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Sweet Corn Water Productivity under Several Deficit Irrigation Regimes Applied during Vegetative Growth Stage using Treated Wastewater as Water Irrigation Source

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***Abstract*—**Yield and Crop Water Productivity are crucial issues in sustainable agriculture, especially in high-demand resource crops such as sweet corn. This study was conducted to investigate agronomic responses such as plant growth, yield and soil parameters (EC and Nitrate accumulation) to several deficit irrigation treatments (100, 75, 50, 25 and 0% of ETm) applied during vegetative growth stage, rainfed treatment was also tested.

The finding of this research indicates that under deficit irrigation during vegetative growth stage applying 75% of ETm lead to increasing of 19.4% in terms of fresh ear yield, 9.4% in terms of dry grain yield, 10.5% in terms of number of ears per plant, 11.5% for the 1000 grains weight and 19% in terms of crop water productivity compared with fully irrigated treatment. While those parameters in addition to root, shoot and plant height has been affected by deficit irrigation during vegetative growth stage when increasing water stress degree more than 50% of ETm.

***Keywords*—**Leaf area, yield, crop water productivity, water saving

I. Introduction

TO meet the acute freshwater challenges facing humankind over the coming 50 years and to fulfil the food gap to feed 8-9 billion people, directing all the efforts to improve water use and management in agriculture is now a must [1]. UNWWD [2] reported that agriculture is the largest consumer of freshwater by far about 70% of all freshwater withdrawals goes to irrigated agriculture. Water scarcity may limit food production and supply, putting pressure on food prices and increasing countries dependence on food imports.

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Treated and reused sewage water is becoming a common source for additional water [3 - 11] in many developing countries, a major part of the wastewater generated by domestic, commercial, and industrial sectors is used for crop production in an untreated or partly treated form. The protection of public health and the environment are the main concerns associated with uncontrolled wastewater irrigation [12]. According to many researches irrigation with effluent led to greater water use efficiency compared to fresh water [13-17].

According to Schultheis [18] field corn was grown in North America before 200 B.C. Field corn is produced primarily for animal feed and industrial uses such as ethanol, cooking oil, etc. In contrast, sweet corn is produced for human consumption as either a fresh or processed product. The specific time when sweet corn originated cannot be pin-pointed; however, sweet corn was grown by the American Indian and first collected by European settlers in the 1770's. The first variety, Papoon, was acquired from the Iroquois Indians in 1779. Sweet corn is available as yellow, white, or bicolored ear types. Cultivars vary in their days to maturity; they are classified as early, mid-, and late season. Late season cultivars generally are the best quality. Many of the new cultivars are higher in sugar content and retain their sweetness longer [19].

Deficit irrigation creates water stress that can affect the growth and development of corn plants. The response of corn plants to water stress has been shown to change with hybrid and can be affected by improving technological level. Effects of water stress on corn include the visible symptoms of reduced growth, delayed maturity, and reduced crop yield. For instance, water stress has been shown to reduce corn canopy height, leaf area index and root growth [20 - 26]. Çakir [21] and Hirich [17] found that stressing corn during the vegetative stage in an arid environment hindered root development, which restricted deep water uptake and led to high yield and crop water productivity.

II. Materials And Methods

A. Experimental Site

The research has been conducted in the experimental field of the Agronomic and Veterinary Medicine Hassan II Institute, Complex of Horticulture in Agadir in the south of Morocco cultivating sweet corn (*Zea mays* sacharata, Var: Oveland) between February 25th, 2011 and June 20th, 2011. The climate is arid, characterized by low precipitation (250 mm), rainfall is occurred from November to Marsh. Sunshine is more than 300 days a year and average temperature is variable form 14 to 16 °C in January and from 19 to 22°C in July.

B. Soil

Soil type was loamy with a pH of 8.13 and EC 0.27 dS/m. The soil was moderately rich in organic matter (1.6%), field capacity humidity (FC_{RH}) was 30%, and the permanent wilting point humidity (PWP_{RH}) 15%. Soil was analyzed in soil laboratory before sweet corn sowing.

