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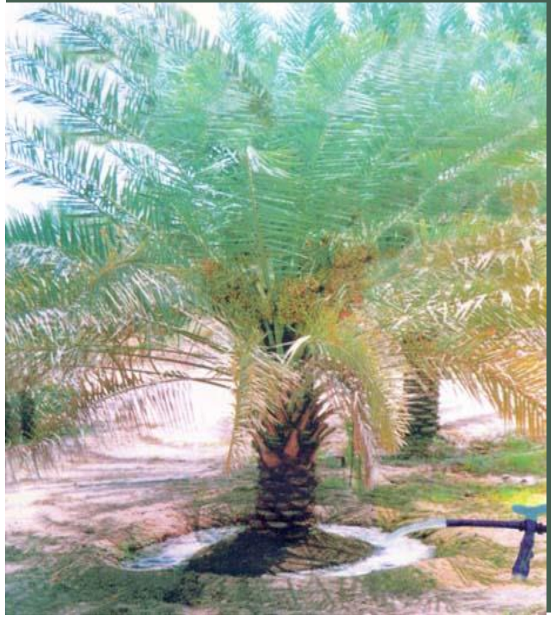
Crowne Plaza, Manama - Kingdom of Bahrain

“Water in the GCC... Towards Integrated Strategies”

جامعة الملك سعود

King Saud University

Irrigation Water Management and Conservation using Modern Irrigation Programs



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Outline

- Introduction
    - Irrigation Water Management definition
    - Irrigation Impacts
    - Irrigation performance evaluation
    - Water production function
- Ways to improve irrigation water conservation
    - Irrigation methods
    - Irrigation scheduling
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- Case Studies
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    - Date palm water requirements
    - Deficit and PRD program on vegetables

Definition

Irrigation Water Management is the process of determining and controlling the crop water requirements, frequency, and application rate of irrigation water in a planned, efficient manner.


Irrigation Water Management

- *Why is Irrigation Water Management Important?*

  - *Manage soil moisture to promote desired crop response.*
  - *Manage salts in the crop root zone.*
  - *Optimize the use of available water supplies.*
  - *Minimize irrigation induced erosion.*

  Decrease non-point source pollution of surface and groundwater resources.
  - *Manage air, soil or plant micro-climate.*

Environmental Impacts of Irrigation

- **1.Salinisation of Salts**
- ***Mitigation***- Leaching requirement, Flash irrigation water to leach the salts out of the root zone, salt tolerant crops depending on severity of problems, drainage system.

2. Over pumping of ground water.

Mitigation - Artificial recharge of ground water .

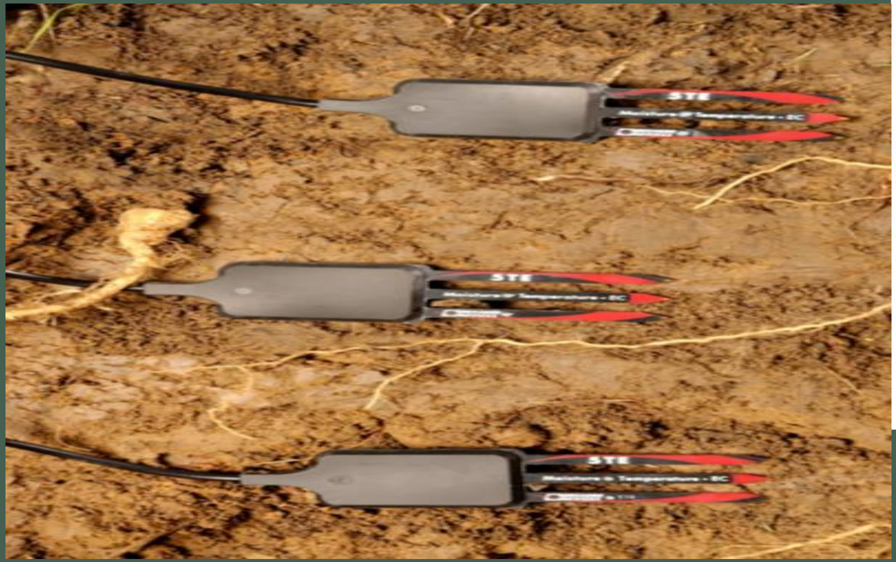
Environmental Impacts of Irrigation Cont.

- **Deterioration of water Quality**
- ***Mitigation*** **-** Apply correct amounts of chemicals , fertilizers and irrigation water, Impose water quality standards on return flow.
- **4.Leaching of nutrients, pesticides**.
- Results: more fertilizers and pesticides application
- ***Mitigation***– Minimise washing way of nutrients from fields into water sources-Correct water and fertiliser and pesticides application.

Soil Erosion

- –e.g. Due poor designed or operated irrigation systems.
- ***Mitigation***- proper design, drainage system, land levelling, practicing soil and water conservation,
- **6.Water logging**
- ***Mitigation*-** Correct application rate, right crop water requirement, proper design, drainage system, land levelling,

Irrigation Scheduling



Estimating Soil Moisture by Feel and Appearance

Appearance of clay, clay loam, and silty clay loam soils at various soil moisture conditions.

Available Water Capacity 1.6-2.4 inches/foot

Percent Available: Currently available soil moisture as a percent of available water capacity.

In./ft. Depleted: Inches of water needed to refill a foot of soil to field capacity.

0-25 percent available
2.4-1.2 in./ft. depleted
Dry, soil aggregations separate easily, clods are hard to crumble with applied pressure. (Not pictured)

25-50 percent available
1.8-0.8 in./ft. depleted
Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.

50-75 percent available
1.2-0.4 in./ft. depleted
Moist, forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger.

75-100 percent available
0.6-0.0 in./ft. depleted
Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger.

100 percent available
0.0 in./ft. depleted (field capacity)
Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky. (Not pictured)

Improve Soil physical properties

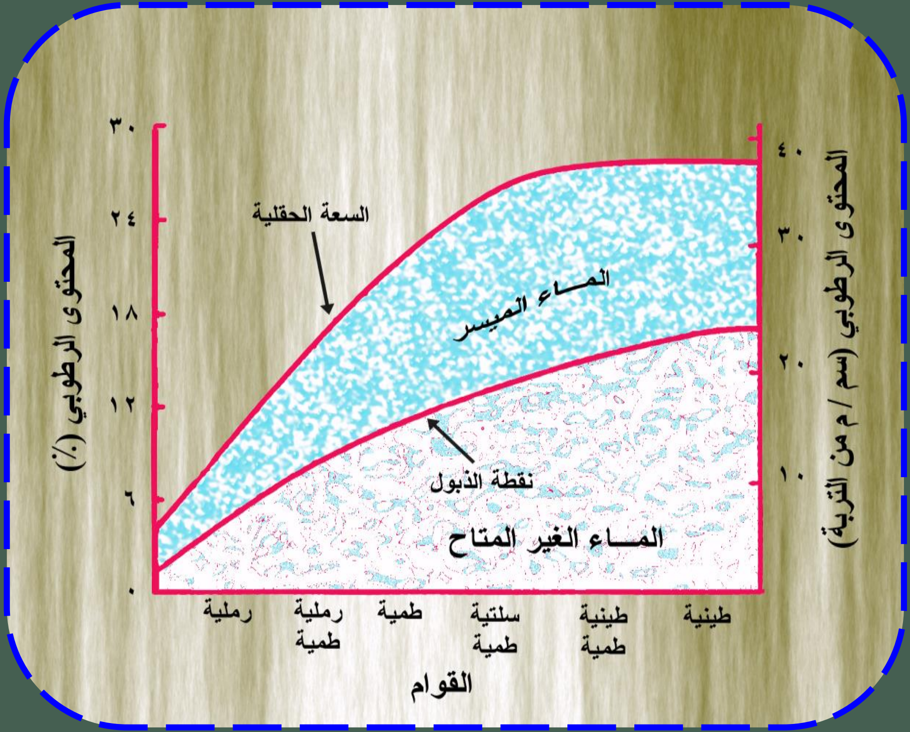
Most of irrigated Agriculture Soils in Saudi Arabia are :

- ➢Calcareous Sandy Soils.
- ➢Low in Fertility Status.
- ➢Low Water Holding Capacity.
- ➢Excessive Deep Percolation.
- ➢Low Water Use Efficiency.

