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Review Article

Water Systems Strategy Relation with Horticultural Crops

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ABSTRACT

Integrated water management means putting all the pieces together. Social, environmental, and technical aspects must be taken into consideration. Issues of concern include: providing forums; Reshaping planning processes; Coordination of land and water resources management; Identify the links between water sources and water quality; Develop protocols for integrated watershed management; Addressing institutional challenges; Protecting and restoring natural systems; Reformulation of existing projects; Knowing the views of society; Clarify education and communication risks; Technology standardization and policy; Form partnerships and emphasize preventive measures. The highest priority for water resource management is to increase the demand for water with limited water resources. Water resources are the foundation for sustainable development, so a sustainable approach must be based on the use and management of water resources. In the twenty-first century, the world faces a major water crisis. The problems stem from errors in the management of water resources. Consequently, the sustainable use of water resources is crucial for humanity. Sustainable development is defined as the goals of supply and today's needs without jeopardizing the goals and requirements of future generations. Long-term goals should be considered instead of short-term goals in assessing water resources. This approach forms the idea of integrated water resource management for horticultural crops. This paper describes the evolution of water use in relation to productivity, how irrigation systems have developed and managed, and a strategy to explore challenges and opportunities for water conservation in horticulture crops.

Keywords: *Water Resources Management, Sustainability, Horticultural Crops, Integrated Management strategy.*

INTRODUCTION

The sustainable management of water resources is very important for the ecosystem in terms of providing the basis for sustainable development because water resources are a vital issue for humans. Building sustainable management and certification awareness is also important in water resource engineering. The integration of the environment with all its natural resources and its commitment to achieving all improvement plans in the philosophy of sustainable development results from the necessity of integrated management of water resources. And because agriculture always involves economic risks, humankind has long sought ways to reduce the weather risks that affect agriculture. Even in early civilizations, farmers noted that complementary application of water to land could reduce the effects of drought. The basic tenants of irrigation have been understood at least since the time of the Sumerian civilization more than 6000 years ago: one needs to get water on Earth, keep it there as long as it is needed, get rid of it when it is no longer required, and keep unwanted water out (Ryan and Pitman, 1998). However, it took several centuries of irrigation for humanity to realize that irrigation could have negative environmental consequences, mainly from salt build-up, and that irrigation practices must be managed to control salt (Gardner, 1993; van Schilfgaarde et al., 1974). Such negative impacts combined with indirect negative societal impacts due to agricultural water diversion, now pose a threat to the future of irrigation that must be appropriately addressed if irrigated gardening is to be a sustainable management system.

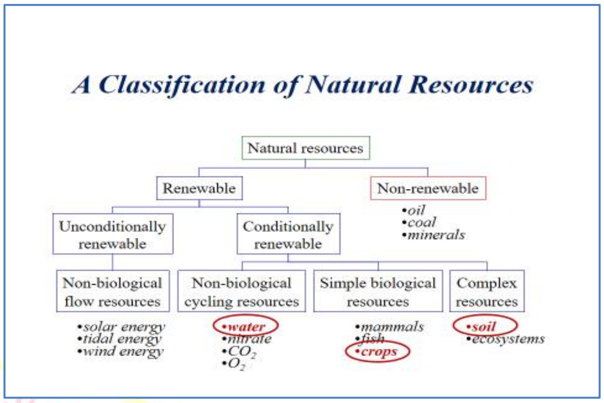
The increasing demand for water for other uses in our society coupled with water scarcity leads to unprecedented pressure to reduce the share of freshwater used in irrigation. Until recently, the community had responded to the increasing demand for water by developing new supplies. This is no longer possible in many cases today, as the economic and environmental costs of new developments in water sources exceed the perceived benefits. The alternative to new development is to conserve existing resources. Therefore, agriculture, as the primary user of the diversed water, is subject to careful scrutiny. Water for agricultural use is the first to be considered a new source of supplies for other uses, especially in situations of scarcity. Indeed, the reallocation of water from agriculture to other sectors has already begun in many areas and is expected to increase in the future. While agriculture is required to give up water, the world's growing population requires agriculture to increase food production. By 2025, the world will need 40% more grains (IFPRI, 1999) and is also turning towards increased consumption of fruits and vegetables. This conflict will not be resolved in the coming years unless we are able to meet the challenge of increasing crop yields per unit of water consumed, especially in irrigated horticulture, a sector in which water has been used generously until recently.

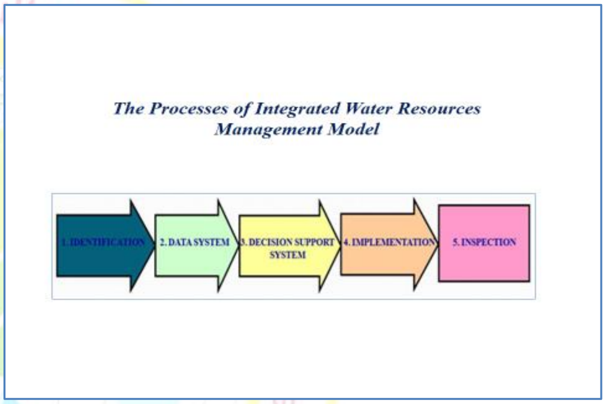
Integrated Water Resources Management

The principles of integrated management to solve the global water crisis come to the fore given the developments that have taken place in recent years. The EU Water Framework Directive, which was implemented in 2000, developed water policies with a watershed-based management approach, protecting them from water resources and controlling them in terms of quantity and quality. With regard to sustainable management policy, the social, environmental, economic, technical and institutional phenomenon as a whole must be dealt with. Integrated water resources management relies on fair and efficient management and sustainable water use.

Integration of environmental media is provided by integrating social, economic, political, institutional, technical, and legal factors with environmental factors (sustainability), specialization integration, integration of actors (coordination), and integration of financial resources, integration of management tools, climate change and risks in integrated water resources management. The integrated management model should consist of the identification stages, the data system, the decision support system, implementation, inspection, and discussion of the stages respectively.

Water demand stakeholders must provide a participatory business approach while practicing all phases. The dispersal of water resources by field of use must be taken into account in integrated water resources management for stakeholder analysis. Water famine, water pollution and water management issues are obligated to deal with watersheds through integrated water resources management in all water resources. The integration of the environment with all its natural resources and the commitment to achieving all plans for improvement in the philosophy of sustainable development leads to the necessity of integrated management of water resources. The protection of water resources and their provision for sustainable use can only be achieved through an integrated management system.





There is a need to improve coordination and cooperation between water resource planning and management agencies. Planning and management contexts must be consistent with the issues they address, and they should recognize relevant ecosystem interactions. Objective forums are needed to address the true dimensions of water management problems, bring stakeholders to the table, and reach consensus. Integrated water management plans should lead decision-making processes over water resources and serve as a basis for developing regulatory programs. Educators play an important role in developing and implementing integrated water management strategies. Teaching, research and service jobs in universities are ideally suited to educating a diverse audience on water management issues. Water management policies must take global dimensions. Coordination, cooperation and cooperation between intergovernmental agencies must be improved. Political processes must be better understood and shaped to focus on holistic approaches to land and water management. Preventive measures must be emphasized, rather than remedial measures.

Water Efficiency in Horticulture

Water used for irrigation is consumed by evaporation from crop or soil surfaces and may also be lost due to runoff or deep filtration. In many cases, these water losses inside the basin can be recovered and reused, albeit with some deterioration in quality. Conservation of water aims to increase the efficiency of irrigation by changing the irrigation method, for example, it may not result in net savings in water if the preserved losses are reversible (Seckler, 1996). Water productivity (WP) is defined as the yield-to-evaporation ratio (ET) (Seckler, 1996). In contrast to efficiency improvements, improving WP by increasing yields and / or reducing ET results in net savings, thereby reducing agricultural water requirements.

Water productivity in irrigated agriculture varies greatly and depends on many biophysical and administrative factors. Since the differences in ET between crops are in order of size, the most important factor affecting white phosphorus is the economic value of the product. Gardening products are usually of high value and therefore white phosphorus usually exceeds field crop products. By using the current crop values and ET properties for California cultivation, the white phosphorus size for corn is about $ 0.20 / m3, compared to $ 0.70 / m3 for almonds, $ 5.00 / m3 for strawberries, and even more for greenhouse crops and ornamental decorations. . An extreme example is vegetable crops grown under plastic in southeastern Spain during the recession. The combination of high market prices and low ET leads to a WP of about $ 10 / m3. While impressive, even this value cannot compete with the value of industrial and urban uses. However, it helps explain the trend of shifting irrigated areas from low-value crops and raw crops to horticultural crops in many water-scarce regions of the United States, a trend that is likely to increase worldwide (National Research Council, 1996).

