Water Conservation
FACTSHEET

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DEVELOPING A TRICKLE IRRIGATION SCHEDULE USING SITE PARAMETERS

Efficient irrigation can be described as applying the crop's water needs, as required, to sustain optimum growth and production at the lowest capital and operating cost possible. Efficient irrigation is obtained by correctly designing and operating the irrigation system to match water, crop and soil management limitations. To develop an effective irrigation schedule that is appropriate for the irrigation system and crops being grown, the following parameters should be calculated.

Effective Soil Water Storage Factor (S)

The effective soil water storage capacity of the plant root zone, also known as the maximum soil water deficit (MSWD) depends upon the following:

i effective rooting depth of mature crops (Table 1)
ii available water storage capacity of the soil (Table 2)
iii availability of the stored water to the crop (Table 3)

Table 1 indicates the maximum effective rooting depth (RD) that can be developed by various crops. These rooting depths should be obtained providing good soil and moisture conditions are present and impermeable boundary layers do not exist.

Table 2 provides values on the available water storage capacities (AWSC) of various soils. The AWSC is the amount of water that can be stored in the soil against the force of gravity. As the soil texture becomes finer, more water can be stored.

Plants are capable of extracting only a portion of the water from the soil before being stressed. To obtain optimum production, the soil regime should be replenished before undue stress occurs. Table 3 indicates the maximum percentage that should be removed before irrigation is again required. This availability coefficient is the allowable depletion of moisture in the soil from field capacity.

The effective soil water storage factor (S) for trickle systems listed in Table 4 is dependent upon the MSWD (see equation below) and the peak ET rate (see Table 2.1 in ***B.C. Trickle Irrigation Manual***).

$$MSWD = AWSC \times RD \times AC$$

Soils and crops that have a high MSWD will have a lower S factor as the crop has more water to draw on during peak conditions. Very low MSWD conditions will have a high S factor (close to 1.0). The S factor increases as the peak ET rate increases.

Example :

What is the MSWD of a mature tree fruit crop growing in 4 ft of loam?

Table 1 Effective rooting depth (RD) = 4 ft

Table 2 AWSC = 2.1 in/ft

Table 3 Availability coefficient = 40% (0.40)

MSWD = 2.1 in x 4 ft x 0.40
= 3.4 in

Note that the AWSC is calculated to the rooting depth of the crop. If a boundary layer or soil conditions reduce the rooting depth, the AWSC must be calculated accordingly.

Table 1 Effective Rooting Depth (RD) of Mature Crops			
Shallow 1.5 ft	**Medium Shallow 2 ft**	**Medium Deep 3 ft**	**Deep 4 ft**
Cabbages	Beans	Brussels Sprouts	Alfalfa
Cauliflowers	Beets	Cereals	Asparagus
Clover (Ladino)	Blueberries	Clover (Red)	Blackberries
Cucumbers	Broccoli	Corn (sweet)	Corn (field))
Lettuce	Carrots	Eggplant	Grapes
Onions	Celery	Kiwifruit	Loganberries
Pasture	Peas	Peppers	Raspberries
Radishes	Potatoes	Squash	Sugar Beets
Turnips	Strawberries	Saskatoons	Tree Fruits (12’ x 18’)
	Tomatoes	Tree Fruits (6’ x 13’)	
	Tree Fruits (3’ x 10’)		

Table 2 Available Water Storage Capacities (AWSC) of Soils	
Textural Class	**AWSC [in/ft]**
Sand	1.0
Loamy Sand	1.2
Sandy Loam	1.5
Fine Sandy Loam	1.7
Loam	2.1
Silt Loam	2.5
Clay Loam	2.4
Clay	2.4
Organic Soils (muck)	3.0

Table 3 Availability Coefficients (AC) of Crops	
Crop	**Maximum Percent [%]**
Peas	35
Potatoes	35
Tree Fruits	40
Grapes	40
Tomatoes	40
Other crops until additional data becomes available	50

Table 4. Effective Soil Water Storage Factor (S)		
Effective Soil Water Storage Capacity [in]	**Peak ET Rate [in/day]**	**S Factor**
3.0+	0.30 0.25 0.20	0.80 0.75 0.75
2.0	0.30 0.25 0.20	0.85 0.80 0.75
1.0	0.30 0.25 0.20	0.95 0.90 0.85

Crop Coefficient Factor (K)

The crop coefficient factor (K) accounts for the field area that is not utilized by the plants’ canopy or root area. The crop coefficient factors listed are for mature crops and can only be used if actual plantings closely approximate the plant spacings shown in Table 5. For larger plant spacings, the crop coefficient factors may possibly be reduced.