Case 1:

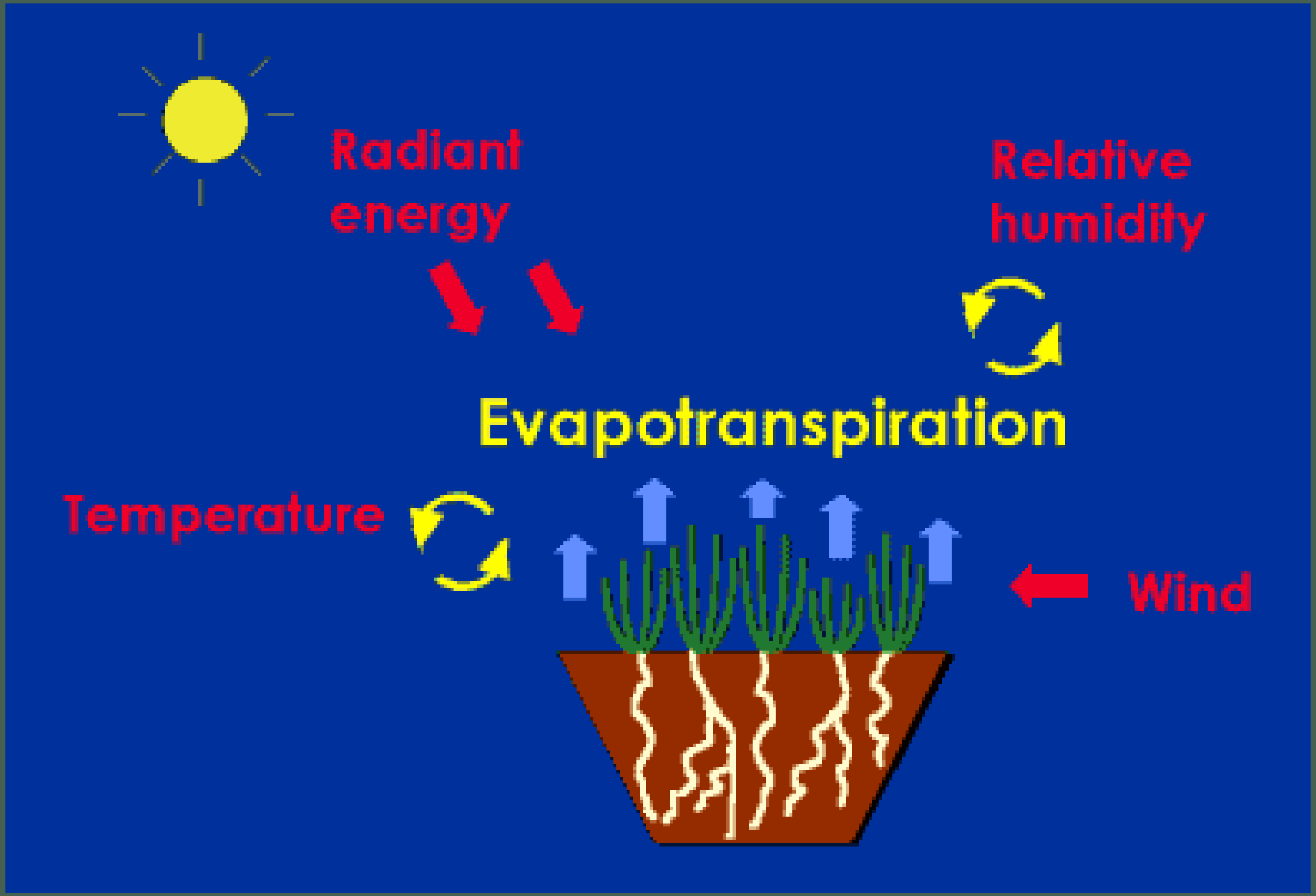
Use of Natural Amendments

Soil Texture and Water Availability



Case 2:

Determining crop water requirements



The amount of water used by the crop in transpiration and building of plant tissue, and that evaporated from adjacent soil or intercepted by plant foliage. It is expressed as depth in mm or as volume in cubic meter per hactar. It can represent the daily, monthly, or seasonal quantity of water needed for plant growth. Often referred to as Crop Evapotranspiration (ET_c).

Determination of Date Palm Water Requirements

Estimation of water requirement of date palm has been reported by many researchers. These estimates differ between 6200-55000 m^3/ha. Alazba (2001) estimates water requirement to be between 15000 -55000 m^3/ha, depend on irrigation system or leaching requirement. Al-Ghobari (2000) has estimated the total annual amount of water required by one date palm tree as 136 m^3 in Najran of south western region. Kassem (2007) monitored water requirements in Qassem region, using soil water balance method, he determined the annual water use with drip irrigation as 16400 m^3/ha, with a density of 100 tree/ha. Al-Amoud et al. (2012) estimate the actual water use in the range between 21360-28290 m^3/ha, for density of 100 tree/ha.

Experimental sites

This study was conducted on eight different regions of Saudi Arabia to estimate monthly and annual irrigation water requirements of date palm (*Phoenix dactylifera L.*) of Klayas variety. Fields measurements and determination of Etc were taken during one year starting Oct. 2013-Sept. 2014