C. Irrigation Water

The irrigation water used was treated domestic wastewater, very rich in nitrogen and organic matter, with EC equal to 1.31 dS/m and pH 7.6. According to the nutrient content in this water, most of the fertilizer requirements of the crop can be covered since 1000 m^3 can provide 22 kg of Nitrogen, 15 kg of Phosphorus and 19 kg of Potassium. In terms of microbiological analysis, the irrigation water remains within the standards of the World Health Organization [27].

D. Treatments

Experimental units (18 m2) were organized in a completely randomized design with 24 plots. Inside plot there were 5 sowing lines, a distance of 50 cm between lines and 40 cm between sowing holes has been adopted.

All treatments have received the same quantity of water during the initial stage (20 days after sowing), this irrigation supply during this stage was necessary for crop to start its growth and to be able after to resist to deficit irrigation supply.

Differences between response variables to deficit irrigation treatments were assessed with a general linear model in the StatSoft STATISTICA 8.0.550. All statistical differences were significant at $\alpha = 0.05$ or lower. Tukey HSD test was used to reveal homogeneous groups.

Six treatments and four replications for each treatment have been adopted as shown in the Table I.

TABLE I
IRRIGATION TREATMENTS (% OF ETM)

Treatment	Germinat-on	Vegetative growth	Flowering	Seed filling	Senescence
T0 (Rainfed)	100	0	0	0	0
T1	100	100	100	100	0
T2	100	75	100	100	0
T3	100	50	100	100	0
T4	100	25	100	100	0
T5	100	0	100	100	0

E. Soil moisture control: installation of the telemetry system

The water quantity required by each treatment was supplied, as any control loss in treatment application or soil moisture sensing will affect negatively the experiment results.

Two kinds of telemetry system were installed: short and long range telemetry (Fig. 1a). The short range telemetry is based on the installation of a capacitance based continuous logging probe (AquaCheck Wireless Probe ACBIIW) in the control plot (Fig. 1 b1). These sensors can be controlled by a mobile datalogger (AquaCheck BII Logger) (Fig. 2 b1) which collects data automatically, from a maximum of 6 depths (10, 20, 30, 40, 50 and 60 cm) (Fig. 1 b2). In each soil depth is achieved moisture and temperature, the data downloaded can be transferred to the computer in which they can be analyzed by a special program CropGRAPH.

In the long range telemetry a fixed sensor with analogical output was used, combined with other sensors for monitoring climate or plants. The communication was made in two different ways, by radio from the field to the server and by GPRS (General Packet Radio Service) that offer unlimited access to data via the internet where the graphs related to the soil moisture was showed and treated by addVANTAGE Pro 5.4.

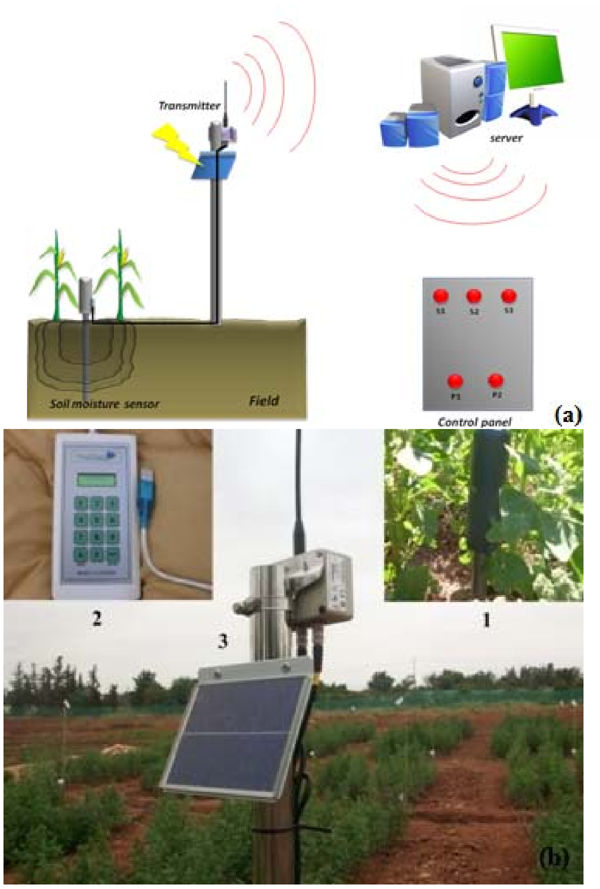

Fig. 1 Long range telemetry system design (a), soil moisture sensor (b1), Datalogger (b2) and soil moisture data transmitter (b3)

