NUTRIENT SOLUTIONS FOR GREENHOUSE CROPS

COLOFON

This booklet is an initiative of various fertiliser companies (Nouryon, SQM, YARA) and a laboratory (Eurofins Agro), which are all active within the fertigation industry. Design and layout were prepared by SQM.

If you have any question about this booklet, please contact one of the companies mentioned above or Geerten van der Lugt at www.geertenvanderlugt.nl.

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Version 4 dd September 2020

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PREFACE

This revised Manual - "Nutrient Solutions for Greenhouse Crops" version 4 - describes nutrient solutions for the most important species of fruiting and leafy vegetables, soft fruits, cut flowers and potted plants cultivated in protected horticulture, such as greenhouses and urban farm systems. Different recommendations are presented for these crops grown in soil, as potted plants or in hydroponic growing systems using either an inert growing medium (e.g. rock wool or pumice) or an organic growing medium (e.g. peat or coco peat). The Manual contains information on best practice for application of nutrient solutions, but does not include soil improvement methods. In this revision, new information is added (e.g. on new crops) and corrections have been made to the text and to the previously published nutrient solutions.

In section A, information is given that will help maintain optimal conditions in the plant's root zone for the uptake of nutrients. An example is shown on how to calculate the composition of a nutrient solution with commonly available fertilisers.

In section B, tables with the composition of nutrient solutions are presented for the main horticultural crops. These nutrient solutions contain all nutrients necessary for plant growth. The values are given in mmol/l and ppm (macronutrients) and µmol/l and ppb (micronutrients). In these tables also the target values for nutrients in the plant's root zone are given, when analysed in water, organic medium or soil samples. Adjustments for growth stages or for specific periods within a growing season are provided for some nutrient solutions. It should be noted that these nutrient solutions can also be applied to recirculating systems, using a calculation such as described in section A of this revised Manual. New in this version are nutrient solutions for crops like soft fruit (raspberry and blueberry) and microgreens.

Much of this information is common knowledge in the Dutch greenhouse sector. Some of the information mentioned in this Manual refers to the original sources in Dutch literature. The main source of information about nutrient solutions is the book Bemestingsadviesbasis Glastuinbouw (Recommendations for Fertiliser Application in Greenhouse Horticulture), last published in 1999 by the former Research Station in Naaldwijk, The Netherlands[1]. However, many of these values have been adapted subsequent to experiences of the field over the last decade.

This Manual has been produced with the support of the following companies, active in horticulture at a global level: Nouryon, SQM and YARA (fertiliser companies), Eurofins Agro (a laboratory for water, soil and plant analysis) and Geerten van der Lugt (consultant for plant nutrition in horticulture).

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Geerten van der Lugt
Editor
Consultant, Plant Nutrition in Horticulture

Version 4, dd September, 2020

*[1]De Kreij, C., W. Voogt, A.L. van den Bos and R. Baas, 1999.
Bemestingsadviesbasis substraten. Naaldwijk - Proefstation voor Bloemisterij en Glasgroente. 145 p.*

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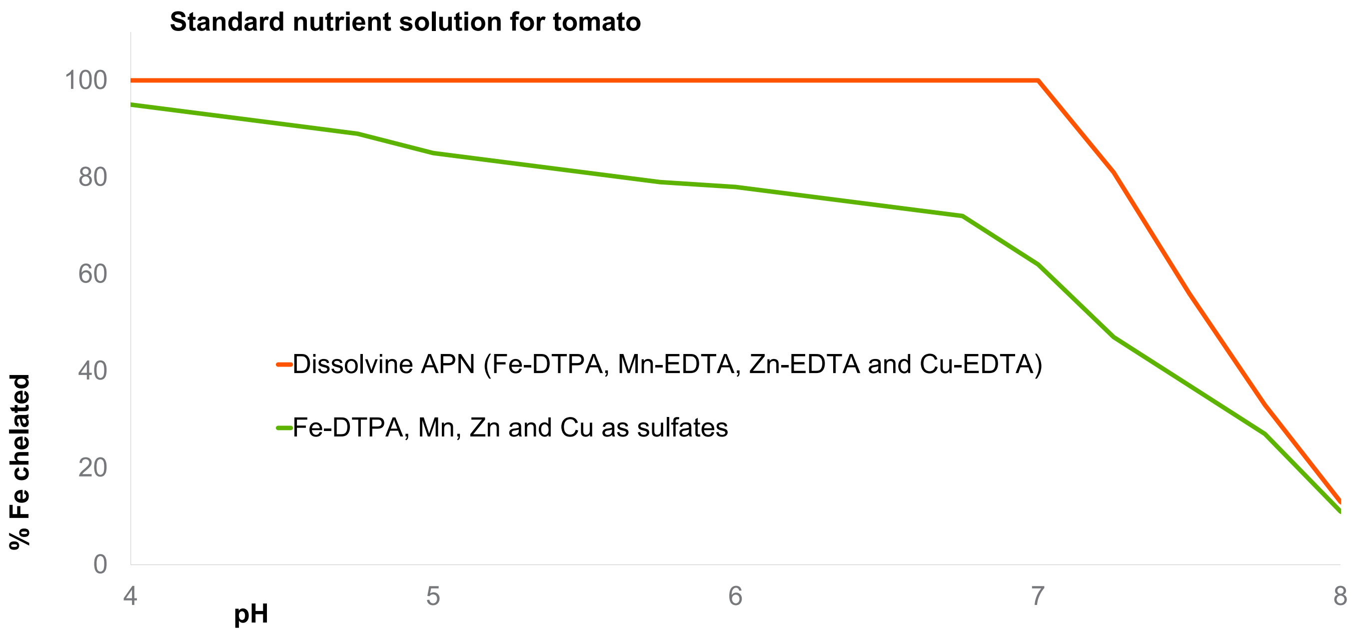
All figures as w/w %



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SECTION A: HOW TO COMPOSE NUTRIENT SOLUTIONS

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1 Input water
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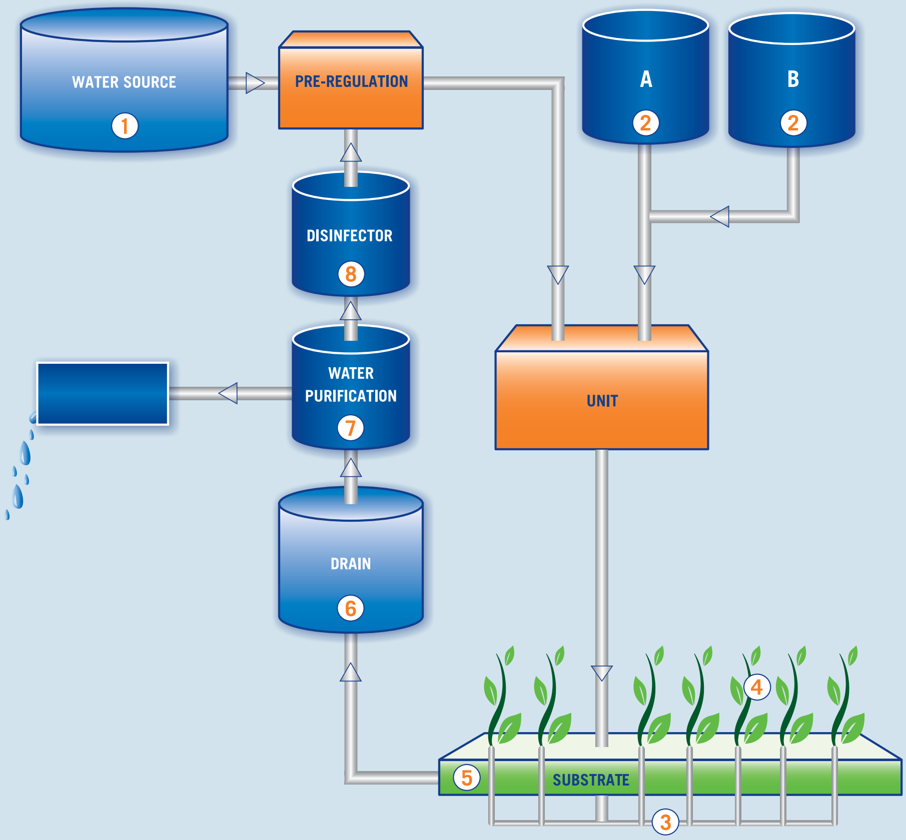

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1. WATER QUALITY AND ANALYSES

The quality of the irrigation water, especially important in hydroponic systems, affects requirements for the composition of nutrient solutions. In soils, roots can obtain available nutrients from a larger root zone compared to hydroponic systems where the root growth is restricted by the limiting dimensions of the substrate, and plants will therefore suffer immediately when nutrient solutions are not adjusted to accommodate water quality.

Irrigation water that will be used for preparation of nutrient solutions can contain minerals and /or residual salts, have increased pH levels or contain a high content of sodium. When calculating nutrient solution requirements, the quantity of nutrients already present in the irrigation water must be subtracted, to ensure that nutrient concentrations do not exceed the desired levels.

The use of rainwater, which usually has an excellent quality and is free of iron, is highly recommended for hydroponic systems. Runoff from greenhouse roofs is an easy way to collect rainwater.

Na and Cl

Water can be classified in three levels of quality according to the levels of sodium and chloride (Table 1).

Table 1. Water quality levels.

Quality level	EC (mS/cm)	Na or Cl (mmol/l)	Na (ppm)	Cl (ppm)	Suitability for hydroponics	Suitable uses
1	< 0.5	< 1.5	< 34	< 53	++	Suitable for all crops
2	0.5 - 1.0	1.5 - 2.5	34 - 57	53 - 87	+	Not suitable when recirculation is necessary
3	1.0 - 1.5	2.5 - 4.0	57 - 92	87 - 142	±	Not to be used for salt-sensitive crops

The salt content of irrigation water - especially the sodium (Na) level - is crucial. Sodium is commonly present in water, but only small quantities are taken up by plants. An excess of sodium causes salinity problems. If the sodium concentration in the root zone is too high, it will be detrimental to the crop. If Na accumulates above the maximum acceptable concentration in the root zone (Table 2), growers must discharge a fraction of the recirculated nutrient solution in order to prevent yield reduction or a decline in product quality. Discharge results in unwanted losses of nutrients and water and in environmental pollution.

The main source of sodium accumulation in the circulated nutrient solution is the salt content of the irrigation water. Sodium content of fertilisers added to create the nutrient solution is too low to contribute to sodium accumulation. In general, irrigation water with a sodium level higher than 1.5 mmol/l is not suitable for recirculating the nutrient solution in hydroponic or aquaponic systems, since recirculation will increase its sodium level over time. The maximum acceptable level of Na in the nutrient solution for some crops is shown in Table 2.

Table 2. Maximum acceptable sodium (Na) levels in the root zone to prevent yield reduction or a decline in produce quality.

Crop	Maximum Na level in the root zone (mmol/l)	Maximum Na level in the root zone (ppm)
Tomato	8	184
Sweet pepper	6	138
Eggplant	6	138
Cucumber	6	138
Melon	6	138
Rose	4	92
Gerbera	4	92
Orchids	1	23
Carnation	4	92

Chloride (Cl) may also be present in many water sources. High levels of chloride are detrimental to crop growth, only low levels of chloride are acceptable. The acceptable Cl level in the root zone is 0.2-0.5 mmol/l higher than for Na.

High levels of sodium and chloride will not directly destroy the crop but will cause a loss of production potential as is shown in Figure 1.

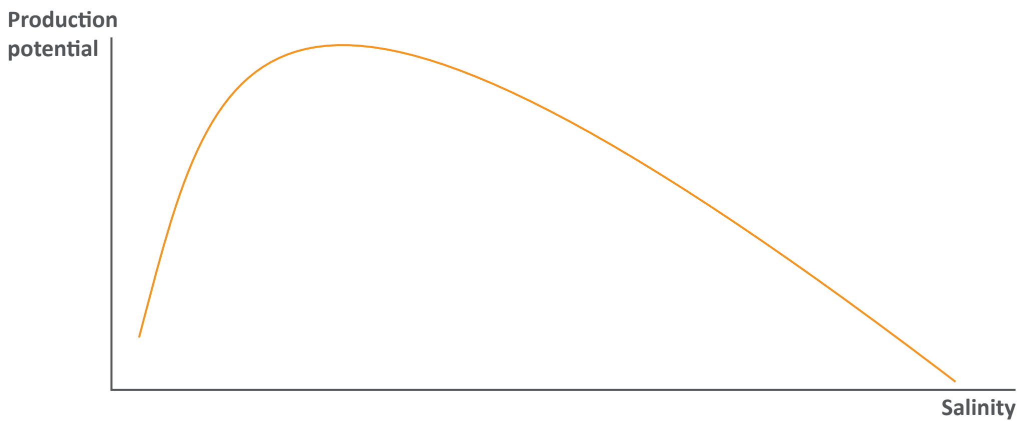

Figure 1: Salinity (Na, Cl + all nutrients) causes loss of production potential[1].

[1]*Nutrient management in substrate systems*
C Sonneveld, W Voogt, 2009: Plant nutrition of greenhouse crops, pages 277-312

pH, $CaCO_3$, hardness of water

Temporary hardness is a type of water hardness caused by the presence of dissolved carbonate minerals (calcium carbonate and magnesium carbonate). When dissolved, these minerals deliver calcium and magnesium cations (Ca^{2+}, Mg^{2+}) and carbonate and bicarbonate anions (CO_3^{2-}, HCO_3^-). The optimal pH level for hydroponics is 5.5. The pH of the water will be too high if the irrigation water contains substantial quantities of carbonate and bicarbonate (CO_3^{2-}, HCO_3^-). This is often the case when well water is used. This water should therefore be treated with acid to neutralise the HCO_3^- and to lower the pH of the nutrient solution. The quantity of acid to be added is determined by the quantity of HCO_3^- present.

When an acid is added to the water, the bicarbonate will be neutralised by the proton of the acid and the pH of the solution will drop. Calcium (or magnesium) will remain available for plant uptake, and the anion of the acid will remain dissolved in the water.

$$Ca^{2+} + 2HCO_3^- + 2HNO_3 \leftrightharpoons Ca^{2+} + 2CO_2 + 2H_2O + 2NO_3^-$$

Nitric acid is commonly used for this purpose, but phosphoric acid and its derivatives like urea phosphate could also be used. With the addition of more acid, the concentration of acid associated anions in the solution, like nitrate and phosphate, will increase. However, these quantities should not exceed the desired concentrations for the nutrient solution. Since these anion concentrations in the nutrient solutions will limit the quantity of acid that can be added, the quantity of HCO_3^- that can be neutralised is limited. Consequently, the initial concentration of HCO_3^- in the irrigation water is a major quality issue.

Treatment of bicarbonate with an acid releases carbon dioxide (CO_2) and water. CO_2 must be allowed to escape from the nutrient solution; if not, the pH of the solution will not be lowered and will fluctuate. This means that the reaction of acid and bicarbonate should take place in open systems, e.g. in an open mixing tank.

Iron (Fe)

Depending on the soil layer from which the water is pumped, there can be large quantities of iron present in the water. Iron is found in anaerobic well water in ionic form as Fe^{2+}. As soon as it comes into contact with the oxygen in the air, these ions react with the oxygen to become Fe^{3+}, precipitating quickly into various insoluble forms of iron (iron hydroxides, oxides and hydroxy-oxides). This will always happen at the moment the water passes through a sprinkler nozzle or drip emitter, since the water will be in sudden contact with air at that point. This means that none of this iron is available to plants since it will have precipitated before it reaches the crop. Although it makes sense to fine-tune fertilisation schemes to the levels of nutrients already present in the water, Fe in the irrigation water should never be brought into the equation. Instead, the dosage of chelated iron which can be taken up by the roots should be calculated independently of the iron already present in the water[2].

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[2] *Technical leaflet 406: Water quality and iron; Nouryon*

Acceptable Fe levels for sprinkler systems

Since sprinkler nozzles do not become obstructed as easily as drip emitters, water containing higher levels of iron can be used, accepting that leaves and (if applicable) greenhouse glass will turn brown due to iron precipitates. The net result of the process from Fe^{2+} to Fe^{3+} to iron precipitates is the formation of H^+; in other words, the pH will drop. The acceptable amount of iron depends on the amount of bicarbonate (HCO_3^-) in the water, since bicarbonate is a pH buffer. Water containing no HCO_3^- (soft water), should not contain more iron than 100 µmol/l (~5 ppm Fe); higher levels can result in leaf damage due to the low pH after aeration. For hard water, a few hundred µmol/l of iron could still be acceptable as long as an overhead irrigation system is not used. In both cases, a certain amount of brown staining will need to be accepted. Where the decorative quality of the crop needs to remain intact, the initial iron concentration should actually not exceed 25-50 µmol/l (~1-2.5 ppm Fe). Remember that none of this iron will be available to the plants.

Acceptable Fe levels for drip irrigation systems

Avoiding the obstruction of drip emitters is crucial for optimal yield. Therefore the only acceptable level of Fe in the irrigation water is 0 µmol/l. If well water does contain iron, then the water must be aerated first to precipitate the iron before the water enters the fertigation system. It is common practice to aerate the water through large gravel beds or filters.

An exception can be made when the water contains organic matter. Then a level of 10-20 µmol/l (0.5-1 ppm) might be acceptable since the Fe will be adsorbed to the organic matter. In this case, precipitation may occur after the water has passed through the drip emitter.

Presence of micronutrients in irrigation water

Irrigation water can contain micronutrients, like boron (B), copper (Cu), manganese (Mn), and zinc (Zn).

Boron can be present in surface water and is naturally present in volcanic mountain areas, like the Andean mountains. The tolerable upper limit is around 30 µmol B/l, but can vary with crop species as shown by different levels for B in the nutrient solution.

The presence of copper in irrigation water is linked to the release from copper-containing parts in the irrigation equipment, like water taps, pipes and pumps.

