Improving Irrigation Efficiency using Modern Irrigation Programs in Saudi Arabia

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Overview

- **Introduction**
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  - Irrigation Impacts
  - Water Production Function
- **Ways to improve irrigation water conservation**
  - Irrigation Methods
  - Irrigation Scheduling
  - Improvement of Soil Physical Properties
  - Conservation Programs
  - Urban Irrigation Water Conservation
  - Irrigation Water Quality
  - Deficit and PRD program on vegetables

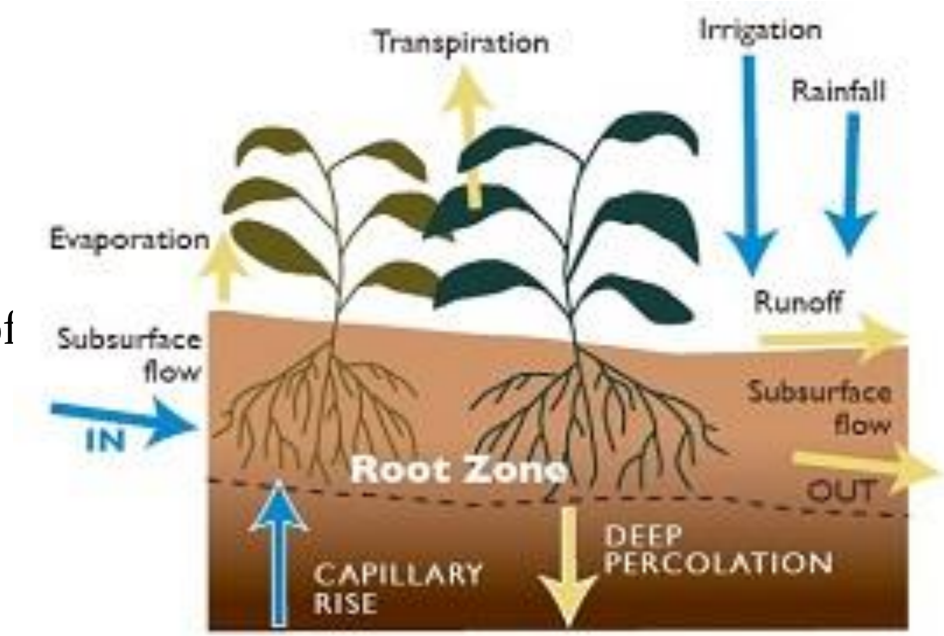
Definition

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

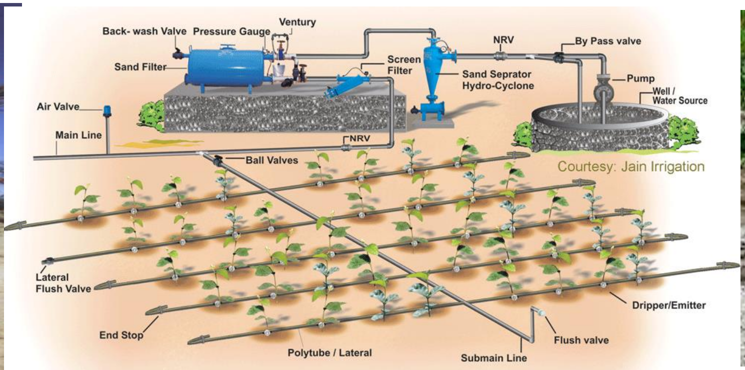
- Why is Irrigation Water Management Important?
  - Manage soil moisture to promote desired crop response.
  - Manage salts in the crop root zone.
  - Optimize the use of available water supplies.
  - Minimize irrigation induced erosion.
  - Decrease non-point source pollution of surface and groundwater resources.



Environmental Impacts of Irrigation

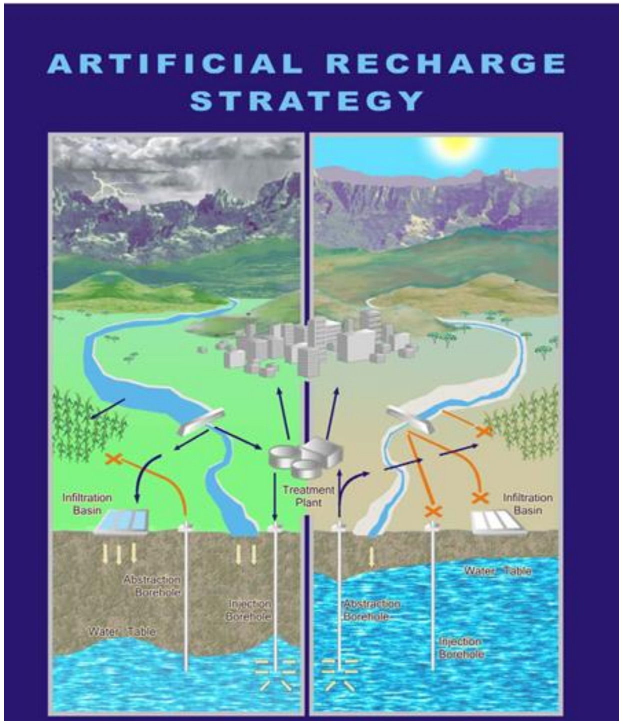
1- Salinization of Salts

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 .



