The Benefits of Nutrigation™

Pioneering the Future Haifa

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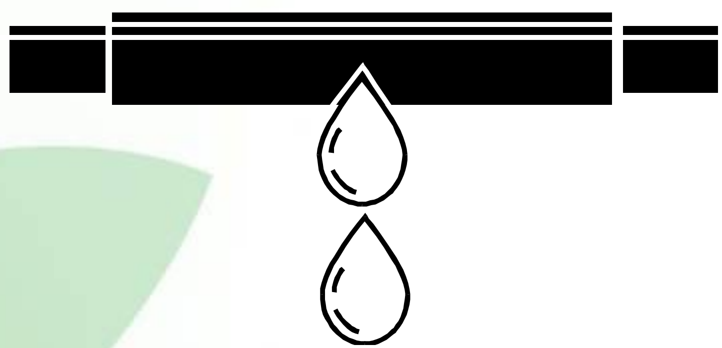
Nutrigation
=
Nutrition + Irrigation



Nutrigation

Water and plant nutrients are delivered simultaneously through the irrigation system, in precise combination and timing.

Basic assumptions

Nutrients availability follows plant's requirements

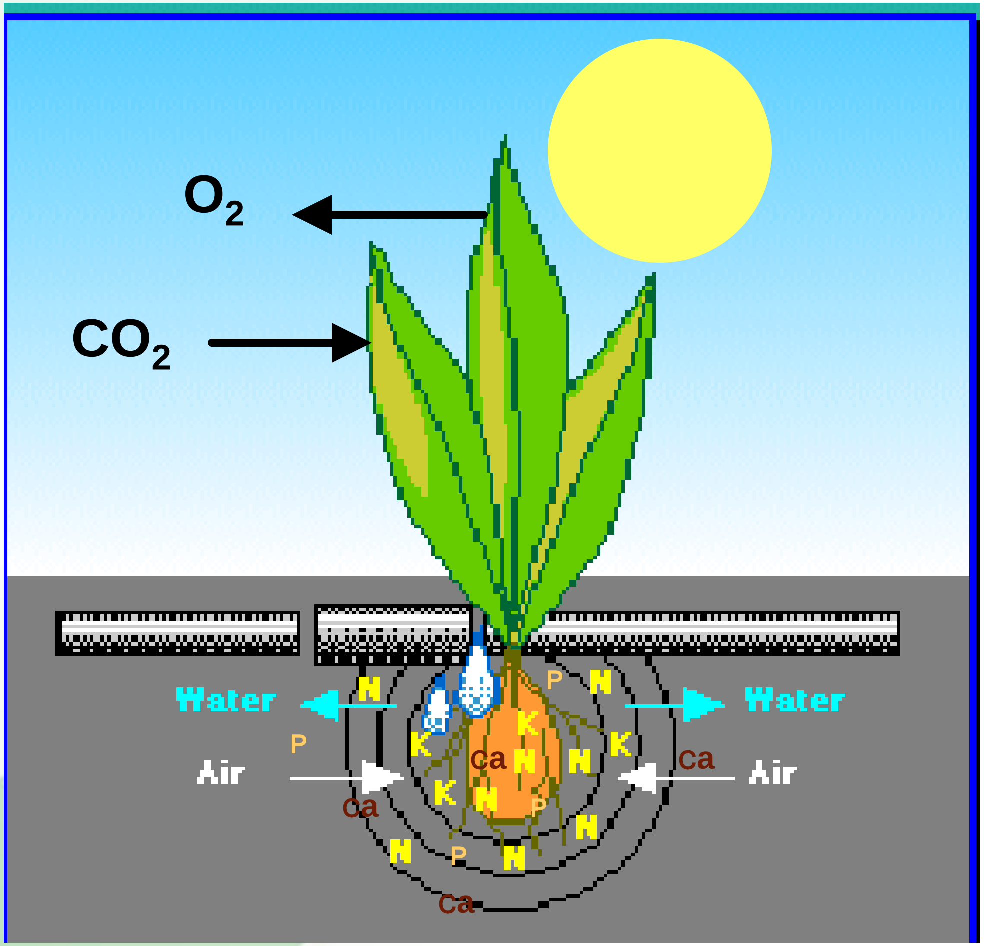
Nutrient uptake rates are crop- specific

No nutrient can replace another one

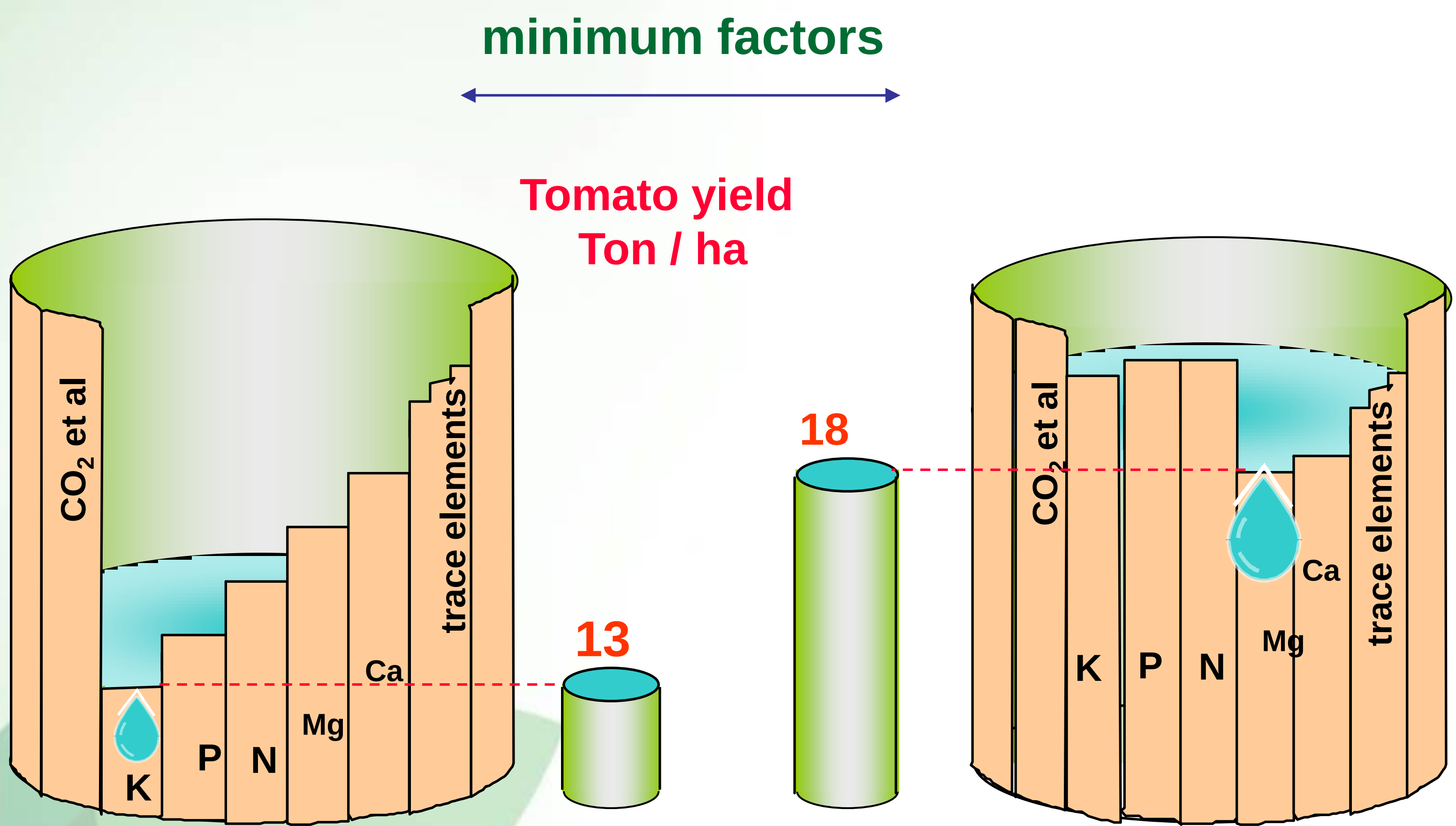
Nutrients should be available to the plants
"Just- on -Time".

Any deficiency or delay in nutrient availability
will result in a reduction in yield and/or quality.

