Fertigation

- **Nutrient solution – aqueous solution of mineral salts that are essential for plant nutrition**
- **Fertigation – simultaneous application of water and nutrients via the irrigation system (mainly micro-irrigation)**

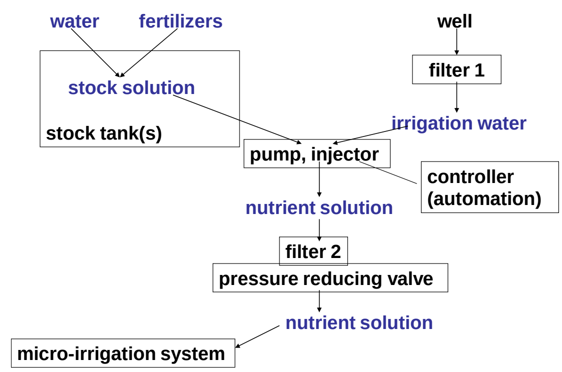
fertilisation **irrigation**

fertigation (fertirrigation)

Advantages and disadvantages of fertigation

- \+ **Precise (quantity, distribution) and continuous application of nutrients**
- \+ **Nutrient <u>amount</u>, <u>concentration</u>, <u>composition</u> can be adjusted to crop requirements →better yield and quality**
- \+ **Increased nutrient and water use efficiency (NUE, WUE) → reduced leaching and fertilizer need**
- \+ **Reduced energy use**
- \+ **Soil conservation (less erosion, compaction, etc.)**
- – **Expensive**
- – **Requires more technical knowledge**
- – **Requires good water quality**
- – **Risk of clogging of emitters**
- – **Risk of local salt accumulation**
- – **Reduction of root volume**

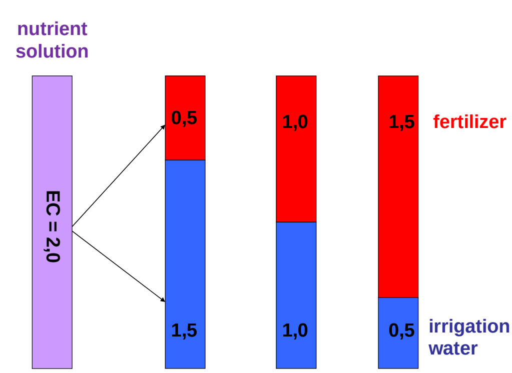
Design of a fertigation system



Water quality requirements for drip irrigation in Hungary

characteristic	risk of clogging		
	any	moderate	high
total floating sediments(mg/l)	<50	50-100	>100
pH	<7,0	7,0-8,0	>8,0
manganese (mg/l)	<0,1	0,1-1,5	>1,5
iron (mg/l)	<0,1	0,1-1,5	>1,5
hidrogen sulfide (mg/l)	<0,5	0,5-2,0	>2,0
number of bacteria (thousand/l)	<10	10-50	>50

(29/2006 FVM directive)



Water quality requirement of the different systems

irrigation water quality ↑

- closed (recycled) soilless production
- open (run-off drainage) soilless production
- fertigation
- traditional irrigation

Irrigation water

- **Physical characteristics:**
- Temperature
- Total floating sediments
- **Chemical characteristics:**
- pH: 5,6-6,2 – soilless system, 6,2-6,8 – on soil
- EC (mS/cm or dS/m) – total dissolved salts (TDS)
- Rate of harmful ions (Na^+, Cl^-, HCO_3^-)(B, F)
- Rate of matter causing clogging (Fe, Mn)
- **Biological characteristics:**
- Number of bacteria
- **Quality improvement:**
- Mixing with rain water
- Acid treatment → decreasing pH
- Removal of Fe and Mn (aeration and depositing)
- Desalinisation (reverse osmosis) → decreasing EC

Fertilizer

- **Important requirements, characteristics:**
  - Solubility – perfect, free from insoluble materials
  - Dissolution – quick
  - Residual salt content – low
  - Nutrient content – high
  - Absence of toxic materials
  - Should not make chemical reaction with the irrigation water
  - Price

- **Types:**
- **Straight**
  - NH_4NO_3, KNO_3, $Ca(NO_3)_2$, $Mg(NO_3)_2$, $(NH_4)H_2PO_4$, $(NH_4)_2HPO_4$, $(NH_4)_2SO_4$, HNO_3
  - KH_2PO_4, H_3PO_4, $(NH_4)H_2PO_4$, $(NH_4)_2HPO_4$,
  - K_2SO_4, KCl, KNO_3, KH_2PO_4,
  - $MgSO_4$, ($CaCl_2$), $Ca(NO_3)_2$, $Mg(NO_3)_2$
  - micro-element compounds, microelement chelates (e.g. EDTA, DTPA)
- **compound/complete fertilizers**
  - balanced e.g. 15:15:15 N:P_2O_5:K_2O
  - N *dominant(?)* e.g. 24:8:16
  - P dominant e.g. 15:30:15
  - K dominant e.g. 14:11:25

