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Evaluation of on-Farm Irrigation Scheduling: Case Study of Drip Irrigated Potatoes in Southern Tunisia

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Restricted supply of adequate water is the most important factor limiting crop production in arid Tunisia where water available for irrigation is frequently very saline. Improved water use efficiency by effective irrigation scheduling and the use of more efficient irrigation system are two possible ways to address the issue of water shortage. Potato species is considered relatively susceptible to salinity (Maas and Hoffman, 1977) and normally is not suited for stressful conditions. Irrigated potato has been expanding rapidly in the arid part of Tunisia around shallow wells having a salinity of 2 to 6 dS/m. The reason of this new development is an easy access to subsidized drip irrigation equipment made possible recently, and because temperature conditions allow to produce potato over the autumn and spring seasons. Drip irrigation is one of the most effective methods to supply water to crops (Sermet et al., 2005). It can result in water saving if the correct management procedures are applied (Ünlü et al., 2006). However, the most common problem encountered with this system amongst growers is that irrigation is applied in excess of crop requirements. In regions with serious water shortage, such a waste cannot be tolerated. Surveys carried out on potato cultivation in the area of Médenine (Nagaz and Ben Mechlia, 2003) show that inadequate management of irrigation has been identified as an important limiting factor to potato production, including areas where this crop is cultivated under drip irrigation on private wells. The advantage of water savings by drip is forfeited with over irrigated.

Following requests received from potato growers regarding best management of irrigation waters, field trials were conducted with the objective to evaluate the applicability of representative irrigation scheduling methods for drip system. Basically, the investigation had to compare yield, water use efficiency and soil salinity for various irrigation scheduling methods under the farmers' conditions. As a reference we used the prevailing common practices, with the expectation to enable potato growers to incorporate irrigation scheduling in their usual production practices.

MATERIALS AND METHODS

SITUATION **RAINFALL**

Commercial farm, Médenine (Tunisia) 26.7 mm (spring) & 72 mm (autumn)

THE CROP Potato cv. Spunta under drip irrigation cultivated on sandy soil **IRRIGATION WATER:** Well water with an EC of 3.25 dS/m

IRRIGATION-SCHEDULING METHODS

►**Producer method** corresponding to irrigation practices traditionally implemented by the local farmers: supplying a fixed amount of water of about 17 mm to the crop every 5 days from planting till harvest.

►**Use of ETo with FAO crop coefficients (Kc*ET0) for a daily irrigation scheduling**

►**Use of a spreadsheet calculation program (Soil Water Balance; SWB) for irrigation when readily available water (RAW) in the root zone has been depleted.**

The ETo estimated daily following the FAO-56 Penman-Monteith method (Allen et al., 1998).

The Kc computed following the dual crop coefficient approach. The approach provides for separate calculations for transpiration and evaporation from soil (Kc=Ks Kcb + Ke). SWB method used a spreadsheet for Excel (Allen et al. 1998).

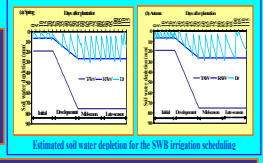
STATISTICAL DESIGN: A randomized block design with four replications

PARAMETERS MEASURED: Fresh tuber yield (t/ha) (FTY), tuber number/m² (TN), & tuber weight (g) (TW); Soil salinity (dS/m) (ECe).

WUE (kg/ha/mm) was calculated as the ratio between yield and total water supply.

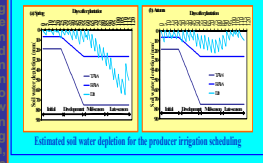
RESULTS AND DISCUSSION

The spreadsheet program develops a water balance and supplies information on the timing and amounts of irrigation events. The SWB irrigation scheduling method keeps the root zone water depletion between the threshold value and field capacity.



Estimated soil water depletion for the SWB irrigation scheduling

The producer irrigation scheduling shows an over irrigation during the initial development and vegetation growth, when crop ETc is low, and during the mid and late seasons, when demand is highest, an under irrigation is observed. This method leads to unavoidable losses in periods of low requirements, and water shortage in periods of high water demand. During the periods of high evaporation, irrigation does not cover totally ETc and the crop makes use of stored soil moisture (case of the spring crop).

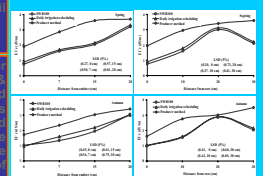


Estimated soil water depletion for the producer irrigation scheduling

Yields are slightly higher under SWB than under Daily irrigation. Producer method decreased significantly the FTY, TN & TW. SWB & Daily scheduling have resulted in consistent increases in yield, over the two seasons; they gave 27-21 % and 36-32% more production than the producer's, respectively, in spring and autumn. Higher salinity associated with water deficits seems to have caused important decreases in yield, through a reduction in tubers number and weight. The lower yields obtained for producer method may be attributed to the fact that the farmer applies water to the crop regardless of the plant needs.

Irrigation scheduling	Spring season			Autumn season		
	FTY	TN	TW	FTY	TN	TW
SWB	39.7	36	110.3	30.4	32	100.6
Daily scheduling	36.7	34	107.2	28.9	29	97.2
Producer method	28.8	32	86.3	19.4	25	77.6
LSD (5%)	4.86	3.87	14.82	3.04	2.23	8.09

The producer method resulted in higher salinity in the rooting zone. The SWB & daily irrigation scheduling decreased the soil salinity beneath the emitter as the zone of salt accumulation moved away from the emitter. Salts were concentrated midway between the emitters and towards the margin of wetted band (20 to 30 cm).



Soil salinity (ECe, dS/m) under the different irrigation scheduling methods along the row and across rows.

With the producer method more water was used than the SWB and the Daily irrigation scheduling methods. WUE values of SWB & the Daily scheduling methods were considerably higher than that of the producer method. The low WUE for the producer method can be attributed to reduced yields but also to higher water use. Combination of these two reasons explains also why WUEs obtained with SWB method were statistically higher than those obtained with Daily irrigation scheduling .

Total water supply (mm) and water use efficiency (WUE, kg/m³) for different irrigation scheduling methods in both seasons

Components	SWB	Daily irrigation	Producer method
	Spring		
Irrigation (I)	311	349	374
Precipitation (P)	26	26	26
Total water received (I+P)	337	375	400
WUE (LSD(5%)=1.32)	11.7	9.7	7.2
	Autumn		
Irrigation (I)	261	313	323
Precipitation (P)	72	72	72
Total water received (I+P)	333	385	395
WUE (LSD(5%)=0.78)	9.1	7.5	4.9

CONCLUSION

► Water supply based on the SWB irrigation scheduling method helps reduce soil salinization, save water and produce higher fresh tuber yield, for potatoes cultivated in two contrasting seasons.

►Daily scheduling seems to be a little less efficient than the SWB irrigation scheduling method, apparently because of a higher direct evaporation rates.

►The " fixed amount approach" used by the farmer caused higher salinity in the rooting zone and gave the lowest fresh tuber yields with 20 and 25 % more water applied, respectively in the spring and autumn seasons.

►These results support the practicality of the optimal irrigation scheduling to facilitate the use of saline water for irrigation.

►In the considered climatic context, the SWB method can be used favourably by farmers to schedule irrigation of potato in arid regions of Tunisia.

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