IRRIGATION MANAGEMENT UNDER WATER SHORTAGE

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ABSTRACT

Located within a semi arid region, Israel faced a shortage of water designated to agriculture. Two developments changed the situation. Drip irrigation systems and the ability to get purification recycle water. About 75% of the used water in Israel is purified and recycled on farms. Farmers have adapted cotton growth controlled tools to assist them efficiency application of water to plant. Growth rate of plants at the beginning of season, and water pressure in leaves at the second part are measured. Farmers compare measurements results to optimum charts and can understand what amount of water the plants will need for the coming days. Lately farmers in Israel started to operate a new hi-tech system – "phytech" – that measures the daily changes of the plant stem diameter which indicates the plant water needs. The data transfer on line to the web for farmer use. Applying this methods farmer reduced water use for cotton by 30% and increased yield by 50%.

Israel is located within a semi-arid region. On average, Israel experience one severe drought every decade that lasts for 3-4 consecutive years (a dry winter defined as 80% or less of the annual average precipitation).

Average annual precipitation, within the agricultural regions, is about 450 mm. The rainy season in Israel, lasts from October until February. During the cotton growing season- between March and September - usually there is no rain in Israel.

Throughout history (period of the Holy Bible and on) – for nearly 4,000 years, agriculture meant dry land farming. During the 1950's, Israel started developing a national infrastructure system to transfer water from The Lake of Galilee in the north to the dry areas in the south. However, within 20 years the population increase caused a major reduction in water designated to agriculture.

Two eminent developments occurred in the mid 1970's that resulted in substantial changes regarding water and agriculture in Israel.

1. DRIP IRRIGATION

The drip irrigation system was first developed in Israel in 1960's, however, only in the late 1970's an Israeli company developed the integrated dripping pipe system that is still in use today in field crops (picture 1.)

This dripping pipe is a continuous pipe with a dripper molded in every 60-100 cm which comes on rolls – about 5 Km each. Farmers lay the pipes in the field at the beginning of the irrigation period and collect them before harvesting. Farmers can use the same pipe for about 20 seasons, thus the yearly cost of the system is reasonable. Water saving is 20-30% in comparison to other methods.

Lately, farmers are using a different method to save more water by burying the pipe at a depth of 40 cm, thus providing water directly to the root zone, leaving the soil surface dry and avoiding evaporative water loss.

Picture 1. Drip irrigated cotton field

2. RECYCLED WATER

First commercial technologies for preliminary purification of recycled water for agricultural use, developed in Israel in the late 1970's. Multiple benefits are achieved; One meets an environmentally friendly goal by reducing discharge of polluted water to the environment and sea; Secondly, providing additional water – a resource in severe shortage – for farming. This process received priority and substantial funding throughout the 1980's, increasing amounts of purification enterprises (picture 2) and reservoirs were established and the water transferred to agricultural areas.

Today, about 75% of water used in Israel is purified and recycled on farms. Water is at a high level of purification. Today the majority of water used in agriculture for approved crops is recycled.

Picture 2. Purification Enterprise provide **200 M** Cubic Meter a year

COTTON GROWTH CONTROL

As a result of the water supply constraints experienced in Israel, every drop is metered and water application is controlled and optimized.

Farmers have adopted tools that assist them to optimize water amount application to plants. Under the drip irrigation system the plant receives a water ration once in 2-3 days. The water quantity is determined according to different parameters used by farmers throughout the season as follows:

EVAPORATION

Evaporation is measured on a daily basis using a Class “A” evaporation pan. At each stage of the growth irrigation amounts are calculated as a percentage of the evaporated loss, considering the water amount that the plant requires, based on coefficients developed for the crop in the research process. In order to verify and monitor the plant water requirement, farmers use additional tools.

PLANT HEIGHT DEVELOPMENT RATE

In every field, farmers choose a number of individual plants which characterize the whole field. Plant height is measured once in 3-4 days (picture 3) and daily growth rates are calculated. Results are then compared to an optimal growth chart (fig. 1), which enables the farmer to correct the amount of water that will be applied during the upcoming irrigation.

