THE EFFECT OF HOMOEOPATHIC *OZONUM* IN VARIOUS POTENCIES ON GROWTH AND YIELD OF THE LOLLO BIONDA LOBI CULTIVAR OF LEAFY LETTUCE (*LACTUCA SATIVA*) CULTIVATED IN A CLOSED HYDROPONIC SYSTEM

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This study represents original work by the author and has not been submitted in any form to another University. Where use was made of the work of others, it has been duly acknowledged in the text.

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ABSTRACT

Lettuce is a cool season crop and requires an optimum growing temperature of 18°C. Lettuce is popular in summer as a salad ingredient but supply cannot always keep up with demand due to high spoilage rates, because of bolting and tip-burn as a result of heat stress while growing (Maboko &Du Plooy 2007). Heat stress reduces oxygen availability. This study sought to demonstrate that administration of homoeopathic *Ozonum* to hydroponic nutrient solution in a nutrient film technique design improves the growth ability and quality of lettuce during the summer season by increasing or improving its ability to absorb oxygen.

The research was conducted at the Agricultural Research Council – Vegetable and Ornamental Plant Institute (ARC-VOPI) facility at Roodeplaat (near Pretoria), South Africa. The trial was conducted in a 40% shade net structure in the summer months of February to April 2012.

Purpose

The general aim was to measure the effect of homoeopathic *Ozonum* 6CH, *Ozonum* 15CH and *Ozonum* 30CH compared to a placebo control (96% alcohol only) on the growth and yield of leafy lettuce, Lollo Bionda Lobi cultivar grown in a closed hydroponic system in South African summer climatic conditions.

Objectives:

- Determine the increase in growth and yield of leafy lettuce as affected by O*zonum* concentration in terms of: (i) leaf fresh mass; (ii) leaf dry mass; (iii) number of leaves; (iv) leaf area; (v) chlorophyll content; (vi) root fresh mass; (vii) root dry mass;
- Determine the impact of heat stress in terms of bolting and tip-burn;
- Determine the differences in specific plant leaf mineral content between the experimental groups and control group; and,

- Determine the differences between dissolved oxygen (DO) concentrations in the nutrient solution of the verum group and control group.

Methodology

This was a placebo controlled randomized plant experiment. A total of 384 plants were laid out in a randomized complete block design with 4 treatments (*Ozonum* 6CH, *Ozonum* 15CH *Ozonum* 30CH and a control) and replicated 4 times. The total number of plants per plot was 24 and the middle 8 plants were selected as data plants while other plants were regarded as border plants. Thus, data was gathered from 96 plants per treatment in total.

Leafy lettuce seeds of cultivar Lollo Bionda Lobi, were sown in polystyrene trays. The seedlings were transplanted 28 days after sowing into a gravel-film technique hydroponic system. *Ozonum* and the placebo was added to the nutrient solution on the first day and every 6 days thereafter, at the same time as the nutrient solution was changed. Various daily measurements were recorded. Plants were harvested 27 days after transplanting when final measurements of nutrient content and growth were made.

Data Analysis

Data was collected over time as repeated measurements; the time factor was included as a sub-plot factor in the analysis of variance (ANOVA). All data items collected were subjected to an appropriate analysis of variance using the GenStat statistical system (VSN International, 2011). The residuals were examined for deviations from normality and outliers causing skewness were removed. Fisher's protected t-LSD (Least Significant Difference) was calculated to compare treatment means of significant effects (Snedecor & Cochran, 1980).

Results

The results for (i) lettuce yield criteria, (ii) DO concentration, (iii) leaf chlorophyll content and (iv) specific mineral content of lettuce leaves (Appendix B) indicate that there was no significant difference between *Ozonum* treatments and the control.

The incidence of bolting was not observed in lettuce plants among the treatment or control groups.

Results showed a reduced tendency in tip-burn percentage for treatment *Ozonum* 30CH although not significantly different to *Ozonum* 15CH or the control.

Conclusion

The conclusion derived from this study is that homoeopathic *Ozonum* was not effective at improving dissolved oxygen levels in the nutrient solution, or in stimulating growth in lettuce under South African summer climatic conditions (February to April). Further research is needed to explore the effect *Ozonum* 30CH may have on tip-burn.

DEFINITION OF TERMS

Chlorophyll Concentration Index (CCI): the ratio of transmission at 931 nm to 653 nm through a leaf (Apogee, 2012).

Homoeopathy: a therapeutic method which clinically applies the law of similars and which uses medicinal substances in weak or infinitesimal doses (Jouanny, 1991).

Law of Similars: *Similia similibus curantur* ‘let likes be cured by likes’. The homoeopathic formula expressing the law of similars i.e. the doctrine that any drug which is capable of producing morbid symptoms in the healthy will remove similar symptoms occurring as an expression of disease (Yasgur, 1998).

Agrohomoeopathy: the safe and chemical free use of homoeopathic remedies in agriculture, to influence biological processes of plants, to either accelerate or delay growth (Moreno, 2008).

Similimum: the remedy which most closely corresponds to the totality of symptoms, and when found is always curative (or in incurable cases, is the best possible palliative remedy) (Gaier, 1991).

Ozone: a colourless gas (O_3) soluble in alkalis and cold water; a strong oxidizing agent; can be produced by electric discharge in oxygen or by the action of ultraviolet radiation on oxygen in the stratosphere (where it acts as a screen for ultraviolet radiation) (Lexic.us, 2012).

ABBREVIATIONS

1. In terms of concentrations: mM = mmole = mol/dm^3 = mol/L = 1/1000 mol.

2. mol-m^2-d^1= number of moles of light per square meter per day

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

1.1 Background

Lettuce (*Lactuca sativa*) has never been found in its wild state but has always been cultivated as far back as the times of the Greeks and Romans, who used it as a salad (Lactuca sativa, 2012). Lettuce (*L.actuca sativa*) is a temperate annual or biennial plant of the daisy family *Asteraceae*. It is most often grown as a leaf vegetable. In many countries, it is typically eaten cold and raw, in salads, hamburgers, tacos, and many other dishes. It has been described over the centuries as a cooling counterbalance to other ingredients in a salad. It is a valuable source of vitamin A, folic acid, potassium, and fibre. In lettuce, the darker green lettuce leaves provide more nutrition than the light green or yellow leaves (Department of Agriculture, Forestry and Fisheries, 2010).

1.2 Description of the lettuce industry in South Africa

Lettuce is becoming an important and popular crop in South Africa, with increased use of soilless cultivation methods (Maboko & Du Plooy, 2008:113), especially as the populations grow and the farmland is overtaken by urban growth, leading to increased production and consumption especially in urban areas. This increased popularity of soilless cultivation methods is mainly because of improved yield and quality of the produce (Maboko & Du Plooy, 2009). Understanding how the benefits of hydroponics blend with environmental conservation is important as we enter the 21st century (Hydroponics, 2012). The majority of vegetables in South Africa are grown in open field systems while a small amount are produced under protection, e.g. shade-net houses and greenhouses (Maboko & Du Plooy, 2009).

Cool growing seasons are optimal for lettuce cultivation with temperature ranges between 7°C and 24°C, with an average of 18°C (Lorenz & Maynard as cited by Maboko & Du Plooy, 2007:319).

1.3 Supply and demand

South Africa is self sufficient in terms of lettuce production and the surplus is exported to other countries. South African average lettuce consumption is approximately 31 958 tons per annum (Department of Agriculture, Forestry and Fisheries, 2010). The prices of lettuce are determined by market demand and supply. Fresh lettuce is sold through fresh produce markets, restaurants, hawkers, retailers and chain stores. Lettuces are exported to other countries through export agents and marketing companies (Benardo 2012). South Africa also imports lettuce from other countries. In 2009, for example, there was a 15% increase in lettuce sales through fresh produce markets and there was a 13% increase in lettuce exports compared to that of the previous year (Department of Agriculture, Forestry and Fisheries, 2010).

According to reports of the Department of Agriculture, Forestry and Fisheries (2010), the volumes of lettuce in the market have been fluctuating over the years, with peak volumes recorded in 2008. The lowest prices were recorded in 1999 due to high volumes supplied to the markets. In 2003, lettuce prices increased by 41% compared to the previous year due to low volumes. In 2005, lettuce prices declined by 18% as volume increased. From 2006 to 2007, the prices increased steadily as supply declined across the markets. In 2009, the lettuce prices eased higher due to low volumes of lettuce supplied across the market.

1.4 Varieties of Lettuce

“Lettuce varieties can be loosely categorized into four groups: crisphead, butterhead, leaf and romaine or cos. Each group has its own growth and taste characteristics.” (Riofrio, 2000).

1.4.1 Crisphead

Crisphead lettuce is probably the most familiar lettuce variety. It is characterized by a tight, firm crispy head made up of light-green leaves. Crisphead lettuce is generally intolerant of hot weather and will readily bolt or send up a flower stalk under hot summer conditions. However, the commonly cultivated varieties are tolerant to bolting prematurely. Iceberg lettuce (a member of the crisphead lettuce) has a water content of 96 per cent and no fat. It is highly rich in fibre, vitamin C and folates. It has low energy (calories) content; a whole head of lettuce plant contains about 85 kilojoules of energy only (Riofrio, 2000).

1.4.2 Butterhead

The butterhead lettuce varieties have smaller, softer heads of loosely folded leaves. The outer leaves may be green or brownish with cream or butter coloured inner leaves. Some kinds are dark green whereas others are light coloured or purple-red. When these varieties are mature, their heads have creamy interiors. Butterhead lettuce contains 45mg of sodium and 2g of protein per 85g (Riofrio, 2000).

1.4.3 Leaf lettuce

Leaf lettuce has ‘open’ growth and does not form a head. Leaf form and colour varies considerably – some cultivars are frilled and crinkled and others deeply lobed. Colour ranges from light green to red and bronze. Leaf lettuce matures quickly and is the easiest to grow. Frilly lettuce is an excellently flavoured Italian lettuce of the type used in salads and also in many other dishes as a tasty garnish. It is compact, non-hearting with a rosette of finely frilled leaves (Riofrio, 2000).

Lollo Bionda Lobi is a type of leafy lettuce. This variety has extremely frizzy, crinkled and compact leaves and is popular in European salads (Seedaholic.com, 2011). It is a cut-and-come-again variety, i.e. if the outer leaves are picked, the plant will continue to grow. Given the right conditions, this type of lettuce will produce leaves for three months or more (Seedaholic.com, 2011).

1.4.4 Romaine or Cos

Romaine or Cos lettuce varieties form upright, cylindrical heads of tightly folded leaves. The outer leaves are medium green with greenish white inner leaves. Cos is the sweetest of the four lettuce varieties. Cos lettuce is thought to have originated in the eastern Mediterranean area and is believed to be the oldest cultivated lettuce. It is a tasty, succulent lettuce with an elongated head and dark green, long, narrow, crisp leaves (Riofrio, 2000).

1.5 Context of research

The context of this research study is the search by agriculturalists for ways to produce good quality lettuce with improved yield in summer, and the search by homoeopaths for ways to apply their knowledge and medicines to the health of plants as well as humans. Furthermore, homoeopaths wish to make a contribution to the economy through improving vegetable production and availability. This research project replicates commercial hydroponic lettuce growing conditions on a small scale and was conducted at the Agricultural Research Council – the facilities of the Vegetable and Ornamental Plant Institute (ARC-VOPI) at Roodeplaat, Pretoria, South Africa (25º 59’S latitude; 28º35’E longitude; an altitude of 1200 m above sea level). The trial was conducted in a 40% shade net structure in the summer months of February to April 2012.

Lettuce is a cool season crop and requires an optimum temperature of 18°C. It would seem they are not well suited for growth under South African summer climatic conditions due to higher summer temperatures. This is unfortunate as lettuce is very popular in summer in a salad. The commercial consequences are such that the supply cannot always keep up with demand due to longer growth cycles and high spoilage rates due to bolting and tip-burn as a result of high temperature (Maboko & Du Plooy, 2009:199).

1.6 Research studies on homoeopathy and plants

Betti, Trebbi, Majewsky, Scherr, Shah-Rossi, Jäger, and Baumgartner (2009) found 44 studies in which homoeopathy was used experimentally on phytopathological models (*in vitro* and *in planta*) and in field trials. They found significant and reproducible effects with decimal and centesimal potencies, including dilution levels beyond the Avogadro's number.

Majewsky, Arlt, Shah, Scherr, Jäger, Betti, and Trebbi (2009) also found a total of 86 studies in which homoeopathic medicine was applied in a healthy plant setting. Specific effects of decimal, centesimal and fifty millesimal potencies were found including dilution levels far beyond the Avogadro number. Based on their findings, the authors concluded that healthy plant models seem to be a useful approach to investigate basic research questions about the specificity of homoeopathic preparations. In addition, Hopkins (1998) investigated the effect of homoeopathic dilutions of Sulphur, Nitric acid and Camphor on lettuce seed germination, using a germination index. The results indicated that significant biological effects on germination were produced due to application of the homoeopathic dilutions.

This study aims to demonstrate that addition of *Ozonum* to hydroponic nutrient solution can improve the growth ability of lettuce during the summer season by increasing or improving its ability to absorb oxygen.

There is no research information available on the utilization of *Ozonum* in hydroponically grown vegetables or vegetable production.

1.7 The research problem

Cool season crops such as lettuce do not grow well in the South African summer seasons because of the effects of heat stress and, in the case of hydroponically grown lettuce, heat predisposes lettuce to increased incidence of tip-burn and bolting, and a reduction of oxygen levels in the nutrient solution.

1.8 Aim

The general aim of this research was to measure the effect of homoeopathic *Ozonum* 6CH, *Ozonum* 15CH and *Ozonum* 30CH on the growth and yield of Lollo Bionda Lobi lettuce cultivar grown in a closed hydroponic system in South African summer climatic conditions, measured in terms of: (i) dissolved oxygen concentration in the nutrient solution; (ii) leaf fresh mass; (iii) leaf dry mass; (iv) number of leaves; (v) leaf area; (vi) chlorophyll content; (vii) root fresh mass;(viii) root dry mass; (ix) bolting; (x) tip-burn; and (xi) specific plant leaf mineral content. This effect will be compared to the effect of a placebo control consisting of 96% alcohol, which is the percentage alcohol the homoeopathic mother tinctures are prepared in.

