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Effect of Spray-N-Grow Foliar Micronutrient Complex on the Growth, Yield and Quality of a Hydroponic Snow Pea Crop.

Dr Lynette Morgan PhD and Simon Lennard M.Hort.Sc

SUNTEC International Hydroponic Consultants

New Zealand

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INTRODUCTION

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The principal objective of this research was to determine the effect of Spray-N-Grow micro nutrient complex on the growth, yield and pod quality of a hydroponically grown (NFT) Snow Pea crop produced under standard greenhouse conditions.

The snow pea is a gourmet vegetable grown for its edible pod which is harvested before the pea seeds have begun to form. Since snow peas are essentially harvested at an immature stage, crop yields are often lower than many other vegetables and the shelf life is thus short. Therefore commercial hydroponic growers of crops such as snow peas need to maximise crop yields using the most cost effective products and proven production techniques. Any cultivation practice which can improve the marketable yield of snow peas and other gourmet speciality crops is a valuable tool for a commercial grower.

The results of this trial carried out in New Zealand, with the Spray-N-Grow foliar fertiliser product are outlined in this report. The findings are divided into the variables under observation.

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BACKGROUND INFORMATION

1.0 BACKGROUND INFORMATION

It is well known that hydroponic systems allow greater control of plant nutrition and can therefore result in improved yields and fruit quality. In hydroponics, the conductivity, formulation, pH and temperature of the nutrient solution all influence yields and produce quality greatly as does the genetic background of the plant and the growing environment.

Nowadays, the use of hydroponic technology to produce a range of `gourmet' fresh vegetable crops is being utilised more and more as consumers come to realise that quality and shelf life are more important than price for many of the vegetable luxury items. Snow peas are one such crop which is recognised as a higher value vegetable with a short shelf life. However, snow pea yields are traditionally low compared to most other hydroponic vegetables produced under protected cultivation, therefore any production method with can increase the weight and overall yield of a hydroponic snow pea crop is well worth investigation. The objective of this trial was to determine the effect of Spray-N-Grow foliar fertiliser applied weekly on the growth, development, yields and shelf life of a hydroponically grown snow pea crop.

1.1 Foliar Fertilisation

The most widely applied method of plant fertilisation is through the root system either via the soil or inorganic media substrates such as those used in hydroponic production. In systems such as NFT (Nutrient film technique) nutrients are supplied dissolved in water with no requirement for a soil media around the roots. While plant root systems are in the most part efficient at absorbing mineral nutrients, certain conditions can prevent optimal uptake rates of some of the elements plants require. Foliar feeding, provides nutrients through the foliage of the plant which has the ability to absorb and translocate certain minerals within plant tissues.

1.2 Benefits of foliar fertilisation

In soil and soil-less systems such as hydroponics, many nutrient interactions can occur within the root zone which makes it difficult for the plant to absorb certain minerals. Soils and even hydroponic systems can become deficient in nutrients - either because of nutrient depletion, antagonism between certain elements, naturally low levels, inadequate fertilisation or due to elements becoming `bound' and therefore unavailable for plant uptake. Imbalances in the combination of nutrients, pH levels which are too high or low for maximum plant uptake, and poor physical properties of the media surrounding the root zone, including oxygen starvation are more common in both soil and soil less systems than many growers realise. Furthermore elements such as iron, an essential trace element, are not only prone to become unavailable for plant use at moderate to high pH levels, their uptake by the plant is also severely limited under certain environmental conditions such as cool temperatures. Iron chlorosis in many crops which are stressed by low temperatures can be a common problem where root uptake is the only source of iron for the plant.

Any situation which damages the root system or restricts its growth, development or physical process such as respiration affects the uptake of minerals. Plant pathogens such as *fusarium, pythium* and *phytophthora* can not only rapidly destroy a crop, but low, less damaging levels can restrict function of the root zone to the point where mineral uptake is affected. While the crop may not show signs of severe infection, mineral and water uptake can be restricted to the point where crop yields and quality are affected. Other plant stress conditions such as anaerobic conditions in the root zone where oxygen is limiting, can limit nutrient uptake, with trace elements such as iron often affected to the greatest degree. Any other condition which stresses the plant - temperature stress, high or excessively low humidity levels, lack of light, high radiation levels, high plant densities, presence of pests or disease, will affect the efficiency of the root system in taking up mineral elements. Many of these conditions are common and occur in many commercial production situations without the grower realising that plant growth and mineral uptake is being limited in some way. It is under these types of very common situations that foliar feeding has its greatest advantage. Since plant stress is dependent on a number of factors - many are environmental, which growers have limited control over, foliar fertilisation provides an `insurance policy' against yield and quality loss from limitations in root mineral absorption and transportation.

