Fertilisation, nutrient solutions and calculations of recipes

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Fertilisation

- Basic feeding the crop
- Improve productivity
- Restore soil chemical properties
- Correct nutrient imbalances
- Feeding micro organisms

Basics of fertilisation

Fertilisation = Fertiliser supply

Nutrient management = Supply of plant nutrients to soil or substrate, taking into account requirements of:

- Crop
- Soil / substrate
- Water quality
- Interactions between nutrients
- Specific fertilizer effects
- Impact on environment

Fertilisers

Classification

- Organic
  - manures (cattle, poultry, horses e.g.)
  - compost (shredded yard waste, city waste
  - Industrial waste (Rice hulls, Straw, Soya)
- Inorganic
  - Minerals (e.g. Potassium sulphate, Phosphorus)
  - Synthetic (e.g. Ammoniumnitrate, Urea)
- Lime stone

Fertilisers

Classification (2)

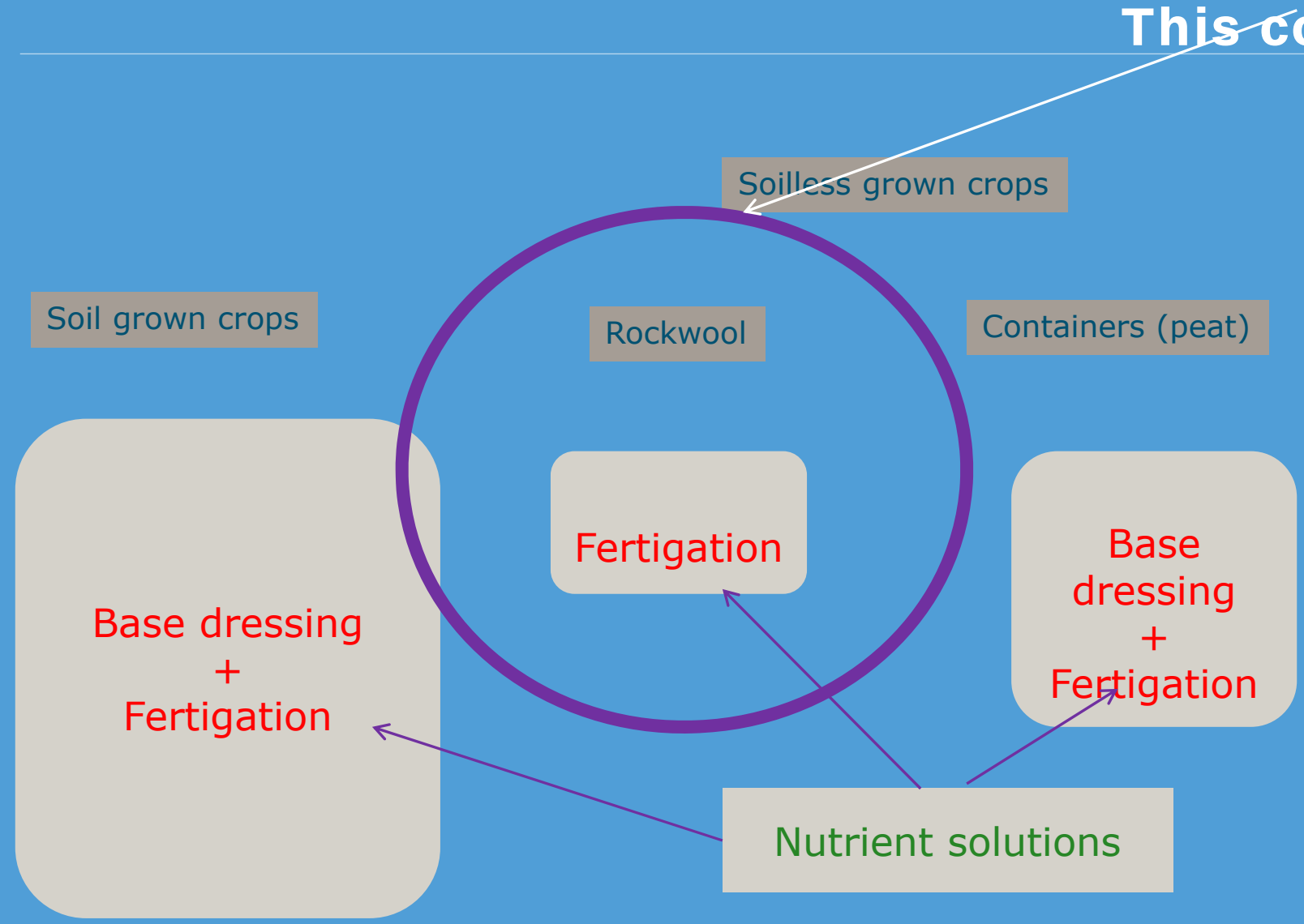
- Insoluble (broadcasting), e.g.
  - Calcium-ammoniumnitrate (CAN)
  - Triplesuperphosphate, (TPS)
  - Potassiumsulphate (SOP)
- Soluble (fertigation), e.g.
  - Potassiumnitrate
  - Calciumnitrate
  - Monoammoniumphosphate
- (Liquid fertilisers)

Fertilisers

classification (3)

- single salts
  - Potassiumnitrate
  - ammoniumnitrate
- compound fertilisers
  - 7 + 14 + 28 (Kristalon)
  - e.g. (Peters, Plantprod….