Estimation method of ET

1.Penman Montieth Method

2. Water balance

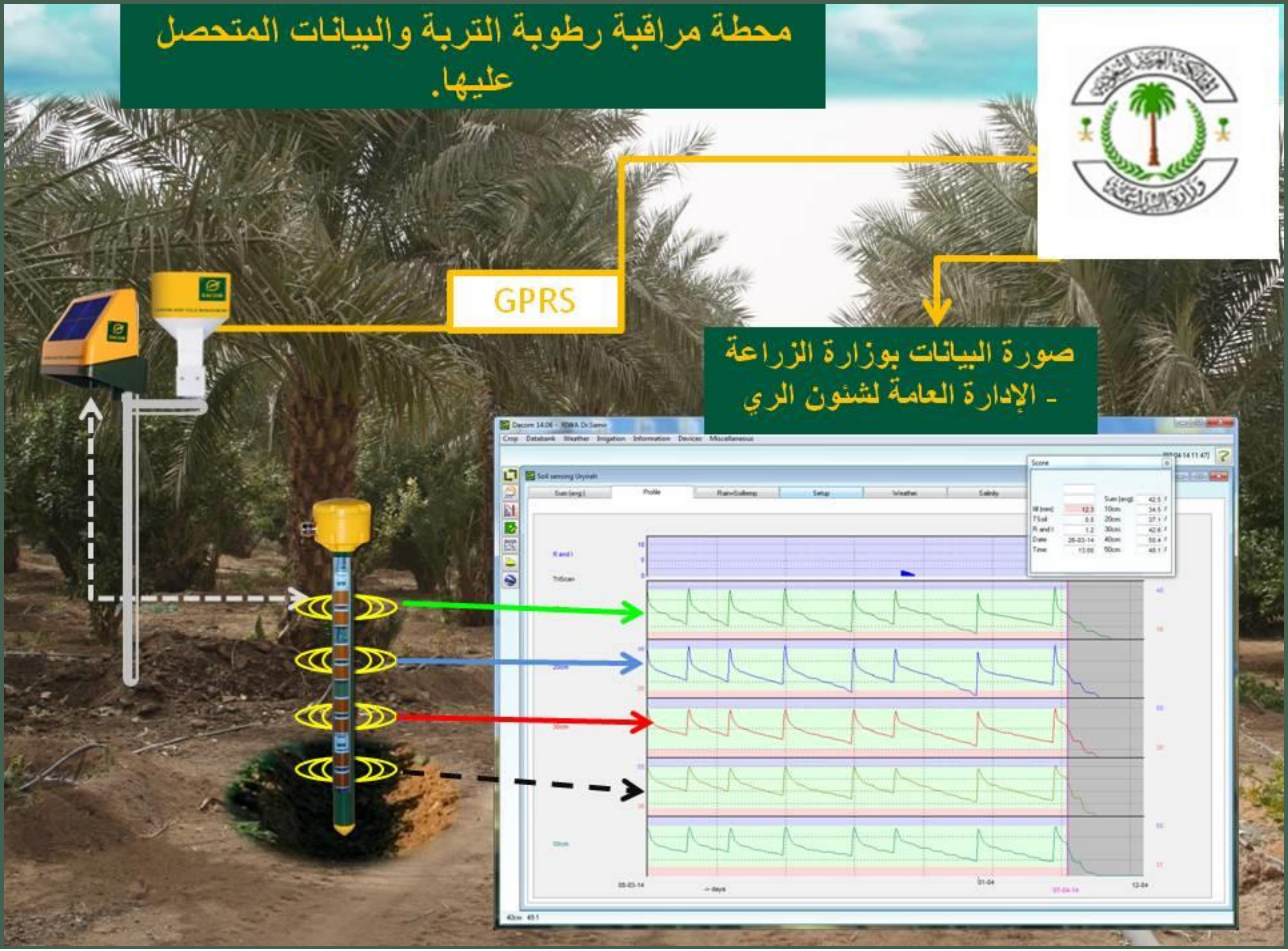
$$ET_c = K_c \times ET_r$$

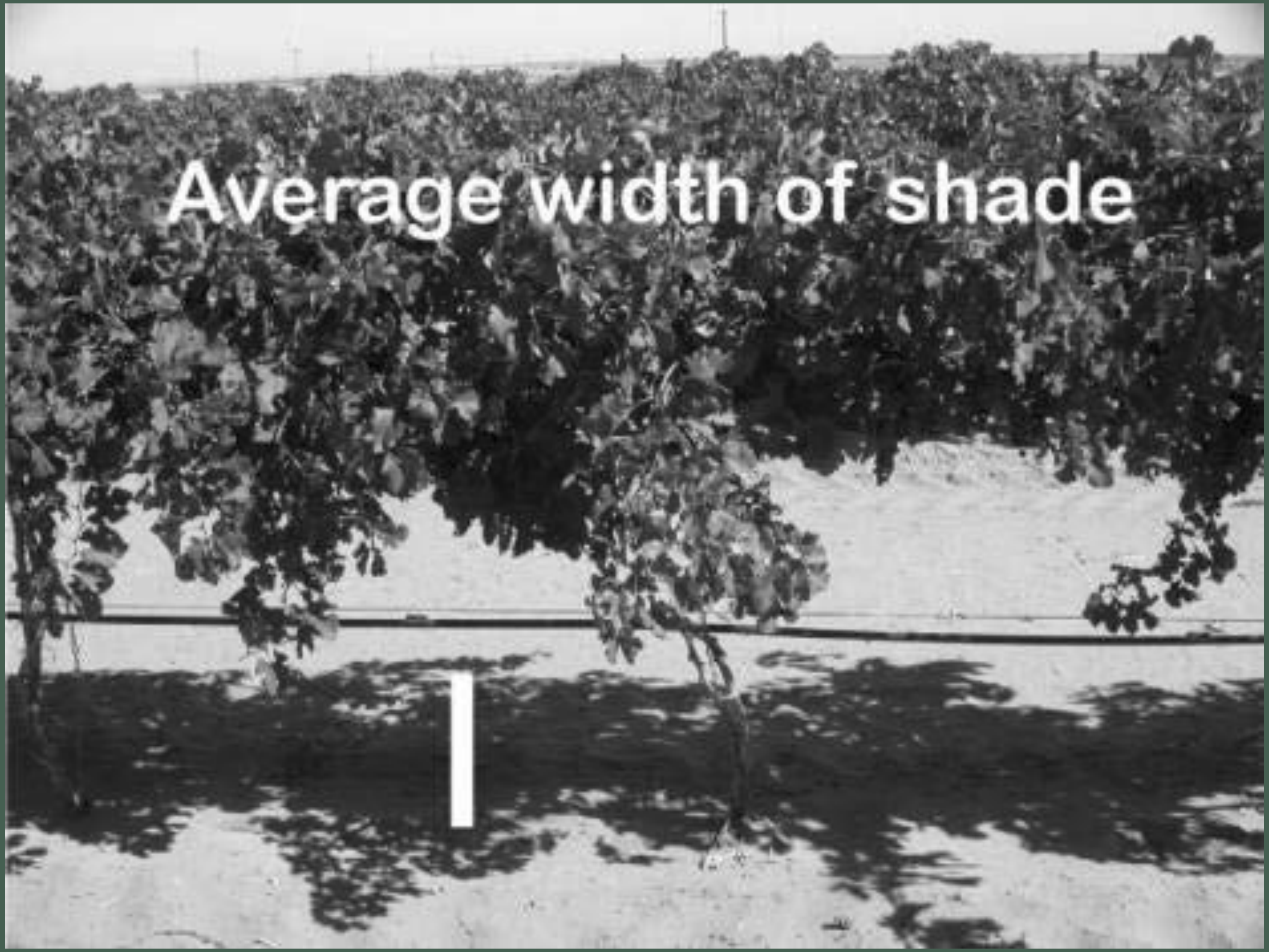
3. Water added

$$S_e = \frac{Shaded\ area\ per\ tree}{Actual\ area}\ x\ 100 = \frac{\pi\ R^2}{10m\ x\ 10m}$$

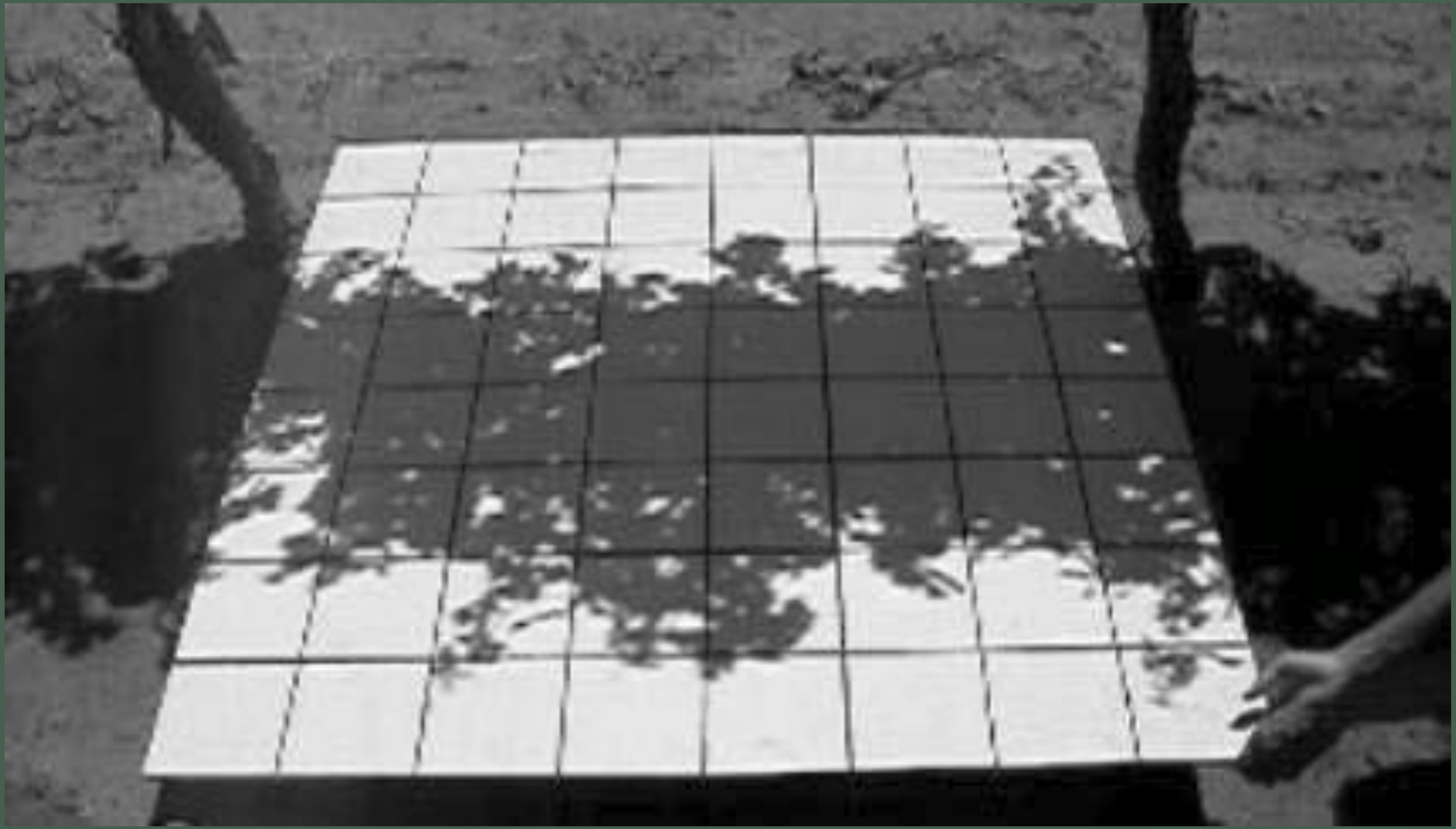
$$LR = \frac{EC_{iw}}{2MaxEC_e} \times \frac{1}{Eff} \qquad GWR = \frac{ET_c \times S_e}{(1 - LR) \times Effir}$$

وحدة ارسال واستقبال البيانات
قياس كمية المطر
وحدة الطاقة الشمسية
قياس اتجاه الرياح
قياس سرعة الرياح
قياس الإشعاع
قياس الرطوبة ودرجة الحرارة


محطة مراقبة رطوبة التربة والبيانات المتحصل عليها.
GPRS
صورة البيانات بوزارة الزراعة - الإدارة العامة لشئون الري



Measuring the average width of canopy shade.



Estimating canopy shade with the use of a 4X4 board with 6 in. gridlines.