1.3 The process of foliar fertilisation

As the third organ of higher plants after the shoot and the root, the leaf is essentially used for photosynthesis and respiration. The leaf blade is flat in shape for this purpose. Most leaves have stomata either only on the underside or on both sides of the leaf which enable gas to be exchanged for photosynthesis and respiration as well as releasing water vapour in stomatal transpiration. The leaf with it's epidermis can also function as an organ that absorbs and excretes water and substances which may be dissolved in it.

Aqueous solutions are absorbed or excreted not throughout the entire leaf cuticle, but through punctiform areas, the location of which coincides with the position of the ectoteichodes that project radially into the wall. If these structures serve to excrete aqueous solutions from the leaf, then they will also carry out the reverse process i.e absorption into the leaf. This has also been demonstrated with the use of radio labelled materials. Since foliar absorption is limited because of the relative barrier of the cuticle it is not possible to solely feed plants via the leaves. For this reason the most effective use of foliar fertilisation is as a rapid and effective method of supplying the micro nutrients. It can, however also be used to satisfy acute needs with lower concentrations of macronutrients.

1.4 History of foliar fertilisation

As early as 1877 Bohm reported that dissolved mineral salts such as calcium are absorbed via leaf surfaces and used in plant metabolism. In the early 1900's, many researchers provided scientific proof that leaves absorb substances. In 1916 in Hawaii, Johnson sprayed his pineapple crop, which had become chlorotic because of iron deficiency, with a solution of iron sulphate and the plants became green again for a few weeks, this achievement had repercussions in that practical farmers in the US in the 1920's increasingly began to use foliar application of micro elements.

1.5 Application of foliar fertilisers

The addition of a wetting agent or surfactant is vital to the application of foliar fertilisers. Wetting agents are necessary to ensure the adherence of droplets on difficult to wet leaves as well as assisting with the absorption of the fertiliser solution into the plant tissue.

1.6 Timing of foliar nutrient application

One very important criterion of the effectiveness of nutrient sprays is the rate at which the foliar applied nutrients are absorbed by the leaves and translocated within the plant. The uptake of nutrients is further affected by a number of interacting factors of which only part are known at the current time - these are shown in Table 1.1.

Table 1.1 Influences determining the efficacy of foliar nutrient sprays

PLANT	ENVIRONMENT	SPRAY SOLUTION
Curricular wax	Temperature	Concentration
Epicuticular wax	Light	Application rate
Age of the leaf	Photo period	Application technique
Stomata	Wind	Wetting agent
Guard cells	Humidity	pH
Trichomes, leaf hairs	Drought	Polarity
Adaxial leaf side	Time of day	Hygroscopicity
Abaxial leaf side	Osmotic potential of root	Sticking ability
Leaf Turgor	Nutrient stress	Sugars
Surface moisture (dew etc)		Nutrient ratio
Cation exchange capacity		Carriers, penetrates
Nutritional status of the plant		Humectants
Cultivar		
Growth stage		

If in certain crops and for certain nutrients, foliar application at an early growth stage is recommended, it is necessary to reach a compromise between early application and allowing the crop to attain a leaf area large enough for the absorption of large amounts of nutrients.

Most crops have certain growth stages needing a particular supply of all or of certain nutrients to reach optimum yields. Plant demand is generally at its maximum during the period of exponential growth. During such critical stages, leaves show a particularly high efficacy for absorbing nutrients. Furthermore, at any stage during growth and development, there are times when nutrient uptake by the root system is impeded to such an extent that plant tissues may not receive an adequate supply of nutrients. Examples of this are during drought or high salinity conditions. During times of limited nutrient uptake due to water stress or other conditions, foliar fertilisation during these critical growth stages, is a means by which full yield can still be ensured.

If a period during which the plants have difficulty in absorbing nutrients via the root system should coincide with a period when there is a particularly vigorous demand for nutrients, the result will be a significant loss in yield potential, without the grower seeing any visible signs of deficiency. Under such conditions foliar fertilisation can give particularly impressive results.