Fertiliser application in practice

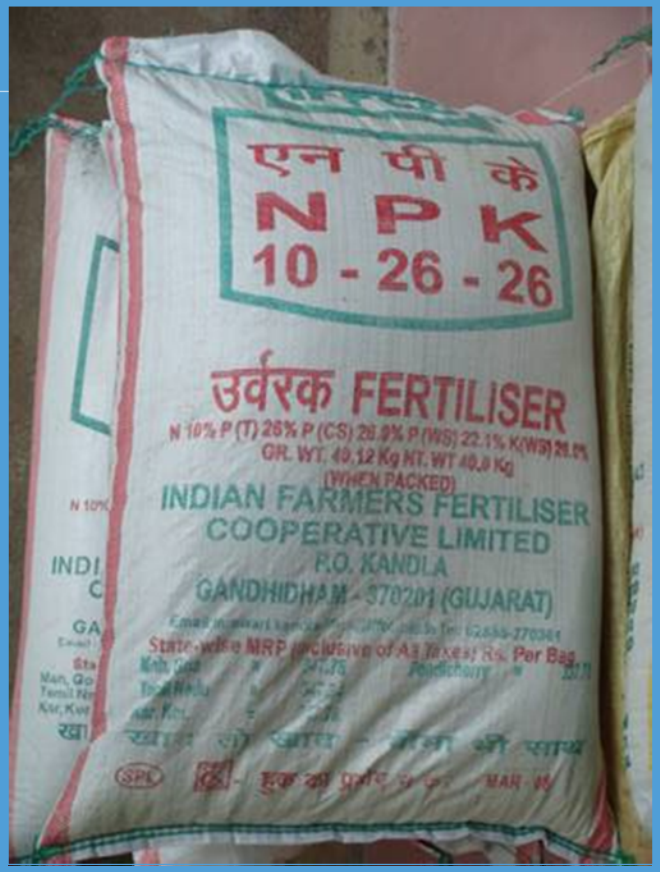


International standard

N P K ratios weight %

- N =N
- P = P_2O_5
- K = K_2O

- Ca = CaO
- Mg = MgO
- S = SO_3



Fertilisers in Hydroponics

Calciumnitrate	$Ca(NO_3)_2$)	N	Ca
Ammoniumnitrate	NH_4NO_3	N	
Potassiumnitrate	KNO_3	K	N
Potassiumsulphate	K_2SO_4	K	S
Monopotassiumphosphate	KH_2PO_4	K	P
Monoammoniumphosphate	NH_4H2PO_4	N	P
Magnesiumnitrate	$Mg(NO_3)_2$	Mg	N
Magnesiumsulphate	$MgSO_4$	Mg	S
Acids			
Nitric acid	HNO_3	N	
Phosphoric acid	H_3PO_4	P	
Sulfuric acid	H_2SO_4	S	

Basic chemical notions and terminology

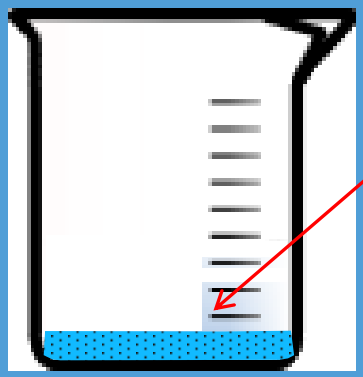
- Concentration:
  - Solids dissolved in water
  - Quantity per liter
    - mg/l
    - mmol/l

Mole

- The mole is a unit in chemistry to express **amounts** of a chemical substance
- defined as the amount of any substance that contains as many elementary entities as there are atoms in 12 grams of pure carbon C.
- This corresponds to "Avogadro constant" which has a value of 6.02×10^{23} elementary entities of the substance.
- It is one of the base units in the International System of Units, and has the unit symbol mol.[1]

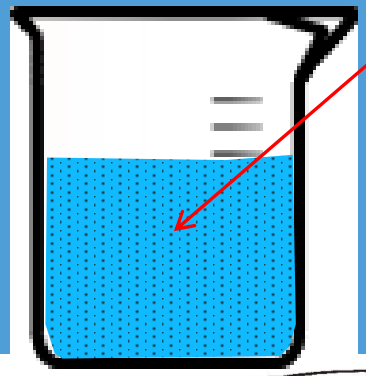
example

1 mole H: hydrogen atoms
= 1 gram



6.2 * 10^{23} atoms

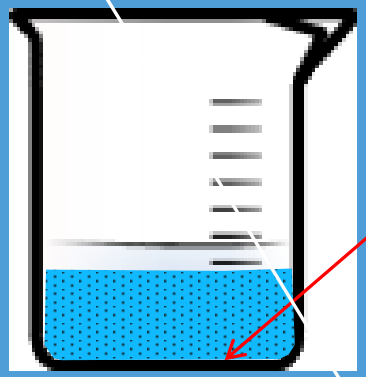
1 mole K: potassium atoms
= 39.1 gram



6.2 * 10^{23} atoms

Avogadro counting the number of molecules in a mole

1 gram N: nitrogen
= 1/14 = 0.07 mol



0.07* 6.2 * 10^{23} atoms
= 0.43 * 10^{23} atoms

1 gram Mg: magnesium
= 1/24.3 = 0.04 mol

Molecular weight
The weight of 1 mole of an element

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	110 Unn								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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So..

- From mole to weight = multiply by molecular weight
  - 1 mol N = 14 gram
  - 5 mol NaCl = 5*(23+35.5) = 292.5
- From weight to mole = divide by molecular weight
  - 50 gram K = 50/39.1 = 1.28 mol
  - 101.1 gram KNO_3 = 1 mol

And more details

- g - mg = 1/1000
- mg – µg = 1/1000

- mol - mmol =1/1000
- mol - µmol =1 1/1000

- 1 mol substance + 1 liter liquid = 1 mol/l

1 mmol KNO_3 1 liter water 1 mmol/l K

1 mmol/l NO_3

1 mmol K_2SO_4 → 2 mmol K + 1 mmol SO_4

One more thing: the milli-equivalent

- 1 mmole K+ = 1 me (milli-equivalen

- 1 mmole Ca^{2+} = 2 me
- 1 mmol Al^{3+} = 3 me

- Sum of cations and anions (me) should be equal
- Rule of thumb: total sum cations or anions / 10 = EC

Example of Ion balance

ANIONS		CATIONS	
	meq/L		meq/L
NO_3^-	15	K^+	7
$H_2PO_4^-$	2	Ca^{++}	10
SO_4^{--}	3	Mg^{++}	3
Total	**20**	**Total**	**20**

Ways of expression

K as K, not K_2O

Quantity:

- **kg K ha^{-1}**
- *(mol K ha^{-1})*

Example:

- 500 kg K ha^{-1}
- (603 kg K_2O)

Ways of expression

K as K, not K_2O

Quantity:

- **kg K ha^{-1}**
- *(mol K ha^{-1})*

Example:

- 500 kg K ha^{-1}
- (603 kg K_2O)

Concentration:

- **mmol K l^{-1}**
- *mg K l^{-1}*

Example:

- 6 mmol l-1
- 235 mg l-1

Ways of expression

K as K, not K_2O

Quantity:

- **kg K ha^{-1}**
- *(mol K ha^{-1})*

Example:

- 500 kg K ha^{-1}
- (603 kg K_2O)

Concentration:

- **mmol K l^{-1}**
- *mg K l^{-1}*

Example:

- 6 mmol l-1
- 235 mg l-1

Ratio:

N : K K : Ca

- mol : mol
- kg : kg

- Example
- N = 20 mmol/l, K = 7 mmol/l
- mole ratio = N : K = 2.86
- weight ratio = N : K = 1.0

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Fertilisation in greenhouse crops

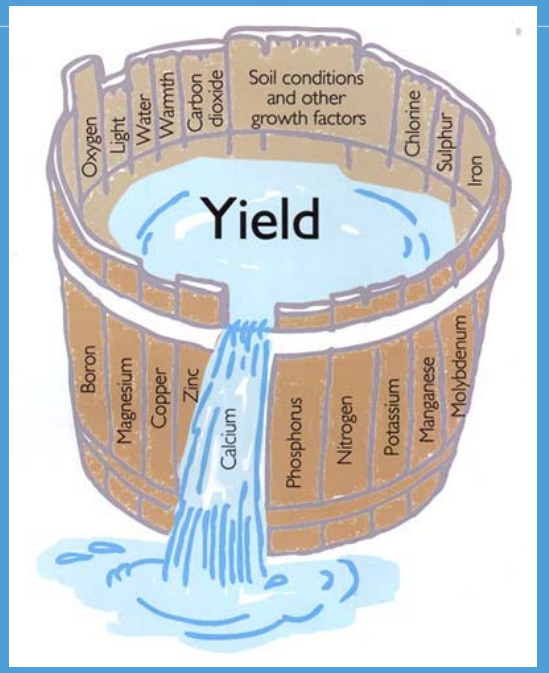
1. Concentrations
    - Supply (fertigation) and Root environment
        - EC, Nutrients mg/l or mmol/l
2. Nutrient ratio's
    - N : P : K : Ca : Mg : S
    - Fe : Mn : Zn : B : Cu

- **Nutrient solutions (water + dissolved nutrients)**
- **Fertilisers source of less importance**

Crop requirement

- Genetically determined
- Cultivar differences

- Total
- Distribution over growing period



Fertiliser application

Quantity of available K in greenhouse crops

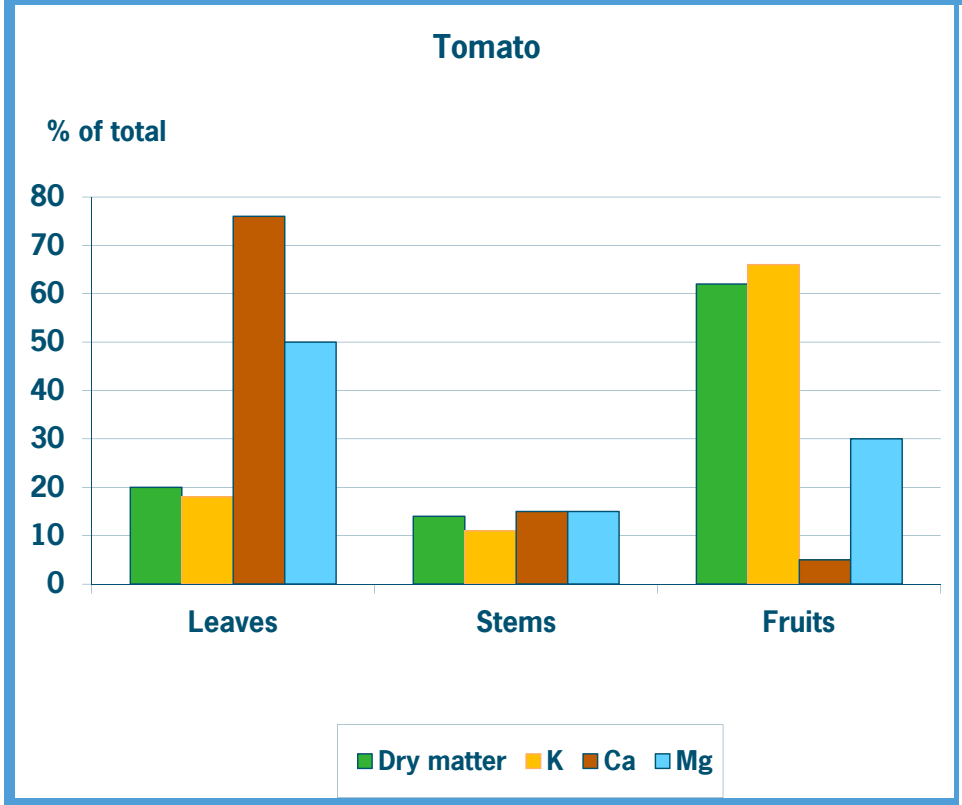
		Greenhouse soil	Rockwool	NFT
Substrate volume	l m^2	300	15	2
Concentration)**	mmol l^{-1}	4	8	8
Crop demand)*	kg ha^{-1}	1750	1750	1750
Directly available	kg ha^{-1}	600	40	6
% of demand	%	34	2	< 1

