**Factsheet** **06/07**

**Strawberry**

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# Principles of strawberry nutrition in soil-less substrates

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**This factsheet summarises the principles of strawberry nutrition in soil-less substrates along with procedures growers can follow to ensure they produce high yields of high quality fruit.**

## Background

In recent years, there has been an increasing move towards production of strawberries in soil-less substrates (Figure 1). For growers who have traditionally grown strawberries in field soils, the biggest change to cope with is the nutrition of the crop.

Given the very high investment costs incurred in setting up a range of soil-less substrate production systems, it is vital that high yields of quality fruit with a high grade-out of class 1 are produced. Incorrect nutrition can not only give rise to poor fruit quality, but can also lead to root damage with subsequent reduction in fruit size, fruit malformation and reduced yield.

This factsheet has been produced to provide growers with a basic understanding of the nutritional requirements of strawberries grown in soil-less substrates (predominantly peat and coir). It should be used in conjunction with the HDC strawberry feed calculator which helps growers to calculate the quantities of fertilisers they need to use to achieve the recipes included in this factsheet.

**1 The feeding of strawberries in soil-less substrates has required traditional strawberry growers to acquire new skills**

## Getting started

Many of the problems associated with strawberry nutrition can be overcome by analysis of raw materials before planting and careful monitoring during the growth and development phase.

### Before Planting

- Sample the bulk substrate or bags randomly to ensure that the structure of the medium, the pH and nutrient levels are satisfactory.
- Analyse the water from all water sources being used including the mains water.

## Quality of substrate materials

Before considering the nutritional requirements of the crop, it is important to be satisfied that the growing medium is in optimum condition for supporting healthy root growth and supplying nutrients to the plant roots (Figure 2).

The structure of the growing medium is very important if the plants are to function fully and utilise the nutrients which are being supplied. For the medium to allow the roots to function fully, it is important that there is adequate Air Filled Porocity (AFP). The minimum AFP for strawberries is 15%. This level will allow good drainage and an adequate air supply to the roots for two seasons.

In the case of peat substrates, the addition of chipped bark or perlite will help to maintain an adequate AFP. The AFP can also be influenced by the blends of peat used or composted waste materials added. Clay granules can be added to improve the buffering capacity of the medium and thus even out fluctuations in nutrition.

Coir can also be used, typically either as a 50:50 blend with peat to improve the AFP or as a pure coir medium. It is likely that very few problems will be encourntered with proprietary blended peat/coir mixes from reputable suppliers. However care should be taken when ordering pure coir media as supplies are occasionally contaminated with sodium chloride. Coir substrates may also have high potassium levels that necessitate flushing with calcium nitrate (some suppliers pre-treat). Samples should therefore be analysed before use.

**2 The correct quality of peat is essential to provide optimum conditions for supporting healthy root growth like this**

## Water quality

Growers must have knowledge of the quality of their water before using it for irrigation in soil-less substrates. Water can be used from a range of different sources.

**Rainwater** is usually regarded as being the best quality for the purposes of crop irrigation, as its pH and content of soluble chemical ions is generally low. However in glasshouse nurseries, care should be taken with rainwater collected from roof areas near to oil boiler chimneys, as oil deposits may build up on the glass and be washed off with the water into the storage tank. Glasshouse shading materials can also be washed off into the tank, although most proprietary shading materials do not affect crops.

The quality and monitoring of **mains water** by water supply companies is driven by drinking water requirements and not plant requirements. Depending upon the prevailing geology in the area covered by the water supply company, the presence of high carbonate/bicarbonate levels can be a problem which may require remedial treatment.

The quality of **borehole water** is also determined by the local geology and high levels of conductivity, sulphate or iron can cause problems. Herbicides may also pose a contamination risk in borehole water.

Irrigation water extracted from **river sources** has a number of potential issues including boron and nitrate contamination as well as biological materials or soil particles.

**Recycled water** collected from bag or container run-off and other nursery areas requires careful consideration: high chloride or sulphate levels for example may be a concern.

The main chemical problems associated with each source of water are summarised in Table 1.

Knowledge of the chemical composition of irrigation water is essential to be able to determine the correct fertiliser and acid requirements (used for achieving optimum pH). Growers should always have their water source analysed for levels of nutrients and bicarbonate content before planning any irrigation and feed programmes (Figure 3).

