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Study of the Validity of the Climatic Approach Based On the Penman Monteith Daily Reference in the Conduct of Localized Irrigation of Sugar Beet (Betavulgarisl.) Using Capacitive Probes Of Fdr Technology For The Control Of The Water And Thermal Status Of The Soil In The First Sectors Of Collective Conversion To Localized Irrigationat The Perimeter Of Beni Moussa West-Tadla.

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Abstract: *The present study was conducted in the field in the pilot area of collective reconversion to localized irrigation at the perimeter of Tadla, aims to study the validity of the climatic approach based on Penman Monteith daily reference in the planning of watering of sugar beet (Betavulgaris, L) at Tadla perimeter. For this purpose,capacitive probesof FDR technology previously calibrated in situ by the gravimetric method(Average Correlation Coefficientr^2 = 0.9, Coefficient of VariationCV = 9.26 %) were used for the simultaneous control of the hydrous and thermal soil profiles. The soil moisture monitoring data are very conclusive and result in a high correlation (r^2 = 0.9) between the estimated water requirement (ETM) and the actual evapotranspiration (ETR) measured by the balance method Ground water.The soil waterstock was maintained between the field capacity (Hcc: 249 mm) and the wilting point (Hpf: 138 mm). Also an index of Crop water stress (CWSI = 1- ETR / ETM) revolving around an average of 0.2. As for the soil heat regime, the results show that the crop has completed its growth cycle under soil temperature conditions that meet the requirements of sugar beet.The results inherent in the agro-economic performance of the crop are very convincing compared to the reference year (irrigations conducted according to the farmer's own experience). There was a substantial gain of +77, +170, +145, +164, +76 and + 28% respectively for root yield, sugar yield, water use efficiency, water recovery, value added and the economy of irrigation water.All the results obtained show a state of comfort and stability of the water supply of the crop during its growth cycle, which allows us to say in the context of the Tadla that the climate approach is completely valuable in predicting water requirements and planning watering of sugar beets.*

Key words*: Piloting, localized irrigation, Penman Monteith, capacitive probes, sugar beet and Tadla perimeter*

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I. Introduction

The results of the study of localized irrigation performance realized out at the scale of the pilot area of collective reconversion at Tadla showed a decline in the use of groundwater following the introduction of localized irrigation. However, there is a cultural intensification resulting in an increase in the use of surface water **[1]** that can be an important source of water saving. In addition, the optimization and preservation of water resources is at the center of agricultural concerns. It is a major stake to secure productions. Quantitative and qualitative water management is a shared challenge **[2]**. For its part, **[3]**has argued that in such a tense water context, the concept of water saving has a special character. According to **[4]**, it begins to be admitted that the use of water for agricultural production must be considered sparingly, as much to avoid wasting a scarce good, as to promote more environmentally friendly agriculture. Moreover, it has now been shown that for many productions, regardless of the price of water, too much input does not provide the best economic performance. However, between good intentions of how to better irrigate and reality, huge progress remains to be made.

[5]Emphasized that soil moisture monitoring is the key to delivering the right amount of water to crops at the right time and applying water and nutrients effectively. This can only lead to increased yields, good quality products, increased plant vigor, reduced disease, increased water efficiency and reduced irrigation costs. **[6]**Reported that few producers use measurement tools to determine when to start irrigations. The latter generally base their decision on the visual aspect of the crop and the touch of the soil, which often leads to inefficient management of the resource in addition to representing diffuse pollution risks.

It is in this spirit of efficient and timely and economical conductof irrigation, reduced to the strict water needs of crops that the present study attempts to study the validity of the climate approach (based on the daily reference of pennman Monteith) in the rational management of watering of sugar beet (Betavulgaris, L) under localized irrigation system with a view to its generalization at the scale of the perimeter of the collective reconversion.