Historical Perspectives

The history of irrigation parallels that of agriculture itself, as early agricultural developments occurred in the Fertile Crescent in an arid environment. Janick (1979) reviewed the history of irrigated gardening until about the beginning of the twentieth century, when ASHS was created. After 1900, irrigation development accelerated in the United States as population growth increased food production and this pattern repeated on a global basis for most of the twentieth century (Howell, 2001). During the last two decades of the century, the irrigated area in the United States remained relatively stable at about 20 million hectares despite regional differences and some expansion in the mid-1990s (Howell, 2001). Irrigated land currently accounts for 18% of all crops, but about 50% of all crops (Howell, 2001). This high productivity of irrigated agriculture, coupled with changing feeding patterns driven in part by the inclusion of fruits and vegetables as essential components of a healthy diet, led to today's situation where Two-thirds of the vegetables and three-quarters of the fruit produced in the United States is harvested from irrigated areas.

The Semi Arid Zone

Not surprisingly, irrigation development in the U.S. started in a semi-dry region, where very limited precipitation made irrigation necessary for viable agricultural development. There is evidence of widespread irrigation in the Salt River Valley in Arizona and other arid regions (Jensen, 1982).

The Spaniards brought irrigation to New Mexico in the 16th century, and the residents of their expeditions in California developed irrigated lands after the 17th century. Modern irrigation development took place during the nineteenth century and by 1870, there were over 60,000 acres of irrigated horticultural crops on the plains around Los Angeles alone (Hundley, 1992).

By the end of the century, there were about 1.5 million acres of irrigated land in California with nearly two thirds of them devoted to horticultural crops (Hundley, 1992). A number of institutional developments, including the formation of organized irrigation areas, helped boost irrigation growth, with the irrigated land in California expanding to 4.5 million acres by 1930, about 50% of today's area (Hundley, 1992). After that, the expansion of irrigation development slowed to the end of World War II. At that time, the total irrigated area in the 17 western states was about 20 million acres, which more than doubled in the next 30 years to 43 million acres (Jensen, 1982). Irrigation also expanded significantly in the rest of the United States after 1950, moving from one million to seven million acres in 1978 (Jensen, 1982).

The results of Veihmeyer, 1927, 1972, were strongly influenced by the nature of the soil on which he worked with high soil water storage capacity and almost unlimited depth. He noted that others have verified that tree crops can extract 300 to 400 mm of water from these types of soil without causing significant stresses on tree water (Fereres and Goldhamer, 1990; Veihmeyer used manual soil sampling to calculate rates of use Horticultural consumer, and AH Hendrickson, a fellow from the Pomology Department at the University of California, Davis, developed guidelines for irrigation management for most tree crops in California (Hendrickson and Veihmeyer, 1951.) Veyhmeyer has shown in later studies that irrigation can be delayed until depletion.The main part of the root zone to the point of permanent wilt without loss in yield. His previous work showed that a large extraction of water can occur to a soil depth of 3.6 m (Veihmeyer, 1927).

And this level of water supply should be sufficient under horticultural conditions that It was present during those times, including trees with wide distances, to avoid negative impacts on yields with non-recurrent irrigation that resulted in very dry soil in the greater part of the root zone. It would take decades (Uriu and Magness, 1967) until the water dynamics in the soil's atmosphere system were understood.

The Humid Zone

Many wet states in the southeastern United States have rainfall in excess of 1,200 mm / year. Citrus and many other crops were successfully cultivated in Florida without irrigation. If the annual rains match or exceed the seasonal season, Savage (1953) stated that citrus irrigation was not economical in Florida. Koo's later work (1963) and others showed that irrigation increased yields enough to make it worth the investment. The main reasons irrigation can be beneficial in wet southeast areas include soils, rainfall variability, and changes in irrigation technology.

From Carolina through Georgia and Florida, the coastal plain has large areas of sandy soil with low water retention capacity. The water content in the field capacity of some Florida citrus soils can be as low as 6%, and the available water can be as low as 0.049 cm 3. These soils do not have the temporary storage capacity needed to handle short droughts and irrigation becomes necessary to improve yields. . Koo (1963) noted that the precipitation ranged from 836 to 1758 mm in two consecutive years. Several El Niño events caused record rains in December in Florida. This is usually a dry month. There were also periodic droughts in the southeast. In addition to limiting crop yields, these droughts have resulted in forest fires, with consequent environmental damage. In addition to the annual variance, precipitation can be quite localized in place and time and not necessarily come when needed. In some parts of the southeast, rainfall patterns produce very clear dry and wet periods, as in Florida, where more than 60% of precipitation falls between June and September. The flower and fruit group are critical periods of citrus and many other crops, and occur during the Florida dry season. Lack of rain or insufficient irrigation during these periods can significantly reduce yields.

When Savage (1953) concluded that irrigation was not economically feasible, the predominant irrigation methods were floods (in coastal and flat timber groves), top sprinkler, portable perforated pipe, and hexagon sized. During dry periods, sprinklers usually worked every 10 to 14 days, and farmers often delay starting watering for several days, in the hope that rain will eliminate this need. Thus, irrigation was not always applied in time. Water stress developed and fruit yields decreased. Ko (1963) showed that irrigation can be economical for citrus fruits, even in years when the rainfall has increased. By maintaining soil moisture above the drain of a third of the available water from January to June and exhausting two-thirds for the rest of the year, yields increased irrigated controls.

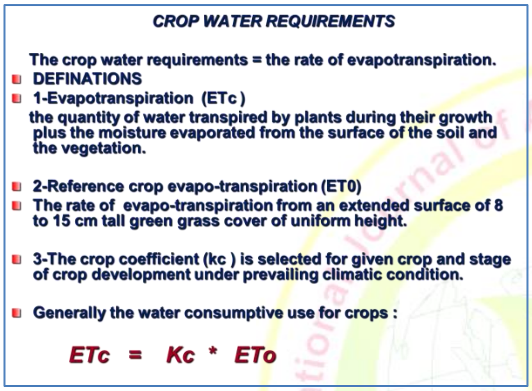
Micro-sprinkler irrigation was introduced to Florida from South Africa in the early 1970s. When it was found that these systems provided some frost protection for citrus fruits (Parsons et al., 1982), small sprinklers were installed on thousands of hectares of citrus in Florida. Florida became one of the fastest growing small irrigation markets in the United States during the 1980s. Most Florida citrus areas are now irrigated with small sprinklers due to the dual advantage of high-frequency irrigation as well as frost protection. Smajstrla et al. (1995) estimate that in 1994, about 20% of the total micro irrigated area in the U.S. were in Florida fruit crops.

Irrigation Processing In Horticultural Crops

Consumptive Use Requirements

Theoretical and experimental research on evaporation from confined surfaces yielded several methods for calculating ET, which is the primary input for determining the amount of water to be applied. Standard procedures for an ET account were successfully developed by Dorenboos and Pruitt (1974) but were recently modified by Allen et al. (1998) and ASCE. All methods are based on the calculation of the reference ET multiplied by the experimentally determined crop factor (Kc) that includes specific features for each crop. At present, there are good estimates of Kc values for most horticultural crops, although most Kc research has been conducted on major field crops (Allen et al., 1998). One exception is the lack of sufficient information on the water requirements of an orchard for young trees. The relationship between ET and terrestrial shaded area, developed for small almond trees (Fereres and Goldhamer, 1990) was used successfully for deciduous and other green fruit trees to adjust a mature ET orchard with those in a canopy of a growing tree. Although piloted, the accuracy of ET estimates is sufficient for most management applications, although there are more mechanical models based on evaporation theory (Monteth, 1965).

Water shortage can reduce crop transpiration (T) either by affecting vegetative growth, thereby reducing the size of the canopy, or by closing stomata, thus reducing canopy delivery. Because of the linearity between radiation interception and biomass production, reducing T by developing small blinds usually reduces white phosphorus and should be avoided in intensive gardening (Hsiao, 2000). Another option, regulating the T canopy by closing the stomata, presents some interesting differences and exploitation between horticultural crops. It is well known that T is controlled by stomata. The transpiration of the parasols is regulated by the air conductivity and the canopy, and the extent to which T is affected by changes in the stomata conduction depends on the relative size of the two. Long rough umbrellas such as those in orchards have much more aerodynamic connectors than those short, smooth shades for field crops and vegetables. Tree curtains are well coupled with the atmosphere and exchange CO2 and H2O effectively with their environment, while short awnings, especially under low winds, are poorly coupled and provide greater resistance to mass transfer (Jarvis and McNaughton, 1986).