The sources of inorganic nutrients are soil and water



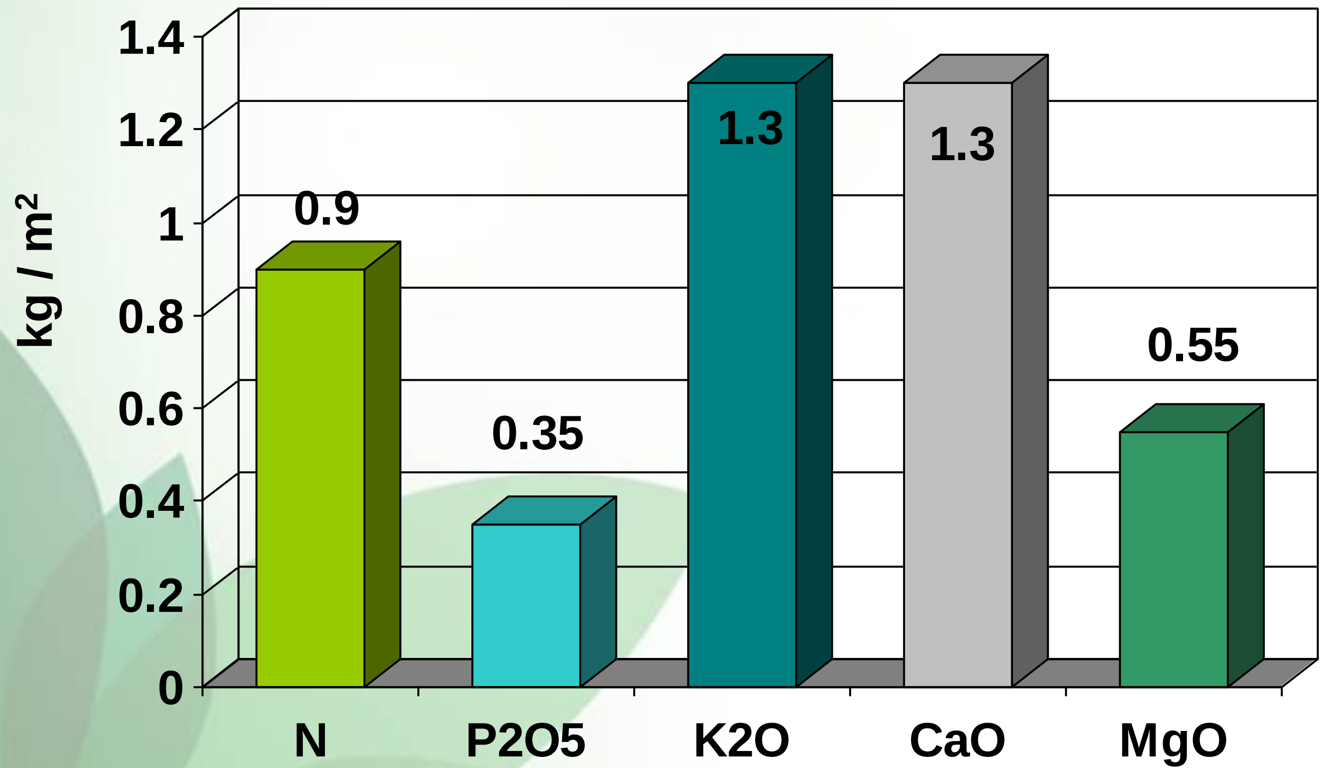
Examples of yield-limiting minimum factors presented as "minimum barrel"



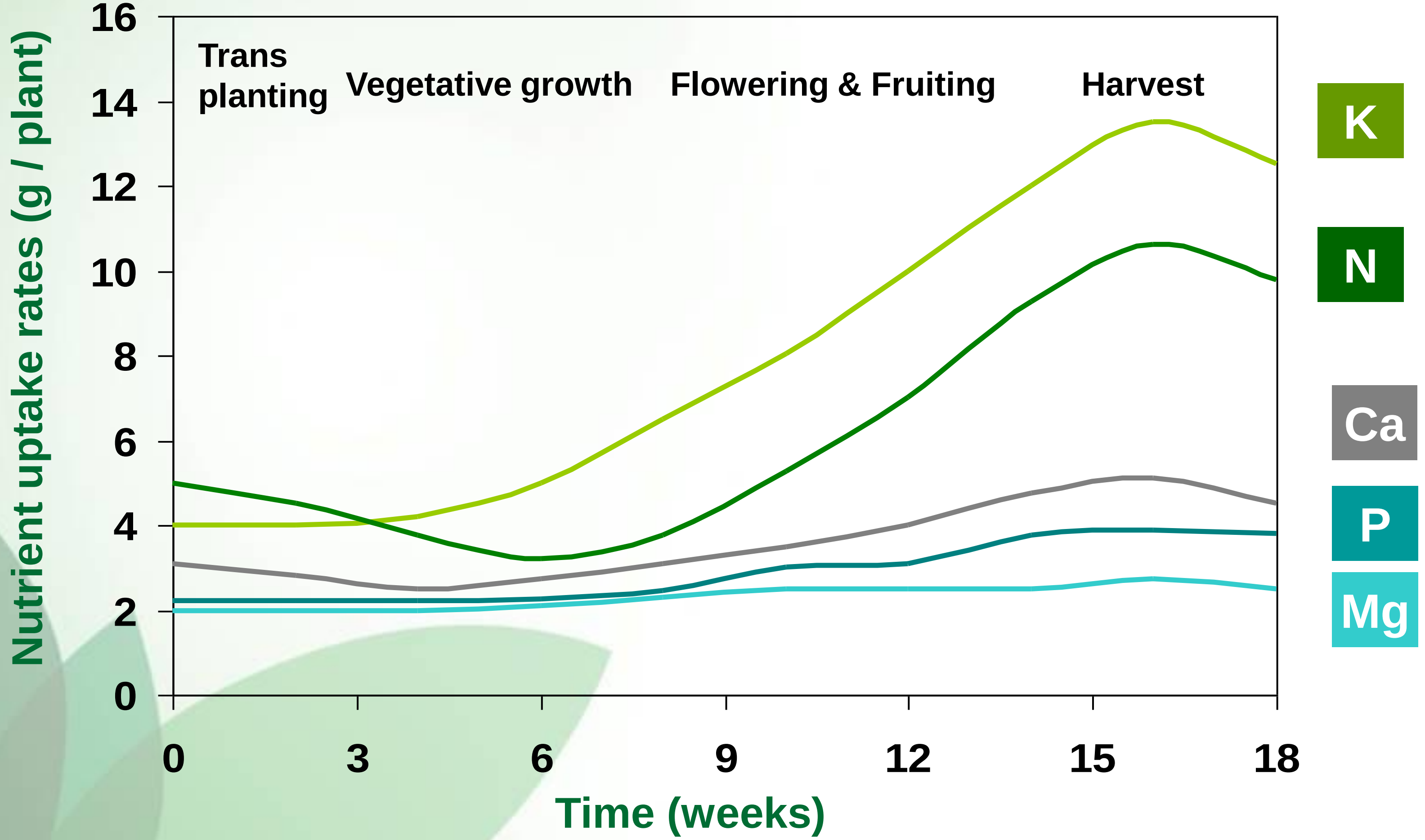
The yield potential of a crop is like a barrel with staves of unequal length.
The capacity of the barrel is limited by the length of the shortest stave (in this case, potassium), and can only be increased by lengthening that stave. When that stave is lengthened, another one becomes the limiting factor.

Annual uptake of nutrients

These rates & ratios must be followed for a reasonable rose yield:



Nutrient uptake carve - Tomatoes



Source: Huett, 1985

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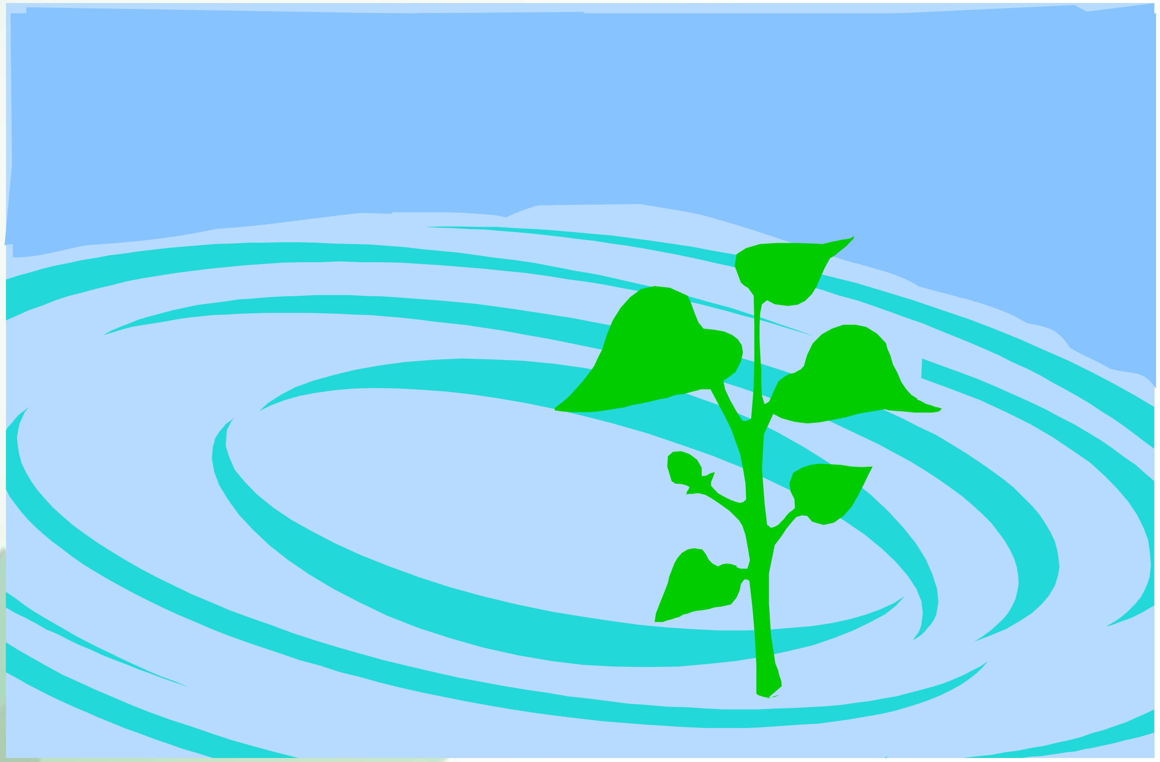
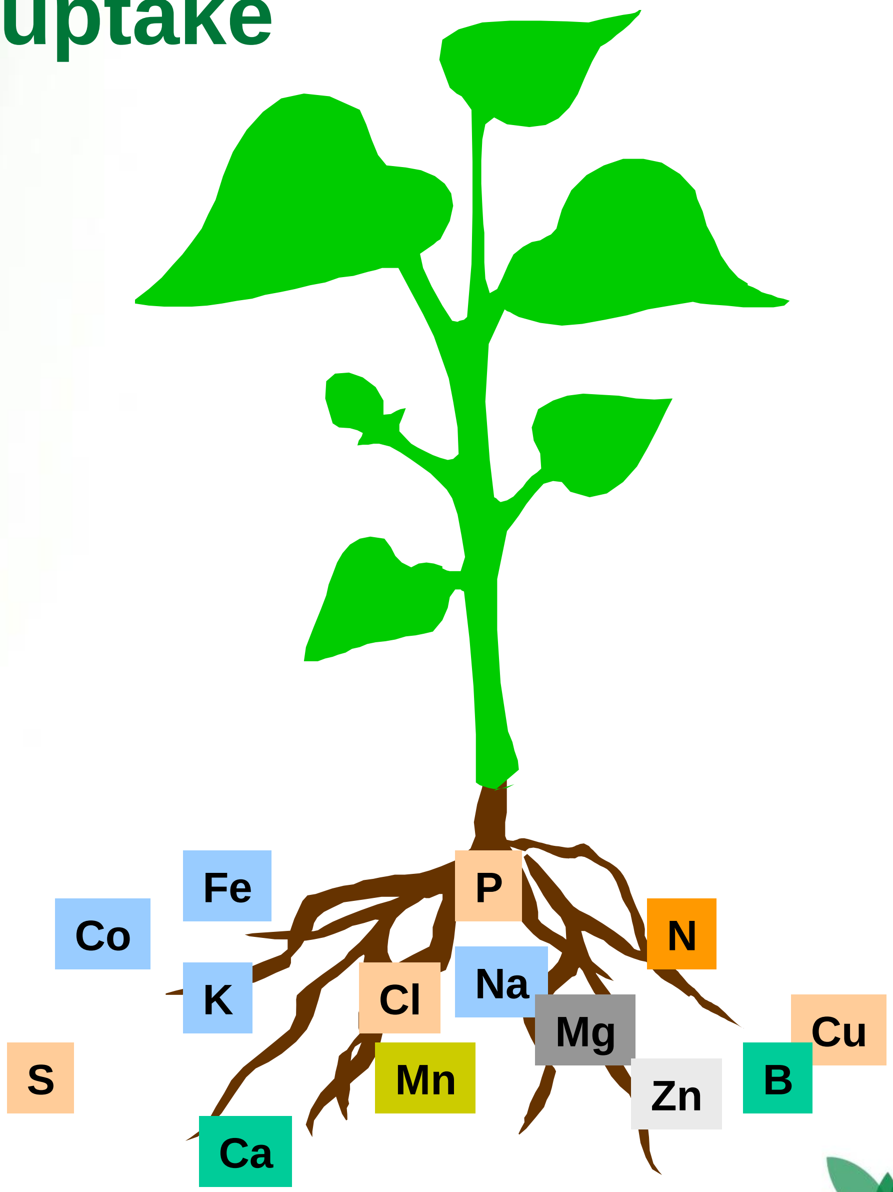
Dynamics of nutrient uptake

Of course, the plant can’t handle it’s entire annual water portion applied at once.



Dynamics of nutrient uptake

Same holds true for nutrients, too.
Nutrients should be applied according to their requirement pace.



The Benefits of Nutrigation

Advantages for the plant:

- Nutrients are directed to the active root zone
- Uniform distribution of nutrients
- Nutrients are already dissolved, hence ready for uptake by the roots
- Plant enjoys continuous nutrition. No temporary deficiency may occur

The Benefits of Nutrigation

Advantages for the system:

- Reduced losses of nutrients by leaching
- Soil and groundwater contamination is minimized
- Less soil compaction, hence better root performance
- Saving on machine / manual spreading
- Reduced weed population, hence less herbicide costs
- Higher application flexibility (time, weather, soil)

The Benefits of Nutrigation

Detailed case studies of yield benefits achieved by Nutrigation

Crop: Lily bulbs

Experiment location: Holland, Lisse, LBO trial Station, 1996

Control treatment: Soil applied NPK's

Nutrigation treatment: 17-8-26+2MgO

Application method	Share of bulb sizes >16 (%)	Botrytis infected (%)	Total profit ($ / ha)
Soil	**35.6**	**6.3**	**116,785**
Nutrigation	**62.0**	**2.0**	**137,900**

The Benefits of Nutrigation

Detailed case studies of yield benefits achieved by Nutrigation

Crop: “ruby- red” grapefruits

Experiment location: U.S., Florida, 1995

Control treatment: Soil applied Multi-K

Nutrigation treatment: Multi-K

Application method	Total yield (boxes/tree)	Fruit size 40 (boxes/ ha)	Gross packed value ($ / ha)
Soil	7.9	1060	16,500
Nutrigation	8.8	1446	19,500

Source: Boman, 1995

The Benefits of Nutrigation

Detailed case studies of yield benefits achieved by Nutrigation

Crop: Open- field tomatoes

Experiment location: India, Andrha Pradesh, 1997

Control treatment: Soil applied MOP

Nutrigation treatment: Multi-K, equal K rate

Application method	Total yield (MT / ha)	Net benefit over control ($ / ha)
Side- dressed with MOP	21.0	--
Nutrigated with Multi-K	26.2	215

Nutrigation program

Nutrigation program should consider:

- Water management

- Nutrient requirements

- Soil conditions

Nutrigation program

Water management

Good Nutrigation program is based on proper water management, considering:

- Plant water requirements
- Soil type
- Irrigation equipment

Nutrigation program

Water management

Plant water requirements are proportional to the rate of evapotranspiration (ETP) which depends on