The principal chemical parameters which are of importance for irrigation water include:

- pH
- Bicarbonate content (which is commonly confused with pH)
- Electrical conductivity (measure of the total salt content)
- Chloride level
- Sulphate level
- Iron and other trace element levels

It is worth noting that some trace elements such as iron and manganese, which are frequently present in water, are not in a form that can be readily taken up by plants. It is normal to apply additional levels of such nutrients even when they are already present in the water.

**3 Analysis of the water supply is essential to allow growers to plan their feeding programme**

**Table 1 Potential chemical issues associated with different water sources**

| Water source | Potential issues |
|---|---|
| Rain water | Low calcium content |
| Mains water | High carbonate/bicarbonate content |
| Borehole water | High salts, sulphate or iron content |
| River water | High boron or nitrate content |
| Recycled water | High chloride or sulphate content |

## pH and alkalinity

pH is the measure of how acid or alkaline the water is. Alkalinity is a measure of the carbonate/bicarbonate content of the water. It is the level of carbonates/bicarbonates (principally calcium, but also magnesium and sodium) in the water which determines whether the water is termed ‘hard’ or ‘soft’. Water may have a high pH but low calcium bicarbonate content.

Water with a high carbonate/bicarbonate content is termed ‘hard’. Hard water occurs in areas where the underlying rocks are calcareous and may be mains, well or borehole in origin. Irrigation water with a high carbonate/bicarbonate content will:

- Increase the pH of the growing medium over time, reducing the availability of certain nutrients, particularly phosphate, iron and manganese leading to leaf chlorosis and generally poor growth (Figure 4)
- Result in the deposition of calcium carbonate or in the formation of

**4 An increase in pH of the growing medium can lead to iron deficiency and leaf chlorosis**

insoluble phosphate salts, both of which build up in irrigation lines and nozzles creating blockages

- Limit the strength of liquid feeds that can be applied to crops (the irrigation water will already have a relatively high conductivity before any feed product is added)

A summary of how to interpret alkalinity (bicarbonate content) and whether there is a need to correct it can be found in Table 2.

## Using acids to reduce alkalinity

Assuming there are no alternative water sources, for water with a high carbonate/bicarbonate level, the only commercial option to reduce the alkalinity level is to use strong acids to remove most of the bicarbonate. Acidifying fertilisers such as urea phosphate can be useful in soil situations but are not normally recommended for substrate grown strawberries because of the risk of build up of excess ureic nitrogen or ammonium nitrogen in the medium.

Adding strong acid to hard water reduces the carbonate/bicarbonate levels by neutralising them to produce carbon dioxide. The aim is not to remove all of the alkalinity but to leave around 50 – 60 mg/l bicarbonate in the water. Various acids can be used but 60% nitric acid is the most common in the UK. A summary of the types of acids that can be used is shown in Table 3.

Acid is added either through a continuous direct injection at a fixed rate or alternatively through an acid dosing system (Figure 5).

Continuous direct injection is the cheaper method, but doesn't automatically adjust the injection rate if the pH of the incoming water changes. In contrast, acid dosing systems monitor the pH of the incoming water and inject acid to maintain a set pH (typically 5.8 – 6.2).

The amount of acid required can be calculated from the bicarbonate content of the water. The HDC Strawberry Feed Calculator has been constructed to work out the acid requirement for the feed once the bicarbonate level has been entered

**Table 2 Interpretation of water hardness**

| Interpretation | Bicarbonate content (mg/l) | Need for correction |
|---|---|---|
| Very soft | 0 – 50 | None |
| Soft | 51–100 | None |
| Moderately soft | 100 – 200 | Above 150 mg/l of bicarbonate hardness, acid injection is recommended |
| Hard | 200 – 300 | Blend water sources/acid injection |
| Very hard | 300 and above | Find an alternative souce if possible |

**Table 3 Types of acid used for acidification**

| Acid | Comments |
|---|---|
| 60% Nitric acid | Suitable for use with very hard water. Available nitrate can be useful. Very caustic, so avoid contact with fumes as well as acid |
| 75% Phosphoric acid | Not suitable for very hard water as excessive amounts of phosphate are applied. |
| 35% Sulphuric acid | Widley used in USA, less available in UK. Sulphate is added but not needed by plants. Must be used with care but less hazardous than 60% nitric acid to handle. |
| Citric acid | Not suitable for bulk acidification of very hard water due to expense but can be used to neutralise liquid feed stock tank alkalinity. Less likely to react with fertiliser salts or pesticides than other acids. |

**5 A typical acid dosing system**

onto the programme. Depending upon the alkalinity of the irrigation water, the use of nitric acid to acidify water typically adds between 50 and 90 mg/l of nitrate. This is also taken into account by the calculator when calculating liquid feed requirements.

