Selecting Proper Dripper Discharge Rate & Spacing

for Various Crops in Different Soil Types

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Ministry of Foreign Affairs

Content

Fresh herbs production

Cotton under drip irrigation at the 70′

Background

Drip irrigation has been an accepted and popular method for decades for irrigating many types of crops: vegetables, row crops, and orchards, both in open fields and in greenhouses. In its first decade, during the early twentieth century, the drip irrigation method was used in small areas, mainly in greenhouses, with drippers made from brass. The breakthrough for using drip irrigation in a large-scale onopen fields came during the mid-twentieth century with the development of the plastic industry which manufactured polyethylene pipes produced by extrusion and other plastic products produced using templates.

During the last twenty years, the integral dripper was developed, in which the path for the waterflow is template produced and transplanted inside the the plastic pipe while producing it, thus creating the dripper as an integral part of the pipe (lateral). The integral dripper piping is manufactured in a range of pipe wall thicknesses, enabling flexibility in choosing the appropriate piping for the specific farming area at affordable and different costs.

In general, the waterflow pathways of the drippers are produced with various discharge rates (0.6 to 24 l/h), (with or without internal pressure regulation and the capability of the waterflow pathways to resist clogging when using poor quality water. The choice of pipe wall thicknesses for the lateral, and the options for different discharge rates and operational conditions, offer the farmers and the agricultural planners flexibility and many options to choose from.

The outstanding characteristic of the drip irrigation method is its ability to bring the water directly to the soil adjacent to the plant. The drippers can be placed on the soil surface or buried under the surface. The discharge rate for individual drippers and their placement in relation to the plant is of utmost importance and contributes enormously to the efficient use of water in all stages of plant growth, from planting , establishment and fruition.

Based on accumulated experience with the drip irrigation method, it can be said that it has the potential to increase water and nutrient (fertilizer) efficiency, through fertigation while reducing contamination of the ground water.

An additional significant advantage of the drip irrigation method is the shortening of the time from the beginning of growth in the vegetative stage to the productive stage. This effect is important and can be exploited both in locations/places/situations where the summer is relatively short, and where the traditional method of farming starts/begins during colder periods. When planting during cold periods, protective measures need to be taken to protect the plants during early stages of growth, usually by means of various types of covering material (each method of protection adds expensives). The drip irrigation method allows the farmers to delay the sowing or planting date (in comparison to the date when using traditional agriculture irrigation), and enables the crop to ripen prior to the arrival of the colder weather at the end of the summer, thereby saving additional costs of protecting the crop as it ripens.

Efficient use of water and nutrients through the drip irrigation, *depends firstly, on the following components of the drip irrigation system:*

A. Discharge rate of individual drippers.

B. The distance between the drippers.

C. The number of laterals and their placement in relation to the spacing of plants and number of rows of the crop.

Secondly, on the soil and crop conditions:

1. Soil characteristics:

1.1. type of soil - light, medium, heavy.

1.2. ability of the soil to absorb water and sensitivity to creating surface crust.

1.3. Soil depth,

1.4. uniformity of the soil layers

1.4. the existence of an impermeable soil layer which hinders drainage.

2. Characteristics of the crop:

herb, grass, vine, bush or tree, the number of units growing per unit of land (plant population/density/stand)

3. Plant stage and physiological condition:

3.1. Sowing – germination until establishment of the plant. The drip irrigation method demands special attention for this stage. The method requires placing the dripper in close proximity to the seed.

3.2. Planting of seedlings or transplants until establishment of the plants. This stage will generally continue until the plant's roots develop in the soil. The placement of the dripper is very important in this phase too. For growing vegetables, this is a relatively short peroid. For trees, this is a longer stage. The dripper placement requires special attention because the sapling ortransplant needs to develop its root system for support in the soil and be able to withstand strong windy periods or short-term severe weather. Aiding the tree to develop a deep root system can be accomplished by using/placing a small number of additional drippers around the trunk. These drippers will provide water to the areas below the roots, causing the root system to develop deep in the soil and strengthen the tree's ability to hold itself upright.

3.3. Vegetative stage

3.4. Productive stage

The major/principle consideration for choosing the appropriate drippers for the various agricultural crops is to obtain uniform irrigation for the specific plot without over watering below the root zone. There are many instances/cases of water and nutrient waste caused by an improper choice of drippers. An additional consideration is to achieve an overlapping of the wetted volumes of adjacent plantsin order to prevent salinity build up and to create a humid microclimate around the plants.

The proper depth of the wetted zone should be determined by the effective depth of the root system and in conjunction with the water quality. Use of brackish water requires wetting an area beyond the root system's effective depth in order to leach salts and to prevent accumulation of salts in the root zone.

Illustration A, shows a lack of uniformity in water dispersion throughout the root zone, and creation of areas with salt accumulation between the wetted volumes created by each dripper, and wasted water below each dripper location.