F. Irrigation scheduling

To calculate net irrigation requirement, four approaches related to soil, climate, crop and irrigation system, have been used. From the soil approach the net maximal dose (NMD) expressed in mm was [28]:

$NMD = f \times (FC_{RH} - PWP_{RH}) \times Z \times \% SH$

Where:

- f: allowable depletion = 10%
- FC_{RH} : humidity at field capacity = 30%
- PWP_{RH}: humidity at permanent wilting point = 15%
- Z: roots depth = 25 cm
- % SH: percentage of wet area = 30%

So NMD = 1,125 mm

Five drippers were installed per m2 and the nominal discharge of each dripper was 2 l/h, so the hourly pluviometry (PH) was: PH = 2l/h x 5 = 10 l/h. Irrigation time (Tirri) required to give 1 NMD was *Tirri =NMD/PH* = 1.125/10 = 7 min, it means that to supply 1 NMD and to satisfy the allowable depletion was needed 7 min.

The net irrigation requirement (NIR) was NIR = ETm/Eff, where ETm is the maximal evapotranspiration and Eff is the system efficiency of 0.85 (drip irrigation). *ETm = Kc x ETo*, with crop coefficient (Kc) and evapotranspiration (ETo). The Kc coefficient serves as an aggregation of the physical and physiological differences between crops [29]. ETo represents the climate approach, provided by the IAV-CHA weather station. It is calculated from the Penman equation which was the first to combine energy and atmospheric vapor transport components to estimate ETo [30].

For example if we yesterday had ETo = 4, and Kc = 0.95, so for irrigation today we must supply:

NIR = ETm/Eff = Kc x ETo/Eff = 0.95 x 4/0.85 = 4.47 mm

Irrigation frequency is one of the most important factors in drip irrigation scheduling. Due to the differences in soil moisture and wetting pattern, crop yields may be different when the same quantity of water is applied under different irrigation frequencies [31].

Frequency is *F = NIR/NMD = 4*.47 / 1.125 = 3.97, so we have to irrigate 3 times, 7 min each time, and the rest we have to give it tomorrow so we should add it to the irrigation supply of tomorrow, and so for all coming days.

Irrigation scheduling was controlled by soil moisture sensing. Soil humidity sensor was installed in a control plot (100% of ETm), an allowable depletion of 10 % under FC_{RH} was fixed for irrigation scheduling. The major part of roots was localized around 20 cm of depth. When the soil moisture curve decreased under the allowable depletion, the irrigation supply should be increased by increasing slightly the crop coefficient Kc, and if this curve increased the Kc should be slightly decreased.

G. Parameters to measure

The destructive measurement of agronomic parameters (roots, stems, leaves, flowers and leaf area) were carried out on 4 plants per treatment. Fresh weight of roots, stem, leaves and flowers or fruits was measured, as well as leaf area, thereafter dried at 60 °C during 48 hours.

Plant height development was determined by measuring (from soil surface to growing tip before tasselling) five labelled plants for each plot since 6 weeks after sowing (WAS), followed by weekly measurements.

There were 2 different yields which were estimated, fresh ear yield and dry grain yield. Fresh ear yield and number of ears per plant were measured taken 32 plants per treatments. The 1000 grains weight was also measured.

When irrigating with treated wastewater, it is necessary to analyze salinity and nitrate accumulation in the soil. If the irrigation is well controlled, it will not have an effect on nitrogen leaching, and the irrigated crops will quickly take up the nitrogen [32]. Soil samples were taken before sowing for analysis of initial chemical and physical capacity of the soil, and after harvest for EC and nitrate.