II. Materials And Methods

To achieve the objectives assigned to this work, a methodological progression has been adopted. It consists in conducting a field experiment at a farmer's farm in the pilot area of collective conversion to localized irrigation on a sugar beet (Betavulgaris L.) crop. The results of the experiment will be compared with those from the irrigated control plot according to the farmer's own. The plots were conducted in a similar way, receiving the same factors of production except for the irrigation method. The choice of sugar beet for this study is justified on the one hand by its importance in the rotation practiced on the perimeter and on the other hand by its high consumption of irrigation water and its efficiency to exploit a natural resource such as solar radiation and water becoming more expensive **[7]**. Irrigation management was based on the Penman Monteith daily reference system for the estimation of reference evapotranspiration (ET °) from a few climatic variables and the subsequent determination of the water needs of the crop (ETM).). According to some authors **[8]**, the ETM remains a theoretical indicator and it is necessary to estimate what will be its actual water consumption (actual evapotranspiration: ETR) determined by the balance sheet method (ETR = Inputs-Losses ± ΔS, ΔS = Stock (j) - Stock (j-1) estimated from the daily volume humidity values measured by the capacitive sensors installed for this purpose). As shown in figure 1 below, three reflectometry probes of FDR technologysimultaneously measuring soil moisture and temperature every 10cm and to a depth of 60cm were installed in the field. The access tubes, as reported in the experimental protocol schema below, were placed diagonally at representative points and at locations where the plant roots are dense. According to **[5]**, there is usually one collection point per field, but more may be required if the field is large and the conditions where management practices are variable.The more data are collected, the better the decisions will be. The same authors recommend in the case of drip irrigation, the location of these measuring instruments halfway between the dripper and the outer limit of the moistening front where the roots are dense). This material was previously calibrated in-situ by the gravimetric method in order to have a reliable control of the water status of the soil. Data collection and information was based on interviews with the farmer on various aspects related to exploitation, resource utilization and productivity. Field visits were made regularly to measure certain technical parameters in situ. In terms of instrumentation, the equipment used consists of manometers, graduated test tubes, chronometers, flasks, auger, precision balance and an oven. The analysis and the data processing, the realization of graphs was carried out on an Excel spreadsheet of Microsoft Office (version 2016) with use of all its functions of statistical processing (computation of average, standard deviation and coefficient of variation). The diagrams were made using Auto C.A.D software version 2009.

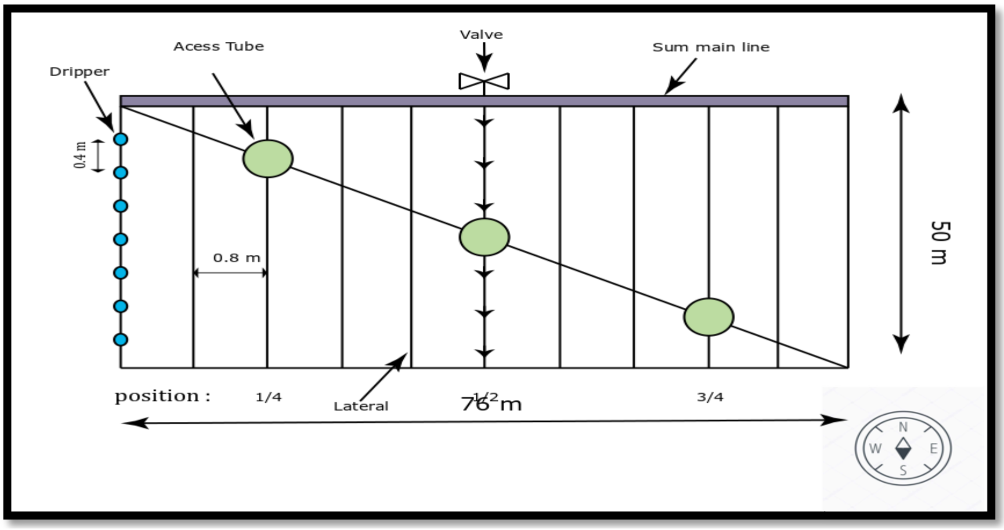

Figure 1: Schematic of the experimental device

III. Results And Discussions

III-1 CONTROL OF SOIL WATER STATUS

The control of irrigation at the plot level can be based on the control of the water status of the soil. This mode of driving developed for several years remains essential to provide references on the use of soil water **[9]**. The control focused on the monitoring of several indicators of soil moisture status.