The specific objectives of the study were to determine

1. The effect of *Ozonum* concentration on plant growth and yield of leafy lettuce;
2. The impact of heat stress in terms of bolting and tip-burn;
3. The differences in specific plant leaf minerals content between the experimental groups and control group, and
4. The differences between dissolved oxygen (DO) concentrations in the nutrient solution of the experimental groups and control group.

1.9 Benefits of this study

Ozonum did not show a beneficial effect on lettuce growth and yield, except for *Ozonum* 30CH, which showed a reduced tendency of tip-burn. This study has added to the body of evidence related to homoeopathy and agriculture. The effect of *Ozonum* 30CH on heat stress in lettuce as evidenced by degree of tip-burn needs to be investigated further.

CHAPTER TWO

LITERATURE REVIEW

2.1 Hydroponics

The word 'hydroponics' is derived from two Greek words: '*hydro'* meaning water, and '*ponos'* meaning labour (Harris, 1992). Hydroponics can be defined as a system where plants are grown in growth media other than natural soil (Harris, 1992). All the nutrients are dissolved in the irrigation water and are supplied on a regular basis to the plants (Niederwieser, 2001). According to Copper as cited by Olympios (1997), the origins of hydroponic agriculture started in the 17th century when, Boyle attempted to grow plants in "vials containing nothing but water" in 1666. His report indicated that spearmint (*Raphanza aquatica*) survived for nine months.

Hydroponics first came to Africa during the 1950's and commercial farms were started at that time. In South Africa, hydroponic vegetable production is almost always done under protective structures such as green houses and shade netting (Niederwieser, 2001).

2.1.1 Advantages of hydroponic vegetable production

Hydroponic vegetable production could have all or some of the following advantages:

- Hydroponically produced vegetables can be of high quality and need little washing.
- Soil preparation and weeding is reduced or eliminated.
- It is possible to produce very high yields of vegetables on a small area because an environment optimal for plant growth is created.

- All the nutrients and water that the plants need are readily available to the plant root stem.
- One does not need good soil to grow vegetables.
- Water is used efficiently.
- Pollution of soil with unused nutrients is greatly reduced (Niederwieser, 2001).

2.1.2 Disadvantages of hydroponic vegetable production

Disadvantages of hydroponic vegetable production include:

- Hydroponic production is management, capital and labour intensive.
- A high level of expertise is required.
- Daily attention is necessary.
- Specially formulated, soluble nutrients must always be used.
- Pests and diseases remain a big risk.
- Finding a market can be a problem (Niederwieser, 2001).

2.2 Hydroponic systems

Two types of hydroponic systems are commercially used in South Africa, namely, the Gravel Film Technique (GFT), which is the most popular closed hydroponic system, and the open bag system (Maboko, Du Plooy & Bertling 2011).

2.2.1 Nutrient Film Technique

According to Morgan (2011), the Nutrient Film Technique (NFT), of which the gravel film technique is an adaption, was developed during the late 1960's by Dr Allan Cooper at the Glasshouse Crops Research Institute in the United Kingdom. With the NFT system, a thin film of nutrient solution flows through plastic channels, which contain the plant roots with no solid planting media. The root mat develops partly in the shallow stream of re-circulating solution and partly above it. It is extremely important to maintain this basic principle of a nutrient film because it ensures the root system has access to adequate oxygen levels.

Key requirements for the NFT are as follows:

- The gradient down which the water flows must be uniform and not subject to localized depressions, not even a depression of a few millimeters;
- The inlet flow rate must not be so rapid that a considerable depth of water flows down the gradient;
- The width of the channels in which the roots are confined must be adequate to avoid any damming up of the nutrient by the root mat. If inadequate, it is to be expected that yields will be directly proportional to channel width; and
- The base of the channel must be flat and not curved, because otherwise there will be a considerable depth of liquid along the centre of the channel because of the shape of the base. (Morgan, 2011.)

A main advantage of this closed hydroponic system in comparison with the other hydroponic techniques is that a largely reduced volume of nutrient solution is required. This may be more easily heated during the winter months to obtain optimal temperatures for plant growth, or cooled during hot summers to avoid bolting and other undesirable plant responses (Morgan, 2011).

2.2.2 Gravel Film Technique

The Gravel Film Technique (GFT) is a modification of the Nutrient Film Technique and is the most popular closed hydroponic system in South Africa, and is commonly used by commercial growers to produce leafy vegetables. A gravel film system consists of a well balanced nutrient solution, which is pumped to the top of hydro-lines and flows down a 3% slope by the pull of gravity. The nutrient solution is collected in a reservoir at the bottom and is pumped back to the hydro-lines (re-circulated). The major role of the gravel is to support the plant, to cover the root system and to protect the nutrient solution from direct sunlight (Niederwieser, 2001).

2.3 Plant Physiology

Of the external factors affecting the rate of respiration in plants, temperature and moisture are the most important, although carbon dioxide, light and oxygen do have some direct influence (Sharma, 2004:136).

Extensive research work has been conducted on the effect on plants of different levels of oxygen concentrations in the water or hydroponic solution and the correlated effect on growth (Cherif, Tirilly & Belanger, 1997; Quickgrow, 2008). The current study is particularly interested in temperature and DO as factors in plant growth. Several studies demonstrated that plants grow better at certain temperature ranges and above certain temperatures there could be insufficient oxygen available to the roots, resulting in the hindering of absorption of nutrients from the soil (Huang, Liu & Xu, 2001; Nxawe, Laubscher & Ndakidemi, 2009).

Common ways of moderating temperature in a hydroponic environment in greenhouses include ventilation and evaporative cooling to reduce heat load. Leow and Wong Shaou-Yi (2006) have successfully experimented with chilled nutrient solution or chilled nutrient mist to chill the root zone of cool season plants. They succeeded in raising these cool season plants in NFT (Nutrient Film Technique) channels and in aeroponic systems in temperate climates. Substances such as Silica dioxide can be added to the nutrient solution to further enhance growth, increase tolerance to heat stress, and increase resistance to fungal disease of the plants (Silica Additives, 2011).

Bacchus (2010) found that biodynamic silica sprays produced lettuce at harvest with higher dry matter and crude protein contents in fresh leaves, although there was no statistically significant effect on lettuce fresh head yield, nitrogen uptake, plant sap nitrate concentrations, NO_3 to TKN ratio, and amino acid content.

2.3.1 Tip-burn

Tip-burn is a physiological symptom caused by unfavourable growing conditions. According to Saure (1998), and Barta and Tibbitts (1991), it is a calcium-related disorder, caused by localized Ca^{2+} deficiency of leaves or leaf margins. This is due to insufficient calcium transport to enlarging areas of susceptible leaves, as opposed to insufficient calcium uptake by the roots. It can also be seen as a stress-related disorder. Calcium movement in plants is passive and mostly regulated by water movement in the xylem, expanding leaves that do not transpire actively, and thereby depleting the supply of calcium (Collier & Tibbitts, 1982). Enough calcium to prevent tip-burn is delivered to the plant when pressure gradients allow mass flow of water from roots. Consequently, factors that affect water potential gradients, including soil moisture, soil salt, oxygen content and soil temperature, have been associated with tip-burn (Hunter, Jones & Walsh, 2002).

Leaves of lettuce plants are particularly susceptible to incidence of tip-burn, especially when they are forming a head, as they do not freely transpire and therefore contain low levels of calcium (Collier & Tibbitts, 1982). Decreasing humidity during the day or raising humidity close to saturation levels at night increases root pressure and is helpful to reduce tendency to tip-burn development (Morrow & Wheeler, n.d.). According to Both (2003), lettuce plants need to transpire at least 13.5 ounces (400 ml) of water per gram of dry mass accumulated in order to be free of tip-burn.

External factors may cause stress, or they may increase the susceptibility to stress. Tip-burn is assumed to occur if stress exceeds stress tolerance. It starts as small spots or narrow lesions along the edge of the leaf, light yellow or off-white in colour. These enlarge and become distinct yellow or brown and have irregular veined margins (Canadian Food Inspection Agency, 2011).

Lorenz & Maynard (as cited by Jenni, 2005) state that tip-burn could be a result of high daytime temperatures. Tip-burn is a major lettuce production problem in tropical and sub tropical regions (Saure, 1998:133). Maboko and Du Plooy (2007:319) point out that tip-burn can occur at temperatures as low as 25°C - 28°C.

Barta and Tibbitts (1991) found that high light exposure does not always result in tip-burn damage and low light intensity does not guarantee freedom from tip-burn. Plants grown in greenhouses are affected sooner and more intensely by tip-burn than field-grown plants, although they receive only half of the total amount of radiation of field-grown plants, and almost no UV radiation. Both (2001) determined that the plants need to transpire at least 400 ml per gram of dry mass accumulated in order not to develop tip-burn and no more than 17 mol-m^2-d^1 of light energy was required to produce good yields without tip-burn manifesting and ruining the crop.

Other factors that could reduce tip-burn incidence include using non-susceptible cultivars (Holtzchulze, 2005). This is in agreement with Saure (1998), who stated that tip-burn is a complicated entity with several affecting factors that can make regulation of this plant physiological disorder challenging. In hydroponically grown lettuce, reducing water nutrient levels at night or circulating 100 ppm calcium nitrate solutions at night reduced incidence of tip-burn in butterhead lettuce compared to plants that received a constant complete nutrient solution. Also, shading with up to 35% shade cloth can reduce tip-burn during hot summer months (Valenzuela, Kratky & Cho, n.d.).

2.3.2 Bolting

Bolting is premature flowering and seeding (Simply Hydroponics and Organics, 2008). This phenomenon occurs when high temperatures shift a plant from a vegetative state to a flowering state. Bolting can be enhanced in warm weather and long days (Dufault, Ward & Hassell, 2009).

Bolting is a problem for lettuce growers, especially in warmer seasons as the yield and marketability of the crop is affected. Environmental factors have a tendency to stimulate bolting. According to Abbott and Jackson (2009) it is possible to genetically breed lettuce cultivars that can ‘delay bolting’ and improve the ‘holding ability’ of commercial lettuce.

Higher temperatures during the summer season are associated with bolting as reported by Glenn (1984). Maboko and Du Plooy (2007:319) state that during the hot summer months in South Africa, crisp head lettuce cultivars are bitter and bolt due to high nutrient solution concentrations and ambient temperatures. This often results in unmarketable yield.

Bolted plants are undesirable to growers because they are bitter and have a lower yield due to the development of the flowering structure, which competes with the root for carbohydrates and consumes the root reserves (Maboko & Du Plooy, 2007:322; Glenn, 1984).

Chun, Watanabe, Kozai, Kim and Fuse (2000) showed that spinach plants grown under a longer photoperiod during transplant production resulted in longer flower stalks at harvest. The long photoperiod and/or high temperature after transplanting, therefore, promoted flower stalk elongation. To overcome these issues, seedlings are generally sown early in spring to take advantage of lower temperatures (Glenn, 1984).

2.3.3 Root zone physiology

Insufficient DO reduces the permeability of the roots to water and permits an accumulation of toxins, inhibiting sufficient water and mineral uptake to support plant growth (Morgan, 2011). It is well understood that insufficient oxygen within plant root zones can greatly diminish plant productivity (Zheng, Wang & Dixon, 2007).

2.4 Heat stress

Cool-season annual crops, such as lettuce, are more sensitive to hot weather than warm-season annual crops. Heat stress is defined as the rise in temperature beyond a threshold level for a period of time sufficient to cause irreversible damage to plant growth and development. In general, a transient elevation in temperature, usually 10°C - 15°C above ambient, is considered heat shock or heat stress. Yield quotas are reduced in crops that undergo heat stresses due to physiological and biochemical changes which limit growth (Hall, 2012).

For obvious reasons, this is a driving factor to find ways to continue to grow heat sensitive crops in regions where the temperature has a tendency to limit growth and yield (Wahid, Gelani, Ashraf & Foolad, 2007). Thompson, Langhans, Both and Albright (1988) verified that it is possible to produce a quality lettuce crop at continuously elevated greenhouse aerial temperatures (above 24°C during the light period) on condition that the nutrient solution is kept around 24°C, indicating lettuce production is possible in warmer climates when the temperature of the root zone is kept at suitable levels. Using a floating hydroponic system, this study demonstrated how important the temperature of the hydroponic solution (root temperatures) was to improve growth, when ambient temperatures are at extremes (17°C and 31°C). Lettuce was exposed to different air temperatures day / night (17°C / 12°C), (24°C / 19°C), (31°C / 26°C) with the roots in a floating hydroponic solution at controlled temperature (17°C / 24°C /31°C).

Thompson et al (1988) found that an ambient temperature of 24°C with a hydroponic solution of 24°C was the optimum temperature at which most growth occurred. Growth parameters including, head size, leaf colour, thickness and root structure were the best in 24°C hydroponic solutions, irrespective of air temperatures. The positive effects of 24°C hydroponic solution temperature can be understood more easily with understanding of what occurs in the root zone physiology and DO content and not on the temperature gradient between hydroponic nutrients solution and ambient temperatures. The optimal 24°C temperature of the hydroponic solution allows quality lettuce growth to occur at elevated air temperatures. It seems that it is important to optimize both hydroponic solution and ambient temperatures to get best growth rate from lettuce crops. When root zone temperature is optimized, it enables a traditionally cool temperature crop, such as lettuce, to grow under warmer air temperatures.

Jie and Kong (1997) studied the effect of plant root zone temperature on growth, using photosynthetic characteristics as a measurement parameter. The authors found results similar to that of Thompson et al (1988), where chilling the plant root zone improved photosynthetic capacity and yield of the plants by approximately 20 - 30%.

2.5 Dissolved oxygen

According to Home Hydro Systems (2011), hydroponic nutrient solution is not just a mix of fertilizer salts and water. One of the most important aspects of hydroponic nutrient solution is dissolved oxygen (DO), which is vital for the health and strength of the root system, and it is essential for nutrient uptake.

Like all organisms, plants breathe via respiration. Plant root systems require oxygen for aerobic respiration, an essential plant process that releases energy for root growth and nutrient uptake. In many water-based hydroponic systems, the oxygen supplied for plant root uptake is provided mostly as DO in the nutrient solution as well as a zone of aeration provided by the fall of the nutrient solution from the surface back to the reservoir water level (Home Hydro Systems, 2011).

Injury from low (or no) oxygen in the root zone can take several forms and these will differ in severity between plant species. Often the first sign of inadequate oxygen supply to the roots is wilting of the plant under warm temperatures and high light intensities (Home Hydro Systems, 2011).