CROP WATER REQUIREMENTS

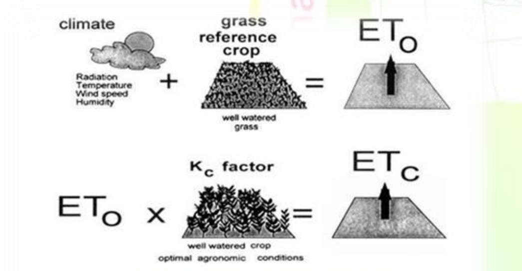
The crop water requirements = the rate of evapotranspiration.

- **DEFINATIONS**
- **1-Evapotranspiration (ETc)**

the quantity of water transpired by plants during their growth plus the moisture evaporated from the surface of the soil and the vegetation.

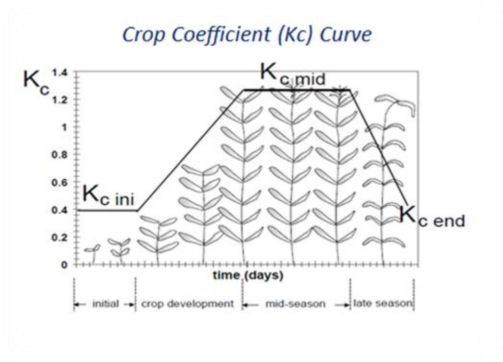
- **2-Reference crop evapo-transpiration (ET0)**
- **The rate of evapo-transpiration from an extended surface of 8 to 15 cm tall green grass cover of uniform height.**
- **3-The crop coefficient (kc) is selected for given crop and stage of crop development under prevailing climatic condition.**
- **Generally the water consumptive use for crops :**

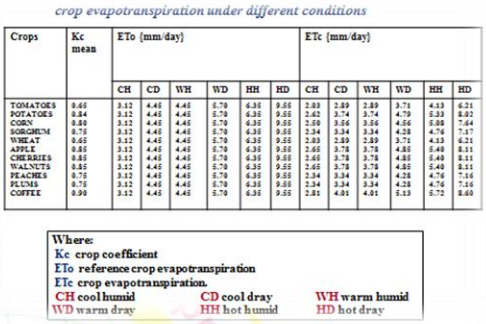
ETc = Kc * ETo



From ETo and estimates of crop evaporation rates, expressed as crop coefficients (Kc)
ETcrop = Kc × ETo

Under weak pairing, the stomatal closure increases the temperature of the crop, which in turn leads to an increase in the vapor pressure gradient between the leaf and the atmosphere, which increases T. In this case, stomatal control is ineffective in controlling T and significant decreases in its size (this It also affects photosynthesis significantly) There is a need to reduce canopy T. On the contrary, in well-coupled orchards, effective heat transfer from leaves prevents a significant difference between canopy and air temperature and there is almost a linear relationship between transpiration and canopy conductor. The olive trees work 3 meters high and about 50% of the ground cover, Villalobos et al. (2000) found a relative sensitivity to T for changes in canopy connection of about 0.9 during most of the day.





crop evapotranspiration under different conditions

Crops	Kc mean	ETo {mm/day}						ETc {mm/day}					
		CH	CD	WH	WD	HH	HD	CH	CD	WH	WD	HH	HD
TOMATOES	0.65	3.12	4.45	4.45	5.70	6.35	9.55	2.03	2.89	2.89	3.71	4.13	6.21
POTATOES	0.84	3.12	4.45	4.45	5.70	6.35	9.55	2.62	3.74	3.74	4.79	5.33	8.02
CORN	0.80	3.12	4.45	4.45	5.70	6.35	9.55	2.50	3.56	3.56	4.56	5.08	7.64
SORGHUM	0.75	3.12	4.45	4.45	5.70	6.35	9.55	2.34	3.34	3.34	4.28	4.76	7.17
WHEAT	0.65	3.12	4.45	4.45	5.70	6.35	9.55	2.03	2.89	2.89	3.71	4.13	6.21
APPLE	0.85	3.12	4.45	4.45	5.70	6.35	9.55	2.65	3.78	3.78	4.85	5.40	8.11
CHERRIES	0.85	3.12	4.45	4.45	5.70	6.35	9.55	2.65	3.78	3.78	4.85	5.40	8.11
WALNUTS	0.85	3.12	4.45	4.45	5.70	6.35	9.55	2.65	3.78	3.78	4.85	5.40	8.11
PEACHES	0.75	3.12	4.45	4.45	5.70	6.35	9.55	2.34	3.34	3.34	4.28	4.76	7.16
PLUMS	0.75	3.12	4.45	4.45	5.70	6.35	9.55	2.34	3.34	3.34	4.28	4.76	7.16
COFFEE	0.90	3.12	4.45	4.45	5.70	6.35	9.55	2.81	4.01	4.01	5.13	5.72	8.60

Where:
Kc crop coefficient
ETo reference crop evapotranspiration
ETc crop evapotranspiration.
CH cool humid **CD cool dray** **WH warm humid**
WD warm dray **HH hot humid** **HD hot dray**

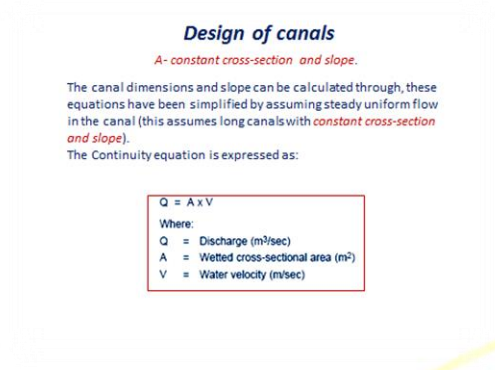
Thus, a specific decrease in the stomatal conduction will reduce the olive T approximately by the same amount. By contrast, similar measurements on garlic with a full cover showed the sensitivity of T to a decrease in stomata less than 0.3, which means that a relative decrease in T would be less than 30% a decrease in the conduction Villalobos et al. (2000). Thus, it is clear that closing stomata will have a variable effect on T depending on the characteristics of the crop canopy and its environment.

Irrigation Methods

There are a number of surface irrigation techniques used in gardening but all of them have basic limitations. The depth of the applied water is determined by the rate of soil leakage. With surface irrigation, better engineering designs, management, and ground preparation (laser leveling), new technologies are now being used to control the depth of application and distribute water as uniformly as possible across the field. However, the inherent variation in soil water consumption rates cannot be overcome, and hence the variation in infiltrated water within the field.

Where leveling was not possible, and although the initial spray systems had more work requirements than surface systems, the current robotic and solid group systems required little labor. The uniform distribution of water applied by wind spray is affected which also leads to increased spray evaporation and loss of drift in arid climates. Moreover, sprinkler irrigation can be problematic in orchards due to the parasol's interception of spray patterns resulting in poor distribution.

Gardeners and the general public work to link drip irrigation or drip irrigation using water efficiently. Drip irrigation consists of a permanent system of plastic tubes that use transmitters to locate water near individual plants using the high-frequency application and low discharge rates.



Design of canals

A- constant cross-section and slope.

The canal dimensions and slope can be calculated through, these equations have been simplified by assuming steady uniform flow in the canal (this assumes long canals with *constant cross-section and slope*).

The Continuity equation is expressed as:

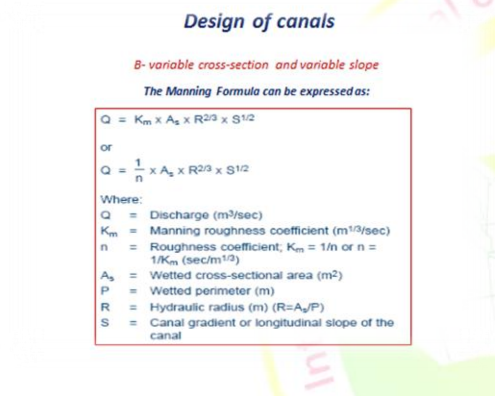
$Q = A \times V$

Where:

Q = Discharge (m^3/sec)

A = Wetted cross-sectional area (m^2)

V = Water velocity (m/sec)



Design of canals

B- variable cross-section and variable slope

The Manning Formula can be expressed as:

$$Q = K_m \times A_s \times R^{2/3} \times S^{1/2}$$

or

$$Q = \frac{1}{n} \times A_s \times R^{2/3} \times S^{1/2}$$

Where:

Q = Discharge (m^3/sec)

K_m = Manning roughness coefficient ($m^{1/3}/sec$)