Illustration A1, shows a cross section of wetted volumes created by, 2 l/h drippers spaced 40 cm apart in the drip line (lateral).

Illustration A2, shows the same as 3D

ILLUSTRATION A1

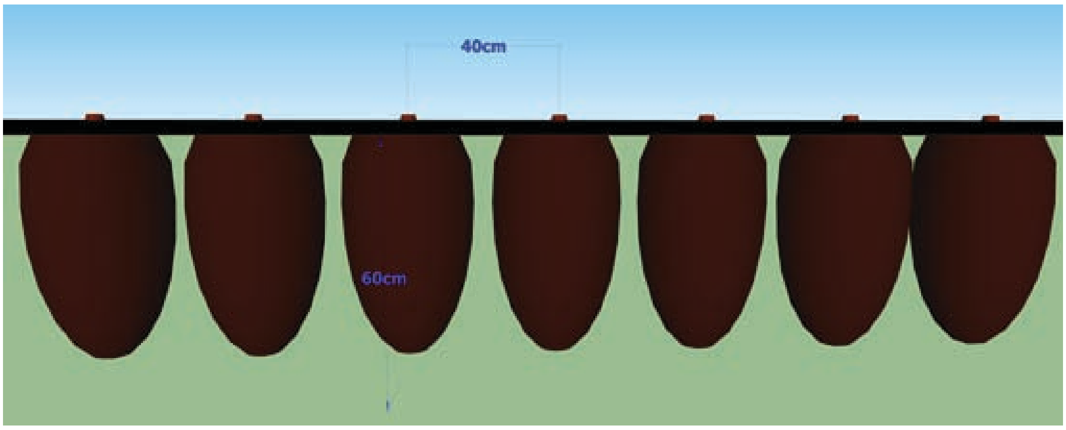


ILLUSTRATION A2

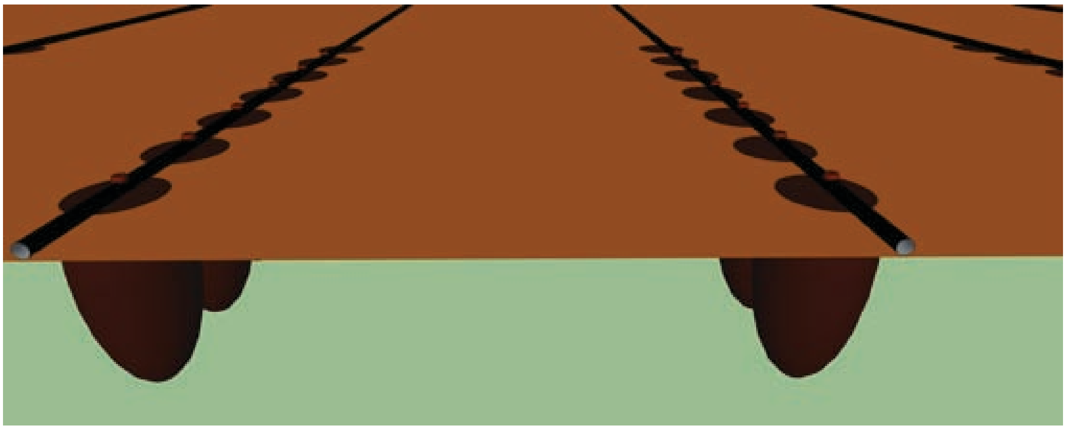


Illustration B, shows dispertion of water dispersion in the root zone, over lapping of the wetted volumes, reduction of salt accumulation, and prevention of water waste below the dripper locations and below the root zone

Illustration B1, shows a cross section of wetted volumes created by, 2 l/h drippers spaced 20 cm apart in the drip line (lateral).

Illustration B2, shows the same as 3D.