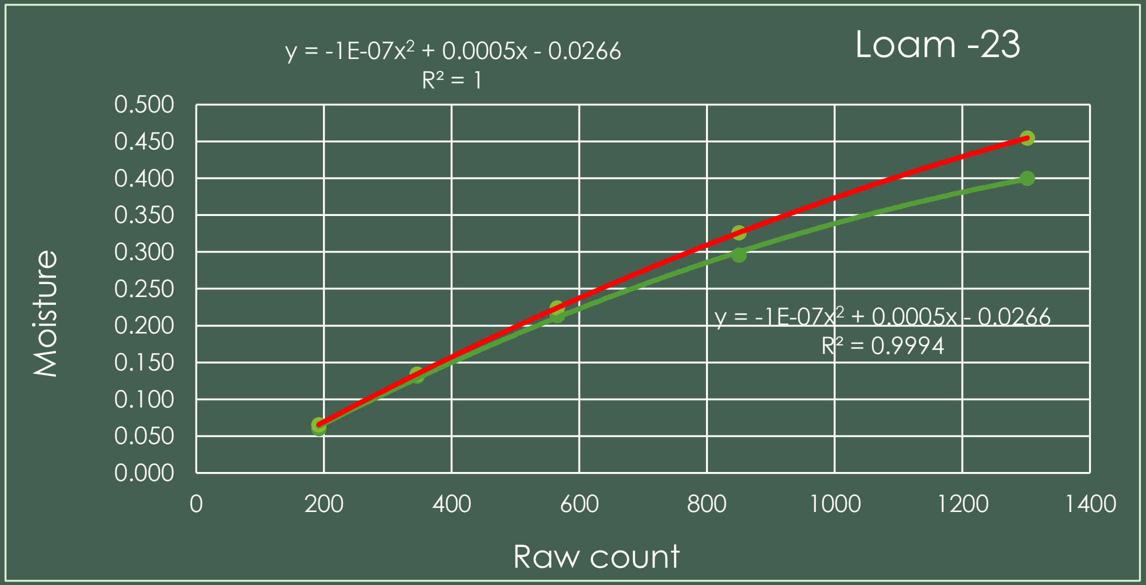
Water Balance Method

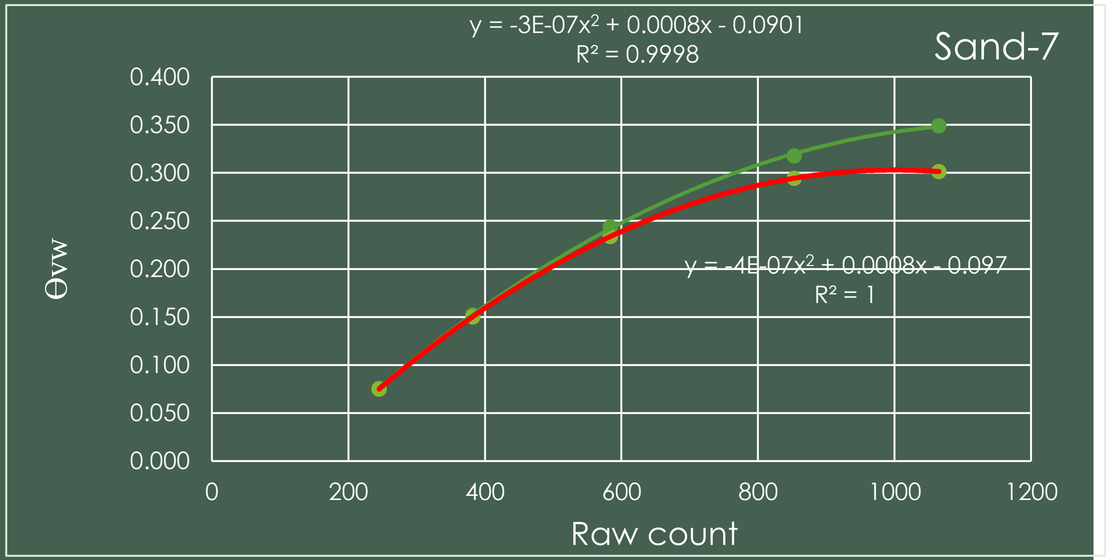
$$ET = P + I - Dr \pm \Delta S$$

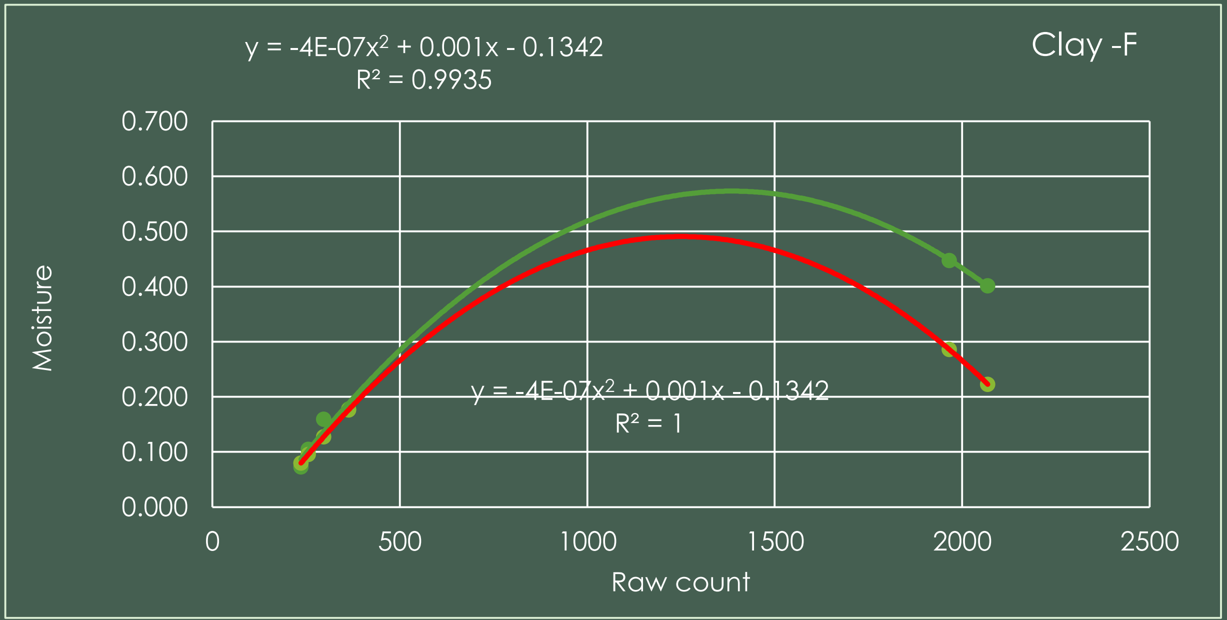
The amount of applied irrigation water

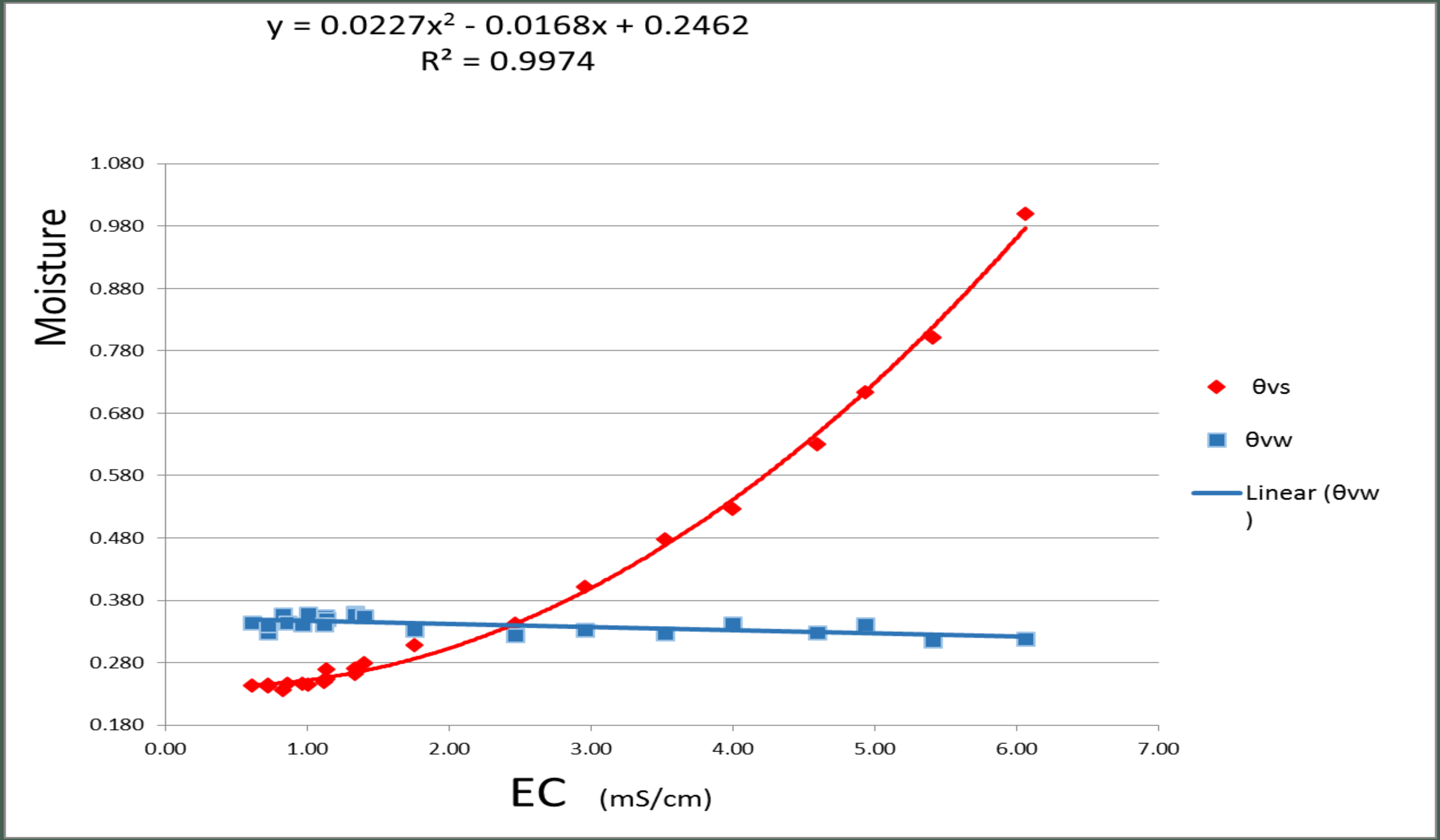
a- The study site: The amount of applied irrigation water throughout the year by readings of flow meter (actually added) in the field experiment using soil moisture and data of meteorological stations.

