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WADIS-MAR
Water harvesting and Agricultural techniques in Dry lands: an Integrated and Sustainable model in MAghreb Regions
Sustainable Water Integrated Management (SWIM) Demonstration Project
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Impact of deficit irrigation on yield and fruit quality in orange (Citrus Sinensis L. Osbeck, cv. Meski Maltaise) in Southern Tunisia

[1]K. Nagaz; [2]F. El Mokh; [3]N. Ben Hassen; [4]M.M. Masmoudi; [5]N. Ben Mechlia; [6]M.O. Baba Sy; [7]O. Belkheiri; [7-8]G. Ghiglieri

[1] [Senior researcher], [Institut des Régions Arides], [4119 Médenine, Tunisia], [Nagaz.Kameleddine@ira.rnrt.tn]
[2] [Engineer PhD student], [Institut des Régions Arides], [4119 Médenine, Tunisia], [fathiamokh@yahoo.fr]
[3] [PhD student], [Institut des Régions Arides], [4119 Médenine, Tunisia], [nadiabenhassen1@hotmail.fr]
[4] [Professor], [INAT], [43 avenue Charles Nicolle, 2083 Tunis, Tunisia], [masmoudi.med@inat.agrinet.tn]
[5] [Professor], [INAT], [43 avenue Charles Nicolle, 2083 Tunis, Tunisia], [netij.benmechlia@iresa.agrinet.tn]
[6] [PhD], [OSS], [Boulevard du Leader Yasser Arafat BP 31 - Tunis Carthage 1080, Tunisie], [lamine.babasy@oss.org.tn]
[7] [PhD], [NRD], [University of Sassari, Viale Italia 39 - 07100 Sassari, Italy], [nrd@uniss.it]
[7-8] [Professor], [University of Cagliari], [Via Trentino 51 - 09127 Cagliari, Italy], [ghiglieri@unica.it]

Presentation outlines

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2. Objectives
3. Materials and methods
4. Results
   - Soil salinity
   - Soil water depletion
   - Yield & fruit quality
   - Water productivity
   - Net income
5. Conclusions

Introduction

- Arid regions of Tunisia (Long-term rainfall average ≤ 150 mm and annual ETo > 1400 mm)
  Limited supplies of quality water for irrigation
  Increasing needs for the intensification of agriculture

- Irrigation of horticulture crops around wells having TDS ≥ 1.5 g/l

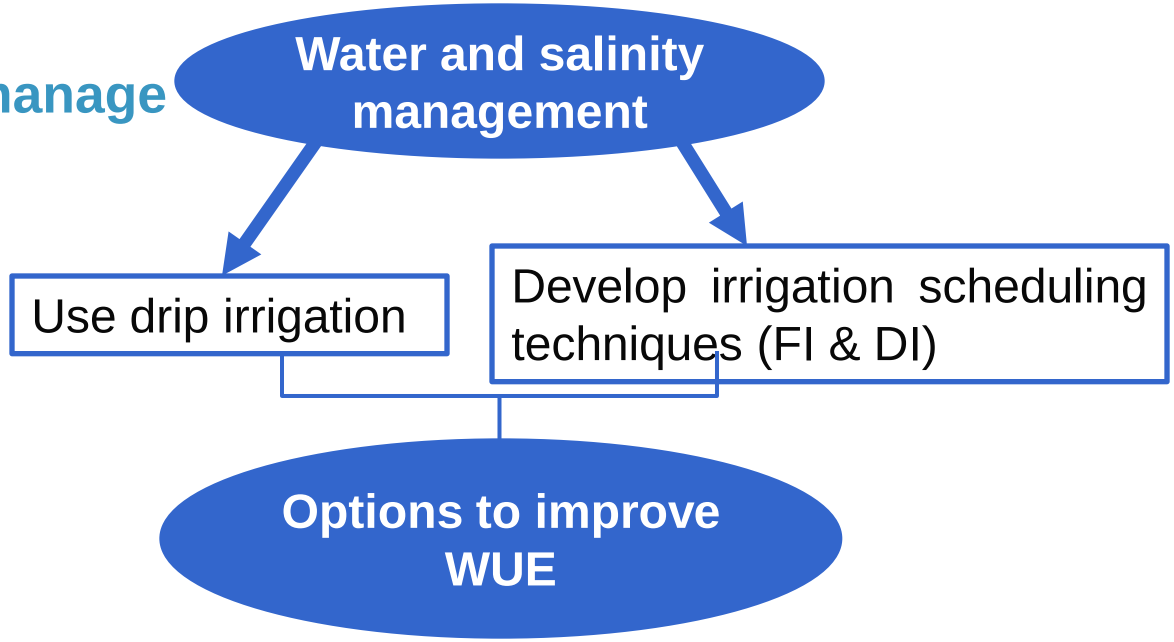
- Irrigation scheduled according to farmers experiences & without provision drainage