Manganese can be naturally present in well water or ground water. The manganese level in irrigation water should be less than 10 µmol/l.

High zinc levels in the irrigation water can be expected when rain water is collected from the roof top of the greenhouse by galvanised (zinc-coated) steel gutters. Especially after rainy periods it is advised to check the zinc level in the irrigation water.

2. pH CONTROL: ACID OR AMMONIUM

The optimum pH for soils is 6-7.5; the optimum pH in hydroponic growing systems is 5.5-6.5. When the pH in the growing medium does not match the desired level, the uptake of certain nutrients can be limited. High pH can limit the uptake of phosphate and most micronutrients (except molybdenum (Mo)). A continuous supply of nutrient solutions with a high pH will lead to severe yellowing of plants (micronutrients deficiency symptoms) because availability of most micronutrients becomes restricted.

Several methods can be applied to prevent too high pH levels in the growing medium. First, check if the irrigation water pH is set at the correct level by checking the fertilisation unit's pH setting, and monitor the quantities of acids actually being added to the mixing tank.

The second method is to reduce too high pH levels by increasing the ammonium level. This is done by adding increased amounts of ammonium to a nutrient solution when the pH in the root zone is rising, which usually occurs as a result of high vegetative crop growth rates. The roots will take up the NH_4^+ ions and release acidifying protons (H^+) into the root zone. This acidification of the root zone will create a beneficial environment for the uptake of nutrients by the plant.

In hydroponic growing systems, the proportion of ammonium cations should be limited to 5-15% of the total amount of nitrogen in the solution. A maximum of 1-1.5 mmol/l (14-21 ppm N) NH_4^+ in the nutrient solution is acceptable; if higher, the pH will drop too much. The exact quantity, however, can vary from 0-1.5 mmol/l (0-21 ppm N) depending on the actual growing conditions and the sensitivity of the crop to a low pH. When the pH is too low, reduce the ammonium input to 0-0.5 mmol/l (0 - 7 ppm N). When the pH is too high, increase NH_4^+ to a maximum of 1.5 mmol/l (21 ppm N). The pH should be checked daily.

It is necessary to check the type of Fe-chelate that is used if the pH becomes high (see Chapter 11, Figure 3).

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3. MONITORING AND SAMPLING INSTRUCTIONS FOR SAMPLING, PACKAGING AND SENDING

The most important parameters allowing monitoring of the condition of crops grown in hydroponic systems are the pH and EC. It is recommended to purchase instruments to measure pH and EC, since daily monitoring of these parameters in the root zone, drain water and irrigation water is advisable. The grower should keep these instruments in good condition, store electrodes according to the manufacturer's instructions and calibrate on a regular basis using appropriate standard buffer solutions.

To monitor the level of the nutrients in the root zone, in the drain water or in the irrigation water, samples for analysis should be taken on a regular basis. When plants are growing steadily, changes in the nutrient level of the root zone are small. However, when the crop is undergoing rapid development (e.g. a high rate of vegetative growth, flowering, or fruit development), substantial changes may occur so quickly that weekly sampling for laboratory analysis is recommended.

Taking samples from the root zone

The concentration of nutrients in the solution around the roots is critical for uptake by the plants and for optimal plant production. It is important to take samples that represent the entire root zone. These two guidelines are helpful:

- Collect water from at least 20 different sites well-distributed throughout the greenhouse, e.g. from 5 different plant rows and 4 different places in each row.
- Draw water from the root zone at different places around the plant: from stem base to the root tips and at different depths within the root zone.

It is better to collect a surplus of water, mix it thoroughly in order to obtain a homogenous and representative sample. Then completely fill the sample bottle with the amount of solution needed by the laboratory. Most laboratories need 200 ml of water.

Monitoring drain water

Drain water should be collected from the drain water collection tanks and analysed before being reused or disposed of. When recirculating drain water, it is essential to know its nutrient content. Collect water samples from the middle of the tank, if possible, so that a representative sample is being collected. Be aware that there will be differences in the nutrients present in the drain water collected in the morning and in the afternoon so either collect water at different times during the day or choose a specific time in the middle of the day. Whichever sampling time is chosen, be consistent for all samples taken.

Monitoring irrigation or drip water

Monitoring irrigation water should be done regularly, to make sure that the fertigation unit is functioning correctly. If drain water is being reused, periodic water analysis is essential to ensure that the plants are being supplied with the correct nutrient concentration.

Sending samples to the laboratory

Collected water should be sent to the laboratory in a clean plastic bottle. Bottles might be provided by the laboratories. Always fill the bottles completely. Air in the bottle will affect the HCO_3 status because of gas exchanges between water and air. Protect the bottle from light as the growth of algae in the bottle will also affect the pH of the sample. Make sure the bottle is tightly closed, and pack it in a suitable box to send to a laboratory.

4. FROM ANALYTICAL METHODS TO TARGET VALUES

Analysing water samples

On arrival at the laboratory, water samples are filtered and then placed in batches for analysis. The following two methods are most commonly used:

- ICP (inductively coupled plasma) is used to analyse most ions (K, Na, Ca, Mg, S, P, B, Fe, Mn, Zn, Cu and Mo).
- Spectrophotometric analysis is used for NO_3, NH_4, HCO_3 and Cl.

Analysing soil and organic media

Soil samples and samples taken from organic material like peat or coco peat are pre-treated by mixing a part of the sample with water to make an extraction. Special extraction methods using water have been developed for horticultural purposes:

- For organic material (potting soil, compost, peat, coco peat), the 1:1.5 volume extraction method with water has been developed. In this method, 1 part of organic material is added to 1.5 parts of water (in volume units). After thorough mixing, the extraction is filtered and measured in the analytical instrument.
- For greenhouse soils, the 1:2 volume extraction method with water is used. One part of soil is added to 2 parts of water (in volume units). After thorough mixing, the extraction is filtered and sent for analysis.

These extraction methods do not show the total quantity of nutrients in the soil or medium. Instead, they reveal the nutrient content that is already diluted or that is easily dissolved in water. The nutrients that are extracted in this way represent the quantities of nutrients that are easily available for the plant to absorb. In horticulture, with its intensive cultivation methods, these nutrients reflect the quantities that plants can take up at any given moment. If analysis shows that the soil or medium contains sufficient quantities of available nutrients for plant growth, no limitations in the uptake of nutrients and the growth of the plant are to be expected.

It is important to realise that these extraction methods dilute the concentration of the nutrients found in the soil/medium solution, so that the findings will indicate a lower concentration than what would be found in the actual soil/medium solution in the root zone.

Target values and analytical findings

In this Manual, these extraction methods provide the basis for the target values at the root zone for crops grown in organic material (e.g. peat or coco peat) or in soils. This means that the analytical findings can be compared directly to the target values. Recalculating the analytical findings is not necessary. However, if other analytical methods are used, the results of the analyses will not apply to the target values shown in this Manual.

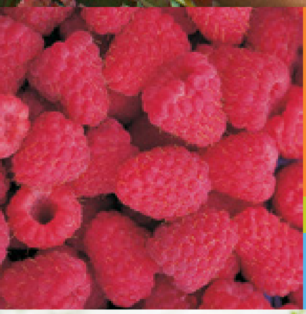
Important aspects of soil structure and organic matter

The composition and structure of soils and organic matter affect the fertility of soils and growing media to a large extent.

To examine soil structural aspects like clay, silt and sand fractions, organic matter, $CaCO_3$, P stock or CEC, a dried soil analytical method is recommended. These parameters can influence the fertiliser recommendations in soils and organic growing media.

Optimization of growing conditions can be achieved by basal dressing of fertilizers and soil amendments, like lime and organic matter, several days before sowing or planting. This will serve to correct the soil nutrient reserves and restore nutrient balances, correct soil pH level, or increase soil carbon content to fit the requirements of the selected crop. Organic matter influences soil structure, moisture holding capacity, nutrient availability and diversity and activity of soil organisms (both those that are beneficial and those that can harm crop production).

When cocopeat is used as a growing medium, it is recommended to analyse the percentage of CEC occupied by cations (Ca^{2+}, Mg^{2+}, K^+, and Na^+) and the ratios between the individual cations. Excessive sodium levels are harmful to crop growth and development and should be avoided. Based on the result of the analysis, adjustments in the fertigated nutrient solution may be required to restore the concentration and balance of nutrients in the root zone to the target levels.



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5. CALCULATIONS ON ANALYTICAL FINDINGS

To evaluate the analytical findings and arrive at a recommendation for a new recipe, certain calculations need to be made. These calculations are explained here, following the next three steps.

- Determine if the sum of cations and anions, expressed in milli-equivalents, are in good agreement with each other.
- Convert by means of the reference EC.
- Apply corrections to match target values in the root zone and/or changed requirements due to development in crop stage.

Ion balance and EC

Fertilisers diluted in water form a nutrient solution. The chemical elements can be cations (positively charged ions: NH_4^+, K^+, Na^+, Ca^{2+} and Mg^{2+}) or anions (negatively charged ions: NO_3^-, SO_4^{2-}, Cl^-, HCO_3^-, $H_2PO_4^-$).

A nutrient solution does not have an electrical charge. Therefore a balance should exist between the positive charge of the cations and the negative charge of the anions. This balance can be calculated by counting the equivalents of the cations and anions in the analytical findings ("equivalent" is the molar concentration of the ion multiplied with the molar charge of that ion). It might be useful to do this in order to verify the analyses produced by the laboratory or to check whether the calculations made to adapt the nutrient solutions have been calculated properly. The method of calculation is presented below:

Use Formula 1 to derive the equivalents of the cations by using the analysed quantities (in mmol/l):

1. Eq Cations = NH_4 + K + Na + Ca*2 + Mg*2

Likewise, calculate the equivalents of the anions according to Formula 2:

2. Eq Anions= NO_3 + Cl + SO_4*2 + HCO_3 + H_2PO_4

Compare the equivalents of cations and anions to see if they are equal (balanced):

3. Eq cations = Eq anions?

If not, then the nutrient solution is not well-balanced and the adaptations to the nutrient solution will have to be altered in order to reach a balance. It should be noted that in practice a small difference (less than 10%) is acceptable as this can result from analytical variation.

The equivalents can also be used to calculate the EC of the nutrient solution by means of Formula 4:

4. (Eq. cations + Eq. anions)/20 = EC (in mS/cm).

Formulas 1 through 4 are for practical use only. They can be used to check calculations. In reality, electrical conductivity is more complex. Laboratories, therefore, use more complex chemical formulas to check their analytical findings and ion balances.

Reference EC

To compare the analytical findings with the target values, the nutrient values need to be converted to the same EC level. Therefore a reference EC is chosen. A reference EC is an EC level closely related to the EC of nutrients in the target values. The reference EC is generally 0.3 mS/cm lower than the EC of the target values (the value of 0.3 mS/cm represents the average amount of Na in the nutrient solutions).

Only nutrients that are listed in the target values can be compared. This means that Na and HCO_3 are not converted, since they never occur in the list of target values. Chloride is only converted when it is also present in the target values (e.g. for tomato).

First the EC of the analytical findings has to be corrected for the influence of Na, to obtain the EC of the nutrients in the analytical findings. The correction for Na is as follows:

$EC_{nutrients} = EC_{analysed} - 0.1$ ($Na_{analysed}$ in mmol Na/litre)

Secondly the analytical findings of the nutrients in mmol/l are multiplied by the factor $EC_{reference} / EC_{nutrients}$. The factor used to multiply the nutrients concentrations is therefore:

$Nutrient_{reference}$ (mmol/l) = $Nutrient_{analysed}$ (mmol/l) * $EC_{reference} / EC_{nutrients}$

Once the analytical findings are calculated to fit the reference EC value, the values found at reference EC are now at the same EC level as the target values, and can be compared with the target values.

Making this comparison might show that the level(s) of nutrients in the sample is/are not equal or closely to the target value(s). If that is the case, it will be necessary to adapt the nutrient solution over the following days in order to correct the nutrient status in the root zone and achieve the required level of nutrients.

Corrections

If the analytical findings for the nutrient levels diverge too much from the target values (showing that the nutrient levels in the root zone are incorrect), corrections made to the nutrient solution can restore the nutrient levels in the root zone. There are decision models (software programs) that direct these corrections. In this booklet the correction factors are not mentioned since they are influenced by local circumstances.

However, commonly accepted corrections are set up using two corrections steps:

• The first correction level indicates adding or subtracting 10-15% of the nutrients.

• The second correction level indicates adding or subtracting another 15-25% of the nutrients.

Corrections have to be made when the analytical findings (read: the nutrient levels recalculated by applying the Reference EC, see above) are found to deviate 25% from the target values. The second correction level is implemented when there is a deviation of 50%.

Corrections for crop stage

With the development of the crop the uptake of nutrients will change. There are two main crop stages: the vegetative (initial) stage of the crop and the generative (production) phase of the crop. Early in the growing season, crops consume relatively more Ca than K. From the start of flowering and fruit development they will consume relatively more K than Ca. Suggestions for correction of the nutrient solution are provided in the tables of section B, for different crop stages of several crops.

6. CALCULATING A RECIPE

The calculation of a recipe for fertilisers can be broken down into several steps. The following steps can be followed when adjusting a basic nutrient solution in which the main nutrients are calculated in mmol/l and the micronutrients in µmol/l (Table 3, the calculations are according to Sonneveld and Voogt 2009[1]).

1. The basic nutrient solution is what all calculations are based on.
2. Corrections are made when analytical findings for certain nutrients are beyond the range of the target values.
3. Adjustments are made to nutrient concentrations to respond to crop stage or seasonal effects.
4. After the corrections and adjustments are made, the main nutrients in the nutrient solution are calculated to meet the required EC level of the irrigation water (NH_4, P, Fe and other micronutrients are not adjusted).
5. The nutrients in the irrigation water are subtracted from the nutrient solution at EC level of 2.6 mS/cm.
6. The nutrients in the drain water are subtracted at a level according to the drain water input in the irrigation water.
7. The balance between the cations and anions is restored.

Below is an example of the calculation results for each step in the process. All main nutrients are included. Fe is added as an example for all the micronutrients. Acid is also included because of the assumed HCO_3 in the irrigation water.

Table 3 : Calculations for each step of the main nutrients in mmol/l and µmol/ for Fe.

step	EC	NH_4	K	Ca	Mg	NO_3	Cl	SO_4	P	Fe	H^+
1	2.6	1.2	9.5	5.4	2.4	15	1	4.4	1.5	25	
2					-0.25				-0.25	0	
3		0	1.5	-0.5	-0.25					0	
4	3.0	1.2	12.9	5.8	2.2	17.4	1.2	5.1	1.25	25	
5				0.25						0	0.5
6	0.8	0	1.4	2.5	1.2	4.4	0.6	1.6	0.6	8.2	0
7	2.1	1.2	11.5	3.0	1	13	0.6	3.5	0.65	16.8	0.5

Note that:

- The corrections in step 2 are given as an example.
- The adjustments in step 3 are an example: they relate to the fruit set stage of crop cultivation.
- All main nutrients, except for NH_4 and P, are calculated to the higher drip irrigation water level; Fe is not (step 4).
- Acid (H^+) is given because of the quality of the irrigation water. In this example, it is assumed that it contains 1.0 mmol/l HCO_3^- (step 5).

[1] *Nutrient solutions for soilless cultures*
C Sonneveld, W Voogt, 2009: Plant nutrition of greenhouse crops, pages 270-273

After the addition of 0.5 mmol/l H^+ in step 5, 0.5 mmol/l HCO_3^- will be neutralized and 0.5 mmol/l HCO_3^- will remain in the water. It is recommended to maintain about 0.5-0.75 mmol/l HCO_3^- in the irrigation water in order to buffer the pH to levels around 5.5-6. If all HCO_3^- in the irrigation water would be neutralized with acid (H^+), then the pH of the irrigation water will drop to undesirable acidic levels (below pH 5).

- It is assumed in this example that drain water is recirculated; the values are given as an example.

Recirculation or re-use of drain water

Recirculation or re-use of drain water in greenhouse crops, became first obliged by law in the Netherlands in 1996 for soilless grown crops in order to prevent environmental pollution with discharged nitrogen and phosphate of the water ways. Nowadays it is also obligatory for greenhouse crops grown in substrate or in soil. Re-use of drain water reduces the applied amount of both water and fertilizers. In general, the water savings amount to around 30% of the total crop water requirement, whereas the reduction in nutrient input with fertilizers can save up to 50% of the total fertilizer consumption.

In greenhouse cultivation, the main sources of irrigation water are rain water and well water (also see Eurofins advertisement on page 10). The percentage of drain water that will be mixed with these main water sources is controlled at a level that ensures a continuous and stable contribution of the recirculated nutrients to the total water demand. To this end, either the targeted percentage of drain water, or the contribution of the drain water to the total EC level of the irrigation solution, is a parameter which can be controlled by the fertigation unit.

The nutrient solutions listed in section B of this Manual can be also applied for recirculating systems. As a first step, the nutrients and other chemical elements, analysed in the drain water, have to be subtracted from the values of the recommended nutrient solution. Use the numbers in the analysis report of the drain water, and subtract these from the targeted values for the nutrient solution, proportional to the percentage of the drain water to the total amount of irrigation water, or to the relative contribution of the EC level of the drain water to the total EC level. To illustrate: the EC level of the drain water is 4.0 mS/cm. The drain percentage is set at 20%. This means that the relative contribution of the EC level of the drain water will be 4.0 mS/cm * 20% = 0.8 mS/cm. This EC-contribution of 0.8 mS/cm can be deducted from the total EC, as shown in table 3.