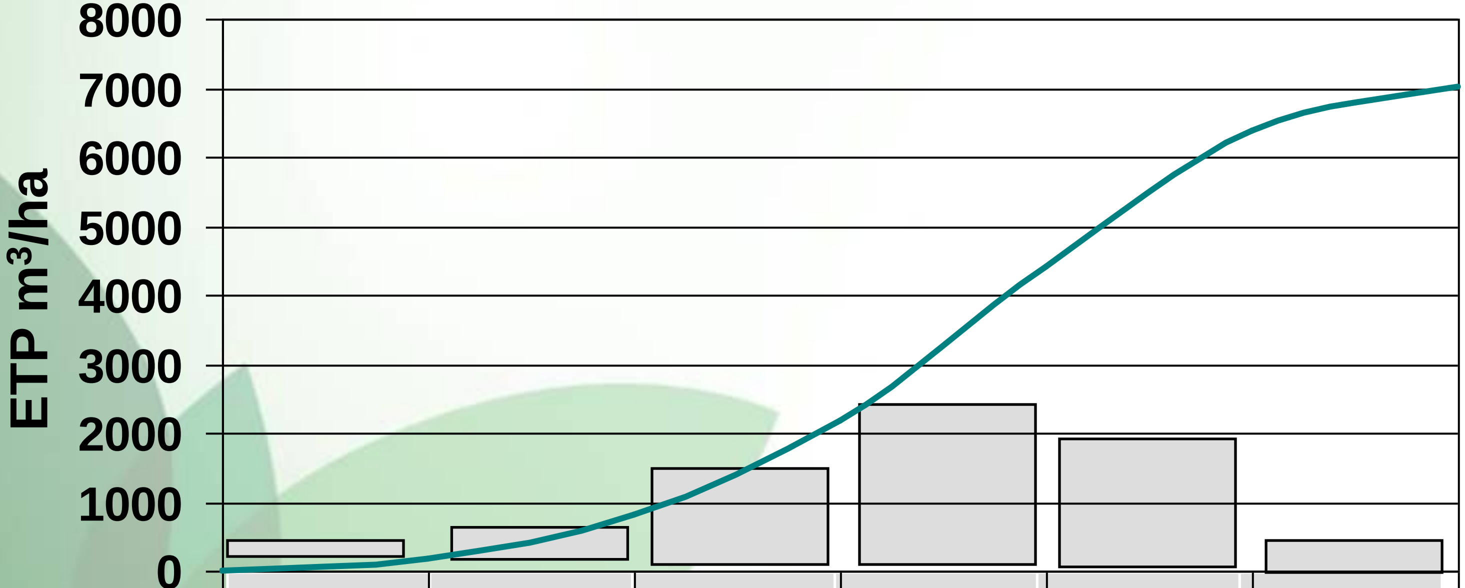
- Plant type
- Stage of plant development
- Meteorological conditions (temp., wind, radiation, humidity)

Nutrigation program

Water management

Total amount of water required = cumulative ETP

Example: monthly and cumulative ETP of cotton

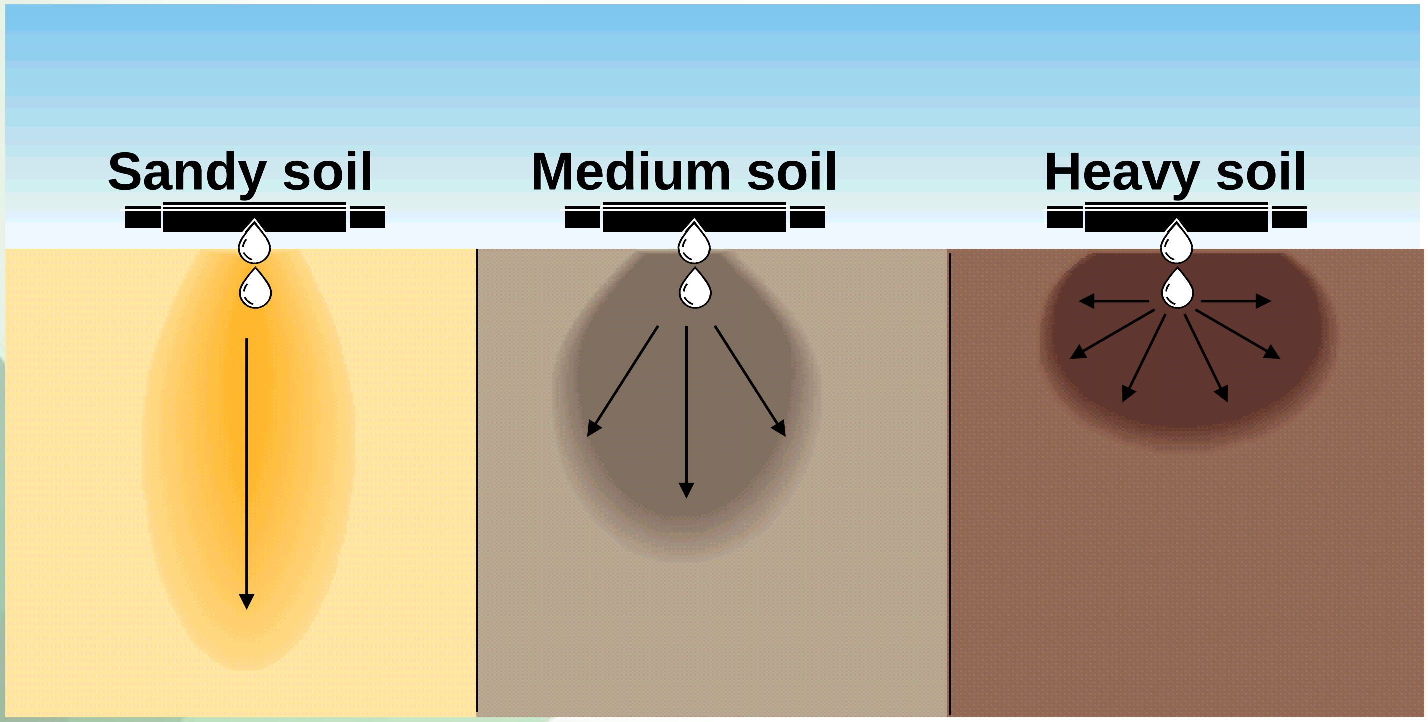


Apr	May	Jun	Jul	Aug	Sep
186	630	1350	2322	1984	630

Nutrigation program

Water management

Soil type affects the direction and speed of water movement.



Nutrigation program

Water management

Choice of irrigation equipment depends on

- Cost consideration
- Soil type → infiltration rate and pattern
- Topography
- Available water pressure
- Density of planting and root system

Nutrigation program

Water management

Type of irrigation equipment determines daily irrigation portions and time intervals between irrigations.

Examples of irrigation cycles during June in Israel coastal area:

Crop	m^3/ha/day	Time intervals between irrigations			
		sprinkler	Micro jet	Drippers	
				Heavy soil	Sandy soil
Citrus	35	35	12	6	5
Avocado	38	8	5	4	2

…and now we have to introduce nutrients into the irrigation water…

Nutrigation Types/Methods

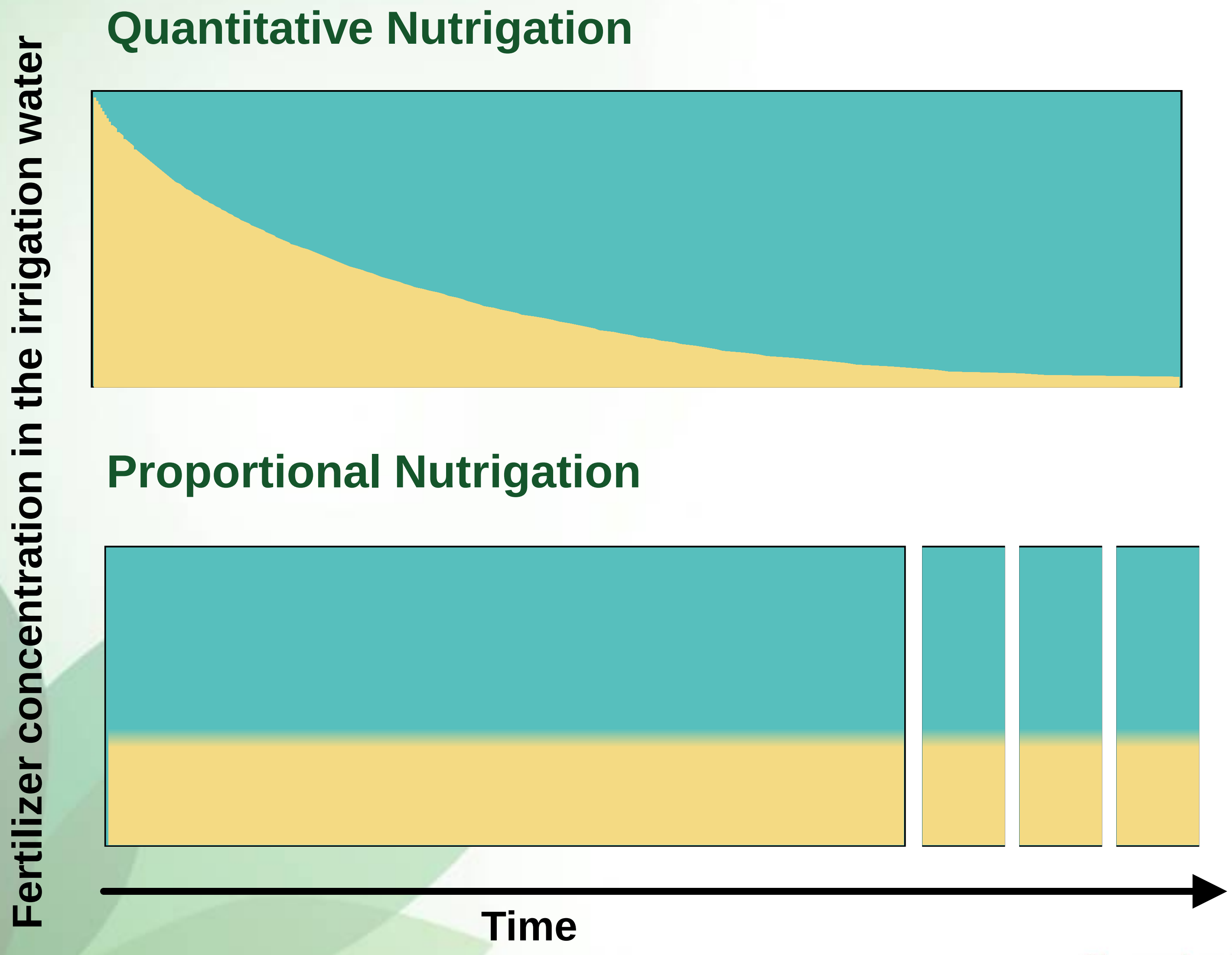
Quantitative Nutrigation

The fertilizer is applied in one pulse during a part of the irrigation time.

