semis direct, non labour, labour de conservation, labour conventionnel, matière organique, durabilité.

Introduction

The past several decades have witnessed a change from traditional to more intensive agriculture

in dryland farming systems of West Asia and North Africa (WANA) and also in the transitional period of Central Asia and Caucasus (CAC). This region is a major area of the world where drought invariably limits crop production in about 1.7 million ha arable land, which is under pressure of increasing population leading to desertification and soil degradation. This has led ICARDA to an assessment of tillage systems for efficiency, enhanced productivity and sustainability together with partners from the NARS (Harris *et al.*, 1991; Harris, 1995; CIMMYT and ICARDA, 2000; Pala *et al.*, 2000, 2005; Suleimenov *et al.*, 2001a,b; Ryan *et al.*, 2004). Over much of the region, it is the usual practice to plough, with a disc or mouldboard to a depth of 20 to 30 cm each year and then prepare the seedbed with either a disk harrow or ducks-foot type implements, which leaves the soil bare and loose increasing the risk of erosion by water and wind. The choice of tillage system must accommodate the need to conserve soil and water. Alternatives to conventional tillage include "zero-till" and other "conservation tillage" systems. The no-tillage (or zero-till) system is a useful approach to solving the problems of soil erosion, soil fertility and soil with low water-holding capacity (FAO, 2002). Conservation tillage retains plant residues from previous crops on the soil surface (stubble-mulch system) that reduces loss of soil or water relative to conventional tillage.

This paper summarizes the outputs of conservation tillage and no-till direct drilling in various cropping systems productivity from selected parts of the CWANA region covering diverse agro ecological conditions from mild lowlands (Syria) to cold continental (CAC), and cold highlands (Turkey).

Results in mild lowlands of West Asia (Syria)

Pala *et al.* (2000) reported that tillage effects on crop performance over 12 years on mean (and most annual) yields of durum wheat showed very little difference between two deep tillage (disk plough and chisel at 20 cm depth) and one shallow tillage (ducks-foot at 10-12 cm depth) systems; but zero-till yields have tended to fall behind the others systems in recent years (Table 1).

Table 1. Crop yields (t/ha) under four tillage systems for a three-course rotations with durum wheat in Tel Hadya, Syria (1986-1997) (Pala *et al.*, 2000)

3-course crop rotation	Tillage systems				Mean	Standard error of the mean
	No-till	Disc plough	Chisel	Ducks-foot		
Durum wheat	2.08 (0.98-3.88) [†]	2.41 (1.24-4.25)	2.40 (1.25-4.33)	2.37 (1.31-4.09)	2.31	0.041
Lentil	0.90 (0.34-1.53)	0.80 (0.15-1.33)	0.85 (0.21-1.47)	0.85 (0.29-1.24)	0.85	0.018
Watermelon	1.04 (0.00-4.73)	2.39 (0.91-7.13)	2.59 (0.75-7.23)	2.70 (0.64-6.88)	2.18	0.138

[†]Values in the parenthesis show the range of crop yields across the years.

This decline in yield under no-till was due apparently to a gradual increase in grassy weed infestation in zero-till plots where pre-planting herbicide did not provide adequate weed control because of dry period at planting, and also due to a larger row spacing (30 cm) in the direct drilling resulting from some technical limitations in the construction of the implement. For lentils in rotation with cereals (Pala *et al.*, 2000), yields showed small but significant differences across all four tillage systems, but deep disking was poorest. Minimum (ducks-foot) tillage or zero-till systems were the best because the row spacing (30 cm) used for direct drilling suited the legumes. Deep disking or mouldboard ploughing need two and three times more fuel per hectare than chisel ploughing and ducks-foot cultivation, respectively, which may lead to environmental deterioration and accelerated rates of natural resource exploitation as threatening to the long-run sustainability of agriculture. The zero-till system needs less fuel than the other systems but requires pre-planting herbicide instead, a major cost which brings its energy requirement per unit area close to that of minimum tillage. Soil organic matter is increased by conservation tillage, particularly by no-till direct drilling from 0.8 to

0.95% in a three-course wheat-lentil-summer crops rotation and from 1.3 to 2.8% in a two-course wheat-lentil cropping systems (Ryan *et al.*, 2003). Results support a preference for the minimum tillage system over deep tillage on the grounds of both energy-use efficiency and increased net revenue. Implements for the minimum tillage system, unlike those for direct drilling, are readily available to farmers in the CWANA region. However, whenever available and tested and adopted by farmers with their participatory evaluation, zero-till direct drilling would increase soil organic carbon and sustain the systems productivity in the long-run.

Conservation tillage and no-till practices tested in Central Asia

Field experiments on tillage systems were conducted in rainfed semi-arid areas on spring wheat-based cropping systems (Northern Kazakhstan), in rainfed dry areas on winter wheat-based cropping systems (Southern Kazakhstan, Kyrgyzstan and Uzbekistan) and in irrigated cropping systems (Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan). This research, which was aimed to test and disseminate soil management technologies, including no-till direct drilling, that improve water and input (nutrient, energy, chemical, etc.) use efficiency, was carried out by a multidisciplinary ICARDA research team in cooperation with national research scientist in the NARS of the region (Ryan *et al.*, 2004; Suleimenov *et al.*, 2004). Simultaneously or following on-station research, on-farm testing was conducted during the last three years in the region. A summary of major outputs for some selected regions is given below.