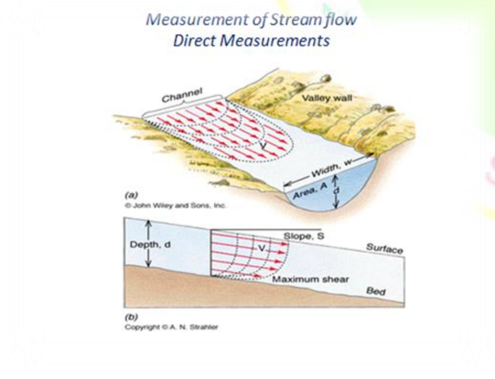
n = Roughness coefficient; $K_m = 1/n$ or $n = 1/K_m$ ($sec/m^{1/3}$)

A_s = Wetted cross-sectional area (m^2)

P = Wetted perimeter (m)

R = Hydraulic radius (m) ($R = A_s/P$)

S = Canal gradient or longitudinal slope of the canal



Measurement of Stream flow

Direct Measurements

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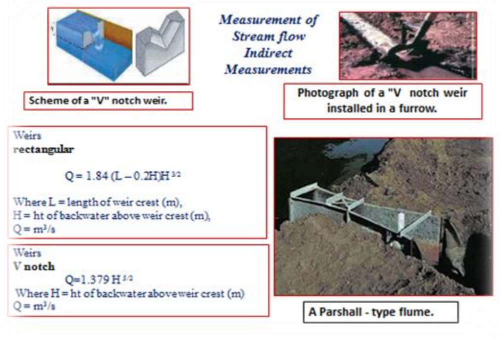


Measurement of Stream flow Indirect Measurements

Scheme of a "V" notch weir.

Photograph of a "V notch weir installed in a furrow.

Weirs
rectangular

$Q = 1.84 (L - 0.2H)H^{3/2}$

Where L = length of weir crest (m),
H = ht of backwater above weir crest (m),
$Q = m^3/s$

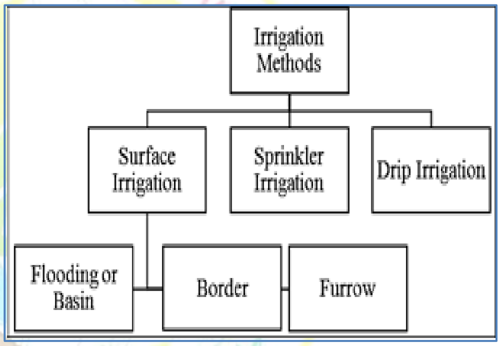
Weirs
V notch

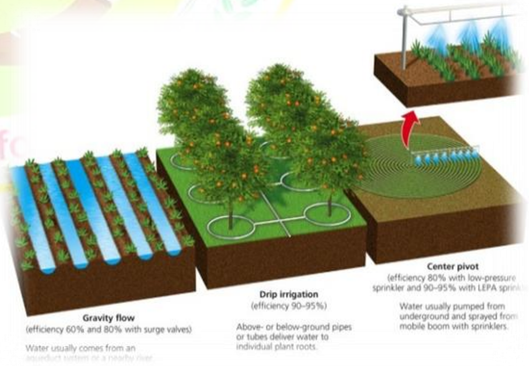
$Q = 1.379 H^{5/2}$

Where H = ht of backwater above weir crest (m)
$Q = m^3/s$

A Parshall - type flume.

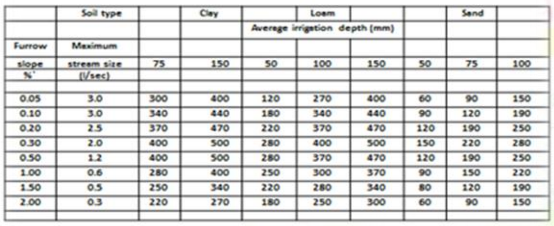
Surface irrigation can be effective in regular soils with moderate to low leakage rate but inactive in heterogeneous and / or with light tissues. The invention of sprinkler irrigation in the 1940s dominated the distribution of leaky water away from the soil. It was then possible to apply any required depth to areas First research reports on this method emerged several years after they were made available commercially (Goldberg et al., 1971). Research has shown that in addition to improving uniformity in water distribution, drip irrigation can increase the efficiency of fertilizer use by direct injection, allow better field access to equipment, reduce fungal diseases associated with moisture, and reduce the spread of weeds. On the other hand, controlling weeds in frequently wet areas has proven difficult due to the accelerated breakdown of herbicides (Fereres and Goldhamer, 1990). Small sprinklers, an extra-distillation technique for drip technology, moisten a larger surface area in various typical shapes and operate at a frequency between drip sprinklers and conventional impact sprinklers. It is also easy to find out if the small sprayers are clogged.





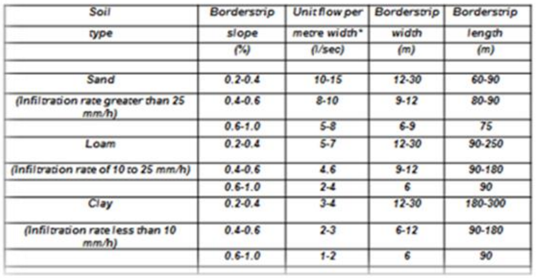
Different Methods of Irrigation

Furrow lengths in metres as related to soil type, slope, stream size and irrigation depth



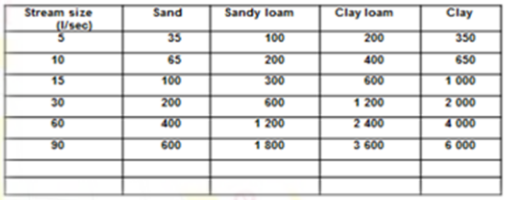
	Soil type		Clay		Loam			Sand	
				Average irrigation depth (mm)					
Furrow	Maximum								
slope %'	stream size (l/sec)	75	150	50	100	150	50	75	100
0.05	3.0	300	400	120	270	400	60	90	150
0.10	3.0	340	440	180	340	440	90	120	190
0.20	2.5	370	470	220	370	470	120	190	250
0.30	2.0	400	500	280	400	500	150	220	280
0.50	1.2	400	500	280	370	470	120	190	250
1.00	0.6	280	400	250	300	370	90	150	220
1.50	0.5	250	340	220	280	340	80	120	190
2.00	0.3	220	270	180	250	300	60	90	150

Maximum border strip widths and lengths for smallholder irrigation schemes



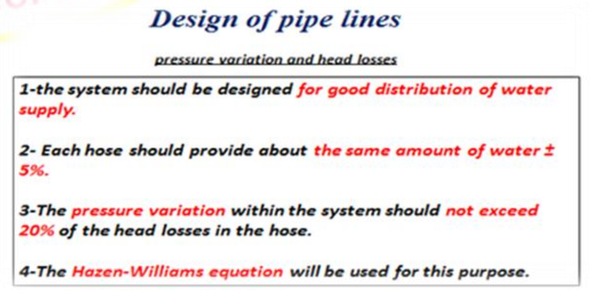
Soil type	Borderstrip slope (%)	Unit flow per metre width* (l/sec)	Borderstrip width (m)	Borderstrip length (m)
Sand	0.2-0.4	10-15	12-30	60-90
(Infiltration rate greater than 25 mm/h)	0.4-0.6	8-10	9-12	80-90
	0.6-1.0	5-8	6-9	75
Loam	0.2-0.4	5-7	12-30	90-250
(Infiltration rate of 10 to 25 mm/h)	0.4-0.6	4.6	9-12	90-180
	0.6-1.0	2-4	6	90
Clay	0.2-0.4	3-4	12-30	180-300
(Infiltration rate less than 10 mm/h)	0.4-0.6	2-3	6-12	90-180
	0.6-1.0	1-2	6	90

Basin area in m^2 for different stream sizes and soil types



Stream size (l/sec)	Sand	Sandy loam	Clay loam	Clay
5	35	100	200	350
10	65	200	400	650
15	100	300	600	1 000
30	200	600	1 200	2 000
60	400	1 200	2 400	4 000
90	600	1 800	3 600	6 000

Sprinkler Irrigation Systems



Design of pipe lines

pressure variation and head losses

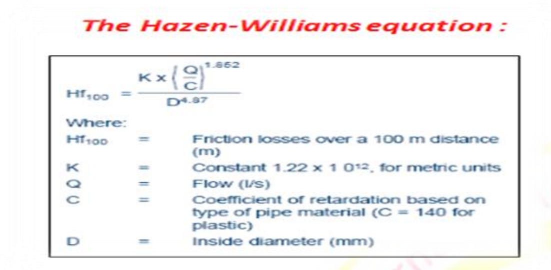
1-the system should be designed for good distribution of water supply.