b- Farmers fields: The amount of applied irrigation water throughout the year by flow meter added by farmers (actually added to the fields by Farmers adjacent to the field of study).

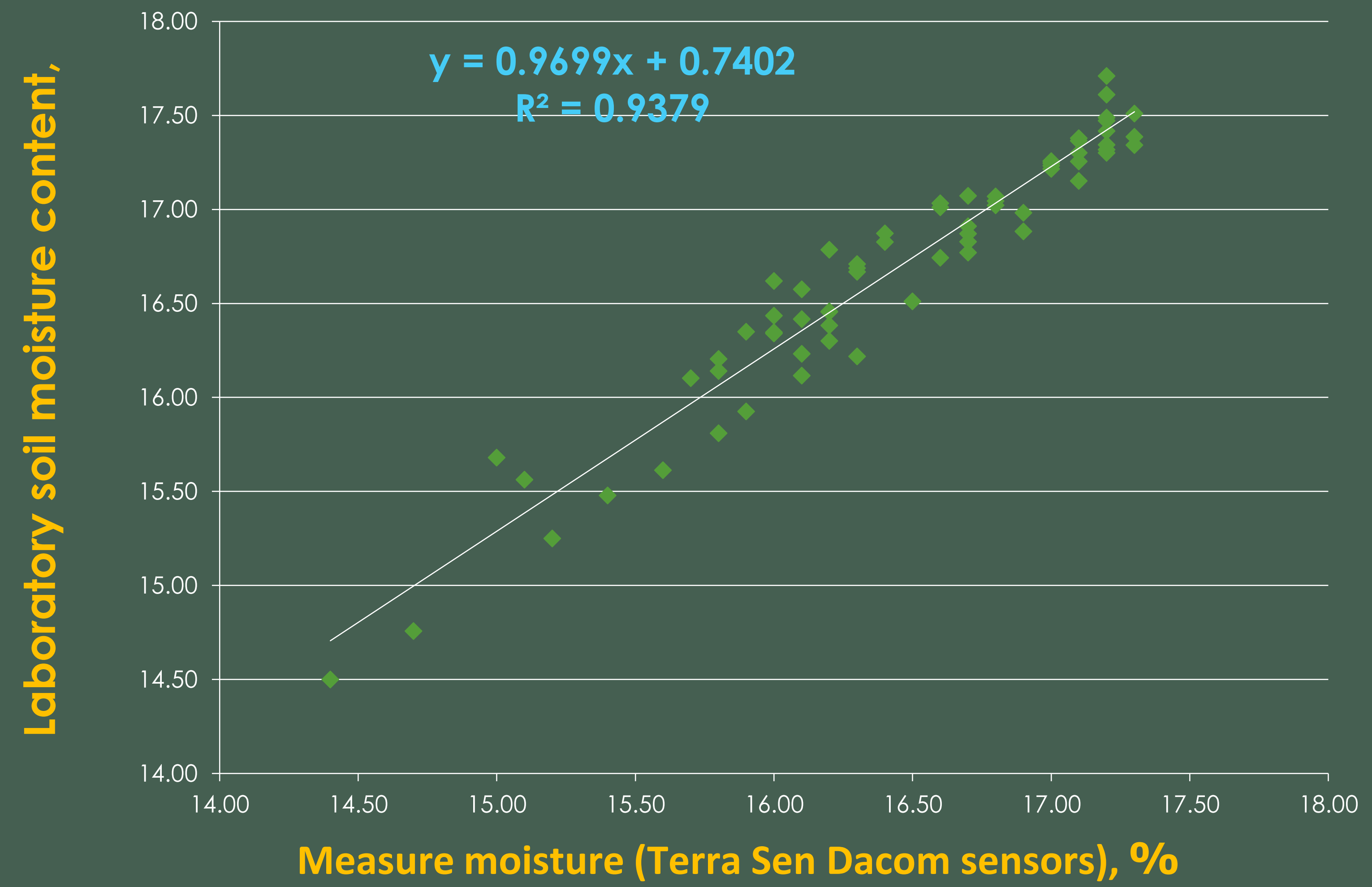

Loam -23
y = -1E-07x² + 0.0005x - 0.0266
R² = 1
y = -1E-07x² + 0.0005x - 0.0266
R² = 0.9994
Moisture
Raw count
0.000 0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400 0.450 0.500
0 200 400 600 800 1000 1200 1400


Sand-7
y = -3E-07x² + 0.0008x - 0.0901
R² = 0.9998
y = -4E-07x² + 0.0008x - 0.097
R² = 1
θvw
Raw count
0.000 0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400
0 200 400 600 800 1000 1200


Clay -F
y = -4E-07x² + 0.001x - 0.1342
R² = 0.9935
y = -4E-07x² + 0.001x - 0.1342
R² = 1
Moisture
Raw count
0.000 0.100 0.200 0.300 0.400 0.500 0.600 0.700
0 500 1000 1500 2000 2500



Red line is the reading from sensor and blue is the actual



y = 0.9699x + 0.7402
R^2 = 0.9379
Laboratory soil moisture content,
Measure moisture (Terra Sen Dacom sensors), %
18.00
17.50
17.00
16.50
16.00
15.50
15.00
14.50
14.00
14.00
14.50
15.00
15.50
16.00
16.50
17.00
17.50
18.00

Compared the amount water applied in the different methods sites and increase water ratio (%) compared to Penman-Monteith Method.

Sites	Water Requirements of Different Methods (m^3/ha/year)				The Increase Water Ratio, (%) Compared to Penman-Monteith Method.	
	Penman-Monteith method	Water balance method	Applied Irrigation Water			
			Field Study	Farmer Adjacent	Field Study	Farmer Adjacent
Medina	9495.24	-	11305.0	13717.00	16.0	30.8
Tabuk	7340.18	-	9463.9	12277.00	22.4	40.2
Makkah	7298.93	-	9692.0	12220.00	24.7	40.3
Al Jouf	8913.59	3515.25	11252.8	13340.00	20.8	33.2
Riyadh	8614.96	-	10007.4	12050.00	13.9	28.5
Qassim	8568.68	3604.31	10035.0	12880.00	14.6	33.5
Hail	7996.99	-	10272.5	12620.00	21.2	36.6
East Region	8510.72	-	10082.8	12610.00	15.6	32.5

Table (9) water use efficiency Kg/m^3, Yield Kg/ha and water saving, % in the field study compared farmer adjacent.