1.7 The role of foliar fertilisation in hydroponic crops

While hydroponic crops may appear to be supplied with optimal nutrition via a well balanced and formulated nutrient, they still benefit from the application of foliar fertilisers. Previous researchers have found that hydroponic crops such as capsicum, treated with a micro nutrient foliar applied solution had an increase in fruit yield over control plants and also an increase in the compound `capsaicin' in the fruit tissue. Hydroponically cultivated potato plants also showed similar results. Potato plants given foliar fertilisation treatments with a micro nutrient solution not only had a greater tuber harvest, but also higher dry matter of the whole plants. These results would also be expected on a number of hydroponic crops with similar nutrient requirements and thus the process of foliar fertilisation is a cultivation technique that must be considered in any commercial production system.

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MATERIALS & METHODS

2.0 MATERIALS AND METHODS

2.1 Objective

To determine the effect of applications of Spray-N-Grow micro nutrient foliar fertiliser complex applied on a weekly basis to an NFT (nutrient film technique) hydroponic snow pea crop as compared to a control, untreated crop. To determine the effects of this treatment on such factors as plant growth rate, timing of flowering, pod number and average weight, total yield, root dry weight and shelf life.

2.2 Treatments

1. Weekly foliar application of Spray-N-Grow (SNG) micro nutrient foliar complex at a rate of 10ml per litre of water sprayed to run off.

2. Control - no treatment applied.

2.3 Experimental Design

A complete randomised block design was used for this trial. Plants were shielded with plastic covers during application of SNG foliar fertilizer applicaions until all foliage was dry.

2.4 The Crop Production System

The trial was conducted in a naturally ventilated greenhouse during the winter-early spring period in Tokomaru, New Zealand. Seedlings of the commercial snow pea variety `Snow Queen' were sown into biodegradable paper pots with a ground bark based media on 15 April 2001. After germination and the production of the first two true leaves, seedlings were transferred into the NFT (nutrient film technique) system. A density of three snow pea plants per pot/planting space was used, with a total of 36 plants per replication (3) of each treatment. When the seedlings had developed a sufficient leaf area the first SNG application as given on 10 May 2001 and every week thereafter until crop completion

A standard hydroponic nutrient solution (Snow pea formula given in Appendix one) was applied at an EC of 2.0 and a pH of 5.8 for the life of the crop. EC and pH was adjusted daily.

Plants were trained to overhead wires for support and grown under standard greenhouse conditions in an unheated greenhouse. Temperatures during this period ranged from a daily minimum of 4° C (night minimum of -2°C) to a daily maximum of 22 °C (night maximum of 7° C).

All plants receiving the SNG foliar fertilizer treatment were sprayed in the morning when stomata are expected to be open for nutrient absorption, apart from days with particularly cold conditions (light frosts) when spraying was not carried out until crop temperature reached at least 7° C. Control plants were shielded with plastic sheeting until foliar treatment leaves were dry.

2.5 Preparation of Spray-N-Grow Foliar solution

Distilled water used as a carrier for the SNG product was warmed to 100F (38° C). The pH of this water was increased to 7.1 using a dilute solution of sodium bicarbonate. 10ml of SNG along with ½ teaspoon of cocowet surfactant was added to the warmed water and left for 20 minutes. After this time, the solution was sprayed onto the treatment plants (treatment 1 blocks) with a small hand held pressure sprayer (4 litre capacity) to the point of run off. Care was taken to apply the solution to as much of the upper and lower leaf surfaces as possible for maximum efficiency.

2.6 Crop Measurements

The size and development of seedlings during the early treatment phase was noted as was the timing of initial floral development. After the final harvest, all plant tops were removed, the system switched off and drained and the root systems allowed to dry - these were then weighed for each replication and treatment block.

2.6.1 Harvesting

The first harvest took place on 6 July 2001, the final harvest on 1 October 2001 when the crop was terminated. Each pod from each plant was weighed, measured for length and assessed for marketability. All pods were harvested when they had reached a minimum size of 7cm, on a weekly basis for a period of 10 weeks. Pods were also assessed for shape, deformities, imperfections and the presence of disorders.