Comparison to a weekly irrigation schedule provides the farmer the opportunity to decide whether to increase or reduce the planned irrigation water amount. The plant growth rate parameter is useful as long as the daily development is over 0.5 cm/day; below that rate farmers turn to other tools.

Picture 3. cotton plant height measured

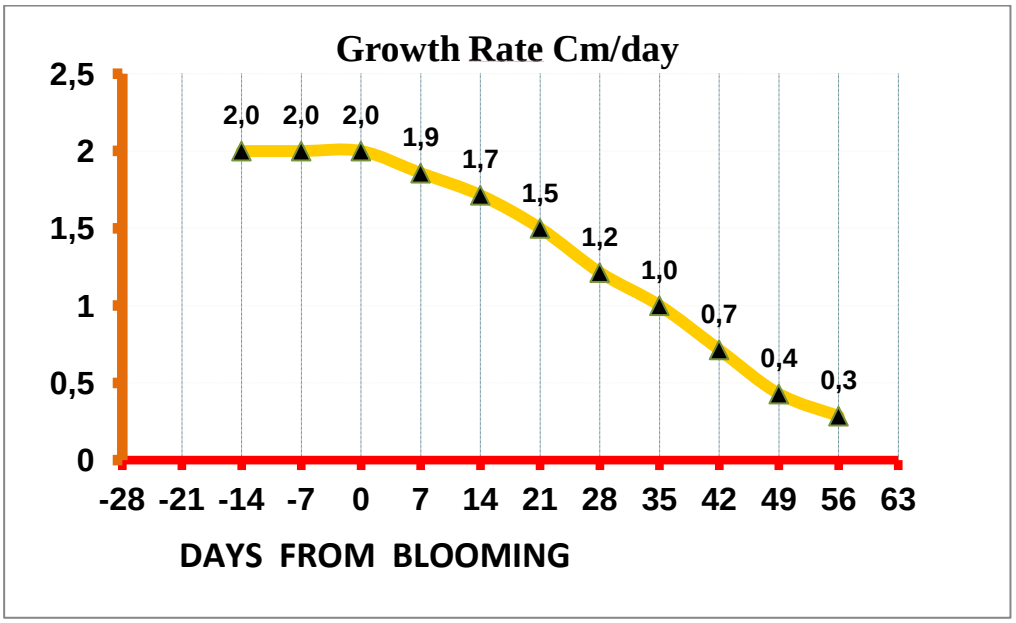

Fig. 1. An optimal growth chart

PRESSURE CHAMBER

The pressure chamber is a device that determines the leaf water potential of a plant (picture 4), thus quantifying its level of thirst.

A farmer collects 5-10 leaves, one per plant – the youngest full size leaf (usually 4-5 leaf from the top). The leaf is entered into the sealed chamber and the operator

applies continuous pressure up to the point he can observe a water drop emerging from the leaf stem (picture 5). The pressure reading represents the leaf water potential – a measure of plant thirst. Results are compared to an optimal chart (fig2) to learn whether the plant is in stress at normal moisture status or over watered. According to the results – the farmer can take irrigation decisions.