Dissolved oxygen is essential for root formation and root growth. The importance of oxygen in supporting the intensive metabolic processes associated with root formation and subsequent growth in the rooting medium during adventitious root formation is well-recognized, but the actual requirements of oxygen have seldom been studied. Oxygen affects the timing of rooting, rooting percentage, number of roots and root length (Soffer & Burger, 1988).

According to Home Hydro Systems (2011), the temperature of the hydroponic nutrient solution affects DO levels and root respiration rates – as the temperature of the solution increases, the ability of that solution to hold DO decreases. This means, for instance, that when the temperature of a hydroponic solution increases during the course of a day from 20°C to 30°C, the requirement for oxygen will double while the oxygen carrying capacity of the solution will drop by 25%. In such a situation, DO in the solution will be much more rapidly depleted and the plants can suffer from oxygen starvation (commonly known as 'root rot') for a period of time.

Soffer and Burger's (1988) study using woody (Ficus) and herbaceous (Chrysanthemum) cuttings proved that dissolved oxygen is essential to root formation and root growth. Lowering the DO concentration in the nutrient solution increased the time required to form adventitious roots, reducing rooting percentages, reducing number of roots formed per cutting, and reducing average root lengths. In this study, DO concentrations were measured using a dissolved O_2 meter, where the readings were taken from 3 different environments of the plant stem, namely, (1) immersed in water, (2) surrounded by a mist and (3) above the mist zone.

Ehret, Edwards, Helmer, Lin, Jones, Dorais and Papadopoulos (2010) carried out research study in soilless culture under greenhouses to determine the effect of oxygen enriched nutrient solution on yield and shelf life of cucumber and pepper plants. Only the cucumber plant growth improved under high oxygen level in the rooting zone, in pumice growing medium under heavy irrigation. Unfortunately this is impractical to implement from a commercial perspective.

Zimmerman (as quoted by Soffer & Burger, 1988) has shown that cuttings from various plant species require different levels of oxygen, for rooting in water. Measurements of DO concentrations were irregular and sometimes, after roots emerged, DO concentrations were affected.

According to Goto, Both, Albright, Langhans and Leed (1996), a floating hydroponics system permits greater control of dissolved oxygen concentration amongst lettuce seedlings by addition of O_2 and N_2 gases.

Goto et al. (1996) found that the effects on growth of lettuce plants of varying DO concentrations were minimal with no significant difference in fresh weight, shoot and root dry weights of the plants. No root damage or delay of shoot growth was observed at any of the studied DO concentrations. Interestingly, the critical DO concentration for vigorous lettuce growth was considered to be lower than 2.1 mg/L, while concentrations of at least 4 mg/L are needed for optimum lettuce growth and development (Goto et al. 1996).

Yoshida, Kitano and Eguchi (1997) studied the effects of low dissolved oxygen on hydroponic growth of lettuce plants and found that the number of leaves was hardly affected by the dissolved oxygen concentration, but leaf expansion was depressed at 0.01mM DO concentration due to reduced leaf water content. Furthermore, the leaf fresh and dry mass as well as roots were clearly reduced at 0.01mM DO. Plant growth was not affected by DO concentrations between 0.10 and 0.20mM.. The results suggest that growth of the lettuce plants at the lowest dissolved oxygen concentration (0.01mM) is depressed through leaf turgor loss caused by a decrease in root water uptake.

Promising results were obtained by Suyantohadi, Kyoren, Hariadi, Purnomo and Morimot (2010), who studied the effect of highly concentrated dissolved oxygen on lettuce plant growth in a deep hydroponic culture under low greenhouse temperatures. High levels of DO were pumped into the nutrient solution during winter seasons. The average temperature of the nutrient solution was 12°C and the electric conductivity was 1.0 mS/cm. They found that a high concentrated DO (20-30mg/l) supply was effective in improving the lettuce plant growth. The growth of the lettuce plant treated with high levels of concentrated DO (23mg/l) was about 2.1 times larger than that treated with just fully aerated room air. These findings are in contrast to a study by Zeroni, Gale and Ben-Asher (1983), who found only a minor change in growth rate in tomato plants when DO was increased from that of ambient air up to 30mg/l.

2.5.1 Mechanism of oxygen at the root zone

According to Morgan (2011), often oxygen levels at the root zone are overlooked with preference given to factors such as calcium boosting formulations, optimal electrical conductivity (EC), carbon dioxide enrichment, correct ratios of potassium to nitrogen, and the process of photosynthesis. This can be fatal, though if the process of respiration is ignored at the root zone, as this is what liberates metabolic energy for root growth, nutrient and water absorption. If DO levels are below optimum, the roots will become hypoxic, and consequently, show reduced growth rates. In hydroponic conditions where potentially all growing factors are supplied at optimum rates, there should be no shortage of oxygen when fall back cascades are put in place, and maybe even oxygenation of the water. It is often overlooked that due to the optimum growing conditions, the mature plants are growing at exaggerated rates requiring larger amounts of oxygen than the root zone can usually supply.

2.5.2 Oxygen and root disease

Frequently the first sign of insufficient oxygen supply to the roots is wilting of a plant, during the warmest part of the day when temperatures and light levels are highest. Insufficient oxygen reduces the permeability of roots to water and there will be an accumulation of toxins. Therefore water and minerals will be unable to be absorbed in sufficient quantities to support plant growth especially under ‘stress’ conditions including opportunistic pathogenic infections such as *Pythium* root rot (Quickgrow, 2008)

2.6 Ozone

Ozone has always been linked to the presence of electrical storms, but it was only in 1867 that Christian Friedrich Schönbein identified it as a chemical compound (Rubin, 2001). Ozone is a triatomic oxygen molecule, an allotrope of oxygen, which is unstable, breaking down with a half life of about half an hour, into normal O_2. It forms by the action of UV light on O_2 and atmospheric lightning strikes (Understanding Ozone, 2012).

Naturally occurring ozone in the stratosphere has no detrimental effects on plant life. Ground level ozone caused by pollutants causes problems and is formed by the action of the sun on combustible fuel pollutants (Understanding Ozone, 2012).

2.6.1 Ozone production

According to Uherek (2006), ozone production can be described in the following Chapman equations:

O_2 + hv Æ 2 O k1 (s-1) (1)

O + O_2 + M Æ O_3 + M k2 (cm6 molecule-2 s-1) (2)

O_3 + hv Æ O + O_2 k3 (s-1) (3)

O + O_3 Æ 2 O_2 k4 (cm^3 molecules-1 s-1) (4) molecules-1 s-1) (4)

M is any non-reactive species that can take up the energy released in reaction (2) to stabilize O_3. Ozone is not a very stable molecule and (without the presence of M) the O_3 formed by the collision of O_2 and O would immediately fall apart to give back O and O_2. Given that N_2 and O_2 are the major components in the atmosphere, M is either O_2 or N_2.

The rate constants k1 and k3 depend on light intensity, which in this case is the light intensity of the sun (Kinetics of Atmospheric Ozone n.d.).

In the case of ozone production using corona discharge (a technique applied in this in current study), the light intensity is produced by the spark of the corona discharge. The electrical current causes the “split” in the oxygen molecules (Ozone Solutions, n.d.).

An electrical discharge (a spark) splits an oxygen molecule into two oxygen atoms. An electrical discharge can also be referred to as a corona discharge. These unstable oxygen atoms combine with other oxygen molecules. This combination forms ozone (O_3). See Figure 1 below.

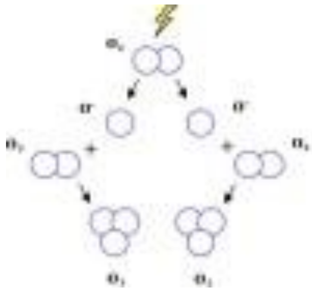


Figure 1 Production from corona discharge of ozone from oxygen (Corona discharge, n.d.)

2.6.2 Biological effects of ozone

According to Mawsouf (2011) ozone has the following actions:

1. Inactivation of bacteria, viruses, fungi and protozoans:
   - Disrupts the integrity of bacterial cell envelope through oxidation of the phospholipids and lipoproteins.
   - Damages viral capsid and upsets reproductive cycle by disrupting virus-to-cell contact with peroxidation.
   - Inhibits cell growth at certain stages in fungi.
2. Enhancement of circulation:
   - Reduce clumping of red cells and restore its flexibility and oxygen carrying ability.
   - Arterial oxygen partial pressure increases and viscosity decreases leading to better tissue oxygenation.
   - Oxidizes plaque in arteries allowing removal of the breakdown products.
3. Stimulation of oxygen metabolism:
   - Increases red blood cell glycolysis rate $\rightarrow$ stimulation of 2,3-diphosphoglycerate (2,3-DPG) $\rightarrow$ increase of oxygen released to tissues.

- Activates Krebs cycle by enhancing oxidative carboxylation of pyruvate $\rightarrow$ stimulating production of ATP.

4. Stimulation of the production of the enzymes which act as a free radical scavengers and cell wall protectors: Glutathione Peroxidase, Catalase, and Superoxide Dismutase.
5. Production of Prostacycline $\rightarrow$ vasodilatation.
6. Activation of the immune system: stimulates production of Interferon, Tumor necrosis factor (TNF) and Interleukin 2.

2.6.3 Ozone in the atmosphere and plants

According to LeBlanc (n.d.) sometimes in summer some plants exhibit an almost autumn look, which can be caused by high levels of ozone pollution produced in the troposphere. Ground level ozone can harm plants by entering the leaves and reacting with the molecular links between the carbon atoms (carbon-carbon bonds) in the plant's photosynthetic machinery. In this way entire ecosystems are affected causing reduction in agricultural yields. Annual crop yield loss caused by ozone in the United States alone is estimated to be $500 million. This was confirmed by Wittig, Ainsworth, Naidu, Karnosky and Long (2009), who state that tree growth measured as biomass is already 7% less than that in the late 1800s, and the decline is expected to be 17% by the end of the century. According to Spash (1994), there is a similar phenomenon in Europe. Matoušková, Novotný, Hunová and Buriánek (2010) state that factors ideal for ozone production (intensive solar radiation, high temperature and low relative air humidity) help to induce stomatal closure, leading to reduced yields. Therefore, it is not logical to assume elevated ozone concentrations alone to necessarily cause injury to native plants and lead to growth reduction. Only the internal ozone dose obtained by plant stomata is harmful. Thus, ozone effect on agriculture and vegetation cannot be based on ozone concentrations alone.

According to Temple, Jones and Lennox (1990), testing the effect of photochemical oxidant air pollutant ozone (at ambient ozone concentrations) on growth and yield of common garden crops, broccoli (*Brassica oleracea* L.), lettuce (*Lactuca sativa* L.), and onion (*Allium cepa* L.), found that severe outer leaf injury occurred but leaf yields were not affected in the lettuce and broccoli test group, unlike the onion plants which were more susceptible to yield losses, and then it was only 5% loss in one of the cultivars tested.

2.6.4 Ozone in agriculture

Ozonated water used in crop irrigation provides increased levels of oxygen to the plant via the root, thus effectively removing viruses, bacteria, fungi and other micro organisms without forming toxic compounds or leaving harmful residues behind, since it decomposes back to oxygen. Ozone further improves respiratory processes in the plant at cellular level, allowing for faster plant growth in a shorter period of time, resulting in a larger harvest in a shorter period. This is achieved with remarkable savings in the amount of water used for irrigation, cost of fertilizer and other inputs (Creative OZ-Air, 2012).

2.6.5 Ozonation and plant growth

Bourbos and Barbopoulou (2005) performed a study using ozonated water (ozone concentrations of 4mg/l) in combination with a biological product, Trichomic®, on tomato plants, instead of using soil chemical treatments. The evaluation was based on the following 2 criteria (i) fruit production and daily growth of plants, (ii) disease processes of *Fusarium* foot rot, and/or *Fusarium* wilt. Results for fruit production indicated increases of 39.7% and 40.4%, when ozone was used alone, either before or before and after planting. With the use of Trichomic® alone or with ozone, increases ranged from 39.2% to 40.5%. The highest plant growth rate was observed where Trichomic® was applied after ozone. The lowest percentage of diseased plants was observed following double applications of ozone or ozone followed by Trichomic®.

Favorable results were also obtained by Violleau, Hadjeba, Albet, Cazalis, and Surel (2008) who with the use of oxygen and oxygen/ozone gas mixtures managed to reduce seed dormancy and improve germination rate vs controls in corn seeds.

Earlier germination leads to more germinated seeds and root growth for seeds, from the time of germination.

Pérez, Sanz, Ríos, Olias and Olías (1999) tested the effect of ozone treatment on the postharvest quality of strawberries. Strawberries (*Fragaria ananassa Duch*. cv. Camarosa) were stored at 2°C in an ozone concentration of 0.35 ppm. After 3 days they were moved to 20°C to mimic retail conditions (shelf life). The following criterion was evaluated, (i) fungal decay, (ii) colour, (iii) sugar and acids distribution, and (iv) aroma. Ozone treatment was ineffective in preventing fungal decay in strawberries after 4 days at 20°C. Significant differences in sugars and ascorbic acid content were found in ozone-treated strawberries. At the end of cold storage, the vitamin C content of ozonated strawberries was three times that of control fruits. In addition, a reduction in aroma with a reduction of 40% in emission of volatile esters was observed.

2.7 Homoeopathy

Homoeopathy was founded by Dr Samuel Hahnemann in about 1796. He was an allopath and chemist who became increasingly disillusioned by the treatment methods of his days and the poor results obtained from medicine. When Dr Hahnemann was translating medical texts from one language to another, he observed that the symptoms of a patient suffering from malaria was very similar to the symptoms of a person that ingested Cinchona bark. It was at that moment that homoeopathy began. Conducting several experiments on himself and on some of his patients, he formalized the ‘law of similars’ and homoeopathic method (Jouanny, 1991).

Jouanny (1991) has articulated the definition of homoeopathy in a scientific manner that assists homoeopathy to be better understood by the scientific minds of our days, that being: “Homoeopathy is a therapeutic method which clinically applies the law of similars and which uses medicinal substances in weak or infinitesimal doses”.