It should be noted that in areas of soft water (less than 150 – 200 mg/l of bicarbonate) it is often necessary to add extra calcium for the purpose of increasing fruit firmness.

## Electrical conductivity and trace elements

The electrical conductivity (EC or sometimes referred to as cF) is a measure of the total salt content of the water, reported in micro-Siemens per cm (μS/cm). The frequent contributors to high conductivity levels are nitrate, chloride and sulphate ions. Water with a naturally high EC could give rise to a build up of salts in the soil-less substrate that could lead to root damage. A typical EC of mains water is around 500 μS. Water with an EC of 850 μS or higher should be avoided or diluted with water from lower sources if possible.

Rainwater generally has a low conductivity and pH and a very low calcium level. Borehole water in coastal and Fenland areas may have a high conductivity due to salt water contamination. A high conductivity due to high salt content may result from high levels of chloride, calcium, magnesium and sodium bicarbonates. High bicarbonate levels commonly give rise to waters of high conductivity. These high levels can restrict the amount of feed that can be added to the water and may cause damage to strawberries due to an accumulation of salts in the substrate (Figure 6).

Plants are also known to be sensitive to high fluoride levels. Therefore irrigation water with less than 0.25 mg/l fluoride is desirable. Boron toxicity is also occasionally found where water (eg river water) contains high boron levels originating from detergents. Table 4 lists the suggested maximum levels of a range of salts for a water source if it is to be used for strawberry production in soil-less substrates.

**6 Marginal leaf browning caused by an accumulation of salts in the substrate**

**Table 4 Suggested maximum levels of salts for water sources to be used for soil-less substrate grown strawberries**

| Parameter | Maximum level |
|---|---|
| Sodium | 35 mg/l |
| Chloride as Cl | 52 mg/l |
| Iron | 1.0 mg/l |
| Zinc | 0.35 mg/l |
| Boron | 0.33 mg/l |
| Sulphate | 144 mg/l |
| Bicarbonate | 240 mg/l |

## Monitoring of chemical water quality

It is important to check the quality of new water sources (including on new sites) before use. This is particularly important prior to committing to the expense of a new borehole. Routine monitoring of water quality (ie at least twice a year) is also important, as there are often seasonal variations, even in the case of mains water.

In systems where water is recycled, more frequent analysis of water is needed to monitor salt accumulation, particularly chlorides and sulphates. Where salts do accumulate, it may be necessary to drain systems occasionally and start with fresh water.

## Microbiological contamination

The main microbiological contaminants of water are fungal spores (eg the mobile spores of *Phytophthora*, the cause of red core and crown rot diseases in strawberries). Although all water sources for irrigation contain bacteria, most customers (particularly supermarket) wish to satisfy themselves that there are insignificant levels of those bacteria recognised as food poisoning organisms. For instance, the presence of bacteria such as *E. coli* would be particularly significant if irrigation water is to be applied overhead.

Therefore, when supplying supermarket customers, grower producers are obliged to carry out routine tests to determine the levels of such bacterial organisms. There are several chemical, biological and physical techniques that can be used to purify the water if such contaminants are present (See section on other useful publications).

## Crop nutrient requirements

From planting onwards, it is important that strawberries receive a balanced nutritional programme.

Before planting into bags or troughs, the substrate should have a pH of 5.5 – 5.8. It is not necessary to have high nutritional levels in the substrate if liquid feeding is to be used thereafter. The inclusion in the substrate of 0.75 kg/m³ of a 12:14:24 (N:P:K) compound fertiliser is adequate as a starter feed for any newly established plants.

Before formulating a feeding programme for strawberries, it is vital to know the quantity of nutrients a typical strawberry crop requires for optimum production. Table 5 provides an indication of the total amount of nutrients taken by each tonne of fruit harvested.