- Irrigated lands: lack of drainage systems and accumulation of salts in the root zone compromising the sustainability of irrigated farming.

- Better management of water application to improve farmers practices, water productivity and reduce the risk of soil salinization

Introduction

Possible ways to manage salinity and water



- Efficiency of drip irrigation not used properly (Farmers tend to over irrigate)

- Irrigation scheduling based on CWR and soil characteristics

-Development of irrigation:
  Overexploited groundwater resources
  DI continuously/regulated

Introduction

- Management options DI instead of FI

- DI Adoption: long term impact on water use, crop yield and soil salinization

- DI particularly important for orchards which represent an important component of the productive farming system in the irrigated lands.

- Productivity low and irrigation with saline waters practiced without provision of drainage.

- Chronic water shortage and soil degradation hazards in irrigated orchards: need to develop strategies to save water and control salinity

- Absence of drainage systems, high evaporative demand conditions & chronic shortages of water, techniques based on irrigation restrictions reasonably appropriate

- Farmers must have prior knowledge of the crop yield responses to DI

Objectives

- Assess the response of orange trees to irrigation strategies in order to define the best irrigation programme based on deficit irrigation with saline water of orange adapted to the arid conditions of Tunisia
- Supply producers with information with regard to irrigation scheduling and deficit irrigation guides and Reinforce their capacities to face the problem of water scarcity

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Materials and Methods

Field experiments

-Two years (2013-2014) in farmer field - Megarine (33º19’N, 10º 27’ E), Médenine, Southern Tunisia

- Experiment in a drip irrigated orchards of Meski Maltaise, early orange cultivar

Materials and Methods

Megarine, Medenine

- Farm size of 55 ha
- Average rainfall less than 150 mm/year
- Water source: Well with flow rate of 8 l/s & depth less than 50 m
- Sandy loam soil texture (Clay: 9%, Loam: 29% & Sand: 62%) having low OM (<0.3%)

SWC at FC and PWP of 0.17 ± 0.02 and 0.092 ± 0.03 $m^3.m^{-3}$; and a bulk density of 1.41 ± 0.02 $g.cm^{-3}$.

The trees were planted in 2001 on sandy loam soil with a density of 238 trees/ha using Bigaradier rootstocks (12 years-old ‘Meski Maltaise trees grafted on Bigaradier with tree spacing of 7x6 m), average height of the trees was 3.25 m, with a canopy diameter of 4.0 m.

Irrigation waters TDS of 1.5 g/l

Four drip emitters per tree (4 l/h) connected to a dual drip line, two per side of the tree, 1 m apart, are used in the experiment

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Materials and Methods

- Irrigation treatments

- Full treatment (FI) at 100% ETc in which the trees were irrigated during the watering season to provide them with their full water requirement based on ETc calculations.

- Deficit treatments irrigated with irrigation water quantities that cover 75 and 50% of ETc (DI75 and DI50).

- FM irrigated according to farmer irrigation practice

- FM, DI & FI implemented during the active period of orange corresponding to different phenological stages (flowering and initial fruit set, fruit growth and maturity) and post-harvest

- Each treatment-block: 16 trees, in which the middle four used for experimental measurements

- Supply of fertilizers

- Nutrient supply was applied according to farmer practices (200-100-150 kg/ha of N, P_2O_5 and K_2O, respectively)

- Rate of 2/3 during the period April-May, no fertilizer supplies during June to August and the 1/3 was applied during September.