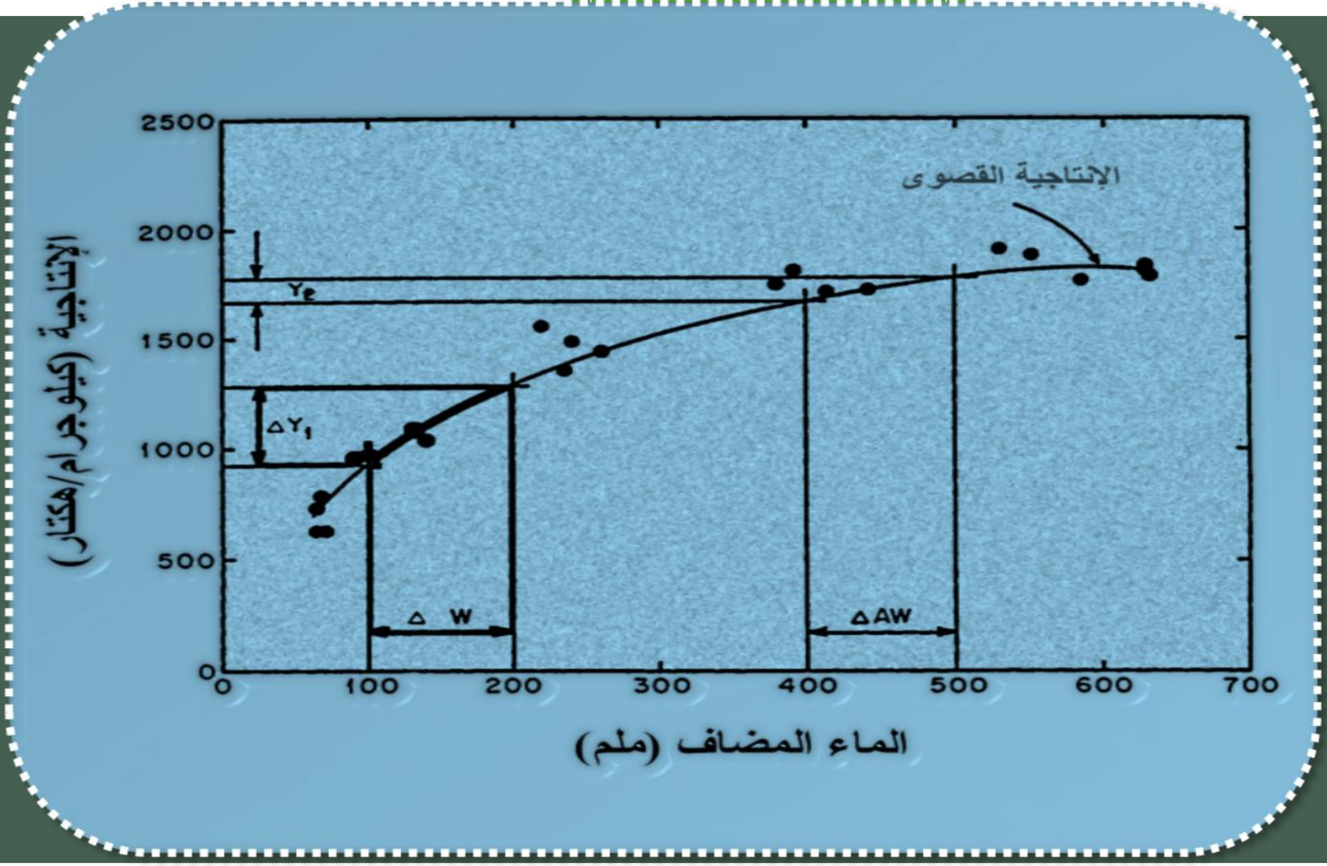
Sites	Field Study			Farmer Adjacent			Water Saving, %	ECe	Yield,%
	Water applied, m^3/ha/year	Yield, Kg/ha	Water use, Kg/m^3	Water applied, m^3/ha/year	Yield, Kg/ha	Water use, Kg/m^3			
Medina	11305	7482	0.66	13717	7374	0.54	17.58	1	**100**
Tabuk	9464	6240	0.66	12277	6170	0.5	22.91	0.935	**100**
Makkah	9692	5406	0.56	12220	5324	0.44	20.69	4.6	**97.84**
Al Jouf	11253	6215	0.55	13340	6150	0.46	15.65	4.84	**96.98**
Riyadh	10007	7620	0.76	12050	7520	0.62	16.95	2.05	**100**
Qassim	10035	6742	0.67	12880	6531	0.51	22.09	10.95	**74.98**
Hail	10273	6908	0.67	12620	6708	0.53	18.6	2.6	**100**
East Region	10083	8400	0.83	12610	8520	0.68	20.04	6.03	**92.69**

Case 3: 1 Deficit Irrigation:

Deficit irrigation practices differ from traditional water supply. It reduces irrigation during the whole season or stage of growth without a significant reduction in crop.

To implement any irrigation conservation program

Water production function



1.1 Research Objectives

- Estimate water consumption of cucumber in both greenhouses and open field.
- Assess the impact of deficit irrigation on cucumber productivity and determine the value of yield response factor (ky).
- Estimate the cucumber water use efficiency and water unit productivity.

2.3 Materials & Methods

Field testing of droppers during planting

Site # 2 a
Open field
Experiment

فكرة PRD:

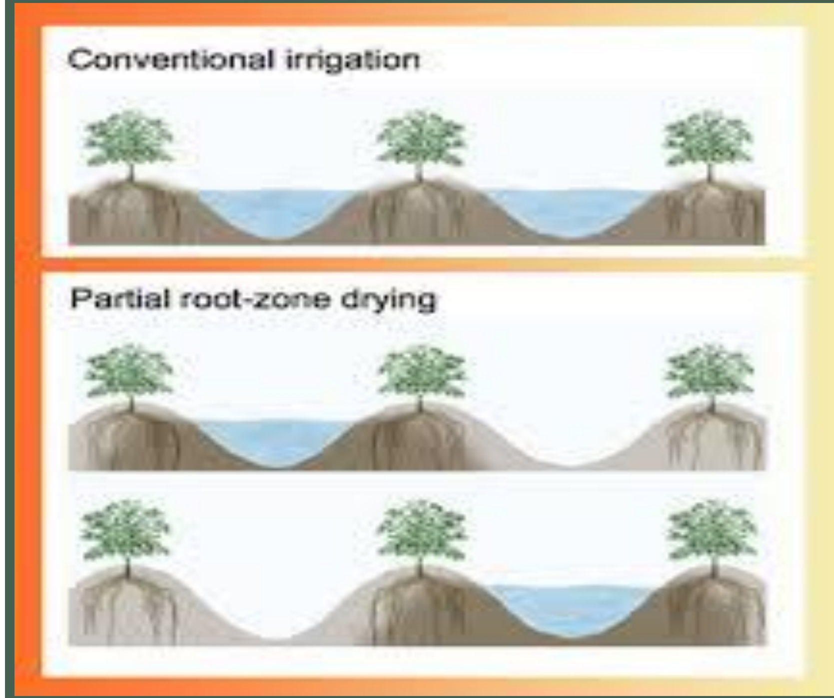


Table 2. Irrigation treatment combination of each experiment.

Treatment	Initial St.[1]	Develop. St.	Mid. St.	Late. St.	Description
T_1-100	1[2]	1	1	1	Full irrigation during the season (100% of ET_m).
T_2-80-0	1	1	1	1	80% of ET_m irrigation during the season has been given.
T_3-80-1	0[3]	1	1	1	A full irrigation up to the end of 1st stage, then 80% of ET_m for the other stages.
T_4-80-2	1	0	1	1	A full irrigation at the development stage, then 80% of ET_m restoration for the other stages.
T_5-80-3	1	1	0	1	A full irrigation at the mid stage, then 80% of ET_m restoration for the other stages.
T_6-80-4	1	1	1	0	A full irrigation at the late stage, then 80% of ET_m restoration for the other stages.
T_7-60-0	1	1	1	1	60% of ET_m irrigation during the season.
T_8-60-1	0	1	1	1	A full irrigation up to the end of the 1st stage, then 60% of ET_m for the other stages.
T_9-60-2	1	0	1	1	A full irrigation at the development stage, then 60% of ET_m restoration for the remaining stages.
T_{10}-60-3	1	1	0	1	A full irrigation at the mid stage, then 60% of ET_m restoration for the other stages.
T_{11}-60-4	1	1	1	0	A full irrigation at the late stage, then 60% of ET_m restoration for the other stages.
T_{12}-40	1	1	1	1	40% of ET_m irrigation during the season has been given.
T_{13}-Trad.	1	1	1	1	The traditional drip irrigation in greenhouse. The farmer does not depend at scientific methods to calculate the amount of applied water and adds more than the required water (more than ET_m).

1= Growth stage
2= The growth stage took same amount of applied water as mentioned on the treatment
3= The growth stage took a 100% level of ET

Account the water requirements for irrigation in a bowl and evaporation

1. **Calculate of Total Water Irrigation Requirements (Cuenca, 1989)**

2. Calculate the value of Reference ETr way pot evaporation

$$GWR = \frac{ET_c}{(1-LR)\times Effir} = \frac{K_c \times ET_r}{(1-LR)\times Effir} = \frac{(K_{cb}+K_e)(K_p\ E_{pan})}{(1-LR)\times Effir}$$

$$ET_o = K_p\ E_{pan}$$

Value was estimated for Eto directly from the evaporation pan inside greenhouses and the open field by equation (Doorenbos and Pruit, 1977):