In grower's practice, accumulation of sodium over time is the main limiting factor when it comes to maintaining zero emission of drain water to the sewage system. Therefore the main inputs, i.e. irrigation water and fertilizers, should be as low as possible in sodium. Dutch research has shown that irrigation water is the main potential source of sodium, while the contribution of sodium with fertilizers is only of minor relevance. In general, macronutrient based fertilizers, produced by reputable companies, are already of technical grade purity with very low sodium levels. The main gain in sodium reduction can be made with micronutrient-containing fertilizers. If required, sodium borates or sodium containing iron, zinc, manganese and copper chelates should be replaced by boric acid or sodium free metal chelates. Alternatively, reverse osmosis units or sodium reduction units can be installed to remove most of the sodium present in the irrigation and drain water.

7. NUTRIENT CONTENT OF FERTILISERS

The nutrient content of fertilisers can be expressed either as a percentage of the elemental nutrient or as a percentage of the oxide of the element. In this manual the content of the main nutrients in fertilisers is given in percentages of the elemental nutrient. For conversion from % elemental to % oxide and vice versa, the conversion factors in Table 4 can be used. Fertilisers used for composing nutrient solutions are listed in Table 5. The molecular weight and the density (if liquid) of the fertilisers are also provided. These are the basic fertiliser ingredients that can be used to compose all nutrient solutions (Chapters 8 and 9).

In addition to this list of fertilisers, highly specialised liquid fertilisers are available in certain markets. Refer to the producers of these fertilisers for more information.

Table 4: Conversion factors to calculate amount of nutrients from % oxide to % elemental and vice versa.

Conversion from % oxide to % elemental			Conversion from % elemental to % oxide		
NO_3	x 0.226	= N	N	x 4.426	= NO_3
NH_4	x 0.776	= N	N	x 1.288	= NH_4
P_2O_5	x 0.436	= P	P	x 2.292	= P_2O_5
K_2O	x 0.830	= K	K	x 1.205	= K_2O
CaO	x 0.715	= Ca	Ca	x 1.399	= CaO
MgO	x 0.603	= Mg	Mg	x 1.658	= MgO
SO_4	x 0.334	= S	S	x 2.996	= SO_4
SO_3	x 0.400	= S	S	x 2.497	= SO_3

Table 5: List of Fertilisers.

Elements	Composition	Nutrients %	Molecular mass g/mol	Density g/cm_3
acid/bases				
Nitric acid (38%) (liquid)	HNO_3	8.4 N	167	1.24
Nitric acid (60%) (liquid)	HNO_3	13.3 N	105	1.37
Phosphoric acid (59%) (liquid)	H_3PO_4	18.6 P	167	1.42
Potassium bicarbonate	$KHCO_3$	39 K	100.1	
Main elements				
Ammonium nitrate (liquid)	NH_4NO_3	18 N	156	1.25
Monoammoniumphosphate	$NH_4H_2PO_4$	12 N; 26.3 P	115	
Urea	$CO(NH_2)_2$	46 N	60	
Urea phosphate	$CO(NH_2)_2.H_3PO_4$	17.5 N; 19.6 P	158	
Calcium nitrate	$5[Ca(NO_3)_2.2H_2O].NH_4NO_3$	15.5 N; 19 Ca	1080	
Calcium nitrate (liquid)	$Ca(NO_3)_2$	8.7 N; 12.5 Ca	320	1.5
Calcium chloride (solid)	$CaCl_2$	36 Ca; 63.9 Cl	111	
Calcium chloride (liquid)	$CaCl_2$	11.8 Ca; 20.9 Cl	339	1.3
Monopotassium phosphate	KH_2PO_4	22.7 P; 28.7 K	136.1	
Potassium nitrate	KNO_3	13.7 N; 38.6 K	101.1	
Potassium sulfate	K_2SO_4	44.8 K; 18.3 S	174.3	
Potassium chloride	KCl	52.2 K; 47.6 Cl	74.6	
Magnesium sulphate	$MgSO_4. 7H_2O$	9.7 Mg; 13 S	246.4	
Magnesiumnitrate	$Mg(NO_3)_2. 6H_2O$	9.5 Mg; 10.9 N	256	
Magnesium nitrate (liquid)	$Mg(NO_3)_2$	6.1 Mg; 7 N	400	1.35
Micro elements				
Iron chelate	Fe-EDTA	13 Fe	429	
Iron chelate	Fe-DTPA	12 Fe	465	
Iron chelate (liquid)	Fe-DTPA	3 Fe	1862	1.3
Iron chelate (liquid)	Fe-DTPA	6 Fe	931	1.3
Iron chelate	Fe-EDDHA*	6 Fe	931	
Iron chelate	Fe-HBED*	6 Fe	931	
Manganese chelate	Mn-EDTA	13 Mn	423	
Zinc chelate	Zn-EDTA	15 Zn	436	
Copper chelate	Cu-EDTA	15 Cu	424	
Manganese sulphate	$MnSO_4.H_2O$	32.5 Mn	169	
Zinc sulphate	$ZnSO_4.7H_2O$	22.7 Zn	287.5	
Boric acid	H_3BO_3	17.5 B	62	
Borax	$Na_2B_4O_7.10H_2O$	11.3 B	381	
Copper sulphate	$CuSO_4.5H_2O$	25.5 Cu	249.7	
Sodium molybdate	$Na_2MoO_4.2H_2O$	39.6 Mo	241.9	

*Please observe the ortho-ortho content on the labels of these fertilisers.

Powerful Micronutrients

Iron chelates for greenhouse crops and soilless cultures

Nouryon

Product	% (w/w) nutrient	Chelating agent	pH stability*	Liquid or solid	Remarks
D-Fe-3	3.1% Fe	DTPA	1.5-7	Liquid	Standard grade DTPA
D-Fe-6	6.1% Fe	DTPA	1.5-7.5	Liquid	High grade DTPA Na, Cl and SO_4 free Recommended for recirculated nutrient solutions
D-Fe-7	6.9% Fe	DTPA	1.5-7.5	Solid	Contains SO_4
D-Fe-11	11.6% Fe	DTPA	1.5-7.5	Solid	Low Na; Cl and SO_4 free Contains some acid Recommended for recirculated nutrient solutions
Q40	6.0% Fe 4.0% Fe as ortho-ortho EDDHA	EDDHA	3.5-10	Solid	As addition at high pH
Q48	6.0% Fe 4.8% Fe as ortho-ortho EDDHA	EDDHA	3.5-12	Solid	As addition at high pH
Bolikel® XP	6.0% Fe 6.0% Fe as ortho-ortho HBED	HBED	3.5-12	Solid	As addition at high pH, Na free

**In case of very high Ca levels or unchelated Mn, Zn and Cu present, this pH stability can be lower*

Rexolin®
Distributed by Yara International ASA under the trademark **YaraTera™ Rexolin®**

Rexene®
Distributed by SQM International N.V. under the trademark **Ultrasol® micro Rexene®**

https://micronutrients.nouryon.com

Dissolvine® master the elements   Rexolin®   Rexene®   bolikel XP

8. FERTILISER RECIPE CALCULATION

The values calculated in Step 7 of Table 3 in Chapter 6 can be converted into quantities of fertiliser ingredients. To do this, the amount of fertiliser ingredients (in mmol/l and µmol/l) is calculated so as to be used in the A+B tank containing 1000 litres and concentrated by a factor of 100.

Use the next steps:

1. Calculate the fertiliser recipe in the following order: H^+, Cl, Ca, NH_4, P, Mg, S, and K in mmol/l and choose the most appropriate fertiliser ingredient so that all the ions are presented in the list of fertiliser ingredients:

a. Choose nitric acid or phosphoric acid to add H^+ to the recipe.

b. Choose calcium chloride or potassium chloride to add Cl.

c. Use calcium nitrate for Ca.

d. Next to the NH_4 contribution of solid calcium nitrate, use ammonium nitrate nitrate or MAP to complete to complete the NH_4 demand.

e. Choose monopotassium phosphate for complete P.

f. Use magnesium sulphate to complete the Mg or S demand.

g. Add magnesium nitrate if more Mg is needed, or replace magnesium sulphate with magnesium nitrate if less sulphate is required.

h. Choose potassium sulphate as a sulphate source in case the sulphate demand is not completed with magnesium sulphate.

i. Use potassium nitrate to complete the NO_3 and K demand.

j. Select the appropriate fertiliser ingredient to supply each micronutrient.

2. Calculate the quantity of the main nutrients in the selected fertiliser by following the next steps:

i. multiply the quantity of the cations (in mmol) with the molecular weight of the fertiliser ingredient, expressed per mmol of the specific cation, to express it in mg/l (= gram/1000 l = gram/m³). E.g. calcium nitrate solid weighs 1080 gram per mol fertiliser. Calcium nitrate solid contains 5 mol of Ca. This leads to 1080/5=216 grams of calcium nitrate fertiliser per mol of Ca. To supply 3 mol of Ca one should add 3 * 216 = 648 grams of calcium nitrate solid.

ii. multiply by 0.001 to convert from gram/m³ into kg/m³.

iii. multiply by 100: to concentrate by a factor of 100.

3. For micronutrients:

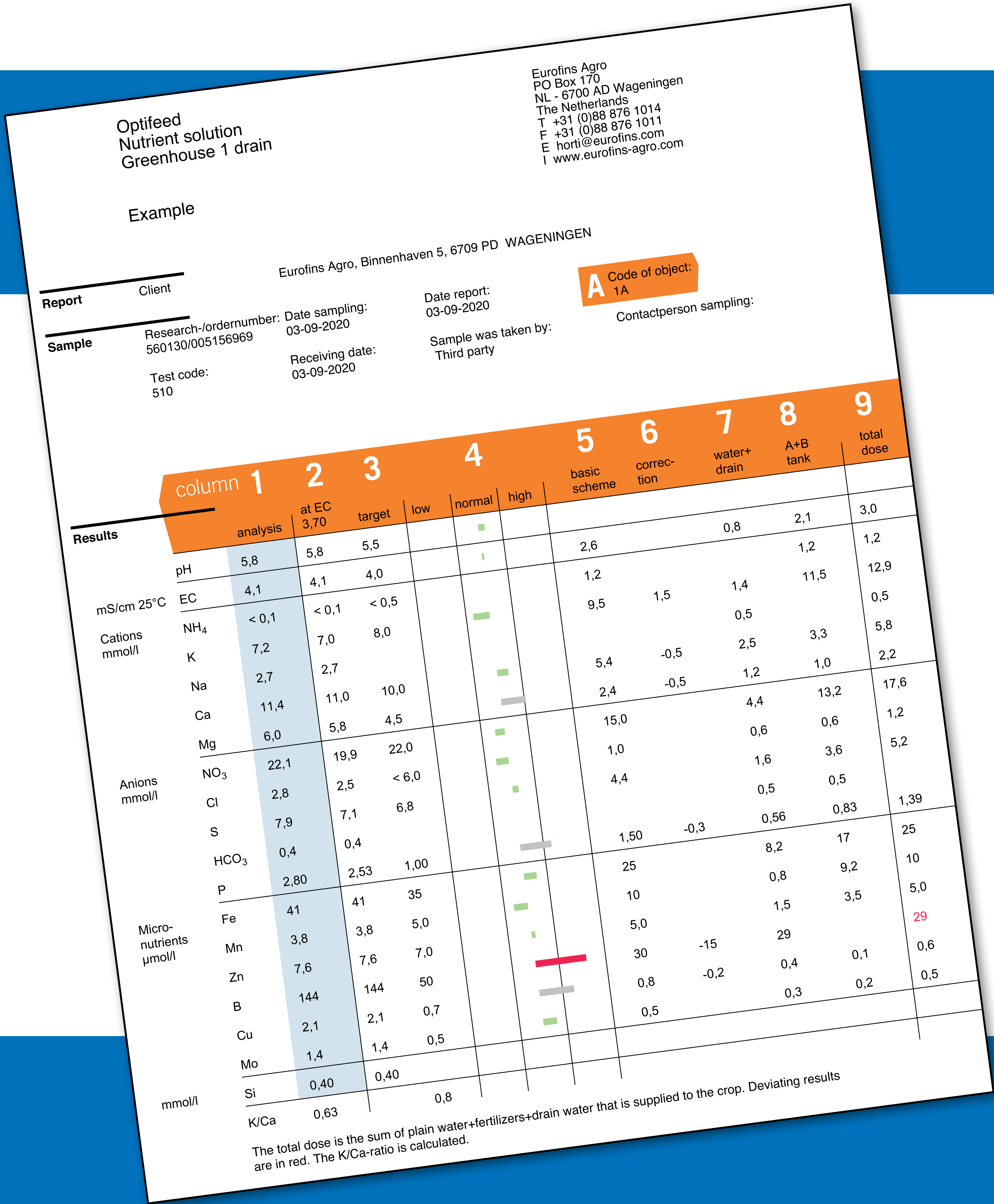
i. multiply the quantity of the micronutrient in µmol/l by the atomic weight of the micronutrient (gram/mol = µg/µmol) (Table 7) and divide the outcome by the percentage of that specific micronutrient in the fertiliser. This results in the amount of micronutrient fertilizer, expressed in µg per litre (= 1000 µg/1000 l = mg/m³).

ii. multiply by 0.001 to convert from mg/m³ into gram/m³.

iii. multiply by 100: to concentrate by a factor of 100.

4. Divide the fertiliser ingredients between the A and B tanks according to information in Chapter 9.

EXAMPLE REPORT WITH CALCULATIONS OF AN A+B TANK RECIPE



Optifeed
Nutrient solution
Greenhouse 1 drain

Eurofins Agro
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NL - 6700 AD Wageningen
The Netherlands
T +31 (0)88 876 1014
F +31 (0)88 876 1011
E horti@eurofins.com
I www.eurofins-agro.com

Example

Report Client: Eurofins Agro, Binnenhaven 5, 6709 PD WAGENINGEN

Sample

Research-/ordernumber: 560130/005156969

Date sampling: 03-09-2020

Date report: 03-09-2020

A Code of object: 1A

Contactperson sampling:

Test code: 510

Receiving date: 03-09-2020

Sample was taken by: Third party

Results

		1 analysis	2 at EC 3,70	3 target	4 low / normal / high	5 basic scheme	6 correction	7 water+ drain	8 A+B tank	9 total dose
	pH	5,8	5,8	5,5						
mS/cm 25°C	EC	4,1	4,1	4,0		2,6		0,8	2,1	3,0
Cations mmol/l	NH_4	< 0,1	< 0,1	< 0,5		1,2			1,2	1,2
	K	7,2	7,0	8,0		9,5	1,5	1,4	11,5	12,9
	Na	2,7	2,7					0,5		0,5
	Ca	11,4	11,0	10,0		5,4	-0,5	2,5	3,3	5,8
	Mg	6,0	5,8	4,5		2,4	-0,5	1,2	1,0	2,2
Anions mmol/l	NO_3	22,1	19,9	22,0		15,0		4,4	13,2	17,6
	Cl	2,8	2,5	< 6,0		1,0		0,6	0,6	1,2
	S	7,9	7,1	6,8		4,4		1,6	3,6	5,2
	HCO_3	0,4	0,4					0,5	0,5	
	P	2,80	2,53	1,00		1,50	-0,3	0,56	0,83	1,39
Micro-nutrients µmol/l	Fe	41	41	35		25		8,2	17	25
	Mn	3,8	3,8	5,0		10		0,8	9,2	10
	Zn	7,6	7,6	7,0		5,0		1,5	3,5	5,0
	B	144	144	50		30	-15	29		29
	Cu	2,1	2,1	0,7		0,8	-0,2	0,4	0,1	0,6
	Mo	1,4	1,4	0,5		0,5		0,3	0,2	0,5
mmol/l	Si	0,40	0,40							
	K/Ca	0,63		0,8						

The total dose is the sum of plain water+fertilizers+drain water that is supplied to the crop. Deviating results are in red. The K/Ca-ratio is calculated.

Greenhouse 1 drain

Recommend.

A		
Calcium nitrate	70,7	kg
Ammonium nitrate liquid	6,8	l
Potassium nitrate	17,0	kg
KCl 52,4%	4,6	kg
Nitric acid 38%	3,2	l
Chelated iron DTPA 6% or	1575	g
Chelated iron 3% liq.	2,4	l
Chelated Mn-EDTA 13%	65	g
Chelated Zn-EDTA 15%	155	g
Chelated Cu-EDTA 15%	6	g

1000 liter 100 ** concentrated*

B		
Nitric acid 38%	3,2	l
Potassium nitrate	32,9	kg
Mono potassium phosphate	11,2	kg
Sulphate of potash	44,3	kg
Magnesium sulphate	25,4	kg
Sodium molybdate	5	g

1000 liter 100 ** concentrated*

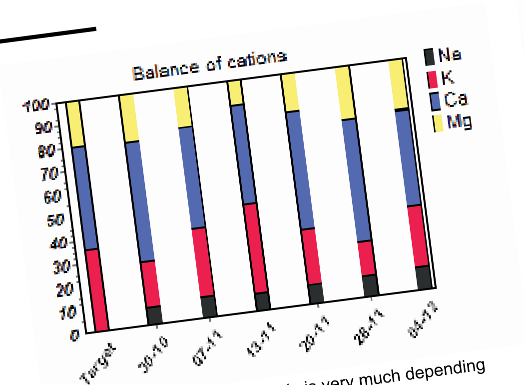
Please maintain one A+B tank. Fertilizer type: solid

Explanation DRIP EC : 3,0 / if the set DRIP EC shows a deviation of more than 50 % from this level, correction of the amount of acid is necessary.

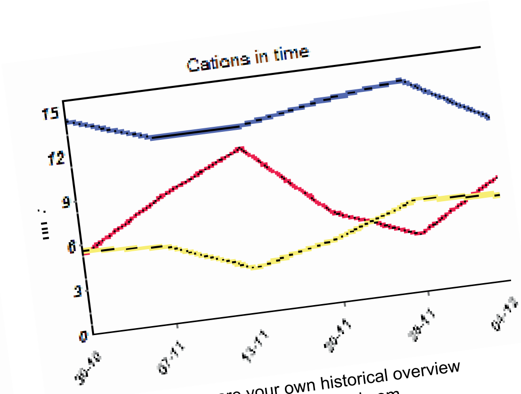
Crop data

Crop	Tomato	DRIP EC	3,0
Type of crop		System	recirculation
Growing stage	flowering 7th truss	Base water	80 % from scheme 1.1.0.0.0.0.
		Drain sample	20 % from testnumber 560130

History



The uptake of the nutrients is very much depending on the ratios of these nutrients.