2.6.2 Shelf Life Assessment

Shelf life is an important variable in the post harvest handling chain and is of concern to all who grow, process, market, transport and consume the final fresh product. The shelf life of snow peas can vary considerably depending on a number of factors including the percentage dry matter of the pods (i.e. how much water is present to be lost before shrivelling occurs), whether the pod is affected by any disease/pathological or physiological problems, the percentage of certain minerals contained within the pod (calcium in particular) and the conditions the crop were grown under. Shelf life assessment of this crop was carried out by selecting 30 pods (10 from each replication) of a similar size and exact same degree of maturity at each of 2 harvests. Each pod was weighed at the time of harvest and again at 2 day intervals until it was determined to be of unacceptable quality. A final weight was taken to determine the percentage of water lost during the shelf life period and the reason for loss of shelf life recorded. This was usually due to shrivelling of the pods, or loss of chlorophyll resulting in a yellowing of the tissue.

2.6.3 Root Dry Weight

The mass or dry weight of the root system of a crop often gives and indication of the health of the plants and plant stress factors usually result in a smaller root mass/thinner individual roots and the presence of pathogen damage. Since fresh root systems contain a large amounts of water in their capillary system, dry weight is the best method of determining differences in the root system. Since roots from individual plants could not be separated at the time of harvest, the entire root mat from each treatment was weighted as a single mass for each hydroponic gully. The results were then averaged for each treatment.

2.7 Statistical analysis

All data was analysed by comparison of standard errors and at the 10% probability level using the Simstat programme for statistical analysis.

SNG/BPF Trial

May 2001
two weeks after planting

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RESULTS & DISCUSSION

3.0 RESULTS AND DISCUSSION

3.1 Treatment effect on crop growth and development

While initial seedling growth was similar in the SNG treated and untreated plants, the SNG treatments flowered on average 4 - 5 days earlier than the control treatment - hence there was a significant increase in early harvests. Root outgrowth and root matt development appeared to be visibly more advanced inside the hydroponic channels in the SNG treatment. There was no visible difference in plant height at the time the plants were harvested for the first time in July 2001.

3.2 SNG Treatment effects on yield

At the time of the first harvest in July 2001, significantly more SNG treated fruit were ripening and ready for harvest as compared to the control fruit. This was a result of earlier flowering, and fruit set in the foliar treatments This indicates an increase in `early harvest' yield from the treated plants.

Early Harvests: The SNG only treated plants produced an average of 49.71 grams per plant in harvests 1 through 7. Control (untreated plants) produced a lower earlier yield of 30.6 grams per plant on average.

Later Harvests: The SNG treated plants produced an average of 374 g per plant in harvests 8 through 10. Control (untreated plants produced a lower rate of harvest yield of 307.67 grams per plant in harvests 8 through 10. Yields by harvest date are shown in the following graphs (Figures 1 - 4).