3.4 Results

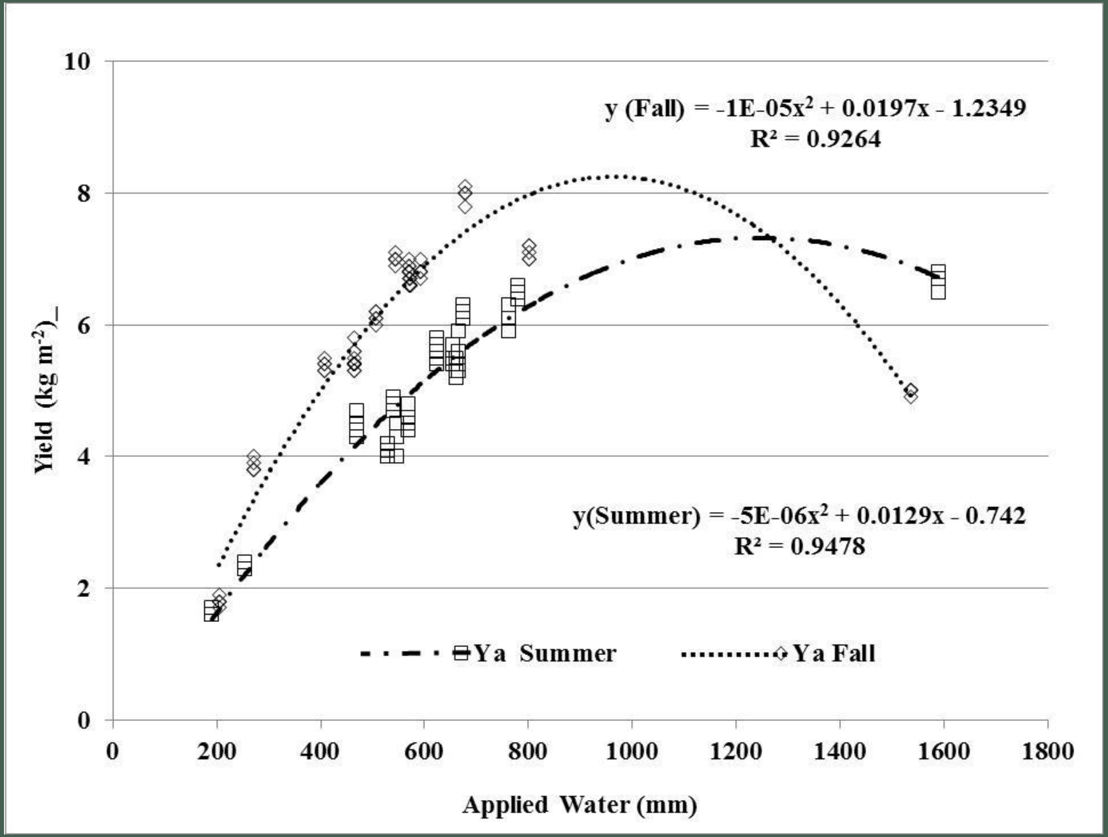
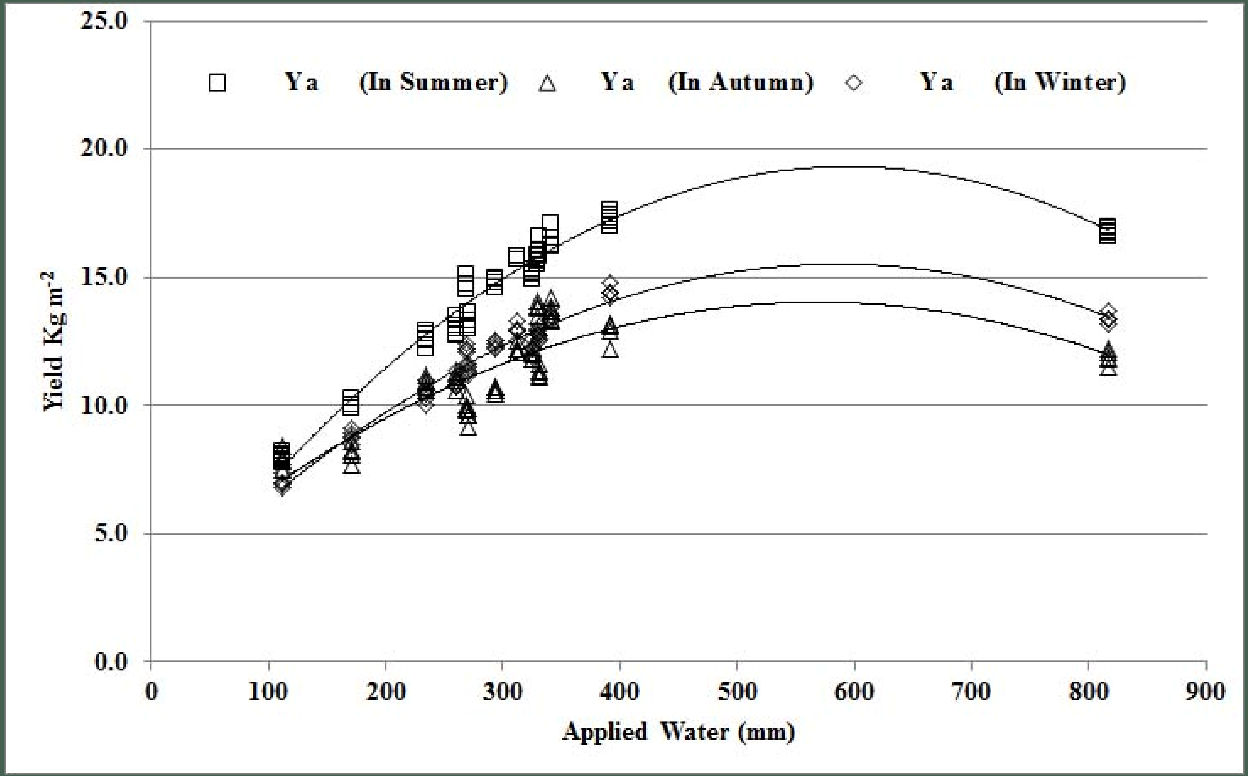


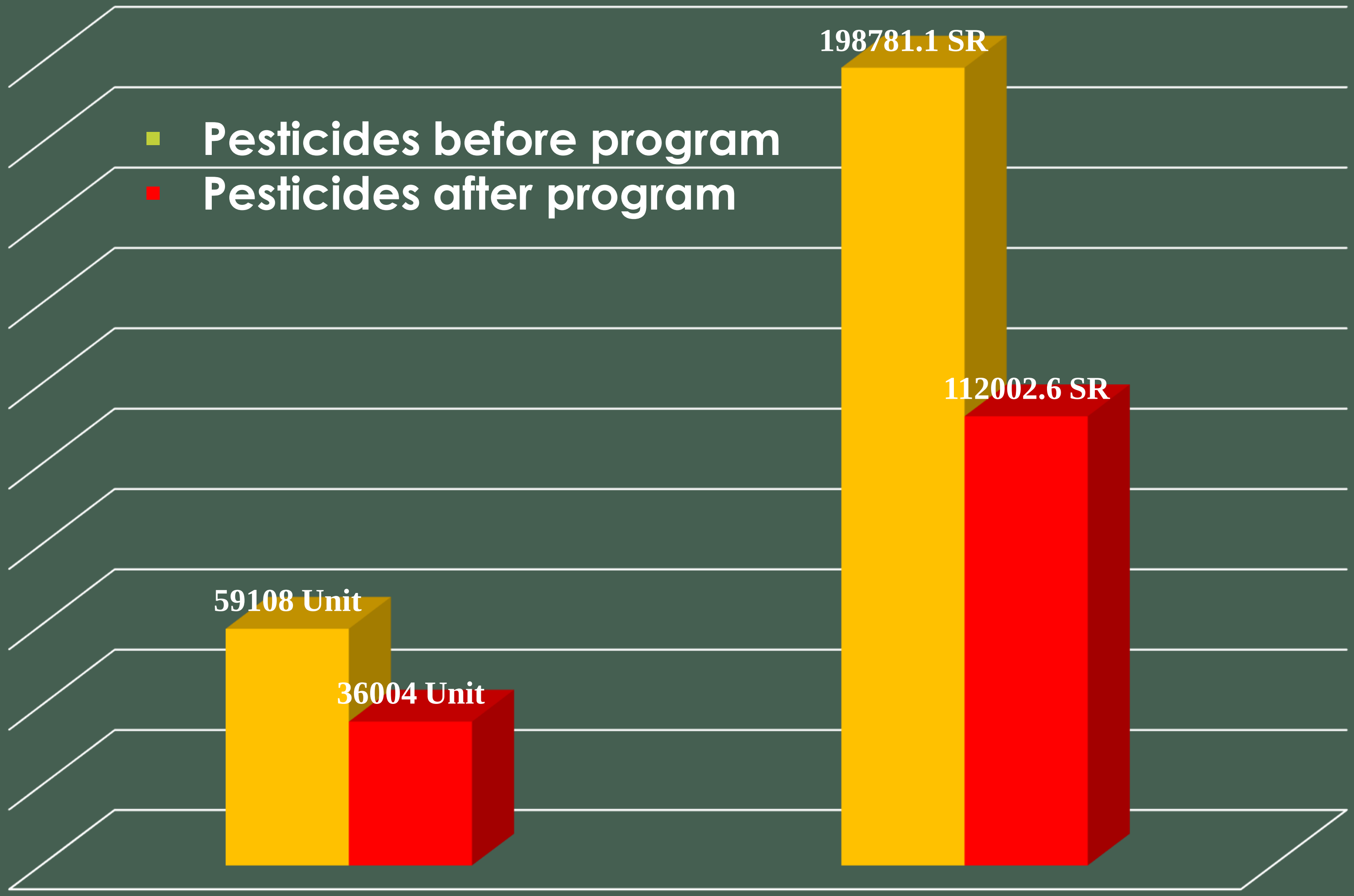
Figure 2.Yield as a function of applied water for both seasons.