Please prepare your own historical overview and graphs at www.horti-digital.com

	pH	EC mS/cm	NH_4 mmol/l	K	Na	Ca	Mg	NO_3	Cl	S	HCO_3	P	Si	Fe µmol/l	Mn	Zn	B	Cu	Mo
03-09-20	5,8	4,1	< 0,1	7,0	2,7	11,0	5,8	19,9	2,5	7,1	0,4	2,53	0,40	41	3,8	7,6	144	2,1	1,4
26-08-20	5,9	3,8	0,1	7,1	1,8	13,7	5,6	25,5	2,1	7,4	0,3	2,04	0,40	90	16	12	285	2,4	1,2
21-08-20	6,2	4,0	0,1	10,6	1,9	11,6	5,6	21,0	3,1	8,4	0,3	1,11	0,40	112	4,6	15	275	2,6	1,6
15-07-20	5,9	5,3	0,2	2,9	5,4	14,7	6,8	27,2	0,7	7,7	0,3	1,12	1,30	255	9,6	16	559	3,9	1,7
09-07-20	5,8	4,7	0,3	7,8	3,3	11,9	4,6	25,3	1,9	5,6	0,2	1,65	0,60	100	8,8	8,5	259	2,9	1,4
02-07-20	5,8	4,5	< 0,1	3,5	3,0	12,2	4,4	27,4	1,6	5,3	0,2	1,32	0,50	83	3,4	4,8	164	2,6	1,1
24-06-20	5,9	5,2	0,1	5,5	4,8	14,4	7,2	24,8	1,2	9,4	0,5	2,28	0,80	133	3,5	8,4	236	3,8	2,4
19-06-20	5,9	4,9	0,1	6,5	3,7	14,4	5,6	20,9	2,4	11,0	0,5	2,49	0,60	90	4,4	8,2	236	3,1	1,9
12-06-20	5,9	4,6	< 0,1	4,1	3,7	15,7	5,4	21,2	2,0	9,9	0,4	1,93	0,50	106	4,1	9,0	245	3,4	1,4
03-06-20	5,6	4,5	0,2	4,8	4,3	14,5	5,5	23,8	2,4	7,7	0,1	1,56	0,50	138	3,5	11	250	3,0	1,4
27-05-20	5,7	5,3	0,5	7,0	5,1	12,7	5,4	27,9	1,0	5,9	0,2	1,40	0,70	96	6,0	6,9	222	2,3	1,8
20-05-20	5,6	4,9	0,1	7,0	4,9	12,7	4,7	26,9	0,6	5,2	0,2	1,81	0,60	78	6,1	4,6	167	2,0	1,2
14-05-20	5,5	5,3	0,2	3,9	7,7	15,6	7,4	23,0	0,8	11,0	0,3	3,35	1,00	154	7,2	10	304	3,5	2,1
08-05-20	6,1	4,5	0,1	6,3	5,2	12,7	6,6	20,1	2,1	9,4	0,6	2,06	0,60	162	3,2	11	251	3,1	2,1

9. PREPARING HIGHLY CONCENTRATED STOCK SOLUTIONS

The standard concentration factor for A+B tank stock solutions is 100. The fertiliser ingredients are dissolved in an A tank and a B tank, each holding 1000 litres (1 m^3). Recipes are usually given for 1 m^3, but other volumes may be indicated; 1 m^3 of stock solution can be used per 100,000 litres (100 m^3) of irrigation water.

To dissolve all the fertilisers in high concentrations, some rules should be obeyed to avoid the precipitation of the fertiliser ingredients in the tanks.

All calcium fertilisers must be separated from phosphate and sulphate fertilisers. This means putting calcium fertilisers into the A tank and sulphate and phosphate fertilisers into the B tank.

Some fertilisers (potassium nitrate, magnesium nitrate, ammonium nitrate and nitric acid) can be dissolved in both the A and B tanks. This spreads the fertiliser load over both tanks so that they both contain roughly the same quantity of dissolved fertilisers.

Micronutrients are put into tank B in case they are added as sulphate salts. Chelates can be put in both tanks. If substantial quantities of acids are used, however, it would be preferable to place the chelated micronutrients in the A tank. Chelates are sensitive to low pH levels in the tanks: at a pH of 3.5 or lower, the chelate structure will break down. This is especially true for the EDDHA and HBED chelates. Therefore, to avoid low pH issues in the A tank, the quantities of acids in the A tank must be limited to only a few litres per m^3, while the remainder should be put in the B tank.

The pH of the stock solutions in both tanks should be lower than 5 so that all the fertilisers will completely dissolve.

Filling the A+B tanks

When filling the tanks with fertilisers listed in Table 5, it is recommended to follow the procedure below. If other fertilisers are used than those listed in Table 5 (e.g. liquid fertilisers), follow the instructions provided by the manufacturer.

Fill the tanks three-quarters full with water. Dissolve the fertilisers by dosing them in at a slow, steady rate. Add one fertiliser after another following the instructions of the laboratory or the recipe provided by the calculation software. Stir continuously and allow the fertilisers sufficient time to fully dissolve. Once all salts composing the main elements are dissolved, fill the tanks completely with water. Check the pH of the tanks. The pH of the B tank should be pH<5 and the pH of the A tank should be pH 3.5- 5. Add the chelated micronutrients to the A tank and the non-chelated micronutrients to the B tank. Work in a well-organised manner in order to make sure that not one fertiliser is being omitted and to avoid that a fertiliser is being added two times.

Compound fertilisers

Nutrient solutions can be made from water soluble compound fertilisers. The use of compound fertilisers (NPK's) can be attractive to growers as they are easy in use with almost all essential nutrients present in one bag, and well-balanced according to the requirements per growth stage or crop. The fertiliser industry has developed numerous compound fertilisers for use in drip irrigation and spray application for soil, potting soils and hydroponic growing systems. Also liquid compound fertilisers are on the market. The N, P and K in the compound fertilisers are mixed in proportions so as to meet the demand of the plants. Most compound fertilisers are developed to be used with Ca-rich water, like tap water or well water. Some compound fertilisers also hold Mg, S and micronutrients. When necessary the NPK fertilisers (e.g. in the B-tank) are applied with Ca fertilisers, like calcium nitrate (e.g. in the A-tank). As stated above, all calcium fertilisers must be separated from phosphate and sulphate containing NPK fertilisers.

In this manual the recipes are meant to be prepared with straight fertilisers, exactly calculated from the nutrient solutions in mmol/l and µmol/l. Using compound fertilisers does not always result in exactly the same nutrient solution composition, but can be considered to be a fair estimate. Some examples of recipes with compound fertilisers will be presented in Table 8, Chapter 18, part B Nutrient Solutions, of this manual.

When calcium and a part of the nitrogen requirement are applied with calcium nitrate, then the remainder of the required nutrients can be applied with (a mixture of) compound fertilisers, according to their respective nutrient compositions. Ask your crop consultant for an adapted fertigation programme in accordance with the local needs and requirements.

Potassium nitrate

two key nutrients for optimal plant growth

Ultrasol® K and Ultrasol® K Plus potassium nitrate are the preferred N and K source for all growth stages. This unique combination of two essential plant nutrients make Ultrasol® K and Ultrasol® K Plus the most efficient and versatile water-soluble K source for fertigation in hydroponically and soil-grown crops and for foliar applications. Nitrogen is present in the form of nitrate for quick absorption by the plant.

The key features and benefits of Ultrasol® K and Ultrasol® K Plus are:

- Virtually free of chloride and very low in sodium and heavy metals.
- Can be mixed with all water-soluble fertilizers and is also compatible with the majority of pesticides in foliar application.
- Nitrate nitrogen is non-volatile and enhances the uptake of cations (K^+, Ca^{2+}, Mg^{2+}).
- Ultrasol® K can be used to cover the potassium needs of a crop without supplying excess of sulphate or chloride.
- Due to its low N/K ratio, Ultrasol® K is suitabe for all crops and growth stages, including flowering and ripening stages.
- Potassium nitrate combats salinity. The nitrate in potassium nitrate enables the plant to minimize chloride uptake and the potassium in potassium nitrate counteracts the harmful effects of sodium. Under saline conditions potassium nitrate has proven to outperform potassium chloride and potassium sulphate in terms of crop growth and yield.
- In hydroponics a high nitrate to ammonium ratio is required. Potassium nitrate is the preferred N and K source enabling the design of a well-balanced program.

Learn all the benefits that are available to your crop and your business on our website.
For more information about potassium nitrate visit: sqmnutrition.com

sqmnutrition.com

10. MICRONUTRIENTS: AVERAGE PLANT NEED (APN)

Remember to use only water soluble compounds for these purposes.

Micronutrients are applied at low levels - micromole per litre (µmol/l) or parts per billion (ppb). Even in highly concentrated stock solutions such as A+B tank solutions, the quantities of these elements that are added are measured in grams.

For many crops, the quantities of micronutrients the plant needs have been thoroughly investigated and recipes are widely available. In Table 6, the quantities are given for three crops in a growing system that uses continuous feeding or hydroponics.

Table 6: Plant needs for micronutrients. The concentrations in this table follow typical guidance[1] regarding the supply in the nutrient solution of open drain systems and are not target levels in the root zone.

	Rose	Potted plants	Tomato
	µmol/l (ppb)	µmol/l (ppb)	µmol/l (ppb)
Fe	25 (1400)	15 (840)	15 (840)
Mn	5 (275)	5 (275)	10 (550)
Zn	3 (196)	4 (262)	5 (327)
B	20 (220)	10 (110)	30 (330)
Cu	0.8 (50)	0.5 (32)	0.8 (50)
Mo	0.5 (48)	0.5 (48)	0.5 (48)

In situations where several crops are grown at the same time in the same greenhouse, it may not be possible to provide each crop with its own recipe. In these cases, the average for all the crops is applied and/or a certain micronutrient needed as a minimum requirement by the most demanding crop is selected and added to the stock solutions.

In situations of varying pH levels in the growing medium (sometimes meaning low levels shown in analytical findings), growers may add more nutrients. Plants normally need low concentrations of micronutrients, but in the situations described above, more micronutrients will be added just to be sure that enough is given.

The average plant need (APN) is regarded as the ‘best known’ solution. Special micronutrient fertilisers are composed for these purposes.

A few crops (e.g. ***Bromeliaceae***) are extremely sensitive to a specific micronutrient (e.g. boron). In these cases, even a small quantity could cause severe problems.

Using micronutrients in chelated form in accordance with the average plant need, instead of sulphate salts, can help to reduce the amount of micronutrients applied and assure their availability at constant levels.

A micronutrient mix can also be used when the grower requires a more convenient use of micronutrients. Instead of adding small quantities of the various micronutrients to the nutrient solution used for each crop, it is more convenient to use a recipe that includes micronutrients that will meet the average plant need for all crops being cultivated at the same time.

In situations where nutrient solutions are composed on the spot (e.g. when stock solutions are prepared in low concentrations) these micronutrient mixes can be very convenient.

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[1] *Nutrient solutions for soilless cultures*
C Sonneveld, W Voogt, 2009: Plant nutrition of greenhouse crops, pages 411-419

11. HOW CHELATES WORK

The metal micronutrients iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) form salts when used in a non-chelated form. They can precipitate with phosphates, carbonates or hydroxides rendering them unavailable for plant uptake. This occurs readily when the pH reaches levels over pH > 6 in both soils and nutrient solutions. Chelation is a process that can protect micronutrients from forming these precipitates; when chelated, the nutrients remain dissolved in solution and available to the plants.

In their natural form, chelates are complex organic compounds that can attract positively-charged ions and become part of the CEC complex present in soils. Chelates can also be synthesised for agricultural purposes to ensure the availability of micronutrients in nutrient solutions or in soil moisture. There are various forms of chelates, each with its own power to attract metal ions. This power of chelates to attract ions is strongly influenced by pH. Figure 3 shows the pH range over which iron chelates are stable. Beyond this range, the chelate will no longer retain ('protect') its iron.

Figure 2. The metal-chelate molecule is negatively charged to enable micronutrients to move freely through the soil.

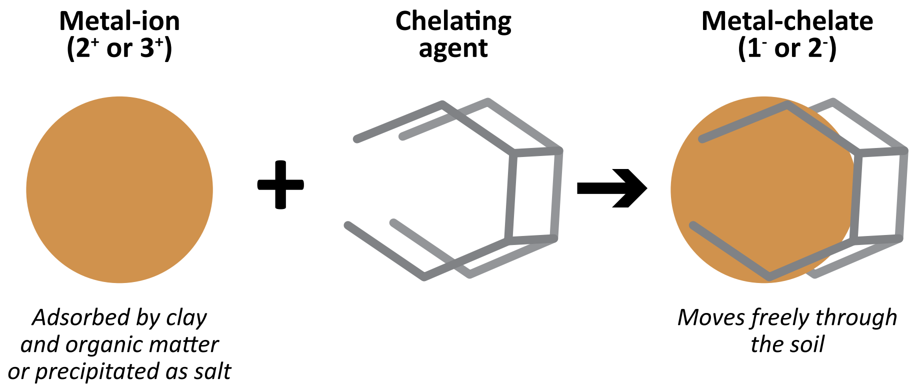
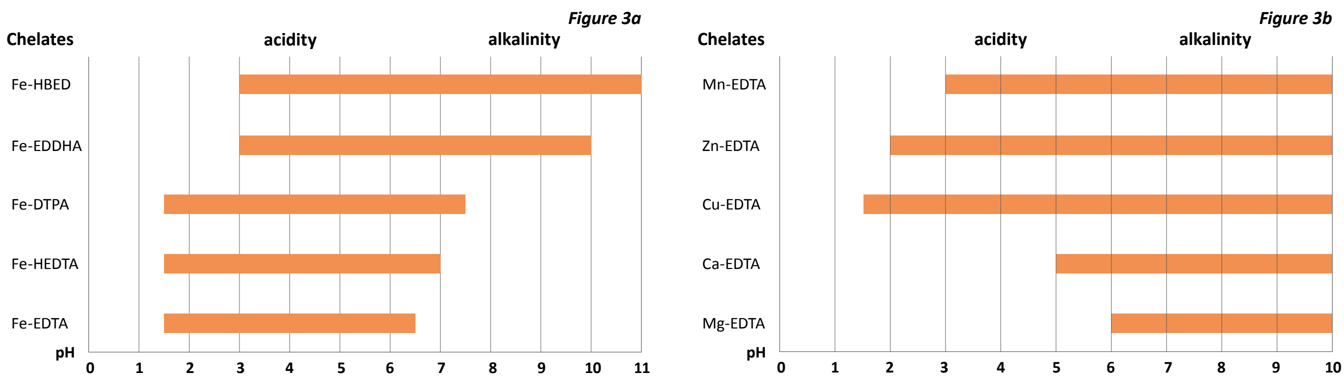


Figure 3. pH stability of several nutrient-chelate combinations under practical agricultural conditions where calcium is present. Figure 3a refers to iron chelates and Figure 3b to other chelates.



The use of chelates to supply iron is a necessity in hydroponic systems. The type of chelates to be used depends on the solution pH. If the pH in the root zone is kept below 6.5, a DTPA chelate will provide sufficient stability. If the pH rises to above 6.5, the use of Fe-EDDHA or Fe-HBED chelates is strongly recommended.

The risk of elevation of pH is relatively high in inert substrates or NFT systems. In these cases, a percentage of the amount of Fe normally given as Fe-DTPA or Fe-EDTA, should be supplied as Fe-EDDHA or Fe-HBED. It is recommended to replace 25% of the total Fe recommendation by these chelates in substrate systems, and in case of NFT 10%, to prevent the risk of iron deficiency in case of increased pH. When the crop is already showing signs of iron deficiency, this percentage can be added on top of the normal amount of iron given by Fe-DTPA (or Fe-EDTA).

In calcareous soils, Fe is always needed in the form of Fe-EDDHA or Fe-HBED. These chelates should, preferably, be products with a high ortho-ortho content (see product label – in Europe, this is an obligatory part of the guaranteed analysis).

Iron which is not present in the products in the form of Fe-ortho-ortho-EDDHA or Fe-ortho-ortho-HBED, will not provide iron to the plant in these soils. The Fe will drop from the non-ortho-ortho chelate immediately after application to the soil, and is no longer available for plant. With this in mind, the amount of 'ortho-ortho-Fe' is the correct amount of active ingredient that should be considered when calculating the dose of product in the nutrient solution of soil-grown crops. In hydroponics, the non-ortho-ortho forms (e.g ortho-para-Fe) are able to keep at least some of the Fe in solution, but in the end products with a low ortho-ortho content are not more stable than a standard Fe-DTPA or Fe-EDTA with increasing pH in the root zone. In this case, when the choice is made to add a more pH-stable Fe-chelate next to the standard Fe-DTPA, also the calculation of the required amount based on the concentration of Fe as "ortho-ortho-Fe" makes sense.

Other micronutrients with sulphate can be used as long as the pH is kept at 5.5.-7.0. The use of metal sulphates, however, will lead to losses of iron due to the exchange of Fe in the chelate by Cu, Zn and Mn ions. Depending on the pH, the losses of Fe can be as large as 20 to 50%. This loss can be compensated by increasing the supply of iron chelates as the pH rises, but could better be handled by using EDTA chelates of Mn, Zn and Cu. An additional benefit of metal chelates is that they often contain less heavy metals than metal sulphates.