٣. 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.

5. Soil Erosion

- –e.g. Due poor designed or operated irrigation systems.
- ***Mitigation***- proper design, drainage system, land levelling, practicing soil and water conservation,

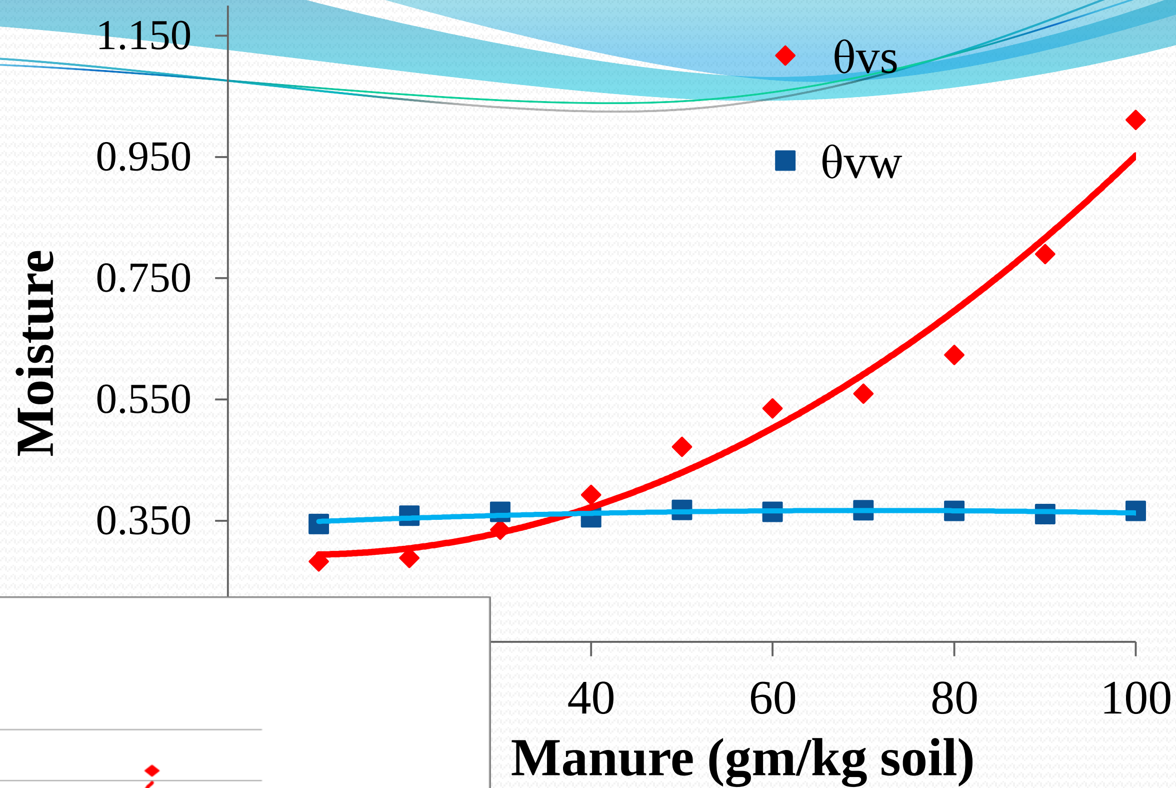
6. Water logging

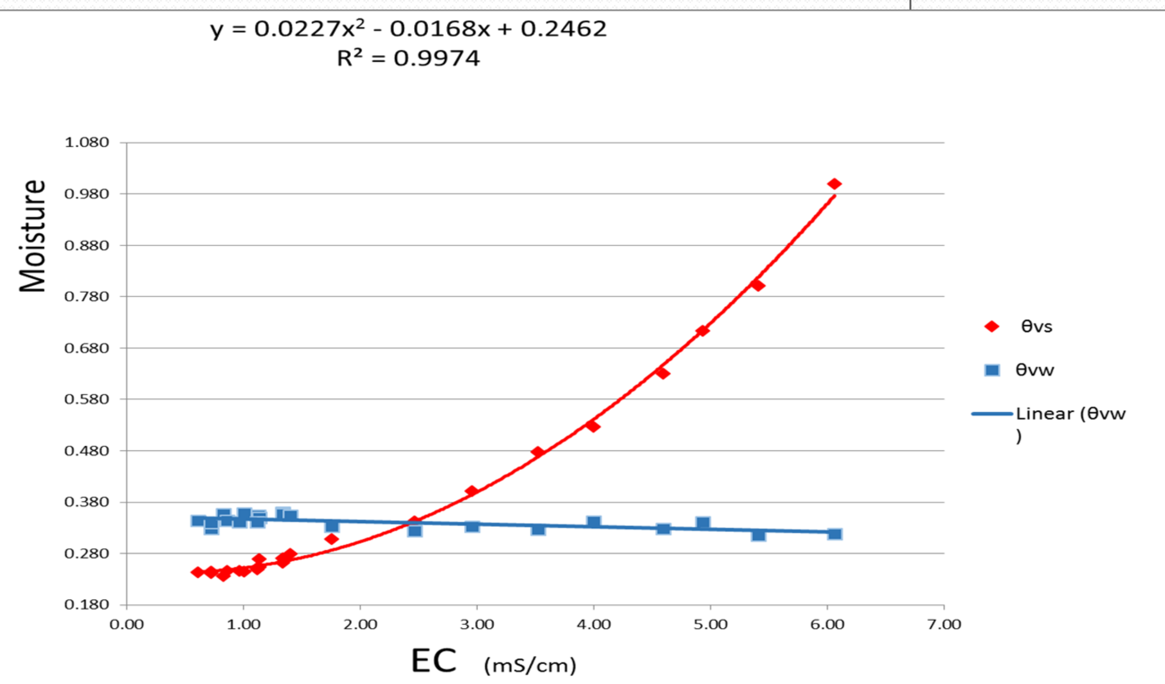
- ***Mitigation*****-** Correct application rate, right crop water requirement, proper design, drainage system, land levelling,

Irrigation Scheduling

Important factors to keep in mind when developing a irrigation scheduling tool:

- The scheduling tool must consider information about the crop, soil, climate, irrigation system, water deliveries and management objectives.
- An irrigation scheduling tool needs only be accurate enough to determine how much water to apply and when.
- A good rule of thumb to follow when developing an irrigation scheduling tool is to keep it simple and easy to understand.