2- Each hose should provide about the same amount of water ± 5%.

3-The pressure variation within the system should not exceed 20% of the head losses in the hose.

4-The Hazen-Williams equation will be used for this purpose.

The operational and administrative advantages of sprinklers and small irrigation systems (drip and micro sprinkler) have led to a major shift in the United States from surface irrigation to these compact methods. Howell (2001) reported that between 1979 and 1994, the surface irrigated area in the U.S. decreased from two-thirds to half the total irrigated land and particularly noted that the use of micro-irrigation grew very rapidly during this period with an annual growth rate of more than 400%. This area reached one million hectares in 2000, or 5% of the total irrigated area. Within the United States, California has the largest area in small irrigation, but many other states, including Florida, Georgia, Hawaii, Michigan, and Texas, have a large area located in wet areas. The irrigation systems now in place are more than sufficient to provide gardening a wide range of options for applying water efficiently and uniformly, to the point that economic and social considerations often determine the final choice of method and equipment.



The Hazen-Williams equation :

$$Hf_{100} = \frac{K \times \left(\frac{Q}{C}\right)^{1.852}}{D^{4.87}}$$

Where:

Hf_{100} = Friction losses over a 100 m distance (m)

K = Constant 1.22×10^{12}, for metric units

Q = Flow (l/s)

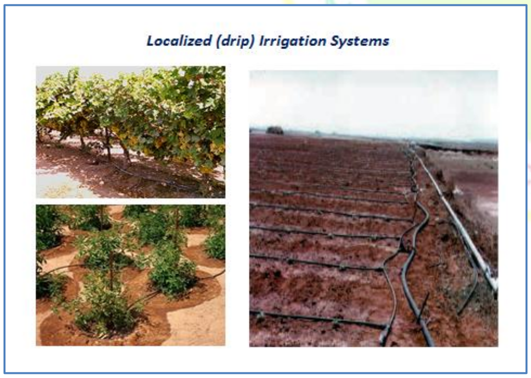
C = Coefficient of retardation based on type of pipe material (C = 140 for plastic)

D = Inside diameter (mm)

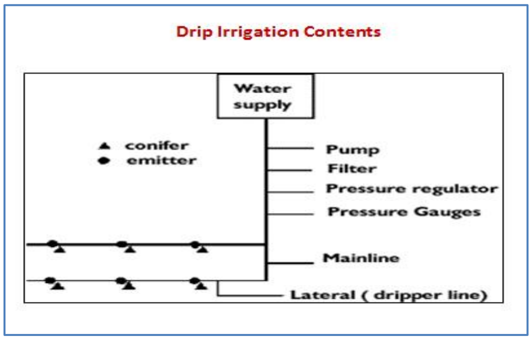
Total head requirements

The total head requirements are composed of:
1- the suction lift ,
2- the head losses in the supply line,
3- the head losses in the field line,
4- the head losses in the hydrant riser and hose,
5-miscellaneous losses for fittings,
6-the difference in elevation between the water level and the highest point in the field.

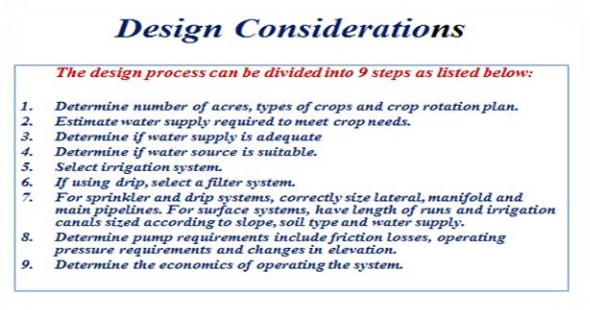
Sprinkler irrigation system



Localized (drip) Irrigation Systems



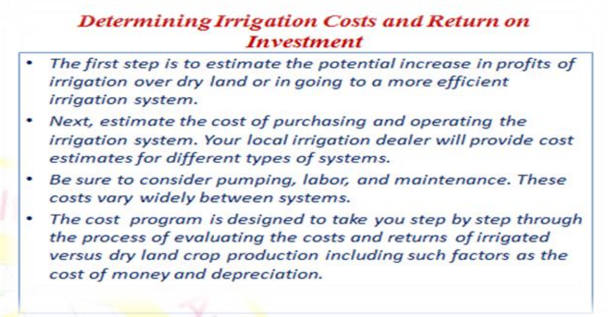
Drip Irrigation Contents



Design Considerations

The design process can be divided into 9 steps as listed below:

1. *Determine number of acres, types of crops and crop rotation plan.*
2. *Estimate water supply required to meet crop needs.*
3. *Determine if water supply is adequate*
4. *Determine if water source is suitable.*
5. *Select irrigation system.*
6. *If using drip, select a filter system.*
7. *For sprinkler and drip systems, correctly size lateral, manifold and main pipelines. For surface systems, have length of runs and irrigation canals sized according to slope, soil type and water supply.*
8. *Determine pump requirements include friction losses, operating pressure requirements and changes in elevation.*
9. *Determine the economics of operating the system.*



Determining Irrigation Costs and Return on Investment

- *The first step is to estimate the potential increase in profits of irrigation over dry land or in going to a more efficient irrigation system.*
- *Next, estimate the cost of purchasing and operating the irrigation system. Your local irrigation dealer will provide cost estimates for different types of systems.*
- *Be sure to consider pumping, labor, and maintenance. These costs vary widely between systems.*
- *The cost program is designed to take you step by step through the process of evaluating the costs and returns of irrigated versus dry land crop production including such factors as the cost of money and depreciation.*

Irrigation Scheduling

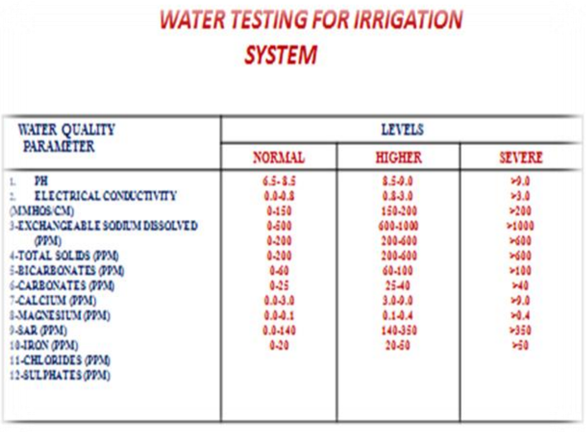
Irrigation scheduling is a systematic method by which a product can determine the time of irrigation and the amount of water to be used. The goal of an efficient scheduling program is to supply plants with adequate water while reducing losses to deep filtration or runoff. The scheduling of irrigation depends on the soil, crops, atmosphere, irrigation system and operational factors. Correct scheduling of irrigation requires a sound basis for making irrigation decisions. The level of decision making ranges from personal experience to adopting practices and techniques based on computer-assisted tools that can assess soil, water and the atmosphere. Irrigation scheduling techniques can be based on soil water measurement, meteorological data, or plant stress monitoring. Conventional scheduling methods are measuring soil water content or calculating or measuring evaporation rates. Research into plant physiology led to tabulation methods by monitoring leaf swelling pressure, stem diameter, and sap flow.

With surface and portable sprinkler irrigation techniques, and the work to be completed, therefore, the primary management objective was to irrigate as regularly as possible. The primary concern is the conformity of applications to crop requirements. While most irrigation uses intuitive or qualitative approaches to tabulation, this topic has been extensively studied in horticulture and several quantitative measures have been proposed based on the water and soil budget and plant indicators. Water budget method is perhaps the most widely used scheduling technique. With surface irrigation, the approach is to calculate the storage of available soil water and the permissible depletion threshold.Then, adjusted precipitation and irrigation inputs are balanced for efficient application versus ET crop yields, runoff and filtration. The increased availability of local and regional ET data, and the expansion of micro irrigation, where water budget information is more easily implemented, has encouraged farmers to adopt a water budget technology. Leading computer models by (Jensen et al., 1970), which have enhanced scientific irrigation scheduling in the United States over the past three decades, have contributed to the success of this technology.

Soil moisture monitoring is another scheduling procedure used in gardening. The first device used to measure the state of soil water was a tonometer, developed by LA Richards (Richards and Neal, 1936). Historically, the main threshold for tonometer was the relatively narrow range of action of soil water potentials, which made its use with surface irrigation methods problematic due to the wide range of soil water contents between irrigation. Hence, it was best used for irrigation management in shallow and / or sandy soils. Rather than assessing the potential of soil water, the neutron probe measures the moisture content, and can therefore be used to assess the quantities of water needed to refill soil features. However, the continuous decrease in surface irrigation, where this information is the most applicable, and the increased regulatory requirements for radioactive materials at the present time dampen enthusiasm for this monitoring technique.