III-1-1 VARIATION OF SOIL MOISTURE CONTENT

The results inherent in the soil water status during the growth and development cycle of sugar beet show comfort in the water supply of the crop. The irrigation control mode adopted has therefore created optimal soil moisture conditions near the roots of the sugar beet.

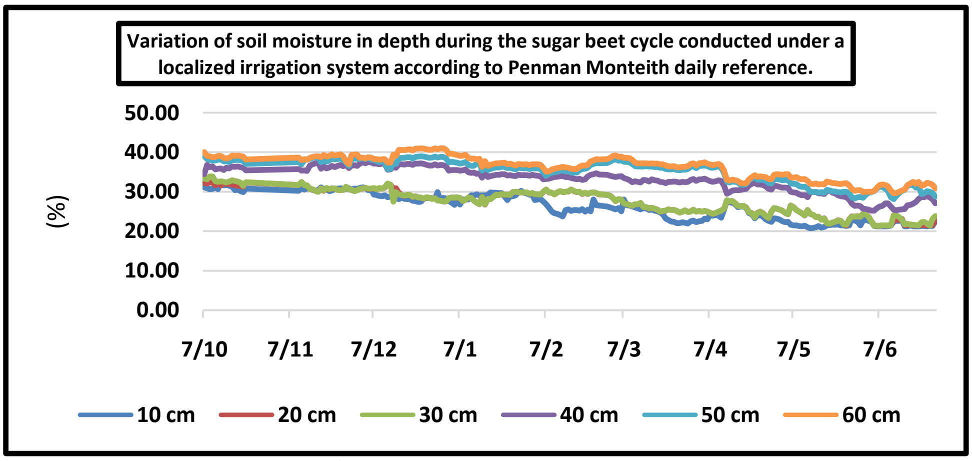

Figure 2: Variation of soil moisture in depth during the sugar beet cycle

From the graph 2 above, the water content decreases with time due to an increase in crop water requirements and water losses through evaporation. Humidity knows slight fluctuations during the crop cycle due to the clay-loam structure of the soil characterized by a high capacity for water retention.The humidity remains within the range of soil moisture characteristics of the study area (Hcc: 249 mm for weight humidityHp (%) from 35 to 36% and Hpf: 138 mm for Hp (%) from 19 to 20% from the ground surface to the depth),which has given the plant water comfort throughout its growth cycle. The evolution of the humidity rate per horizon of the soil shows an increase of this with the depth. These results confirm those obtained by**[10]**having worked on the productivity of corn silage under localized irrigation at the perimeter of Tadla by prospecting a soil horizon of 0 to 1mand **[11]**, having studied the moisture distribution of a soil planted by sugar beet under drip irrigated surface on the horizon 0-75 cm.The layers of the soil surface are subject to evaporation, which decreases their water content compared to deep layers. **[11]**Found for the surface horizon that the humidity is low and is close to the wilting point (Pf = 11.48%) for the irrigation regime 100% of water requirements, and slightly above the Pf for the 80% treatment. In the 30-60 cm soil horizon, the moisture is below the value of the field capacity.**[8]**Have found in some cases in Tadla perimeterthat the water content increases in depth compared to the superficial horizons, this is explained by the high root density favoring the vertical flow of the water, combined with a strong evaporation at the surface level.

