

# 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

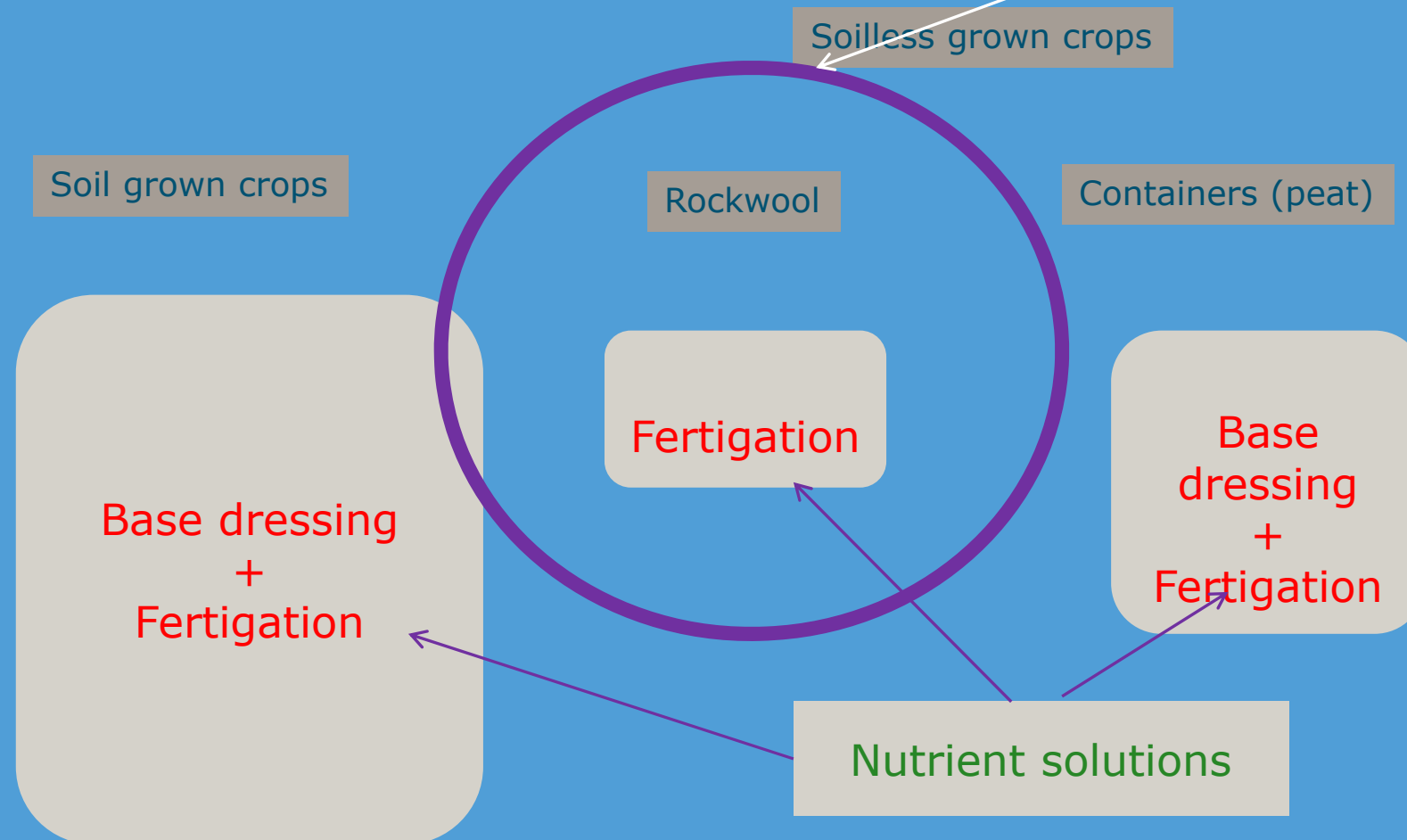
## classification (3)

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



# Fertiliser application in practice

**This course**





# 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         | $\text{Ca}(\text{NO}_3)_2$         | N  | Ca |
| Ammoniumnitrate        | $\text{NH}_4\text{NO}_3$           | N  |    |
| Potassiumnitrate       | $\text{KNO}_3$                     | K  | N  |
| Potassiumsulphate      | $\text{K}_2\text{SO}_4$            | K  | S  |
| Monopotassiumphosphate | $\text{KH}_2\text{PO}_4$           | K  | P  |
| Monoammoniumphosphate  | $\text{NH}_4\text{H}_2\text{PO}_4$ | N  | P  |
| Magnesiumnitrate       | $\text{Mg}(\text{NO}_3)_2$         | Mg | N  |
| Magnesiumsulphate      | $\text{MgSO}_4$                    | Mg | S  |
| <b>Acids</b>           |                                    |    |    |
| Nitric acid            | $\text{HNO}_3$                     | N  |    |
| Phosphoric acid        | $\text{H}_3\text{PO}_4$            | P  |    |
| Sulfuric acid          | $\text{H}_2\text{SO}_4$            | S  |    |

# Basic chemical notions and terminology

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



# Mole

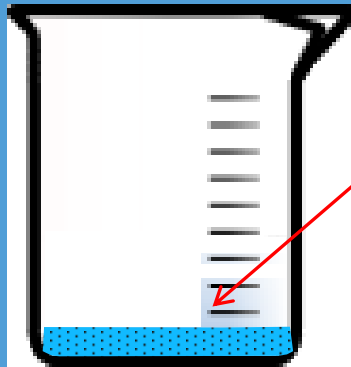


- The mole is a unit in chemistry to express amounts of a chemical substance
- defined as the amount of any substance that contains as many elementary entities as there are atoms in 12 grams of pure carbon C.
- This corresponds to "Avogadro constant" which has a value of  $6.02 \times 10^{23}$  elementary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



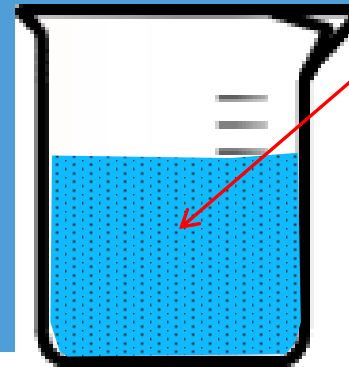
# example

1 mole H: hydrogen atoms  
= 1 gram



$6.2 \times 10^{23}$  atoms

1 mole K: potassium atoms  
= 39.1 gram

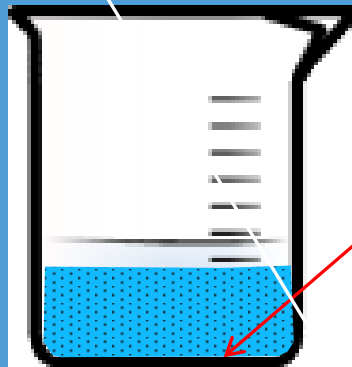


$6.2 \times 10^{23}$  atoms



Avogadro counting the number  
of molecules in a mole

1 gram N: nitrogen  
 $= 1/14 = 0.07 \text{ mol}$



$0.07 * 6.2 * 10^{23} \text{ atoms}$   
 $= 0.43 * 10^{23} \text{ atoms}$

1 gram Mg: magnesium  
 $= 1/24.3 = 0.04 \text{ mol}$



Molecular weight  
 The weight of 1 mole of an element

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

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

# So..

- From mole to weight = multiply by molecular weight

- 1 mol N = 14 gram
- 5 mol NaCl =  $5 \times (23 + 35.5) = 292.5$

- From weight to mole = divide by molecular weight

- 50 gram K =  $50 / 39.1 = 1.28$  mol
- 101.1 gram  $\text{KNO}_3 = 1$  mol





# And more details

- $\text{g} - \text{mg} = 1/1000$
- $\text{mg} - \mu\text{g} = 1/1000$
  
- $\text{mol} - \text{mmol} = 1/1000$
- $\text{mol} - \mu\text{mol} = 1 \text{ } 1/1000$
  
- $1 \text{ mol substance} + 1 \text{ liter liquid} = 1 \text{ mol/l}$



1 mmol  $\text{KNO}_3$



1 liter water



1 mmol/l K

1 mmol/l  $\text{NO}_3$



# One more thing: the milli-equivalent

- 1 mmole  $K^+$  = 1 me (milli-equivalent)
- 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<sup>-1</sup>**
- (*mol K ha<sup>-1</sup>*)