The law of similars can further be explained by the following:

- Pharmacologically active substances produce in healthy individuals a set of symptoms characteristic of that substance;
- Every ill subject shows a set of morbid symptoms, which are characteristic of his/her disease, e.g. the manner in which the patient acts or feels due to his/her disease;
- The cure of the disease is shown by the objective disappearance of the morbid symptoms in the ill subject as a result of the prescription of infinitesimal doses of the substance that experimentally produces those same symptoms in the healthy individual (Jouanny, Crapanne, Masson, & Dancer, 1996).

Homoeopathy is based on the fundamental principle of 'like cures like', that is, "Any substance that can produce a totality of symptoms in a healthy human being can cure that totality of symptoms in a sick human being" (Vithoulkas, 1980:92). Hahnemann observed that this law was only fully successful when very weak or infinitesimal doses were used.

A practical example is bee's venom which, when administered to healthy individuals, causes a sudden onset of pinkish red stinging, burning oedema which is relieved by cold water. The same venom, when administered in infinitesimal doses, improves or cures stinging, burning eruptions of sudden onset which are relieved by application of cold compresses, but which have another origin, for example, sunstroke or alimentary urticaria (Jouanny, 1991).

Initially, homoeopathy was applied only to human medicinal practices, but was introduced into the veterinary field in 1819 by Johann Joseph Wilhelm Lux (veterinary surgeon) and Ernst Ferdinand Ruckert (physician) in Leipzig with immediate success. Recently, it has been employed in phyto-pathology and agricultural practices, also with success (Gaier, 1991).

2.7.1 Potentization and the question of potency

Homoeopathic potencies consist of matter raised to extremely high rates of vibration, simulating the quality and vibratory rate of the life force that animates the body (Bernard, 1999). Potentization imparts via serial dilutions, the pharmacological message of the original substance, by creating a template of the active principle, through succussion or trituration (Gaier, 1991). Hahnemann found that potentized substances acted more powerfully than crude substances. It is believed that trituration and succussion rendered remedies more potent because of the breaking up or disintegration of thin atomic relationships that place them in a form where they can act directly on the vital force of the individual (Tafel & Boericke, 1917:72).

2.8 Agrohomoeopathy

The use of homoeopathy on plants was first mentioned about 200 years ago by Baron von Boenninghausen, who was the son-in-law of Hahnemann, the founder of homoeopathy. Boenninghausen noted that the excess or leftover remedies he threw into his plant pots were having an effect on the plants (Homeopathy Plus, 2012).

The homoeopathic method in agriculture activates biological plant processes to accelerate or delay growth. The use of homoeopathic dynamizations ensures no toxicity to the plant or environment and, in some cases, the remedy can actually detoxify the ecosystem involved. From an economic perspective, it brings huge financial saving as there is no comparison in costs between agri-chemicals and pesticides compared to homoeopathic preparations (Moreno, 2008).

2.8.1 Biodynamic agriculture

Other similar practices to homoeopathy in agriculture include biodynamic agriculture, based on agricultural methods devised by Rudolph Steiner and Eugen and Lily Kolisko (Garuda Biodynamic Institute, n.d.). Plant material is combined in certain recipes to facilitate plant growth or pest inhibition. Dilutions of the individual preparations are 1 part to 9 parts water and alcohol rhythmically shaken for two and a half minutes. This dilution process is then repeated up to 30 times. The final product is generally utilised as a spray (Atkinson, 2008). The Garuda Biodynamic Institute is based in Te Puke, New Zealand, and is focused on developing the agricultural applications of biodynamics. Their website has several case studies of success in agriculture, and describes four successful formal research projects, three of which were conducted by the Horticulture and Food Research Institute of New Zealand Limited (Garuda Biodynamic Institute, n.d.).

2.8.2 Homoeopathic agricultural research

Homoeopathic plant research has been used as a popular model in homoeopathic research circles as it eliminates the arguments against homoeopathy and the placebo effect, so often raised, especially in human scientific trials (Coulter, 1980; Linde *et al.,* 1997). Plants have a lower level of consciousness than that of human's; therefore, they are not influenced by the placebo effect, and avoid any ethical issues (Hopkins, 1998; Him Lok, 2001).

2.8.2.1 Homoeopathic plant studies

Betti et al (2009) found 44 studies in which homoeopathy was used experimentally on phytopathological models (*in vitro* and *in planta*) and in field trials. In general, Betti et al. (2009) found significant and reproducible effects with decimal and centesimal potencies, including dilution levels beyond the Avogadro's number. The authors still believe much more experimentation is needed, especially at a field level, and on potentisation techniques, effective potency levels and conditions for reproducibility.

Majewsky et al. (2009) found a total of 86 studies in which homoeopathic medicine was applied in a healthy plant setting. Specific effects of decimal, centesimal and fifty millesimal potencies were found including dilution levels far beyond the Avogadro number. They concluded that healthy plant models seem to be a useful approach to investigate basic research questions about the specificity of homoeopathic preparations. Schofield (1984), who reviewed the use of homoeopathy in agriculture, found that low and high dilutions promoted growth.

Brizzi and Betti, (2010) statistically assessed 3 experiments involving wheat germination rates, wheat plant growth (stem length and root growth) and a phytopathological plant model involving tobacco plants inoculated with the tobacco mosaic virus (TMV) as a form of biotic stress. In all of the three experiments the homoeopathic treatment used was *Arsenicum album* (arsenic trioxide) in potencies between 5DH and 45DH with distilled water as a control. In the TMV experiment, distilled water was also dynamised (potentised) and used as a treatment. *Arsenicum album* 45DH was found to be the most effective potency out of all potencies tested compared to the control. *Arsenicum album* 45DH had a significant stimulatory effect on wheat seedling germination and wheat plant growth compared to the control, and in the TMV experiment produced a highly significant mean reduction of necrotic lesions. In that experiment, dynamised water also had a significant reduction effect on TMV lesions, suggesting that solvent dynamisation alone is able to induce effects similar, but weaker, to homoeopathic *Arsenicum album*.

Boff, Madruga, Nunes and Boff (2008) conducted field experiments in Brazil in response to concerns regarding high pesticide use and chemical residues in food. They worked with potato farmers who were attempting to switch from regular commercial farming techniques to more holistic and organic anti-pest methods. Homoeopathic *Chamomilla 60CH, Silicea 60CH, Thuja 60CH, Kali 60CH, and Phytophthora infestans 60CH, and* homemade preparations of *Bordeaux mixture at 0.3% and propolis extract at 0.5%* were combined with water at a rate of 12 ml per litre and applied via a foliar spray at 2 weekly intervals. The control group consisted of non-sprayed plots. The statistical design was of randomized blocks with four replicates. The researchers found that there were no significant differences among the different homoeopathic preparations regarding yield, disease and pest intensity, but they did improve yield in comparison to the untreated plots. Their conclusion was that homoeopathic preparations are as good as the Bordeaux mixture, a standard spray generally used on organic farm systems. Unfortunately this study did not specify which Kali salt was used as a homoeopathic application.

Bonato and Silva (2003) studied the effect of homoeopathic dilutions of Sulphur (5CH up until M) on the growth and productivity of radish grown in 3 litre vases (pots). The Sulphur dilutions were applied in the proportion of twenty drops (1.5ml) per litre of water. Each vase received 100ml of the solution every seven days. The application of *Sulphur* improved the general conditions of the plants in practically all the studied variables, when compared with a control.

Shah-Rossi, Heusser and Baumgartner (2009) studied the effects of a homoeopathic complex called Biplantol SOS® on control of *Pseudomonas syringae* infection in *Arabidopsis thaliana* plants. The plants were treated before and after infection. Plants were fully plunged upside down for 30 seconds into 20 ml of the homoeopathic preparation or the control solution. The remaining solution was added to the irrigation water. Compared to Bion® (a common SAR inducer used as positive control), the magnitude of the treatment effect of Biplantol was about 50%. The authors concluded that homoeopathic formulations might have a potential for the treatment of plant diseases after further optimization.

In a study by Datta (2006) the effect of homoeopathic *Cina* M.T. and *Cina* 200CH was evaluated in combating the nematode *Meloidogyne incognita* (also known as root-knot) on Mulberry trees, in the form of a foliar spray. All treatment groups experienced significantly reduced nematode infection in terms of root gall number and nematode population in roots. Other growth aspects that improved included fresh biomass of shoot and root, length of shoot and root, number of leaves, leaf surface area, and root and leaf-mass. The inoculated and treated plants were not only less affected by nematodes, but also had a better growth than the uninoculated, untreated control.

Hamman, Koning and Him Lok (2003) examined the effects of homoeopathically prepared gibberellic acid (HGA_3) on the germination performance of barley (*Hordeum vulgare L.)* seeds. The effect of HGA_3 (4CH, 30CH, 200CH) on seed germination rate and seedling development was compared to HGA_3 at a concentration of 0.5g L^{-1} and control (distilled water). From a statistical point of view, the homoeopathically treated seeds resulted in consistently larger seedlings. High-vigour seeds treated with HGA_3 4CH, 30CH and 200CH germinated faster, and roots of medium-vigour seed lots treated in HGA_3 15CH were longer. Biphasic effects of HGA_3 were also demonstrated. As a plant model, germinating barley seeds successfully demonstrated the ability of HGA_3 to produce a biological response.

Hopkins (1998) investigated the effect of homoeopathic dilutions (*Sulphur, Nitric acid and Camphor*) on lettuce seed germination in varying potencies, using a germination index. The results indicated that homoeopathic medication produced biological effects on germination. . Recommendations by Hopkins (1998) included that evaluating potencies above 30CH and testing homoeopathically prepared plant growth regulators. Report of Jones and Jenkins (1981) also indicated that the use of *Pulsatilla* in several dilutions up to 13CH increased the growth of wheat seedlings.

2.9 Preparation and dispensing of plant homoeopathic medication

Vaikunthanath Das Kaviraj is a Dutch homoeopath and author of *Homeopathy for Farm and Garden* (Kaviraj, 2011a). This researcher entered into correspondence with him regarding this research project. His recommendation (09 September, 2011) was that lower potencies be used as the higher potencies could have the opposite effect on oxygen uptake, and that the same dosage of medication be used as for plants rooted in soil. He also recommended that the water be regularly renewed so that a proving is not set up. In this research project the medication (in 6CH, 15CH, 30CH and control) was renewed every 6 days along with the renewal of the nutrient solution.

According to Kaviraj (2011c), homoeopathic remedies should be applied on plants as follows: addition of one 6XH or 6CH potency pill to each 200 ml of water, shake vigorously, and then sprayed on the leaves of the plant or water into its roots. Moreno (2008) reported that the ratio of homoeopathic potency to vehicle used is one drop to one liter of water, to be mixed for one minute. Where larger volumes are required, take this prepared liter and mix it in the water of the container to be used to disperse the medication. The Moreno (2008) methodology is the one which was followed in this study. Standard procedure for application of the homoeopathic medication to plants is at the root of the plant since the roots are likened to the mouth in humans (Kaviraj, 2011b).

In humans, it is traditional that homoeopathic medication should be taken in a clean mouth and not mixed with other substances such as food or drink that may nullify the effect of the medication. Further to this homoeopathic medication should not be taken when using substances such as camphor, peppermint and essential oils. Also caffeine type substances (coffee) should be avoided as they may antidote the medication's action (Touchstone Naturopathic Centre, 2009). In light of this, there is a valid concern that needs to be addressed regarding whether the effect of the homoeopathic medicine in this study will be nullified, considering that it will be mixed with other chemicals.

Considering the extent to which homoeopathic medicine has been used in an agricultural context as referenced above, it is evident that it can still have an effect even after being added to the soil where it mixes with mineral salts, microorganisms and possibly even toxic compounds before it comes into contact with the plant roots. Further evidence of homoeopathic medication mixed with minerals and still being effective is demonstrated by Biologische Heilmittel Heel GmbH (1997), where homoeopathic remedies are added to isotonic sodium chloride solutions without their effect being neutralized. The HEEL homoeopathic company produces injection ampoules of homoeopathic medication using sodium chloride as a carrier fluid.

2.10 Ozone and oxygen

Ozone is an unstable molecule and will revert back to oxygen after approximately 20-30 minutes (Understanding Ozone, 2012). No homoeopathic work has been found that applies this homoeopathic remedy to plant or agricultural applications.

A leading authority on the use of ozone in a human homoeopathic context is Anne Schadde (1997). She has conducted a proving, the main symptoms of which are available in Appendix D. When looking at the proving symptoms with an eye to their relevance to this study, the following symptoms are pertinent:

- Sensation of lightness in head, as if brain were not getting enough oxygen;
- Floating sensation;
- Difficulty in breathing. Shortness of breath;
- Change in pigmentation;
- Vitiligo (bleached patches).

There are not many cases studies of *Ozonum* in the literature. Hardy (2012) presents three case studies. He points out that ozone is formed in the earth's atmosphere at altitudes of 20 to 50 kilometres through the action of the sun's short-wave ultraviolet radiation. In this way, it provides protection for life on earth from the sun's lethal UV rays. It is understandable, therefore, that symptoms that are amenable to treatment with *Ozonum* would include "floating sensation" (Schadde, 1997) and "like being in a different space ... a bubble", "drifting off into another place, nothingness" (Hardy, 2012). Hardy makes the observation that tiredness is also a major feature or the remedy, which makes sense considering that ozone is generated in the stratosphere where there is no or very little oxygen, and the lack of oxygen can certainly lead to tiredness. One of the case studies he presents is of a 40 year male with depression who exhibits symptoms of "floating" and "tiredness". The patient says, "I am feeling so tired. At half-past eight I want to go to bed. It is strange, in the past I used to feel almost hollow, fragile, as if someone had knocked the breath out of me. As if I could be blown over by the wind, as if there wasn't much substance to me as a person …. It is like I am not on solid ground, a kind of floating, nothing substantial. I am almost on quick-sand, no stability. It is a kind of emptiness." After treatment with *Ozonum* he says: "I feel very relaxed, solid. Very well and more grounded …. Last year you could have pushed me over with a finger …. Before I felt almost transparent as if people could see through me. I had no substance. Since the remedy I feel centred and solid and I have presence. Previously it was like my feet were not on the ground, I was floating."

The potencies of *Ozonum* utilised in this study range from below to above Avogadro's number (the equivalent of 12CH), namely *Ozonum* 6CH, 15CH, 30CH.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Methodology

3.1.1 Study design

The experimental design was a randomized complete block design with four replicates. Where data was measured over time (repeated measurements), time was included as a sub-plot factor in the analysis of variance.