Proportional Nutrigation

The fertilizer concentration in the irrigation water is kept constant.

Nutrigation Types/Methods



Quantitative_Nutrigation

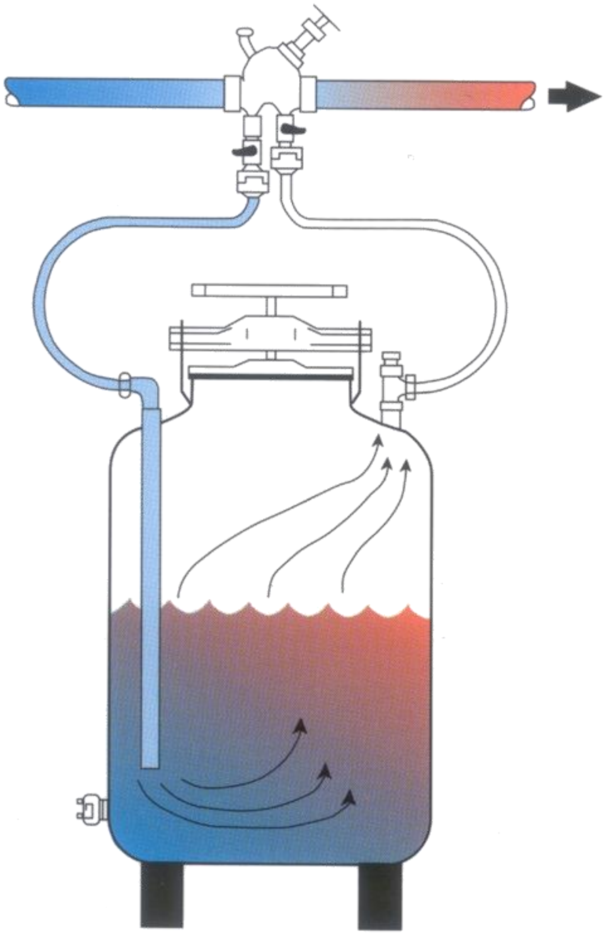
Used in orchards and in heavy soils.

The grower determines the total amount of fertilizer.

The fertilizer is applied in one pulse during a part of the irrigation time.

Concentration decreases along the time.

When the fertilizer is fully dissolved 4 times of fertilizer tank volume should be passed to fully deliver all nutrients.



Quantitative Nutrigation

Advantages

- Low cost; simple maintenance.
- No need to pre-dissolve dry fertilizers.
- Allows high discharge rates.

Disadvantages

- The distribution of the applied fertilizer might not be fully homogenous.

Proportional Nutrigation

Used in light and sandy soils.

The fertilizer/nutrients concentration in the irrigation water is kept constant.

Equipment:
- Venturi
- Fertilizer pumps (water or electricity propelled)

Proportional Nutrigation

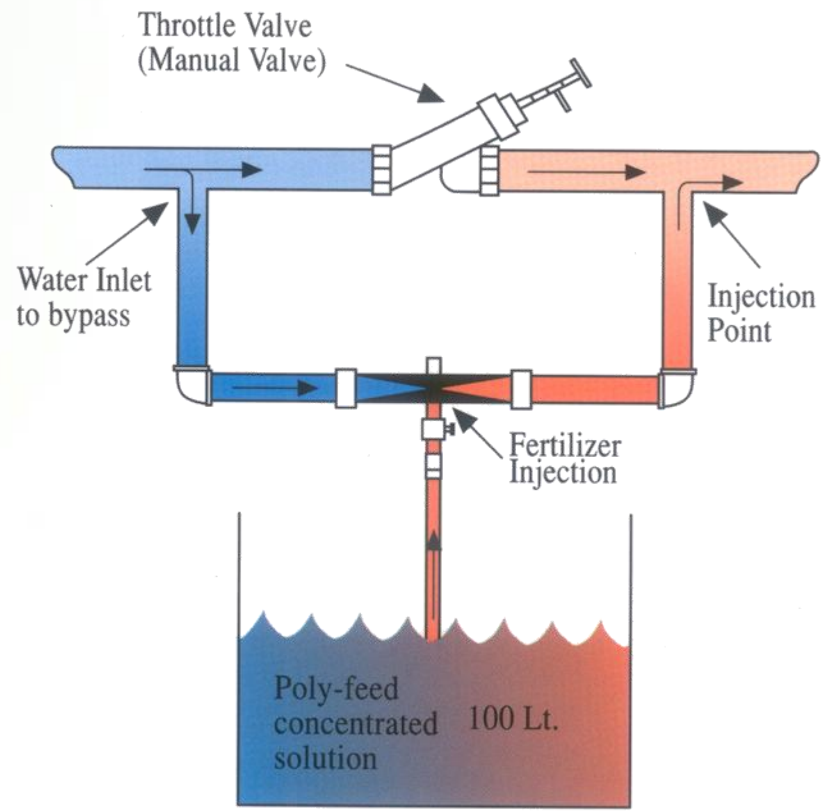
Venturi (bypass)

Advantages

- Relatively inexpensive and simple to maintain.
- Size of orifice controls fertilizer concentration.

Disadvantages

- High loss of pressure if installed directly on main pipeline
- Relatively low discharge rate



Proportional Nutrigation

Powered fertilizer pump

Power may be either electrical or hydraulic

Advantages

- Very flexible discharge rates
- Negligible loss of pressure
- Fine control over fertilizer concentration
- Allows automated control

Disadvantages

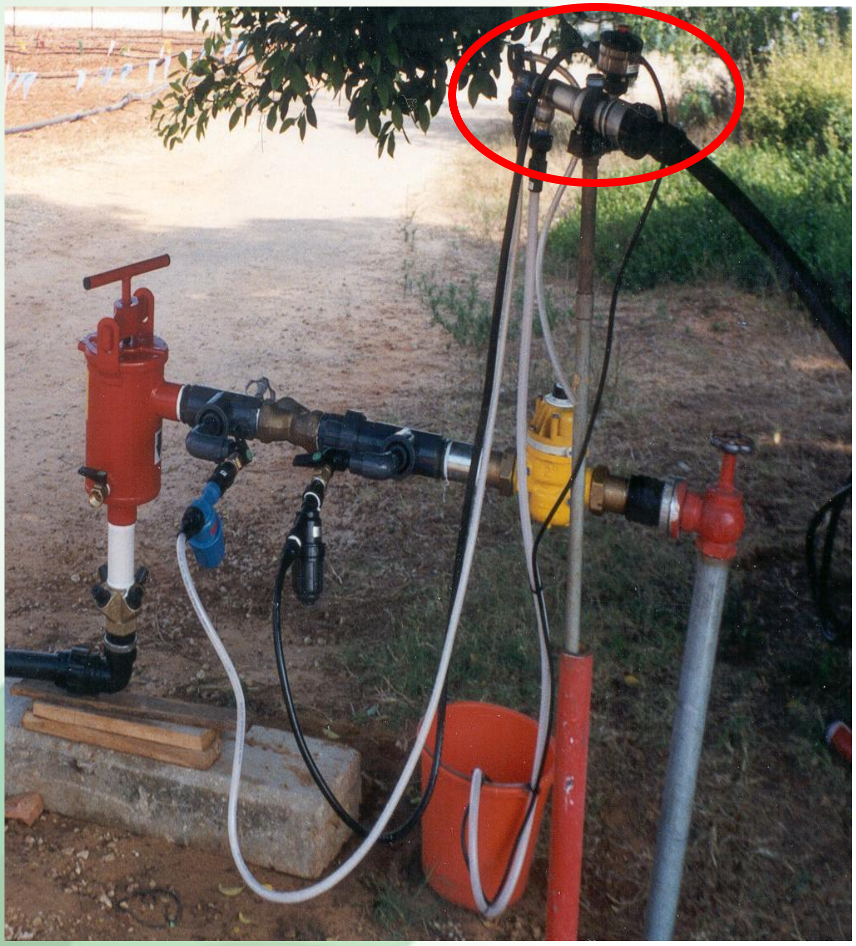
- Expensive
- Complicated to maintain, requires skilled operator

Proportional Nutrigation

Amiad fertilizer pump

Proportional Nutrigation

Amiad fertilizer pump



Preparation of nutrient solutions

Solubility

- Solid fertilizers vary in their solubility and dissolution rates
- Maximal concentration of a tank mix is determined by the solubility of the least soluble fertilizer
- Fertilizer solubility increases with temperature
- Some fertilizers has endothermic dissolution reaction which lowers the temperature of the water
- Acid fertilizers corrode metallic and asbestos-cement components of the irrigation system.