## Example:

- 500 kg K ha<sup>-1</sup>
- (603 kg K<sub>2</sub>O)

# Ways of expression

K as K, not  $K_2O$

Quantity:

- **kg K ha<sup>-1</sup>**
- (*mol K ha<sup>-1</sup>*)

Example:

- 500 kg K ha<sup>-1</sup>
- (603 kg K<sub>2</sub>O)

Concentration:

- **mmol K l<sup>-1</sup>**
- (*mg K l<sup>-1</sup>*)

Example:

- 6 mmol l<sup>-1</sup>
- 235 mg l<sup>-1</sup>



# Ways of expression

K as K, not  $K_2O$

Quantity:

- **kg K ha<sup>-1</sup>**
- (*mol K ha<sup>-1</sup>*)

Example:

- 500 kg K ha<sup>-1</sup>
- (603 kg K<sub>2</sub>O)

Concentration:

- **mmol K l<sup>-1</sup>**
- *mg K l<sup>-1</sup>*

Example:

- 6 mmol l<sup>-1</sup>
- 235 mg l<sup>-1</sup>

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



# Fertilisation in greenhouse crops

## 1. Concentrations

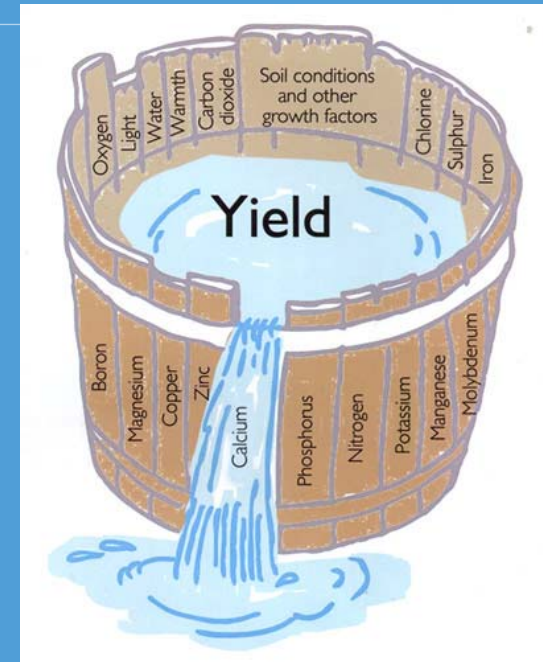
- Supply (fertigation) and Root environment
  - EC, Nutrients mg/l or mmol/l

## 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

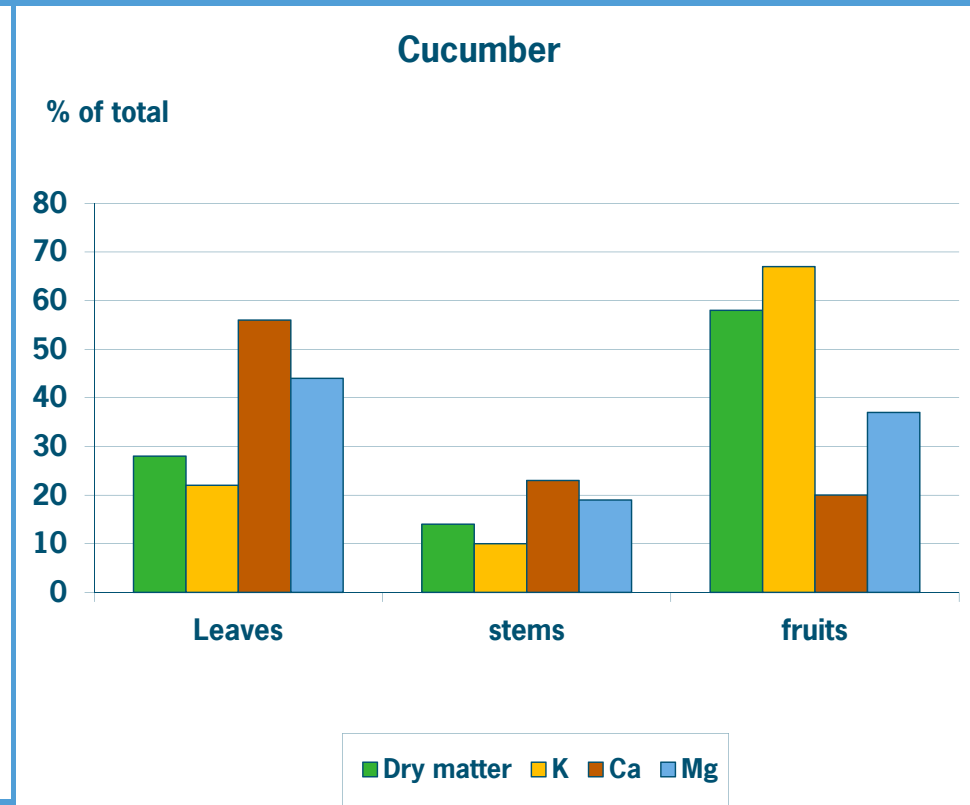
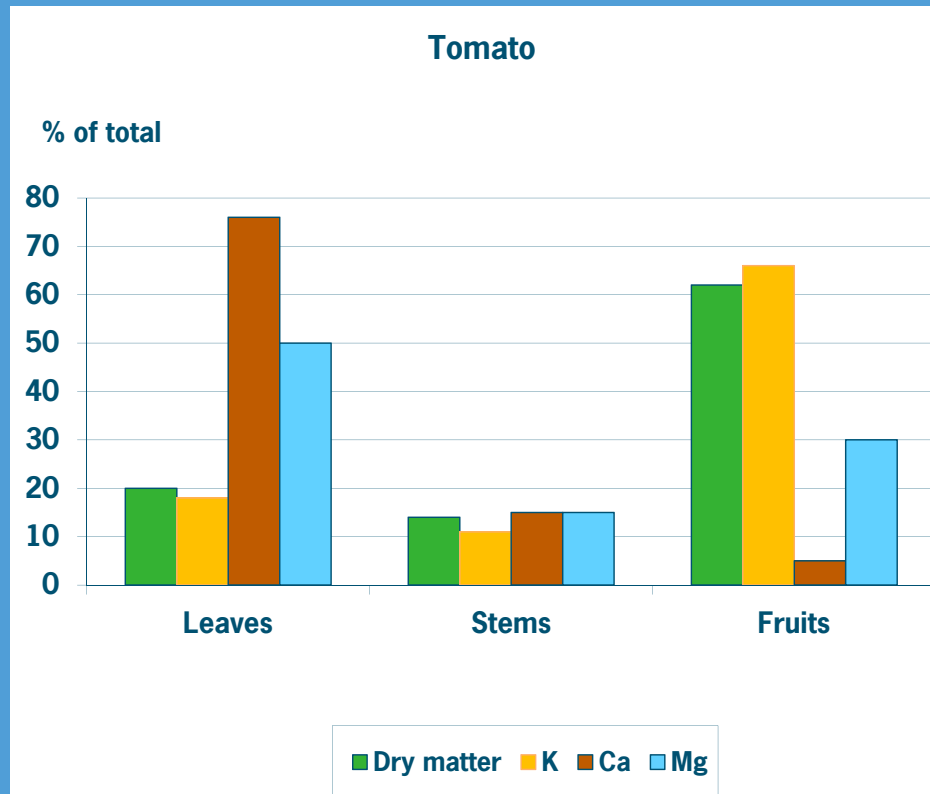
## Quantity of available K in greenhouse crops



|                                                         |                      | <b>Greenhouse<br/>soil</b> | <b>Rockwool</b> | <b>NFT</b> |
|---------------------------------------------------------|----------------------|----------------------------|-----------------|------------|
| Substrate volume                                        | l m <sup>2</sup>     | 300                        | 15              | 2          |
| Concentration)**                                        | mmol l <sup>-1</sup> | 4                          | 8               | 8          |
| Crop demand )*                                          | kg ha <sup>-1</sup>  | 1750                       | 1750            | 1750       |
| Directly available                                      | kg ha <sup>-1</sup>  | 600                        | 40              | 6          |
| % of demand                                             | %                    | 34                         | 2               | < 1        |
| ) * Year round tomato crop; yield 50 kg m <sup>-2</sup> |                      |                            |                 |            |
| ) ** In 1: 2 Volume extract                             |                      |                            |                 |            |