Stock solution

- Stock solution: concentrated solution of fertilizers (nutrients)
- Its concentration is 50-100 times more than that of the optimum nutrient solution, which is (<u>0,15-0,3%</u>)
- Its composition defines the nutrient ratio, and the rate of its dilution defines the concentration of the nutrient solution
- Should be used up within a few days
- Precipitation should be avoided

Tanks

Made from plastic, fiberglass, metal(!?), (concrete)

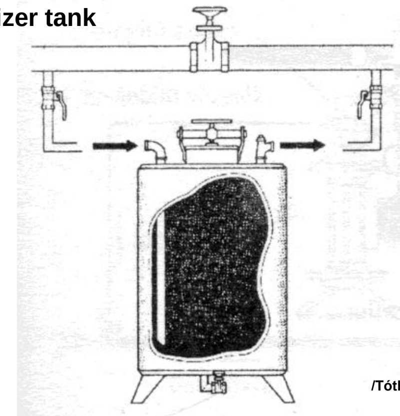
Protection against direct light and contamination

- **Single tank systems**
  - 1 nutrient solution tank – direct nutrient solution preparation
  - 1 stock solution tank – divided fertigation
- **Dual tank (A, B) system** – for avoiding precipitation
- **A tank:** Ca, nitrates, Mg, Fe, micro-element chelates, nitric acid
- **B tank:** sulphates, phosphates, phosphoric acid, complete fertilizers, nitrates, nitric acid, chelates
- **Two tanks + acid tank**
- **Acid tank:** nitric acid, phosphoric acid
- **One tank per fertilizer (min. 5-6 tanks)**

Devices for adding fertilizers to the irrigation water

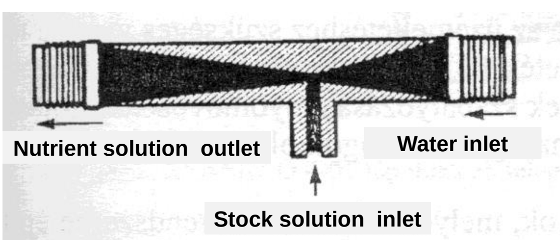
- With gravitation from nutrient solution tank – not suitable for big area
- Fertilizer tank – can not keep constant concentration
- Venturi pump – decreases water pressure
- Piston pump - working with the energy of irrigation water
- Fertigation machine - sophisticated equipment (enclose a computer), needs other energy source

Fertilizer tank



/Tóth, 2000/

Venturi pump



/Tóth, 2000/

Evaluation of the different devices

	Fertilizer tank	Venturi pump	Fertigation machine
Price	low	medium	high
Solid fertilizer	+	-	-
Liquid fertilizer	+	+	+
Know-how	low	medium	high
Quantity control	good	medium	good
Concentr. control	nil	medium	good
Pressure loss	low	high	nil
Automation	nil	medium	high

Control of irrigation (fertigation)

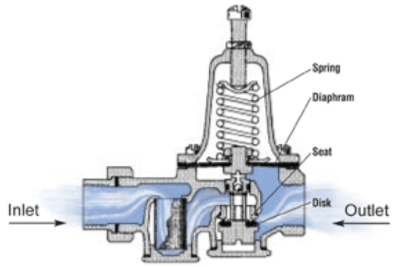
- Manual
– Water meter
- Automatized (needs hydraulic solenoid valves)
– Based on time
– Based on volume – volumetric control valve
– Based on volumetric water capacity of soil/substrate (usually at 60-70%)
– Based on drainage, or plant and substrate weight
– Based on radiation (2-3,5 ml/m^2 volume for 1 J, e.g. start when a 60 J unit accumulated)
– Based on information of plant sensors

Filters

- Role: preventing clogging of emitters
- Types:
– Hydrocyclone (centrifugal) filter – uses centrifugal power, not suitable for filtering of light pollutants
– Gravel filter – uses several layers of mineral (arti-ficial) materials, having different sizes; can pro-vide a kind of biological filtration too, quite slow
– Net filter – size of filtered pollutants can be precisely controlled
– Ring filter – size of scratches on the surface of the rings determines the size of the filtered pollutants

Pressure reducing valve

- **Function:** automatically cuts off the flow of a liquid (e.g. nutrient solution) at a certain pressure.