- A calibration of soil moisture sensor is must.

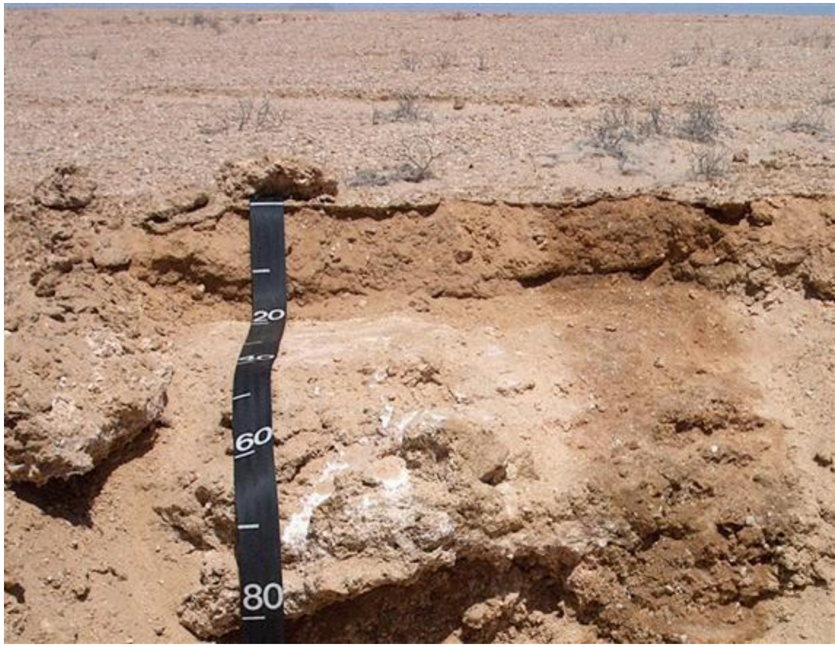

1.150
0.950
0.750
0.550
0.350
Moisture
θvs
θvw
40
60
80
100
Manure (gm/kg soil)


y = 0.0227x² - 0.0168x + 0.2462
R² = 0.9974
Moisture
1.080
0.980
0.880
0.780
0.680
0.580
0.480
0.380
0.280
0.180
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
EC (mS/cm)
θvs
θvw
Linear (θvw
)

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.



Deficit Irrigation:

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

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.

2.1 Materials & Methods

- Location & Experiments:

- Thadiq governorate, Al-Mehouse farm, 120 km North West of Riyadh, Saudi Arabia, (25°17N and 45º 53E).
- Specialized in growth of Cucumber in greenhouses since 1987.

Materials & Methods

Experiments Location

Experiments sites of Greenhouse and Open Field at Thadeq.

