Conservation Agriculture as Alternative to Reduce Impact of Climate Change for Smallholder in North Africa: Tunisian Case

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Background

Tunisia is located in North Africa, on the border of the Mediterranean. A big part of Tunisia have semiarid and arid climates, which are marked by extremes in daily high and low temperatures, with hot summers and cold winters, and little rainfall approximately 200 to 400 mm per year for semiarid regions and less than 100 mm per year for desert regions (Radhouene, 2013). Tunisia is vulnerable to climate change impacts (Vicente-Serrano, 2006) and has been qualified as the « hot spot for climate change» (Giorgi, 2006). Water scarcity, even in the absence of climate change, will be one of the most critical problems facing North African countries and especially in Tunisia in the next few decades (Ashton, 2002). Water is at the heart of the main expected impacts of climate change on the natural environment in the Mediterranean (El-Quosy, 2009). According to the simulations made by climate specialists on the basis of the IPCC scenarios (GTZ, 2007), the dramatic effects of climate change will be observed in Tunisia. However, they show that: **i)** the annual average temperature will increase by 1.1°C by 2030 and that at the 2100 horizon, a potential increase of the temperature from 1.3 to 2.5 °C, and an elevation of the sea levels from 38 cm to 55 cm will occur , **ii)** the number and intensity of droughts will increase, **iii)** 28% of water resources will decrease by 2030, **iv)** The loss of groundwater reserves in particular will become a problem, **v)** 20% loss in arable cropland by 2030, and **vi)** substantial increase in the vulnerability of ecosystems. The decrease in annual precipitation that is predicted for Northern Africa in the 21st century will exacerbate these effects, particularly in semiarid and arid regions that rely on irrigation for crop growth (Hulme *et al*., 2001). Conservation Agriculture (CA) practices has been proposed as an adapted set of management principles that assures a more sustainable agricultural production (Verhulst *et al*., 2012), and can also contribute to making agricultural systems more resilient to climate change. In many cases, conservation agriculture has been proven to reduce farming systems' greenhouse gas emissions and enhance their role as carbon sinks in order to improve soil health and structure holds the key to improving water use efficiency (WUE) which leads to improved farm profits and benefits the farm environment. Also, CA is as an approach to farming that seeks to increase food security, alleviate poverty, conserve biodiversity and safeguard ecosystem services.

Results

Results showed that for the three cropping season, the grain yield, Total Dry Matter (TDM), grain Water Use Efficiency (WUE-g) and biological Water Use Efficiency (WUE-b) of durum wheat under CA system were increased compared to conventional tillage. However, under CA system and for the second crop rotation (Durum wheat/Faba bean), Durum wheat had the highest WUE-g (8,24 kg/ha/mm) and WUE-b (19,69 kg/ha/mm) than for the first crop rotation (Durum wheat/Durum wheat) tested, with respectively 7,74 kg/ha/mm and 18,28 kg/ha/mm for WUE-g and WUE-b.

Applications and Implications for Conservation Agriculture

Conservation agriculture (CA) has been proposed as an adapted set of management principles that assures a more sustainable agricultural production. It combines the following basic principles: **i)** reduction in tillage, **ii)** retention of adequate levels of crop residues and permanent soil surface cover, **iii)** Crop diversification and use of adequate crop sequences. These CA principles allow to increase water infiltration and to reduce in water evaporation and erosion (Ma *et al.* 2006). CA based on no tillage system and crop residue retention gives positive control of surface water (Bachmann and Friedrich 2003) and increase plant available water in arid and semi-arid rainfed agriculture, and may lead to enhanced water use efficiency (WUE) by crops. Also, CA based on no tillage system alters the partitioning of the water balance, decreasing soil evaporation and increasing transpiration, infiltration and deep percolation, leading to increased yields and WUE (Wang *et al.* 2004).