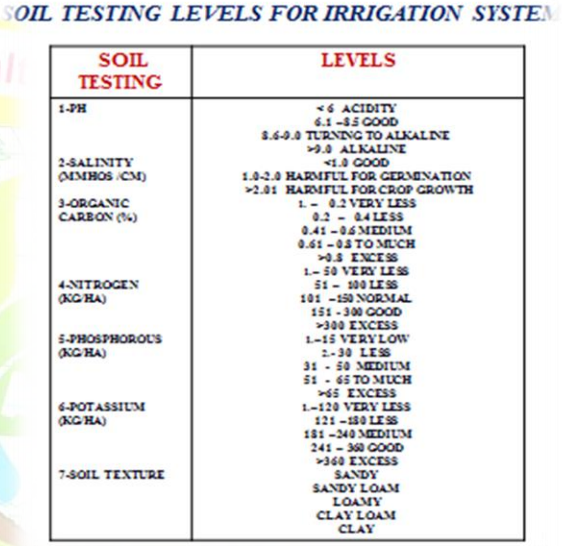
The past decade has seen renewed efforts to develop a new generation of soil moisture sensors based on certain electrical properties, such as resistance, capacitance, and reflection time field measurement. New features include continuous monitoring and assessment of trends using appropriate software. All of these new sensors require very accurate fixation due to the very small measurement field. An important limitation of soil moisture monitoring is the difficulty in adapting to the spatial diversity of soil water properties and the distribution of irrigation water.

Although improving plant biomass or fruit production is the goal of irrigation, the plant is rarely the primary focus of irrigation scheduling techniques. Although there are a variety of methods for assessing the state of plant water directly or indirectly, there are few suggestions for using such measurements to schedule irrigation in gardening (Peretz et al., 1984; Shackel et al., 1997). Infrared temperature measured canopy temperature (Jackson et al., 1977), an indirect measurement technique used in agricultural crops, and now improved knowledge of plant responses to water along with recent developments in monitoring equipment and sensors is generating renewed interest in scheduling approaches ,this is for irrigation of fruit trees.



WATER TESTING FOR IRRIGATION SYSTEM

WATER QUALITY PARAMETER	LEVELS		
	NORMAL	HIGHER	SEVERE
1. PH	6.5-8.5	8.5-9.0	>9.0
2. ELECTRICAL CONDUCTIVITY	0.0-0.8	0.8-3.0	>3.0
(MMHOS/CM)	0-150	150-200	>200
3-EXCHANGEABLE SODIUM DISSOLVED	0-600	600-1000	>1000
(PPM)	0-200	200-600	>600
4-TOTAL SOLIDS (PPM)	0-200	200-600	>600
5-BICARBONATES (PPM)	0-60	60-100	>100
6-CARBONATES (PPM)	0-25	25-40	>40
7-CALCIUM (PPM)	0.0-3.0	3.0-9.0	>9.0
8-MAGNESIUM (PPM)	0.0-0.1	0.1-0.4	>0.4
9-SAR (PPM)	0.0-140	140-350	>350
10-IRON (PPM)	0-20	20-50	>50
11-CHLORIDES (PPM)			
12-SULPHATES (PPM)			

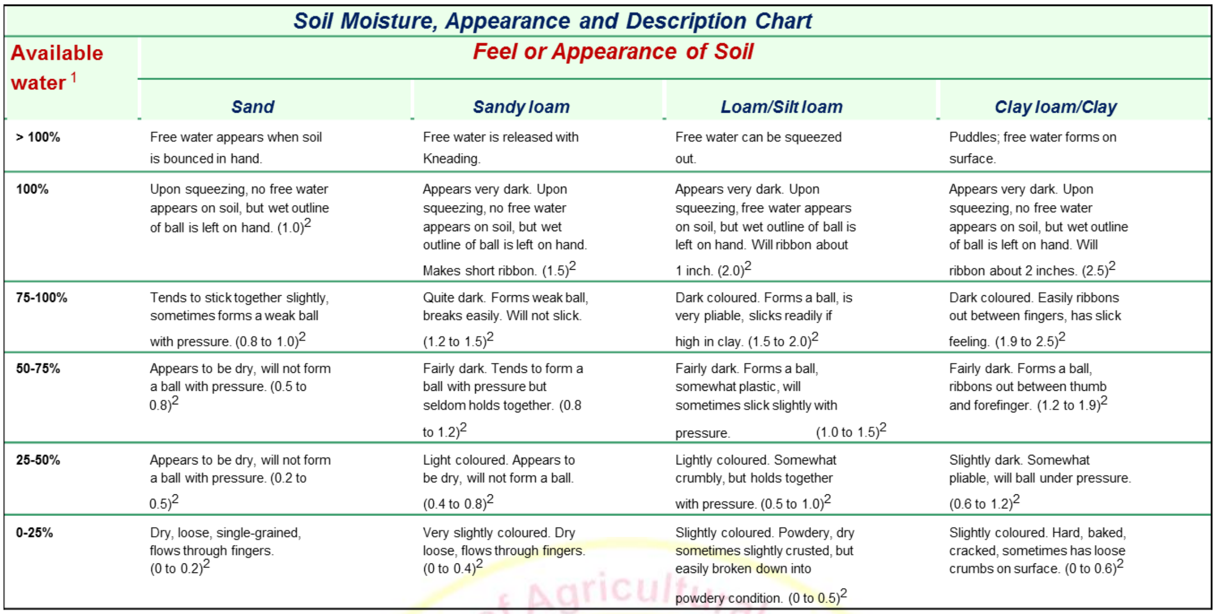


OIL TESTING LEVELS FOR IRRIGATION SYSTE

SOIL TESTING	LEVELS
1-PH	< 6 ACIDITY 6.1 – 8.5 GOOD 8.6-9.0 TURNING TO ALKALINE >9.0 ALKALINE
2-SALINITY (MMHOS /CM)	<1.0 GOOD 1.0-2.0 HARMFUL FOR GERMINATION >2.01 HARMFUL FOR CROP GROWTH
3-ORGANIC CARBON (%)	1. – 0.2 VERY LESS 0.2 – 0.4 LESS 0.41 – 0.6 MEDIUM 0.61 – 0.8 TO MUCH >0.8 EXCESS
4-NITROGEN (KG/HA)	1.– 50 VERY LESS 51 – 100 LESS 101 –150 NORMAL 151 - 300 GOOD >300 EXCESS
5-PHOSPHOROUS (KG/HA)	1.–15 VERY LOW 2.-30 LESS 31 - 50 MEDIUM 51 - 65 TO MUCH >65 EXCESS
6-POTASSIUM (KG/HA)	1.–120 VERY LESS 121 –180 LESS 181 –240 MEDIUM 241 – 360 GOOD >360 EXCESS
7-SOIL TEXTURE	SANDY SANDY LOAM LOAMY CLAY LOAM CLAY

The specific parameter for measuring plant water state is water potential (Hsiao, 1990). Shackle et al. (1997) suggested the use of the stem, which is measured on a covered sheet, making it less associated with the atmospheric environment and less varied than leaf measurements influenced by the behavior of stomata and the date of leaf shade. Naour (2000) found that the stem was a better indication of water stress than dawn or noon leaves. Another indicator of the state of the water is based on the daily stem diameter fluctuations that are directly related to changes in the state of the plant water (Klepper et al., 1971). Recent developments in sensor technology allow continuous monitoring of stem or fruit diameter (Huguet et al., 1992).

The commercial adoption of these indicators for tabulation requires knowledge of how measurements affect yields, which is a complex issue due to the difference in species and processes in their sensitivity to water stress. However, there are some promising commercial methods of plant scheduling for watering fruit trees, such as those suggested by Lampinen et al.