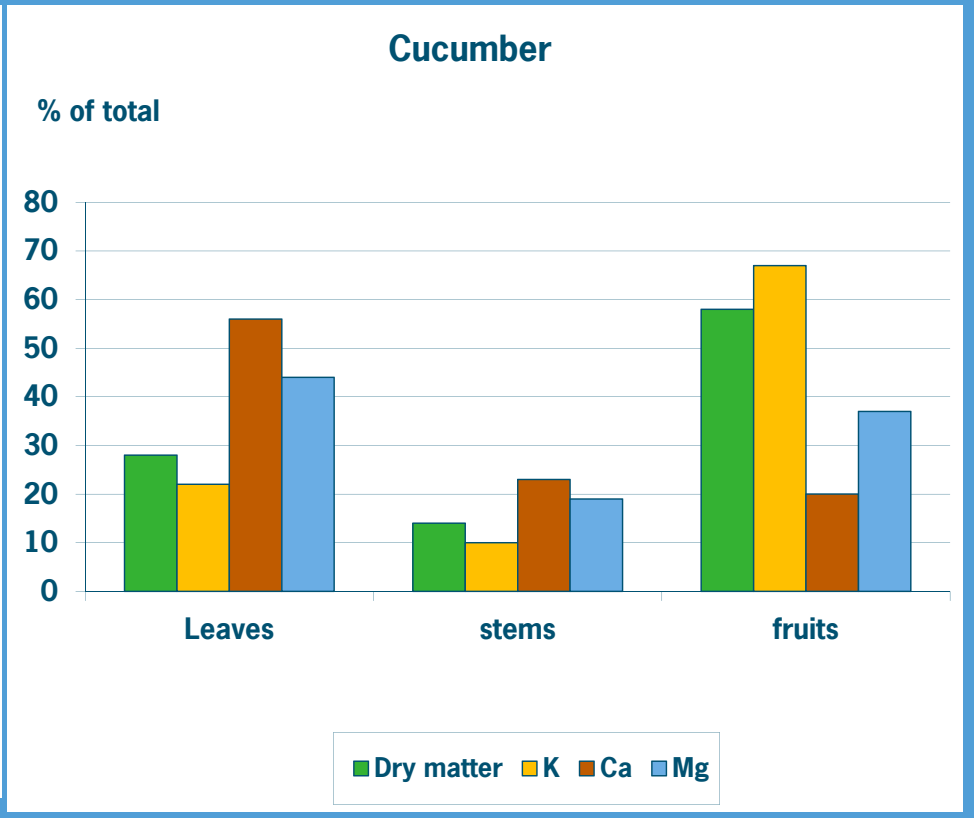
) * Year round tomato crop; yield 50 kg m^{-2}

)** In 1: 2 Volume extract

Example of crop differences

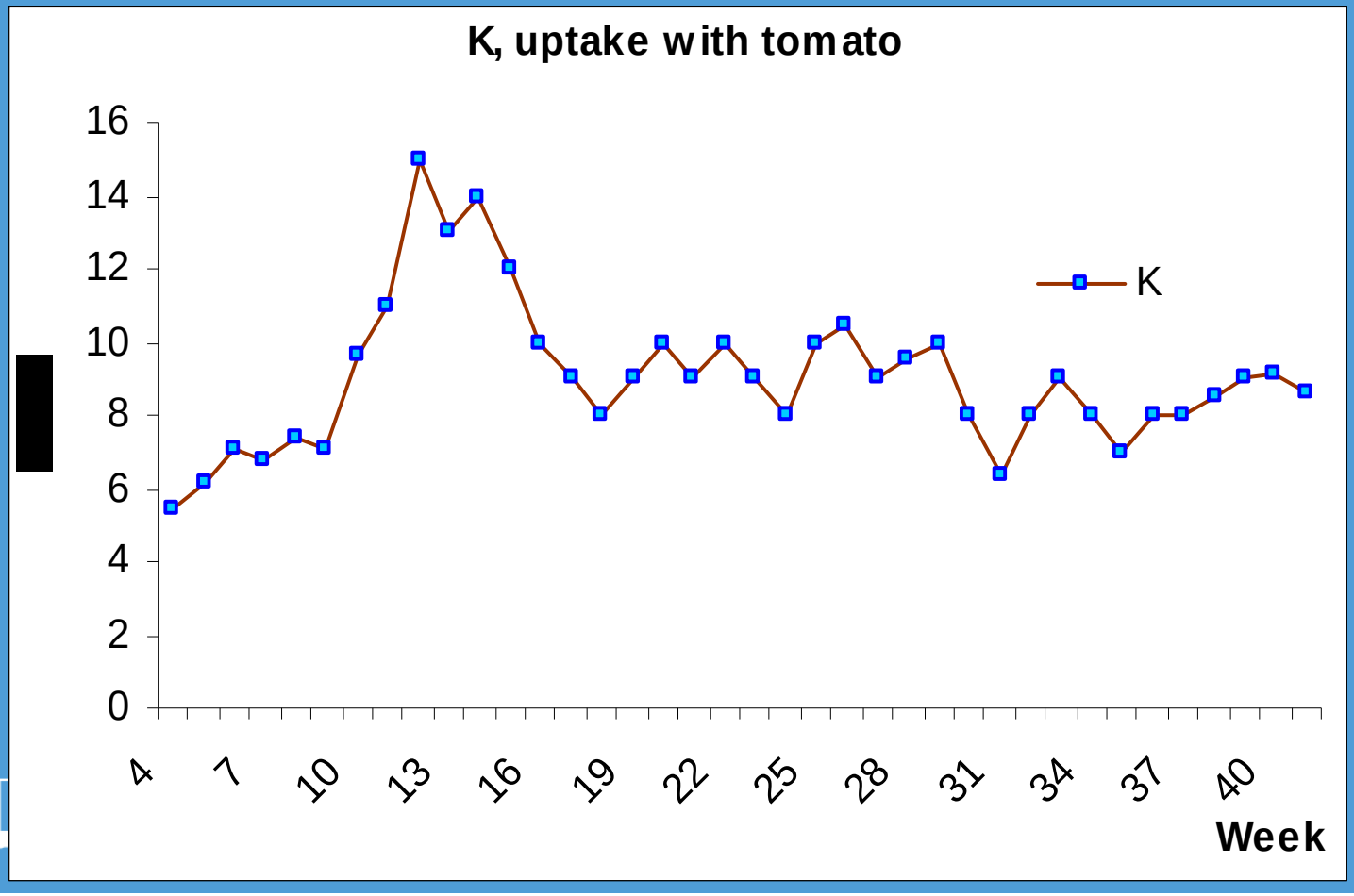
Distribution of K, Ca and Mg in the plant, in % of the total uptake