III. Results

A. Climatic parameters

Table II shows the climatic data recorded during crop cycle, February was the cooler month and June was the hottest. May received 58% of total rainfall recorded during sweet corn crop cycle; a total of 642 mm was recorded in terms of reference evatranspiration, ETo increased as temperature increased. Fresh ear yield was carried out in the end of June, while waiting ears to be dried to measure dry grain yield.

TABLE II
Rainfall, Min, Average and Max temperature, Relative humidity and Reference Evatranspiration (ETo) during the experiment

Climate parameter	February	Marsh	April	May	June	Total
Rainfall (mm)	0	42	53	133	0	229
T° Min (°C)	6	8	13	17	18	62
T° Average (°C)	13	14	19	22	25	94
T° Max (°C)	21	22	26	28	33	132
Relative Humidity (%)	70	70	70	66	61.	338
ETo (mm)	88	110	132	150	160	642

B. Soil EC and Nitrate concentration

Leaching of some chemical substances, particularly nitrogen is an important factor potentially is limiting the sustainability of effluent-irrigated plantations, so it is important to follow the soil parameters such as soil EC and nitrate concentration in order to assess the impact of irrigation using wastewater on soil and groundwater pollution.

EC and soil nitrate were measured in the end of vegetative growth stage and after crop cycle in order to evaluate the effect of different treatments on salt and nitrate accumulation and to find out the treatment less pollutant.

No significant difference was revealed in terms of soil EC and soil nitrate concentration after harvest, treatment fully irrigated (T1) recorded high salt accumulation after crop cycle followed by treatment receiving 50% of ETm during vegetative growth stage (T3), while treatments receiving 0% of ETm (T0 and T5) during vegetative growth stage showed the lowest soil EC after harvest, as well as soil nitrate concentration was decreasing during crop cycle for all treatments except T5 (receiving 0% of ETm during vegetative growth) which recorded increasing in soil nitrate, in the end of vegetative growth stage treatment fully irrigated (T1) recorded the highest nitrate accumulation, while other treatments are equals statistically.

TABLE III
SOIL EC AND SOIL NITRATE CONCENTRATION IN THE END OF VEGETATIVE GROWTH STAGE AND AFTER SWEET CORN HARVEST

Treatments	End of vegetative growth stage		After harvest	
	Soil EC (us/cm)	Soil Nitrate* (ppm)	Soil EC (us/cm)	Soil Nitrate (ppm)
T0	152.1 ± 29.8	22.7 b	154.2 ± 35.2	19.9
T1	119.8 ± 24.1	42.6 a	278.7 ± 52.2	21.6
T2	142.8 ± 26.9	22.7 b	170.6 ± 41.3	15.3
T3	139.8 ± 39.6	22.2 b	202.6 ± 117.5	13.1
T4	131.5 ± 29.7	26.1 b	179.0 ± 67.8	15.9
T5	140.7 ± 23.4	20.5 b	154.3 ± 22.8	22.7

*p= 0.04 with significance level is equal to 95% (α = 0.05)

C. Growth parameters

Data concerning the effect of deficit irrigation on sweet corn height are plotted in Fig. 2. Deficit irrigation applied at vegetative growth stage affected plant height growth significantly (Table 4). During all crop cycle treatment fully irrigated (T1) showed the highest plant height followed by treatment receiving 50% of ETm (T3), treatment receiving 0% of ETm during vegetative growth stage (T5) recorded the lowest plant height overall crop cycle, while rainfed treatment (T0) showed plant height higher than treatment T5 which was receiving full irrigation during the rest of crop cycle.

TABLE IV
STATISTICAL ANALYSIS AND HOMOGENOUS GROUPS OF SWEET CORN PLANT HEIGHT

Treatments	Days after sowing					
	6	7	8	9	10	12
p*	0.49	0.02	0.002	< 0.001	< 0.001	< 0.001
T0		ab	b	bc	cd	b
T1		ab	a	a	a	a
T2		b	b	abc	abc	ab
T3		a	ab	ab	ab	ab
T4		a	ab	abc	bc	b
T5		ab	b	c	d	c

*significant difference was revealed when 0.05< p <0.01, very highly significant difference when 0.01 < p < 0.001, very highly significant difference was revealed when p was less than 0.001.