Materials and Methods

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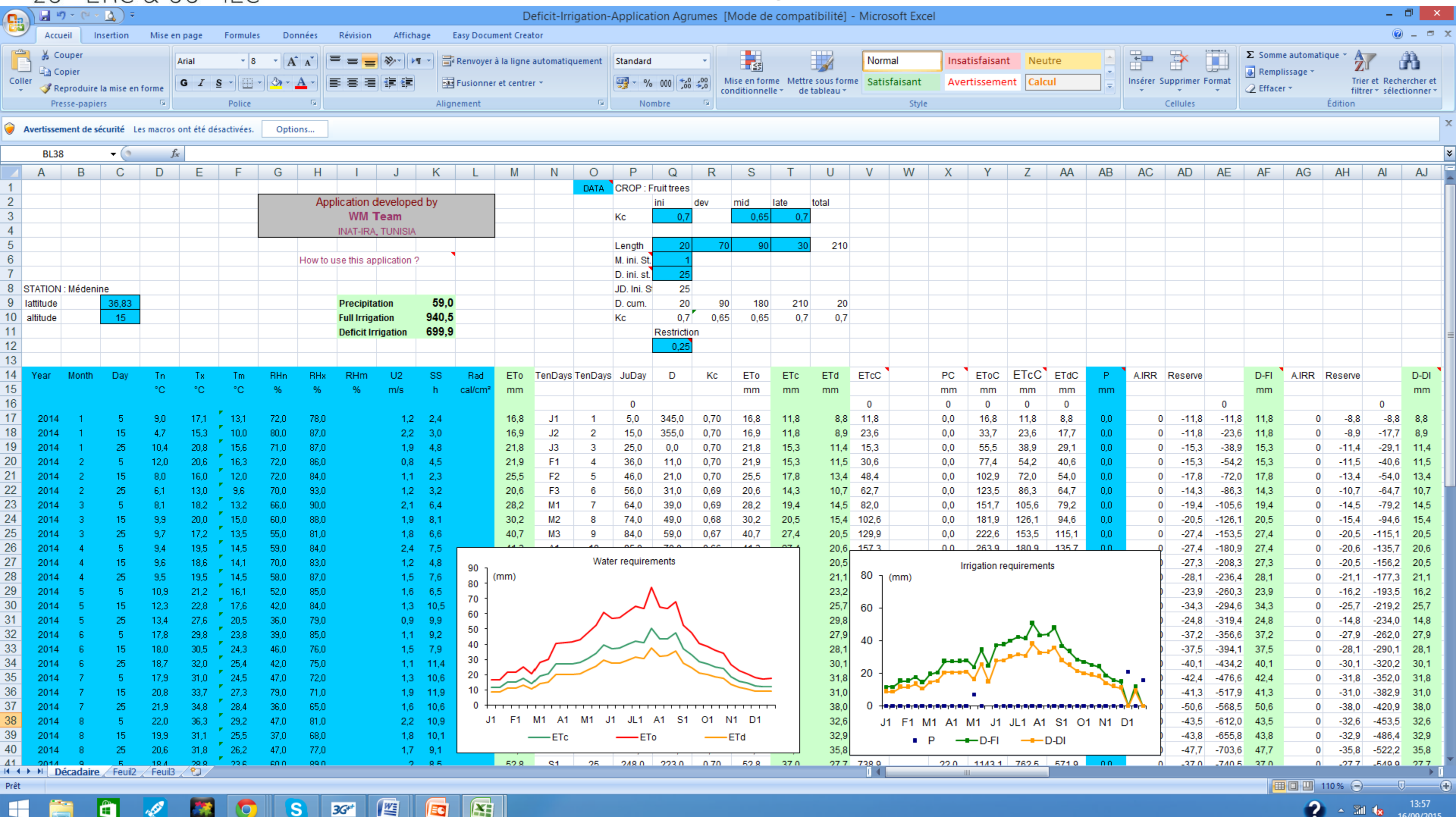
WATER AND IRRIGATION REQUIREMENTS