Feed programmes should be formulated to supply the nutrients required by the plant. This includes the nutrients required by both the leaf and also the root's requirements to develop the plant. It also includes those nutrients removed from the plant to produce the fruit.

**Table 5 Levels of nutrients removed by a tonne of harvested strawberries**

| Nutrient | kg/tonne |
|---|---|
| Nitrogen (Total N) | 1.6 |
| Phosphorous ($P_2O_5$) | 0.69 |
| Potassium ($K_2O$) | 2.29 |
| Calcium (Ca) | 0.24 |
| Magnesium (MgO) | 0.22 |

## Formulating the correct feed recipe

Based upon the crop requirements, it is possible to calculate optimum levels of nutrients to be applied in feeds at different stages in crop growth during the season. The majority of feed recipes used in strawberries follow these optimum levels. Recipes are listed for a typical Junebearer (Elsanta) and Everbearer in Tables 6, 7 and 8.

Initially June bearing strawberries need a high ratio of nitrogen to other nutrients in order to help promote growth and leaf area to sustain the crop load. Once the fruit starts to ripen, then additional potassium is required in relation to the nitrogen applied.

Nitrogen levels are reduced in the second cropping year to avoid excessive leaf growth, soft fruit and increased disease levels.

For Junebearer crops grown in predominantly coir based media, during the first growing season (60-day crop) when the substrate is fresh, a slightly modified nutrient regime should be used to allow for the nitrogen 'draw down' from coir as it breaks down and to take account of the elevated potassium levels and higher calcium requirement.

For most everbearer varieties, slightly higher levels of nitrogen are used over the season compared with Junebearers. At the start of fruiting both the nitrogen and potassium levels need to be further increased. The extra nitrogen is required to help to maintain plant growth as the crop load develops. Failure to sustain

**Table 6 Suggested nutrient recipes for both 60-day and 2nd/3rd year Elsanta crops grown in peat based media**

| Macro Nutrients | mg/litre in dilute feed | | | |
|---|---|---|---|---|
| | 60 Day crop | | 2nd/3rd Year crop | |
| | Starter (to first green fruit) | Fruiting | Starter (to first green fruit) | Fruiting |
| Nitrogen ($NH_4$ – N) | 14 | 14 | 9 | 9 |
| ($NO_3$ – N) | 120 | 140 | 100 | 120 |
| Phosphorous | 46 | 46 | 46 | 46 |
| Potassium | 175 | 250 | 175 | 250 |
| Magnesium | 20 | 30 | 20 | 30 |
| Calcium | 140 | 125 | 140 | 125 |

Table continued...

plant growth through cropping will result in reduced growth and a loss of total yield. Results from a recent Link project (SF 53) indicate that (for Everest at least) further increases in nitrogen rates increased fruit yield, but care should be taken to avoid adversely affecting fruit quality.

Tables 6,7 and 8 are just typical examples of recipes which may be used for an average UK water supply. In practice however, the final recipe chosen by an individual grower may need to be modified to take account of existing levels of nutrients in the water supply and the HDC Strawberry Feed Calculator offers this facility to growers.

In both Junebearer and Everbearer varieties, it is best to irrigate with plain water for the first 7–10 days after planting while roots are becoming established in the substrate. Thereafter, feeding should begin using a starter feed (see formulation in the tables below). This feed should continue until the first fruit is set on 50% of the plants, when the fruiting feed should begin.

| **Micro Nutrients** | **mg/litre in dilute feed** | | | |
|---|---|---|---|---|
| | **60 Day crop** | | **2nd/3rd Year crop** | |
| | **Starter (to first green fruit)** | **Fruiting** | **Starter (to first green fruit)** | **Fruiting** |
| Iron – Fe | 1.25 | 1.25 | 1.5 | 1.5 |
| Manganese – Mn | 0.80 | 0.80 | 0.80 | 0.80 |
| Zinc – Zn | 0.5 | 0.5 | 0.5 | 0.5 |
| Boron – B | 0.2 | 0.2 | 0.2 | 0.2 |
| Copper – Cu | 0.05 | 0.05 | 0.05 | 0.05 |
| Molybdenum – Mo | 0.05 | 0.05 | 0.05 | 0.05 |