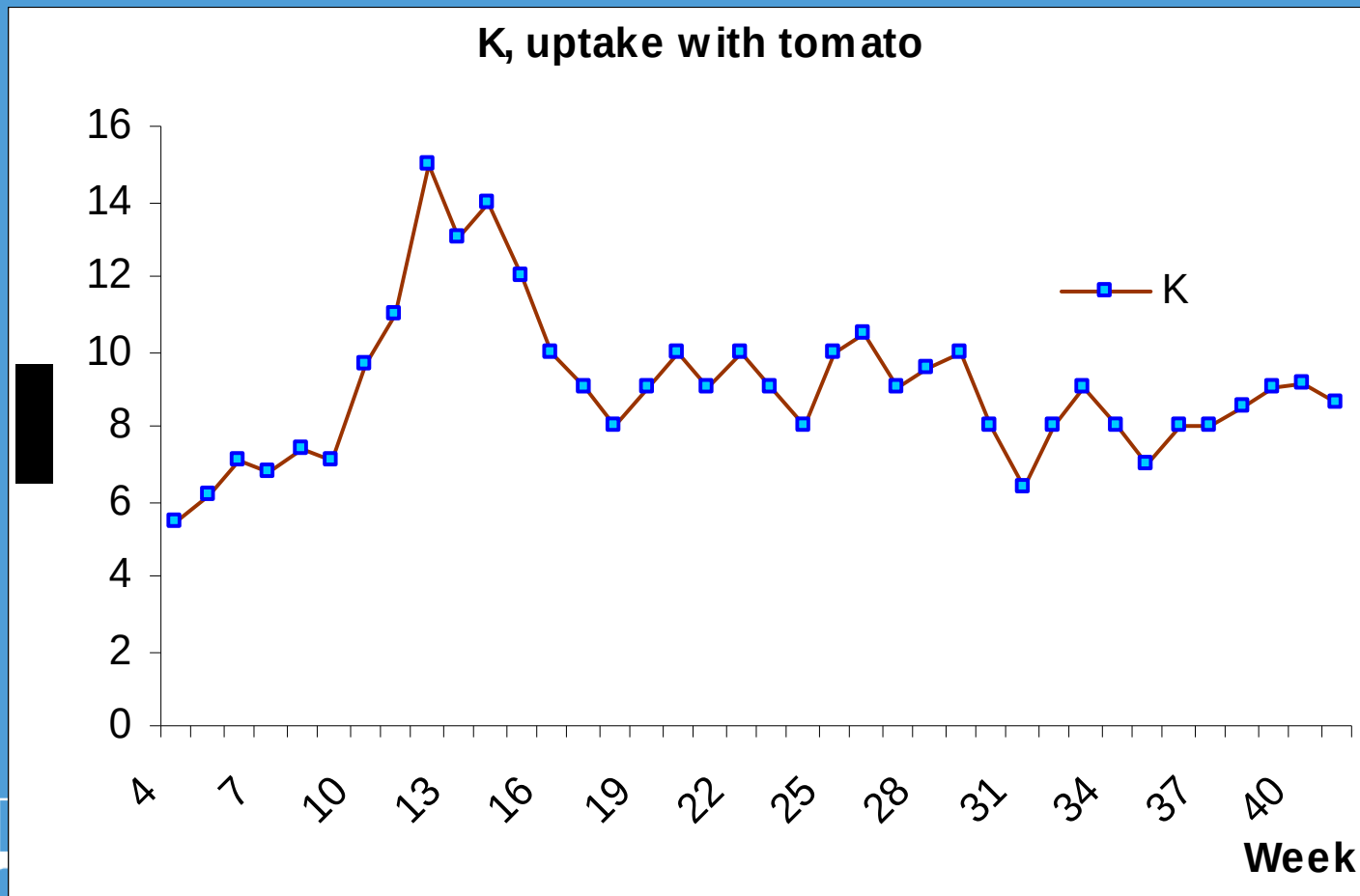
# Example of crop differences

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

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- large volume
  - 150 – 250 l/m<sup>2</sup>
  - 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<sup>-2</sup>
- Restricted quantity water and nutrients
  - 2 - 5 % of total demand



**Adequate water and nutrient supply !**



# Fertilisation in Soilless culture

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

# Nutrient solutions

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- 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



WAGENINGEN **UR**  
*For quality of life*

# basic solutions

## ■ Basic composition

- Crop specific

## ■ Adjustments

- Water quality
- System
- Substrate
- Crop stage

| EC mS/cm                       | 2             |
|--------------------------------|---------------|
|                                | <u>mmol/l</u> |
| NH <sub>4</sub>                | 2             |
| K                              | 9.6           |
| Ca                             | 2.9           |
| Mg                             | 1.3           |
| NO <sub>3</sub>                | 14.1          |
| Cl                             | 0             |
| SO <sub>4</sub>                | 2.1           |
| H <sub>2</sub> PO <sub>4</sub> | 1.7           |
| Si                             | 0             |
|                                | <u>umol/l</u> |
| Fe                             | 15            |
| Mn                             | 8             |
| Zn                             | 4             |
| B                              | 20            |
| Cu                             | 0.75          |
| Mo                             | 0.5           |

# 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?

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| Nutrient Solution                              |        |          |
|------------------------------------------------|--------|----------|
| example                                        |        | Standard |
| EC                                             | mS/cm  | 1.5      |
|                                                |        |          |
| N: NH <sub>4</sub> <sup>+</sup>                | mmol/l | 1        |
| K: K <sup>+</sup>                              | "      | 5        |
| Ca: Ca <sup>++</sup>                           | "      | 2.5      |
| Mg: Mg <sup>++</sup>                           | "      | 1        |
|                                                |        |          |
| N: NO <sub>3</sub> <sup>-</sup>                | "      | 10       |
| S: SO <sub>4</sub> <sup>--</sup>               | "      | 1        |
| P: H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | "      | 1        |
|                                                |        |          |
| Sum cation                                     | me/l   | 13       |
| Sum anion                                      | "      | 13       |
|                                                |        |          |
| K:Ca                                           |        | 2        |



Cations,  
positive charge



Anions,  
negative charge

| Nutrient Solution                              |        |          |
|------------------------------------------------|--------|----------|
| example                                        |        | Standard |
| EC                                             | mS/cm  | 1.5      |
|                                                |        |          |
| N: NH <sub>4</sub> <sup>+</sup>                | mmol/l | 1        |
| K: K <sup>+</sup>                              | "      | 5        |
| Ca: Ca <sup>++</sup>                           | "      | 2.5      |
| Mg: Mg <sup>++</sup>                           | "      | 1        |
|                                                |        |          |
| N: NO <sub>3</sub> <sup>-</sup>                | "      | 10       |
| S: SO <sub>4</sub> <sup>--</sup>               | "      | 1        |
| P: H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | "      | 1        |
|                                                |        |          |
| Sum cation                                     | me/l   | 13       |
| Sum anion                                      | "      | 13       |
|                                                |        |          |
| K:Ca                                           |        | 2        |

How to  
increase K by  
25 % ?

Cation You cannot  
po only add K<sup>+</sup>

Anions,  
negative charge

| Nutrient Solution                              |        |          |
|------------------------------------------------|--------|----------|
| example                                        |        | Standard |
| EC                                             | mS/cm  | 1.5      |
|                                                |        |          |
| N: NH <sub>4</sub> <sup>+</sup>                | mmol/l | 1        |
| K: K <sup>+</sup>                              | "      | 5        |
| Ca: Ca <sup>++</sup>                           | "      | 2.5      |
| Mg: Mg <sup>++</sup>                           | "      | 1        |
|                                                |        |          |
| N: NO <sub>3</sub> <sup>-</sup>                | "      | 10       |
| S: SO <sub>4</sub> <sup>--</sup>               | "      | 1        |
| P: H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | "      | 1        |
|                                                |        |          |
| Sum cation                                     | me/l   | 13       |
| Sum anion                                      | "      | 13       |
|                                                |        |          |
| K:Ca                                           |        | 2        |



Cation You cannot  
po only add K<sup>+</sup>



An

Add equal  
amount NO<sub>3</sub>

→EC increases  
to 1.6

How to  
increase K by  
25 % ?