In 2001 and 2002 cropping years, three tillage methods [mouldboard ploughing, conservation tillage (minimum tillage) and direct seeding] were tested on 12 ha with different farmers in Almaty province of Kazakhstan. As in plot experiments the lowest barley yield was obtained on direct seeding because of higher weed infestation. Conservation tillage provided the highest yield: 0.9 t/ha against 0.8 t/ha under mouldboard ploughing. However, in the same region, direct seeding of safflower on 140 ha gave the same yield (0.8 t/ha) as on ploughed land. Thus, conservation tillage was found to be the most economical practice for seedbed preparation. Its effect might be strengthened under proper weed control and fertilization as obtained at research station trials (Suleimenov *et al.*, 2004). As to direct seeding with the cultivator-drill, weed control with herbicides is critical for wider adoption. In Gallaaral rainfed areas of Uzbekistan, the grain yield on summer fallow land depended on sowing equipment. In both years, the lowest yield was obtained when double disking was used for seedbed preparation, followed by planting with disk drill (0.9 t/ha). The highest yields were obtained when sowing was done directly with the cultivator-drill (1.2 t/ha), which was 10% more than the conventional deep tillage with ploughing + harrow + disk drill (1.1 t/ha). Hence, sowing method was more important than the seedbed preparation. On stubble land, sowing method was also most important: cultivator-drill combined equipment provided the highest grain yields in both years (1.3 t/ha). Unlike in fallow, the efficiency of direct seeding with cultivator-drill on stubble was greater in both favourable (rainfall more than long-term average) and dry years. In Northern Kazakhstan, no-tillage combined with direct seeding of spring wheat has now been adopted on almost 100,000 ha area. In the rainfed winter wheat production system of southern Kazakhstan, conservation tillage did not show any noticeable effect on crop yield than traditional practice of deep ploughing, but was found more economical through less energy needs as direct benefit to farmers. Technology of direct sowing with a combine cultivator-drill was accepted by five farmers, after having successfully tested this technology over two years.

No-tillage and minimum tillage as an alternative practice for wheat-fallow, wheat-chickpea and wheat-wheat rotations in Central Anatolian Plateau of Turkey

In the Central Anatolian plateau, crop management research programs have so far focused on conventional tillage in the fallow/wheat system, with limited or no consideration of other systems such as no tillage or minimum tillage. Tillage and management systems which retain crop residue on the surface of the fields, such as no-tillage and minimum tillage, might play a significant role in water conservation, preventing soil loss, increasing yield and sustaining long-term production. At this respect, Avci (2005) reported the outputs from such trials in different cropping systems that are given in Table 2.

Table 2. Effects of no-tillage and conventional tillage on wheat yields (t/ha) under different cropping systems, 2001-2003 cropping seasons, Ankara, Turkey (Avci, 2005)

Cropping systems	2000/01 (216 mm rainfall)		2001/02 (403 mm rainfall)		2002/03 (375 mm rainfall)	
	No-tillage	Conventional tillage	No-tillage	Conventional tillage	No-tillage	Conventional tillage
Wheat/fallow	1.9	1.9	2.9	2.6	2.7	3.6
Wheat/chickpea	1.5	1.4	2.7	2.3	2.2	3.2
Wheat-wheat	2.1	1.7	1.9	2.0	2.0	3.0

Results indicated that wheat grain yields were equal or better under no-till system as compared to conventional tillage in the first two cropping seasons, but in 2003 wheat yields under conventional tillage were greater than yields under no-tillage in all the cropping systems. The reason was that a very favourable rainfall at planting in 2002/03 season eliminated the advantage of water conservation by no-till system compared to other seasons. As a conclusion, in Turkish dryland agriculture the following outputs were drawn from this three year research: (i) chemical fallow will be a good alternative to clean fallow and particularly provide savings in tillage cost; (ii) continuous wheat increased the cheat grass (*Bromus tectorum*) infestation. No-tillage aggravated this problem. In spite of these drawbacks, no-tillage seemed economic and superior in terms of water conservation and erosion control. With an efficient herbicide controlling cheat grass, no-tillage in continuous wheat can attain adequate yield levels; and (iii) the huge amount of research conducted so far in the world shows that in terms of sustainable agriculture, the practice of no-tillage or reduced tillage systems is a prerequisite. Therefore, research on this field should be intensified in Turkey and similar countries of the region.

Conservation tillage-no till direct drilling systems have also been tested in Jordan, Iran, Morocco, and Sudan (Suleiman, 1994; Khalaf, 1996; Eskandari *et al.*, 2003; Namr and Mrabet, 2004; Rasheed and Hamid, 2003) with promising and similar results to those for the selected regions given above.

Conclusions

There is an opportunity for conservation tillage, including no-till direct drilling systems, in dry area cropping systems of cereals-based production systems for resource use efficiency across the CWANA region on the basis of the research results from selected agro-ecosystems. Increasing soil organic matter from below 1% to about 2.8% in the top soil under no-till systems compared with conventional tillage systems for long-term fertility build up and improvement of soil aggregate stability (increasing organic matter contributes to fertility build up and improvement of aggregate stability) are positive points for no-till systems. However, the local industry should be concerned about producing proper no-till direct drill equipment adapted to local soil conditions. Some other factors such as integrated weed/pest management, role of mulching, residue management, integration of crop-livestock, use of adapted varieties and external inputs, recuperation of soil fertility need to be monitored. Also constraints to adoption as technical and sociological factors, policies and environmental impacts need to be considered for the success of the system. However, still more research is necessary for widespread adoption of conservation tillage including no-till direct drilling systems in different agro-ecosystems of the region with farmers' participatory evaluation of the system to benefit directly and to improve livelihood of rural population.

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