Figure 1

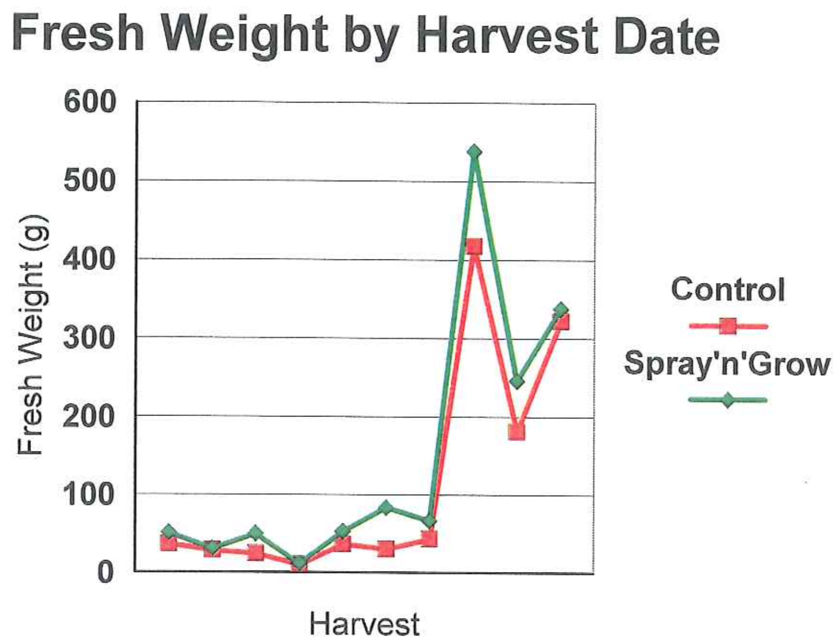


Figure 2

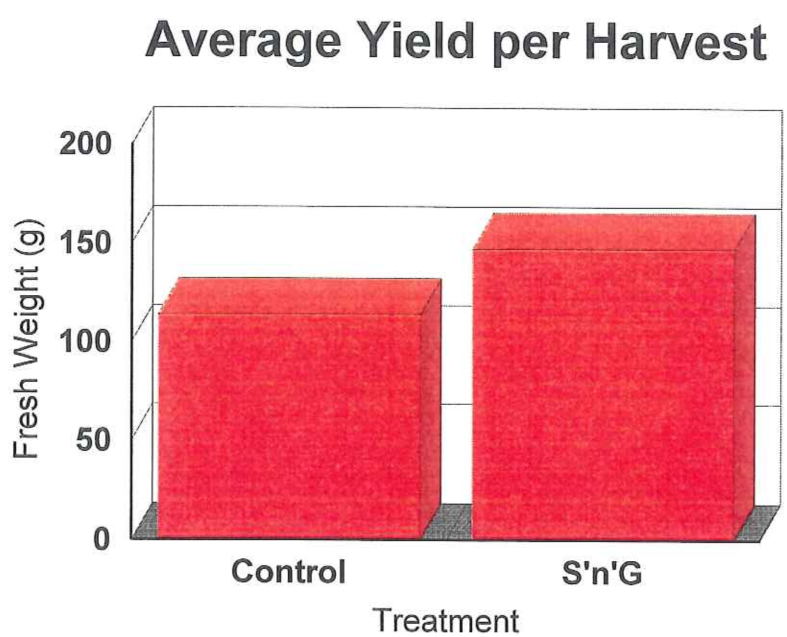


Figure 3

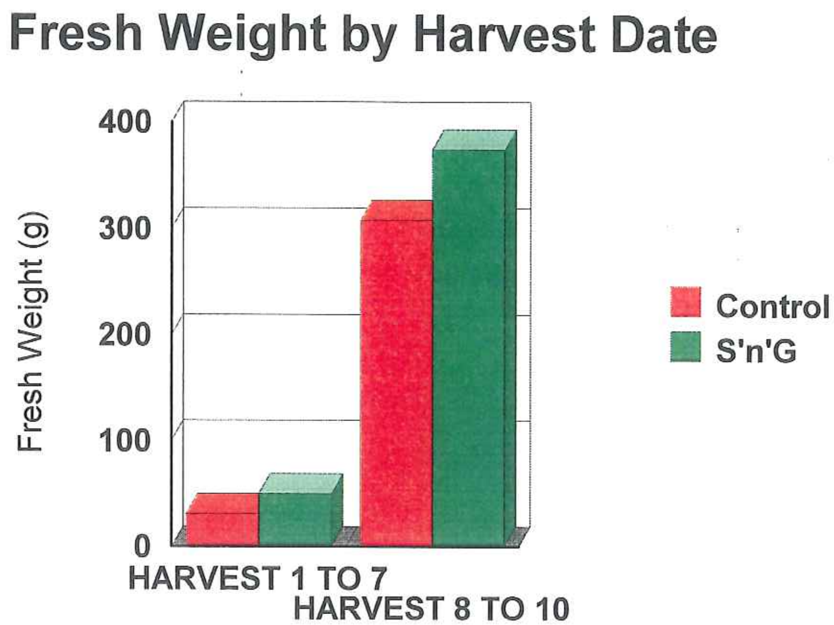
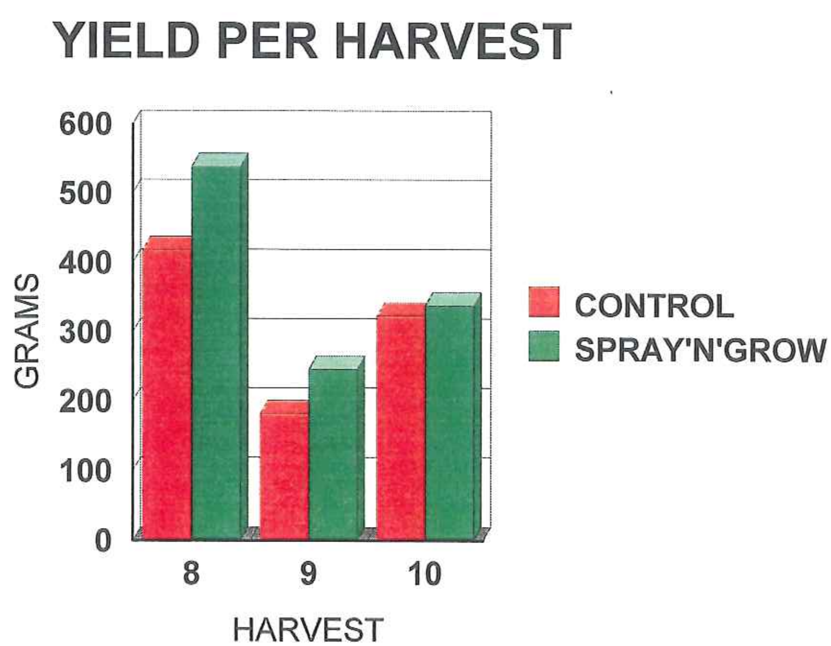