Experiment Replications	Area (m^2)	Location	Location #
٧	١٠٠٠	Greenhouse	١
٥	٩٨٠	Open Field	٢
٣	١٠٠٠	Greenhouse	٣
٢	٩٦٠	Open Field	٤
٧	٢٢٦٨	Greenhouse	٥
Total	٦٢٠٨		

2.3 Materials & Methods

Field testing of droppers during planting

Site # 2 a Open field Experiment

2.4 Materials & Methods

Measuring climate conditions and containers of soil moisture evaporation

PRD method

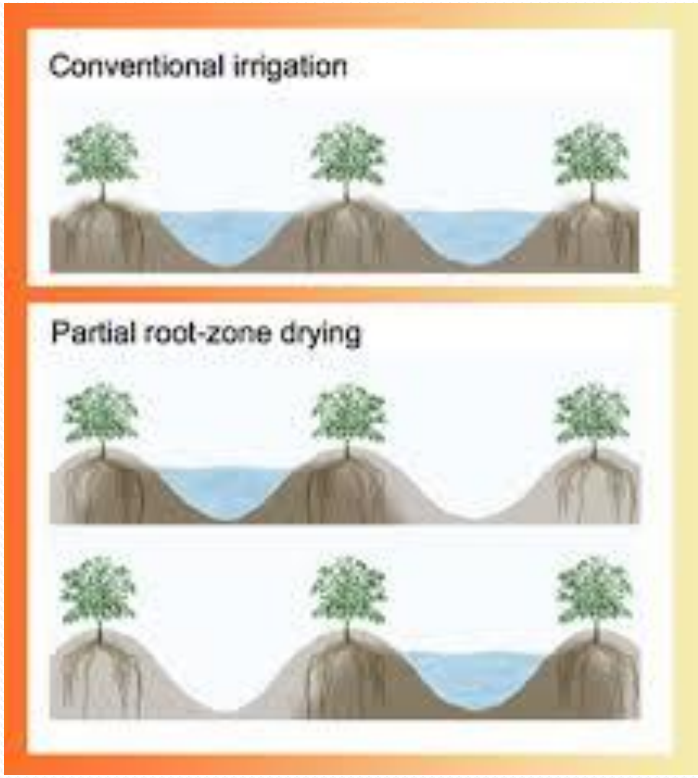


Table: Irrigation treatment combination of each experiment.

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_m

Calculation Procedure

- Water Requirements
- Uniformity of irrigation water distribution
- Controlling of Treatments Irrigation
- Water production function
- Crop factor K_c
- Crop response factor K_y

2.8 Materials & Methods

Account the water requirements for irrigation in a bowl and evaporation

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

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

2. Calculate the value of Reference ETr way pot evaporation

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

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

3.1 Results

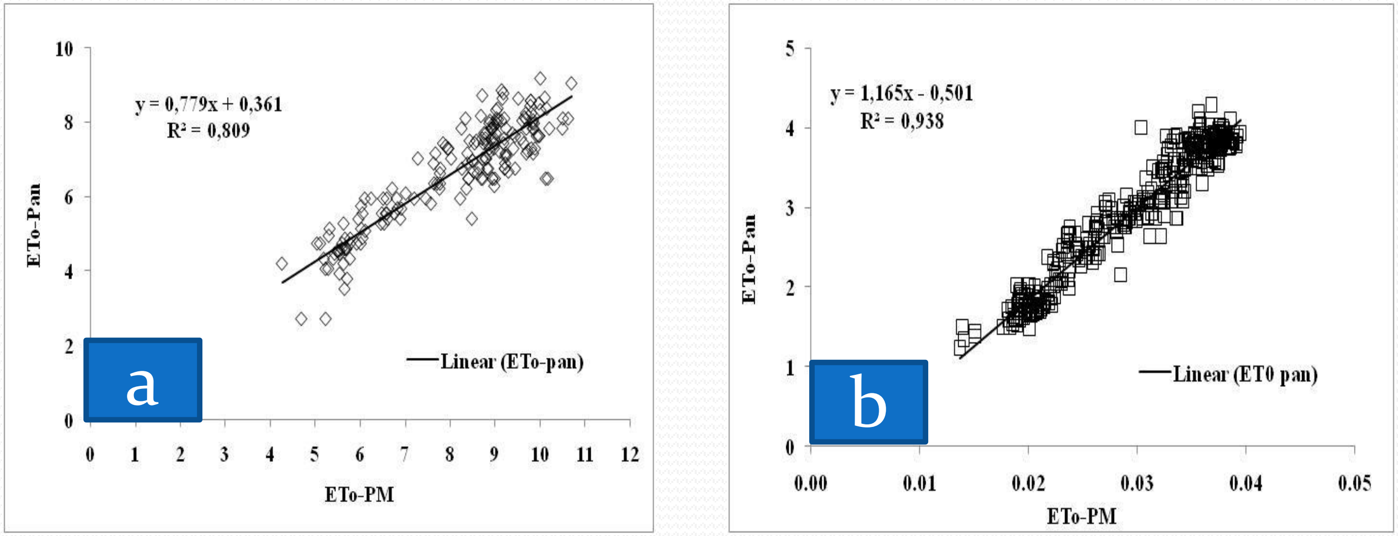


Fig 2. Correlations between ETo calculated by Penman-Monteith equation and pan
a) open field, b) green house

Table. Yield, evapotranspiration (ETc), applied water (AW), and water productivity (WP) as affected by deficit irrigation treatments at different growth stages of cucumber in greenhouse.