Table 5. Crop Coefficient Factor (K)		
Plant	**Crop Coefficient**	**Approximate Spacing**
Apples Apricots Cherries Peaches Pears Plums	0.90 0.80 0.90 0.80 0.80 0.80	7’ x 12’ to 20’ x 20’
Tree Fruits – High Density	1.00	3’ x 10’ to 5’ x 12’
Grapes	0.70	5’ x 12’
Blueberries	0.80	5’ x 10’
Blackberries	0.60	8’ x 10’
Kiwi Fruit	1.00	15’ x 15’
Logan Berries	0.60	2.5’ x 10’
Raspberries	0.70	2.5’ x 10’
Strawberries	0.75	1’ x 4’
Tomatoes	0.90	1.5’ x 5’
Vegetables	0.75	1’ x 3’

Plant Water Requirement (G/P/D)

The amount of water to be applied to a parcel of land by a trickle irrigation system will depend on climatic conditions, soil characteristics, crop type and plant spacings. The plant water requirement (G/P/D = US gallons per plant per day) is calculated using peak evapotranspiration (ET), effective soil water storage

factor (S), plant area (A) and crop coefficient (K) as shown in the equation below:

$$G / P / D = 0.623 \times ET \times S \times A \times K$$

Refer to Table 2.1 in the ***B.C. Trickle Irrigation Manual*** for peak evapotranspiration rates for various locations in B.C.

Leaching Requirement (L)

Irrigation water contains some salts. To prevent the build-up of salts within the wetted plant root volume, additional irrigation should be applied to ensure salts are leached beyond the plant rooting zone. To ensure that the trickle system has the capacity to apply the leaching requirement, it must be added to the design requirement (Table 6). The trickle system manager must ensure that enough water is applied during the irrigation season to ensure that leaching of salts does occur.

Table 6. Leaching Factor (L)

Region or Special Conditions	Rooting Depth (RD)	Leaching Factor (L)
Okanagan, Kootenays, Thompson	< 2 ft > 2 ft	1.05 1.10
South Coastal	All rooting depths	1.00
Fertigation Systems	All rooting depths	1.10

Application Efficiency (E)

The application efficiency (Table 7) takes into account losses due to evapotranspiration during the application process and from the soil surface after application. Not all of the water applied will be available to the plant.

Table 7. Trickle Irrigation System Efficiencies

Trickle Irrigation System	Application Efficiency
Spray or Microjet	85%
Drip	90%
Mulch cover such as straw or shavings	93%
Plastic Mulch	95%
Subsurface Drip	95%

Emission Uniformity (Eu)

Emission uniformity (Eu) assesses the uniformity of a new system and uses the manufacturer's coefficient for the emitter and pressure variation. For trickle irrigation system, an Eu of 85 – 90% should be used. Ensure that the system is designed to meet the Eu chosen.

Trickle System Design Requirement (TC)

The trickle system design requirement must take into account the plant water requirement (TC), a leaching factor (L), an application efficiency (E) and an emission uniformity (Eu). Refer to the equation below:

$$TC = \frac{G / P / D \times L}{E \times Eu}$$

Lateral Water Movement Radius

The amount of lateral movement achievable will be determined by the rate and duration of application. The lateral water movement will determine how many emitters should be provided for each plant to ensure that enough of the root zone is irrigated. The values of lateral water movement in Table 8 below are for point source systems operating on the surface. These are maximum values assumed for deep-rooted crops with the right combination of application rate and duration.

Table 8. Lateral Water Movement in Soils from Surface Point Source Emitters

Soil Type	Lateral Movement [ft]	
	Shallow Soil < 2 ft	Deep Soil > 2 ft
Coarse Sand	0.5	1.5
Fine Sand	0.75	2.5
Loamy Sand	1.0	3.0
Silt, Silt	1.0	3.0
Sandy Loam, Loam	1.25	3.5
Clay	1.5	4.0

Total System Operating Time

The maximum operating time per zone should not exceed 12 hours. This will allow lateral lines to drain, and allow a proper air-water balance to be maintained in the soil to reduce algae growth.

For drip line systems,

$$Irrigation\ Output = \frac{Emitter\ Flow\ Rate\ per\ 100\ m \times E}{No.\ of\ Plants\ per\ 100\ m \times 100\%}$$

For emitter systems,

$$\text{Irrigation Output} = \frac{\text{Emitter Flow Rate} \times \text{No. of Emitters per Plant} \times E}{100\%}$$

The operating time per zone can be obtained by using the following equation:

$$\text{Zone Operating Time} = \frac{G / P / D}{\text{Irrigation Output}}$$

The total system operating time calculated using the equation below should not exceed 20 hours during peak climatic requirements; otherwise, it suggests that the emitter flow rate be adjusted.

$$\text{Total System Operating Time} = \text{Zone Operating Time} \times \text{No. of Zones}$$

The irrigation system manager can use the above values in making scheduling decisions. The use of soil moisture monitoring devices should be used in conjunction with the operational parameters in making a decision on when to start a new irrigation interval. Additional information is available from other factsheets and the ***B.C. Trickle Irrigation Manual***.