| Nutrient Solution                              |        |          |
|------------------------------------------------|--------|----------|
| example                                        |        | Standard |
| EC                                             | mS/cm  | 1.5      |
|                                                |        |          |
| N: NH <sub>4</sub> <sup>+</sup>                | mmol/l | 1        |
| K: K <sup>+</sup>                              | "      | 5        |
| Ca: Ca <sup>++</sup>                           | "      | 2.5      |
| Mg: Mg <sup>++</sup>                           | "      | 1        |
|                                                |        |          |
| N: NO <sub>3</sub> <sup>-</sup>                | "      | 10       |
| S: SO <sub>4</sub> <sup>--</sup>               | "      | 1        |
| P: H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | "      | 1        |
|                                                |        |          |
| Sum cation                                     | me/l   | 13       |
| Sum anion                                      | "      | 13       |
|                                                |        |          |
| K:Ca                                           |        | 2        |



Cation You cannot  
po only add K<sup>+</sup>



An

Decrease Ca,  
Mg, NH<sub>4</sub>

→ K:Ca ratio  
changes by  
more than 25 %

How to  
increase K by  
25 % ?



| Nutrient Solution                              |        |          |
|------------------------------------------------|--------|----------|
| example                                        |        | Standard |
| EC                                             | mS/cm  | 1.5      |
|                                                |        |          |
| N: NH <sub>4</sub> <sup>+</sup>                | mmol/l | 1        |
| K: K <sup>+</sup>                              | "      | 5        |
| Ca: Ca <sup>++</sup>                           | "      | 2.5      |
| Mg: Mg <sup>++</sup>                           | "      | 1        |
|                                                |        |          |
| N: NO <sub>3</sub> <sup>-</sup>                | "      | 10       |
| S: SO <sub>4</sub> <sup>--</sup>               | "      | 1        |
| P: H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | "      | 1        |
|                                                |        |          |
| Sum cation                                     | me/l   | 13       |
| Sum anion                                      | "      | 13       |
|                                                |        |          |
| K:Ca                                           |        | 2        |

How to  
increase K by  
25 % ?

Cation  
po You cannot  
only add K<sup>+</sup>

Keep K:Ca constant

K increase < 25 %  
Some increase Ca,  
Mg, NH<sub>4</sub>

| Nutrient Solution                              |        |          |
|------------------------------------------------|--------|----------|
| example                                        |        | Standard |
| EC                                             | mS/cm  | 1.5      |
|                                                |        |          |
| N: NH <sub>4</sub> <sup>+</sup>                | mmol/l | 1        |
| K: K <sup>+</sup>                              | "      | 5        |
| Ca: Ca <sup>++</sup>                           | "      | 2.5      |
| Mg: Mg <sup>++</sup>                           | "      | 1        |
|                                                |        |          |
| N: NO <sub>3</sub> <sup>-</sup>                | "      | 10       |
| S: SO <sub>4</sub> <sup>--</sup>               | "      | 1        |
| P: H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | "      | 1        |
|                                                |        |          |
| Sum cation                                     | me/l   | 13       |
| Sum anion                                      | "      | 13       |
|                                                |        |          |
| K:Ca                                           |        | 2        |

**Nutrient solution is made up from the following components:**

|   |                                   |
|---|-----------------------------------|
|   | <u>fertilisers</u>                |
| A | NH <sub>4</sub> NO <sub>3</sub>   |
|   | Ca(NO <sub>3</sub> ) <sub>2</sub> |
|   |                                   |
| B | MgSO <sub>4</sub>                 |
|   | KH <sub>2</sub> PO <sub>4</sub>   |
|   | KNO <sub>3</sub>                  |
|   | K <sub>2</sub> SO <sub>4</sub>    |

# Fertiliser application in practice

Tomato kg/ha

yield

50 kg/m<sup>2</sup>

Base dressing

Top Dressing

Demand

N

fertiliser

N

fertiliser

N

P

K

## Free drainage

EC dS m<sup>-1</sup>

2.6

pH

5.5

mmol/l

mg/l

NH<sub>4</sub>

1

14

K

9.5

371

Na

0

0

Ca

5.4

217

Mg

2.4

58

NO<sub>3</sub>

16.0

224

Cl

2.5

89

SO<sub>4</sub>

4.4

136

H<sub>2</sub>PO<sub>4</sub>

1.5

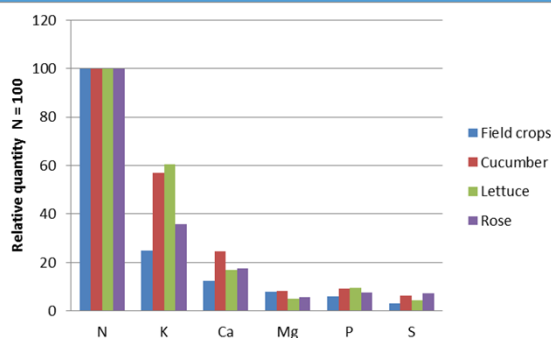
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# Calculation of a fertilizer recipe

From nutrient requirements



To basic solutions

|                                |        |
|--------------------------------|--------|
| EC mS/cm                       | 2      |
|                                | mmol/l |
| NH <sub>4</sub>                | 2      |
| K                              | 9.6    |
| Ca                             | 2.9    |
| Mg                             | 1.3    |
| NO <sub>3</sub>                | 14.1   |
| Cl                             | 0      |
| SO <sub>4</sub>                | 2.1    |
| H <sub>2</sub> PO <sub>4</sub> | 1.7    |
| Si                             | 0      |
|                                | umol/l |
| Fe                             | 15     |
| Mn                             | 8      |
| Zn                             | 4      |
| B                              | 20     |
| Cu                             | 0.75   |
| Mo                             | 0.5    |

To recipes

| Fertiliser recipe      |                                                                        |             |       | datum | 03-sep-15 |
|------------------------|------------------------------------------------------------------------|-------------|-------|-------|-----------|
| Name                   | Tomato                                                                 |             |       |       |           |
| Water source           | well water                                                             |             |       |       |           |
| EC irrigation          | 2.6                                                                    |             |       |       |           |
| quantity (l)           | 1000                                                                   |             |       |       |           |
| Concentration (times)  | 100                                                                    |             |       |       |           |
| <b>A Tank</b>          |                                                                        |             |       |       |           |
| Calciumnitrate         | 5[Ca(NO <sub>3</sub> ) <sub>2</sub> ]. NH <sub>4</sub> NO <sub>3</sub> | crystalline | 95.1  | kg    |           |
| Iron chelate (6%)      | Fe-DTPA                                                                | powder      | 999   | gram  |           |
| Potassiumnitrate       | KNO <sub>3</sub>                                                       | crystalline | 34.4  | kg    |           |
| calciumchloride        | CaCl <sub>2</sub>                                                      | crystalline | 5.56  | kg    |           |
| <b>B Tank</b>          |                                                                        |             |       |       |           |
| Potassiumnitrate       | KNO <sub>3</sub>                                                       | crystalline | 0.0   | kg    |           |
| Magnesium sulphate     | MgSO <sub>4</sub>                                                      | crystalline | 51.7  | kg    |           |
| Potassiumsulphate      | K <sub>2</sub> SO <sub>4</sub>                                         | crystalline | 39.2  | kg    |           |
| Monopotassiumphosphate | KH <sub>2</sub> PO <sub>4</sub>                                        | crystalline | 20.4  | kg    |           |
| Manganesesulphate      | MnSO <sub>4</sub> ·H <sub>2</sub> O                                    | crystalline | 165.6 | gram  |           |
| Zinsulphate            | ZnSO <sub>4</sub> ·6H <sub>2</sub> O                                   | crystalline | 135.1 | gram  |           |
| Borax                  | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O      | crystalline | 259   | gram  |           |
| Coppersulphate         | CuSO <sub>4</sub> ·5H <sub>2</sub> O                                   | crystalline | 19    | gram  |           |
| Sodium-molybdate       | Na <sub>2</sub> MoO <sub>4</sub> ·2H <sub>2</sub> O                    | crystalline | 12.1  | gram  |           |



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# Nutrient solution calculation