Preparation of nutrient solutions

Fertilizer compatibility

Mixing of incompatible fertilizers in same tank may cause the formation of insoluble precipitates.

Fertilizers containing phosphates or sulfates should be dissolved separately from calcium and magnesium fertilizers.

Preparation of nutrient solutions

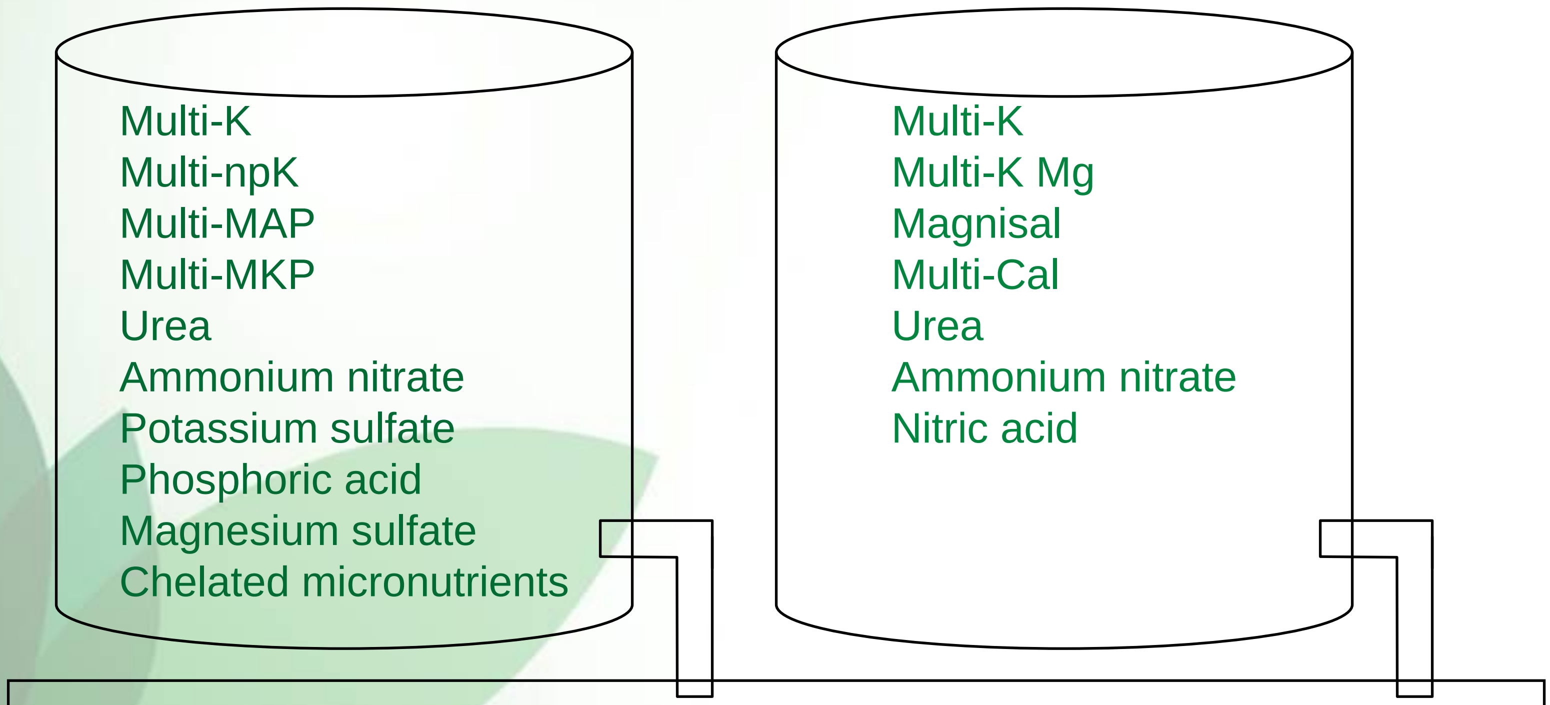
Fertilizer compatibility, the Two Tanks Method

Tank A

No fertilizers containing calcium

Tank B

No fertilizers containing phosphates or sulfates



Soil conditions:
base dressing and Nutrigation

Soil type and nutrient levels in the soil determine the partition between base dressing and Nutrigation.

NPK levels in the soil	Sandy soil	Medium soil	Heavy soil
Deficiency	Only Nutrigation	Corrective base-dressing + Nutrigation	base-dressing + Nutrigation
Normal level	Only Nutrigation	Only Nutrigation	base-dressing + Nutrigation
High or excessive level	Only Nutrigation	Only Nutrigation	Only Nutrigation

Soil conditions: soil analysis

Actual application rates should take into account nutrient levels in the soil:

No information is available	Application rates = requirements x empiric correction factors
Partial information from rapid soil analysis	Nutrients in the soil are considered if soil concentration exceeds threshold
Full information from lab analysis	Nutrigation program is determined according to actual soil conditions

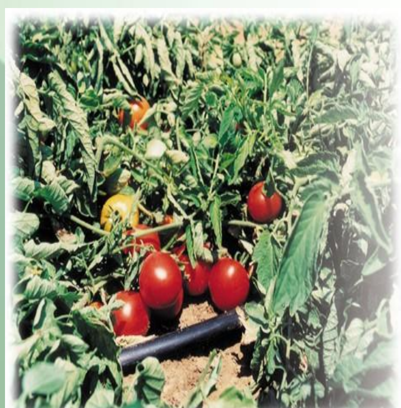
Example of Nutrigation Program

Processing Tomatoes

Nutrigation of Processing Tomatoes

Expected yield 100 mt/ha

Soil type – Loam



Nutrient requirements (kg/ha):

N	P_2O_5	K_2O
Removal by yield		
150	40	280
Uptake by whole plants		
303	78	522

When soil analysis is not available, the uptake nutrients quantity multiply by the corresponding correction factor should be applied.

Recommended application rates (kg./Ha)

N	P_2O_5	K_2O
363	150	678

For soils with light texture, additional K_2O may be needed.

Nutrigation of Processing Tomatoes

Correction factors in use, due to partial availability of the applied fertilizers/nutrients

Nutrient	Soil application (base- or- side- dressing)	Nutrigation
N	1.2 - 1.3	1.1 - 1.2
P_2O_5	1.9 - 2.2	1.6 - 1.9
K_2O	1.4 - 1.6	1.2 - 1.4

Nutrigation of Processing Tomatoes

Base-dressing and Nutrigation rates

	N	P_2O_5	K_2O
	Kg/Ha		
Total application rate	363	150	678
Base-dressing	30%	50%	30%
	109	75	203
Nutrigation	70%	50%	70%
	254	75	475

Nutrigation of Processing Tomatoes

Base-dressing

		N	P_2O_5	K_2O
Required (kg/ha):		109	75	203
Source	Fertilizer	A.S.	TSP	SOP
	Formula	21-0-0	0-46-0	0-0-50
Application rate kg/ha		519	163	406

Nutrigation of Processing Tomatoes

Nutrigation

Growth stage	$N:P_2O_5:K_2O$ ratio	kg/ha/day			days	Total kg/ha		
		N	P_2O_5	K_2O		N	P_2O_5	K_2O
Planting → flowering	1:1:1	1.5	1.5	1.5	20	30	30	30
Flowering → Fruit-set	2:0.4:3	4.0	0.8	6.0	30	120	20	180
Fruit-set → ripening	1:0:2	3.0	0.5	6.0	35	105	20	210
Ripening → harvest	2:0:3	1.3	-	1.7	20	26	-	34
		Total				280	70	454