Irrigation water test

Öntözővíz vizsgálati eredmények

Mérés száma: *M000223*
Megrendelő neve:
Megrendelő címe: ,
Mérés dátuma: 2000. 08. 03.

Minta jele	pH	EC mS/cm	NO3-N mg/l	P mg/l	K mg/l	Ca mg/l	Mg mg/l	Na mg/l	Cl mg/l	HCO3 mg/l
1.	6,83	0,57	5,1	0,2	1	51,5	45,7	9,7	15,6	370,2

Soil sampling, soil analysis

- Soil sampling
  - method (depth, number of sampling places)
  - time
  - frequency
  - necessary information about the sample
- Soil analysis
  - which extraction method to use – water
- Evaluation of the results
  - comparison to reference values
  - units – mg, mmol, meq

reference values   method used

Erdősné Kühn Teréz

6500 Baja,Mészöly Gy. u. 30.

Tel. és Fax.:79/321-141
Mobil: 30/252-48-39
e-mail: erdos@fibermail.hu

Talajvizsgálati eredmények

Megrendelő neve: SZIE MKK Kertészeti Technológiai Tanszék
Megrendelő címe: 2103 Gödöllő, Páter K. u. 1.
Minta száma: 1 db
Érkezés dátuma: "2004.05.11.
Növény neve: uborka

Minta	pH	EC(mS/cm) Só (%)	NO_3-N	P_2O_5	K_2O	Ca	Mg	Fe	Cu	Bór	SO_4-S	Cl	HCO_3	Na	Kötött-ség
			mg/kg						mg/kg				mg/kg		
Uborka	5,6-7,5	EC=max.2,0	112	22	170	176	58				96	max.140		max.92	
1. minta f.s=0,92 g/m	7,57	EC=0,34 0,05%	8,4	27,2	146,4	42,6	5,2				5,2	40	366	16	33

A vizsgálat 1:2 vizes kivonatból készült.

Javaslat: **Alaptrágyázásra:** Ammónium-nitrát 4 dkg/m2 és Kálium-szulfát 1 dkg/m2 és Gipsz 4 dkg/m2 és Magnézium-szulfát 4 dkg/m2
Kiültetéskor beöntözés Ferticare S(15:30:15) 1,5 kg/1000 l víz tápoldattal.

bulk density   reference values

Generative effect	Vegetative effect
abundant radiation	insufficient radiation
long daylight	short daylight
low temperature	high temperature
big diurnal temperature variation	small diurnal temperature variation
P,K predominance	N predominance
high EC	low EC
less water	more water
low relative humidity	high relative humidity
low plant density	high plant density
big fruit load	small fruit load
Flower initiation, fertilization, ripening	*Shoot growth, fruit growth*

Main characteristics of nutrient solution/fertigation and their control

- **EC** (mS/cm, dS/m), **concentration** (%, mmol/l, meq/l) – determined by the cc. of the stock solution and the rate of the dilution

  its value depends on
  - species (lettuce, cucumber; watermelon, sweet pepper; tomato)
  - cultivar (generative or vegetative character)
  - environmental factors (radiation, temperature, soil)
  - phenological stage; fruit load
- **pH** – determined by the pH of the irrigation water, rate of acid added, type of the applied fertilizers

- **Nutrient ratio – N:(P):K – determined by the rate of fertilizers put into the stock solution**

  depends on

  – **species; cultivar; environmental factors; phenological stages; fruit load**
- **Frequency of the application and the supplied amount per one occasion**

  depends on

  – **cultivation system**

  – **technical background**

  – **soil/substrate characteristics**

  – **species**

Structure of a basic recipe for soil grown crop

- **Basal fertilization – manure**
- **Starter fertilization – based on soil test**
- **Fertigation (by phenological stages)**

  – **rooting**

  – **intensive shoot growth**

  – **fruit set**

  – **fruit growth**

  – **fruit ripening, harvest period**

  – **(end of the culture)**
- **Characteristics/parameters**

  – **N:K, EC or %, dose (g/m²/week), (frequency)**

Base fertilization of semi-determinate tomato

yield kg/ha	manure kg/m²	fertilizer	dkg/m²	nutrient g/m²			
				N	P_2O_5	K_2O	MgO
6-12	10-25	CROPCARE 10-10-20	6-10	10	10	20	4
12-18	10-25	CROPCARE 10-10-20	10-15	15	15	30	6

Phenological stage	1	2	3	4
Description	planting – 6th leaf	6th leaf – fruit set	fruit set – full size fruit	fruit ripening
Duration of the stage (days)	10	25	50	15
N kg/ha/day	2	3-3,5	3,6	2,5
N:P:K ratio	1:1:1	2:1:2	2:1:3	2:0:3
fertilizer composition	18:18:18	18:9:18	16:8:24	
dose in kg/ha/day	11,1	16,7-19,4	22,5	7,4
Dose for the whole stage in kg/ha	111	417-485	1125	110
dose in dkg/m²/week	0,8	1,2-1,4	1,6	0,5