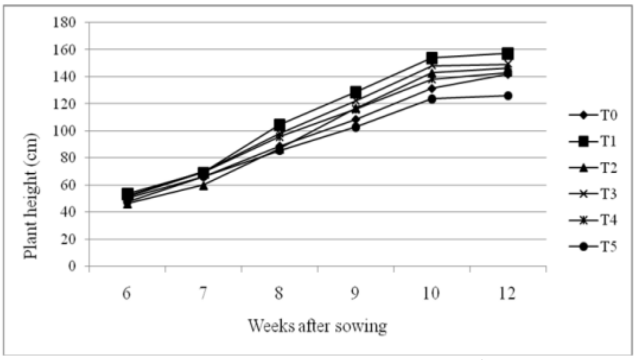

Fig. 2 Plant height evolution during crop cycle of sweet corn

Change in stem diameter was measured twice during sweet corn cycle. Table 5 shows stem diameter recorded in the end of vegetative growth stage and in the end of crop cycle, no significant difference was revealed for the first measurement while in the end of crop cycle a highly significant difference was obtained, treatment receiving 50% of ETm (T3) recorded the highest stem diameter, followed by treatment fully irrigated (T1), treatment receiving 0% of ETm (T5) recorded the lowest stem diameter.

TABLE V
STEM DIAMETER (CM) MEASURED IN THE END OF VEGETATIVE GROWTH STAGE, AND IN THE END OF CROP CYCLE

Treatments	End of vegetative growth stage	End of crop cycle
p	0.58	0.001
T0	2.39 ± 0.45	3.28 ± 0.43 bc
T1	2.25 ± 0.29	3.72 ± 0.39 ab
T2	2.18 ± 0.30	3.58 ± 0.40 abc
T3	2.21 ± 0.32	3.74 ± 0.41 a
T4	2.23 ± 0.33	3.37 ± 0.48 abc
T5	2.22 ± 0.30	3.20 ± 0.49 c

Root dry matter was measured several times during crop cycle in order to evaluate the effect of deficit irrigation during vegetative phase on root system development. Fig. 3 shows the root dry weight evolution during crop cycle, data indicated increasing in root dry matter during crop cycle for all treatments, when reaching senescence stage root dry weight decreased slightly.

No significant difference between treatments was obtained, which means that deficit irrigation during vegetative growth stage has not affected significantly root system development, however in general observations indicated that treatment receiving 75% of ETm during vegetative growth stage (T2) recorded the highest root dry weight, followed by treatment receiving 50% of ETm during vegetative growth (T3), as plant height treatments showed the same trend in terms of root development, treatment receiving 0% of ETm during vegetative growth stage (T5) showed the lowest root weight during crop cycle.

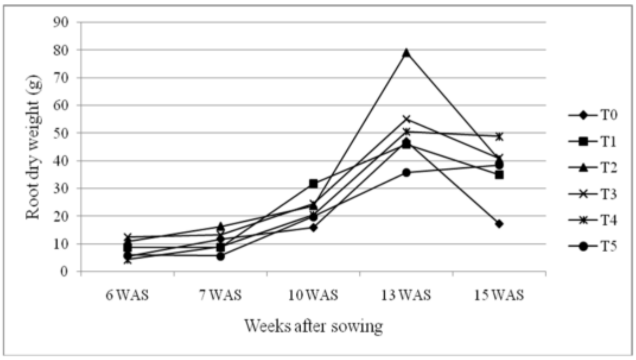

Fig. 3 Root dry weight evolution during crop cycle of sweet corn

Shoot dry weight was the total of dry stem and leaves weight, statistical analysis has revealed a significant difference (p = 0.04) only 13 weeks after sowing (Fig. 4). Treatment receiving 25% of ETm during vegetative growth stage (T4) recorded the highest shoot dry weight even more than treatment fully irrigated (T1), rainfed treatment (T0) showed the lowest shoot dry weight, while other treatments (T1, T2, T3, T5) showed statistically the same shoot dry weight. Shoot dry weight has increased for all treatments during crop cycle until 13 weeks after sowing and it has decreased as response to senescence process.

