Irrigation management strategies to improve Water Use Efficiency of potatoes crop in Central Tunisia

Hiba Ghazouani[1,2], Giuseppe Provenzano[1], Giovanni Rallo[3], Amel Mguidiche[2], Boutheina Douh[2] and Abdelhamid Boujelben[2]

1) Dipartimento Scienze Agrarie e Forestali, Università degli Studi, viale delle Scienze 13, 90128 Palermo, Italy.

2) Département de Génie rural, Institut Supérieur Agronomique de Chott Mériem (ISA-CM), BP 47, Sousse 4042, Tunisie.

3) Dipartimento Science Agrarie, Alimentari, Agro-ambientali, Università di Pisa. Via del Borghetto 80, 56124 Pisa, Italy.

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INTRODUCTION

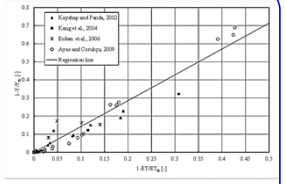
Population growth, drought and climate change require the adoption of management strategies to improve water use efficiency (WUE) in agriculture. To increase WUE, Tunisian government encourages the use of micro-irrigation; moreover, deficit irrigation is a powerful strategy to optimize the production by limiting crop water requirement. Even if deficit irrigation has shown great results on various crops, for some of them like potatoes, water management is difficult due to the rapid impact of water stress on tuber yield.

OBJECTIVES

Objective of the work was to assess the effects of different on-farm irrigation strategies on water use efficiency of potatoes crop irrigated with subsurface drip irrigation in a semiarid area of central Tunisia.

HYPOTHESIS

- Subsurface drip irrigation (SDI) allows to increase WUE.
- Irrigation frequency is a key factor for SDI scheduling, specially under deficit irrigation.
- Different frequencies of watering induce different wetting patterns and yield production.
- Decline of potatoes crop relative yield can be evaluated according to the reduction of actual evapotranspiration, as recognized from the literature.



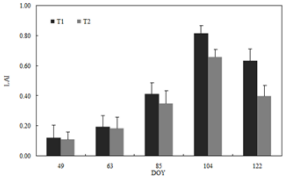
STRATEGIES

Initially, validation of Hydrus-2D model, based on a comparison between measured and predicted soil water contents at different distances from the emitter was carried out. The model was then used to evaluate actual crop evapotranspiration and to estimate Water Use Efficiency (WUE) and Irrigation Water Use Efficiency (IWUE).
Finally, scenario analysis allowed examining the effects, on crop transpiration and water use efficiency, of reducing irrigation doses and increasing frequency of watering.

RESULTS AND DISCUSSION

	P [mm]	I [mm]	E_a [mm]	T_a [mm]	D_r (mm)	Y [t/ha]
T1	108.4	124.4	14.8	139.0	97.8	27.4±2.3
T2	108.4	61.5	14.8	137.1	57.5	24.9±1.1

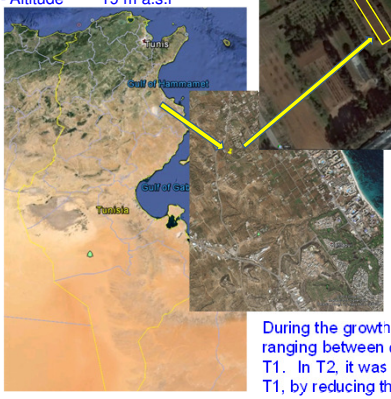
Components of soil water balance and yield obtained in plot T1 and T2



Cumulative T_a in T1, resulted slightly higher than in T2, whereas E_a resulted equal in both the treatments. In T1, a consistent rate of irrigation was lost through the bottom layer. Even if limited, the observed differences in actual crop transpiration were consistent with the values of leaf area index measured at different days of the growth season and with crop yield, whose differences between treatments resulted statistically not significant (P=0.05)

MATERIALS AND METHODS

Experiments were carried out from January 15 to May 6, 2014, at Institut Supérieur Agronomique de Chott Mériem, Sousse (TN).
- Longitude 10.5632° W
- Latitude 35.9191° N
- Altitude 19 m a.s.l

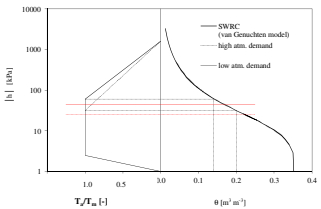


EXPERIMENTAL FIELD

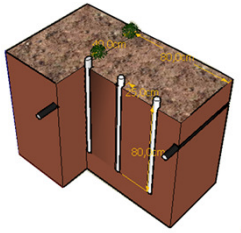
Plants were spaced 0.40x0.80 m and irrigated with laterals buried at 0.20 m depth and containing 0.40 m spaced emitters, with a flow rate of 4.0 l/h at 100 KPa.