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- Step by step



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

| From nutrient solution to<br>fertilise recipe | Sum<br>cations | Sum<br>anions | <b>NH<sub>4</sub></b> | <b>K</b> | <b>Ca</b> | <b>Mg</b>     | <b>NO<sub>3</sub></b> | <b>SO<sub>4</sub></b> | <b>H<sub>2</sub>PO<sub>4</sub></b> | <b>Cl</b> |
|-----------------------------------------------|----------------|---------------|-----------------------|----------|-----------|---------------|-----------------------|-----------------------|------------------------------------|-----------|
|                                               | 20.00          | 20.00         | 2.0                   | 9.6      | 2.9       | 1.3           | 14.1                  | 2.1                   | 1.7                                | 0.0       |
|                                               | <i>me/l</i>    | <i>me/l</i>   |                       |          |           | <i>mmol/l</i> |                       |                       |                                    |           |

## Step 1a      choice of Ca - fertilizer

| From nutrient solution to<br>fertilise recipe                                             | Sum<br>cations                    | Sum<br>anions | <b>NH<sub>4</sub></b> | <b>K</b> | <b>Ca</b> | <b>Mg</b> | <b>NO<sub>3</sub></b> | <b>SO<sub>4</sub></b> | <b>H<sub>2</sub>PO<sub>4</sub></b> | <b>Cl</b> |
|-------------------------------------------------------------------------------------------|-----------------------------------|---------------|-----------------------|----------|-----------|-----------|-----------------------|-----------------------|------------------------------------|-----------|
|                                                                                           | 20.00                             | 20.00         | 1.0                   | 10       | 3         | 1.5       | 14.5                  | 2.0                   | 1.5                                | 0.0       |
|                                                                                           | <i>me/l</i>                       | <i>me/l</i>   |                       |          |           |           | <i>mmol/l</i>         |                       |                                    |           |
| 1a Fill in as much<br>Ca(NO <sub>3</sub> ) <sub>2</sub> as<br>needed for Ca <sup>2+</sup> | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                       |          | 3         |           | 6                     |                       |                                    |           |

## Step 1b

## Supplement $\text{NH}_4$ with $\text{NH}_4\text{NO}_3$

| From nutrient solution to<br>fertilise recipe | Sum<br>cations             | Sum<br>anions | $\text{NH}_4$ | K  | Ca | Mg  | $\text{NO}_3$ | $\text{SO}_4$ | $\text{H}_2\text{PO}_4$ | Cl  |
|-----------------------------------------------|----------------------------|---------------|---------------|----|----|-----|---------------|---------------|-------------------------|-----|
|                                               | 20.00                      | 20.00         | 1.0           | 10 | 3  | 1.5 | 14.5          | 2.0           | 1.5                     | 0.0 |
|                                               | <i>me/l</i>                | <i>me/l</i>   |               |    |    |     | <i>mmol/l</i> |               |                         |     |
| 1b                                            | $\text{Ca}(\text{NO}_3)_2$ | 3             |               |    | 3  |     | 6             |               |                         |     |
| Additional $\text{NH}_4^+$                    | $\text{NH}_4\text{NO}_3$   | 1             | 1             |    |    |     | 1             |               |                         |     |



**Step 1c****Add phosphate fertilizer**

| From nutrient solution to<br>fertilise recipe | Sum<br>cations                    | Sum<br>anions | <b>NH<sub>4</sub></b> | <b>K</b> | <b>Ca</b> | <b>Mg</b> | <b>NO<sub>3</sub></b> | <b>SO<sub>4</sub></b> | <b>H<sub>2</sub>PO<sub>4</sub></b> | <b>Cl</b> |
|-----------------------------------------------|-----------------------------------|---------------|-----------------------|----------|-----------|-----------|-----------------------|-----------------------|------------------------------------|-----------|
|                                               | 20.00                             | 20.00         | 1.0                   | 10       | 3         | 1.5       | 14.5                  | 2.0                   | 1.5                                | 0.0       |
|                                               | <i>me/l</i>                       | <i>me/l</i>   |                       |          |           |           | <i>mmol/l</i>         |                       |                                    |           |
| 1c                                            | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                       |          | 3         |           | 6                     |                       |                                    |           |
|                                               | NH <sub>4</sub> NO <sub>3</sub>   | 1             | 1                     |          |           |           | 1                     |                       |                                    |           |
| Phosphate source                              | KH <sub>2</sub> PO <sub>4</sub>   | 1.5           |                       | 1.5      |           |           |                       |                       | 1.5                                |           |

## Step 1d

## Add magnesium fertiliser

| From nutrient solution to<br>fertilise recipe | Sum<br>cations                    | Sum<br>anions | <b>NH<sub>4</sub></b> | <b>K</b> | <b>Ca</b> | <b>Mg</b>     | <b>NO<sub>3</sub></b> | <b>SO<sub>4</sub></b> | <b>H<sub>2</sub>PO<sub>4</sub></b> | <b>Cl</b> |
|-----------------------------------------------|-----------------------------------|---------------|-----------------------|----------|-----------|---------------|-----------------------|-----------------------|------------------------------------|-----------|
|                                               | 20.00                             | 20.00         | 1.0                   | 10       | 3         | 1.5           | 14.5                  | 2.0                   | 1.5                                | 0.0       |
|                                               | <i>me/l</i>                       | <i>me/l</i>   |                       |          |           | <i>mmol/l</i> |                       |                       |                                    |           |
| 1d                                            | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                       |          | 3         |               | 6                     |                       |                                    |           |
|                                               | NH <sub>4</sub> NO <sub>3</sub>   | 1             | 1                     |          |           |               | 1                     |                       |                                    |           |
|                                               | KH <sub>2</sub> PO <sub>4</sub>   | 1.5           |                       | 1.5      |           |               |                       |                       | 1.5                                |           |
| Choose Mg source                              | MgSO <sub>4</sub>                 | 1.5           |                       |          |           | 1.5           |                       | 1.5                   |                                    |           |

## Step 1e

## Sulphate fertiliser

| From nutrient solution to<br>fertilise recipe                         | Sum<br>cations                    | Sum<br>anions | <b>NH<sub>4</sub></b> | <b>K</b> | <b>Ca</b> | <b>Mg</b> | <b>NO<sub>3</sub></b> | <b>SO<sub>4</sub></b> | <b>H<sub>2</sub>PO<sub>4</sub></b> | <b>Cl</b> |
|-----------------------------------------------------------------------|-----------------------------------|---------------|-----------------------|----------|-----------|-----------|-----------------------|-----------------------|------------------------------------|-----------|
|                                                                       | 20.00                             | 20.00         | 1.0                   | 10       | 3         | 1.5       | 14.5                  | 2.0                   | 1.5                                | 0.0       |
|                                                                       | <i>me/l</i>                       | <i>me/l</i>   |                       |          |           |           | <i>mmol/l</i>         |                       |                                    |           |
| 1e                                                                    | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                       |          | 3         |           | 6                     |                       |                                    |           |
|                                                                       | NH <sub>4</sub> NO <sub>3</sub>   | 1             | 1                     |          |           |           | 1                     |                       |                                    |           |
|                                                                       | KH <sub>2</sub> PO <sub>4</sub>   | 1.5           |                       | 1.5      |           |           |                       |                       | 1.5                                |           |
|                                                                       | MgSO <sub>4</sub>                 | 1.5           |                       |          |           | 1.5       |                       | 1.5                   |                                    |           |
| Choose remaining<br>SO <sub>4</sub> as K <sub>2</sub> SO <sub>4</sub> | K <sub>2</sub> SO <sub>4</sub>    | 0.5           |                       | 0.5      |           |           |                       | 0.5                   |                                    |           |

## Step 1f

## Complete the balance with K and NO<sub>3</sub> fertiliser

| From nutrient solution to<br>fertilise recipe          | Sum<br>cations                    | Sum<br>anions | NH <sub>4</sub> | K   | Ca | Mg  | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | Cl  |
|--------------------------------------------------------|-----------------------------------|---------------|-----------------|-----|----|-----|-----------------|-----------------|--------------------------------|-----|
|                                                        | 20.00                             | 20.00         | 1.0             | 10  | 3  | 1.5 | 14.5            | 2.0             | 1.5                            | 0.0 |
|                                                        | <i>me/l</i>                       | <i>me/l</i>   |                 |     |    |     | <i>mmol/l</i>   |                 |                                |     |
| 1f                                                     | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                 |     | 3  |     | 6               |                 |                                |     |
|                                                        | NH <sub>4</sub> NO <sub>3</sub>   | 1             | 1               |     |    |     | 1               |                 |                                |     |
|                                                        | KH <sub>2</sub> PO <sub>4</sub>   | 1.5           |                 | 1.5 |    |     |                 |                 | 1.5                            |     |
|                                                        | MgSO <sub>4</sub>                 | 1.5           |                 |     |    | 1.5 |                 | 1.5             |                                |     |
|                                                        | K <sub>2</sub> SO <sub>4</sub>    | 0.5           |                 | 1   |    |     |                 | 0.5             |                                |     |
| remaining K and<br>NO <sub>3</sub> as KNO <sub>3</sub> | KNO <sub>3</sub>                  | 7.5           |                 | 7.5 |    |     | 7.5             |                 |                                |     |