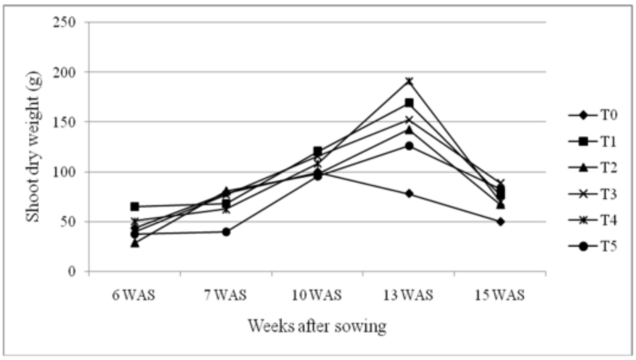

Fig. 4 Shoot dry weight evolution during crop cycle of sweet corn

A significant difference was found for measurements carried out 7 weeks after sowing (p = 0.002) and 13 weeks after sowing (p = 0.017). As shown in Fig. 5 treatment fully irrigated (T1) and treatment receiving 50% of ETm during vegetative stage showed both the highest leaf area, followed successively by treatment receiving 75% (T2), 25% (T4), 0% of ETm (T5) during vegetative growth stage and rainfed treatment (T0). During crop cycle leaf area was increasing to record the maximum during the grain filling stage and decrease in the end of cycle as the crop entered to the senescence stage.

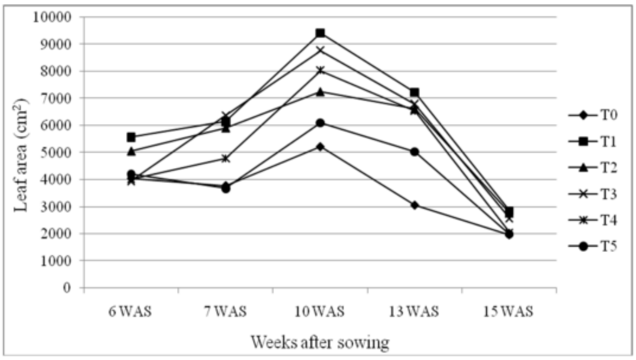

Fig. 5 Shoot dry weight evolution during crop cycle of sweet corn

D. Yield Components

Sweet corn is a horticultural crop, where the fresh ears are marketable, in this research two kinds of yield has been measured: fresh ear yield and dry grain yield, a number of 32 plants per treatment was harvested to estimate yield. Number of ears per plant and 1000 grains weight has been also recorded as yield components.

According to table 6 statistical analysis revealed a significant difference for fresh ears and dry grain yield and the 1000 grains weight, for number of ears per plant all treatments are equals statistically. For fresh ears yield treatment receiving 75% of ETm (T2) recorded the highest yield followed by treatment fully irrigated (T1) and treatments receiving 50 (T3), 25 (T4) and 0% (T5) of ETm during the vegetative growth stage, while rainfed treatment (T0) has recorded the lowest fresh ears yield with a reduction of about 50% compared to treatment fully irrigated (T1).

For dry grain yield all treatments except rainfed treatment (T0) recorded statistically an equal dry grain yields, where a reduction of 40% compared to treatment control (T1) was recorded for rainfed treatment (T0). The same comments can be applied for the 1000 grain weight where all treatments except rainfed treatment (T0) recorded statistically the same 1000 grain weight while rainfed treatment (T0) showed a reduction of 25% compared to control treatment (T1).

TABLE VI
FRESH EARS YIELD, DRY GRAIN YIELD, NUMBER OF EARS PER PLANT AND THE 1000 GRAINS WEIGHT OF SWEET CORN AT HARVEST.