3.1.2 Population and Sample:

In total, 384 plants were grown and divided into 4 replicates. Each replicate contained 96 plants made up of 4 groups (i.e. *Ozonum* 6CH, *Ozonum* 15CH, *Ozonum* 30CH, control (no treatment)) with 24 plants per group. The data sample (plants used for measurements) consisted of 8 plants randomly selected from each group of 24 plants i.e. a total of 32 data plants per replicate.

3.1.3 Statistical Analysis and Procedures'

A hydroponic experiment was performed with four week old (27 days) lettuce seedlings planted in a hydroponic table. Each plot consisted of 24 seedlings. The experimental design was a randomized completed block with four treatments (three concentrations of *Ozonum* and a control) randomly replicated four times. When data was collected over time as repeated measurements as in the dissolved oxygen measurements, the time factor was included as a sub-plot factor in the analysis of variance (ANOVA). All data collected were subjected to an appropriate analysis of variance using the GenStat statistical system (VSN International, 2011). The residuals were examined for deviations from normality, and outliers causing skewness were removed. Fisher's protected t-LSD (Least Significant Difference) was calculated to compare treatment means of significant effects (Snedecor & Cochran, 1980).

3.2 Practical management

Day to day management of the project was done by the staff of the Agricultural Research Council – Vegetable and Ornamental Plant Institute. The researcher was trained in the skills and technology required, and participated in key activities including sowing of seedlings, transplanting of plantlets, initial measuring protocols, final measuring protocols and other important aspects that occurred.

3.2.1 Place of study

The research was conducted at the Agricultural Research Council – Vegetable and Ornamental Plant Institute (ARC-VOPI) facilities at Roodeplaat (Pretoria), South Africa (25º 59'S latitude; 28º35'E longitude; an altitude of 1200 m above sea level). The trial was conducted in a 40% shade net structure (white in colour) in the autumn season months of February to April 2012.

3.3 Planting procedure

Green curly leafy lettuce (cultivar 'Lollo Bionda Lobi') was sown in polystyrene seedling trays of 200 cavities. Twenty eight days after sowing, seedlings were transplanted into a gravel-film technique hydroponic system. The different concentrations of *Ozonum* and control were added to the nutrient solution on the first day and every 6 days thereafter, at the same time that the nutrient solution was changed. Various daily measurements were taken. Plants were harvested 27 days after transplanting, and final measurements of nutrient content and growth parameters were made.

3.3.1 Instruments

The following instruments were calibrated before use and during use if necessary, as per manufacturer's instructions:

- Chlorophyll meter SPAD-502 Plus (Konica Minolta Sensing, Inc. Japan).
- Dissolved Oxygen (DO) meter (Insite IG 1000 D.O. Analyser. USA).
- Electrical conductivity and pH meter (HANNA Instruments, Mauritius).
- Ambient temperature data logger (Tinyview, Gemini data loggers (UK) Ltd).

3.3.2 Experimental protocol

1. Leafy lettuce of cultivar 'Lollo Bionda Lobi' 'Lollo ' (Hygrotech Pty. Ltd, South Africa) was used for this experiment. Seeds were sown in 2 x 200 cavity polystyrene trays. Hygromix® (Hygrotech Pty. Ltd, South Africa) was used as a growing medium and vermiculite used to cover the seeds after seeding.
2. Seedlings were watered using micro-jet sprinklers, 3 times a day (9h00, 12h00 and 15h00).
3. As soon as the first two true leaves were fully developed, foliar fertiliser (i.e. Multifeed® at 1g/L of water) was applied to seedlings daily using a watering can.

4. Four weeks old (28 days) lettuce seedlings were transplanted 5 cm deep by hand into a hydroponic unit table filled with crushed granite rocks of irregular shape with a diameter ranging from 9 to 19mm. The gravel supported the plants to grow upright and covered the nutrient solution so that it was not exposed to sunlight (Figure 2 and Figure 3).

Figure 2. Transplanting lettuce plantlets (28 days) into gravel-film technique hydroponic system.

Figure 3. Transplanting lettuce plantlets from polystyrene trays into the gravel-film technique hydroponic system

5. A gravel-film technique hydroponic system at a 3% gradient was utilized to perform the trial (as per Maboko & Du Plooy, 2007:319). The nutrient solution was released from the top of each gully at a rate of 500 ml per tube per minute, day and night. The solution flowed down the gullies by gravitational flow and was collected at the bottom and pumped back to the top where it was released again (Figure 4).

Figure 4. The gravel-film technique hydroponic system used to perform the trial as described by Maboko and Du Plooy (2007:319).

6. Lettuce seedlings were transplanted in each plot or treatment block of size 1.2 m x 0.8 m (0.96 m^2); at a plant spacing of 20 cm x 20 cm to give a plant population of 24 plants/plot.
7 Plants were subjected to four treatments i.e. three concentrations of *Ozonum* (*Ozonum* 6CH, 15CH and 30CH) and a control (96% alcohol only) and replicated 4 times. All treatments were added to the water in a drop like fashion from a bottle with a dropper The experiment was laid out in a randomized complete block design (Figure 5).

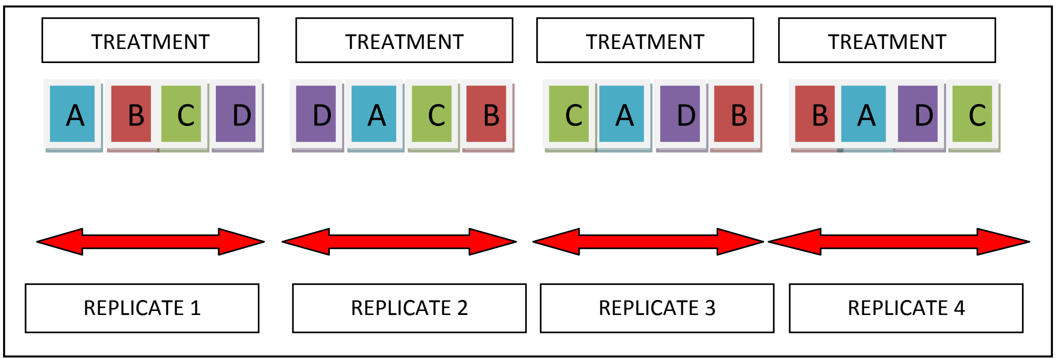


Figure 5. Experimental layout of the trial (four treatments and replicates).

8 Each reservoir contained 70 litres of nutrient and treatment solution and a pump of 55 watts that circulated the solution at the same rate in each group. This solution was replaced with fresh nutrient solution every 6 days, at 08h30.

9 The nutrient and treatment solution was replaced every 6 days. On day 1 then every 6 days thereafter, 70 drops of *Ozonum* potency or control (1 drop per litre of nutrient solution as per Moreno, 2008) was added to 1 litre of water in a measuring cylinder, and gently mixed for 30 seconds (Figure 6). This was added to the reservoir which already contained 69 litres of fresh nutrient solution, making up a total of 70 litres. The whole solution was then mixed for 30 seconds to ensure uniform mixing. Thereafter, this uniform solution was pumped up out of the reservoir and where five tubes (per table) released nutrient solution at a rate of 300ml per minute day and night, thereby ensuring that root system of each plant was bathed in the same uniform solution at the same rate (Figures 7 and 8).

Figure 6. Application of *Ozonum* potencies and control to the nutrient solution.

Figure 7. Ensuring that the nutrient solution is running correctly within the gravel-film technique hydroponic system.

Figure 8. Leafy lettuce ready to be harvested

10 The nutrient solution utilised from transplanting until maturity comprised 1g Hygroponic® and 1g $Ca(NO_3)_2$ per 1L of *water* (Appendix A), every 6 days. The pH of the water was corrected to a range of 5.5-6.5 by using nitric acid before nutrients were added into the reservoir.

Pre-harvest measurements:

- Dissolved oxygen concentrations of the nutrient and treatment solution were measured twice daily at 8h00 and 12h00 along with temperature readings (taken by the DO meter) of the nutrient solution.

- Ambient temperature was recorded daily at hourly intervals over a 24 hour period using data-loggers.
- Chlorophyll content of the leaves was measured on a weekly basis at 12h00 on day 1 then every 7 days after that, straight after measurement of DO. This was performed on 4 selected plants per treatment per replication.
- Electrical conductivity and pH of nutrient solution were tested every second day at 8h00 and maintained within a range of 1.8 to 2.3 mS/cm and 5.8 to 6.1, respectively.

11 Tip-burn was recorded/scored as a percentage, i.e. the number of plants showing tip-burn divided by the total number of plants per plot (24) (as per Maboko, 2012) (Figure 9).

Figure 9. Lettuce plants showing physiological symptoms of tip-burn at leaf edges.

12 Plants were harvested 27 days after transplanting. Data was collected on 8 data plants per treatment block (32 plants) per replicate regarding: number of leaves, (Figure 10) leaf area (cm^2), leaf fresh and dry mass (g), root fresh and dry mass (g) Leaf area of harvested leaves was measured using a leaf area meter (LI-3100 area meter, USA) (Figure 11). Leaves and roots (of data plants) were dried in an oven at 70°C for 48 hours for root and leaf dry mass determination (Figure 12).

Figure 10. Counting the number of lettuce leaves per data plant.

Figure 11. Determining leaf area of harvested leaves using a leaf area meter (LI-3100 area meter, USA).

Figure 12. Lettuce leaf samples placed in an oven for 48 hours at 70°C.

After harvesting, the macro-nutrient content of leaves were tested by the ARC-Institute for Soil, Climate and Water laboratory, using two methodologies as follows (Matejovic, 1995; Jimenez and Ladha, 1993; Dionex Corporation, 1998; Varian, 1997):

- Nitrogen content was determined using combustion and oxygen, using a CNS analyser;
- Calcium, Magnesium, Potassium, and Iron were determined after wet digestion with nitric and perchloric acid by ICP-OES (Zasoski & Burau 1977).

Lettuce leaves were dried in an oven at 70˚C for 48h (Figure 13) and subsequently ground using a mill with a 1 mm sieve to determine the leaf N, K, Ca, Mg, and Fe concentration. The samples were digested with Nitric and Perchloric acid. An aliquot of the digest solution was used for the ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry) determination of Ca, Mg, K and Fe. Nitrogen was determined on dry milled material using a Carlo Erba NA 1500 C/N/S Analyzer.

Figure 13. Post harvest weighing of fresh leaf and root mass.

3.4 Preparation of the treatment and control substances

The homoeopathic potencies of *Ozonum* and the placebo were prepared in liquid form by Natura Homoeopathic Laboratory in Pretoria.

3.4.1 *Ozonum* mother tincture

Ozone was produced by means of the corona discharge method, using ambient air and delivering an ozone output of 500g/h, thus producing an ozone concentration of 0.2-0.3 ppm O_3/ml O_2. The mother tincture *Ozonum* was produced by bubbling this ozonated air through purified water for 10 minutes. The water was purified by means of the Sawyer POINTone^{TM} gravity operated filter (Levien, 2012; Sawyer Products, 2012). Although ozone decomposes much quicker in water than in air, this period of time is still sufficient to enable the ozone concentration to build up in the water so that it becomes saturated with ozone, as the half life is approximately 15 minutes in water at 25°C (Mawsouf, 2012; Lenntech, 2011)

Potentisation of *Ozonum* mother tincture into the appropriate centesimal potencies used in the study (6CH, 15CH, 30CH) occurred in Natura Laboratory (Pretoria) according to Method 5a of the German Homoeopathic Pharmacopoeia (British Homoeopathic Association, 1985) (Levien, 2012). Natura Laboratory has been preparing and supplying homoeopathic single potencies to South African homeopaths and complexes to the general public since 1966 (Natura, 2012).

3.4.2 Control

The control consisted of 96% ethanol from the same batch of alcohol that was used to prepare the final potencies of *Ozonum.*

3.4.3 Application of the treatment

Treatments were applied by combining the treatment (experimental and placebo) with the nutrient solution in the proportion of one drop per a litre of solution. This was performed similarly for the control as well (Moreno, 2008).

This method was selected rather than spray or individual dropper injection for the following reasons:

- it is a common form of application in homoeopathic plant studies (see 2.8.2.1 above);
- it is the simplest considering the hydroponic system being utilised for the study. The system being used is the gravel film technique, which is the most popular re-circulating hydroponic system in South Africa, commonly used by commercial growers to produce leafy vegetables.
- The re-circulation of the nutrient solution ensures an even distribution of ingredients throughout the system.

3.5 Ethics

This study did not involve humans or animals as subjects, so there were no issues of privacy, human rights or animal rights. At all times, care was taken to treat the plants and materials used in this study with respect. No bio hazardous chemicals or dangerous reagents were used, and thus there was no threat or risk to researchers or environment. The lettuce leaves were destroyed after the experiment and not allowed for human consumption.

CHAPTER FOUR
RESULTS

4.1 Lettuce yield measurement

As shown in Table 1, there were no significant differences found across any of the lettuce growth and yield parameters for any of the treatment groups, indicating that the *Ozonum* potencies had no growth effects on any of the lettuce yield parameters. A significant difference ($P < 0.035$) was noted regarding tip-burn percentage, with the highest being recorded for plants treated with *Ozonum* 6 CH although not significantly different to *Ozonum* 15 CH. There was a reduced tendency of tip-burn incidence when plants were treated with *Ozonum* 30 CH compared to other treatments, indicating that there was a lower occurrence in this group, although not significantly different to *Ozonum* 15CH or the control. Application of *Ozonum* 30CH was the only treatment which resulted in a reduced percentage of plants showing incidence of tip-burn.

Table 1. Effect of *Ozonum* concentration on growth and yield of leafy lettuce/plant and percentage tip-burn.