ILLUSTRATION B1

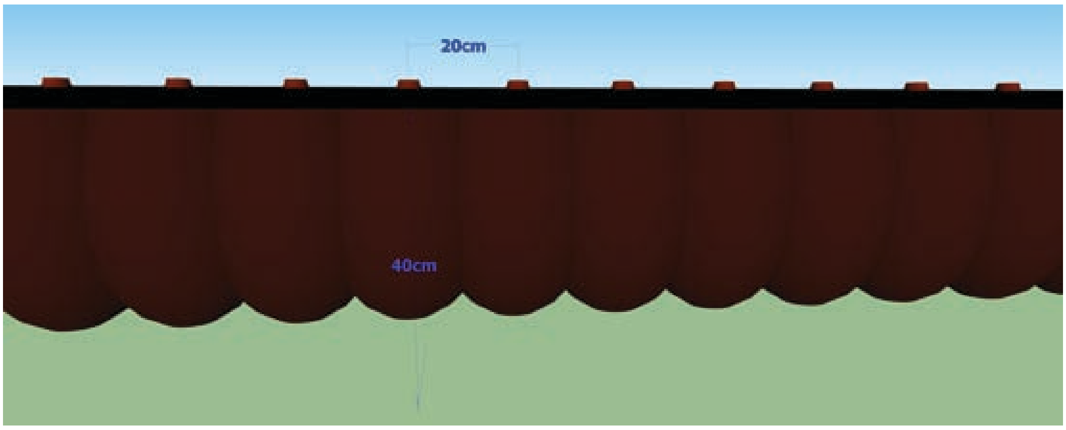
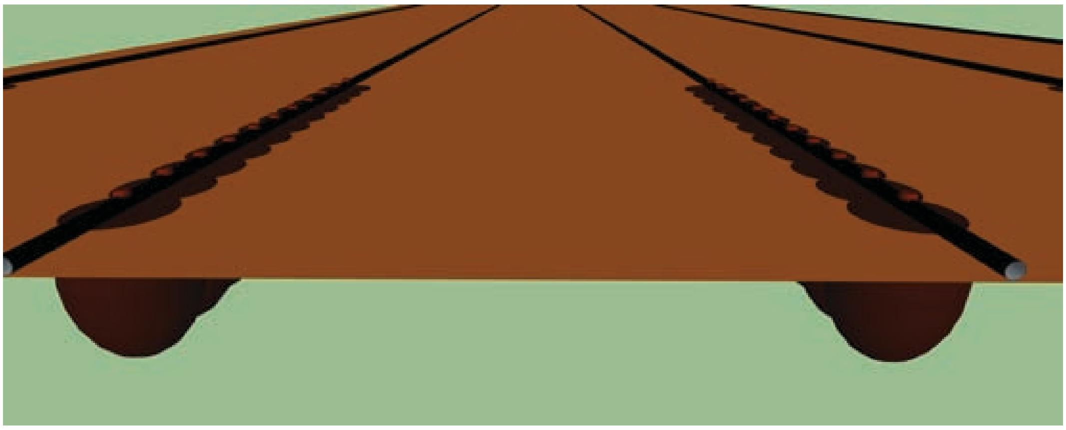


ILLUSTRATION B2



Types of drippers

Two types of drippers are common: Pressure regulated and nonpressure (regular).

- A **regular** dripper is produced with a molded (non-flexible) waterflow pathway. The waterflow in this type of dripper is influenced by the entrance pressure of the water.
- A **regulated** dripper is constructed, in addition to the non-flexible waterflow pathway, with a diaphragm within a regulator. Its discharge rate does not change as a result of changes in the water pressure as long as they are within the specific regulated range.

The two types of drippers both have a waterflow pathway. In modern-day drippers the waterflow pathway is constructed from two components:

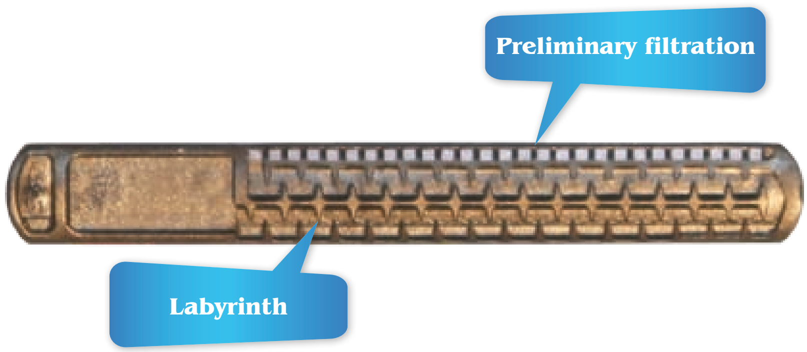
A. Preliminary filtration

B. A waterflow pathway called the labyrinth, for lowering the pressure inorder to achieve the desired discharge rate.

The flow through the labyrinth in modern drippers is turbulent, which enables attaining small discharge rates (2 l/h and less) using similarlabyrinth dimensions that delivered 4 l/h in the past. This condition enables secure and reliable usage of drippers that can deliver discharge rates between 1-2 l/h.

Illustration C. The structure of the water pathway of a modern dripper:

ILLUSTRATION C



Integral Drippers: Laterals and drippers

Two distinct families of drip irrigation piping exist, in which the dripper is an integral part of the pipe, in accordance with the lateral's wall thickness.

A. Lateral with normal or less than normal wall thickness of 0.9-1.2 mm.

B. Thin-walled lateral (tape), wall thickness of 0.2-0.6 mm. The wall thickness can be also measured in mil. [mil = 0.001 of an **inch** (0.0254 mm)].

A. Lateral with thick or medium wall thickness or thin wall thickness

A.1. Lateral with normal wall thickness (1.2 mm) and maximum working pressure: 4 atm.:

These laterals are suitable for multi-season use

- these are appropriate for vegetable and row crops for open fields and for using specially designed equipment for rolling up the laterals at the end of the season for reuse over a number of growing seasons.
- This type is suitable for orchards and can be reused for many years. Past experience has shown that this family of laterals can be used for up to 25 years.