Treatments	Fresh ears yield	Dry grain yield	Number of ears/plant	1000 grains weight
	g/plant	g/plant		g
p	< 0.001	< 0.001	0.24	0.05
T0	285 ± 106 c	95 ± 3 b	1.7 ± 0.3	91± 9 b
T1	556 ± 178 ab	159 ± 17 a	1.9 ± 0.3	122 ± 34 a
T2	664 ± 248 a	174 ± 29 a	2.1 ± 0.2	136 ± 24 a
T3	544 ± 101 b	163 ± 8 a	2.0 ± 0.1	131 ± 13 a
T4	538 ± 145 b	162 ± 36 a	1.7 ± 0.4	130 ± 27 a
T5	519 ± 120 b	146 ± 15 a	1.9 ± 0.1	146 ± 27 a

E. Crop Water Productivity

Crop water productivity (CWR) was calculated by dividing the dry grain yield on the consumed water quantity by each treatment.

According to table 6 there was no significant difference in terms of the effect of deficit irrigation applied during vegetative growth stage on sweet corn water productivity, highest CWP was obtained for rainfed treatment (T0) because it was only receiving rain water compared to other irrigated treatments. Treatment receiving 0% of ETm during vegetative growth (T5) stage has recorded the highest CWR among irrigated treatments and this due to high grain yield which was statistically equal to control treatment (T1) yield and reduced water supply.

TABLE VII
WATER SUPPLY AND CROP WATER PRODUCTIVITY OF SWEET CORN

Treatments	Crop Water Productivity	Water supply including rain (mm)
	kg/m^3	mm
T0	2.2 ± 0.1	217
T1	1.6 ± 0.2	492
T2	1.9 ± 0.3	456
T3	2.0 ± 0.1	419
T4	2.1 ± 0.5	382
T5	2.1 ± 0.2	345

IV. DISCUSSION

Deficit irrigation during vegetative growth stage was affecting negatively plant height of sweet corn. Good correlation was found (R^2 = 0.85) between the percentage of ETm applied during vegetative growth stage and plant height 12 weeks after sowing (Fig. 6) , plant height decreased as water deficit during vegetative growth stage increased. Similar result has been found on sweet corn by [33, 34, 21, 35]. Effects of water deficits on plant height have been determined for other crops as chickpeas [36], black bean [37], wheat [38, 39], dill [40], rice [41], bean [42], and cotton [43].

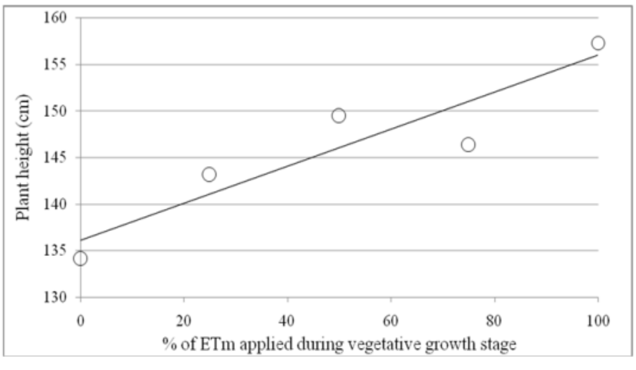

Fig. 6 Relationship between percentage of ETm applied during vegetative growth stage and plant height of sweet corn

Deficit irrigation during vegetative growth stage was affecting negatively stem diameter as plant height, good correlation (R^2 = 0.75) was found between plant height and plant diameter (Fig. 7). According to Çakir [21] and Gheysari et al. [44] water stress was affecting negatively stem diameter and plant height of maize.

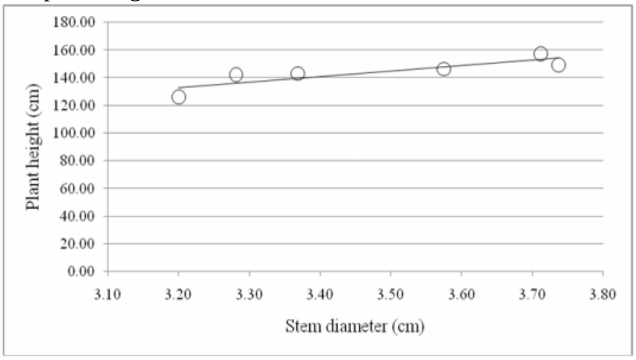

Fig. 7 Relationship between stem diameter and plant height of sweet corn

Final root dry matter decreased as water deficit during vegetative growth was increased [45, 46, 25], applying 50% of ETm during vegetative growth (T3) stage has improved root system development comparing to treatment receiving 75% of ETm (T2).