Example of crop stage effects

K uptake by tomato during growth



types of growing media

- Soil
  - natural soil: clay, sand, peat
  - “artificial” : raised beds, lay-on
- Soilless
  - substrate (rockwool, pumice, perlite, peat)
  - hydroponic (water culture)

Soil

- large volume
  - 150 – 250 l/m2
  - water content, contact with ground water
  - organic matter
- Fertilisation based on the soil properties
  - phosphate buffer
  - K buffer / fixation
  - pH liming

Substrate

- Restricted Root Volume
  - 10 - 15 l m^{-2}
- Restricted quantity water and nutrients
  - 2 - 5 % of total demand

Adequate water and nutrient supply !

Fertilisation in Soilless culture

- Nutrient solution
- Water quality
- Substrate
- Irrigation method
- Crop / growing stage

Nutrient solutions

- Macro elements
  - N *(NO_3 and NH_4)*
  - K, Ca, Mg
  - S *(SO_4)*, P *(H_2PO_4)*
- Micro elements
  - Fe, Mn, Zn
  - B
  - Cu , Mo
- Other
  - Si

What is the correct nutrient solution

basic solutions

- Basic composition
  - Crop specific
- Adjustments
  - Water quality
  - System
  - Substrate
  - Crop stage

EC mS/cm	2
	mmol/l
NH_4	2
K	9.6
Ca	2.9
Mg	1.3
NO3	14.1
Cl	0
SO4	2.1
H2PO4	1.7
Si	0
	umol/l
Fe	15
Mn	8
Zn	4
B	20
Cu	0.75
Mo	0.5

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Example Cations

K^+ Potassium

Ca^{++} Calcium

Mg^{++} Magnesium

Na^+ Sodium

NH_4^+ Ammonium

What to do, if you want to change one cation in the nutrient solution?

Nutrient Solution		
example		Standard
EC	mS/cm	1.5
N: NH4+	mmol/l	1
K: K+	"	5
Ca: Ca++	"	2.5
Mg: Mg++	"	1
N: NO3-	"	10
S: SO4--	"	1
P: H2PO4-	"	1
Sum cation	me/l	13
Sum anions	"	13
K:Ca		2

Cations,
positive charge

Anions,
negative charge

Nutrient Solution		
example		Standard
EC	mS/cm	1.5
N: NH4+	mmol/l	1
K: K+	"	5
Ca: Ca++	"	2.5
Mg: Mg++	"	1
N: NO3-	"	10
S: SO4--	"	1
P: H2PO4-	"	1
Sum cation	me/l	13
Sum anions	"	13
K:Ca		2

Cation
po

Anions,
negative charge

How to increase K by 25%?

You cannot only add K^+

Nutrient Solution		
example		Standard
EC	mS/cm	1.5
N: NH4+	mmol/l	1
K: K+	"	5
Ca: Ca++	"	2.5
Mg: Mg++	"	1
N: NO3-	"	10
S: SO4--	"	1
P: H2PO4-	"	1
Sum cation	me/l	13
Sum anions	"	13
K:Ca		2

Cation

An

How to increase K by 25%?

You cannot only add K^+

Add equal amount NO_3

→EC increases to 1.6

Nutrient Solution		
example		Standard
EC	mS/cm	1.5
N: NH4+	mmol/l	1
K: K+	"	5
Ca: Ca++	"	2.5
Mg: Mg++	"	1
N: NO3-	"	10
S: SO4--	"	1
P: H2PO4-	"	1
Sum cation	me/l	13
Sum anions	"	13
K:Ca		2

Cation

An

How to increase K by 25%?

You cannot only add K^+

Decrease Ca, Mg, NH_4

→K:Ca ratio changes by more than 25%

Nutrient Solution		
example		Standard
EC	mS/cm	1.5
N: NH4+	mmol/l	1
K: K+	"	5
Ca: Ca++	"	2.5
Mg: Mg++	"	1
N: NO3-	"	10
S: SO4--	"	1
P: H2PO4-	"	1
Sum cation	me/l	13
Sum anions	"	13
K:Ca		2

Cation
po

How to increase K by 25%?

You cannot only add K^+

Keep K:Ca constant

K increase <25%
Some increase Ca, Mg, NH_4

Nutrient Solution		
example		Standard
EC	mS/cm	1.5
N: NH4+	mmol/l	1
K: K+	"	5
Ca: Ca++	"	2.5
Mg: Mg++	"	1
N: NO3-	"	10
S: SO4--	"	1
P: H2PO4-	"	1
Sum cation	me/l	13
Sum anions	"	13
K:Ca		2

Nutrient solution is made up from the following components:

	fertilisers
A	NH4NO3
	Ca(NO3)2
B	MgSO4
	KH2PO4
	KNO3
	K2SO4

Fertiliser application in practice

Tomato kg/ha				
yield				
50 kg/m2	Base dressing		Top Dressing	
Demand	N	fertiliser	N	fertiliser
N				
P				
K				

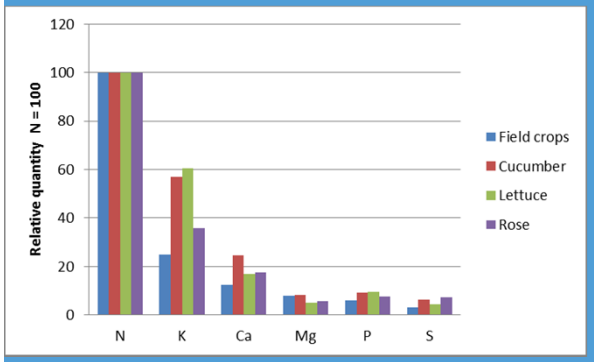
Free drainage		
EC dS m^{-1}	2.6	
pH	5.5	
	mmol/l	mg/l
NH_4	1	14
K	9.5	371
Na	0	0
Ca	5.4	217
Mg	2.4	58
NO_3	16.0	224
Cl	2.5	89
SO_4	4.4	136
H_2PO_4	1.5	48