Chelates are complex structures with stability constraints[1]. Fe chelates are sensitive to light, hydrogen peroxide, UV or ozone, especially in the solutions actually applied to the crop, but less so in the more darkly coloured stock solutions. For this reason, nutrient solutions containing chelates should be protected from exposure to daylight. And, because disinfecting drain water using UV or ozone will break down chelate structures to some extent, replacing the chelates should be done after disinfection.

The breakdown of chelates is increased by high temperatures and microorganism activity.

Some chelates (see Figure 3) are less stable at low pH levels (pH <3.5). This means that concentrated stock solutions containing chelates should be kept at a pH above 3.5. Since chelates are normally added to the A-tank, this limits the quantity of acid that can be put into the A tank.

When the drain of the nutrient solution is recycled, it is required that the sodium input is reduced to a minimum. Under these circumstances a change from the standard sodium-based chelates to sodium free K-based chelates can help to maintain low levels of sodium in the recirculated nutrient solution.

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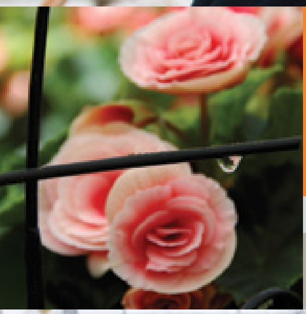
[1]*http://www.chemguide.co.uk/inorganic/complexions/stabconst.html*



FERTICARE™

Crop Specific Water Soluble NPK

Based on the Dutch Fertilization Manuals*

FERTICARE™ is an easy to apply, crop specific, fully water-soluble NPK concept of the highest quality raw materials, for fertigation systems. It will lead farmers to healthier crops (fewer chemicals required) and the best yield in both quantity and quality. FERTICARE™ is available for tomato, vegetables (sweet pepper and cucumber), strawberry, lettuce (leafy vegetables) and roses.

Always use FERTICARE™ together with **YaraLiva™ CALCINIT™** to complete the recipe with calcium, and to fine-tune the level of NO_3 to optimize growth.

**Manuals originally developed by the WUR* and the Dutch horticulture sector (* Wageningen University Research)*

SECTION B: NUTRIENT SOLUTIONS

12. NUTRIENT SOLUTIONS

The following pages present nutrient solutions in mmol/l (main nutrients) and µmol/l (micronutrients).

From mmol/l and µmol/l to ppm and ppb

These values can be converted into ppm and ppb (where ppm = mg/l and ppb = µg/l) by using the atomic weight of the various nutrients (Table 7). The formula is:

Nutrient (mmol/l) x atomic weight (mg/mmol)= nutrient (mg/l or ppm)

Table 7: Atomic weight of various elements (g/mol; mg/mmol)

Cation	Atomic weight	Anion	Atomic weight	Micronutrient	Atomic weight
$N\text{-}NH_4$	14	$N\text{-}NO_3$	14	Fe	55.85
K	39.10	Cl	35.45	Mn	54.94
Na	22.99	S	32.06	Zn	65.38
Ca	40.08	HCO_3	61.02	B	10.81
Mg	24.31	P	30.97	Cu	63.55
				Mo	95.94

Following (Chapters 16-17) are examples of an A+B tank recipe with the nutrient solutions in mmol/l. This recipe is calculated starting from the basic nutrient solution without any adjustments. Only straight fertilisers are given for main nutrients and only chelates are given for metal micronutrients. The recipe is calculated for 1000-litre A+B tanks and for solutions concentrated by a factor of 100.

In Dutch greenhouses crop demand for NH_4 is largely met by solid calcium nitrate. The remaining amount of NH_4 that is required, is routinely provided by liquid ammonium nitrate. However, liquid ammonium nitrate is not a commonly available fertiliser in most other countries. Therefore MAP has been chosen as the additional source of ammonium to calculate the A and B tanks recipe examples provided in the following chapters. For the same reason, solid magnesium nitrate and solid calcium chloride have been chosen as respective sources of magnesium and chloride, instead of the liquid products.

13. NUTRIENT SOLUTIONS FOR FRUITING VEGETABLES

- Cucumber
- Eggplant
- Melon
- Sweet pepper
- Tomato

CROP: ***CUCUMBER (Cucumis sativus)*** **INERT SUBSTRATE**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.2-6.0	5.3		5.2-6.0	5.3			*		**		***	
EC	mS/cm	3	2.2	mS/cm	3	2.2								
Na	mmol/l	< 6		ppm	< 138									
Cl		< 6			< 212									
HCO_3		< 0.5			< 30									
$N\text{-}NH_4$	mmol/l	< 0.5	1.25	ppm	< 7	18	-0.5	-7					-1	-14
K		8	8		313	313	-1	-39	1	39	-1	-39		
Ca		6.5	4		260	160	0.5	20			0.5	20		
Mg		3	1.375		73	33	0.25	6						
$N\text{-}NO_3$	mmol/l	18	16	ppm	252	224			1	14				
S		3.5	1.375		112	44								
P		0.9	1.25		28	39							-1	-31
Fe	µmol/l	30	15	ppb	1680	840	10	560						
Mn		7	10		385	550								
Zn		7	5		458	327								
B		50	25		540	270	10	108						
Cu		1.5	0.75		95	48								
Mo		0.5	0.5		48	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

A		
Calcium nitrate solid	86	kg
Potassium nitrate	18	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	55	kg
Monopotassium phosphate	11	kg
Magnesium sulphate 16% MgO	34	kg
Monoammonium phosphate	5	kg
Borax 11.3% B	239	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***CUCUMBER (Cucumis sativus)*** **ORGANIC MATERIAL**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.2-6.0	5.3		5.2-6.0	5.3			*		**		***	
EC	mS/cm	1.4	2.2	mS/cm	1.4	2.2								
Na	mmol/l	< 2		ppm	< 46									
Cl		< 2			< 71									
HCO_3		< 0.1			< 6									
N-NH_4	mmol/l	< 0.5	1	ppm	< 2	14	-0.5	-7					-1	-14
K		3	8		117	313	-1	-39	1	39	-1	-39		
Ca		3	4.5		120	180	0.5	20			0.5	20		
Mg		1.5	1.5		36	36	0.25	6						
N-NO_3	mmol/l	8	16.75	ppm	112	235			1	14				
S		1.5	1.5		48	48								
P		0.7	1.25		22	39							-1	-31
Fe	µmol/l	10	30	ppb	560	1680	10	560						
Mn		3	10		165	550								
Zn		4	5		262	327								
B		20	25		216	270	10	108						
Cu		1	0.75		64	48								
Mo		0.3	0.5		29	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate solid	97	kg
Potassium nitrate	13	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2793	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	56	kg
Monopotassium phosphate	16	kg
Magnesium sulphate 16% MgO	37	kg
Monoammonium phosphate	1	kg
Borax 11.3% B	239	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***CUCUMBER (Cucumis sativus)*** **SOIL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1	1	mS/cm	1	1
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 106	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		1.8	3.5		70	137
Ca		2.2	2		88	80
Mg		1.2	1		29	24
-	mmol/l	4	7.9	ppm	56	111
S		1.5	1		48	32
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		10	10		108	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimum pH depends on soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	43	kg
Potassium nitrate	11	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	24	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *EGGPLANT (Solanum melongena)* — INERT SUBSTRATE

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.5-6.0	5.3		5.5-6.0	5.3			*		**		***	
EC	mS/cm	3	2.1	mS/cm	3	2.1								
Na	mmol/l	< 6		ppm	< 138									
Cl		< 6			< 212									
HCO_3		< 0.5			< 30									
N-NH_4	mmol/l	< 0.5	1.5	ppm	< 7	21	-1	-14					-1	-14
K		6.2	6.75		242	264	-1	-39	1	39	-1	-39		
Ca		6.2	3.25		248	130	0.5	20			0.5	20		
Mg		4.5	2.5		109	61	0.5	12						
- O_3	mmol/l	20	15.5	ppm	280	217			1	14				
S		3	1.5		96	48								
P		0.9	1.25		28	39							-1	-31
Fe	µmol/l	25	15	ppb	1400	840	10	560						
Mn		7	10		385	550								
Zn		7	5		458	327								
B		80	35		864	378	10	108						
Cu		0.7	0.75		44	48								
Mo		0.5	0.5		48	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

A		
Calcium nitrate solid	70	kg
Potassium nitrate	36	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	28	kg
Monopotassium phosphate	5	kg
Magnesium sulphate 16% MgO	37	kg
Magnesium nitrate solid	26	kg
Monoammonium phosphate	10	kg
Borax 11.3% B	335	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***EGGPLANT (Solanum melongena)*** **ORGANIC MATERIAL**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.5	5.3		5.5	5.3			*		**		***	
EC	mS/cm	1.2	2.1	mS/cm	1.2	2.1								
Na	mmol/l	< 2		ppm	< 46									
Cl		< 2			< 71									
HCO_3		< 0.1			< 6									
N-NH_4	mmol/l	< 0.1	0.75	ppm	< 2	10	-0.5	-7					-0.5	-7
K		2.5	6		98	235	-1	-39	1	39	-1	-39		
Ca		2.5	3.75		100	150	0.5	20			0.5	20		
Mg		1.5	2.75		36	67	0.25	6						
- O_3	mmol/l	8	15.5	ppm	112	217			1	14				
S		1	1.5		32	48								
P		0.5	1.25		16	39							-0.5	-16
Fe	µmol/l	15	15	ppb	840	840	10	560						
Mn		3	10		165	550								
Zn		4	5		262	327								
B		25	35		270	378	10	108						
Cu		0.5	0.75		32	48								
Mo		0.3	0.5		29	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	81	kg
Potassium nitrate	26	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B

Potassium nitrate	22	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	37	kg
Magnesium nitrate solid	32	kg
Borax 11.3% B	335	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***EGGPLANT (Solanum melongena)*** **SOIL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1.2	1	mS/cm	1.2	1
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 106	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		1.8	3.5		70	137
Ca		2	2		80	80
Mg		1.5	1		36	24
-	mmol/l	4.5	7.9	ppm	63	111
S		2	1		64	32
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		10	10		108	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimum pH depends on soil type

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A

Calcium nitrate solid	43	kg
Potassium nitrate	11	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B

Potassium nitrate	24	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***MELON (Cucumis melo)***	**INERT SUBSTRATE**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**	**Adjustments**							
							Start		**Fruit Set**		**High water**		**End season**	
pH		5.5-6.0	5.3		5.5-6.0	5.3			*		**		***	
EC	mS/cm	3	2.2	mS/cm	3	2.2								
Na	mmol/l	< 6		ppm	< 138									
Cl		< 6	0		< 212	0								
HCO_3		< 0.5			< 30									
$N\text{-}NH_4$	mmol/l	< 0.5	1.25	ppm	< 7	18	-1	-14					-1	-14
K		7	8		274	313	-1	-39	1	39	-1	-39		
Ca		7	4		280	160	0.5	20	-0.5	-20	0.5	20		
Mg		2.5	1.4		61	34	0.5	12						
$-\ O_3$	mmol/l	20	16	ppm	280	224								
S		3.5	1.4		112	45								
P		0.8	1.25		25	39							-1	-31
Fe	µmol/l	25	15	ppb	1400	840	10	560						
Mn		5	10		275	550								
Zn		7	5		458	327								
B		50	25		540	270	10	108						
Cu		1	0.75		64	48								
Mo		0.5	0.5		48	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

A		
Calcium nitrate solid	86	kg
Potassium nitrate	18	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	54	kg
Monopotassium phosphate	11	kg
Magnesium sulphate 16% MgO	34	kg
Monoammonium phosphate	5	kg
Borax 11.3% B	239	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***MELON (Cucumis melo)*** — ORGANIC MATERIAL

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.8	5.3		5.8	5.3			*		**		***	
EC	mS/cm	1.7	2.2	mS/cm	1.7	2.2								
Na	mmol/l	< 2		ppm	< 46									
Cl		< 2	0		< 71									
HCO_3		< 0.1			< 6									
$N\text{-}NH_4$	mmol/l	< 0.1	1	ppm	< 2	14	-1	-14					-1	-14
K		3.8	7.5		149	293	-1	-39	1	39	-1	-39		
Ca		3.8	4.75		152	190	0.5	20	-0.5	-20	0.5	20		
Mg		1.5	1.25		36	30	0.5	12						
$-\ O_3$	mmol/l	7	16.25	ppm	98	228								
S		2.5	1.5		80	48								
P		0.5	1.25		16	39							-1	-31
Fe	µmol/l	10	15	ppb	560	840	10	560						
Mn		2	10		110	550								
Zn		3	5		196	327								
B		20	25		216	270	10	108						
Cu		0.5	0.75		32	48								
Mo		0.3	0.5		29	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	103	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B

Potassium nitrate	59	kg
Potassium sulphate	4	kg
Monopotassium phosphate	16	kg
Magnesium sulphate 16% MgO	31	kg
Monoammonium phosphate	1	kg
Borax 11.3% B	239	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***MELON (Cucumis melo)*** **SOIL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1	1	mS/cm	1	1
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 106	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.8	ppm	< 2	11
K		1.8	4		70	156
Ca		2.2	1.5		88	60
Mg		1.2	1		29	24
-	mmol/l	4	7.3	ppm	56	102
S		1.5	1		48	32
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		10	10		108	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimum pH depends on soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A

Calcium nitrate solid	32	kg
Potassium nitrate	19	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B

Potassium nitrate	21	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***SWEET PEPPER (Capsicum annuum)*** **INERT SUBSTRATE**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		6	5.3		6	5.3			*		**		***	
EC	mS/cm	3	2.2	mS/cm	3	2.2								
Na	mmol/l	< 6		ppm	< 138									
Cl		< 6			< 212									
HCO_3		< 0.5			< 30									
N-NH_4	mmol/l	< 0.5	1	ppm	< 7	14	-0.5	-7					-1	-14
K		5	6.75		313	264	-1	-39	1	39	-1	-39		
Ca		8.5	5		400	200	0.5	20			0.5	20		
Mg		3	1.5		109	36	0.25	6						
- O_3	mmol/l	17	16	ppm	308	224			1	14				
S		3	1.75		218	56								
P		1.2	1.25		31	39							-1	-31
Fe	µmol/l	25	15	ppb	1960	840	10	560						
Mn		5	10		275	550								
Zn		7	5		458	327								
B		80	30		540	324	10	108						
Cu		0.7	1.0		44	64								
Mo		0.5	0.5		48	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustmens for high water supply are recommended when water supply exceeds 5 l/m^2/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

A

Calcium nitrate solid	108	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	42	g

B

Potassium nitrate	51	kg
Potassium sulphate	4	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	37	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***SWEET PEPPER (Capsicum annuum)*** **ORGANIC MATERIAL**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.8	5.3		5.8	5.3			*		**		***	
EC	mS/cm	1.4	2.1	mS/cm	1.4	2.1								
Na	mmol/l	< 2		ppm	< 46									
Cl		< 2			< 71									
HCO_3		< 0.1			< 6									
$N\text{-}NH_4$	mmol/l	< 0.1	1.05	ppm	< 2	15	-0.5	-7					-1	-14
K		3	6.2		117	242	-1	-39	1	39	-1	-39		
Ca		3	5.25		120	210	0.5	20			0.5	20		
Mg		1.5	1.5		36	36	0.25	6						
$N\text{-}NO_3$	mmol/l	8	16	ppm	112	224			1	14				
S		1.5	1.75		48	56								
P		0.7	1.25		22	39							-1	-31
Fe	µmol/l	10	30	ppb	560	1680	10	560						
Mn		3	10		165	550								
Zn		4	5		262	327								
B		25	30		270	324	10	108						
Cu		0.5	1		32	64								
Mo		0.3	0.5		29	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	113	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2793	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	42	g

B

Potassium nitrate	45	kg
Potassium sulphate	4	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	37	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***SWEET PEPPER (Capsicum annuum)***						**SOIL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1.1	1.1	mS/cm	1.1	1.1
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 106	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		2	4		78	156
Ca		2.5	2		100	80
Mg		1.2	1		29	24
-	mmol/l	4.5	8.4	ppm	63	118
S		2	1		64	32
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		10	10		108	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimum pH depends on soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	43	kg
Potassium nitrate	14	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	27	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***TOMATO (Solanum lycopersicum)***	**INERT SUBSTRATE**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments							
							Start		Fruit Set		High water		End season	
pH		5.5-6.0	5.3		5.5-6.0	5.3			*		**		***	
EC	mS/cm	4	2.6	mS/cm	4	2.6								
Na	mmol/l	< 8		ppm	< 184									
Cl		< 8	1		< 284	35								
HCO_3		< 0.5			< 30									
N-NH_4	mmol/l	< 0.5	1.2	ppm	< 7	17	-1	-14					-1	-14
K		8	9.5		313	371	-1	-39	1.5	59	-1	-39		
Ca		10	5.4		400	216	0.5	20	-0.5	-20	0.5	20		
Mg		4.5	2.4		109	58	0.5	12	-0.25	-6				
- O_3	mmol/l	22	15	ppm	308	210								
S		6.8	4.4		218	141								
P		1	1.5		31	47							-1	-31
Fe	µmol/l	35	15	ppb	1960	840	10	560						
Mn		5	10		275	550								
Zn		7	5		458	327								
B		50	30		540	324	10	108						
Cu		0.7	0.75		44	48								
Mo		0.5	0.5		48	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

A		
Calcium nitrate solid	106	kg
Potassium nitrate	23	kg
Calcium chloride anhydrous	6	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	20	kg
Potassium sulphate	35	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	59	kg
Monoammonium phosphate	3	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *TOMATO (Solanum lycopersicum)* — ORGANIC MATERIAL

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments: Start		Fruit Set		High water		End season	
pH		5.8	5.3		5.8	5.3			*		**		***	
EC	mS/cm	1.5	2.6	mS/cm	1.5	2.6								
Na	mmol/l	< 2		ppm	< 46									
Cl		< 2	1		< 71	36								
HCO_3		< 0.1			< 6									
N-NH_4	mmol/l	< 0.1	1	ppm	< 2	14	-1	-14					-1	-14
K		2.8	9.3		109	364	-1	-39	1.5	59	-1	-39		
Ca		3.8	5.5		152	220	0.5	20	-0.5	-20	0.5	20		
Mg		1.8	2.4		44	58	0.5	12	-0.25	-6				
- O_3	mmol/l	8.25	14.8	ppm	116	207								
S		2.5	4.4		80	141								
P		0.5	1.5		16	47							-1	-31
Fe	µmol/l	15	30	ppb	840	1680	10	560						
Mn		2	10		110	550								
Zn		5	5		327	327								
B		25	30		270	324	10	108						
Cu		0.5	0.75		32	48								
Mo		0.3	0.5		29	48								

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

** Adjustments for high water supply are recommended when water supply exceeds 5 l/m²/day.

*** End of the crop, after removal of the growth point of the ranks. This is mostly in autumn, when the ranks are no longer growing and the last fruits are ripening.