Treatments	Average days per season	Yield kg m^{-2}	ETc mm	AW mm	AW mm day^{-1}	WP kg m^{-3}
T_1-100	108	15.0 a*	307	355	3.3	42.3
T_2-80-0	108	13.8 bc	245	283	2.6	48.8
T_3-80-1	108	13.2 d	256	295	2.7	44.7
T_4-80-2	108	14.2 b	259	299	2.8	47.5
T_5-80-3	108	14.6 ab	269	309	2.9	47.2
T_6-80-4	108	13.5 cd	260	300	2.8	45.0
T_7-60-0	108	11.4 f	184	213	2.0	53.5
T_8-60-1	108	11.7 f	204	236	2.2	49.6
T_9-60-2	108	12.4 e	210	243	2.3	51.0
T_{10}-60-3	108	12.7 e	232	267	2.5	47.6
T_{11}-60-4	108	11.5 f	213	246	2.3	46.7
T_{12}-40	108	9.1 g	123	147	1.4	61.9
T_{13}-Trad.	108	14.2b	307	722	6.7	19.7

*Values at the same letter were not significant at 5% level

3.4 Results

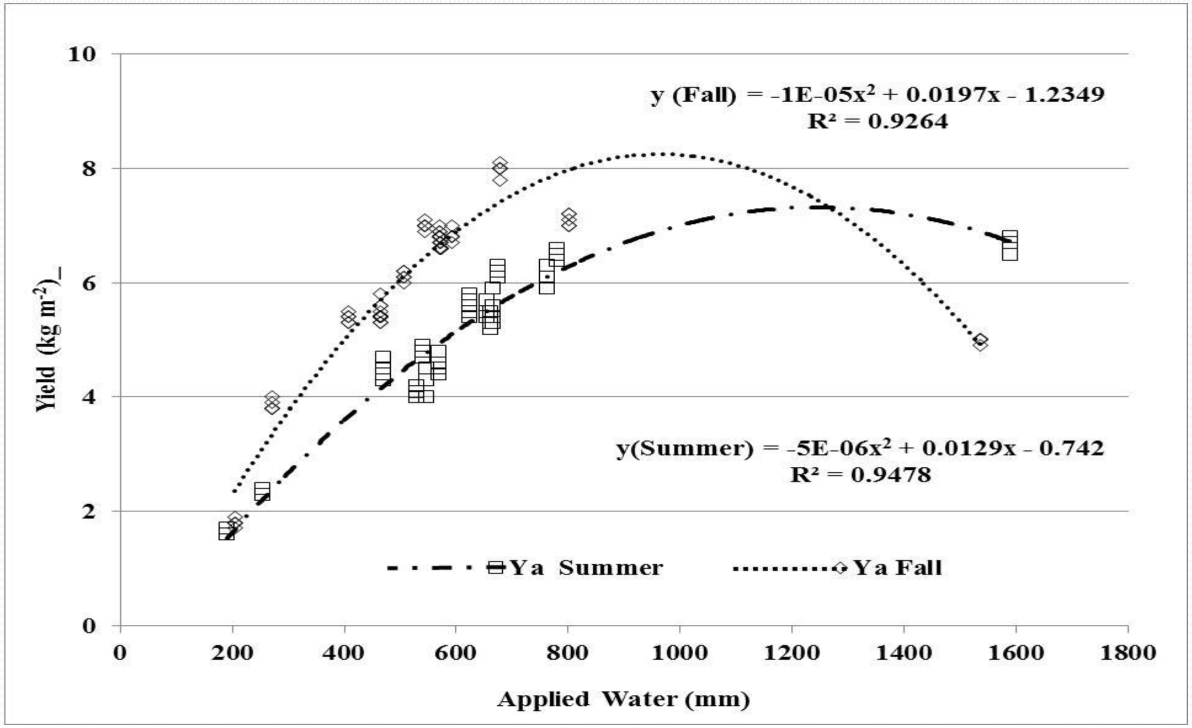
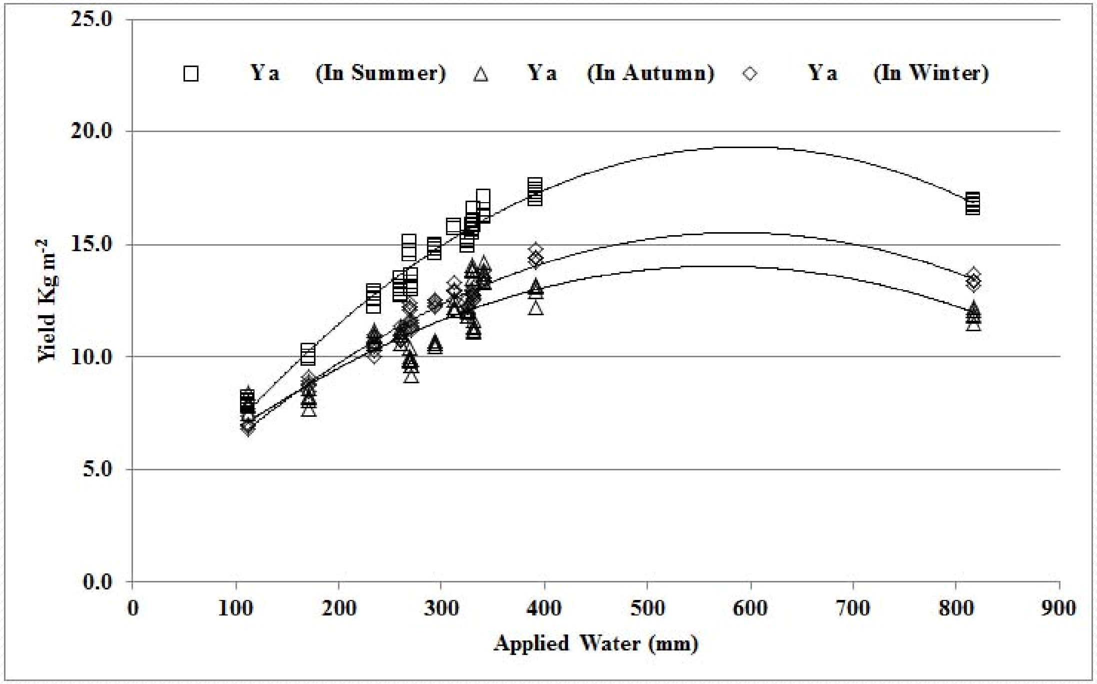