***Ozonum* concentration**	**Number of leaves**	**Leaf area (cm^2)**	**Leaf fresh mass (g)**	**Leaf dry mass (g)**	**Root fresh mass (g)**	**Root dry mass (g)**	**Percentage (%) tip-burn**
6CH	15.47[a]	1241[a]	108.3[a]	8.69[a]	49.41[a]	9.12[a]	32.29[a]
15CH	14.59[a]	1087[a]	92.5[a]	8.25[a]	45.11[a]	9.78[a]	25.00[ab]
30CH	14.25[a]	1256[a]	107.5[a]	9.50[a]	48.58[a]	8.56[a]	12.50 [b]
Control	14.81[a]	1223[a]	110.0[a]	8.94[a]	48.03[a]	8.91[a]	18.75 [b]
[1]F-Prob =	0.517	0.609	0.634	0.340	0.319	0.749	0.035
[2]SEM =	0.568	97.2	10.52	0.462	1.609	0.801	4.02

[3]$LSD_{p=0.05}$ =	n/a	n/a	n/a	n/a	n/a	n/a	12.87

[1] A F-Prob ≤ 0.05 is considered as significant
[2] SEM = Standard error of mean
[3] $LSD_{p=0.05}$ = Fisher's Least significant difference at a 5% significance level. Means within columns with the same letter or letters (a, b) do not differ significantly at the 5% level.

4.2 Dissolved oxygen concentrations

As shown in Table 2, there was significant difference ($P < 0.001$) in dissolved oxygen readings between the means of the two times, 8 am (15.40) and 12 pm (14.21). This is to be expected as the reading at 8am will typically be at a cooler time of the day when the plants are able to absorb more oxygen from the water, whereas the 12pm reading typically occurs at a warmer time of the day, so less oxygen is available for the plant to absorb due to the higher temperature.

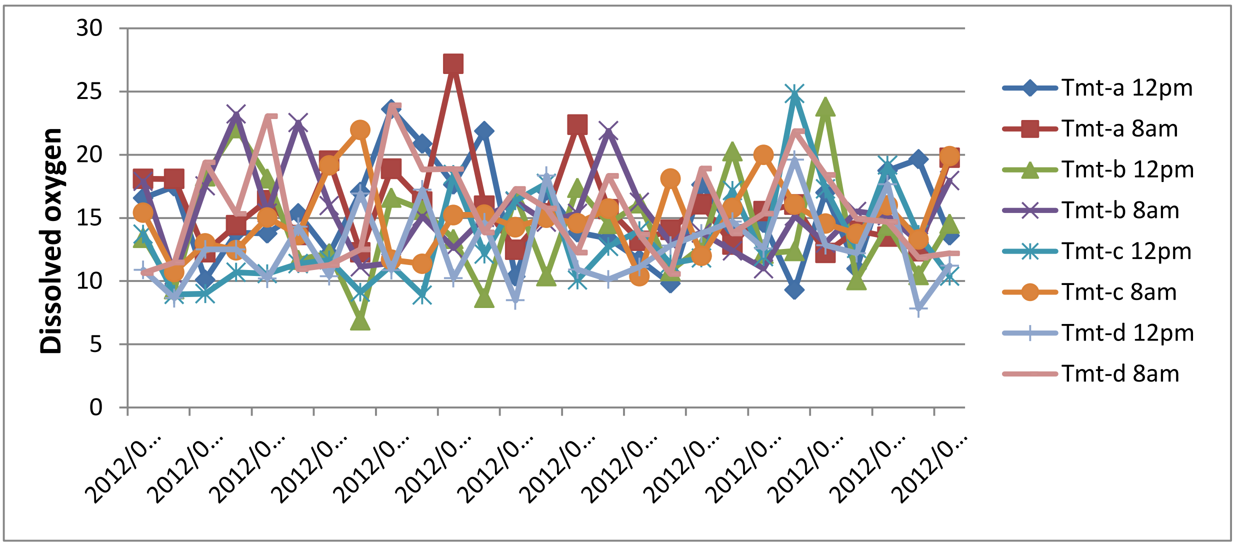
Table 2. Analysis of Variance (ANOVA) for DO with Date and Time as Subplot and Sub-Subplot respectively showing the significance levels of various source effects.

Source	d.f.	s.s.	m.s.	v.r.	F pr.
REP	3	713.16	237.72	4.41	
TMT	3	306.39	102.13	1.90	0.201
Error(a)	9	484.70	53.86	0.89	
DATE	26	1346.88	51.80	0.85	0.677
TMT.DATE	78	4845.33	62.12	1.02	0.439
Error(b)	312	18977.61	60.83	1.29	
TIME	1	533.80	533.80	11.34	<.001
TMT.TIME	3	147.72	49.24	1.05	0.372
DATE.TIME	24	1068.26	44.51	0.95	0.539
TMT.DATE.TIME	72	3373.86	46.86	1.00	0.494
Error(c)	300	14120.20	47.07		

Total	831	43885.52			

d.f. = Degrees of freedom, s.s. = Sum squares m.s. = Mean squares v.r. = variance ratio and F pr. = Probability for a type I error.

As shown in Figure 14, there was no significant difference found for DO concentration readings across the 4 treatment groups, indicating that the *Ozonum* potencies had no effect in changing the amount of oxygen available for the lettuce to absorb from the nutrient solution.



Tmt-a = *Ozonum* 6CH, Tmt-b = *Ozonum* 15CH, Tmt-c = *Ozonum* 30CH, Tmt-d = Control

Figure 14. Graphical representation of the three factor interaction means of DO.

4.3 Dry Lettuce leaf mineral analysis of selected nutrients

As shown in the Table 3, there was no significant difference in leaf minerals content tested across all four treatment groups. This indicates that the *Ozonum* potencies had no effect in improving mineral uptake by the lettuce plant.

Table 3. Effect of *Ozonum* concentration on leaf mineral content of lettuce.

Ozonum concentration	**Tot N (%)**	**Mg (%)**	**K (%)**	**Fe (mg/kg)**	**Ca (%)**
6CH	5.555[a]	0.4795[a]	5.612[a]	390[a]	1.474[a]
15CH	5.377[a]	0.4643[a]	5.292[a]	360[a]	1.431[a]
30CH	5.525[a]	0.4855[a]	5.769[a]	392[a]	1.450[a]
Control	5.255[a]	0.4768[a]	5.613[a]	395[a]	1.401[a]
[1]F-Prob =	0.235	0.457	0.270	0.910	0.528
[2]SEM =	0.1064	0.0092	0.1614	39.5	0.0344
[3]$LSD_{p=0.05}$ =	n/a	n/a	n/a	n/a	n/a

[1] A F-Prob≤ 0.05 is considered as significant
[2] SEM = Standard error of mean
[3] $LSD_{p=0.05}$ = Fisher's Least significant difference at a 5% significance level. Means within columns with the same letter or letters (a, b) do not differ significantly at the 5% level.

It is clear from Table 4 and Table 5 that there were no significant differences in the chlorophyll content between the treatments, indicating that the *Ozonum* potencies had no effect in stimulating faster growth as seen in the amount of chlorophyll produced.

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Table 4. Chlorophyll content measured over the duration of the experiment.

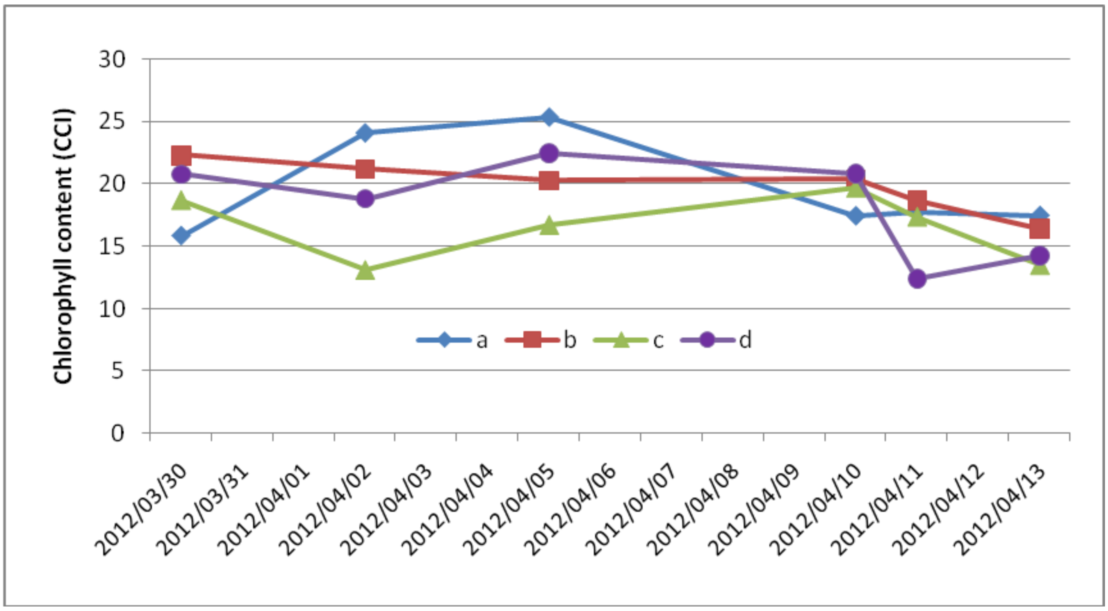
Source	d.f.	s.s.	m.s.	v.r.	F pr.
REP	3	153.96	51.32	2.29	
TMT	3	174.30	58.10	2.60	0.117
ERROR(a)	9	201.48	22.39	0.42	
DATE	5	372.19	74.44	1.39	0.241
TMT.DATE	15	503.17	33.54	0.63	0.842
ERROR(b)	60	3215.95	53.60		

Table 5. Effect of Ozonum concentration on leaf chlorophyll content.

Ozonum concentration	10 DAT	13 DAT	15 DAT	20 DAT	21 DAT	23 DAT
			Leaf chlorophyll content (SPAD)			
6CH	15.83[a]	24.07[a]	25.34[a]	17.42[a]	17.79[a]	17.44[a]
15CH	22.32[a]	21.21[a]	20.31[a]	20.41[a]	18.68[a]	16.40[a]
30CH	18.68[a]	13.11[a]	16.70[a]	19.67[a]	17.36[a]	13.51[a]
Control	20.79[a]	18.83[a]	22.48[a]	20.83[a]	12.41[a]	14.27[a]
[1]F-Prob =	0.683	0.235	0.227	0.639	0.522	0.712
[2]SEM =	3.92	3.56	2.76	1.983	3.14	2.67
[3]$LSD_{p=0.05}$ =	n/a	n/a	n/a	n/a	n/a	n/a

[1] A F-Prob≤ 0.05 is considered as significant
[2] SEM = Standard error of mean
[3] $LSD_{p=0.05}$ = Fisher's Least significant difference at a 5% significance level. Means within columns with the same letter or letters (a, b) do not differ significantly at the 5% level.
DAT = Number of days after transplanting

Figure 15 shows chlorophyll readings at very similar levels between all treatment groups, including the control, with no significant differences. This indicates that *Ozonum* had no effect on growth determined via chlorophyll content.



a = Ozonum 6CH, b = Ozonum 15CH, c = Ozonum 30CH, d = Control

Figure 15 Effect of *Ozonum* concentration on leaf chlorophyll content (SPAD) Chlorophyll content measured over the duration of the experiment.

CHAPTER FIVE

DISCUSSION

This study was conducted to determine the effect of homoeopathic *Ozonum* in various potencies on growth and yield of the Lollo Bionda lobi cultivar of leafy lettuce (*Lactuca sativa*) cultivated in a closed hydroponic system.

The results indicated that the dissolved oxygen concentration in the nutrient solution did not affect, leaf chlorophyll content, leaf fresh and dry mass, leaf area, and root fresh and dry mass: there was no significant improvement or increase in growth in any of the treatment groups relative to themselves or relative to the control group, indicating that none of the *Ozonum* potencies had any effect on growth of the lettuce.

In regard to plant physiological disorders i.e. tip-burn and bolting, no bolting was experienced by any plants in all of the three treatment groups as well as the control. Tip-burn was significantly reduced in treatment with *Ozonum* 30CH dilution (12.50), indicating a lower occurrence in this group, although not significantly different from that of *Ozonum* 15CH dilution (25.00) or the control (18.75). Tip-burn is a sign of heat stress (Jenni & Yan, 2009), so the positive *Ozonum* 30CH finding is worth pursuing for its possible heat stress protective capacity. Tip-burn is significant from a commercial point of view because it affects the appearance of lettuce which is a major factor influencing consumer choice. More focused research on this tip-burn lowering effect is warranted.

Further review of the literature reveals that many hydroponically grown lettuce varieties are susceptible to tip-burn when temperatures at plant height are above 25°C for 10-20 minutes, with tip burn resistant lettuce varieties being able to tolerate temperatures of up to 27-28°C (Slade, n.d.). This is confirmed by Misaghi and Grogan (1978), who experimented with head lettuce and found that tip-burn development and severity is mainly due to increases in temperature, rather than changes in relative humidity (Abd-Elmoniem, Abdrabbo, Farag, & Medany. 2006). Environmental factors can also play a part in the occurrence of tip-burn, including foggy weather, which reduces transpiration, especially in the last 6-10 days before harvest, which can trigger tip-burn in sensitive varieties by reducing calcium flow to leaves (Smith, Hartz & Hayes, 2011). In light of the literature, and the fact that the mineral analysis performed on all 4 treatment groups yielded no significant difference in calcium content in the leaves, other factors or specific criteria need to be investigated regarding tip-burn and the effect that *Ozonum* 30CH has on the lettuce leaves. These may include experimental methodologies which will examine aspects of transpiration rates (Hunter, Jones & Walsh, 2002) and light intensity (Both, 2001).

Leaf chlorophyll content is often used as a measure of plant growth via plant bio mass (Ali, Griffiths, Williams & Jones, 2007). Photosynthesis can be measured through an increase in biomass. If batches of plants are harvested at a series of times and the biomass of these batches is calculated, the increasing rate in biomass gives an indirect measure of the rate of photosynthesis in the plants (IB guides Photosynthesis, 2010). In this study, chlorophyll measurements yielded no significant differences between treatment groups, indicating that there was no difference in growth (carbohydrates produced) in any of the treatment groups, again confirming from another angle that *Ozonum* in the potencies used does not have any growth stimulating properties in relation to hydroponically grown lettuce.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

The results of current study indicate that homoeopathic *Ozonum* was not effective method of improving dissolved oxygen levels in the nutrient solution, or in stimulating growth in lettuce under South African summer climatic conditions. Further research is needed to explore the effect *Ozonum* 30CH may have on tip-burn incidence.