Calculation of a fertilizer recipe

To recipes

To basic solutions

From nutrient requirements



EC mS/cm	2
	mmol/l
NH_4	2
K	9.6
a	2.9
Mg	1.3
NO3	14.1
Cl	0
SO4	2.1
H2PO4	1.7
Si	0
	umol/l
Fe	15
Mn	8
Zn	4
B	20
Cu	0.75
Mo	0.5

Fertiliser recipe datum **03-sep-15**

Name	Tomato
Water source	well water
EC irrigation	2.6
quantity (l)	1000
Concentration (times)	100

A Tank				
Calciumnitrate	5[Ca(NO3)2)]. NH4NO3	*crystaline*	95.1	kg
Iron chelate (6%)	Fe-DTPA	*powder*	999	gram
Potassiumnitrate	KNO3	*crystaline*	34.4	kg
calciumchloride	CaCl2	*crystaline*	5.56	kg
B Tank				
Potassiumnitrate	KNO3	*crystaline*	0.0	kg
Magnesium sulphate	MgSO4	*crystaline*	51.7	kg
Potassiumsulphate	K2SO4	*crystaline*	39.2	kg
Monopotassiumphosphate	KH2PO4	*crystaline*	20.4	kg
Manganesesulphate	**Mn**$SO_4 \cdot H_2O$	*crystaline*	165.6	gram
Zinsulphate	**Zn**$SO_4 \cdot 6H_2O$	*crystaline*	135.1	gram
Borax	Na_2**B**$_4O_7 \cdot 10H_2O$	*crystaline*	259	gram
Coppersulphate	**Cu**$SO_4 \cdot 5H_2O$	*crystaline*	19	gram
Sodium-molybdate	Na_2**Mo**$O_4 \cdot 2H_2O$	*crystaline*	12.1	gram

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Nutrient solution calcualtion

- Step by step

Step 1 **Setting up table with the n.s. to be calculated**

From nutrient solution to fertilise recipe	Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
	20.00	20.00	2.0	9.6	2.9	1.3	14.1	2.1	1.7	0.0
	me/l	*me/l*				*mmoll/l*				

Step 1a choice of Ca - fertilizer

From nutrient solution to fertilise recipe	Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
	20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
	me/l	*me/l*				*mmoll/l*				
1a Fill in as much $Ca(NO_3)_2$ as needed for Ca^{2+}	$Ca(NO_3)_2$	3			3		6			

Step 1b Supplement NH_4 with NH_4NO_3

From nutrient solution to fertilise recipe	Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
	20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
	me/l	*me/l*					*mmol/l*			
1b	$Ca(NO_3)_2$	3			3		6			
Additional NH_4^+	NH_4NO_3	1	1				1			

Step 1c Add phosphate fertilizer

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1c	$Ca(NO_3)_2$	3				3		6			
	NH_4NO_3	1	1					1			
Phosphate source	KH_2PO_4	1.5			1.5					1.5	

Step 1d Add magnesium fertiliser

From nutrient solution to fertilise recipe	Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
	20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
	me/l	*me/l*				*mmoll/l*				
1d	$Ca(NO_3)_2$	3			3		6			
	NH_4NO_3	1	1				1			
	KH_2PO_4	1.5		1.5					1.5	
Choose Mg source	$MgSO_4$	1.5				1.5		1.5		

Step 1e Sulphate fertiliser

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1e		$Ca(NO_3)_2$	3			3		6			
		NH_4NO_3	1	1				1			
		KH_2PO_4	1.5		1.5					1.5	
		$MgSO_4$	1.5				1.5		1.5		
Choose remaining SO_4 as K_2SO_4		K_2SO_4	0.5		0.5				0.5		

Step 1f Complete the balance with K and NO3 fertiliser

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1f	$Ca(NO_3)_2$	3				3		6			
	NH_4NO_3	1	1					1			
	KH_2PO_4	1.5			1.5					1.5	
	$MgSO_4$	1.5					1.5		1.5		
	K_2SO_4	0.5			1				0.5		
remaining K and NO_3 as KNO_3	KNO_3	7.5			7.5			7.5			

Step 1 Check result

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1f Finally remaining K and NO_3 as KNO_3	$Ca(NO_3)_2$	3				3		6			
	NH_4NO_3	1	1					1			
	KH_2PO_4	1.5			1.5					1.5	
	$MgSO_4$	1.5					1.5		1.5		
	K_2SO_4	0.5			1				0.5		
	KNO_3	7.5			7.5			7.5			
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0

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Step 2 From nutrient solution to fertilise recipe

	Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
	20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
	me/l	*me/l*				*mmoll/l*				
$Ca(NO_3)_2$	3				3		6			
NH_4NO_3	1	1					1			
KH_2PO_4	1.5			1.5					1.5	
$MgSO_4$	1.5					1.5		1.5		

Calculation fertilisers quantity from mmol/

use molecular weight (g/mol = mg/mmol)

1) $Ca(NO_3)_2$ = 3 mmol/l * 181 = 543 mg/l

Step 2 From nutrient solution to fertilise recipe

	Sum cations	Sum anions	NH_4	K	Ca		PO_4	Cl
	20.00	20.00	1.0	10	3		1.5	0.0
	me/l	*me/l*						
$Ca(NO_3)_2$	3			3		6		
NH_4NO_3	1	1				1		
KH_2PO_4	1.5		1.5				1.5	
$MgSO_4$	1.5				1.5		1.5	

Fertiliser solution
= 1000 l
100 times concentrated

Calculation fertilisers quantity from mmol/

use molecular weight (g/mol = mg/mmol)

1) $Ca(NO_3)_2$ = 3 mmol/l * 181 = 543 mg/l

Step 2 From nutrient solution to fertilise recipe

	Sum cations	Sum anions	NH_4	K	Ca	SO_4	Cl
	20.00	20.00	1.0	10	3	1.5	0.0
	me/l	*me/l*					
	$Ca(NO_3)_2$	3			3	6	
	NH_4NO_3	1	1			1	