III-1-2 CALCULATION OF THE WATER STOCK IN THE SOIL

The soil water stock is calculated according to equation (1) by integrating the water profiles relating to the D domains (10cm, 20cm,30cm, 40cm, 50cm, 60cm) composed of elementary volumes of soil for a depth of 60 cm. Soil volumes were considered homogeneous to facilitate calculations. According to **[12]**, the soil water stock (S) is given as follows:

$$(1)\ S = \iiint_D \theta\,(x, y, z)\ dx, dy, dz$$

The water stocks calculated by integrating the function θt (x, y, z), thanks to the different measurements of soil water contents at different depths and at different points.
θ (x, y, z): The water content of the soil in (%) at the nodal point of coordinates (x, y, z).
dx, dy, dz: Dimension of the space covering the whole DomainIntegration D [L] in mm.

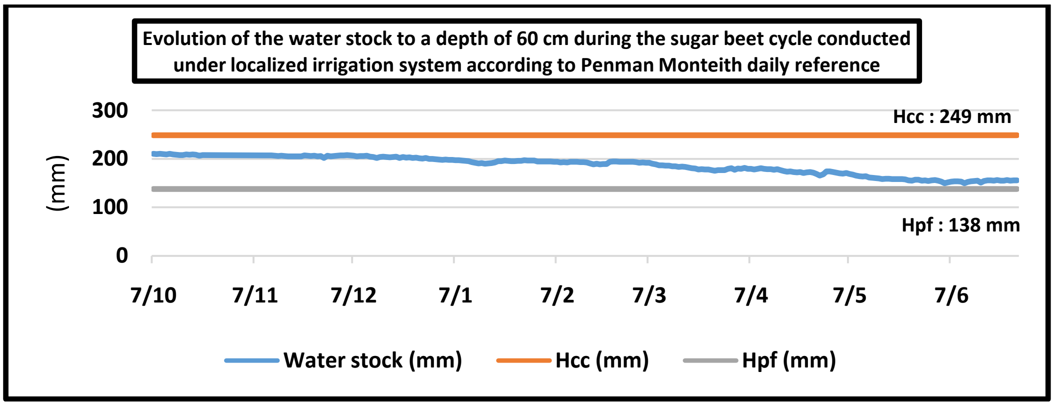

Figure 3: Evolution of soil water stock to a depth of 60 cm

At the beginning of the cycle(as related on the figure 3 above), the stock of the water supply was close to the field capacity (Hcc).This is attributed to the rainfall during this period and to the irrigations operated at sowing to ensure the germination and emergence of the sugar beet seed of which Sclerenchyma sockets are very resistant to water penetration and require more prolonged humidification **[13]**.The water supply decreases as the cycle progresses. This is imputed to increasing climatic demand without reaching moisture at the wilting point (Hpf). The decrease in the water supply is pronounced as the climate becomes warmer and the plant reaches a more advanced vegetative stage, which corroborates with what was found by **[14]**.The maintenance of soil moisture throughout the cycle at levels close to Hcc for most of the cycle and above the lower limit of the soil's characteristic humidity (Hpf), indicates more comfortable water conditions for stable feeding of the plant.

III-1-3 VARIATION IN DAILY WATER STOCK

As mentioned in the graph 4 below, the variation of the daily water stock($\Delta S = S_{jn}-S_{jn-1}$) fluctuates between a minimum of -4.98 mm / day and a maximum of 8.87 mm / day (with a daily average of 0.06 mm). Overall, the fluctuation is low except for a few points where the variation is negative (due to the importance of the water exports by the plantand the evaporation of the soil). This small variation gives the crop a stable and comfortable water supply.