Fertigation of semi-determinate greenhouse tomato, and the advised outgoing EC values

composition	phenological stages			
	1. truss EC= 2,5-3,0	2-4. truss EC= 1,8-2,5	5-6. truss EC= 2,0-3,0	During harvest EC= 1,8-2,5
A- Tank (3x weekly)	kg/1000 litre of water			
KALCIUM-NITRÁT	0,8	0,6	0,45	0,35
KÁLIUM-NITRÁT	0,8	0,85	0,75	0,65
Nitric acid	2 dl	2 dl	2 dl	2 dl
B- Tank (3x weekly)	kg/1000 litre of water			
FERTICARE 14-11-25	0,8	0,7	0,65	0,7
KÁLIUM-NITRÁT	0,4	0,35	0,35	0,15
Magnesium-sulphate	0,25	0,25	0,25	0,2
Ammónium-nitrát	0,15	0,1	–	–
Nitric acid	2 dl	2 dl	2 dl	2 dl
C- Tank (1x weekly)	dl/1000 litre of water			
Nitric acid	2 dl	2 dl	2 dl	2 dl

* Megjegyzés: Az A és B tápoldatot váltakozva, folyamatosan juttassuk ki a hét folyamán, zárás a C tápoldattal. ** Csak általános javaslat.

Tomato

- **Rooting - N:P:K = 1:2:1; EC = 2,0-2,3**
- **Intensive growth - N:K = 1:1,2-1,6; EC = 2,5-3,5**
- **Set of 1-3rd trusses - N:K = 1:2-2,5; EC = 2,5-4,0**
- **Set of 4-5th trusses - N:K = 1:2; EC = 2-3**
- **Set of 6-8th trusses - N:K = 1:1,5**
- **Ripening period - N:K = 1:1,8-2,5; EC = 1,8-2,5**

- **Dose is 10-30 g/m²/week, continuously rising from the transplant stage, reaching the maximum at the set of the 5th-6th trusses**
- **Critical stage is the set of the 6th truss**
- **L(ong)S(helf)L(ife) cultivars – more K**
- **Semi-determinate cultivars – more N, lower EC**
- **Indeterminate – less N, higher EC**
- **Open field – N:K = 1:1,3-1,5, at ripening 1:1,5-2,0**

Green pepper

- Rooting - N:P:K = 1:2:1
- Intensive shoot growth - N:K = 1:1,0-1,2(-1,5)
- Fruit set – K, P and EC are raised
- First fruit set – first harvest N:K = 1:0,7-1,0
- Harvest period N:K = 1:1-2 (species!)

- Dose is 10-30 g/m^2/week, from the start of fruit growth becomes higher, concentration 0,1-0,15%, EC = 1,5-2,2
- Critical stage is the first fruit set (EC = 2,8-3,0)
- Red coloured cultivars – more K for ripening
- Generative cultivars – more N is needed
- Question of blossom-end-rot – $Ca(NO_3)_2$ (enough?)

Cucumber

- Rooting – N:P:K = 1:2:1
- Intensive growth – N:K = 1:1-1,2
- Beginning of harvest - N:K = 1:1
- Full fruit load – slicing cucumber N:K = 1:1-1,3; gherkin N:K = 1:0,7-1

- EC is under 2-2,2, 0,05-0,15%
- 15-25 g/m^2/week
- Big Mg and Ca requirements
- Higher N ratio for parthenocarpic cultivars and lower for gynoecious cultivars

Watermelon

- Rooting – P predominance
- Intensive growth – N:K = 1:1, $Ca(NO_3)_2$
- First female flowers, fruit set – N:K = 1:1-1,2
- Fruit growth – N:K = 1:1,2-1,5
- Ripening – N:K = 1:2 ($Ca(NO_3)_2$ + KNO_3)

- 10-20 g/m^2/week, 0,05-0,12%
- prominent role of K (flesh colour, Brix°)
- N overdose → tasteless fruit, pale flesh colour, thick rind, late ripening, cavities in the flesh, fruit deformation

Modification of the recipe

- Based on personal observations
- state of the soil
- state of the plant
  - water supply
  - nutrient supply – deficiency/overdose symptoms
  - generative/vegetative balance
- Based on objective measurements
- soil test performed during the cultivation period
- tissue test
- measurements made by the grower/consultant
  - soil – ionic activity (salt content), water content
  - soil solution – EC, pH, concentration of nutrients
  - plant parameters → automation (?)