Figure. Yield as a function of applied water for both seasons.

3.5 Results



The relationship between marketable total cucumber yield and applied water at different seasons

3.7 Results

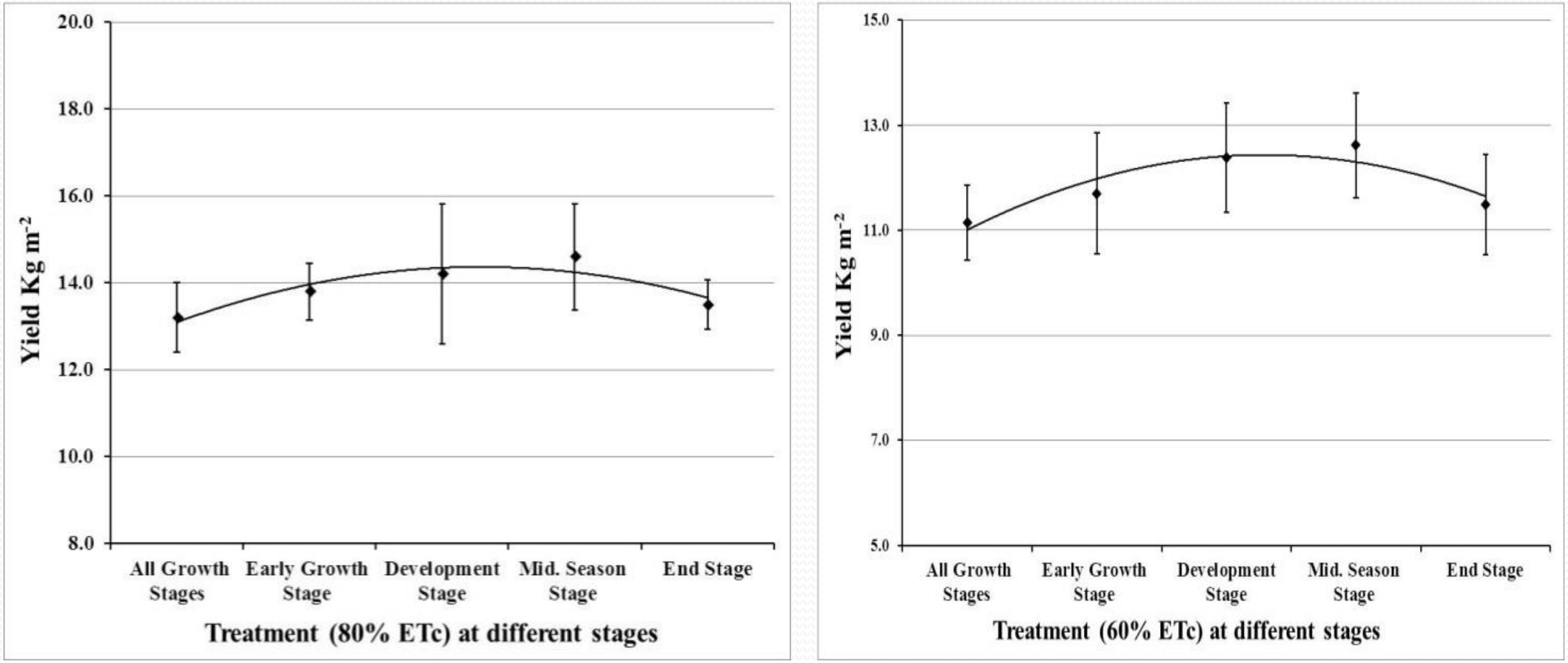
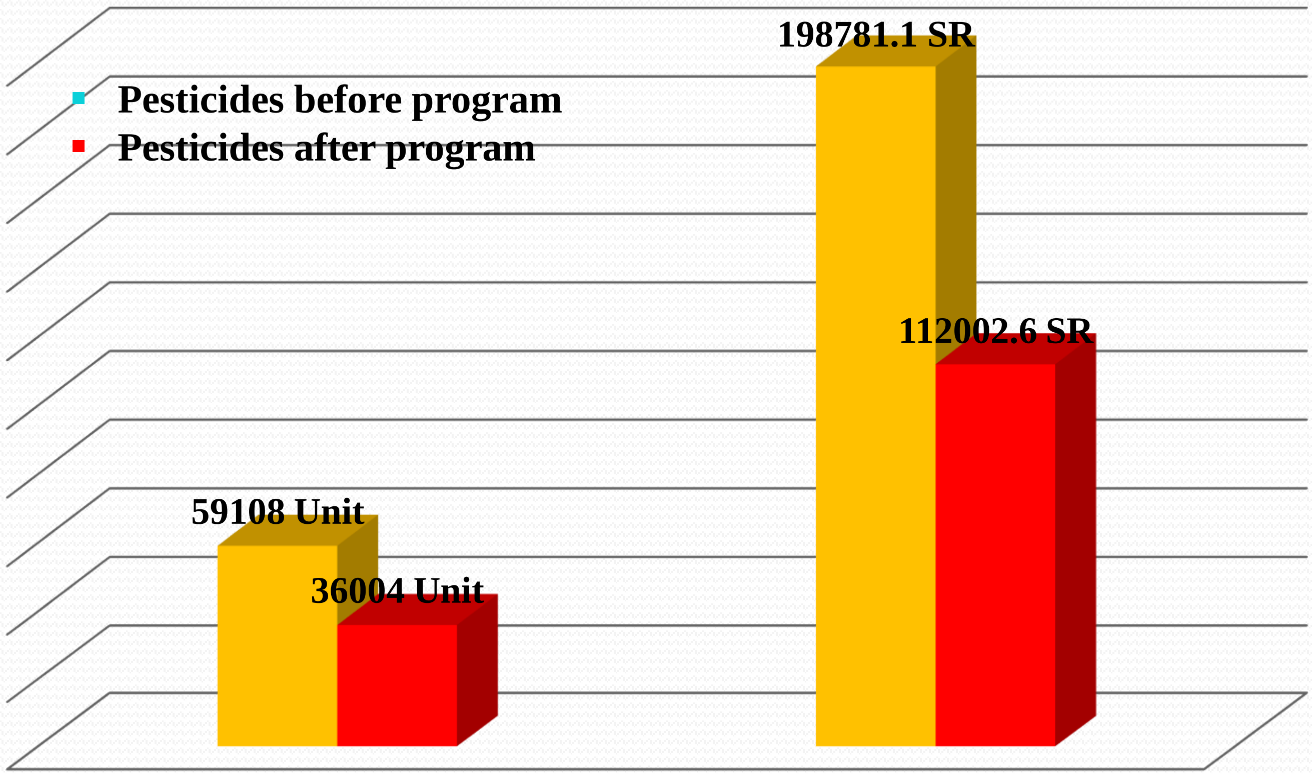


Fig 4. Effect of deficit irrigation at different growth stages on cucumber yield (a) 80% ETc, (b) 60% ETc.