Soil Moisture, Appearance and Description Chart

Available water[1]	Feel or Appearance of Soil			
	Sand	**Sandy loam**	**Loam/Silt loam**	**Clay loam/Clay**
> 100%	Free water appears when soil is bounced in hand.	Free water is released with Kneading.	Free water can be squeezed out.	Puddles; free water forms on surface.
100%	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. (1.0)[2]	Appears very dark. Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. Makes short ribbon. (1.5)[2]	Appears very dark. Upon squeezing, free water appears on soil, but wet outline of ball is left on hand. Will ribbon about 1 inch. (2.0)[2]	Appears very dark. Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. Will ribbon about 2 inches. (2.5)[2]
75-100%	Tends to stick together slightly, sometimes forms a weak ball with pressure. (0.8 to 1.0)[2]	Quite dark. Forms weak ball, breaks easily. Will not slick. (1.2 to 1.5)[2]	Dark coloured. Forms a ball, is very pliable, slicks readily if high in clay. (1.5 to 2.0)[2]	Dark coloured. Easily ribbons out between fingers, has slick feeling. (1.9 to 2.5)[2]
50-75%	Appears to be dry, will not form a ball with pressure. (0.5 to 0.8)[2]	Fairly dark. Tends to form a ball with pressure but seldom holds together. (0.8 to 1.2)[2]	Fairly dark. Forms a ball, somewhat plastic, will sometimes slick slightly with pressure. (1.0 to 1.5)[2]	Fairly dark. Forms a ball, ribbons out between thumb and forefinger. (1.2 to 1.9)[2]
25-50%	Appears to be dry, will not form a ball with pressure. (0.2 to 0.5)[2]	Light coloured. Appears to be dry, will not form a ball. (0.4 to 0.8)[2]	Lightly coloured. Somewhat crumbly, but holds together with pressure. (0.5 to 1.0)[2]	Slightly dark. Somewhat pliable, will ball under pressure. (0.6 to 1.2)[2]
0-25%	Dry, loose, single-grained, flows through fingers. (0 to 0.2)[2]	Very slightly coloured. Dry loose, flows through fingers. (0 to 0.4)[2]	Slightly coloured. Powdery, dry sometimes slightly crusted, but easily broken down into powdery condition. (0 to 0.5)[2]	Slightly coloured. Hard, baked, cracked, sometimes has loose crumbs on surface. (0 to 0.6)[2]

[1] Available water is the difference between field capacity and permanent wilting point.

[2] Numbers in parentheses are available water contents expressed as inches of water per foot of soil depth.

(2001) to use the trunk in the plum. Ebel et al. (1995) suggested using fruit growth to schedule irrigation in apples and Goldhammer and Ferreris (2001) presented protocols based on stem diameter measurements for irrigation scheduling in orchards.Reducing Irrigation Needs In Horticulture

As the population grows, there is no doubt that in the near future some of the water currently used by agriculture will be diverted to the competing sectors of society. For horticultural crops in intensely irrigated areas such as California and Florida where the use of drip and small irrigation has become widespread, the efficiency of application in well-designed, maintained and managed systems is already high. The two required components of the water budget approach to irrigation scheduling Kc and ET were created with decades of research.

Reducing Surface Evaporation

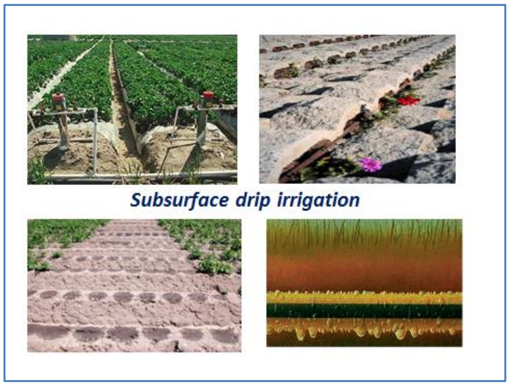
One of the obvious methods of reducing ET is to reduce or eliminate E because it has no direct effect on crop production as with T. In vegetable crops, potential E savings by switching to drips are negligible, as evaluated in a scale study Thaw, where the drip ET and the tomato irrigated were equal (Pruitt et al., 1984).

However, in tree crops, E savings in the early years of the orchard are significant when the surface system is changed to small irrigation (Fereres et al., 1982). During the past two decades, drip emitters have been developed to combat root infiltration, which is the most troublesome factor in developing subsurface drip.

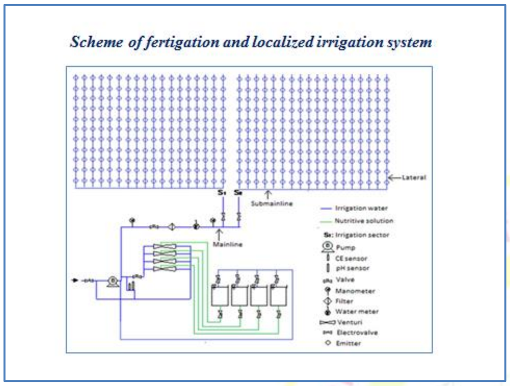
Irrigation Deficit and Stress Management

Not using cultivated areas or switching to winter crops that use less water than summer crops is the most direct way to reduce water demand for modern and efficient agricultural operations and is to reduce the actual consumption of plants. Impotence irrigation is the application of water below the ET rate and can be done in many fashions. Deficient or continuous irrigation of the deficit is the systematic application of water in a fixed portion of the probable ET throughout the season. RDI is implemented by imposing water deficits only at certain stages of crop growth (Chalmers et al., 1981). It should be understood that, depending on the levels of stored soil water and rainfall patterns and amounts, deficient irrigation may or may not reduce ET to its maximum potential.

The potential to provide irrigation water from the deficit of orchard crops has not been explored relatively yet. This is due to the lack of irrigation in most field and zero crops, the oldest and most researched crop plants usually reduces yields, and therefore the profit is directly proportional to the size of the ET deficit. The prospects for reducing ET in many vegetable crops are also limited because most relationships between the crop and ET are linear. However, the nature of tree crop production, where fruit instead of biomass is a marketable product and the quality of the fruit is important, provides the ability to use irrigation deficits to reduce water use while maintaining farm profitability or even improving it without changes in the cultivated area and / or patterns Crops.



Subsurface drip irrigation



Scheme of fertigation and localized irrigation system

Increase the area where impotence irrigation can be used effectively to save water by reducing T. The initial work of RDI in the 1970s in Australia and New Zealand was aimed at reducing vegetative growth and, consequently, summer pruning, in late-ripening peach trees. Associated water savings were of secondary importance. The researchers succeeded in maintaining or even increasing yields when they stressed only trees in the slow fruit growth stages and saved about 25% of potential ET (Mitchell et al., 1989). Researchers in Spain and California tried to reproduce these results under different conditions and failed (Girona et al., 1993, 2002; Goldhamer et al., 2002). This explains the specificity of RDI results and how convertibility requires adjustments to diversity, soil type, and evaporative demand.

A common feature of many impotence irrigation systems is the improvement of fruit quality, as has long been reported by Oreo and Magnes (1967). The protests carried out numerous experiments that clearly demonstrated that mild water deficits enhance the quality of apples (Proebsting et al., 1984). By working with mature navel oranges, Goldhamer and Salinas (2000) found that the yields of the applied fruit and water are linearly related but with a slope above the 1: 1 relationship.

Unlike the appearance of fruit, horticultural crops often have other unique productive ingredients that can be used to reduce T without reducing farm profit. One example is the hydration of fruits in peach orchards. Goldhamer et al. (1994), Mabinin et al. (2001) showed that within 6 to 8 weeks before harvest, water stress can reduce fruit hydration without affecting the weight of dry fruits or the subsequent load of fruits. In addition, energy is provided and 200 to 250 mm of water, as the plum should be dried in the ovens. The rapid growth of the nucleus and shell structure occurs in the first three to four weeks of the season but the rapid growth of the nucleus does not begin until about week 10. Therefore, RDI (100 to 200 mm of water below potential ET) can be imposed between these two periods without negative effects on production (Goldhamer and Beede, 1992). In the olive, Moriana et al. (2003) demonstrated that the relationship between ET and yield is linear.

Deficient irrigation after harvest may be another way to conserve water in some species. Larson et al. (1988) With peach trees in the early harvest season, reducing the number of surface irrigation after harvest by more than half did not adversely affect the production of orchards later. A distinction must often be made between the current and potential positive effects of RDI. An example of this can be found in almond trees. Goldhamer and Viveros (2000) have demonstrated that the moderate stress imposed by the SDI system (water applied at 85% of ET) does not affect production. However, potentially more significant outcomes included medium to severe RDI systems prior to the harvest (April-July). These strategies reduced the size of the parachute and the weight of the individual core but had no effect on the fruit load.

In other words, smaller and smaller RDI trees have a higher fruit density than fully irrigated trees. Consequently, increasing the intensity of cultivation under RDI can increase yields compared to fully irrigated orchards with standard intensity. Moreover, this type of RDI will address two critical health issues facing the industry - agricultural burn and dust during harvest. The first will be reduced or eliminated due to a significantly lower vegetative drop and pruning residue. The latter will be eliminated because earlier splitting of the structure Goldhamer and Viveros (2000) will allow the nuts to dry on the trees and be harvested directly into boxes or carriers, rather than drying and harvesting on the ground, which is the current practice that produces dust during wiping and nut retrieval. Ant damage and soil borne bacteria infection will also be eliminated using this RDI-driven technology. Grape is another crop where stress management has improved the quality of fruits. In fact, it was illegal to irrigate wine grapes until recently in some countries, such as Spain, simply because of the noticeable negative impact on the quality of wine.