Figure 4



3.3 SNG Treatment Effects on pod numbers

The greater yield obtained in the SNG treatment was attributable to both an increase in average pod weight at harvest and a greater number of pods produced per plant. Control plots produced on average 58.36 pods per harvest. SNG plots produced an average of 83.5 pods per harvest (Figure 5).

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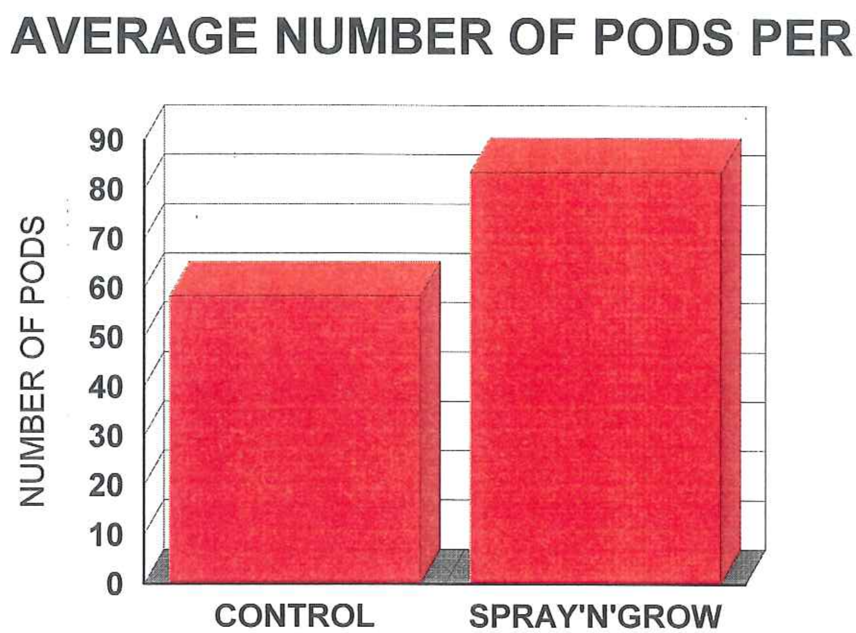
Figure 5 ` average pod numbers per treatment in harvests 1 - 10



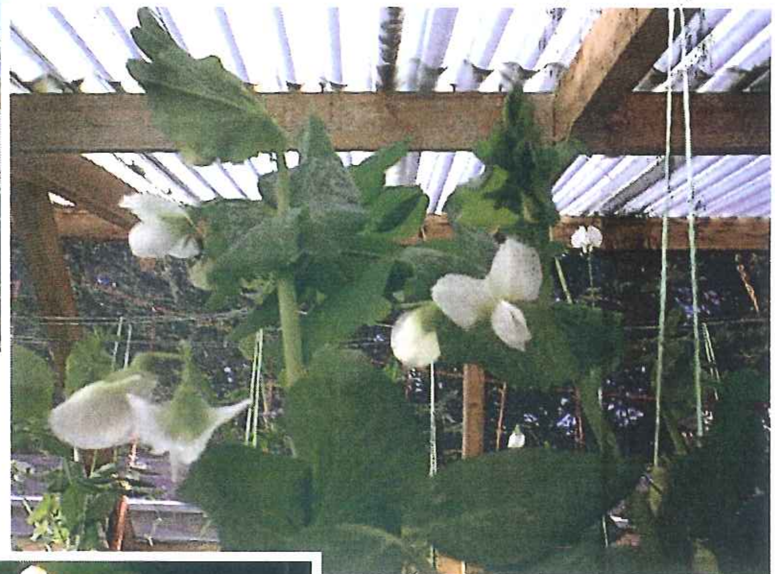
3.4 SNG Treatment effect on pod shelf life

Shelf life assessment was carried out on pods from harvest number 5, 6 and harvest number 7. The results from these three shelf life trials gave no significant difference in storage times and post harvest moisture loss between the SNG and control treatments. On average, all pods had a shelf life of 17 days at room temperature stored in polythene bags. Loss of shelf life was the result of slight shrivelling and softening due to water loss and a loss in green coloration resulting in yellowing of the pods.