Nutrigation of Processing Tomatoes

Nutrigation

Growth stage	Fertilizers	$N:P_2O_5:K_2O$	kg/ha/day	kg/ha/day		
				N	P_2O_5	K2O
Planting → flowering	**Multi-K**	13:0:46	3.2	0.28	-	1.5
	Multi-MAP	0:61:12	2.45	0.18	1.5	-
	A.N	34:0:0	2.35	0.54	-	-
	Total	**1:1:1**		**1.5**	**1.5**	**1.5**
Flowering → Fruit Set	**Multi-K**	13:0:46	13.0	1.7	-	6.0
	Multi-MAP	0:61:12	1.3	0.15	0.8	-
	A.N	34:0:0	6.3	2.15	-	-
	Total	**3:0.4:2**		**4.0**	**0.8**	**6.0**

Nutrigation in Processing Tomatoes

Nutrigation

Growth stage	Fertilizers	$N:P_2O_5:K_2O$	kg/ha/day	kg/ha/day		
				N	P_2O_5	K_2O
Fruit set→ ripening	**Multi-K**	13:0:46	13.0	1.7	-	6.0
	A.N.	34:0:0	3.8	1.3	-	-
	Urea	46:0:0	2.8	1.3	-	-
	Total	**1:0:2**		**3.0**		**6.0**
Ripening → harvest	**Multi-K**	13:0:46	3.7	0.5	-	1.7
	Multi-MAP	34:0:0	2.4	0.8	-	-
	A.N	46:0:0	1.8	0.8	-	-
	Total	**2:0:3**		**1.3**		**1.7**

Nutrigation in Processing Tomatoes
Trial results

- Trial in Italy
- Compared between Nutrigation and side-dressing
- K source: Multi-K

Nutrigation in Processing Tomatoes
Trial results

Trial details:

Location: Azienda Agricola di Cesa (Ar)
Arsia Regione, Toscana, Italy. Year 2000.

Supervision: technical manager of Arsia – Mr. Marco Quattrucci

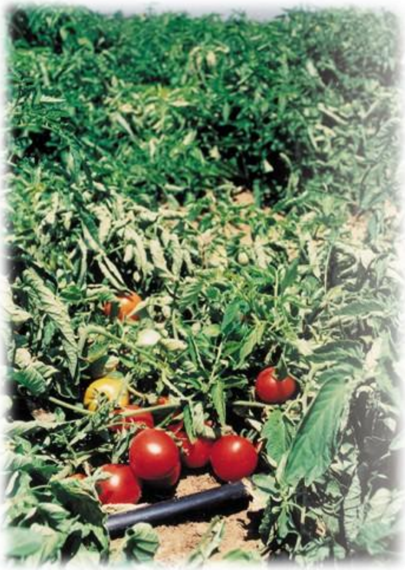
Cultivar: Perfectpeel F1 (*Peto*)

Plant density: 30,000 plants / ha

Irrigation: drip, 2,000 m^3/ha

Transplant date: May, 26th, 2000

Harvest date: September 4th, 2000



Nutrigation in Processing Tomatoes
Trial results

Control treatment: side-dressing with granular fertilizers

Application rates (kg/ha):

N	P_2O_5	K_2O
120	140	260

Applications

	N	P_2O_5	K_2O
10 days before transplanting	65%	100%	65%
26 days after transplanting (initial flowering):	10%	-	10%
51 days after transplanting (initial fruit-set):	25%	-	25%

Nutrigation in Processing Tomatoes
Trial results

Nutrigation treatment

Application rates (kg/ha):

N	P_2O_5	K_2O
120	140	260

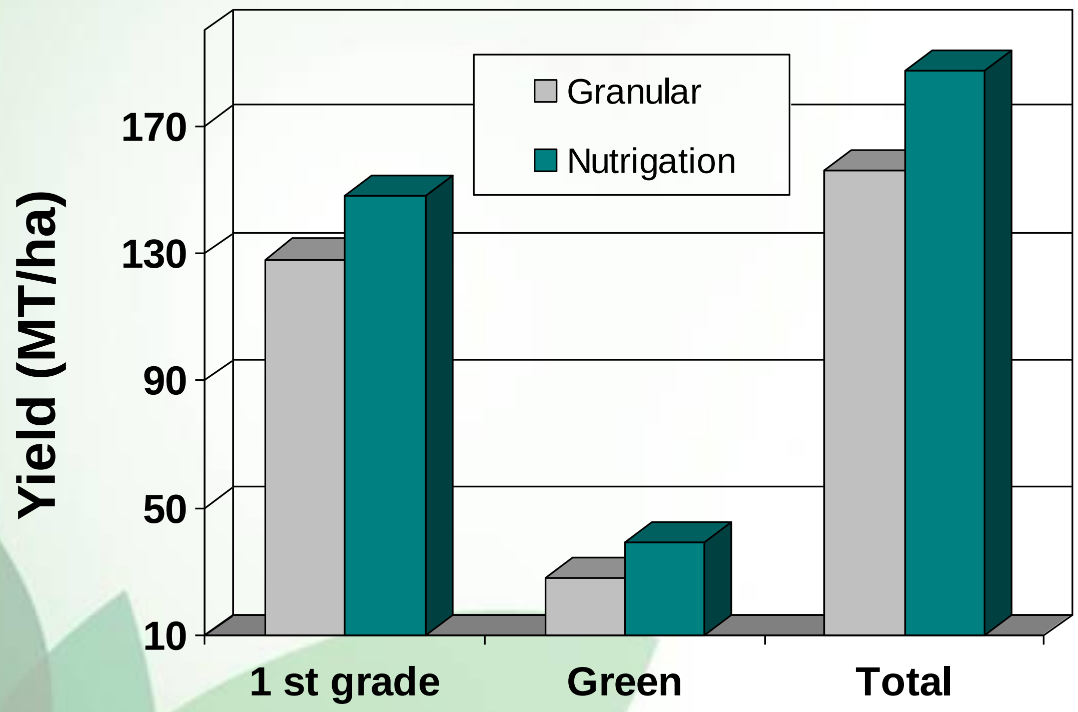
Applications

1. 10 days prior to transplanting:
   30% of N, P & K rates as 350 kg/ha of Poni-Ter (granular 12-20-27)

2. During the entire plant development stages June 2nd – August 16th
   12 weekly Nutrigation applications 70% of N-P-K as crystalline Multi-K + Soluble NPK's + Multi-P (phos. acid)

Nutrigation in Processing Tomatoes
Trial results

Effect of application method on tomato yield



Haifa Chemicals & Azienda Agricola, Toscana, Italy, 2000

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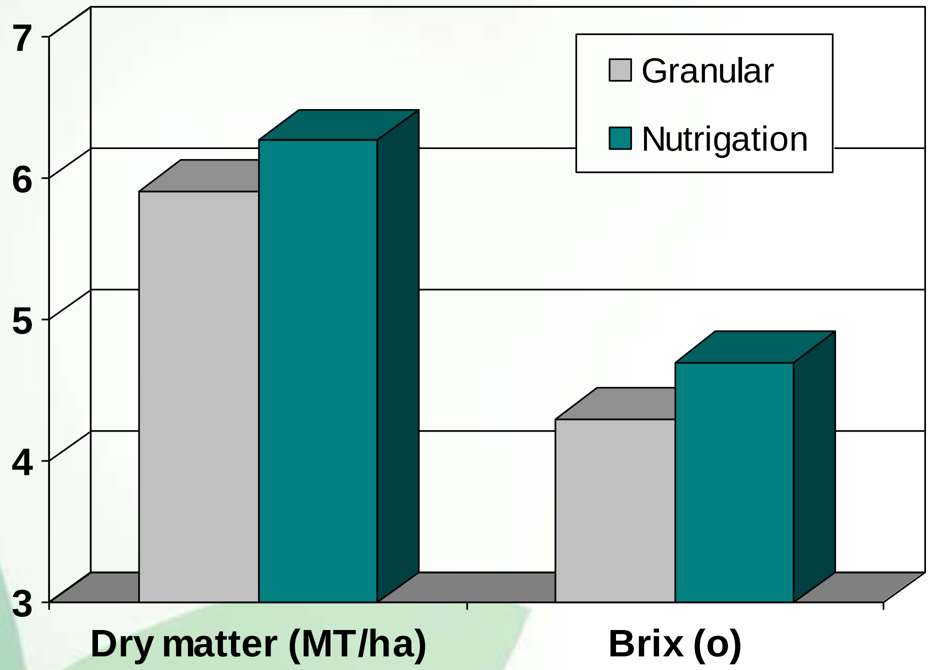
Nutrigation in Processing Tomatoes
Trial results