For laterals with both thick and medium wall thickness there are two types of drippers (waterflow pathways) from the operational characteristics: **unregulated** and **regulated**. Waterflow pathways intended for thick-walled laterals are designed to perform for lengthy periods of time in fields with problematic water conditions.

Waterflow pathways are made of rigid plastic material and manufactured separately in a process using molds. In an **unregulated** dripper the entire waterflow pathway is one part, that is, molded as one piece. In a **regulated** dripper the waterflow pathway is constructed from two separate parts – two molds are used to produce rigid parts and an additional mold for producing the diaphragm (which has the responsibility for regulating the waterflow). The parts must be assembled to obtain the complete (regulated) waterflow pathway. The waterflow pathway is inserted in the polyethylene lateral during production by using an extruder.

A.2. Laterals with thinner wall thickness (0.9 mm) maximum working pressure: 3 atm:

This type of lateral is also intended for extended use during a number of growing seasons. Attention must be paid to the fact that the overall water pressure needs to be lower or equal to 3 atm., especially when employing regulated drippers. The cost of a lateral with a thinner wall thickness is understandably lower.

B. Strip laterals (tapes) with a thin wall

These laterals are appropriate for use during a single growing season or, at best, a limited number of seasons.

- For growing vegetables and row crops this type of equipment is especially fitting for large stands of crops. that is characterized by the need for a large number of drippers. It can be said that the thinnest of all the equipment is serviceable for a single season and only with clean water. Equipment with a thicker wall is manufactured to be used for a number of seasons, as long as the equipment is laid out in the fields and rolled up at the end of the season with equipment especially made for that purpose.
- For orchards this type of equipment meets the needs of the first year of growth during which the saplings establish themselves. In the following years this equipment will be replaced by equipment that will be in place for multiple seasons and place somewhat differently in comparison with the equipment of the first year.

Strip laterals (tapes) with a thin wall thickness are between 0.2 mm (the thinnest) and 0.6 mm. The maximum working pressure changes in accordance with the lateral's wall thickness. When the wall thickness is 0.2 mm, maximum working pressure will be only 0.7 atm. This kind of lateral is intended for a single growing season with Deployment at the beginning of the season and collection at the end in order to remove it from the area. It will not be reused for future crops. The wall thickness determines the lateral's lifetime. In the group of thin-walled laterals there is only one unregulated waterflow pathway. The waterflow pathway is characterized by very small water gateways. The waterflow pathways of thin-walled laterals can be divided into two groupings:

B.1. The waterflow pathway is created by a type of " VACUUM FORMING"

The waterflow pathway is constructed of the same material as the drip pipe. Manufacturing the piping and the dripper is completed in a single step.

B.2. The waterflow pathway is molded using rigid plastic.

The pathway is inserted into the lateral during production. There are three types of waterflow pathways formed using a mold:

- The waterflow pathway intended for laterals with the thinnest of wall thicknesses - a pathway with the smallest gateways (includes the preliminary filtration) is intended for a single season (as are the thin-walled laterals). The waterflow pathway can be installed at different distances according to the need.
- The waterflow pathway intended for laterals with thicker wall thicknesses - a pathway with larger gateways (includes the preliminary filtration) is intended for a few seasons and therefor are installed in thicker-walled laterals. The waterflow pathway can be installed at different distances according to the need.
- Continuous waterflow pathway - This waterflow pathway is manufactured in a continuous mold (dripper after dripper, section after section) - each section contains the preliminary filtration and the waterflow pathway. The pathway is threaded into the lateral during production.

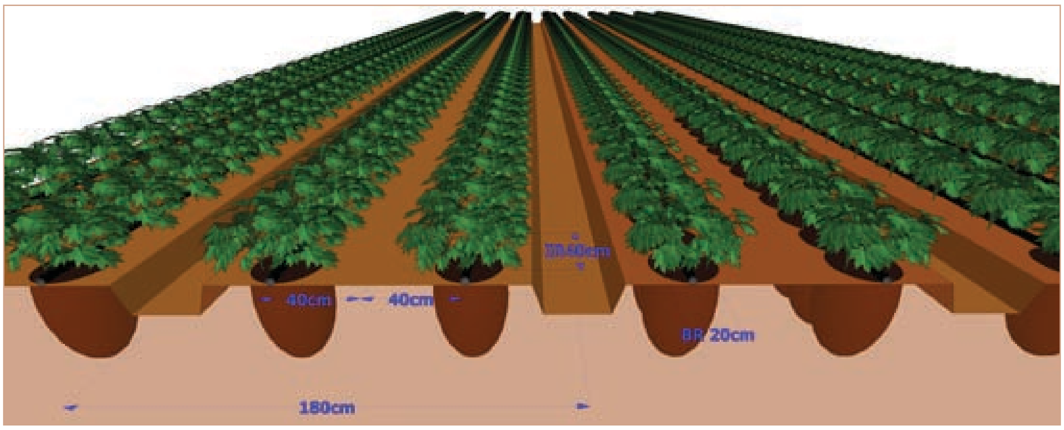
Choice of dripper and lateral:

When choosing the type of dripper and type of lateral there are situations in which it is easy to determine the right combination. These situations are described below:

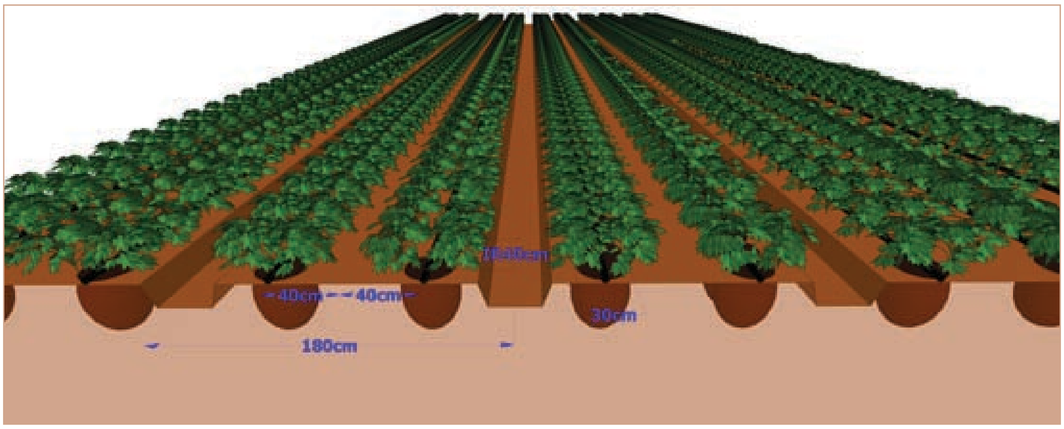
- Regulated dripper - Fits sloped areas: 2% and greater. In addition, a regulated dripper enables lengthening the lateral by exploiting the existing water pressure at the main valve of the farming plot. In order to take maximum advantage of the dripper's regulator properties the lateral should be of the proper wall thickness.
- Unregulated dripper - On both leveled surfaces and surfaces with a slope of up to 2% it is possible to lay a network on the farming plot such that uniformity in waterflow can be attained over the entire plot when using unregulated drippers. (The unregulated dripper's cost is lower than the regulated dripper.)
- Lateral with normal thickness or less than normal - For crops where the plant population is between 2000 and 3000 plants per dunam (20000-30000 per hectare) and the growing season is lengthy (from a few months to as much as a year) and the economic potential is large - it is recommended to use a lateral with normal wall thickness that is built with waterflow pathways are suitable for season after season.
- Thin-walled lateral - For crops that have more than 5000 plants per dunam (50000 per hectare), and when the desired number of drippers is 5000 or more per dunam (50000 or more per hectare), and when the number of laterals per garden-bed is 4 or more, consideration should be given to choosing strip (tape) laterals. The thickness of the lateral and the number of drippers required influence the cost of the drip irrigation system. This cost will be significantly lower when strip (tape) drippers are chosen. The cost of a regular lateral can be 2.5 to 5 times as expensive as a strip dripper. Note that most of the tape laterals are intended for use during a single season in spite of the manufacturers' descriptions.

Schematics of drip-irrigation systems in farms

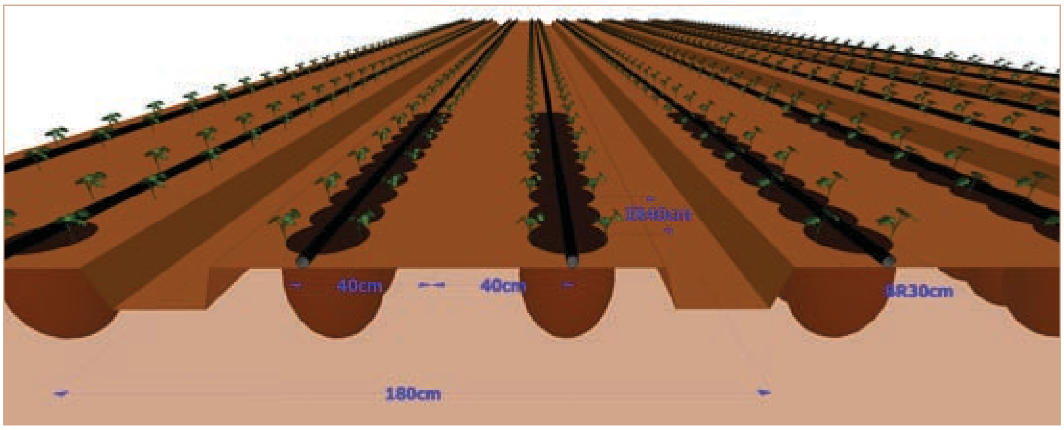
Scheme A Vegetables, Bed 180 cm, 4 rows (2 couples) 20cm apart, between plants 40 cm mature plants