3.5 Results

Fig 3. The Relationship between marketable total cucumber yield and applied water at different seasons



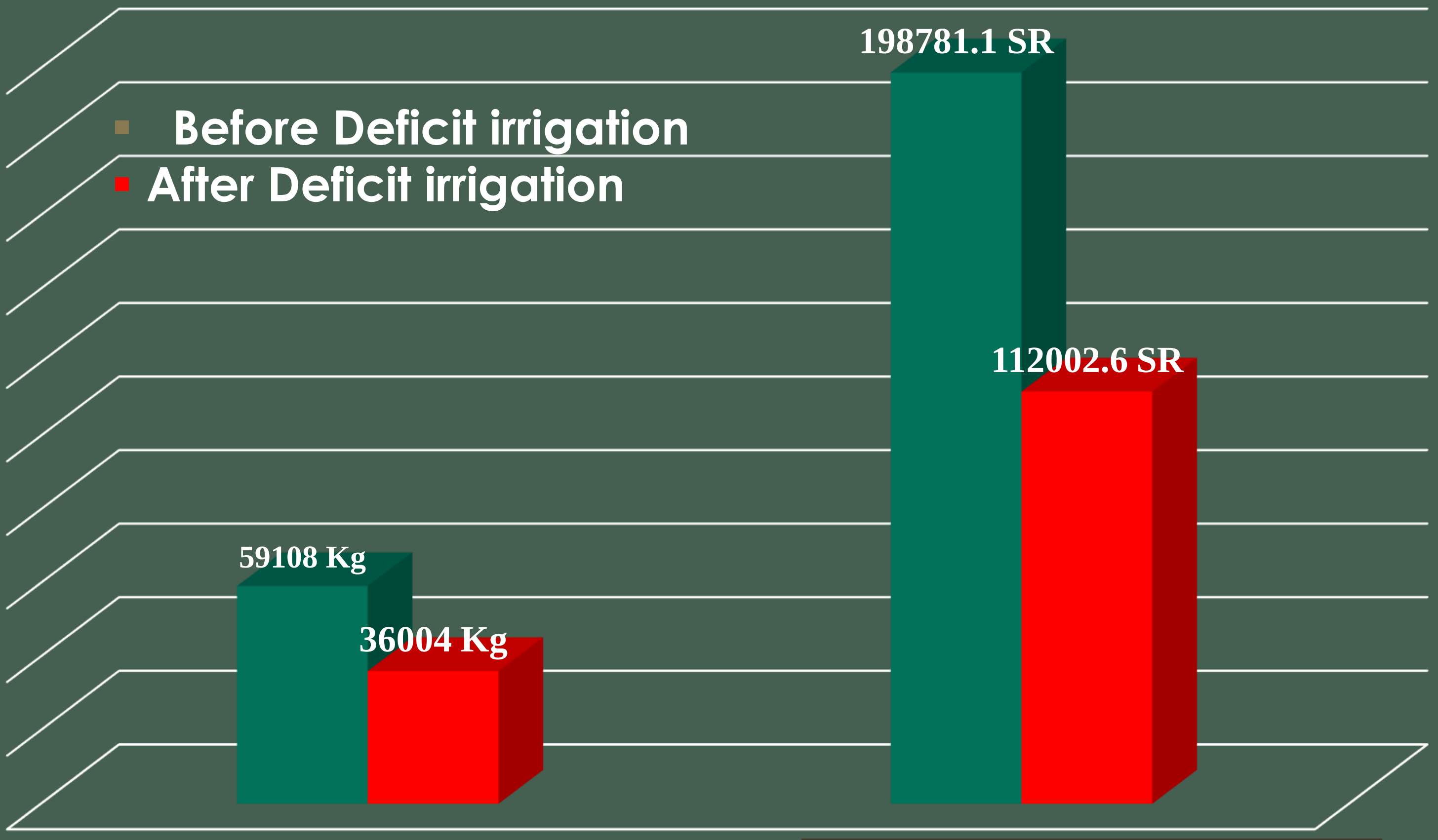
3.12 Results



Pesticides before program
Pesticides after program
59108 Unit
36004 Unit
198781.1 SR
112002.6 SR

3.13 Results

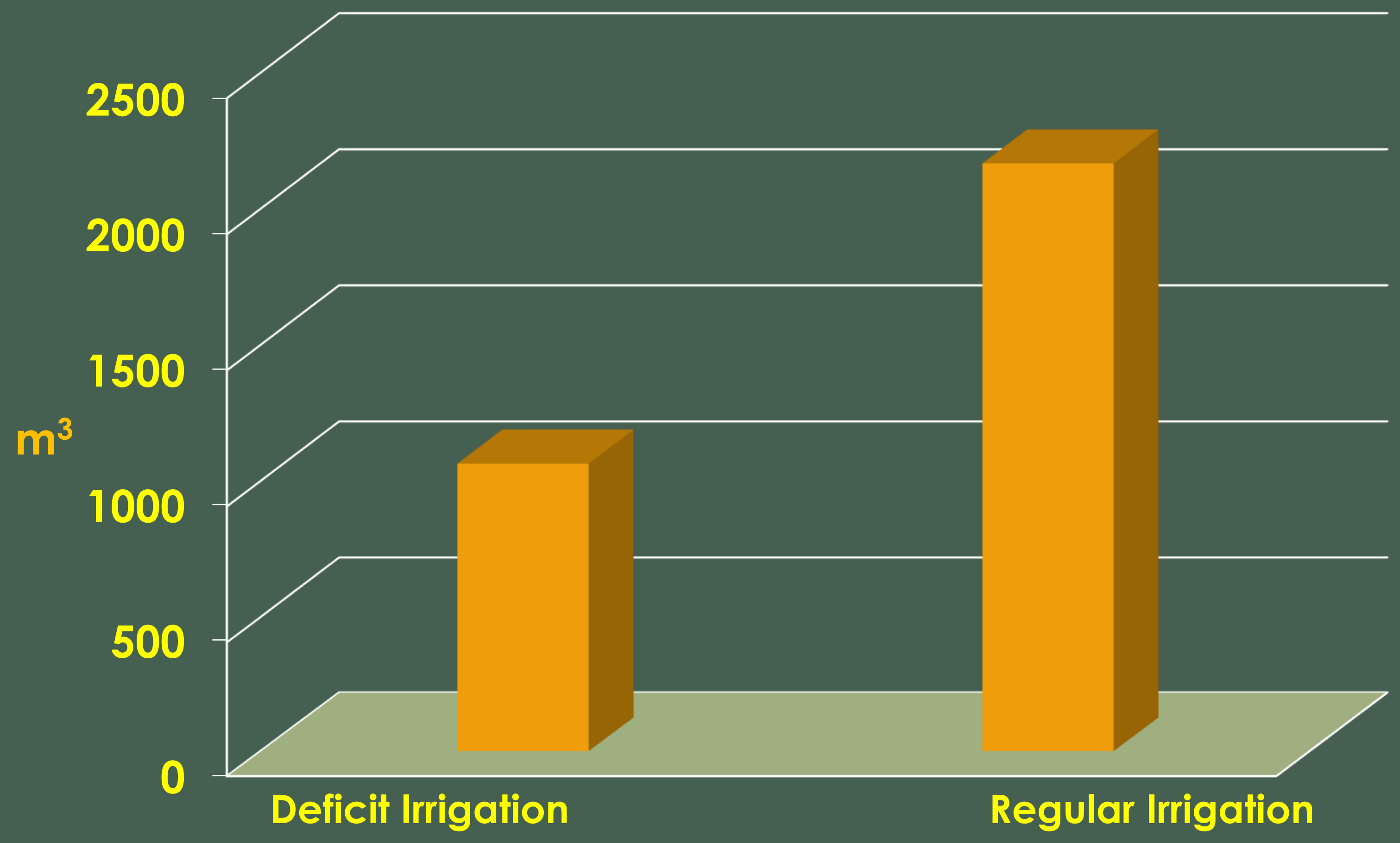
Fertilizer



The amount of consumption (kg / year)

In Saudi Riyals

The difference in the amount of water consumed (m ^{3})



4.1 Conclusions and recommendations

Economic importance for the application of deficit irrigation program on the Cucamber

- Maintaining soil fertility.
- Crop Protection.
- Increase the productivity and unit area in greenhouses.
- Conservation of water resources.
- The possibility of agricultural expansion in limited quantities of water.
- Increase farm profitability.