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	108	kg
Potassium nitrate	20	kg
Calcium chloride anhydrous	6	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2793	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B

Potassium nitrate	19	kg
Potassium sulphate	35	kg
Monopotassium phosphate	20	kg
Magnesium sulphate 16% MgO	59	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *TOMATO (Solanum lycopersicum)* **SOIL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1.4	1.3	mS/cm	1.4	1.3
Na	mmol/l	< 8		ppm	< 184	
Cl		< 8			< 284	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		2.2	5		86	196
Ca		2.5	2		100	80
Mg		1.7	1.5		41	36
-	mmol/l	5	9.4	ppm	70	132
S		2.5	1.5		80	48
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		10	10		108	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimum pH depends on soil type

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A

Calcium nitrate solid	43	kg
Potassium nitrate	25	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B

Potassium nitrate	26	kg
Magnesium sulphate 16% MgO	37	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

14. NUTRIENT SOLUTIONS FOR SOFT FRUITS (BERRIES)

- Blueberry
- Raspberry
- Strawberry

CROP: ***BLUEBERRY***								**ORGANIC MATERIAL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**	**Adjustments**	
							Fruit Set	
pH		4.8	5.3		4.8	5.3		
EC	mS/cm	0.7	1.3	mS/cm	0.7	1.3		
Na	mmol/l	< 2		ppm	< 46			
Cl		< 4			< 140			
HCO_3		< 0.1			< 6			
N-NH_4	mmol/l	< 0.1	1	ppm	< 2	14		
K		1.1	2.6		43	102	1.4	55
Ca		1.4	3		56	120	-0.8	-32
Mg		0.8	1.1		19	24	0.1	2
N-NO_3	mmol/l	3	8.5	ppm	42	119		
S		1.1	1		35	32	0.1	3.2
P		0.3	1.1		9	34	-0.2	-6.2
Fe	µmol/l	7	18	ppb	392	1008		
Mn		0.8	7.5		44	413		
Zn		1	4		65	260		
B		7	20		77	220		
Cu		0.7	1.0		44	64		
Mo		0.1	0.5		10	48		

The target values for soils are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate	65	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1676	g
Manganese EDTA 13%	317	g
Zinc EDTA 15%	174	g
Copper EDTA 15%	43	g

B		
Potassium nitrate	19	kg
Monoammonium phosphate	5	kg
Monopotassium phosphate	10	kg
Magnesium sulphate 16% MgO	25	kg
Borax 11.3% B	191	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *RASPBERRY*	ORGANIC MATERIAL

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments	
							Fruit Set	
pH		5.5	5.3		5.5	5.3		
EC	mS/cm	1	2	mS/cm	1	2		
Na	mmol/l	< 4		ppm	< 100			
Cl		< 4			< 140			
HCO_3		< 0.5			< 30			
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13		
K		2.25	5.35		88	209	0.5	19.5
Ca		2.25	4.5		90	180	-0.5	-20
Mg		1	1.75		24	42		
$N\text{-}NO_3$	mmol/l	5	13.5	ppm	70	189	-0.5	-7
S		1.5	2		48	64		
P		0.4	1.25		12	39		
Fe	µmol/l	10	20	ppb	560	1120		
Mn		2	10		110	550		
Zn		5	5		325	325		
B		10	10		110	110		
Cu		0.5	0.75		32	47		
Mo		0.1	0.5		10	48		

The target values for soils are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate	97	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1862	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	36	kg
Potassium sulphate	4	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	43	kg
Borax 11.3% B	95	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *STRAWBERRY (Fragaria x ananassa)* **INERT SUBSTRATE**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments			
							Start		Fruit Set	
pH		5.5-6.0	5.3		5.5-6.0	5.3			*	
EC	mS/cm	2	1.6	mS/cm	2	1.6				
Na	mmol/l	< 4		ppm	< 92					
Cl		< 4			< 141					
HCO_3		< 0.5			< 30					
$N\text{-}NH_4$	mmol/l	< 0.5	1	ppm	< 7	14			-0.5	-7
K		5	4.8		196	188			2	78
Ca		4.5	3.6		180	144	1	40		
Mg		2	1.5		49	36				
- O_3	mmol/l	12	12	ppm	168	168	1.75	25	1.5	21
S		2.5	1.5		80	48				
P		0.7	1		22	31	0.25	8		
Fe	µmol/l	35	30	ppb	1960	1680	10	560		
Mn		7	10		385	550	5	275		
Zn		7	7		458	458				
B		20	10		216	108	10	108		
Cu		0.7	0.75		44	48				
Mo		0.5	0.5		48	48				

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

A

Calcium nitrate solid	78	kg
Potassium nitrate	7	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2793	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	305	g
Copper EDTA 15%	32	g

B

Potassium nitrate	35	kg
Monopotassium phosphate	10	kg
Magnesium sulphate 16% MgO	37	kg
Monoammonium phosphate	3	kg
Borax 11.3% B	96	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *STRAWBERRY (Fragaria x ananassa)* **ORGANIC MATERIAL**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation	Adjustments			
							Start		Fruit Set	
pH		5.5-6.0	5.3		5.5-6.0	5.3				
EC	mS/cm	1	1.6	mS/cm	1	1.6				
Na	mmol/l	< 1.5		ppm	< 35					
Cl		< 1.5			< 53					
HCO_3		< 0.1			< 6					
N-NH_4	mmol/l	< 0.1	0.75	ppm	< 2	11			-0.5	-7
K		1.7	4.5		66	176			2	78
Ca		1.7	3.75		68	150	1	40		
Mg		0.7	1.5		17	36				
N-NO_3	mmol/l	3.8	11.75	ppm	53	165	1.75	25	1.5	21
S		1.25	1.5		40	48				
P		0.3	1		9	31	0.25	8		
Fe	µmol/l	8	30	ppb	448	1680	10	560		
Mn		2	10		110	550	5	275		
Zn		6	7		392	458				
B		4	10		43	108	10	108		
Cu		0.7	0.75		44	48				
Mo		0.3	0.5		29	48				

* The adjustments for fruit set may vary from 0.25 to 2 mmol/l for K and 0.2 to 0.75 mmol/l for Ca.

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate solid	81	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2793	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	305	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	35	kg
Monopotassium phosphate	14	kg
Magnesium sulphate 16% MgO	37	kg
Borax 11.3% B	96	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***STRAWBERRY (Fragaria x ananassa)***	**SOIL**

Nutrient		**Target value root zone**	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH*		6	5.7		6	5.7
EC	mS/cm	0.8	1	mS/cm	0.8	1
Na	mmol/l	< 1.5		ppm	< 35	
Cl		< 1.5			< 53	
HCO_3		< 0.1			< 6	
N-NH_4	mmol/l	< 0.1	0.8	ppm	< 2	11
K		1	3		39	117
Ca		1.5	2		60	80
Mg		1	1		24	24
-	mmol/l	2	7.3	ppm	28	102
S		1.5	1		48	32
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		10	10		108	108
Cu		0.5	0.3		23	19
Mo		0.3	0		29	0

* The optimum pH depends on soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	43	kg
Potassium nitrate	8	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	21	kg
Monopotassium phosphate	1	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	5	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

Ultrasol® by stage

Initial • Development • Growth • Production • Multipurpose

Ultrasol® Growth stage is a complete range of growth-stage specific plant nutrition management tools for fertigation that help maximize crop yield and quality and increase the grower's net income. Ultrasol® Growth stage fully satisfies the macro and micronutrient requirements in each phenological stage of the plant.

The standard range consists of the following five Ultrasol® formulae: Initial, Growth, Development, Production and Multipurpose. In addition growth-stage specific, tailor-made solutions are offered under the Ultrasol® Special brand.

15. NUTRIENT SOLUTIONS FOR LEAFY VEGETABLES

- Herbs
- Lettuce
- Microgreens

CROP: ***HERBS (e.g. Ocimum basilicum)***	WATER / AQUA

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation
pH		5.5-6.0	5.3		5.5-6.0	5.3
EC	mS/cm	3	2.4	mS/cm	3.0	2.4
Na	mmol/l	< 4		ppm	< 92	
Cl		< 4			< 141	< 35
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.5	1.25	ppm	< 7	18
K		7	6.75		274	264
Ca		7	4.5		280	180
Mg		2.5	3		61	73
-	mmol/l	20	16.75	ppm	280	235
S		3.5	2.5		112	80
P		0.8	1.25		25	39
Fe	µmol/l	25	25	ppb	1400	1400
Mn		5	10		275	550
Zn		7	5		458	327
B		50	35		540	378
Cu		1	1		64	64
Mo		0.5	0.5		48	48

A		
Calcium nitrate solid	97	kg
Potassium nitrate	26	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2327	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	42	g

B		
Potassium nitrate	33	kg
Monopotassium phosphate	12	kg
Magnesium sulphate 16% MgO	62	kg
Magnesium nitrate solid	13	kg
Monoammonium phosphate	4	kg
Borax 11.3% B	335	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***HERBS (e.g. Ocimum basilicum)***						**ORGANIC MATERIAL**
Nutrient		**Target value root zone***	**Nutrient solution fertigation**		**Target value root zone**	**Nutrient solution fertigation**
pH		5.5-6.0	5.3		5.5-6.0	5.3
EC	mS/cm	0.8	1.7	mS/cm	0.8	1.7
Na	mmol/l	< 2		ppm	< 46	
Cl		< 2			< 70	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	1.2	ppm	< 2	17
K		1.6	6.1		63	239
Ca		1.2	3.3		48	132
Mg		0.5	0.85		12	21
-	mmol/l	4	12.1	ppm	56	169
S		0.8	1.2		26	38
P		0.5	1.1		16	34
Fe	µmol/l	10	20	ppb	560	1120
Mn		2	5		110	275
Zn		2	3		131	196
B		10	10		108	108
Cu		0.7	0.5		44	32
Mo		0.3	0.5		29	48

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate solid	71	kg
Potassium nitrate	9	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1862	g
Manganese EDTA 13%	211	g
Zinc EDTA 15%	131	g
Copper EDTA 15%	21	g

B		
Potassium nitrate	40	kg
Potassium sulphate	6	kg
Monopotassium phosphate	8	kg
Magnesium sulphate 16% MgO	21	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *LETTUCE (Lactuca sativa)* **WATER / AQUA**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation
pH		5.5-6.0	5.3		5.5-6.0	5.3
EC	mS/cm	2.5	2.2	mS/cm	2.5	2.2
Na	mmol/l	< 6		ppm	< 138	
Cl		< 6			< 213	
HCO_3		< 0.5			< 30	
$N\text{-}NH_4$	mmol/l	< 0.5	1	ppm	< 7	14
K		6	9.5		235	371
Ca		6	4.5		240	180
Mg		2	1		49	24
-	mmol/l	14	16	ppm	196	224
S		2	2		64	64
P		2	1.5		62	47
Fe	µmol/l	40	40	ppb	2240	2240
Mn		8	7		440	385
Zn		8	7		523	458
B		50	40		540	432
Cu		1.5	1		95	64
Mo		1.5	1		144	96

A

Calcium nitrate solid	97	kg
Potassium nitrate	13	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	3723	g
Manganese EDTA 13%	296	g
Zinc EDTA 15%	305	g
Copper EDTA 15%	42	g

B

Potassium nitrate	48	kg
Potassium sulphate	17	kg
Monopotassium phosphate	19	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	1	kg
Borax 11.3% B	383	g
Sodium molybdate 39.6%	24	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***LETTUCE (Lactuca Sativa)***										**SOIL**
Nutrient		**Target Values root zone Headweight < 300g**		**Target Values root zone Headweight > 300g**			**Target Values root zone Headweight < 300g**		**Target Values root zone Headweight > 300g**	
		Summer	**Winter**	**Summer**	**Winter**		**Summer**	**Winter**	**Summer**	**Winter**
pH*		6	6	6	6		6	6	6	6
EC	mS/cm	1	1.2	1.2	1.4	mS/cm	1	1.2	1.2	1.4
Na	mmol/l	< 2	< 2	< 2	< 2	ppm	< 46	< 46	< 46	< 46
Cl		< 2	< 2	< 2	< 2		< 71	< 71	< 71	< 71
HCO_3		< 0.1	< 0.1	< 0.1	< 0.1		< 6	< 6	< 6	< 6
$N\text{-}NH_4$	mmol/l	< 0.1	< 0.1	< 0.1	< 0.1	ppm	< 2	< 2	< 2	< 2
K		2.5	3	3	3.5		98	117	117	137
Ca		3.25	3.25	3.25	3.25		130	130	130	130
Mg		1	1	1	1		24	24	24	24
-	mmol/l	4	5	5	6	ppm	56	70	70	84
S		3.5	3.5	3.5	3.5		112	112	112	112
P		0.1	0.1	0.1	0.1		3	3	3	3
Fe	µmol/l	5	5	5	5	ppb	280	280	280	280
Mn		0.5	0.5	0.5	0.5		27	27	27	27
Zn		0.5	0.5	0.5	0.5		33	33	33	33
B		10	10	10	10		108	108	108	108
Cu		0.3	0.3	0.3	0.3		19	19	19	19
Mo		0.2	0.2	0.2	0.2		19	19	19	19

* The optimum pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

In the Netherlands, just before the next cropping cycle starts, soil samples are taken for nutrient analysis. Based on the outcome of the soil analysis, lettuce fertilisation is provided by granular fertilisers. During the cropping cycle, potassium nitrate or calcium nitrate may be applied via the overhead irrigation system.

CROP: *MICROGREENS* **WATER/AQUA**

Nutrient		Target value root zone	Nutrient solution fertigation		Target value root zone	Nutrient solution fertigation
pH		5.5	5.3		5.5	5.3
EC	mS/cm	2.5	2	mS/cm	2.5	2
Na	mmol/l	< 4		ppm	92	
Cl		< 4			142	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.5	0.85	ppm	< 7	12
K		6	5.4		235	211
Ca		6.5	4.25		260	170
Mg		3	2.75		73	67
- O_3	mmol/l	18	14.5	ppm	252	203
S		3	2.25		96	72
P		1	1.25		31	39
Fe	µmol/l	25	35	ppb	1400	1960
Mn		5	10		275	550
Zn		7	5		458	327
B		50	35		540	378
Cu		1	1		64	64
Mo		0.5	1		48	96

A

Calcium nitrate solid	92	kg
Potassium nitrate	18	kg
Iron DTPA liq 6% or EDDHA 6% or HBED 6%	3260	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	218	g
Copper EDTA 15%	42	g

B

Potassium nitrate	24	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	55	kg
Magnesium nitrate solid	13	kg
Borax 11.3% B	334	g
Sodium molybdate 39.6%	24	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

16. NUTRIENT SOLUTIONS FOR CUT FLOWERS

- Alstroemeria
- Anthurium
- Carnation
- Chrysanthemum
- Gerbera
- Rose
- Zantedeschia

CROP: ***ALSTROEMERIA*** **INERT SUBSTRATE**

Nutrient		Target values root zone	Nutrient solution fertigation	Adjustments Start	Adjustments Flowering		Target values root zone	Nutrient solution fertigation	Adjustments Start	Adjustments Flowering
pH		5.5	5.3				5.5	5.3		
EC	mS/cm	2.8	3			mS/cm	2.8	3		
Na	mmol/l	< 2.5				ppm	< 58			
Cl		< 2.5					< 88			
HCO_3		< 0.5					< 30			
$N\text{-}NH_4$	mmol/l	< 0.5	1.5	-0.5		ppm	< 7	21	-7	
K		8	10	-1	1		313	391	-39	39
Ca		10	7.5	0.5			400	300	20	
Mg		3	2	0.25			73	49	6	
-	mmol/l	20	20.75		1	ppm	280	291		14
S		6.5	4				208	128		
P		1	1.75				31	54		
Fe	µmol/l	30	50	10		ppb	1680	2795	560	
Mn		3	7				165	385		
Zn		2	3				131	196		
B		20	30	10			216	324	108	
Cu		1	1				64	64		
Mo		0.3	0.7				29	67		

A		
Calcium nitrate solid	162	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	4654	g
Manganese EDTA 13%	296	g
Zinc EDTA 15%	131	g
Copper EDTA 15%	42	g

B		
Potassium nitrate	43	kg
Potassium sulphate	35	kg
Monopotassium phosphate	24	kg
Magnesium sulphate 16% MgO	49	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	17	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ALSTROEMERIA***	**ORGANIC MATERIAL**

Nutrient		Target values root zone	Nutrient solution fertigation	Adjustments			Target values root zone	Nutrient solution fertigation	Adjustments	
				Start	Flowering				Start	Flowering
pH		5.5-6.0	5.3				5.5-6.0	5.3		
EC	mS/cm	1	3			mS/cm	1	3		
Na	mmol/l	< 2				ppm	< 46			
Cl		< 2					< 70			
HCO_3		< 0.1					< 6			
$N\text{-}NH_4$	mmol/l	< 0.1	1.5	-0.5		ppm	< 2	21	-7	
K		3	10	-1	1		117	391	-39	39
Ca		2.5	7.5	0.5			100	300	20	
Mg		1	2	0.25			24	49	6	
-	mmol/l	7	20.75		1	ppm	98	291		14
S		1	4				32	128		
P		1	1.75				31	54		
Fe	µmol/l	15	50	10		ppb	840	2795	560	
Mn		3	7				165	385		
Zn		1	3				65	196		
B		30	30	10			324	324	108	
Cu		0.3	1				19	64		
Mo		0.2	0.7				19	67		

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate solid	162	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	4654	g
Manganese EDTA 13%	296	g
Zinc EDTA 15%	131	g
Copper EDTA 15%	42	g

B		
Potassium nitrate	43	kg
Potassium sulphate	35	kg
Monopotassium phosphate	24	kg
Magnesium sulphate 16% MgO	49	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	17	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ALSTROEMERIA***						**SOIL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1	1	mS/cm	1	1
Na	mmol/l	< 3			< 69	
Cl		< 3			< 105	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		1.5	4		59	156
Ca		2	2		80	80
Mg		1.2	1		29	24
-	mmol/l	4	8	ppm	56	112
S		1.5	1.2		48	38
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	1		65	65
B		20	10		216	108
Cu		0.5	0.3		32	19
Mo		0.3			29	

* The optimal pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	43	kg
Potassium nitrate	14	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	23	kg
Potassium sulphate	3	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ANTHURIUM (Anthurium scherzerianum)*** **INERT SUBSTRATE**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**	**Adjustments**		**Target values root zone**	**Nutrient solution fertigation**	**Adjustments**
				Start*				**Start***
pH		5.2-6.0	5.3			5.2-6.0	5.3	
EC	mS/cm	1	0.9		mS/cm	1	0.9	
Na	mmol/l	< 2			ppm	< 46		
Cl		< 2				< 71		
HCO_3		< 0.5				< 30		
$N\text{-}NH_4$	mmol/l	< 0.5	0.3	-0.3	ppm	< 7	4	-4
K		3	3.9	0.55		117	152	22
Ca		2	1.3	-0.5		80	52	-20
Mg		1.2	1			29	24	
-	mmol/l	5	6.4	-0.75	ppm	70	90	-11
S		1.5	0.8			48	26	
P		0.75	0.8			23	25	
Fe	µmol/l	15	15	5	ppb	840	840	280
Mn		2	0			110	0	
Zn		4	3			262	196	
B		40	30	5		432	324	54
Cu		1	0.75			64	48	
Mo		0.5	0.5			48	48	

* New. limed polyphenol substrate.