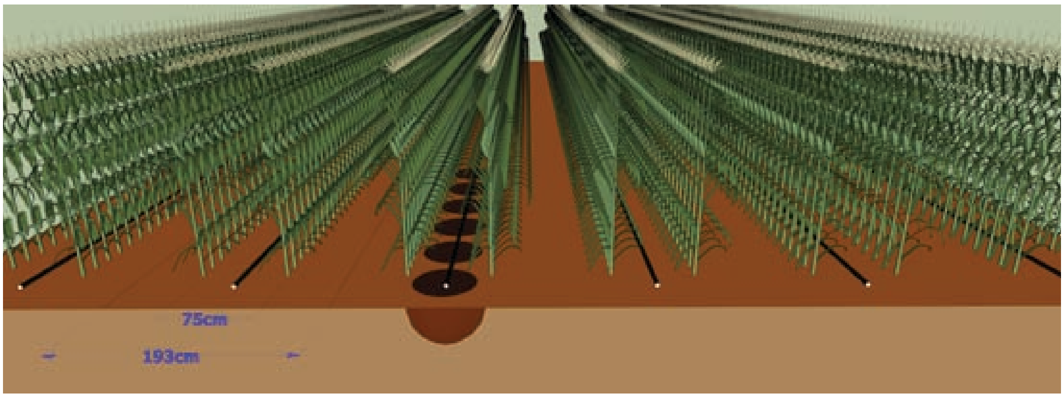
Scheme B Vegetables, Bed 180 cm, 4 rows (2 couples) 30cm apart, between plants 40 cm mature plants



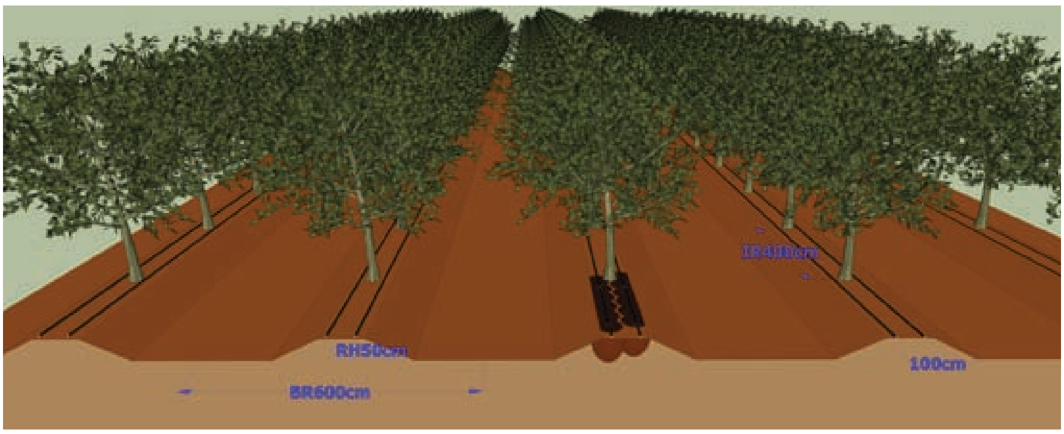
Scheme C **Vegetables, Bed 180 cm, 4 rows (2 couples) 20cm apart, between plants 40 cm mature plants**



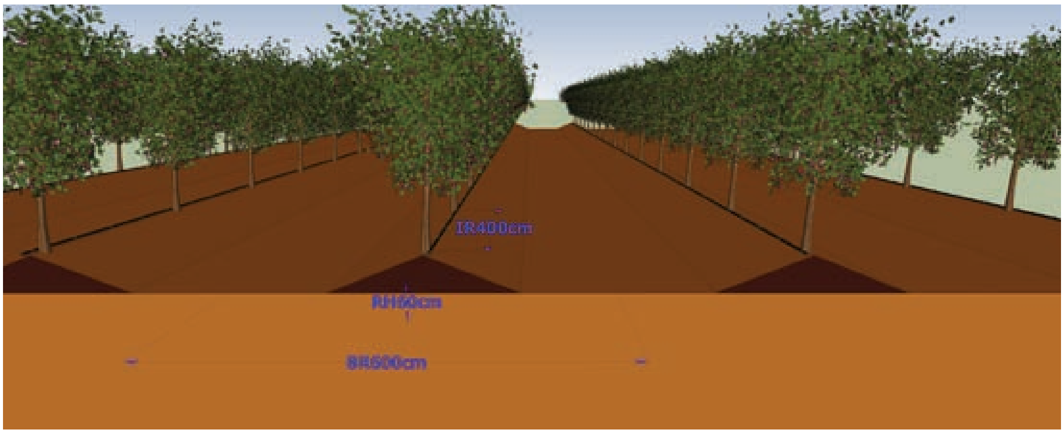
Scheme D **Corn couple of rows 193 cm apart, 1 lateral**