6.2 Recommendations

Recommendations for further research include:

1. The study be repeated to confirm the validity of the significant result on tip-burn reduction in the treatment group C (*Ozonum* 30CH).
2. The study be repeated in the months of November, December, January.
3. The models of hydroponics be changed from closed system to include open field systems for lettuce cultivation and growth.
4. Use a different mode of application of the homoeopathic substance to the lettuce, e.g. by means of a foliar spray as in many other studies (Atkins, 2008; Boff, P., Madruga, Nunes, & Boff., 2008; Bacchus, 2010).
5. Use a variety of homoeopathic medications which are still in line with the deficiency of oxygen rationale experienced by lettuce under warmer temperatures, including *Oxygenium* and *Carbo vegetabilis*.
6. Preparation of the *Ozonum* remedy with medical oxygen instead of with ambient air.
7. Compare the effects of different degrees of dilution, e.g. decimal (1:9), centesimal (1:99) and quinquagenimillesimal 1:49 999) of the homoeopathic substance.

8. Adapt the methodology to measure different factors which affect tip-burn more accurately, including measurement of transpiration rates (Hunter, Jones & Walsh, 2002) and light intensities (Both, 2001).
9. Use of other lettuce varieties that have known weaknesses in summer climatic conditions.

REFERENCES

Abbott, A.R. and Jackson, S. 2009. Identification of alleles conferring delayed bolting in lettuce. *Comparative Biochemistry and Physiology* [online], 153(A):S195–S199. Available at: http://www.sciencedirect.com [Accessed 3 March 2012].

Abd-Elmoniem, E. M, Abdrabbo, M.A., Farag, A.A., and Medany, M.A. 2006. Hydroponics for food production: comparison of open and closed systems on yield and consumption of water and nutrient. Papers read at the 2nd international conference on water resources and arid environments (2006) held at Riyadh, Saudia Arabia, 26-29 November 2006. Saudia Arabia. Available at: http://www.icwrae-psipw.org/index.php?option=com_content&view=article&id=55&Itemid=231 [Accessed 16 August 2012].

Ali, M., Griffiths, A.J., Williams, K.P. and Jones, D.L. 2007. Evaluating the growth characteristics of lettuce in vermicompost and green waste compost. *European Journal of Soil Biology* [online], 43 (2007) S316e-S319. Available at: http://www.earthworm.co.za/wp-content/uploads/2009/04/evaluate-growth-charact-lettuce-vc.pdf [Accessed 2 June 2012].

Apogee. 2012. Chlorophyll Concentration Index (CCI) [online]. Available at: http://www.apogeeinstruments.com/chlorophyllmeter/cciunits.html [Accessed 22 June 2012].

Atkinson, G. 2008. Garuda Biodynamics Research Institute (NZ). *Hpathy Ezine*, December. Available at: http://hpathy.com/homeopathy-papers/garuda-biodynamic-research-institute-nz/ [Accessed 12 February 2012].

Bacchus, G.L. 2010. An Evaluation of the influence of biodynamic practises including foliar-applied Silica spray on nutrient quality of organic and conventionally fertilized lettuce (Lactuca Sativa L.). *Journal of Organic Systems* [online], 5(1):5-10. Available at: http://www.organic-systems.org/journal/Vol_5%281%29/pdf/Bacchus_JOS_Volume-5_Number-1-2.pdf [Accessed 20 November 2011].

Barta, D.J. & Tibbitts, T.W. 1991. Calcium localization in lettuce leaves with and without tip-burn: comparison of controlled environment and field-grown plants. *Journal of American Society Horticultural Science* [online], 116(5):870-875. Available at: http://journal.ashspublications.org/content/116/5/870.full.pdf [Accessed 17 March 2012].

Benardo, R. 2012. Interview with Mr Richard Benardo, Owner of Mr Veg Foods, Nelspruit, 20 February.

Bernard, J. 1999. Potency in homoeopathic prescribing: penetrating the mystique (Part 1), *Simillimum: Journal of the Homoeopathic Academy of Naturopathic Physicians* 7(3):60-72.

Betti, L., Trebbi, G., Majewsky, V., Scherr, C., Shah-Rossi, D., Jäger, T. & Baumgartner, S. 2009. Use of homeopathic preparations in phytopathological models and in field trials: a critical review. *Homeopathy* [online], 98:244–266. Available at: http://www.sciencedirect.com. [Accessed on 8 March 2012].

Biologische Heilmittel Heel GmgH. 1997. *Biotherapeutic Index: Ordinatio Antihomotoxica et Materia Medica.* (4th ed.) Medical Scientific Department. Baden-Baden: Biologische Heilmittel Heel GmbH.

Boff, P., Madruga, E.S., Nunes, M.Z. & Boff, M.I.C. 2008. Pest and disease management of potato crops with homeopathic preparations and germplasm variability [online]. Poster at: Cultivating the Future Based on Science: 2nd Conference of the International Society of Organic Agriculture Research ISOFAR, Modena, Italy, 18-20 June 2008. Available at: http://orgprints.org/12452/. [Accessed 2 April 2012].

Bonato, C.M. & Silva, E.P. 2003. Effect of the homeopathic solution *Sulphur* on the growth and productivity of radish. *Acta Scientiarum. Agronomy* [online], 25(2):259-263. Available at: http://www.comenius.edu.mx/Bonato%20and%20Silva%20%282003%29.pdf [Accessed 11 February 2012].

Both, A.J. 2001. *Ten years of hydroponic lettuce research* [online], Available at: http://www.ecaa.ntu.edu.tw/weifang/lab551/vegetable/culturalpractice/ten%20years%20of%20hydroponic%20lettuce%20research.pdf [Accessed on 8 March 2012].

Both, A.J. 2003. Hydroponic lettuce research at Cornell University. *Horticultural Engineering* [online], (18)5. Available at: http://aesop.rutgers.edu/~horteng [Accessed 3 June 2012].

Bourbos, V.A. & Barbopoulou, E.A. 2005. Control of soilborne diseases in greenhouse cultivation of tomato with ozone and *Trichoderma* spp. *Acta Horticulture* (ISHS) [online], 698:147-152. Available at: http://www.actahort.org/books/698/698_19.htm [Accessed 6 June 2012].

Brizzi, M. & Betti, L. 2010. Statistical tools for alternative research in plant experiments. *Metodološki zvezki* [online], 7(1):59-71. Available at http://www.google.co.za/url?sa=t&rct=j&q=Brizzi%2C+M.%2C+Betti%2C+L.2010.+Statistical+Tools+for+Alternative+Research+in+Plant+Experiments+&source=web&cd=1&ved=0CEcQFjAA&url=http%3A%2F%2Fmrvar.fdv.uni-lj.si%2Fpub%2Fmz%2Fmz7.1%2Fbrizzi.pdf&ei=pUWaT_67MKSH4gSgzpXxDg&usg=AFQjCNHxL1v0uLRIBGnlp1pGlET26x2Mlw [Accessed on 8 April 2012].

British Homoeopathic Association. 1985. *German Homoeopathic Pharmacopoeia*. Stuttgart: Deutscher Potheker Verlag. Translation of the 1st, 1978 edition. 4th Supplement. 1917.

Canadian Food Inspection Agency. 2011. Lettuce [online]. Available at: http://www.inspection.gc.ca/food/fresh-fruits-and-vegetables/quality-inspection/vegetable-inspection-manuals/lettuce/eng/1303757738980/1303757814479 [Accessed 10 February 2012].

Cherif, M., Tirilly, Y. & Belanger, R.R. 1997. Effect of oxygen concentration on plant growth, lipid peroxidation, and receptivity of tomato roots to Pythium F under hydroponic conditions*. European Journal of Plant Pathology,* (103):255–264.

Chun, C., Watanabe, A., Kozai, T., Kim, H. & Fuse, J. 2000. Bolting and growth of *Spinacia oleracea* L. can be altered by modifying the photoperiod during transplant production. *Horticultural Science* [online], 35(4):624-626. Available at: http://hortsci.ashspublications.org/content/35/4/624.full.pdf+html [Accessed on 8 March 2012].

Collier, G.F. & Tibbitts, T.W. 1982. Tipburn of lettuce*. Horticulture Review* [online], 4:49-65 Available at: http://www.sciencedirect.com/science/article/pii/S0304423898001538 [Accessed 8 March 2012].

Coulter, H.L. 1980. Homoeopathy and modern medical science. *Journal of the American Institute of Homoeopathy*. 1(4/5):249-253

Creative OZ-Air. 2012. Ozone in Agriculture [online]. Available at: http://www.oz-air.com/agriculture.html [Accessed 6 June 2012].

Datta, S.C. 2006. Effects of Cina on root-knot disease of Mulberry. *Homeopathy* [online], 95(2):98-102. Available at http://www.sciencedirect.com. [Accessed on 17 March 2012].

Dionex Corporation. 1998. Peaknet *Software User's Guide.* Revision 08. Doc. No. 034914.

Dufault, R.J., Ward, B. & Hassell, R.L. 2009. Dynamic relationships between field temperatures and romaine lettuce yield and head quality. *Scientia Horticulturae* [online], 120(4):452–459. Available at: http://www.sciencedirect.com [Accessed on 14 March 2012].

Ehret, D., Edwards, D., Helmer, T., Lin, W., Jones, G., Dorais, M. & Papadopoulos, A. 2010. Effects of oxygen-enriched nutrient solution on greenhouse cucumber and pepper production. *Scientia Horticulturae* [online], 25(4):602-607 *Available at:* http://www:sciencedirect.com *[Accessed 3 March 2012]*.

Gaier, H.1991. *Thorson's Encyclopedic Dictionary of Homoeopathy*. London: Thorsons.

Garuda Biodynamic Institute. n.d. *Case studies* [online]. Available at: http://www.garudabd.org/node/25 [Accessed 12 February 2012].

Glenn, E.P. 1984. Seasonal effects of radiation and temperature on growth of greenhouse lettuce in a high isolation desert environment. *Scientia Horticulturae* [online], 22(1-2):9-21.Available at: *http://www.sciencedirect.com* [Accessed 29 November 2011].

Goto, E., Both, A.J., Albright, L.D., Langhans, R.W. & Leed, A.R. 1996. Effect of dissolved oxygen concentration on lettuce growth in floating hydroponics. *Acta Hortic* [online], 12(440):205-10. Available at: htttps://Qir.Kyushu-U.Ac.Jp/Dspace/Bitstream/2324/8228/1/Kj00004506877.Pdf [Accessed on 8 March 2011].

Grimes, M. 2006. Ozonum [online]. Available at http://www.otherhealth.com/homeopathy-list-discussion/7028-ozonum.html [Accessed 7 June 2012].

Hall, A.E. 2012. Heat stress and its impact [online]. Available at: http://www.plantstress.com/Articles/heat_i/heat_i.htm [Accessed 7 April 2012].

Hamman, B., Koning, G. & Him Lok, K. 2003. Homeopathically prepared gibberellic acid and barley seed germination. *Homoeopathy* [online], 92:140–144. Available at: http://www.sciencedirect.com [Accessed 4 December 2011].

Harris, D. 1992. *Hydroponics: the complete guide to gardening without soil*. London: New Holland Publishers.

Hardy, J. 2012. *Oxygen* and *Ozonum* [online]. Available at http://www.britishhomeopathic.org/hh_article_bank/medicines_k_to_z/oxygen_and_ozonum.html [Accessed 6 July 2012].

Him Lok, K. 2001. The effect of homeopathically prepared dilutions of gibberellic acid on germination of barley seed as measured by a germination index. M.Tech.: Homoeopathy, Durban University of Technology.

Holtzchulze, M. 2005.Tipburn in head lettuce. The role of calcium and strategies for preventing the disorder. Dr. Agr., Hohen Landwirtschaftlichen Fakultat, Rheinischen Friedrich-Wilhelms-Universitat, Bonn.

Home Hydro Systems. 2011. Nutrients for hydroponic systems [online]. Available at: http://www.homehydrosystems.com/nutrients/nutrients_page.html [Accessed 16 September 2011].

Homeopathy Plus. 2012. Agrohomeopathy: an introduction to healing plants and planet with homeopathy [online]. Available at: http://homeopathyplus.com.au/agrohomeopathy-an-introduction-to-healing-plants-and-planet-with-homeopathy/ [Accessed 22 November 2011].

Hopkins, C.R. 1998. The effect of homoeopathic treatment on percentage germination of lettuce (*Lactuca sativa)* seeds and the homoeopathic antidote upon this. M.Tech.: Homoeopathy, Technikon Natal, Durban.

Huang, B., Liu, X. & Xu, Q. 2001. Supraoptimal soil temperature induced oxidative stress in creeping bentgrass cultivars differing in heat tolerance. *Crop Sciences* [online], 41:430-435. Available at https://www.crops.org/publications/cs/abstracts/41/2/430 [Accessed 7 March 2012].

Hunter, P.J., Jones, J.E. & Walsh, J.A. 2002. Involvement of *Beet western yellows virus*, *Cauliflower mosaic virus*, and *Turnip mosaic virus* in internal disorders of stored white cabbage. *Phytopathology* [online], 92(8):816-826. Available at: http://apsjournals.apsnet.org/doi/pdf/10.1094/PHYTO.2002.92.8.816 [Accessed 7 March 2012].

Hydroponics 2012. [online]. Available at: http://www.tn.gov/education/cte/standardscurr/doc/ag_hydroponics.pdf [Accessed 3 March 2012].

IB guides Photosynthesis [online] 2010 Available at:Available at: http://www.ibguides.com/biology/notes/photosynthesis [Accessed 16 September 2011].

Jenni, S. 2005. Rib discoloration, a physiological disorder induced by heat stress in crisphead lettuce. *Horticultural Science* [online], 40(7):2031-2035. Available at: http://hortsci.ashspublications.org/content/40/7/2031.full.pdf [Accessed 16 September 2011].

Jenni, S. & Yan, W. 2009. Genotype by environment interactions of heat stress disorder resistance in crisphead lettuce**.** *Plant Breeding* [online], 128 (4) 374-380**.** Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1439-0523.2009.01657.x/abstract [Accessed 16 August 2012].

Jie, H. & Kong, L. 1997. Growth and photosynthetic characteristics of lettuce (*Lactuca sativa L*.) under fluctuating hot ambient temperatures with the manipulation of cool root-zone temperature. *Journal of Plant Physiology* [online], *Available at:* http://www.sciencedirect.com [Accessed 17 March 2012].

Jimenez, R.R. & Ladha, J.K. 1993. Automated elemental analysis: a rapid and reliable but expensive measurement of total carbon and nitrogen in plant and soil samples. *Communication in Soil Science and Plant Analysis* [online], (24)1897-1924. Available at: http://www.tandfonline.com/doi/abs/10.1080/00103629309368926 [Accessed 7 July 2012].