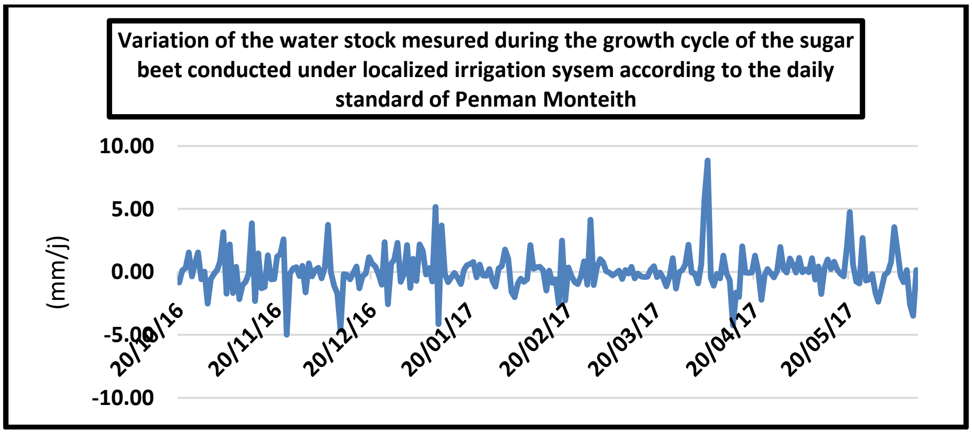

Figure4: Variation of water stock measured

III-1-4 COMPARISON BETWEEN ETM AND ETR

The comparison between the Real Evapotranspiration (ETR) and the Maximum Evapotranspiration (ETM), Lets appreciatethe practice of irrigation and its influence on the hydrous state of the ground and the plant. The ETM was determined through daily Evapotranspiration (ET °: mm/day) estimated by Penman Monteith formula:

$$ETM\ (mm / day) = ET° \times Kc \times Kr$$

Kc is defined as beingcultural coefficient depending on the type of crop and its phonological stage (initial phase, development, mid-season and late season) and Kr: Reduction coefficient varying with the rate of soil cover (Cs) by the plant during the cycle increased by 15%,

$$Kr = Cs \times 1.15$$ **[15]**

The ETR calculated using the water balance method taking into account several parameters: Rainfall (P), Volume content of soil water ($\Delta\theta = \theta n - \theta$ n-1), RealEvapotranspiration (ETR) and water supply by irrigation (I). The water balance equation defined as follows:

$$\theta n = \theta n\text{-}1 + P + I - ET$$ **[16]**

Other authors have introduced to the equation of the water balance, the parameters related to losses by drainage (-D) and runoff (-R) and the contributions by capillary rise (+RC) and the water balance is reducedto equation:

$$ETR = (P + I + RC) - (D+R) \pm \Delta S.$$

According to **[8]**, having worked in the same study area, percolation losses (D) are neglected because the soils in the area are weak to moderately permeable. The average Ks coefficient of permeability is 0.32 cm / hour varying from 0.37 to 0.28 cm / h from the 0-30 cm surface horizon to the 30-50 cm deep horizon, source **[17]**. These soils have a high retention capacity due to a high clay content (44 to 46%), which makes them sticky and impermeable, thus constituting a barrier to capillary rise (RC) and infiltration. In addition, losses (R) due to leaks in the irrigation network are absent.

III-1-4-1 CORRELATION BETWEEN ETM AND ETR

The correlation curve (figure 5) between these two parameters makes it possible to assess the efficiency of the piloting mode adopted in this experiment. It emerges from the correlation equation, as shown in the graph below, that the water requirements estimated by the Penman Monteith formula (ETM) are highly correlated ($r^2 \approx$ 0.9) with those measured by the water balance method Soil (ETR).These results prove the efficiency of the method tested in controlling watering of sugar beet in the context of Tadla perimeter.