**Table 7 Suggested nutrient recipes for 60-day Elsanta crops grown in coir based media**

| **Macro Nutrients** | **mg/litre in dilute feed** | |
|---|---|---|
| | **60 Day crop** | |
| | **Starter (to first green fruit)** | **Fruiting** |
| Nitrogen ($NH_4$ – N) | 14 | 14 |
| ($NO_3$ – N) | 140 | 160 |
| Phosphorous | 46 | 46 |
| Potassium | 150 | 200 |
| Magnesium | 20 | 30 |
| Calcium | 160 | 140 |
| **Micro Nutrients** | | |
| Iron – Fe (DTPA form) | 1.25 | 1.25 |
| Manganese – Mn | 0.80 | 0.80 |
| Zinc – Zn | 0.5 | 0.5 |
| Boron – B | 0.08 | 0.08 |
| Copper – Cu | 0.05 | 0.05 |
| Molybdenum – Mo | 0.05 | 0.05 |

**Table 8 Suggested nutrient recipes for everbearer crops grown in peat based media**

| Macro Nutrients<br>Micronutrients as for Junebearers | mg/litre in dilute feed | |
|---|---|---|
| | Starter (to first green fruit) | Fruiting |
| Nitrogen ($NH_4-N$) | 14 | 14 |
| ($NO_3-N$) | 110 | 150 |
| Phosphorous | 46 | 46 |
| Potassium | 200 | 300 |
| Magnesium | 20 | 30 |
| Calcium | 140 | 125 |

## Choosing a feed for your crop

There are many different formulations of feed available to choose from. Included in the formulations is a wide range of levels for each nutrient. Experience has shown with a range of crops that plants grown in soil-less substrates take what nutrients they require from feed supplied. The important thing is that nutrients are supplied in adequate volume.

There are three options which should be considered when selecting soluble feeds for strawberries:

1 The use of pre-formulated dry or liquid concentrates (Proprietary Feeds).

2 The use of bespoke mixes to meet farm conditions and water supply.

3 The use of straight fertilisers, mixed on the farm to a recipe appropriate to the farm.

### Proprietary feeds

This is considered by most strawberry growers to be the easiest option. The concentrate feed is purchased from a supplier, mixed to the stated dilution to give a stock feed, which is then diluted before applying to the plants. Proprietary concentrated feeds are easy to use, but are typically formulated for average conditions (including the water supply) and do not take account of existing levels of nutrients in the water supply. They are therefore considered to offer a compromise between crop requirements, the water supply and the compost nutrient reserves.

This option is suitable for small areas of production or those producers who wish to operate with a very simple system.

### Bespoke mixes

Bespoke mixes are feeds formulated for specific farm conditions, taking account of the farm water supply. This approach works out to be more expensive than using proprietary feeds, but has the advantage of being tailored to specific farm conditions. This system is suitable for all production systems, particularly those high value crops grown in bags and other containers under polythene or glass where optimising yield is essential.

### Straight fertilisers

The use of straight fertilisers is the cheapest of the three options and allows complete flexibility to adapt liquid feeds to plant needs, as circumstances require.

The mixing of straight fertilisers for liquid feeds requires a suitable recipe to take account of crop requirements and the water analysis. It is necessary to obtain the correct fertilisers and to use accurate scales when weighing out the constituents, to be confident that the feed is formulated correctly. It is also important to ensure that all the component fertilisers are fully dissolved before feeding begins. The stock tank should be agitated regularly to ensure that plants receive a balanced feed at all times.

Mixing straight fertilisers allows the feed to be modified during the season according to how the plants are growing and to allow for the prevailing weather conditions. This flexibility, when used correctly can help to improve the yield and quality of fruit.

Where calcium is to be included with either phosphate or sulphate in the feed, it will be necessary to use two tanks for concentrate feeds (Figure 7). This prevents the irrigation systems from being blocked by insoluble deposits from the feed which would occur if fertilisers containing these salts are mixed in the same concentrate tank. If only one stock tank is available, the calcium feed will have to be omitted or supplied on a separate occasion from the phosphate or sulphate containing feed.

When mixing straight fertilisers, the addition of nitric acid is often necessary to compensate for the bicarbonate hardness in some water supplies. Nitric acid is very corrosive and very hazardous when being handled. **It is important to remember that for safety reasons water should never be added to acid, but the acid should be added to water.** When handling acid always use suitable gloves, rubber boots, an apron and a face shield.