3.12 Results

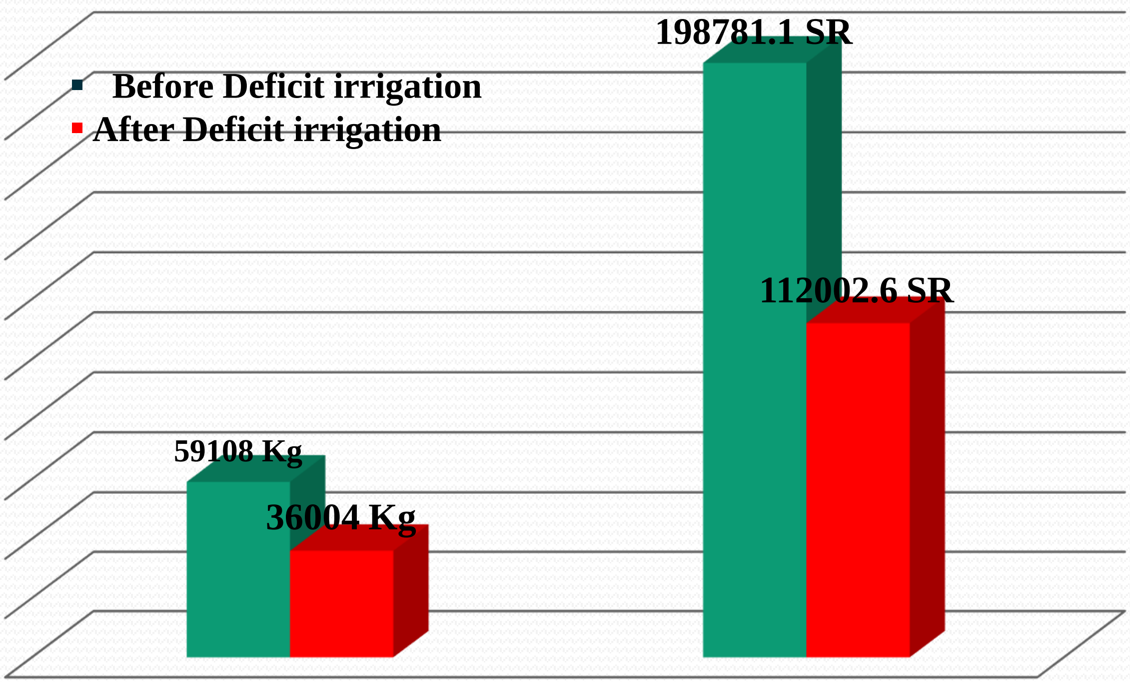


Pesticides before program
Pesticides after program
198781.1 SR
112002.6 SR
59108 Unit
36004 Unit

3.13

Results

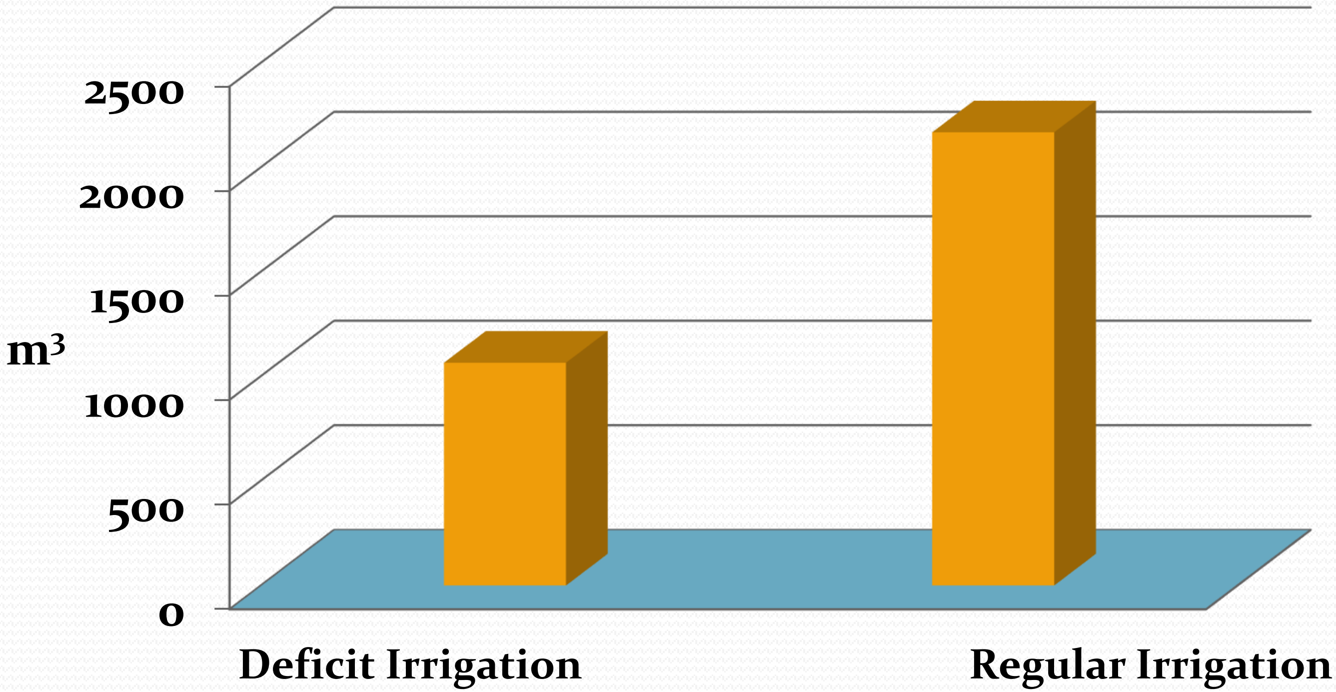
Fertilizer



[redacted]

[redacted]

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



4.1 Conclusions and recommendations

Economic importance for the application of deficit or PRD irrigation programs

- 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.
- Thus, the conservation programs such as deficit and PRD, to boost agricultural productivity are imperative.