In rainfed conditions crop had low shoot dry matter comparing when irrigation was provided, this indicated that water shortage has affected negatively dry matter production [21, 47, 48].Water stress occurring during vegetative growth stage reduced leaf area development [21, 25]. Results concerning the effect of water stress on leaf area confirm that leaf elongation is among the plant processes most sensitive to water deficit [49, 35], our results indicated that maximum leaf area was obtained when the crop was subjected to full irrigation, the same results has been obtained by many studies [50, 21, 51, 52, 25].

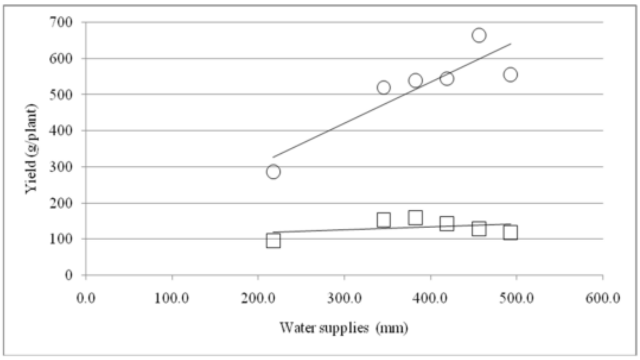

Fig. 8 Relationship between water supplies and dry grain yield (□), water supplies and fresh ears yield (○), with R^2= 0.1 for dry grain yield and R^2= 0.8 for fresh ears yield.

A good correlation (R^2 = 0.8) was found between the water supplies during crop cycle and fresh ears yield while between water supplies and dry grain yield R^2 was very low, it is equal to 0.1 (Fig. 8). This relationship indicated that fresh ears yield was responding well to water supplies than dry grain yield. Yield as other agronomic parameters has been affected negatively by water deficit [20, 25, 53] in terms of fresh ears yield deficit irrigation applied during vegetative growth was affecting negatively fresh ears yield, while in terms of dry grain yield there was no significant difference between deficit irrigation treatments, difference was obtained only between rainfed treatment and other deficit irrigation treatments, this work confirms the results of many researches carried out in order to evaluate the effect of irrigation on sweet corn yield compared to rainfed conditions, where irrigation was improving sweet corn yield and biomass production. In Mediterranean region experiments showed that rainfed treatment recorded fresh ear yield, dry grain yield and number of ears per plant less than those obtained by irrigated treatment [54]. In China conditions under rainfed conditions, the relationship between yield and water supplies has been evaluated and in order to achieve optimum crop yields nearly 1000 mm was needed [55]. In United State of America climate, a significant difference in crop water productivity for both fresh ear yield and ear dry matter was found between the irrigated and the rainfed treatment while rainfed treatment recorded low yield compared when irrigation was provided [53].The result related to crop water productivity did not show any significant difference between treatments, as well as our results indicated that deficit irrigation applied during vegetative growth stage has not affected crop water productivity and this can be explained by the slight difference obtained for irrigated treatments, while for rainfed treatment the reduced water quantity increased crop water productivity even yield was low compared to irrigated treatments.

V. Conclusion

Improving irrigation water management is becoming important to produce a profitable crop in the arid region, especially in the south of Morocco. Applying deficit irrigation can be the key solution to save water resources where the water scarcity is in chronic situation as in the south of Morocco. Using treated wastewater has a great potential in agriculture, this water resources is renewable and increasing day after day as the demographic rate is increasing.

Water deficit occurred during vegetative growth stage stimulated roots development as well as shoot growth, crops in order to respond to early water deficit produces more flowers and so more yield, supplying full irrigation during the rest of cycle give chance to plant to absorb more water and nutrients compared to treatments where full irrigation was provided during the whole crop cycle.

Applying 75% of ETm during vegetative growth stage was the optimal treatment giving maximum fresh and dry yield for sweet corn, while other water stress degree during vegetative growth stage was affecting negatively yield, this result indicated that to stimulate plant growth a slight water stress should be occurred during vegetative growth stage in order to improve yield and so crop water productivity.

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