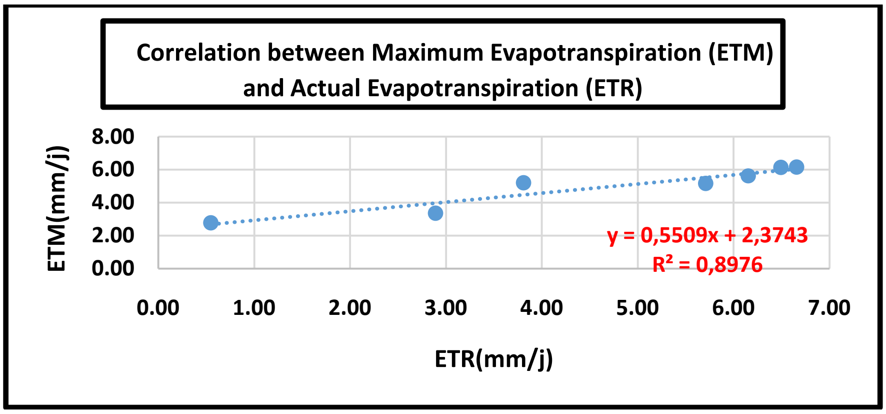

Figure 5: Correlation between ETM and ETR

III-1-4-2 EVOLUTION OF THE CUMULATING OF THE ETR AND THE ETM.

The shape of the graph 6 below showsthat the ETR at the beginning of the cycle significantly exceeds the ETM, which is imputed to:

- Copious supplies of irrigation water(2x25 mm) operated at the time of the installation of the crop, far exceeding the plant's exports and the climatic demand in order to ensure a good imbibition of the seed of the sugar beet requiring high soil moisture to trigger the germination process and ensure good emergence of seedlings,
- Autumn and winter rains prevalent in the region during this period of the crop cycle amounting to 73 mm.

These different inputs compensate and excessively the needs of the plant and consequently improve the variation of the soil water stock ($\Delta S > 0$), thus increasing the ETR at the level of the water balance equation.

From the end of March, the cumulative ETR begins to decrease to approach that of the ETM and the plant is thus in comfortable water supply conditions. In certain periods, the ETR even falls below the water requirements, the plant is then in conditions of water stress and regulates its stomata.

Overall, over the whole cycle, the ETR remains below the ETM with respectively a daily average of 4.61 and 4.91 mm and a total of 478 and 504 mm for the last part of the cycle from the month of March.

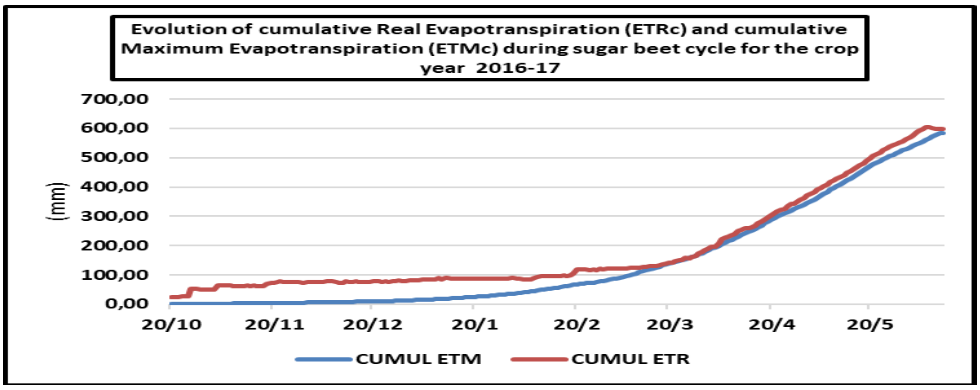

Figure6: Evolution cumulativeof ETM and ETR

III-1-5CALCULATION OF THE WATER STRESS INDEX(CWSI)

This index used to control irrigation in arid zones, quantifies water stress. **[18]**From the energy balance equation, showed that: CWSI = 1 –(ETR / ETM).In our study, where irrigation was conducted at 100% ETM according to the Penman Monteith daily reference, this index is on average 0.2, which shows that the average ETR is kept close to the ETM conferring on the crop a water comfort during all its cultural cycle. **[19]**In Doukkala with water intakes at 100% ETM kept this index in the neighborhood of 0.5).

As the water balance method is sensitive to daily variations, the interpretation of the data was established on the basis of daily average for periods ranging from 10 to 15 days.