Effect of application method on tomato yield & quality



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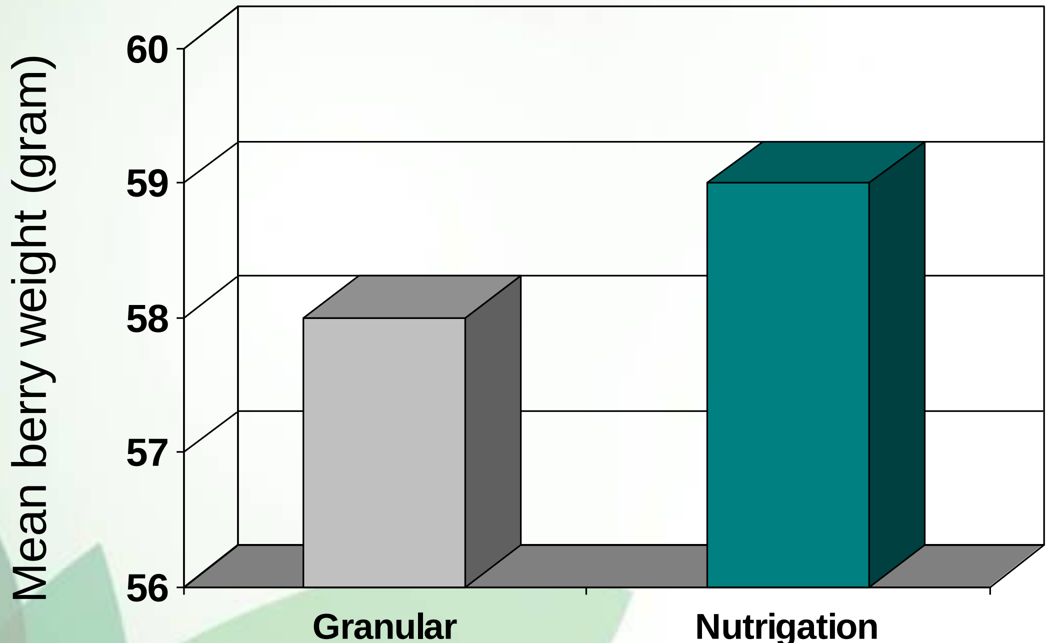
Nutrigation in Processing Tomatoes
Trial results

Effect of application method on fruit size



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Nutrigation in Processing Tomatoes
Trial results

Economic analysis

	Granular fertilizers	Nutrigation
Grade I berries	128 MT/ha	148 MT/ha
Revenue on grade I berries	12.2K US$/ha	14K US$/ha
Cost of treatment	351 US$/ha	582 US$/ha
Net benefit	11.9K US$/ha	13.4K US$/ha **+12.6%**

Haifa Chemicals & Azienda Agricola, Toscana, Italy, 2000

Haifa Products

for

Nutrigation

Haifa Products for Nutrigation

- 100% water soluble
- Contain plant-nutrients only
- Efficiently absorbed by the plant
- Free of chloride, sodium, and any other detrimental materials

Haifa portfolio of water-soluble fertilizers covers the entire range of plant nutrients.

Nutrients are available in the form of straight fertilizers or ready-made blends.

Haifa Products for Nutrigation

Straight fertilizers

Multi-K Products

Haifa MAP

Haifa MKP

Haifa Cal

Magnisal

Haifa Micro

Ready-made blends

- Poly-Feed

Multi-K potassium nitrate

Crystalline products for Nutrigation:

- Multi-K
- Multi-K GG
- Multi-K pHast
- Multi-K Top
- Multi-npK
- Multi-K Mg
- Multi-K Zn
- Multi-K S
- Multi-K B
- Multi-K ME

Multi-K potassium nitrate

N total	13.2%
$N\text{-}NO_3$	13.2%
K_2O	46.0%
K	38.1%
Insoluble matter	300 ppm
Bulk density	1.0 g/cm^3

Packaging

25, 50, 500 and 1000kg bags

Haifa MAP Mono-ammonium phosphate

N total	12%
$N\text{-}NH_4$	12%
P_2O_5	61%
P	27%
pH (5% soln.)	4.2
Bulk density	1.1 g/cm^3

Packaging

25, 500 and 1000kg bags

Haifa MKP Mono-potassium phosphate

P_2O_5	52%
P	22.7%
K_2O	34%
K	28.7%
pH (5% soln.)	4.4
Bulk density	1.2 g/cm^3

Packaging

25, 500 and 1000kg bags

Magnisal - Magnesium nitrate

N total	11.0%
$N\text{-}NO_3$	11.0%
MgO	16.0%
Mg	9.7%
pH (5% soln.)	4.1
Insoluble matter	300 ppm
Bulk density	0.7 g/cm^3

Packaging

25 kg bags

Haifa Cal - Calcium Nitrate Greenhouse Grade

N total	15.5%
$N\text{-}NO_3$	14.4%
$N\text{-}NH_4$	1.1%
CaO	26.5%
Ca	19.0%
Insoluble matter	300 ppm

Packaging

25 kg bags

Haifa Micro Chelated Micronutrients

	Nutrient	
Multi-Micro Fe	Iron	Fe-EDTA 13%
		Fe-EDDHA 6%
Multi-Micro Mn	Manganese	Mn-EDTA 13%
Multi-Micro Zn	Zinc	Zn-EDTA 14%
Multi-Micro Cu	Copper	Cu-EDTA 14%
Multi-Micro Comb	Mix	7.1%Fe, 3.48% Mn, 1.02% Zn, 0.76% Cu, 0.485% Mo

Packaging

1kg cardboard boxes, 25kg bags

Poly-Feed GG

Greenhouse-grade NPK fertilizers

Formulae for Nutrigation of soil-grown crops and for foliar feeding:

Growth stage	Formula	%N-NH_2	%N-NO_3	%N-NH_4
Establishment	15-30-15+ME	5.3	4.0	5.7
Vegetative	19-19-19+ME	10.0	5.5	3.5
productive	20-9-20+ME	-	12.0	8.0
	17-10-27+ME	-	11.5	5.5
	16-8-32+ME	-	11.7	4.3

Poly-Feed GG

Greenhouse-grade NPK fertilizers

Formulae for soilless culture and hydroponics

Growth stage	Formula	K_2O/N ratio	$N\text{-}NO_3$ %	$N\text{-}NH_4$ %	SO_3 %
Establishment	18-18-18+ME	1.0	10	8	-
Vegetative	20-9-20+ME	1.0	12	8	-
productive	17-10-27+ME	1.6	11.5	5.5	-
	16-8-32+ME	2.0	12	4	-
	14-10-34+ME	2.4	11	3	-
	11-12-33+2MgO+ME	3.0	9	2	3.9
	11-8-34+2MgO+ME	3.1	10	1	3.9
	9-12-36+3MgO+ME	4.0	8.3	0.7	5.8
	9-10-38+3MgO+ME	4.4	9	-	3.9

Poly-Feed Drip

NPK fertilizers for Nutrigation in open-field

Growth stage	$N:P_2O_5:K_2O$ ratio	Formula
Establishment	1-4-1	11-44-11+ME
	1-3-1	36-13-36+2MgO+ME
	1-2-1	15-30-15+ME
Vegetative	1-1-1	20-20-20+ME
	1-1-1	19-19-19+1MgO+ME
	2-1-1	26-12-12+2MgO
	2-1-2	21-11-21+2MgO+ME
productive	2-1-3	14-7-21+2MgO+ME
	2-1-4	14-7-28+2MgO+ME
	3-1-3	23-7-23+2MgO+ME
	High K	12-5-40+2MgO+ME

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Poly-Feed Foliar

Stage-specific formulae

	Micronutrients (ppm)					
	Fe	Mn	Zn	Cu	Mo	B
Vegetative Booster 21-21-21	1300	660	200	140	90	200
Flowering Booster 8-52-17	500	250	75	55	35	100
Fruiting Booster 16-8-34	1200	600	180	130	80	200

Poly-Feed Foliar

Stage-specific formulae

	Micronutrients (ppm)					
	Fe	Mn	Zn	Cu	Mo	B
Poly-Wheat 23-7-23	1700	850	250	1000	110	200
Poly-Potato 12-5-40	2000	1000	300	220	140	300
Poly-Citrus 16-7-30+2MgO	1000	500	2000	110	70	300
Poly-Olive 15-7-30+2MgO	1000	500	150	110	40	4500
Poly-Rice 15-15-30	1000	1500	150	110	70	200
Poly-Vineyard 4-15-37+3MgO	2300	500	150	110	70	200
Poly-Cotton 12-5-40	2000	1000	300	220	140	300
Poly-Sugarbeet 15-7-30+2MgO	1000	500	150	110	70	4500

Thanks

for yours

Attention