7 To avoid insoluble precipitates and blockage in the irrigation system, calcium should always be added separately from phosphates or sulphates

## Calculating quantities of feed to achieve required recipes

This factsheet deals with the principles of strawberry nutrition in soil-less substrates, with details of the substrate and nutrient requirements. It suggests feed recipes for different strawberry crops. The next stage is to calculate the quantities of fertiliser required to achieve these suggested recipes.

The HDC Strawberry Feed Calculator has been constructed and designed to do this for substrate grown crops, as well as soil grown crops. It has been produced in a spreadsheet form and can be used by growers who use both straight fertilisers and proprietary feeds. It relies upon growers undertaking analysis of their water supply and entering the results of this into the spreadsheet. The calculator automatically works out the required volume of acid to be added and the quantity of nutrients this will add.

Growers can then choose the fertiliser products they wish to use and set a target recipe using these feeds. The calculator can be used to work out the required quantity of each feed to achieve the target recipe, whilst taking account of the water analysis, quantity of acid added and existing electrical conductivity.

Instructions on how to use the calculator are provided in the computer programme.

## Irrigation management

Apart from the use of plain water in the first 7–10 days after planting, it is best to feed continuously during every period of irrigation. This will avoid rapid fluctuations in the level of nutrients available to the plant roots.

During each irrigation cycle, it is important to apply sufficient quantities of water to achieve a level of 10% run-off through the compost. Given that feed recipes are formulated very carefully to ensure that the plant receives an exact quantity of nutrients during particular growth stages, it is important that the correct concentration of feed and quantity of nutrients is always available in the plant root zone. By irrigating to run-off, the grower ensures that the concentration of feed entering the compost becomes identical to that leaving it, thus avoiding the build up of high salt concentrations which may lead to plant toxicity in certain situations.

Good irrigation management is also important to ensure that the plant receives a regular supply of water and feed (especially during fruit development and ripening). However, the frequency of irrigation will vary between growth stages, time of day and differing weather conditions. Plants are most demanding of moisture on bright, sunny days from the middle of the day and through the afternoon.

Irrigation of coir based media requires particular care. The surface of the medium can appear dry but there may be sufficient moisture beneath the surface. There is a tendency for the roots to develop at the bottom of the trough or bag, so excess watering can easily result in root loss. In general the 50:50 peat coir mixes are easier to manage.

Irrigation cycles should be set up to reflect the demand of the plants and not just at regular intervals during the day. In particular, it is important to avoid the use of excess water early in the morning, when much of the water and feed will drain through the compost and be wasted. In addition, excessive use of water can lead to waterlogging of the substrate and death of roots, resulting in lack of nutrient uptake (Figure 8).

Following harvest (in Junebearer varieties), the demand for water will decline, but a regular supply of irrigation must still be maintained to prevent wilting, especially during the flower initiation period.

8 Comparison of healthy roots (left) with those damaged by excessive irrigation (right)

## Monitoring

Having assessed the compost and water quality/nutrition analysis, calculated an appropriate feed recipe, chosen a feed, formulated a feeding programme and started to fertigate the crop, it is essential that the whole nutrition programme is monitored throughout the production process. Essentially, there are two key methods of monitoring. The first is by assessing the nutrition status of the plant leaves to assess if the plant is suffering from either a surplus of feed or any deficiencies. The second is by monitoring the concentration of the feed solution which enters the compost and that which drains out. Analysis of the growing medium can also be useful; if, for example, there is a build up of EC, analysis will indicate which salts are responsible and the feed can be adjusted.

## Leaf analysis

Leaf analysis is a useful guide to confirm that the feeding programme is supplying the plants' nutritional requirements at various stages of the season. Leaves selected for analysis should be fully expanded, having just reached maturity. Old leaves should not be included in the sample. Table 9 provides a guide to satisfactory nutrient ranges in strawberry leaves.

Leaf analysis is particularly helpful in checking for deficiencies of minor nutrients and for establishing trends of nutrient levels through the season and from year to year.

Different varieties show different leaf symptoms and climatic conditions can affect plant growth and nutritional status. It is therefore not possible to rely totally on foliar analysis, but it is a useful guide.