## Step 1

## Check result

| From nutrient solution to<br>fertilise recipe                     | Sum<br>cations                    | Sum<br>anions | <b>NH<sub>4</sub></b> | <b>K</b> | <b>Ca</b> | <b>Mg</b>     | <b>NO<sub>3</sub></b> | <b>SO<sub>4</sub></b> | <b>H<sub>2</sub>PO<sub>4</sub></b> | <b>Cl</b> |
|-------------------------------------------------------------------|-----------------------------------|---------------|-----------------------|----------|-----------|---------------|-----------------------|-----------------------|------------------------------------|-----------|
|                                                                   | 20.00                             | 20.00         | 1.0                   | 10       | 3         | 1.5           | 14.5                  | 2.0                   | 1.5                                | 0.0       |
|                                                                   | <i>me/l</i>                       | <i>me/l</i>   |                       |          |           | <i>mmol/l</i> |                       |                       |                                    |           |
| 1f                                                                | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                       |          | 3         |               | 6                     |                       |                                    |           |
| Finally remaining<br>K and NO <sub>3</sub> as<br>KNO <sub>3</sub> | NH <sub>4</sub> NO <sub>3</sub>   | 1             | 1                     |          |           |               | 1                     |                       |                                    |           |
|                                                                   | KH <sub>2</sub> PO <sub>4</sub>   | 1.5           |                       | 1.5      |           |               |                       |                       | 1.5                                |           |
|                                                                   | MgSO <sub>4</sub>                 | 1.5           |                       |          |           | 1.5           |                       | 1.5                   |                                    |           |
|                                                                   | K <sub>2</sub> SO <sub>4</sub>    | 0.5           |                       | 1        |           |               |                       | 0.5                   |                                    |           |
|                                                                   | KNO <sub>3</sub>                  | 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

## From nutrient solution to fertilise recipe

|                                   | Sum<br>cations | Sum<br>anions | NH <sub>4</sub> | K   | Ca | Mg  | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | Cl  |
|-----------------------------------|----------------|---------------|-----------------|-----|----|-----|-----------------|-----------------|--------------------------------|-----|
|                                   | 20.00          | 20.00         | 1.0             | 10  | 3  | 1.5 | 14.5            | 2.0             | 1.5                            | 0.0 |
|                                   | <i>me/l</i>    | <i>me/l</i>   |                 |     |    |     | <i>mmol/l</i>   |                 |                                |     |
| Ca(NO <sub>3</sub> ) <sub>2</sub> |                | 3             |                 |     | 3  |     | 6               |                 |                                |     |
| NH <sub>4</sub> NO <sub>3</sub>   |                | 1             | 1               |     |    |     | 1               |                 |                                |     |
| KH <sub>2</sub> PO <sub>4</sub>   |                | 1.5           |                 | 1.5 |    |     |                 |                 | 1.5                            |     |
| MgSO <sub>4</sub>                 |                | 1.5           |                 |     |    | 1.5 |                 | 1.5             |                                |     |

Calculation fertilisers quantity from mmol/

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

$$1) \text{Ca(NO}_3)_2 = 3 \text{ mmol/l} * 181 = 543 \text{ mg/l}$$



## Step 2

## From nutrient solution to fertilise recipe

|                                   | Sum<br>cations | Sum<br>anions | NH <sub>4</sub> | K   | Ca | CO <sub>3</sub> | Cl  |
|-----------------------------------|----------------|---------------|-----------------|-----|----|-----------------|-----|
|                                   | 20.00          | 20.00         | 1.0             | 10  | 3  | 1.5             | 0.0 |
|                                   | me/l           | me/l          |                 |     |    |                 |     |
| Ca(NO <sub>3</sub> ) <sub>2</sub> |                | 3             |                 |     | 3  | 6               |     |
| NH <sub>4</sub> NO <sub>3</sub>   |                | 1             | 1               |     |    | 1               |     |
| KH <sub>2</sub> PO <sub>4</sub>   |                | 1.5           |                 | 1.5 |    |                 | 1.5 |
| MgSO <sub>4</sub>                 |                | 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)

$$1) \text{Ca(NO}_3)_2 = 3 \text{ mmol/l} * 181 = 543 \text{ mg/l}$$



## Step 2

## From nutrient solution to fertilise recipe

|                                   | Sum<br>cations | Sum<br>anions | NH <sub>4</sub> | K  | Ca | CO <sub>3</sub> | Cl  |
|-----------------------------------|----------------|---------------|-----------------|----|----|-----------------|-----|
|                                   | 20.00          | 20.00         | 1.0             | 10 | 3  | 1.5             | 0.0 |
|                                   | <i>me/l</i>    | <i>me/l</i>   |                 |    |    |                 |     |
| Ca(NO <sub>3</sub> ) <sub>2</sub> |                | 3             |                 |    | 3  | 6               |     |
| NH <sub>4</sub> NO <sub>3</sub>   |                | 1             | 1               |    |    | 1               |     |

Fertiliser solution  
= 1000 l  
100 times concentrated

Calculation fertilisers quantity from mmol/

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

$$1) \text{Ca(NO}_3)_2 = 3 \text{ mmol/l} * 181 = 543 \text{ mg/l}$$

$$\begin{aligned} \text{Ca(NO}_3)_2 &= 543 \text{ mg/l} * 100 * 1000 \text{ l} = 54\,300\,000 \text{ mg} \\ &= 54.3 \text{ kg/m}^3 \end{aligned}$$



| Sum<br>cations                    | Sum<br>anions        | NH <sub>4</sub> | K   | Ca | Mg            | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | Cl  |
|-----------------------------------|----------------------|-----------------|-----|----|---------------|-----------------|-----------------|--------------------------------|-----|
| 20.00<br><i>me/l</i>              | 20.00<br><i>me/l</i> | 1.0             | 10  | 3  | 1.5           | 14.5            | 2.0             | 1.5                            | 0.0 |
|                                   |                      |                 |     |    | <i>mmol/l</i> |                 |                 |                                |     |
| Ca(NO <sub>3</sub> ) <sub>2</sub> | 3                    |                 |     | 3  |               | 6               |                 |                                |     |
| NH <sub>4</sub> NO <sub>3</sub>   | 1                    | 1               |     |    |               | 1               |                 |                                |     |
| KH <sub>2</sub> PO <sub>4</sub>   | 1.5                  |                 | 1.5 |    |               |                 |                 | 1.5                            |     |
| MgSO <sub>4</sub>                 | 1.5                  |                 |     |    | 1.5           |                 | 1.5             |                                |     |
| K <sub>2</sub> SO <sub>4</sub>    | 0.5                  |                 | 1   |    |               |                 | 0.5             |                                |     |
| KNO <sub>3</sub>                  | 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<br>concentrated A B<br>solution | Ca(NO <sub>3</sub> ) <sub>2</sub> |  | 52.3 | kg |      |   |
|                                            | NH <sub>4</sub> NO <sub>3</sub>   |  | 30.5 | kg | 23.7 | l |
|                                            | KNO <sub>3</sub>                  |  |      |    |      |   |
|                                            |                                   |  |      |    |      |   |
|                                            |                                   |  |      |    |      |   |
|                                            | Tank B                            |  |      |    |      |   |
|                                            | KNO <sub>3</sub>                  |  | 64.1 | kg |      |   |
|                                            | KH <sub>2</sub> PO <sub>4</sub>   |  | 22.7 | kg |      |   |
|                                            | K <sub>2</sub> SO <sub>4</sub>    |  | 13.7 | kg |      |   |
|                                            | MgSO <sub>4</sub>                 |  | 33.9 | kg |      |   |



# 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(NO <sub>3</sub> ) <sub>2</sub> ]. NH <sub>4</sub> NO <sub>3</sub> | crystalline | 95.1 | kg   |
| Iron chelate (6%) | Fe-DTPA                                                                | powder      | 999  | gram |
| Potassiumnitrate  | KNO <sub>3</sub>                                                       | crystalline | 34.4 | kg   |
| calciumchloride   | CaCl <sub>2</sub>                                                      | crystalline | 5.56 | kg   |