Picture 4. Pressure chamber

Picture 5. drop emerging from the leaf stem

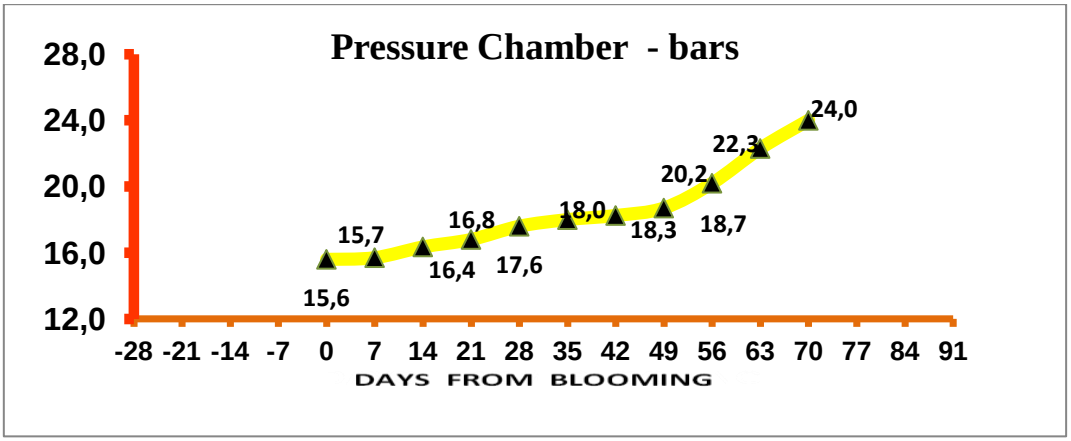

Fig 2. An optimal water pressure chart

PHYTECH SYSTEM

Hi-tech system consists of three main data components:

1. Information on soil moisture and salinity.

2. Climate data of temperature, humidity, solar radiation, wind, and calculated evaporation and saturated vapor pressure deficit.

3. Information on the behavior of the stem, Daily growth and daily contraction, receives by measuring the Stem diameter changes. Comparison of various information elements and test their effects on plant behavior following information through the stem is the heart of the system for decision-making

Growing season is divides into 3 stages (fig3)

Stage I – Active vegetative growth stage.
Irrigation according to daily stem diameter increment (Stem height)

Stage II – Pick flowering / Boll development stage.
Irrigation according to the maximum stem daily contraction (leaf water potential level)

Stage III – Boll maturing / opening stage.
Irrigation according to soil moisture level (residual soil moister levels)

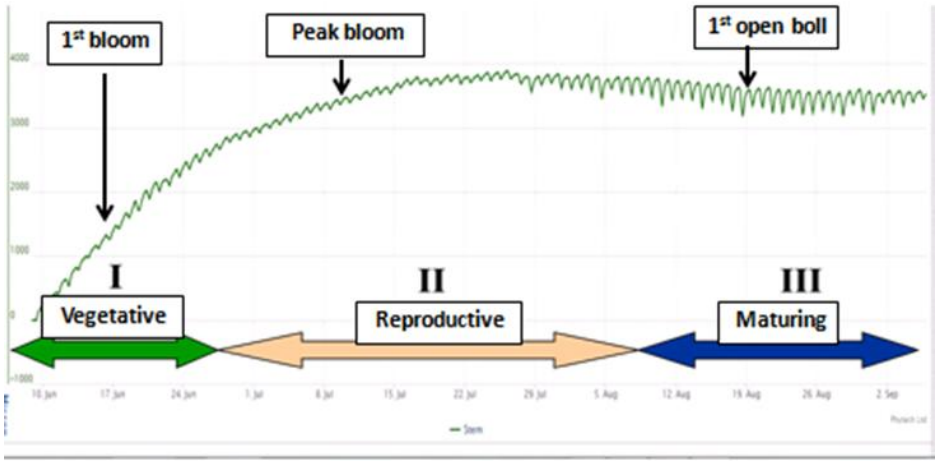

Fig3. cotton stem diameter changes along season

RESULTS

Pima lint yield in Israel, between 1980 and 2013, increased from 1200 kg/ hectare to 1800 kg/hectare - 50% improvement.

Water use per hectare reduced from 6000cubic meter to 4000 cubic meter – 30% saved.

Cost of production – water terms – reduced from 2.3 cubic meter for 1 pound of cotton lint at 1980, to 1.0 cubic meter in 2013

CONCLUSIONS

Drip irrigation reduced water use by 20%.

Recycle water supply enables cotton farming.

Using cotton growth control practices increases water efficiency.

Response to plant needs increases yields.