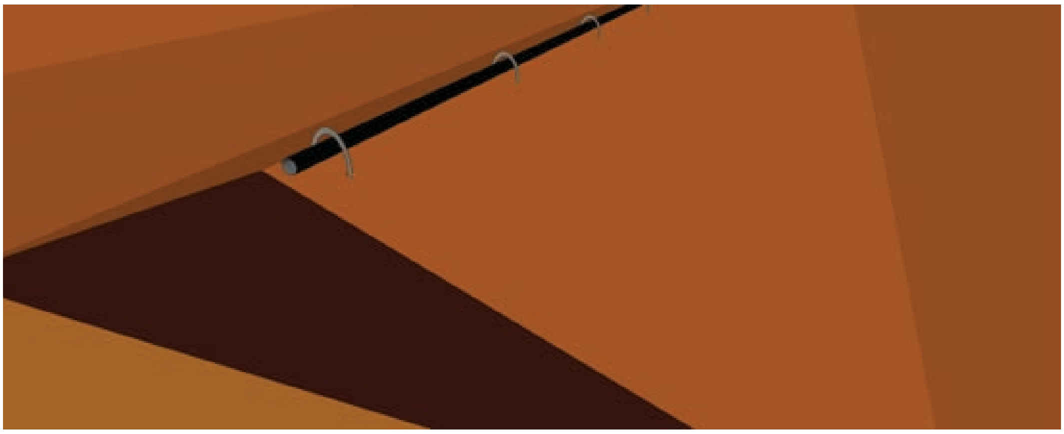
Scheme E **Orchard trapezic ridge, 2 laterals**



Scheme F Orchard sharp ridge, 1 lateral



Scheme G orchard, sharp ridge, 1 lateral located on top with U stabilizers



✻ BR- disatnce between rows or distance between plant rows in bed, RH- row height, IR- distance between plants in row,

Drip Irrigation Calculations & Recommendations

Drip irrigation calculations are done by using Excel worksheet. In such a method it is easy to compare several calculations based on the real conditions (of a certain location) of soil &crop. And come out with reasonable drip system (dripper discharge rate & dripper Spacing) & which are suitable to implement at that location.

The recommendations are presented separately in a Excel worksheet, divided into two sections:

- **A worksheet with active cells for filling in information about the plot of land.**
- **A worksheet for calculations based on the choice of various components in the drip irrigation system chosen.**

Various combinations can be selected and calculations made for each combination. According to the decision based on the actual agronomic information, the data is used for the hydraulic design of the drip irrigation system so it will match the plot.

The recommendations are presented in 3 separate worksheets in accordance with the type of crop: Vegetables, industrial crops, and orchards.

Using the Excel, Manual

Cells with green background are for filling in data.

Cells with brown background have choices prepared in advance in a scroll box. After clicking on the cell a scroll bar will appear. When the arrow on the right side is clicked it will open a window with a list of values from which to choose.

All the information is transferred automatically to a calculation worksheet in which the calculations are carried out automatically. At the conclusion of the process the worksheet can be printed for further stages of planning

Cell Name	Explanation
Farmer's Name	
Field /Plot Name	The name as used by the farmer
Field /Plot Location	Description of the plot's location
Area Unit of Measure	Unit of measure used; choices include: dunam, hectare, feddan, (acres)
Area size (m^2)	This cell converts the unit of measure used into square meters. All further calculations are based on square meters A13
Actual Area	Area of plot in units of measure used locally A14
Soil Type	scroll box with choices
Profile Depth	scroll box with choices
Hard Pan Depth	scroll box with choices
Stones Presence in Profile	scroll box with choices
Percentage	scroll box with choices for percentage of stones
Crop	scroll box for type of crop
Soil Surface Shape	scroll box with choices
Bed Width	Width of the bed in meters, necessary for planning.
Rows per Bed	Number of crop rows in the bed
Distance Between Plants	Distance between plants in the row
Laterals per Bed	Number of lateral to be employed on the bed.This data is necessary for the calculation worksheet.
Distance Between Drippers	The distance between drippers on the lateral.
Dripper Discharge	Waterflow rate of individual drippers

Fill-in Form

Farmer's Name		Jacob	
Field / Block Name		Valley	
Field / Block Location		GPS	
Area Unit of Measure		Acre	
Area size	Acre	10	
Actual Area	[m^2]	40,470	
Crop		Broccoli	

Soil Type	Light
Profile depth	90
Hard pan depth	No
Stones present in soil	No
Soil Surface Shape	Bed