A		
Calcium nitrate solid	28	kg
Potassium nitrate	20	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Zinc EDTA 15%	131	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	12	kg
Monopotassium phosphate	10	kg
Magnesium sulphate 16% MgO	20	kg
Magnesium nitrate solid	5	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ANTHURIUM (Anthurium Scherzerianum)***	**DRAIN FROM ORGANIC MATERIAL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH		5.2-6.0	5.3		5.2-6.0	5.3
EC	mS/cm	1	0.8	mS/cm	1	0.8
Na	mmol/l	< 2		ppm	< 46	
Cl		< 2			< 71	
HCO_3		< 0.5			< 30	
$N\text{-}NH_4$	mmol/l	< 0.5	0.8	ppm	< 7	11
K		3	3		117	117
Ca		2	1		80	40
Mg		1.2	0.7		29	17
-	mmol/l	5	4.5	ppm	70	63
S		1.5	1		48	32
P		0.75	0.7		23	22
Fe	µmol/l	15	15	ppb	840	840
Mn		2	0		110	0
Zn		4	3		262	196
B		40	20		432	216
Cu		1	0.5		64	32
Mo		0.5	0.5		48	48

No standard fertiliser program is available. The fertiliser program is fully dependent on the outcome of the drain water analysis. Nutrient contents present in the drain water will be completed with water soluble fertilisers in order to match the required levels in the nutrient solution.

CROP: ***ANTHURIUM (Anthurium scherzerianum)*** **ORGANIC MATERIAL**

Nutrient		**Target values root zone**		**Nutrient Solution fertigation**			**Target values root zone**		**Nutrient Solution fertigation**	
		Growth	**Flowering**	**Growth**	**Flowering**		**Growth**	**Flowering**	**Growth**	**Flowering**
pH		5.5-6.0	5.3	5.3	5.3		5.5-6.0	5.3	5.3	5.3
EC	mS/cm	0.8	0.8	1.7	1.5	mS/cm	0.8	0.8	1.7	1.5
Na	mmol/l	< 1.7	< 1.7			ppm	< 40	< 40		
Cl		< 1.7	< 1.7				< 60	< 60		
HCO_3		< 0.1	< 0.1				< 6	< 6		
$N\text{-}NH_4$	mmol/l	< 0.1	< 0.1	1.1	1	ppm	< 2	< 2	15	14
K		1.6	1.6	5.5	5.5		63	63	215	215
Ca		1.2	1	3	2.5		48	40	120	100
Mg		0.5	0.5	0.75	0.75		12	12	18	18
-	mmol/l	4	3	10.9	8.5	ppm	56	42	153	119
S		0.8	1.4	1.1	1.75		26	45	35	56
P		0.5	0.5	1	1		16	16	31	31
Fe	µmol/l	8	8	15	15	ppb	448	448	840	840
Mn		2	2	0	0		110	110	0	0
Zn		2	2	3	3		131	131	196	196
B		15	15	10	10		162	162	108	108
Cu		0.7	0.7	0.5	0.5		44	44	32	32
Mo		0.3	0.3	0.5	0.5		29	29	48	48

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A	Growth	Flowering	
Calcium nitrate solid	65	54	kg
Potassium nitrate	8	12	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	1396	g
Zinc EDTA 15%	131	131	g
Copper EDTA 15%	21	21	g

B	Growth	Flowering	
Potassium nitrate	36	18	kg
Potassium sulphate	6	17	kg
Monopotassium phosphate	7	7	kg
Magnesium sulphate 16% MgO	18	18	kg
Monoammonium phosphate	6	6	kg
Borax 11.3% B	96	96	g
Sodium molybdate 39.6%	12	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *CARNATION (Dianthus caryophyllus)* **ORGANIC MATERIAL**

Nutrient		Target values root zone	Nutrient solution fertigation		Target values root zone	Nutrient solution fertigation
pH		5.5-6.0	5.3		5.5-6.0	5.3
EC	mS/cm	1.3	1.8	mS/cm	1.3	1.8
Na	mmol/l	< 1.7		ppm	< 40	
Cl		< 1.7			< 60	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	1	ppm	< 2	14
K		3	6.25		117	244
Ca		3	3.75		120	150
Mg		1.5	1		36	24
-	mmol/l	6	13	ppm	84	182
S		2	1.25		64	40
P		0.8	1.25		25	39
Fe	µmol/l	15	25	ppb	840	1400
Mn		1	10		55	550
Zn		2	4		131	262
B		25	30		270	324
Cu		1	0.75		64	48
Mo		0.3	0.5		29	48

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	81	kg
Potassium nitrate	6	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2327	g
Manganese EDTA 13%	423	g
Zinc EDTA 15%	174	g
Copper EDTA 15%	32	g

B

Potassium nitrate	42	kg
Potassium sulphate	4	kg
Monopotassium phosphate	14	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	3	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***CARNATION (Dianthus caryophyllus)*** **SOIL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	2.2	1.2	mS/cm	2.2	1.2
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 105	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 7	13
K		1.5	4		59	156
Ca		2.5	2		100	80
Mg		1.2	1		29	24
-	mmol/l	4	8.4	ppm	56	118
S		1.5	1		48	32
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	2		65	131
B		15	10		162	108
Cu		0.5	0.3		32	19
Mo						

* The optimum pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A

Calcium nitrate solid	43	kg
Potassium nitrate	14	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	87	g
Copper EDTA 15%	13	g

B

Potassium nitrate	27	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***CHRYSANTHEMUM (Dendranthema)***	**SOIL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**	**Adjustments**		**Target values root zone**	**Nutrient solution fertigation**	**Adjustments**
				Start				**Start**
pH*		6	5.3			6	5.3	
EC	mS/cm	0.8	1.2		mS/cm	0.8	1.2	
Na	mmol/l	< 2			ppm	< 46		
Cl		< 2				< 71		
HCO_3		< 0.1				< 6		
$N\text{-}NH_4$	mmol/l	< 0.1	0.4	-0.4	ppm	< 2	6	-6
K		1	4	-1		39	156	-39
Ca		1.5	2	0.5		60	80	20
Mg		0.8	1	0.2		19	24	5
-	mmol/l	2	7.9		ppm	28	111	
S		1.5	1			48	32	
P		0.1	0.5			3	16	
Fe	µmol/l	8	5	10	ppb	448	280	560
Mn		1	2			55	110	
Zn		1	1			65	65	
B		15	10	10		162	108	108
Cu		0.5	0.3			32	19	
Mo		0.3	0			29	0	

* The optimum pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	43	kg
Potassium nitrate	12	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	44	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	24	kg
Monopotassium phosphate	7	kg
Magnesium sulphate 16% MgO	25	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***GERBERA (Gerbera jamesonii)***	**INERT SUBSTRATE**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**	**Adjustments**			
							Start		**Flowering**	
pH		5.5-6.0	5.3		5.5-6.0	5.3				
EC	mS/cm	2	1.6	mS/cm	2	1.6				
Na	mmol/l	< 6		ppm	< 138					
Cl		6	1		212	36				
HCO_3		< 0.5			< 30					
$N\text{-}NH_4$	mmol/l	< 0.5	1.5	ppm	< 7	21	-0.5	-7		
K		6	5.5		235	215	-1	-39	1	39
Ca		5	3		200	120	0.5	20		
Mg		2	1		49	24	0.25	6		
-	mmol/l	13	10.25	ppm	182	144			1	14
S		2.5	1.25		80	40				
P		1	1.25		31	39				
Fe	µmol/l	40	35	ppb	2240	1960	10	560		
Mn		3	5		165	275				
Zn		5	4		327	262				
B		40	30		432	324	10	108		
Cu		1	0.75		64	48				
Mo		0.5	0.5		48	48				

A		
Calcium nitrate solid	54	kg
Potassium nitrate	16	kg
Calcium chloride anhydrous	6	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	3258	g
Manganese EDTA 13%	211	g
Zinc EDTA 15%	174	g
Copper EDTA 15%	32	g

B		
Potassium nitrate	32	kg
Potassium sulphate	4	kg
Monopotassium phosphate	3	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	12	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***GERBERA (Gerbera jamesonii)*** **ORGANIC MATERIAL**

Nutrient		Target values root zone	Nutrient solution fertigation		Target values root zone	Nutrient solution fertigation	Adjustments			
							Start		Flowering	
pH		5.5-6.0	5.3		5.5-6.0	5.3				
EC	mS/cm	0.8	1.6	mS/cm	0.8	1.6				
Na	mmol/l	< 2		ppm	< 46					
Cl		1.5	0.5		53	18				
HCO_3		< 0.1			< 6					
$N\text{-}NH_4$	mmol/l	< 0.1	0.75	ppm	< 2	11	-0.5	-7		
K		2.2	5		86	196	-1	-39	1	39
Ca		2	3.25		80	130	0.5	20		
Mg		0.8	1.25		19	31	0.25	6		
-	mmol/l	5	10	ppm	70	140			1	14
S		1	1.5		32	48				
P		0.75	1.25		23	39				
Fe	µmol/l	15	35	ppb	840	1960	10	560		
Mn		1	5		55	275				
Zn		2	4		131	262				
B		20	30		216	324	10	108		
Cu		1	0.75		64	48				
Mo		0.3	0.5		29	48				

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	65	kg
Potassium nitrate	9	kg
Calcium chloride anhydrous	3	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	3258	g
Manganese EDTA 13%	211	g
Zinc EDTA 15%	174	g
Copper EDTA 15%	32	g

B

Potassium nitrate	25	kg
Potassium sulphate	4	kg
Monopotassium phosphate	15	kg
Magnesium sulphate 16% MgO	31	kg
Monoammonium phosphate	2	kg
Borax 11.3% B	287	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***GERBERA (Gerbera jamesonii)***	**SOIL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1	1.2	mS/cm	1	1.2
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 105	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		1.5	3.5		59	137
Ca		2	2		80	80
Mg		1.2	1.1		29	27
-	mmol/l	4	7.9	ppm	56	111
S		1.5	1.1		48	35
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	2		65	131
B		20	10		216	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimal pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A

Calcium nitrate solid	43	kg
Potassium nitrate	12	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	87	g
Copper EDTA 15%	13	g

B

Potassium nitrate	23	kg
Magnesium sulphate 16% MgO	27	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ROSE (Rosa)*** **INERT SUBSTRATE**

Nutrient		Target values root zone	Nutrient solution fertigation		Target values root zone	Nutrient solution fertigation	Adjustments							
							Start		Flowering		High water supply		Winter	
pH		5.5-6.0	5.3		5.5-6.0	5.3								
EC	mS/cm	2.2	1.6	mS/cm	2.2	1.6								
Na	mmol/l	< 6		ppm	< 138									
Cl		< 6			< 212									
HCO_3		< 0.5			< 30									
$N\text{-}NH_4$	mmol/l	< 0.5	0.7	ppm	< 7	10							-0.5	-7
K		4.8	4.5		188	176	-1	-39	1	39	-1	-39		
Ca		4.8	3.4		192	136	0.5	20			0.5	20		
Mg		2.5	1.6		61	39								
-	mmol/l	12.7	10.75	ppm	178	151			1	14			-0.5	-7
S		2.6	1.6		83	51								
P		1.1	1.25		34	39								
Fe	µmol/l	40	35	ppb	2240	1960	10	560						
Mn		4	7		220	385								
Zn		5	3.5		327	229								
B		20	35		216	378	10	108						
Cu		1.5	1.1		95	70								
Mo		0.8	1		77	96								

A

Calcium nitrate solid	73	kg
Potassium nitrate	8	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	3258	g
Manganese EDTA 13%	296	g
Zinc EDTA 15%	153	g
Copper EDTA 15%	47	g

B

Potassium nitrate	25	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	39	kg
Borax 11.3% B	335	g
Sodium molybdate 39.6%	24	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ROSE (Rosa)*** — ORGANIC MATERIAL

Nutrient		Target values root zone	Nutrient solution fertigation		Target values root zone	Nutrient solution fertigation	Adjustments							
							Start		Flowering		High water supply		Winter	
pH		5.5-6.0	5.3		5.5-6.0	5.3								
EC	mS/cm	1	1.6	mS/cm	1	1.6								
Na	mmol/l	< 2		ppm	< 46									
Cl		< 2			< 71									
HCO_3		< 0.1			< 6									
$N\text{-}NH_4$	mmol/l	< 0.1	0.75	ppm	< 2	11							-0.5	-7
K		2.3	4.25		90	166	-1	-39	1	39	-1	-39		
Ca		2.3	3.75		92	150	0.5	20			0.5	20		
Mg		1.1	1.75		27	43								
-	mmol/l	5	11.25	ppm	70	158			1	14			-0.5	-7
S		1.7	1.75		54	56								
P		0.8	1.25		25	39								
Fe	µmol/l	15	35	ppb	840	1960	10	560						
Mn		1.3	7		72	385								
Zn		1.4	3.5		92	229								
B		15	35		162	378	10	108						
Cu		1	1.1		64	70								
Mo		0.5	1		48	96								

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate solid	81	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	3258	g
Manganese EDTA 13%	296	g
Zinc EDTA 15%	153	g
Copper EDTA 15%	47	g

B		
Potassium nitrate	30	kg
Monopotassium phosphate	17	kg
Magnesium sulphate 16% MgO	43	kg
Borax 11.3% B	335	g
Sodium molybdate 39.6%	24	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ROSE (Rosa)*** **SOIL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	1	1.2	mS/cm	1	1.2
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 105	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		1.5	3.5		59	137
Ca		2	2		80	80
Mg		1.2	1.1		29	27
-	mmol/l	4	7.9	ppm	56	111
S		1.5	1.1		48	35
P		0.1	0.5		3	16
Fe	µmol/l	8	5	ppb	448	280
Mn		1	2		55	110
Zn		1	2		65	131
B		20	10		216	108
Cu		0.5	0.3		32	19
Mo		0.3	0		29	0

* The optimal pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	43	kg
Potassium nitrate	12	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%	465	g
Manganese EDTA 13%	85	g
Zinc EDTA 15%	87	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	23	kg
Magnesium sulphate 16% MgO	27	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ZANTEDESCHIA*** — ORGANIC MATERIAL

Nutrient		Target values root zone		Nutrient Solution fertigation			Target values root zone		Nutrient Solution fertigation	
		Growth	Flowering	Growth	Flowering		Growth	Flowering	Growth	Flowering
pH		5.5-6.0	5.5-6.0	5.3	5.3		5.5-6.0	5.5-6.0	5.3	5.3
EC	mS/cm	0.9	0.7	1.6	1.6	mS/cm	0.9	0.7	1.6	1.6
Na	mmol/l	< 2.5	< 2.5			ppm	< 58	< 58		
Cl		< 2.5	< 2.5				< 88	< 88		
HCO_3		< 0.1	< 0.1				< 6	< 6		
$N\text{-}NH_4$	mmol/l	< 0.1	< 0.1	1.4	1	ppm	< 2	< 2	20	14
K		2.4	2.5	7.3	6.5		94	98	285	254
Ca		1.4	1	4	2.5		56	40	160	100
Mg		0.6	0.5	1	0.75		15	12	24	18
-	mmol/l	6	3.5	14.1	9	ppm	84	49	197	126
S		1.4	1.4	1.3	1.75		45	45	42	56
P		0.5	0.5	2	1.5		16	16	62	47
Fe	µmol/l	8	8	15	15	ppb	448	448	840	840
Mn		2	2	5	5		110	110	275	275
Zn		2	2	3	3		131	131	196	196
B		15	15	10	10		162	162	108	108
Cu		0.7	0.7	0.5	0.5		44	44	32	32
Mo		0.3	0.3	0.5	0.5		29	29	48	48

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A	Growth	Flowering	
Calcium nitrate solid	86	54	kg
Potassium nitrate	11	18	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	1396	g
Manganese EDTA 13%	211	211	g
Zinc EDTA 15%	131	131	g
Copper EDTA 15%	21	21	g

B	Growth	Flowering	
Potassium nitrate	42	17	kg
Potassium sulphate	5	17	kg
Monopotassium phosphate	19	14	kg
Magnesium sulphate 16% MgO	25	18	kg
Monoammonium phosphate	7	6	kg
Borax 11.3% B	96	96	g
Sodium molybdate 39.6%	12	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***ZANTEDESCHIA*** **DRAIN FROM ORGANIC MATERIAL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH		5.5	5.3		5.5	5.3
EC	mS/cm	0.7	1.3	mS/cm	0.7	1.3
Na	mmol/l	< 2		ppm	< 46	
Cl		< 2			< 71	
HCO_3		< 0.5			< 30	
$N\text{-}NH_4$	mmol/l	< 0.5	0	ppm	< 7	0
K		5.25	5		205	196
Ca		4.25	2.5		170	100
Mg		2	1		49	24
-	mmol/l	12	8	ppm	168	112
S		2.25	1.5		72	48
P		0.6	1		19	31
Fe	µmol/l	10	30	ppb	560	1680
Mn		5	5		275	275
Zn		5	4		327	262
B		35	20		378	216
Cu		0.7	1		44	64
Mo		0.5	1		48	96

No standard fertiliser program is available. The fertiliser program is fully dependent on the outcome of the drain water analysis. Nutrient contents present in the drain water will be completed with water soluble fertilisers in order to match the required levels in the nutrient solution.