Experimental Approach

The experiment was carried out on farm located 30 km from Tunis, Tunisia (36° 36' 37,3" N Lat, 10° 0,8' 30,7" E Long, 65 m asl), during three cropping seasons (2007/2008, 2008/2009 and 2009/2010). The climate is semi-arid and the annual rainfall average is about 400 mm. The soil had a clay texture with 180 mm m^{-1} total available water. The biennial rotation was tested [Durum wheat/ Durum wheat (W/W), Durum wheat/ Faba bean (W/F)]. Soil water balance and crop water uptake was determined (soil moisture was measured under different soil depth using gravimetrically method each month). At the harvest, the TDM and yields compound of durum wheat were determined.

- Biological Water Use Efficiency (WUE-b) = Total dry matter/ETR (kg/ha/mm)
- Grain Water Use Efficiency (WUE-g) = Grain yield/ETR (kg/ha/mm)

An analysis of variance for all measured parameters was made, using Statistical Analysis System software (SAS, 1985).

Results and Discussion

Results of this study were given in the table below (table 1).

Cropping season	Treatment	Grain yield (kg/ha)		TDM (kg/ha)		WUE-g (kg/ha/mm)		WUE-b (kg/ha/mm)	
		W/W	W/F	W/W	W/F	W/W	W/F	W/W	W/F
2007-2008	CA	2800[a]	3100[a]	6900[a]	7500[a]	7.36[a]	8.15[a]	18.15[a]	19.73[a]
	CoA	2600[b]	3300[b]	6300[b]	7950[b]	6.19[b]	7.85[b]	15.00[b]	8.92[b]
	LSD$_{(0.05)}$	175	193	266	320	0.15	0.28	1.13	1.41
2008-2009	CA	3200[a]	3420[a]	7600[a]	8050[a]	8.08[a]	8.50[a]	19.00[a]	20.12[a]
	CoA	3000[b]	3460[a]	7250[b]	8100[b]	6.66[b]	7.55[b]	16.15[b]	18.00[b]
	LSD$_{(0.05)}$	192	210	320	460	0.36	0.42	1.32	1.18
2009-2010	CA	3050[a]	3430[a]	7300[a]	8080[a]	7.14[a]	8.09[a]	17.38[a]	19.23[a]
	CoA	2980[a]	3640[a]	7280[a]	8250[a]	6.52[b]	7.82[a]	15.82[b]	7.93[b]
	LSD$_{(0.05)}$	160	202	380	500	0.41	0.38	0.95	1.22

CA: Conservation agriculture; CoA: Conservation Agriculture; W: Durum wheat; F: Faba bean; TDM: Total Dry Matter; LSD: Least Significant Difference

Results of three years of experimentation showed that under CA system, the average grain yield (3000 kg / ha) and TDM (7266 kg/ha) of Durum wheat were better than conventional agriculture (2800 kg /ha and 6940 kg/ha), respectively for grain yield and TDM for the first crop rotation (W/W). However, for the second crop rotation (W/F) , the average grain yield and TDM were higher under conventional agriculture compared to CA system, with respectively (3500 kg/ha , 8100 kg/ha) and (3300 kg / ha , 7870 kg/ha) . In fact, grain yield and TDM of Durum wheat conducted under conventional agriculture were improved compared to those under CA system, which is probably because the biomass yield of the previous crop (Faba bean) was more important under conventional agriculture than CA. Grain Water Use Efficiency (WUE -g) and biological Water Use Efficiency (WUE -b) under CA system increased compared to conventional agriculture for both crop rotations tested. Improvement of WUE - g under CA compared to conventional agriculture are 15%, 18% and 10%, respectively for the years 2007/2008, 2008/2009 and 2009/2010 for the first rotation tested (W/W). However, a smaller improvement is recorded when the durum wheat is grown in succession of faba beans under CA compared to conventional agriculture. This improvement was 4%, 12% and 5%, respectively for the years 2007/2008, 2008/2009 and 2009/2010. Also, same results were recorded for the case of WUE -b.

This finding confirms that CA practices improves WUE and proposed as set adapted that contribute to making agricultural systems more resilient to climate change in semiarid and arid regions, especially as water scarcity , in the odd lack of climate change, will be one of the most critical problems of Tunisia.

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