Bed Width	[m]	1.6
Rows per Bed		4
Distance Between Plants	[m]	0.3
Laterals per Bed		2
Distance btwn Drippers	[m]	0.15
Dripper Discharge	[l/h]	1.2

Drip Calculation for Vegetables ▪ 01/2016

Farmer Name	**Jacob**
Field / Block Name	**Valley**
Field / Block Location	**GPS**

Crop	**Broccoli**
Area Unit	**Acre**
Crop actual area	**10**

Soil Type	**Light**
Soil Surface Shape	**Bed**

		Calaulation for Area	
Field / Block	**Unit**	**Acre**	**Actual area**
Bed Width	**(m')**	1.60	
Running bed	**(m')**	25,294	252,938
Rows per Bed	**(No.)**	4	
Running Rows	**(m')**	101,175	1,011,750
Distance Between Plants	**(m')**	0.30	
Plants	**(No.)**	337,250	3,372,500

Dripper's Choice			
Laterals per Bed	**(No.)**	2	
Runnig Laterals	**(m')**	50,588	505,875
Distance Bet' Drippers	**(m')**	0.15	
Drippers	**(No.)**	337,250	3,372,500
Dripper Discharge	**(l/h)**	1.20	
Irrigation Rate	**(mm/h)**	**10.00**	
Total discharge	**(m^3/h)**	**404.70**	4,047

for whole area in single operation

Fill-in Form

Farmer's Name		Jacob	Soil Type	Silt	Bed Width	[m]	1.93
Field / Block Name		Valley	Profile depth	90	Rows per Bed		2
Field / Block Location		GPS	Hard pan depth	90	Distance Between Plants	[m]	0.5
Area Unit of Measure		Hectare	Stones present in soil	No			
Area size	Hectare	10		0-10%	Laterals per Bed		2
Actual Area	[m^2]	100,000	Soil Surface Shape	Bed	Distance btwn Drippers	[m]	0.5
Crop		Cauliflower for industry			Dripper Discharge	[l/h]	1.6

Drip Calculation for Row & Industry Crops ▪ 11/2015

Farmer Name	Jacob
Field / Block Name	Valley
Field / Block Location	GPS

Crop	Corn
Area Unit	Hectare
Crop actual area	10

Soil Type	Silt
Soil Surface Shape	Bed

		Calaulation for Area	
Field / Block	**Unit**	**Hectare**	**Actual area**
Bed Width	(m')	1.93	
Running bed	(m')	51,813	518,135
Rows per Bed	(No.)	2	
Running Rows	(m')	103,627	1,036,269
Distance Between Plants	(m')	0.30	
Plants	(No.)	345,423	3,454,231
Dripper's Choice			
Laterals per Bed	(No.)	2	
Runnig Laterals	(m')	103,627	1,036,269
Distance Bet' Drippers	(m')	0.50	
Drippers	(No.)	207,254	2,072,539
Dripper Discharge	(l/h)	1.60	
Irrigation Rate	(mm/h)	**3.32**	
Total discharge	(m^3/h)	**331.61**	3,316

for whole area in single operation

Fill-in Form

Farmer's Name		Jacob
Field / Block Name		Valley
Field / Block Location		GPS
Area Unit of Measure		Mu
Area size	Mu	10
Actual Area	[m^2]	6,670
Crop		Orange

Soil Type	Clay
Profile depth	120
Hard pan depth	No
Stones present in soil	Medium [3-6 cm]
percentage	0-10%
Soil Surface Shape	Flat

Distance Between Rows	[m]	6
Distance Between Trees	[m]	4
Laterals per Row		2
Distance btwn Drippers	[m]	0.15
Dripper Discharge	[l/h]	1.2

Drip Calculation for Orchard Crops ▪ 01/2016

Farmer Name	**Jacob**
Field / Block Name	**Valley**
Field / Block Location	**GPS**

Crop	**Orange**
Area Unit	**Mu**
Crop actual area	**10**

Soil Type	**Clay**
Soil Surface Shape	**Flat**

		Calaulation for Area	
Field / Block	**Unit**	**Mu**	**Actual area**
Row Width	**(m')**	6.00	
Running Rows	**(m')**	1,112	11,117
Distance Between Trees	**(m')**	4.00	
Trees	**(No.)**	278	2,779

Dripper's Choice			
Laterals per Bed	**(No.)**	2	
Runnig Laterals	**(m')**	2,223	22,233
Distance Bet' Drippers	**(m')**	0.15	
Drippers	**(No.)**	14,822	148,222
Dripper Discharge	**(l/h)**	1.20	
Irrigation Rate	**(mm/h)**	**2.67**	
Total discharge	**(m^3/h)**	**17.79**	178

for whole area in single operation

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VEGETABLES PICTURES

Selecting Proper Dripper Discharge Rate & Spacing for Various Crops in Different Soil Types

ORCHARD PICTURES