Fertiliser solution
= 1000 l
100 times concentrated

Calculation fertilisers quantity from mmol/

use molecular weight (g/mol = mg/mmol)

1) $Ca(NO_3)_2$ = 3 mmol/l * 181 = 543 mg/l

$Ca(NO_3)_2$ = 543 mg/l *100 *1000 l = 54 300 000 mg

= 54.3 kg/m^3

Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
20.00 *me/l*	20.00 *me/l*	1.0	10	3	1.5	14.5	2.0	1.5	0.0
					mmoll/l				
$Ca(NO_3)_2$	3			3		6			
NH_4NO_3	1	1				1			
KH_2PO_4	1.5		1.5					1.5	
$MgSO_4$	1.5				1.5		1.5		
K_2SO_4	0.5		1				0.5		
KNO_3	7.5		7.5			7.5			
20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0

Step 2	Tank A					
convert to concentrated A B solution	$Ca(NO_3)_2$		52.3	kg		
	NH_4NO_3		30.5	kg	23.7	l
	KNO3					
	Tank B					
	KNO3		64.1	kg		
	KH2PO4		22.7	kg		
	K2SO4		13.7	kg		
	MgSO4		33.9	kg		

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Example

Fertiliser recipe datum **03-sep-15**

Name	Tomato
Water source	well water
EC irrigation	2.6
quantity (l)	1000
Concentration (times)	100

A Tank				
Calciumnitrate	5[Ca(NO3)2)]. NH4NO3	*crystaline*	95.1	kg
Iron chelate (6%)	Fe-DTPA	*powder*	999	gram
Potassiumnitrate	KNO3	*crystaline*	34.4	kg
calciumchloride	CaCl2	*crystaline*	5.56	kg
B Tank				
Potassiumnitrate	KNO3	*crystaline*	0.0	kg
Magnesium sulphate	MgSO4	*crystaline*	51.7	kg
Potassiumsulphate	K2SO4	*crystaline*	39.2	kg
Monopotassiumphosphate	KH2PO4	*crystaline*	20.4	kg
Manganesesulphate	$\mathbf{Mn}SO_4 \cdot H_2O$	*crystaline*	165.6	gram
Zinsulphate	$\mathbf{Zn}SO_4 \cdot 6H_2O$	*crystaline*	135.1	gram
Borax	$Na_2\mathbf{B}_4O_7 \cdot 10H_2O$	*crystaline*	259	gram
Coppersulphate	$\mathbf{Cu}SO_4.5H_2O$	*crystaline*	19	gram
Sodium-molybdate	$Na_2\mathbf{Mo}O_4 \cdot 2H_2O$	*crystaline*	12.1	gram

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Specials situations

Calciumnitrate $Ca(NO_3)_2$

Specific for Yara product

$Ca(NO_3)_2$

=

$5[Ca(NO_3)_2 .2H_2O] . NH_4NO_3$

Or

1 mol = 5 mol Ca 11 mol NO_3 1 mol NH_4

Details

Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
20.00 *me/l*	20.00 *me/l*	1.0	10	3	1.5	14.5	2.0	1.5	0.0
					mmoll/l				
$Ca(NO_3)_2$	3			3		6			
NH_4NO_3	1	1				1			

Using YARA Calciumnitrate

		NH4	K	Ca	Mg	NO3	SO4	P	Cl
fertiliser	mmol/l	2.0	10	3	1.5	14.5	2.0	1.5	0.0
$5[Ca(NO_3)_2].NH_4NO_3$	0.6	0.6		3		6.6			
NH_4NO_3	0.4	0.4				0.4			

Using MAP instead of MKP

Step 1c **Add phosphate fertilizer**

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1c		$Ca(NO_3)_2$	3			3		6			
		NH_4NO_3	1	1				1			
Phosphate source		KH_2PO_4	1.5		1.5					1.5	

Step 1c **Add phosphate fertilizer**

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1c		$Ca(NO_3)_2$				3		6			
		NH_4NO_3	1	1				1			
Phosphate source		$NH_4H_2PO_4$	1.5	1.5						1.5	

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Using MAP instead of MKP

Step 1c **Add phosphate fertilizer**

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1c		$Ca(NO_3)_2$	3			3		6			
		NH_4NO_3	1	1				1			
Phosphate source		KH_2PO_4	1.5		1.5					1.5	

Step 1c **Add phosphate fertilizer**

From nutrient solution to fertilise recipe		Sum cations	Sum anions	NH_4	K	Ca	Mg	NO_3	SO_4	H_2PO_4	Cl
		20.00	20.00	1.0	10	3	1.5	14.5	2.0	1.5	0.0
		me/l	*me/l*				*mmoll/l*				
1c		$Ca(NO_3)_2$	3			3		6			
		NH_4NO_3	1								
Phosphate source		$NH_4H_2PO_4$	1.0	1.0						1.0	
		KH_2PO_4	0.5		0.5					0.5	

Alternative all SO_4 as $MgSO_4$

all SO4 as MgSO4

		NH4	K	Ca	Mg	NO3	SO4	P	Cl
fertiliser	mmol/l	1.0	1		1.5	14.5	2.0	1.5	0.0
5[Ca(NO3)2].NH4NO3	0.6	0.6		3		6.6			
NH4H2PO4	1.4	0.						0.4	
KH2PO4	1.1		1.1					1.1	
Difference									
MgSO4	2.0				2.0		2.0		
K2SO4	0.0		0.0				0.0		
KNO3	9.4		8			9.4			
		2.0	9.0	3.0	2.0	16	2.0	1.5	0.0

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Introduction of Cl^-

Introduction of Cl		NH4	K	Ca	Mg	NO3	SO4	P	Cl
fertiliser	mmol/l	1.0	10	3	1.5	13.0	2.0	1.5	1.5
5[Ca(NO3)2].NH4NO3	0.6	0.6		3		6.6			
NH4NO3	0.4	0.4				0.4			
KH2PO4	1.5		1.5					1.5	
MgSO4	1.5				1.5		1.5		
K2SO4	0.5		1.0				1.0		
KCl	1.5		1.5						1.5
KNO3	6.0		6			6.0			
		1.0	10	3	1.5	13.5	2.0	1.5	1.5