3.5 SNG Treatment effect on root dry weight

There was a significant increase in root dry weight per lot from the SNG treatment plants. Control root system plots averaged 61.33 g dry weight per plot. SNG treatment plots (treatment 1) averaged 106.66 g per plot.

August - September 2001



4.0 Conclusions and summary

Treatment with the SNG foliar micro nutrient complexe has previously been proven the boost the plant's foliar levels of zinc and iron (two important trace elements) in hydroponic tomato crops. Zinc is a co-factor in the production of chlorophyll and is also involved in the formation of the plant hormone auxin. Auxin is implicated in the transport of photosynthates from leaves to developing `sinks' such as fruit and roots. Iron is an integral part of proteins involved in electron transfer across membranes in chloroplasts, utilised in the photosynthetic process. Optimum levels of available iron enhance photosynthesis, by allowing the unimpeded flow of electrons, and hence maximise sugar formation in the leaves. In this way, it appears that the SNG micro nutrient complex affects many plant processes which in turn influence flowering, pod yield and numbers.

Furthermore, even in hydroponic systems, the uptake of elements such as iron can be limited by factors such as pH level, interactions with other ions, conditions within the root zone and low temperature. This can result in lower than optimal levels of certain plant nutrients without the crop showing any visible signs of deficiency. It appears that boosting foliar mineral levels with the use of a micro nutrient complex not only rectifies any deficiency in root uptake, but also has a synergistic effect on many plant processes. In this particular trial, which was conducted under low light and temperature in winter conditions, it is probable that iron uptake from the hydroponic system was often limiting. Iron is one nutrient which requires warmth for good uptake, a requirement which was not met in the nutrient solution during cooler conditions (nutrient temperatures were often recorded to be as low as 2°C). Hence the use of foliar applications of certain trace elements becomes increasingly beneficial under cooler environmental conditions.

SNG treatment had the effect of advancing flowering and increasing the number of flowers and hence pods per plant - this could be an effect of improved plant nutrition, assisting the plants to absorb minerals in an environment where root uptake could be limiting. However there may be other as yet unexplained reasons why the SNG complexes benefit plant physiological processes and assist flower production and pod set. The increase in root dry weight in both foliar treatments over the control plants indicates the greater nutritional status of the treated plants.

Foliar fertilisation with the SNG micro nutrient complex can result in not only advanced flowering and greater flower and hence pod numbers, but also an increase in yields within the crop - an important consideration for any commercial hydroponic producer.

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APPENDIX ONE
Snow Pea Nutrient Formula

APPENDIX ONE

SNOW PEA NUTRIENT FORMULA

Standard hydroponic nutrient formula for high quality, low mineral water sources.

This nutrient formula contains the following element contents:

Macro Nutrients in ppm	Micro Nutrients in ppm
Nitrogen (N) 200 ppm	Iron (Fe) 4.90 ppm
Potassium (K) 90 ppm	Zinc (Zn) 0.25ppm
Phosphorus (P) 201 ppm	Boron (B) 0.70ppm
Magnesium (Mg) 80ppm	Copper (Cu) 0.07ppm
Calcium (Ca) 218 ppm	Molybdate (Mo) 0.05ppm
Sulphur (S) 106 ppm	Manganese (Mn) 1.97ppm

Nutrient salts by Weight

Stock soluton volume 100 litres, dilution rate 1:100 to give an EC of 2.0, pH of 5.8, TDS of 1512.

Part A

Calcium Nitrate 10896.5 g
Potassium Nitrate 1204.6 g
Iron EDTA 500g

Part B

Potassium Nitrate 1204.6 g
MonoPotassium phosphate 4290.3 g
Magnesium sulphate 8172.1 g
Manganese sulphate 80 g
Zinc Sulphate 11 g
Boric acid 39 g
Copper sulphate 3.02 g
Ammonium molybdate 1.022 g

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