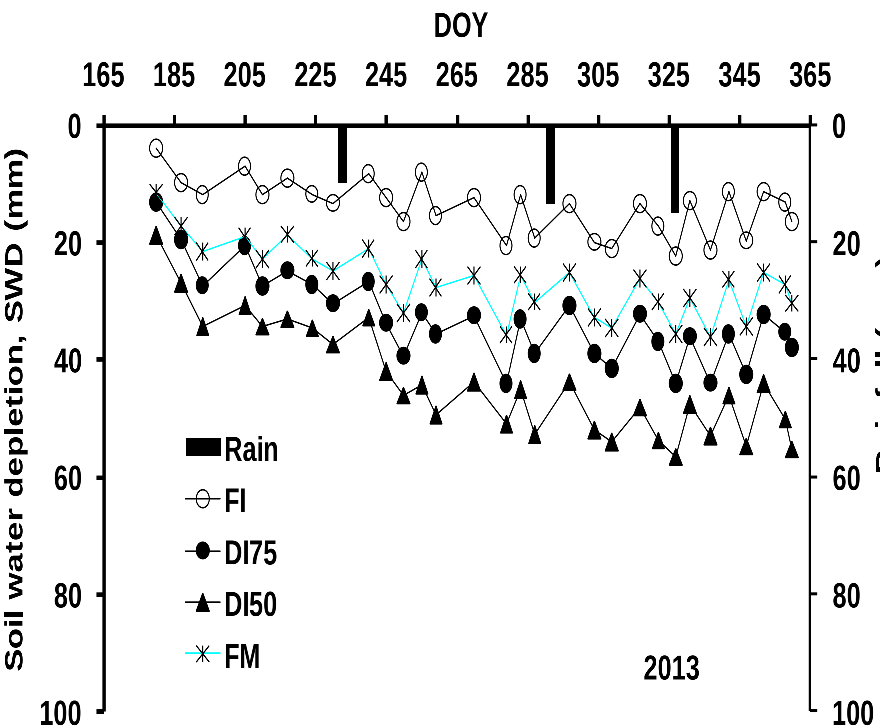


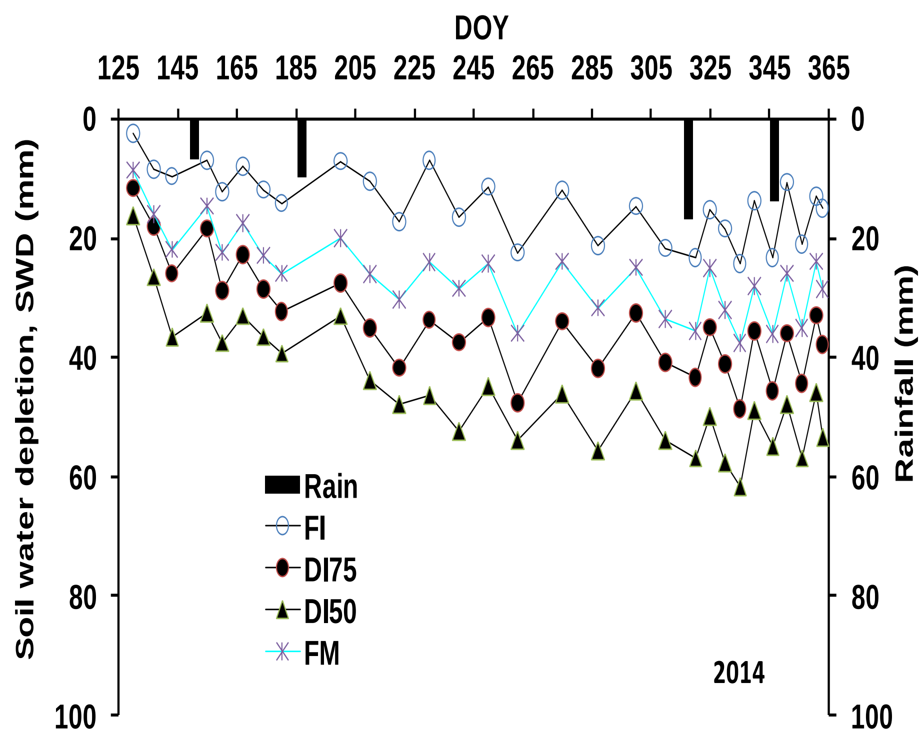
Materials and Methods

- Farmer provided by simple irrigation chart and asked to use it for the first thee treatments while continuing to use his traditional irrigation practice.
- Irrigation chart: information's on irrigation timing and the volume of water (l/tree) per week
- Irrigation scheduling: Irrigation treatments scheduled weekly
- Field monitoring :