The assessment carried out only from March because it was necessary to wait for the drying of the soil of the rain received at the beginning of the cycle. The average crop cycle ETR (4.61 mm / day) measured by the water balance method remains below the average water requirement estimated empirically by the climate approach based on Penman Monteith daily reference (4.91 mm/day). This finding reflected in the reduction of evapotranspiration of plants by the regulation of exchanges with the surrounding environment when they are in a situation of water stress and high evaporation of air.

III-2 CONTROL OF THE THERMAL SOIL SYSTEM

In this part, we will try to relate the thermal conditions of the soil that prevailed during the crop cycle and analyze their likely effects on the conditions of growth and development of sugar beet.

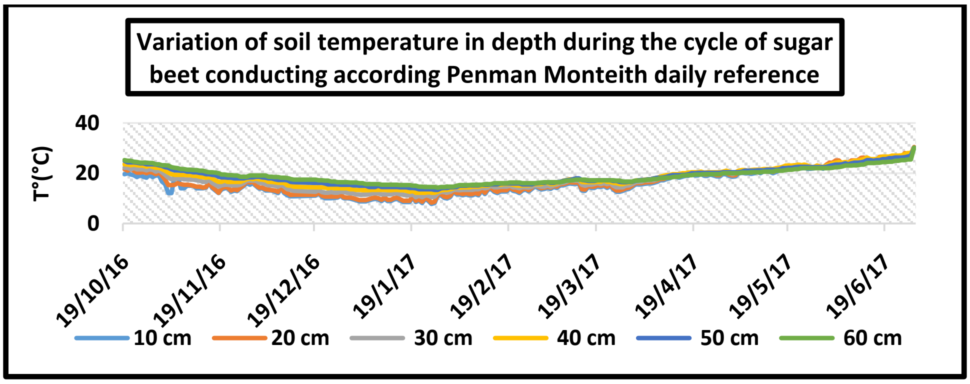

Figure7: Evolution of soil temperature in depth

Asshown in figure 7 below, the soil temperature, all depths combined, changes during the crop's growth cycle according to the succession of seasons, reaching high average temperatures at the end of the season.As stated in the graph below, the mean soil temperatures range from a minimum of 7.7 ° C (recorded early season at the surface horizon of 10 cm) to 30.2 ° C (measuredat the end of the culturing cycle for the horizon 50 cm).Overall the soil temperature for the first part of the cycle increases from the soil surface to the deep horizons, which is in agreement with the results of **[20]**, who studied the variation of temperature as a function of time for different depths of the ground (4, 6 and 8 feet).However, from the beginning of April, the temperature profiles tend to reverse, which can be mainly attributed to changes in climatic conditions between the beginning and the end of the crop cycle.According to **[21]**, the distribution of soil temperature is affected by several factors, including daily variations in ambient climate conditions that can affect soil temperature to a depth of approximately 1 meter.**[22]** Reported that the temperature of the ground changes with depth because a certain amount of heat is absorbed or released along the path once the temperature of the materials in the conductive soil changes.

By referring to the thermal requirements of the crop and through the analysis of the variation of the temperature per horizon of the soil, it emerges that the plant has completed its cycle of growth and development under suitable conditions. This regime has undoubtedly created an environment favorable to the culture in terms of both water supply and nutrition. In fact, according to Lemaire P., 1981 cited in **[23]** the optimum growth for all phases of sugar beet is around 20 -25 ° C, with a mean night temperature of 15 ° C. Furthermore, it was reported in a study that the growth of the beet is often altered by compaction and cold temperatures. Root growth is low at 10 ° C than at 20 ° C. In terms of mineral nutrition, soil temperature affects the influx of phosphorus **[24]**.