Soil water content (SWC) was measured in two plots (T1, T2) every 10 cm, with a TRIME-FM TDR, on three 0.80 m long access tubes, installed at 0.0, 0.25 and 0.50 m from the lateral. The plots were maintained under the same management, except for irrigation doses, equal to about 6 l/plant in T1 and 3 l/plant in T2. **Irrigation was scheduled according to the average soil matric potentials (h) in T1 by assuming, in the wetting bulb, h>-25kPa till the stage of tuberization (absence of stress), and h>-45kPa in the following stages (limited water stress).**

During the growth season, a total of 8 watering with duration ranging between one and three hours were provided in plot T1. In T2, it was applied only 50% of the water provided in T1, by reducing the irrigation duration.

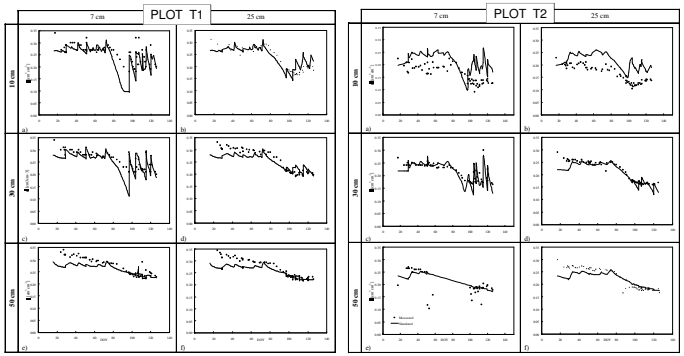


To apply the model, soil evaporation (E_p) and crop transpiration (T_p) were determined according to the modified FAO Penman-Monteith equation and the dual crop coefficient approach (Allen et al., 1998).



Position of access tubes in T1 and T2 and TDR sensor

VALIDATION OF HYDRUS-2D MODEL



	T1	T2
N	585	605
MBE	0.012	-0.010
RMSE	0.029	0.036
Nash E	0.580	0.310

Statistical analysis showed that Hydrus-2D allows accurate estimation of soil water content in the root zone. A slightly better performance was observed in T1 compared to T2, with a Nash-Sutcliffe efficiency index positive and equal to 0.58 (T1) and 0.31 (T2). This result supports the use of Hydrus-2D for the scenario analysis, to simulate the average soil matric potential in the root zone, to evaluate actual ET and estimate WUE.

SCENARIO ANALYSIS

According to the scenario analysis, reductions of irrigation doses determined negligible effects on actual cumulative evapo-transpiration and on WUE. However, these effects resulted more remarkable when irrigation water use efficiency was considered as indicator of water application efficiency.
On the other hands, increasing the frequency of water application, even maintain the same seasonal volumes, determined a slight improvement of crop yield, as well as of the efficiency of water application.

Scenario	Irrig. depth [mm]	Freq. [-]	E_a [mm]	T_a [mm]	D_r (mm)	$1-ET_a/ET_m$ [-]	$1-Y_a/Y_m$ [-]	WUE [Kg/m³]	IWUE [Kg/m³]
S100	65.62	F=3	14.8	138.4	55.9	0.04	0.05	16.92	39.52
		F=6	14.8	140.2	55.0	0.03	0.04	17.02	40.21
S50	32.81	F=3	14.8	126.5	27.7	0.11	0.16	16.27	70.07
		F=6	14.8	129.2	26.2	0.09	0.13	16.60	72.86
S25	16.40	F=3	14.8	125.4	26.1	0.12	0.17	16.21	138.58
		F=6	14.8	126.5	25.7	0.11	0.16	16.26	140.13
S0	0		14.8	99.1	24.3	0.29	0.41	14.25	-

REMARKS

- Hydrus 2-D model is an able predictor of soil water contents around a buried emitter.
- Limited crop water deficit after stolonization and tuber building does not produce significant reductions of potatoes crop yield.
- Irrigation doses has to be identified according to economic evaluations.
- Increasing irrigation frequency slightly improves WUE.

ESSENTIAL REFERENCES

- *Allen R.G., Pereira L.S., Raes D., Smith M. 1998. Crop Evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. Rome.*
- *van Genuchten, M.Th. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Sci. Soc. Am. J. 44, 892–898.*
- *Šimůnek, J., M. Th. van Genuchten, M. Šejna. 2011. The HYDRUS Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media. Technical Manual, Version 2.0, PC Progress, Prague, Czech Republic.*