CROP: ***ZANTEDESCHIA*** **SOIL**

Nutrient		**Target values root zone**	**Nutrient solution fertigation**		**Target values root zone**	**Nutrient solution fertigation**
pH*		6	5.3		6	5.3
EC	mS/cm	0.9	1	mS/cm	0.9	1
Na	mmol/l	< 3		ppm	< 69	
Cl		< 3			< 105	
HCO_3		< 0.5			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	0.9	ppm	< 2	13
K		1.8	3.5		70	137
Ca		1.8	1.8		72	72
Mg		1	1		24	24
-	mmol/l	3	7.3	ppm	42	102
S		1.5	1.1		48	35
P		0.1	0.5		3	16
Fe	µmol/l	5	5	ppb	280	280
Mn		1	1		55	55
Zn		1	0.5		65	33
B		10	10		108	108
Cu		0.5	0.3		32	19
Mo		0.1	0		10	0

* The optimal pH depends on the soil type.

The target values for soils are related to the analytical results with the 1:2 volume extract with water.

A		
Calcium nitrate solid	39	kg
Potassium nitrate	13	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	465	g
Manganese EDTA 13%	43	g
Zinc EDTA 15%	22	g
Copper EDTA 15%	13	g

B		
Potassium nitrate	20	kg
Potassium sulphate	2	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	6	kg
Borax 11.3% B	96	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

17. NUTRIENT SOLUTIONS FOR POTTED PLANTS

- Bedding plants
- Euphorbia pulcherrima (Poinsettia)
- Flowering plants
- Foliage plants
- Orchids

CROP: ***BEDDING PLANTS (e.g. Viola)***										**ORGANIC MATERIAL**
Nutrient		**Target values root zone**		**Nutrient solution fertigation****			**Target values root zone**		**Nutrient solution fertigation****	
		Growth	**Flowering**	**Growth**	**Flowering**		**Growth**	**Flowering**	**Growth**	**Flowering**
pH		5.5-6.0	5.5-6.0	5.3	5.3		5.5-6.0	5.5-6.0	5.3	5.3
EC	mS/cm	0.6	0.6	1.1	1.1	mS/cm	0.6	0.6	1.1	1.1
Na	mmol/l	< 2.5	< 4			ppm	< 58	< 92		
Cl		< 2.5	< 4				< 88	< 141		
HCO_3		< 0.1	< 0.1				< 6	< 6		
$N\text{-}NH_4$	mmol/l	< 0.1	< 0.1	0.8	0.6	ppm	< 2	< 2	11	8
K		1.2	1.3	3.7	4.4		47	51	145	172
Ca		1	0.9	2	1.7		40	36	80	68
Mg		0.3	0.5	0.5	0.5		7	12	12	12
-	mmol/l	2.5	2	7.1	6	ppm	35	28	99	84
S		0.6	1	0.7	1.2		19	32	22	38
P		0.5	0.5	1	1		16	16	31	31
Fe	µmol/l	8	8	15	15	ppb	448	448	840	840
Mn		2	2	5	5		110	110	275	275
Zn		2	2	3	3		131	131	196	196
B		15	15	10	10		162	162	108	108
Cu		0.7	0.7	0.5	0.5		44	44	32	32
Mo		0.3	0.3	0.5	0.5		29	29	48	48

** Nutrient solutions are developed for ebb/flood systems

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A	Growth	Flowering	
Calcium nitrate solid	43	37	kg
Potassium nitrate	6	12	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	1396	g
Manganese EDTA 13%	211	211	g
Zinc EDTA 15%	131	131	g
Copper EDTA 15%	21	21	g

B	Growth	Flowering	
Potassium nitrate	21	11	kg
Potassium sulphate	3	12	kg
Monopotassium phosphate	8	10	kg
Magnesium sulphate 16% MgO	12	12	kg
Monoammonium phosphate	5	3	kg
Borax 11.3% B	96	96	g
Sodium molybdate 39.6%	12	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***POINSETTIA (Euphorbia pulcherrima)*** **ORGANIC MATERIAL**

Nutrient		Target values root zone	Nutrient solution fertigation**		Target values root zone	Nutrient solution fertigation**
pH		5.5-6.0	5.3		5.5-6.0	5.3
EC	mS/cm	0.7	1.8	ms/cm	0.7	1.8
Na	mmol/l	< 2.5		ppm	< 58	
Cl		< 2.5			< 88	
HCO_3		< 0.1			< 6	
$N\text{-}NH_4$	mmol/l	< 0.1	1.75	ppm	< 2	25
K		1.6	3.5		63	137
Ca		1.4	3.75		56	150
Mg		0.6	1		15	24
-	mmol/l	4	11.75	ppm	56	165
S		0.8	1		26	32
P		0.5	1		16	31
Fe	µmol/l	8	15	ppb	448	840
Mn		2	5		110	275
Zn		2	3		131	196
B		15	10		162	108
Cu		0.7	0.5		44	32
Mo		0.3	0.5		29	48

** Nutrient solutions are developed for ebb/flood systems

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A		
Calcium nitrate solid	81	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	211	g
Zinc EDTA 15%	131	g
Copper EDTA 15%	21	g

B		
Potassium nitrate	35	kg
Magnesium sulphate 16% MgO	25	kg
Monoammonium phosphate	12	kg
Borax 11.3% B	96	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: ***FLOWERING PLANTS (e.g. Pelargonium)*** **ORGANIC MATERIAL**

Nutrient		Target values root zone		Nutrient solution fertigation**			Target values root zone		Nutrient solution fertigation**	
		Growth	Flowering	Growth	Flowering		Growth	Flowering	Growth	Flowering
pH		5.5-6.0	5.5-6.0	5.3	5.3		5.5-6.0	5.5-6.0	5.3	5.3
EC	mS/cm	1	0.8	2.2	1.6	mS/cm	1	0.8	2.2	1.6
Na	mmol/l	< 3.5	< 3.5			ppm	< 80	< 80		
Cl		< 3.5	< 3.5				< 125	< 125		
HCO_3		< 0.1	< 0.1				< 6	< 6		
$N\text{-}NH_4$	mmol/l	< 0.1	< 0.1	1.4	1	ppm	< 2	< 2	20	14
K		2.4	2.5	7.3	6.5		94	98	285	254
Ca		1.4	1	4	2.5		56	40	160	100
Mg		0.6	0.5	1	0.75		15	12	24	18
-	mmol/l	6	3.5	14.1	9	ppm	84	49	197	126
S		1	1.4	1.3	1.75		32	45	42	56
P		0.5	0.5	2	1.5		16	16	62	47
Fe	µmol/l	10	8	20	20	ppb	560	448	1120	1120
Mn		2	2	5	5		110	110	275	275
Zn		2	2	3	3		131	131	196	196
B		10	15	10	10		108	162	108	108
Cu		0.7	0.7	0.5	0.5		44	44	32	32
Mo		0.3	0.3	0.5	0.5		29	29	48	48

** Nutrient solutions are developed for ebb/flood systems

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A	Growth	Flowering	
Calcium nitrate solid	86	54	kg
Potassium nitrate	11	18	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1862	1862	g
Manganese EDTA 13%	211	211	g
Zinc EDTA 15%	131	131	g
Copper EDTA 15%	21	21	g

B	Growth	Flowering	
Potassium nitrate	42	17	kg
Potassium sulphate	5	17	kg
Monopotassium phosphate	19	14	kg
Magnesium sulphate 16% MgO	25	18	kg
Monoammonium phosphate	7	6	kg
Borax 11.3% B	96	96	g
Sodium molybdate 39.6%	12	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: *FOLIAGE PLANTS (e.g. Ficus)* **ORGANIC MATERIAL**

Nutrient		Target values root zone		Nutrient solution fertigation**				Target values root zone		Nutrient solution fertigation**		
		Growth	Market Phase	Standard	Heavy Growth	Slow Growth		Growth	Market Phase	Standard	Heavy Growth	Slow Growth
pH		5.5-6.0	5.5-6.0	5.3	5.3	5.3		5.5-6.0	5.5-6.0	5.3	5.3	5.3
EC	mS/cm	1.2	1	1.7	2.5	1.5	mS/cm	1.2	1	1.7	2.5	1.5
Na	mmol/l	< 2.5	< 2.5				ppm	< 58	< 58			
Cl		< 2.5	< 2.5					< 88	< 88			
HCO_3		< 0.1	< 0.1					< 6	< 6			
$N\text{-}NH_4$	mmol/l	< 0.1	< 0.1	1	1.75	1	ppm	< 2	< 2	14	25	14
K		4	3	6	9	5.5		156	117	235	352	215
Ca		2	1.7	3.25	5	2.5		80	68	130	200	100
Mg		0.7	0.6	1	1.25	0.75		17	15	24	30	18
-	mmol/l	7.5	6	12.1	18	8.5	ppm	105	84	169	252	119
S		1.5	1	1.2	2	1.75		48	32	38	64	56
P		0.5	0.5	1	1.25	1		16	16	31	38	31
Fe	µmol/l	10	10	20	20	15	ppb	560	560	1120	1120	840
Mn		2	2	5	5	5		110	110	275	275	275
Zn		2	2	3	3	3		131	131	196	196	196
B		10	10	10	10	10		108	108	108	108	108
Cu		0.7	0.7	0.5	0.5	0.5		44	44	32	32	32
Mo		0.3	0.3	0.5	0.5	0.5		29	29	48	48	48

** Nutrient solutions are developed for ebb/flood systems

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A	Standard	Heavy Growth	Slow Growth	
Calcium nitrate solid	70	108	54	kg
Potassium nitrate	10	11	12	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1862	1862	1396	g
Manganese EDTA 13%	211	211	211	g
Zinc EDTA 15%	131	131	131	g
Copper EDTA 15%	21	21	21	g

B	Standard	Heavy Growth	Slow Growth	
Potassium nitrate	40	60	18	kg
Potassium sulphate	3	13	17	kg
Monopotassium phosphate	9	7	7	kg
Magnesium sulphate 16% MgO	25	31	18	kg
Monoammonium phosphate	4	9	6	kg
Borax 11.3% B	96	96	96	g
Sodium molybdate 39.6%	12	12	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: **ORCHIDS (*Phalaenopsis*)**	**DRAIN FROM BARK SUBSTRATE**

Nutrient		Target values root zone	Nutrient solution fertigation			Target values root zone	Nutrient solution fertigation	
			Growth	Flowering			Growth	Flowering
pH		5.1	5.5	5.5			5.5	5.5
EC	mS/cm	1.1	1.2	1.1	mS/cm		1.2	1.1
Na	mmol/l	<1.7			ppm	< 38		
Cl		<1.7				< 55		
HCO_3		<0.1				< 6		
$N\text{-}NH_4$	mmol/l	0.9	0.5	0.4	ppm	16	7	6
K		2.8	3.6	4.6		98	141	180
Ca		1.5	2.5	1.7		60	100	68
Mg		1	1.5	1.2		24	36	29
$N\text{-}NO_3$	mmol/l	6.5	7.7	6	ppm	91	108	84
S		1	1.7	1.9		32	55	61
P		1	1	1		31	31	31
$N\text{-}NH_2$			5	5			70	70
Fe	µmol/l	10	30	30	ppb	559	1677	1677
Mn		5	15	15		275	824	824
Zn		4	4	4		262	262	262
B		8	15	15		87	162	162
Cu		0.5	0.5	0.5		32	32	32
Mo		0.1	0.5	0.5		10	48	48

A	Growth	Flowering	
Calcium nitrate solid	54	37	kg
Potassium nitrate	0	13	kg
Urea ($CO[NH_2]_2$)	15	15	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	2793	2793	g
Manganese EDTA 13%	634	634	g
Zinc EDTA 15%	174	174	g
Copper EDTA 15%	21	21	g

B	Growth	Flowering	
Potassium nitrate	22	10	kg
Potassium sulphate	3	12	kg
Monopotassium phosphate	14	13	kg
Magnesium sulphate 16% MgO	37	30	kg
Monoammonium phosphate	0	1	kg
Borax 11.3% B	143	143	g
Sodium molybdate 39.6%	12	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

CROP: **ORCHIDS** — ORGANIC MATERIAL

Nutrient		Target values root zone	Nutrient solution fertigation		Target values root zone	Nutrient solution fertigation	Adjustments Flowering	
pH		5.5-6.0	5.3		5.5-6.0	5.3		
EC	mS/cm	0.7	1.1	mS/cm	0.7	1.1		
Na	mmol/l	< 2		ppm	< 46			
Cl		< 2			< 70			
HCO_3		< 0.1			< 6			
$N\text{-}NH_4$*	mmol/l	< 0.1	0.8	ppm	< 2	11.2	-0.2	-3
K		1.2	3.7		47	145	0.7	27
Ca		1	2		40	80	-0.3	-12
Mg		0.3	0.5		7	12	0.2	5
-	mmol/l	2.5	7.1	ppm	35	99	-1	-14
S		0.6	0.7		19	22	0.35	11
P		0.5	1		16	31		
Fe	µmol/l	8	15	ppb	448	840		
Mn		2	5		110	275		
Zn		2	3		131	196		
B		15	10		162	108		
Cu		0.7	0.5		44	32		
Mo		0.3	0.5		29	48		

* $N\text{-}NH_4$ or N-urea

The target values for organic material are related to the analytical results with the 1:1.5 volume extract with water.

A

Calcium nitrate solid	43	kg
Potassium nitrate	6	kg
Iron DTPA 6% or EDDHA 6% or HBED 6%*	1396	g
Manganese EDTA 13%	211	g
Zinc EDTA 15%	131	g
Copper EDTA 15%	21	g

B

Potassium nitrate	21	kg
Potassium sulphate	3	kg
Monopotassium phosphate	8	kg
Magnesium sulphate	12	kg
Monoammonium phosphate	5	kg
Borax 11.3%	96	g
Sodium molybdate 39.6%	12	g

Fertiliser amounts are calculated for a volume of 1000 L, and will result in a 100x concentrated nutrient solution.
** Type and ratio of the iron chelates depends on the pH, see chapter 11.*

18. COMPOUND FERTILISERS

Nutrient solutions can be applied with compound fertilisers, as also described in chapter 9. Here a number of example recipes are provided in the form of a formula of compound fertilisers.

Calcium and a part of the nitrogen is applied with calcium nitrate, the remainder of the required nutrients can be applied with compound fertilisers. Table 8 gives the formulas of a mixture of compound fertilisers that suits most the standard nutrient solution, when they are applied in combination with calcium nitrate. The kg's are equal to the kg's in the A+B tanks with straight fertilisers.

Remember to use water soluble compounds only for these purposes. Depending on the content of the compound fertiliser additional micronutrients might be necessary.

Table 8: Examples of compound fertilisers formulas, applied together with calcium nitrate to fit best with the standard nutrient solution of some crops. The amounts of compound fertiliser and calcium nitrate are given as kg to be dissolved in 1000 L tanks, for a 100 times concentrated solution. ** Total N should be predominantly applied as* NO_3.

Crop	Growing System	Nutrient				Compound fertiliser dose rate	Calcium Nitrate
		N*	P_2O_5	K_2O	MgO	kg/1000 L	kg/1000 L
Tomato	Inert	4	7	30	6	150	100
	Organic	3	7	27	6	150	110
	Soil	8	4	25	6	90	40
Carnation	Organic	7	10	32	4	90	40
	Soil	9	5	26	6	90	80
Pelargonium	Organic	6	13	32	4	100	85

YaraTera™ KRISTA™

Free flowing and fully water soluble straight fertilizers

The YaraTera KRISTA range is a complete nutrient solution for all types of production systems and fertigation systems. The YaraTera KRISTA products are free flowing and dissolve quickly without leaving any residues.

With the YaraTera KRISTA range, Yara is able to offer a comprehensive range of soluble straights for those preparing their own nutrient solutions, and together with YaraTera CALCINIT and YaraTera REXOLIN (chelated micronutrients) this will complete the nutrient need for any crop under any type of fertigation system.

NUTRIENT SOLUTIONS FOR GREENHOUSE CROPS