**Table 9 Satisfactory nutrient ranges of macro and micro nutrients in strawberry leaves**

| **Macro Nutrients** | **% in Dry Matter** | **mg/kg in Dry Matter** |
|---|---|---|
| Nitrogen (N) | 2.0 – 3.5 | |
| Phosphorous (P) | 0.3 – 0.6 | |
| Potassium (K) | 1.5 – 3.0 | |
| Magnesium (Mg) | 0.3 – 0.5 | |
| Sulphur (S) | > 0.01 | |
| Calcium (Ca) | 1.0 – 2.0 | |
| **Micro Nutrients** | | |
| Sodium (Na) | < 0.1 | |
| Boron (B) | | 30 – 50 |
| Iron (Fe) | | 50 – 200 |
| Zinc (Zn) | | 20 – 65 |
| Manganese (Mn) | | 50 – 250 |
| Copper (Cu) | | 5 – 20 |

# Analysis of feed and pH

When growing in bags or troughs, it is important to monitor conductivity levels of the feed, both at the point of drip and in the drainage water (Figure 9). The pH should also be monitored to avoid variability and adverse effects on nutrition.

- Ideally, monitoring should be undertaken daily; but at least 3 times per week as a minimum.

- The readings should be taken at the same time each day using a portable conductivity meter (Figure 10). They should be recorded for reference and also to comply with Assured Produce and other similar protocols.

As a general guide for both Junebearer (Elsanta) and Everbearer varieties, growers should aim for the conductivity levels listed in Table 10.

The feed conductivity should be varied + or -0.2 mS according to weather conditions, lower ECs being applied in hot sunny conditions when maximum irrigation is being applied. In practice, the conductivity of the run-off solution can sometimes be up to 0.2 mS more than the EC of the input feed. In such cases, the EC of the input feed should be reduced.

9 **The conductivity level of the feed can be analysed if the drainage water is collected**


10 **Probe attached to meter for measuring conductivity**

**Table 10 Optimum conductivity levels in strawberry feeds**

| **Starter feed** | **Conductivity of input feed (µS/cm at 20ºC)** |
|---|---|
| First 10–14 days feeding | 1.4 |
| Increase to | 1.6 |
| **Fruiting feed** | |
| Fruit set | 1.6 |
| Start picking | 1.8 |

# Action points

- Before establishing a plantation, randomly sample the bulk substrate to ensure that its structure, the pH and nutrient levels are satisfactory.

- Analyse the water from all water sources being used, including the mains water.

- Take account of existing pH, alkalinity and salt content in the irrigation water and take corrective action where appropriate.

- Account for existing nutrient levels in the water when calculating feed requirements.

- Monitor water quality routinely during the year.

- Decide on the type of feed you wish to use.

- Use the HDC Strawberry Feed Calculator to achieve the suggested recipes for Junebearers and Everbearers.

- Manage irrigation very carefully to provide the plants with the correct level of feed throughout.

- Monitor nutrition carefully throughout by analysing leaf tissue and liquid feed.

# Other useful publications

- HDC Factsheet 15/06 – Water quality for the irrigation of ornamental crops

- HDC Guide – A guide to slow sand filtration

- HDC Strawberry nutrient feed calculator

# Further information

**Contact points for equipment suppliers and analytical laboratories**

*Suppliers of acid dosing equipment:*

**Phoenix Instrumentation**
Unit 2, Ivel Road, Shefford
Bedfordshire SG17 5AE
Tel. (01462) 851747

**Flowering Plants**
11–12 Homeground
Buckingham Industrial Park
Buckinghamshire MK18 1UH
Tel. (01280) 813764

**Water Horticultural Products Ltd**
69 Ramley Road, Lymington
Hampshire SO41 8GY
Tel. (01590) 679911

**Lubron Water Technologies**
Luborn House,
Commerce Way, Colchester
Essex C02 8HL
Tel. (01206) 866444

*Laboratories for water analysis:*

**Gooch Garfoth**
Ipswich Road
Needham Market
Ipswich IP6 8EL
Tel. (01449) 721192

**Eurofins Laboratories Ltd**
Woodthorne, Wergs Road
Wolverhampton WV6 8TQ
Tel. (01902) 743222

**FAST Ltd**
North Street, Sheldwich
Faversham, Kent ME13 0LN
Tel. (01795) 533225

**Natural Resource Management Ltd**
Coopers Bridge, Braziers Lane
Bracknell, Berkshire RG42 6NS
Tel. (01344) 886338

**Yara Analytical**
Manor Place, Wellington Road
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