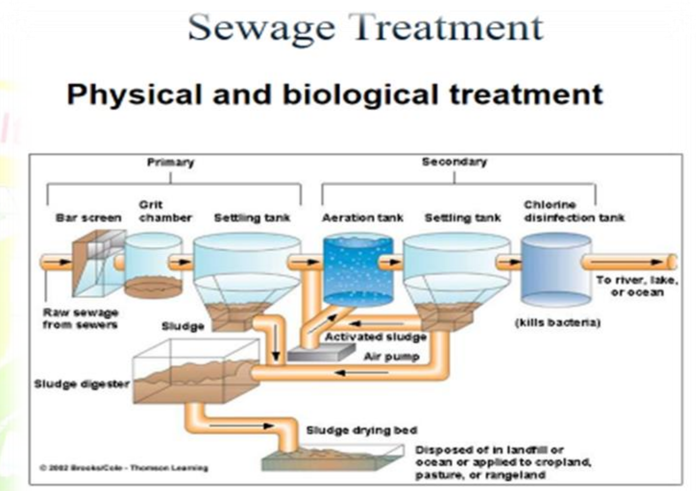
The lack of water reduces the size of the berries at harvest and thus increases the ratio of the skin to the pulp, resulting in a more appropriate color and flavor. The lower RDI yield is reflected in the smaller and lesser berries per cluster and fewer clusters per vine. Ecologists usually say this is more than compensating for the improved wine quality. Recently, the beneficial aspects of root zone partial drying (PRD) - a technique where deficits are applied by alternating watering on each side of the tree or vine almost every two weeks on wine grape production has gained much attention as a technique that applies RDI to improve wine quality while reducing T (Stoll et al., 2000). The hypothesis behind this approach is that hormonal signals from the dry part of the roots change the division and reduce vegetative growth, allowing better penetration of light that improves the quality of the fruit.

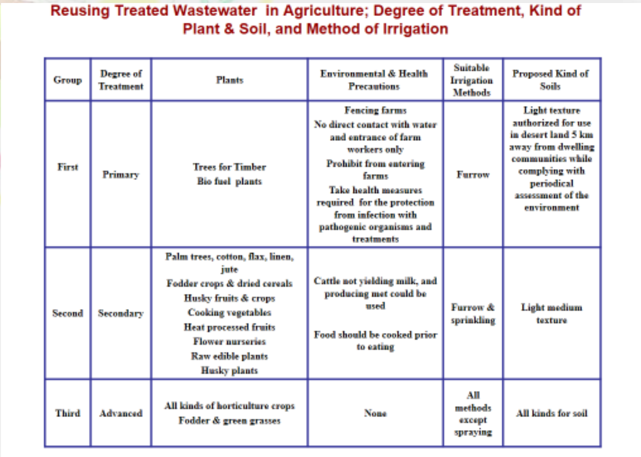
However, Goldhamer et al. (2002) on Peaches and Caspari et al. (2002) on comparing apples to traditionally applied RDI and PRD systems reported no differences in yields and quality standards between placement methods and thus do not support positive claims by PRD supporters of these two types. Reducing the crop water requirements in gardening should be based on a systematic assessment of the benefits of managing stress. There is an urgent need to invest in the research needed to document the benefits of stress in terms of 1) improving fruit quality, 2) reducing consumer use or irrigation requirements, and 3) improving farmers 'profits. Without proven benefits, stress management strategies will not be adopted by most farmers.

Increasing Supplys: The Use of Reclaimed Water

An indirect benefit of irrigation deficiency is the more efficient use of precipitation, as partial water depletion of the soil allows rain to be captured within the crop root zone, thus reducing drainage losses. Current developments in weather forecasting can help develop flexible deficit irrigation strategies that leave some storage capacity for expected rain. Future irrigation schedules should be designed to achieve the most effective use of monsoons as a means of increasing available supplies. Alternative water is the source of water. Treated water is treated wastewater that is recycled and used again. In the past, urban wastewater disposal has generally been dealt with by treating wastewater and then disposing in a more appropriate manner. Usually, this means draining water in a nearby river or lake, spraying it on a field, or loading it into a filtration pool. Disposal was the primary consideration as the amount of wastewater continued to increase as an unavoidable consequence of population growth. With the increase in the volume of wastewater, concerns have been raised about the impacts on the drainage sites. This led to consideration of alternative uses such as irrigation.

Florida citrus growers initially refused to use reclaimed water because of concerns about potential heavy metal contamination, potential disease problems, floods, and a lack of flexibility in water use during periods of heavy rains. Farmers also raised concerns about public perceptions and feared the degradation of the quality of fruit from trees irrigated with treated water. Fears proved to be unfounded, and citrus performance was very good even at excessive irrigation rates (2500 mm / year) with treated water (Parsons et al., 2001). Reclaimed water is now used in about 80,000 hectares of public access areas, golf courses, and agricultural crops in Florida (Florida DEP, 2002). Many severe droughts have increased interest in the use of reclaimed water, and Florida now leads the nation in its total reuse flow, followed by California, Texas, and Arizona. The four states that account for more than 90% of water reuse in the United States will continue and a reliable source of irrigation water will continue to be used in Future increase.





Reusing Treated Wastewater in Agriculture; Degree of Treatment, Kind of Plant & Soil, and Method of Irrigation

Group	Degree of Treatment	Plants	Environmental & Health Precautions	Suitable Irrigation Methods	Proposed Kind of Soils
First	Primary	Trees for Timber Bio fuel plants	Fencing farms No direct contact with water and entrance of farm workers only Prohibit from entering farms Take health measures required for the protection from infection with pathogenic organisms and treatments	Furrow	Light texture authorized for use in desert land 5 km away from dwelling communities while complying with periodical assessment of the environment
Second	Secondary	Palm trees, cotton, flax, linen, jute Fodder crops & dried cereals Husky fruits & crops Cooking vegetables Heat processed fruits Flower nurseries Raw edible plants Husky plants	Cattle not yielding milk, and producing met could be used Food should be cooked prior to eating	Furrow & sprinkling	Light medium texture
Third	Advanced	All kinds of horticulture crops Fodder & green grasses	None	All methods except spraying	All kinds for soil

Strategic Water Resource Management In Horticultural Crops

Strategic management of water resources refers to all competing water demands and seeks to allocate water on a fair basis to meet all uses and demands. The will to treat and reuse water has a crucial role in sustainable development in the public, industrial and agricultural sectors. There are technologies in place to control many types of pollutants. The future challenge will be to control micro-pollutants and heavy metals. For water-intensive industries, reducing water consumption will become a necessity, and will be a major factor determining the market compatibility of industrial products. For the agricultural sector, new irrigation techniques will be required to minimize water consumption and prevent unsustainable groundwater extraction. Strategic water management is activities related to planning, development, distribution and management of the optimal use of water resources.

One fifth of the world's population, more than 1.2 billion people, live in water-scarce regions, where there is not enough water to meet all demands. An additional 1.6 billion people live in areas with economic water scarcity, where a lack of investment in water or insufficient human capacity makes it impossible for the authorities to meet the demand for water.Improvements have been made in the standardization of irrigation application and scheduling management steadily over the past century, which has resulted in increased water productivity, especially for horticultural crops. Low water availability, high costs, and increasing environmental concerns for agricultural water transfers are issues that farmers will not be able to ignore in the future. The solutions will not be easy and possibly multifaceted. The reuse of wastewater in selected agricultural crops is sure to expand. However, we believe that opportunities to improve application efficiency and develop new supplies of agricultural water will be increasingly limited in the future.

There are greater possibilities for developing more accurate methods for scheduling irrigation that use soil and more clearly the state of crop water as catalysts for applying irrigation water. This will require better technologies to monitor the state of the water, including robust and affordable sensors that can be linked to automatic system controllers.

In the future, the use of structured disability irrigation (RDI) should be more widespread, especially in areas with high water costs and high value crops. R&D innovation will depend on farmers ’awareness that they can save large amounts of water while managing water stress to improve some yield components in a number of important tree and vineyards. More broadly, the improved availability of more accurate ET information will increasingly encourage the adoption of scientific scheduling for irrigation where plant stress is not desirable. As research continues to provide new information and technologies, the often hostile relationships between urban, agricultural, and environmental interests in water resources are likely to be replaced by a more cooperative atmosphere created around established scientific facts.

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