Below is an example of how to prepare an irrigation schedule for a trickle system. A blank version of this information sheet is provided at the back as working copies.

Example

Crop and Soil Report

Pit	Crop	Root Depth (RD) [ft]	Soil Texture	AWSC [in/ft]	Max. Lateral Water Movement Radius [ft]
A	Tree Fruits	4	Loam	2.1	3.5
B	Grapes	3	Sandy Loam	1.5	2.5
C					

Design Parameters

	FIELD/BLOCK 1		FIELD/BLOCK 2	
Crop	Tree Fruit		Grapes	
Root Depth (RD)	4	ft	3	ft
Soil Type	Loam		Sandy loam	
Effective Soil Water Storage Capacity or Maximum Soil Water Deficit (MSWD) = AWSC x RD x AC	3.4	in	1.8	in
Evapotranspiration Rate (ET) for location Kelowna	0.24	in/day	0.24	in/day
Effective Soil Water Storage Capacity Factor (S)	0.75		0.80	
Plant Spacing	10 ' x 15 '		5 ' x 10 '	
Plant Area (A)	150	ft^2	50	ft^2
Crop Coefficient Factor (K)	0.90		0.70	
Leaching Factor (L)	1.10		1.10	
Application Efficiency (E) (microjet – tree fruit, drip – grapes system)	0.85		0.90	
Emission Uniformity (Eu)	0.90		0.90	

Plant Water Requirement

Gallons/Plant/Day (G/P/D = 0.623 x ET x S x A x K)	15.1	G/P/D	4.2	G/P/D
Trickle System Design Requirement (TC) = $\frac{\text{G/P/D x L}}{\text{E x Eu}}$	21.7	G/P/D	5.7	G/P/D

Design Data

Emitter Type	Spray		Point Source	
Emitter Operating Pressure	20	psi	15	psi
Emitter Discharge	5.7	gph	1.0	gph
Emitter Spacing	2 @ 10	ft	3	ft
Emitters per Plant	2		1.67	
Zone Operating Time per Day (must be < 12 hr)	2.0	hr/day	3.4	hr/day
Zone Flow Rate	72	gpm	49	gpm
Number of Zones	5	zones	3	zones
Total System Operating Time (Zone Op. Time x # of Zones)	10	hr	13.5	hr
Total System Operating Time for all fields/blocks	**23.5**	**hr**		

TRICKLE IRRIGATION SYSTEM SCHEDULE

Farm Name: _____
Farmer's Name: _____
Date: _____
Water Source Flow Rate: _____ gpm
Pressure at Water Source: _____ psi

Schedule Developed by:

_____ Name _____ Signature

☐ Registered Environmental Farm Plan Planning Advisor

☐ Certified Irrigation Designer

Crop and Soil Report

Pit	Crop	Root Depth (RD) [ft]	Soil Texture	AWSC [in/ft]	Max. Lateral Water Movement Radius [ft]
A					
B					
C					

Design Parameters	FIELD/BLOCK 1	FIELD/BLOCK 2	FIELD/BLOCK 3	FIELD/BLOCK 4
Crop				
Root Depth (RD)	ft	ft	ft	ft
Soil Type				
Effective Soil Water Storage Capacity or Maximum Soil Water Deficit (MSWD) = AWSC x RD x AC	in	in	in	in
Evapotranspiration Rate (ET) for location _____	in/day	in/day	in/day	in/day
Effective Soil Water Storage Capacity Factor (S)				
Plant Spacing	' x '	' x '	' x '	' x '
Plant Area (A)	ft^2	ft^2	ft^2	ft^2
Crop Coefficient Factor (K)				
Leaching Factor (L)				
Application Efficiency (_____ system)				
Emission Uniformity (Eu)				
Plant Water Requirement				
Gallons/Plant/Day (G/P/D = 0.623 x ET x S x A x K)	G/P/D	G/P/D	G/P/D	G/P/D
Trickle System Design Requirement (TC) = $\frac{\text{G/P/D x L}}{\text{E x Eu}}$	G/P/D	G/P/D	G/P/D	G/P/D
Design Data				
Emitter Type				
Emitter Operating Pressure	psi	psi	psi	psi
Emitter Discharge	gph	gph	gph	gph
Emitter Spacing	ft	ft	ft	ft
Emitters per Plant				
Zone Operating Time per Day (must be < 12 hr)	hr/day	hr/day	hr/day	hr/day
Zone Flow Rate	gpm	gpm	gpm	gpm
Number of Zones	zones	zones	zones	zones
Total System Operating Time (Zone Op. Time x # of Zones)	hr	hr	hr	hr
Total System Operating Time of all fields/blocks	**hr**			

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