- Soil water content and salinity
- Yield, fruit size, total soluble solids TSS (°Brix)
- Amount of irrigation water saving
- Water productivity
  WP (kg/m^3) = Yield (kg/ha) / irrigation water (m^3/ha)
- Net income for each treatment was computed by subtracting all the production costs from gross incomes.

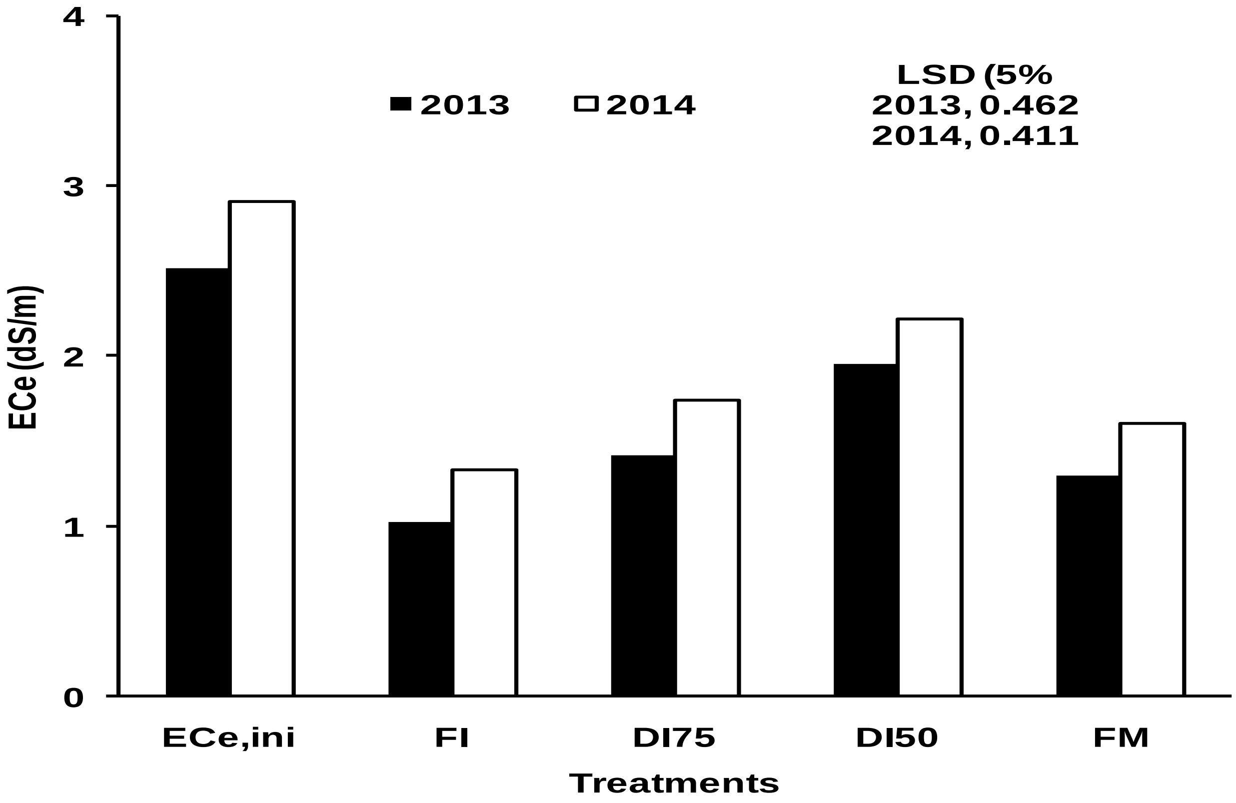
Results





Soil water depletion under different irrigation treatments

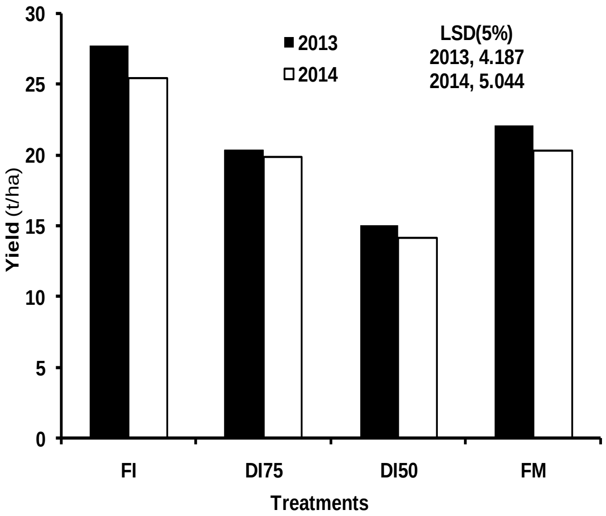
Results

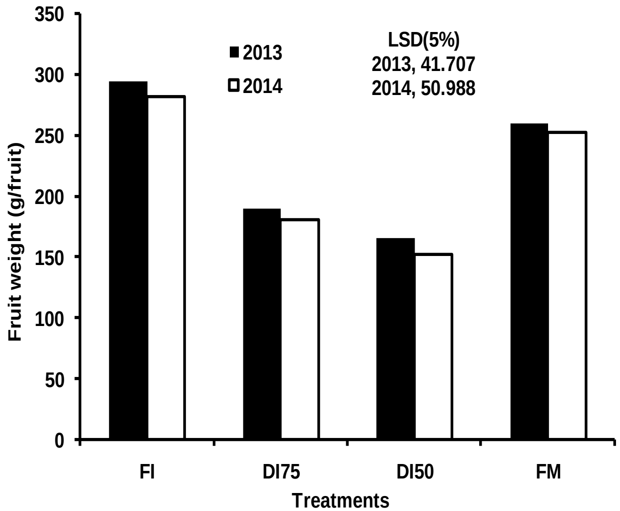