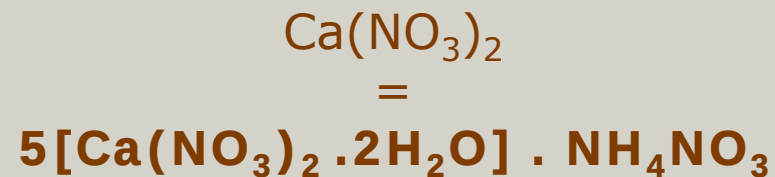
### B Tank

|                        |                                                                   |             |       |      |
|------------------------|-------------------------------------------------------------------|-------------|-------|------|
| Potassiumnitrate       | KNO <sub>3</sub>                                                  | crystalline | 0.0   | kg   |
| Magnesium sulphate     | MgSO <sub>4</sub>                                                 | crystalline | 51.7  | kg   |
| Potassiumsulphate      | K <sub>2</sub> SO <sub>4</sub>                                    | crystalline | 39.2  | kg   |
| Monopotassiumphosphate | KH <sub>2</sub> PO <sub>4</sub>                                   | crystalline | 20.4  | kg   |
| Manganesesulphate      | MnSO <sub>4</sub> •H <sub>2</sub> O                               | crystalline | 165.6 | gram |
| Zinsulphate            | ZnSO <sub>4</sub> •6H <sub>2</sub> O                              | crystalline | 135.1 | gram |
| Borax                  | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> •10H <sub>2</sub> O | crystalline | 259   | gram |
| Coppersulphate         | CuSO <sub>4</sub> •5H <sub>2</sub> O                              | crystalline | 19    | gram |
| Sodium-molybdate       | Na <sub>2</sub> MoO <sub>4</sub> •2H <sub>2</sub> O               | crystalline | 12.1  | gram |

# Specials situations

## Calciumnitrate $\text{Ca}(\text{NO}_3)_2$

Specific for Yara product



Or



# Details

| Sum<br>cations                    | Sum<br>anions        | NH <sub>4</sub> | K  | Ca | Mg  | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | Cl  |
|-----------------------------------|----------------------|-----------------|----|----|-----|-----------------|-----------------|--------------------------------|-----|
| 20.00<br><i>me/l</i>              | 20.00<br><i>me/l</i> | 1.0             | 10 | 3  | 1.5 | 14.5            | 2.0             | 1.5                            | 0.0 |
| Ca(NO <sub>3</sub> ) <sub>2</sub> | 3                    |                 |    | 3  |     | 6               |                 |                                |     |
| NH <sub>4</sub> NO <sub>3</sub>   | 1                    | 1               |    |    |     | 1               |                 |                                |     |

## Using YARA Calciumnitrate

|                                                                       |        | NH <sub>4</sub> | K  | Ca | Mg  | NO <sub>3</sub> | SO <sub>4</sub> | P   | Cl  |
|-----------------------------------------------------------------------|--------|-----------------|----|----|-----|-----------------|-----------------|-----|-----|
| fertiliser                                                            | mmol/l | 2.0             | 10 | 3  | 1.5 | 14.5            | 2.0             | 1.5 | 0.0 |
| 5[Ca(NO <sub>3</sub> ) <sub>2</sub> ].NH <sub>4</sub> NO <sub>3</sub> | 0.6    | 0.6             |    | 3  |     | 6.6             |                 |     |     |
| NH <sub>4</sub> NO <sub>3</sub>                                       | 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 <sub>4</sub> | K   | Ca | Mg     | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | 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 |                 |                 |                                |     |
| 1c                                         | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3          |                 |     | 3  |        | 6               |                 |                                |     |
|                                            | NH <sub>4</sub> NO <sub>3</sub>   | 1          | 1               |     |    |        | 1               |                 |                                |     |
| Phosphate source                           | KH <sub>2</sub> PO <sub>4</sub>   | 1.5        |                 | 1.5 |    |        |                 |                 | 1.5                            |     |

## Step 1c Add phosphate fertilizer

| From nutrient solution to fertilise recipe | Sum cations                                    | Sum anions | NH <sub>4</sub> | K  | Ca | Mg     | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | 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 |                 |                 |                                |     |
| 1c                                         | Ca(NO <sub>3</sub> ) <sub>2</sub>              | 3          |                 |    | 3  |        | 6               |                 |                                |     |
|                                            | NH <sub>4</sub> NO <sub>3</sub>                | 1          | 1               |    |    |        | 1               |                 |                                |     |
| Phosphate source                           | NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> | 1.5        | 1.5             |    |    |        |                 |                 | 1.5                            |     |



# Using MAP instead of MKP

## Step 1c Add phosphate fertilizer

| From nutrient solution to<br>fertilise recipe | Sum<br>cations                    | Sum<br>anions | NH <sub>4</sub> | K   | Ca | Mg            | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | Cl  |
|-----------------------------------------------|-----------------------------------|---------------|-----------------|-----|----|---------------|-----------------|-----------------|--------------------------------|-----|
|                                               | 20.00                             | 20.00         | 1.0             | 10  | 3  | 1.5           | 14.5            | 2.0             | 1.5                            | 0.0 |
|                                               | <i>me/l</i>                       | <i>me/l</i>   |                 |     |    | <i>mmol/l</i> |                 |                 |                                |     |
| 1c                                            | Ca(NO <sub>3</sub> ) <sub>2</sub> | 3             |                 |     | 3  |               | 6               |                 |                                |     |
|                                               | NH <sub>4</sub> NO <sub>3</sub>   | 1             | 1               |     |    |               | 1               |                 |                                |     |
| Phosphate source                              | KH <sub>2</sub> PO <sub>4</sub>   | 1.5           |                 | 1.5 |    |               |                 |                 | 1.5                            |     |

## Step 1c Add phosphate fertilizer

| From nutrient solution to<br>fertilise recipe | Sum<br>cations                                 | Sum<br>anions | NH <sub>4</sub> | K   | Ca | Mg            | NO <sub>3</sub> | SO <sub>4</sub> | H <sub>2</sub> PO <sub>4</sub> | Cl  |
|-----------------------------------------------|------------------------------------------------|---------------|-----------------|-----|----|---------------|-----------------|-----------------|--------------------------------|-----|
|                                               | 20.00                                          | 20.00         | 1.0             | 10  | 3  | 1.5           | 14.5            | 2.0             | 1.5                            | 0.0 |
|                                               | <i>me/l</i>                                    | <i>me/l</i>   |                 |     |    | <i>mmol/l</i> |                 |                 |                                |     |
| 1c                                            | Ca(NO <sub>3</sub> ) <sub>2</sub>              | 3             |                 |     | 3  |               | 6               |                 |                                |     |
|                                               | NH <sub>4</sub> NO <sub>3</sub>                | 1             |                 |     |    |               |                 |                 |                                |     |
| Phosphate source                              | NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> | 1.0           | 1.0             |     |    |               |                 |                 | 1.0                            |     |
|                                               | KH <sub>2</sub> PO <sub>4</sub>                | 0.5           |                 | 0.5 |    |               |                 |                 | 0.5                            |     |

# Alternative all SO<sub>4</sub> as MgSO<sub>4</sub>

## all SO<sub>4</sub> as MgSO<sub>4</sub>

|                                                                       |        | NH <sub>4</sub> | K   | Ca  | Mg  | NO <sub>3</sub> | SO <sub>4</sub> | P   | Cl  |
|-----------------------------------------------------------------------|--------|-----------------|-----|-----|-----|-----------------|-----------------|-----|-----|
| fertiliser                                                            | mmol/l | 1.0             | 1.0 | 3.0 | 1.5 | 14.5            | 2.0             | 1.5 | 0.0 |
| 5[Ca(NO <sub>3</sub> ) <sub>2</sub> ].NH <sub>4</sub> NO <sub>3</sub> | 0.6    | 0.6             |     | 3   |     | 6.6             |                 |     |     |
| NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>                        | 1.4    | 0.6             |     |     |     |                 |                 | 0.4 |     |
| KH <sub>2</sub> PO <sub>4</sub>                                       | 1.1    |                 | 1.1 |     |     |                 |                 | 1.1 |     |
| Difference                                                            |        |                 |     |     |     |                 |                 |     |     |
| MgSO <sub>4</sub>                                                     | 2.0    |                 |     |     | 2.0 |                 | 2.0             |     |     |
| K <sub>2</sub> SO <sub>4</sub>                                        | 0.0    |                 | 0.0 |     |     |                 | 0.0             |     |     |
| KNO <sub>3</sub>                                                      | 9.4    |                 | 8.4 |     |     | 9.4             |                 |     |     |
|                                                                       |        | 2.0             | 9.0 | 3.0 | 2.0 | 16              | 2.0             | 1.5 | 0.0 |