III- AGRO-ECONOMIC PERFORMANCES OF CULTURE

III-1 QUANTITATIVE AND QUALITATIVE INDICES

The effect of the treatment studied will be reflected through the analysis of agro-economic indicators. The parameters retained for this purpose relate to the quantitative and qualitative yield, the efficiency of use of irrigation water and the added value provided.The parameters selected for this purpose is aboutthe quantitative and qualitative yield, the efficiency of use of the irrigation water and the added value provided. By comparing the results of table 1 below, we see an increase of 77%, 31% and 170%, respectively, for the root yield, the saccharin content and the sugar yield, which can be attributed essentially to the rationalization of the use of irrigation water by bringing that strict needs of culture and at the right time.Indeed, any deficit or excess of irrigation water can only harm the normal development of sugar beet: **[4]** pointed out that the use of agricultural water must be considered with sparingly.It should be noted that the plot serving as a controlplot was conducted by the farmer according to his cumulative experience in the irrigation of sugar beet.

Table 1: Comparative statement of quantitative and qualitative results of sugar beet

	RY (t/ha)	**SC (%)**	**SY (t/ha)**
2016-17	109,73	20,02	19,8
Control	62,02	15,33	7,32
Variation (%)	**77**	**31**	**170**

(Source **[25]**)

RY: Root Yield; **SY**: Sugar Yield; **SC**: Sugar Content

III-2 ECONOMY AND VALORIZATION OF IRRIGATION WATER

In terms of consumption and valorization of irrigation water by sugar beet as stipulated in table 2 below, it should be noted that irrigation water savings of around 28% provided by the method of piloting adopted in comparison with the one adopted by the farmer.The latter, impregnated with the gravity irrigation mode, is often based on the visual aspect of the crop and the touch of the soil, which often leads according to **[6]**to an inefficient management of the resource in addition to representing diffuse pollution risks.

Table 2: Comparative status of water allocation and its valorization by sugar beet.

	Co	**WV**	**EUE**	
	(m^3 water /ha)	**(DH/ m^3water)**	**(kg.root /m^3water)**	**(kg.sugar /m^3water)**
2016-17	5830	7,14	16,26	2,50
Control	8083	3,75	7,67	0,91
Variation %	**-28**	**91**	**112**	**176**

Co: Consumption**, EUE**: Water Use Efficiency, **WV:** water valorization

In terms of efficiency (EUE) and valorization of irrigation water, we note a clear exceedance compared to the control of 112, 176 and 91 respectively. In fact, the irrigation method based on the climate approach has ensured substantial water saving and better quantitative and qualitative yields than the one adopted by the farmer.

III-3 PROFITABILITY OF CULTURE

The results relating to the profitability of sugar beet prepared in Table 3 below show a clear superiority of the treatment studied compared to the control of 55, 38 and 70% respectively for the gross product, the income and the value added per hectare. The 7% CHfm change in costs is related solely to the cost of water consumed in excess of the control plot due to the irrigation method adopted by the farmer.

Table 3: Comparative state of the results of agro economic indices of sugar beet

(*) : Source SUTA 2016)

	CHfm (DH/ha)	**PB(*) (DH/Ha)**	**RV(*) (DH/Ha)**	**VA(*) (DH/Ha)**
2016-17	9379	66647	41654	57268
Control	10100	43037	30277	33537
Variation (%)	**-7**	**55**	**38**	**70**

CHfm: Charges related to the supply and equipment; **PB:** Gross product; **VA**: Value Added; **RV**: Revenue

IV. CONCLUSIONS AND PRACTICAL RECOMMENDATIONS

As a conclusion and taking into account the results obtained, the climate approach based on the Penman Monteith daily reference is quite valid in the context of the Tadla to predict the water needs and plan the irrigation of the sugar beet. The irrigation-piloting mode tested has created favorable water conditions for the plant allowing it to express fully its production potential both qualitatively and quantitatively. For this purpose,it can be an effective tool for an optimal management of irrigations avoiding all the risks of wastage and diffuse pollution. In matter of instrumentation, FDR type capacitive probes appear to be effective tools for monitoring moisture and providing references on the use of soil water. It is therefore necessary to ensure support for the development of drip irrigation for accompanying agricultural users in a timely and economical management, reduced to the strict water requirements of the crop to ensure even a sober use of production factors and ward off environmental problems.

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