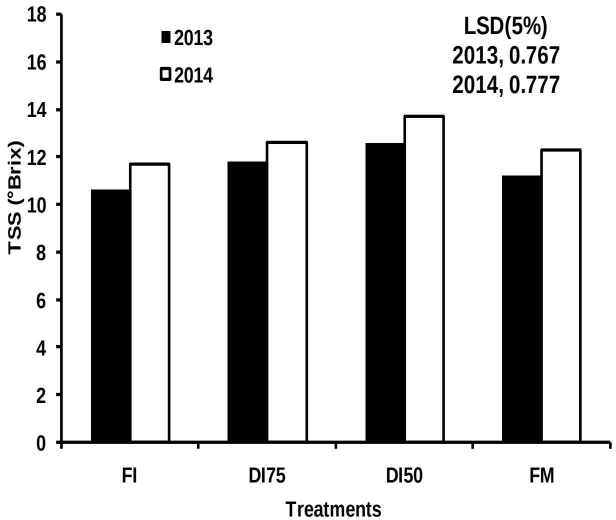
Soil salinity (ECe, dS/m) under different irrigation treatments

Results

Yield and fruit quality under irrigation strategies for the study period







Yield and fruit-quality: Overall monitoring period 2013-2014

	Yield (t/ha)	Fruit weight (g/fruit)	TTS (°Brix)	Fruit number (Fruit/tree)
FI	26.64	288.2	11.20	264.3
DI75	20.11	185.5	12.25	192.5
DI50	14.65	159.0	13.15	153.6
FM	21.24	256.4	11.75	205. 5
LSD (5%)	4.211	24.870	0.780	3.03