# Introduction of Cl<sup>-</sup>

| Introduction of Cl                                                    |        | NH <sub>4</sub> | K   | Ca | Mg  | NO <sub>3</sub> | SO <sub>4</sub> | P   | Cl  |
|-----------------------------------------------------------------------|--------|-----------------|-----|----|-----|-----------------|-----------------|-----|-----|
| fertiliser                                                            | mmol/l | 1.0             | 10  | 3  | 1.5 | 13.0            | 2.0             | 1.5 | 1.5 |
| 5[Ca(NO <sub>3</sub> ) <sub>2</sub> ].NH <sub>4</sub> NO <sub>3</sub> | 0.6    | 0.6             |     | 3  |     | 6.6             |                 |     |     |
| NH <sub>4</sub> NO <sub>3</sub>                                       | 0.4    | 0.4             |     |    |     | 0.4             |                 |     |     |
| KH <sub>2</sub> PO <sub>4</sub>                                       | 1.5    |                 | 1.5 |    |     |                 |                 | 1.5 |     |
| MgSO <sub>4</sub>                                                     | 1.5    |                 |     |    | 1.5 |                 | 1.5             |     |     |
| K <sub>2</sub> SO <sub>4</sub>                                        | 0.5    |                 | 1.0 |    |     |                 | 1.0             |     |     |
| KCl                                                                   | 1.5    |                 | 1.5 |    |     |                 |                 |     | 1.5 |
| KNO <sub>3</sub>                                                      | 6.0    |                 | 6   |    |     | 6.0             |                 |     |     |
|                                                                       |        | 1.0             | 10  | 3  | 1.5 | 13.5            | 2.0             | 1.5 | 1.5 |





# Using $\text{CaCl}_2$ instead of KCL of $\text{Cl}^-$

| 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             |
|                                | <u>mmol/l</u> |
| NH <sub>4</sub>                | 2             |
| K                              | 9.6           |
| Ca                             | 2.9           |
| Mg                             | 1.3           |
| NO <sub>3</sub>                | 14.1          |
| Cl                             | 0             |
| SO <sub>4</sub>                | 2.1           |
| H <sub>2</sub> PO <sub>4</sub> | 1.7           |
| Si                             | 0             |
|                                | <u>umol/l</u> |
| Fe                             | 15            |
| Mn                             | 8             |
| Zn                             | 4             |
| B                              | 20            |
| Cu                             | 0.75          |
| Mo                             | 0.5           |

Direct conversion from  $\mu\text{mol/l}$  to weight  $\text{g/m}^3$



For quality of life

# Example

|                      |      |         |        |
|----------------------|------|---------|--------|
|                      | Type |         |        |
| Iron chelate<br>(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<br>(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

|    | $\mu\text{mol/l}$                    |  | mol. weight | $\mu\text{g/l}$ | 1 m3 200 * conc |      |
|----|--------------------------------------|--|-------------|-----------------|-----------------|------|
| Fe | 15 Fe-DTPA 6%                        |  | 932         | 13980           | 2796            | gram |
| Mn | 8 $\text{MnSO}_4$                    |  | 16          | 128             | 25.6            | gram |
| Zn | 4 $\text{ZnSO}_4$                    |  | 287         | 1148            | 229.6           | gram |
| B  | 20 $\text{Na}_2\text{B}_4\text{O}_7$ |  | 381         | 7620            | 1524            | gram |
| Cu | 0.75 $\text{CuSO}_4$                 |  | 250         | 187.5           | 37.5            | gram |
| Mo | 0.5 $\text{Na}_2\text{MoO}_4$        |  | 242         | 121             | 24.2            | gram |



# Final result

| Fertiliser recipe          |                     |             | datum | 03-sep-15 |
|----------------------------|---------------------|-------------|-------|-----------|
| Name                       | Tomato              |             |       |           |
| Water source               | well water          |             |       |           |
| EC irrigation quantity (l) | 2.6                 |             |       |           |
| Concentration (times)      | 1000                |             |       |           |
|                            | 100                 |             |       |           |
| <b>A Tank</b>              |                     |             |       |           |
| Calciumnitrate             | 5[Ca(NO3)2]. NH4NO3 | crystalline | 95.1  | kg        |
| Iron chelate (6%)          | Fe-DTPA             | powder      | 999   | gram      |
| Potassiumnitrate           | KNO3                | crystalline | 34.4  | kg        |
| calciumchloride            | CaCl2               | crystalline | 5.56  | kg        |
| <b>B Tank</b>              |                     |             |       |           |
| Potassiumnitrate           | KNO3                | crystalline | 0.0   | kg        |
| Magnesium sulphate         | MgSO4               | crystalline | 51.7  | kg        |
| Potassiumsulphate          | K2SO4               | crystalline | 39.2  | kg        |
| Monopotassiumphosphate     | KH2PO4              | crystalline | 20.4  | kg        |
| Manganesesulphate          | MnSO4•H2O           | crystalline | 165.6 | gram      |
| Zinsulphate                | ZnSO4•6H2O          | crystalline | 135.1 | gram      |
| Borax                      | Na2B4O7•10H2O       | crystalline | 259   | gram      |
| Coppersulphate             | CuSO4•5H2O          | crystalline | 19    | gram      |
| Sodium-molybdate           | Na2MoO4•2H2O        | crystalline | 12.1  | gram      |

# Example calculation tools

- WUR
- Incrocci

The screenshot shows the 'Input' section of the WUR Incrocci fertilizer calculator. It includes a header with the WUR logo, a 'Quick start guide' button, and a 'Unit converter ppm> mM' button. Below the header, there are buttons for 'Adjust window to your monitor', 'Recipes', 'Report', 'Fertilizers and acids', and 'Calculation'. The main input area is titled '1) Insert ion composition of irrigation water (mM for macronutrients and uM for micronutrients)'. It features a table with columns for various ions and nutrients, including EC (dS/m), HCO<sub>3</sub><sup>-</sup>, N-NO<sub>3</sub><sup>-</sup>, N-NH<sub>4</sub><sup>+</sup>, P-PO<sub>4</sub><sup>3-</sup>, K, Ca, Mg, Na, S-SO<sub>4</sub><sup>2-</sup>, Cl, Fe, B, Cu, Zn, Mn, and Mo. The table is currently empty, with a '0.00' value entered in the EC column. Below the table, there are sections for 'Electro-chemical neutrality test' (showing 'OK'), 'Water quality evaluation' (showing 'OK'), and '2) Fertigation device parameters' (showing '100 X' and '20'). The bottom section is titled '3) Select recipe' and shows a '?' in a box.

**Input**

Adjust window to your monitor

Quick start guide

Unit converter ppm> mM

Recipes

Report

Fertilizers and acids

Calculation

1) Insert ion composition of irrigation water (mM for macronutrients and uM for micronutrients)

| EC (dS/m) | HCO <sub>3</sub> <sup>-</sup> | N-NO <sub>3</sub> <sup>-</sup> | N-NH <sub>4</sub> <sup>+</sup> | P-PO <sub>4</sub> <sup>3-</sup> | K | Ca | Mg | Na | S-SO <sub>4</sub> <sup>2-</sup> | Cl | Fe | B | Cu | Zn | Mn | Mo |
|-----------|-------------------------------|--------------------------------|--------------------------------|---------------------------------|---|----|----|----|---------------------------------|----|----|---|----|----|----|----|
| 0.00      |                               |                                |                                |                                 |   |    |    |    |                                 |    |    |   |    |    |    |    |

millimoles/L

micromoles/L

Electro-chemical neutrality test

OK

Water quality evaluation

OK

2) Fertigation device parameters

Dilution ratio of stock nutrient solutions

Volume of stock nutrient solution tanks (L)

100 X

20

3) Select recipe

?

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Questions or  
remarks ?

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