Using $CaCl_2$ instead of KCL of Cl^-

Introduction of Cl		NH4	K	Ca	Mg	NO3	SO4	P	Cl
fertiliser	mmol/l	1.0	10	3	1.5	13.0	2.0	1.5	1.5
5[Ca(NO3)2].NH4NO3	0.45	0.45		2.25		4.95			
NH4NO3	0.55	0.55				0.55			
CaCl2				0.75					1.5
KH2PO4	1.5		1.5					1.5	
MgSO4	1.5				1.5		1.5		
K2SO4	0.5		1				0.5		
KNO3	8		8			8			
		1.0	10	3	1.5	13.5	2.0	1.5	1.5

How to calculate the micro elements ?

basic solutions

EC mS/cm	2
	mmol/l
NH_4	2
K	9.6
Ca	2.9
Mg	1.3
NO3	14.1
Cl	0
SO4	2.1
H2PO4	1.7
Si	0
	umol/l
Fe	15
Mn	8
Zn	4
B	20
Cu	0.75
Mo	0.5

Direct conversion from µmol/l to weight g/m3

Example

	Type		
Iron chelate (6%)	AKZO	Fe-DTPA	powder

How to calculate the "molecular weight"

6 % Fe	= 6g/100g		
	=60g/1000 g		
1 kg =	= 60/ 55.9	1.07	mol
1 mol=	=1/1.07	935	gram
1 mmol		935	mg
1 µmol		935	µg

Example

	Type		
Iron chelate (6%)	AKZO	Fe-DTPA	powder

How to calculate the "molecular weight"

Atomic weight Fe

6 % Fe	= 6g/100g		
	=60g/1000 g		
1 kg =	= 60/ 55.9	1.07	mol
1 mol=	=1/1.07	935	gram
1 mmol		935	mg
1 µmol		935	µg

	µmol/l			
Fe	15	= 15 * 934	14025	µg/l
Mn	8		for 1 m3	200 * conc
Zn	4		2805	g
B	20			
Cu	0.75			
Mo	0.5			

Other micro elements

	µmol/l	mol. weight	µg/l	1 m3 200 * conc	
Fe	15 Fe-DTPA 6%	932	13980	2796	gram
Mn	8 $MnSO_4$	16	128	25.6	gram
Zn	4 $ZnSO_4$	287	1148	229.6	gram
B	20 $Na_2B_4O_7$	381	7620	1524	gram
Cu	0.75 $CuSO_4$	250	187.5	37.5	gram
Mo	0.5 Na_2MoO_4	242	121	24.2	gram

Final result

Fertiliser recipe datum **03-sep-15**

Name	Tomato
Water source	well water
EC irrigation	2.6
quantity (l)	1000
Concentration (times)	100

A Tank				
Calciumnitrate	5[Ca(NO3)2)]. NH4NO3	*crystaline*	95.1	kg
Iron chelate (6%)	Fe-DTPA	*powder*	999	gram
Potassiumnitrate	KNO3	*crystaline*	34.4	kg
calciumchloride	CaCl2	*crystaline*	5.56	kg
B Tank				
Potassiumnitrate	KNO3	*crystaline*	0.0	kg
Magnesium sulphate	MgSO4	*crystaline*	51.7	kg
Potassiumsulphate	K2SO4	*crystaline*	39.2	kg
Monopotassiumphosphate	KH2PO4	*crystaline*	20.4	kg
Manganesesulphate	$\mathbf{Mn}SO_4 \cdot H_2O$	*crystaline*	165.6	gram
Zinsulphate	$\mathbf{Zn}SO_4 \cdot 6H_2O$	*crystaline*	135.1	gram
Borax	$Na_2\mathbf{B}_4O_7 \cdot 10H_2O$	*crystaline*	259	gram
Coppersulphate	$\mathbf{Cu}SO_4 \cdot 5H_2O$	*crystaline*	19	gram
Sodium-molybdate	$Na_2\mathbf{Mo}O_4 \cdot 2H_2O$	*crystaline*	12.1	gram

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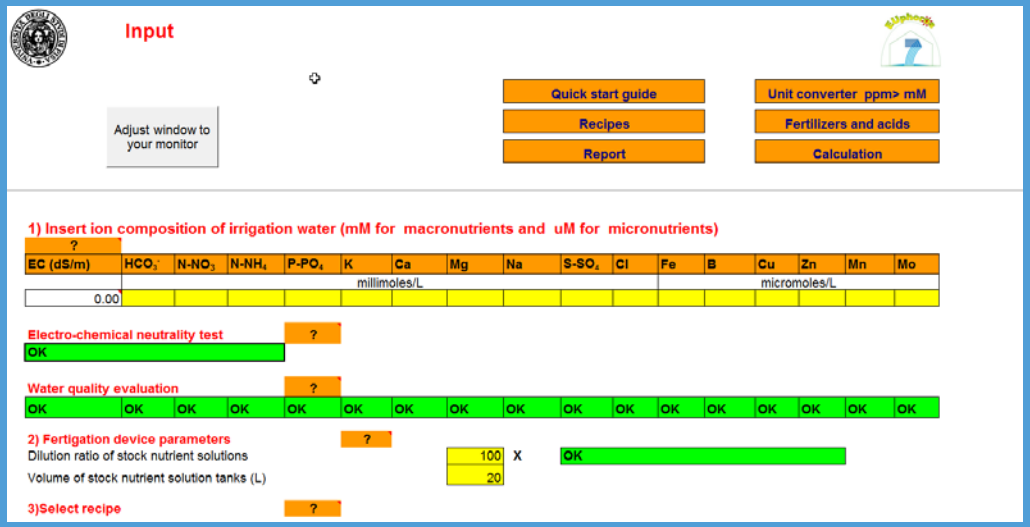
Example calculation tools

- WUR
- Incrocci



Questions or remarks ?

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