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Results

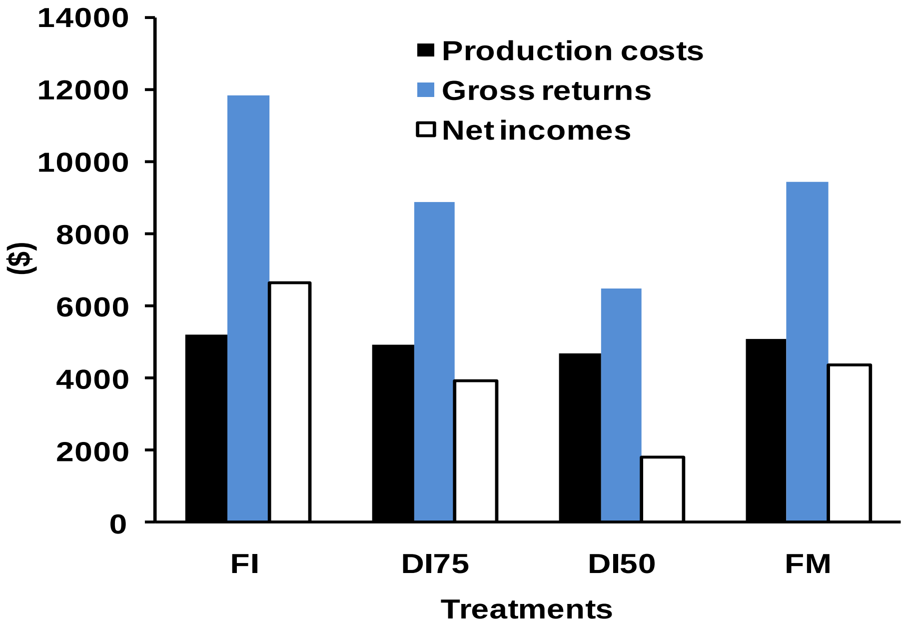
Irrigation supplies, water saving and productivity (kg/m^3) under different strategies

Treatments	Irrigation (mm)		Water saving (m^3/ha)		IWP (kg/m^3)	
	2013	2014	2013	2014	2013	2014
FI	711	704	-	-	3.60	3.51
DI75	530	522	1810	1820	3.87	3.77
DI50	349	341	3620	3540	4.31	4.06
FM	654	607	578	960	3.48	3.44
LSD (5%)	-	-	-	-	0.413	0.281

Results

Production costs and net return of orange production under different irrigation treatments (US$ ha^{-1}) (average of 2 years)

	Production costs ($)	Gross return ($)	Net financial return ($)
FI	5190.8	11824.1	6633.3
DI75	4935.5	8874.8	3939.0
DI50	4680.7	6488.4	1807.7
FM	5085.2	9427.4	4342.2



Conclusions

- Highest soil salinity values were observed under DI50 compared to FI. DI75 and FM strategies reduced the build-up of salinity compared to DI50.

- Irrigation strategy adopted by farmer (FM) resulted in using 8-13.7% less water than FI in orange orchards indicating that farmer practices DI.

- Additional savings of irrigation water achieved when deficit irrigation was applied using 25% less water than that in FI, with 21-26% reduction in orange yield.

- No significant differences in yield between DI75 and FM treatments even though numerically lower yield was observed in the former (DI75) as compared to the latter (FM) with 14-19% less irrigation water than FM used in DI75.

- A further reduction of irrigation water (DI50) caused lower orange yield with a reduction in size and weight.

- IWP under deficit treatments, DI75 or DI50, was comparatively higher than FI treatment.

- DI50 significantly reduced the economic return compared to FI treatment. DI75 resulted in a better economic return.

Conclusions

Climatic conditions in arid areas of Tunisia

- Available water for irrigated land the most limiting factor

Force farmers to improve water-use efficiency to maintain profitable crop yields with less water.

Application of deficit irrigation (DI with Water restriction of 25%)
Promising irrigation strategy for optimizing irrigation and increasing water productivity for orange orchards, with relatively small impact on soil salinity and some yield and net income reductions.

- DI potential way to improve WP and control soil salinization: Benefit from the leaching capacity of rains.

Investigation: Evaluate the efficiency of the small amounts of rain (fall-winter periods) for natural leaching

- **Conducting experiments within farm & with farmer's participation**

Facilitate the extension as the results are fully accessible to the local farmers

Dissemination of experimental results

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Thank you for your attention

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