Jones, R.L. & Jenkins, M.D. 1981. Plant responses to homoeopathic remedies. *British Homoeopathic Journal* [online], 70(3):120-128. Available at: http://www.sciencedirect.com [Accessed 2 April 2012].

Jouanny, J. 1991. *The Essentials of Homoeopathic Materia Medica.* Lyon: Editions Boiron.

Jouanny, J., Crapanne, J.B., Masson, J.L. & Dancer, H.1996. *Homoeopathic therapeutics: possibilities in acute pathology*. Lyon: Editions Boiron.

Kaviraj, V.D. 2011a. Homeopathy for farm and garden [online]. Available at: http://www.narayana-publishers.com/Homeopathy-for-Farm-and-Garden/Vaikunthanath-Das-Kaviraj/b8241 [Accessed 17 November 2011].

Kaviraj, V.D. 2011b. *Ask the Plant Doctor - January 2011* [online]. Available at: http://hpathy.com/agrohomeopathy/ask-the-plant-doctor-%E2%80%93-january-2011/ [Accessed 10 February 2012].

Kavaraj, V.D. 2011c. *Ask Kaviraj - October 2011. Instructions for Agrohomeopathy remedy use and storage* [online]. Available at: http://homeopathyplus.com.au/ask-kaviraj-october-2011/ [Accessed 20 November 2011].

Kinetics of Atmospheric Ozone n.d. [online]. Available at: http://www.columbia.edu/itc/chemistry/chem-c2407/hw/ozone_kinetics.pdf [Accessed 8 June 2012].

LeBlanc, M.J. n.d. Ozone – the good, the bad and the ugly [online]. Available at: http://www.leblancarborists.net/ozone----the-good-the-bad-and-the-ugly.html [Accessed 6 June 2012].

Lenntech. n.d. Water treatment solutions [online]. Available at: http://www.lenntech.com/library/ozone/decomposition/ozone-decomposition.html [Accessed 22 June 2012].

Leow, A.C.T. & Wong Shaou-Yi, R. 2006. Chilling the root zone: revolutionary energy cost-saving chilling system for temperate plant production in tropical climates. *Practical Hydroponics and Greenhouses* [online], 91. Available at: http://hydroponics.com.au/free-articles/issue-91-chilling-the-root-zone [Accessed 20 November 2011].

Lettuce (Lactuca Sativa). 2012. [online]. Available at: http://bookdome.com/gardening/Vegetable-Gardening/Lettuce-Lactuca-Sativa.html [Accessed 14 March 2012].

Levien, M. 2012. Telephonic communication with Dr Michael Levine, Homoeopath, Naturopath and Osteopath by de Pontes. Levien manufactured the *Ozonum* used in this study, under the auspices of Natura Laboratory. White River, 29 May.

Lexic.us. n.d. Ozone [online]. Available at: http://www.lexic.us/definition-of/ozone [Accessed 6 June 2012].

Linde, K., Clausius, N., Ramirez, G., Melchart, D., Eitel, F., Hedges, L.V. & Jonas, W.B. 1997. Are the clinical effects of homoeopathy placebo effects? A meta-analysis of placebo controlled trials. *The Lancet* [online], 350(81):834-843. Available at: www.sciencedirect.com [Accessed 27 February 2012].

Maboko, M.M. & Du Plooy, C.P. 2007. Production of crisphead lettuce in a soilless production system. *African Crop Science Conference Proceedings* [online], (8):319-

325. Available at: http://www.acss.ws/Upload/XML/Research/227.pdf [Accessed 16 September 2011].

Maboko, M.M. & Du Plooy, C.P. 2008. Evaluation of crisphead lettuce cultivars (*Lactuca sativa L*.) for winter production in a soilless production system. *African Journal of Plant Science* [online], 2(10):113-117. Available at: http://www.academicjournals.org/ajps/contents/2008cont/Oct.htm [Accessed 16 September 2011].

Maboko, M.M. & Du Plooy, C.P. 2009. Effect of plant spacing on growth and yield of lettuce (*Lactuca sativa L*.) in a soilless production system*. South African Journal of Plant and Soil*, 26(3):199-201.

Maboko, M.M., Du Plooy, C.P. & Bertling,I. 2011. Comparative performance of tomato cultivars cultivated in two hydroponic production systems*. South African Journal of Plant and Soil 2011*, 28(2):97-102

Maboko, M.M. 2012. Interview with Mr Martin Maboko, Researcher – Vegetable Production and Hydroponic Systems, Agricultural Research Council, Pretoria, 15 April.

Majewsky, V., Arlt, S., Shah, D., Scherr, C., Jäger, T., Lucietta Betti, L. & Grazia Trebbi, G. 2009. Use of homeopathic preparations in experimental studies with healthy plants. *Homeopathy* [online], 98:228-243. Available at: http://www.sciencedirect.com [Accessed 4 December 2011].

Matejovic, I. 1995. Total nitrogen in plant material determined by means of dry combustion: a possible alternative to determination by Kjeldahl digestion. *Communications in Soil Science and Plant Analysis,* 26: 2217-2229.

Matoušková, L., Novotný, R., Hunová, I. & Buriánek, V. 2010. Visible foliar injury as a tool for the assessment of surface ozone impact on native vegetation: a case study from the Jizerské hory Mts. *Journal Of Forest Science* [online], 56(4):177–182.

Available at: http://agriculturejournals.cz/publicFiles/19676.pdf [Accessed on 6 June 2012].

Mawsouf, N. 2011. Ozone therapy training course. Egyptian Society for Ozone Therapy and Complementary Medicine, held in Johannesburg 30 June 2011 - 1 July 2011, organized by the Ozone Association of South Africa, Tel 0826008908.

Mawsouf, N. 2012. Email from N. Mawsouf (nabil_mawsouf@yahoo.co.uk) to A. De Pontes (Anthony@vibranthealthsolutions.co.za), 18 May.

Misaghi, I.J. & Grogan, R.G. 1978. Effect of temperature on tipburn development in head lettuce, *Phytopathology* [online], 68:1738-1743. Available at: http://www.apsnet.org/publications/phytopathology/backissues/Documents/1978Articles/Phyto68n12_1738.PDF [Accessed 16 August 2012].

Moreno, N.M. 2008. Agro-Homeopathy – an alternative for agriculture [online], Available at: http://hpathy.com/homeopathy-papers/agro-homeopathy-an-alternative-for-agriculture/ [Accessed 16 September 2011].

Morgan, L. 2011. Nutrient Film Technique (NFT) production of lettuce [online]. Available at: http://www.cropking.com/NFT_lettuce1.shtml [Accessed on 8 March 2012].

Morrow, R.C. & Wheeler, R.M. n.d. Plant physiological disorders [online]. Available at: http://www.controlledenvironments.org/Growth_Chamber_Handbook/Ch09.pdf [Accessed 8 March 2012].

Natura. 2012. Natura's history [online]. Available at: http://www.natura.co.za/index.php?q=con,7 [Accessed 14 July 2012].

Niederwieser, J.G. (ed.) 2001. *Guide to Hydroponic Vegetable Production*. Agricultural Research Council, Roodeplaat Vegetable and Ornamental Plant Institute. ISBN: 1-86849-196-X.

Nxawe, S., Laubscher, C.P. & Ndakidemi, P.A. 2009. Effect of regulated irrigation water temperature on hydroponics production of Spinach (*Spinacia oleracea L*), *African Journal of Agricultural Research* [online], 4(12)1442-1446. Available at: http://www.academicjournals.org/AJAR [Accessed 2 April 2012].

Olympios, C.M. 1997 Overview of soilless culture: advantages, constraints and perspectives for its use in mediterranean countries [online]. Available at: http://ressources.ciheam.org/om/pdf/c31/CI020854.pdf [Accessed 7 March 2012].

Ozone Solutions. n.d. Corona Discharge vs. UV Ozone Generation [online]. . Available at: http://www.ozoneapplications.com/info/cd_vs_uv.htm [Accessed 8 June 2012].

Pérez, A.G., Sanz, C., Ríos, J.J., Olías, R. & Olías, J.M. 1999. Effects of ozone treatment on postharvest strawberry quality. *Journal of Agricultural and Food Chemistry* [online], 47(4):1652–1656. Available at: http://pubs.acs.org/doi/abs/10.1021/jf980829l [Accessed 6 June 2012].

Quickgrow. 2008. Dissolved oxygen levels and nutrient temperature battle the *Pythium* virus in hydroponics [online]. Available at: http://www.quickgrow.com/gardening_articles/dissolved_oxygen_levels.html [Accessed 27 February 2012].

Republic of South Africa. Department of Agriculture, Forestry and Fisheries. 2011. A Profile of the South African Lettuce Market Value Chain:Pretoria: Government Printer

Riofrio, M. 2000. *Lettuce* [online]. Available at: http://www.uri.edu/ce/factsheets/prints/lettuceprint.html [Accessed 27 February 2012].

Rubin, M.B. 2001. The history Of ozone. The Schönbein period, 1839-1868. *Bull. Hist. Chem* [online], 26(1). Available at:

http://www.scs.illinois.edu/~mainzv/HIST/awards/OPA%20Papers/2001-Rubin.pdf [Accessed 6 June 2012].

Saure, M.C. 1998. Causes of the tipburn disorder in leaves of vegetables. *Scientia Horticulturae* [online], 76(1998):131-147. Available at: http://www.sciencedirect.com/ [Accessed 8 March 2012].

Sawyer Products. 2012. The Sawyer PointONE™ Bucket Assembly Kit [online]. Available at: http://www.sawyer.com/sawyersaves//products-pointone.html (Accessed 11 July 2012).

Schadde, A. 1997. *Ozone: a homeopathic proving*. Seattle: Alethea Book Company, ISBN 0965955001

Schofield, A.M. 1984. Homoeopathy and its potential role in agriculture – a critical review. *Biological Agriculture and Horticulture*. 2:1-8;

Seedaholic.com. 2011. Lettuce "Lollo bionda" [online]. Available at: http://www.seedaholic.com/lettuce-lollo-bionda-green-continental.html [Accessed 27 February 2012].

Shah-Rossi, D., Heusser, P. & Baumgartner, S. 2009. Homeopathic treatment of *Arabidopsis thaliana* plants Infected with *Pseudomonas syringae*. *The Scientific World Journal* [online], (9):320–330. Available at: www.thescientificworld.com [Accessed 11 February 2012].

Sharma, R. 2004. *An introduction to plant physiology.* New Delhi: Campus Books International.

Silica Additives. 2011. [online]. Available at: http://www.flairform.com/hints/silica_additives.htm [Accessed 22 November 2011].

Simply Hydroponics and Organics. 2008. Article 6-1 Soilless salad [online]. Available at: http://www.simplyhydro.com/soiless_salad.htm [Accessed 10 February 2012].

Simply Hydroponics and Organics. 2008. Article 4-3 Nutrient Temp [online]. Available at: http://www.simplyhydro.com/nutrient_temp.htm [Accessed 10 February 2012].

Slade, D.A. n.d. Tipburn avoidance in leafy hydroponics crops, blossom end rot of tomatoes and side collapse of sweet peppers [online]. Available at: http://purehydroponics.com/wp-content/uploads/2012/07/Avoiding-Tip-Burn-on-Hydroponic-Crops.pdf [Accessed 16 August 2012].

Smith, R., Hartz, T., & Hayes, R. 2011. Overview of tipburn of lettuce [online]. Available at: http://ucanr.org/blogs/SalinasValleyAgriculture/index.cfm?tagname=tipburn [Accessed 16 August 2012].

Snedecor, G.W. & Cochran, W.G. 1980. Statistical methods 7th Ed. Ames: Iowa State University Press.

Soffer, H. & Burger, D.W. 1988. Effects of dissolved oxygen concentrations in aero-hydroponics on the formation and growth of adventitious roots. *Journal American Society Horticultural Science* [online], 113(2):218-221. Available at: http://www.eurohydro.com/pdf/articles/gb_dissolved_oxygen.pdf [Accessed 16 September 2011].

Spash, C.L. 1994. The benefits of preventing crop loss due to tropospheric ozone. *Journal of Economic Surveys* [online], 1(11): 47-70. Available at: http://ideas.repec.org/p/pra/mprapa/38557.html [Accessed on 6 June 2012].

Suyantohadi, A., Kyoren, T., Hariadi, M., Purnomo, M. H. & Morimot, T. 2010. Effect of high concentrated dissolved oxygen on plant growth in a deep hydroponic culture under a low temperature. *Agricontrol* [online], 3: part 1. Available at: http://www.ifac-papersonline.net/Detailed/42816.html [Accessed on 9 March 2012].

Tafel, A. & Boericke, W. (eds) 1917. *Organon of the art of healing – Hahneman*. New Delhi :B. Jain Publishers.

Temple, P.J., Jones, & T.E. Lennox, R.W. 1990. Yield loss assessments for cultivars of broccoli, lettuce, and onion exposed to ozone. *Environmental Pollution* [online], 66(4):289-99. Available at http://www.sciencedirect.com [Accessed 8 June 2012].

Thompson, H.C., Langhans, R.W., Both, A.J, & Albright, L.D. 1988. Shoot and root temperature effects on lettuce growth in a floating hydroponic solution. *Journal American Society Horticultural Science* [online], 123(3):341-364. Available at: http://journal.ashspublications.org/content/123/3/361.full.pdf [Accessed on 14 March 2012].

Touchstone Naturopathic Centre. 2009. *Directions for taking homoeopathic medication* [online]. Available at: http://www.touchstonecentre.com/pdf/directions%20for%20taking%20homeopathic%20medicines.pdf [Accessed 20 November 2011].

Uherek, E. 2006. Upper Atmosphere [online]. Available at: http://www.atmosphere.mpg.de/enid/208.html [Accessed 6 July 2012].

Understanding Ozone. 2012. Essential ozone [online]. Available at: http://www.understandingozone.com/article_essentialozone.asp [Accessed 8 June 2012].

Valenzuela, H., Kratky, B. & Cho, J. n.d**.** Crop production guidelines [online]. Available at: http://www.extento.hawaii.edu/kbase/reports/lettuce_prod.htm [Accessed 6 July 2012].

Varian. 1997. Liberty Series II ICP-OES. Hardware operation manual.

Violleau, F., Hadjeba, K., Albet, J., Cazalis, R. & Surel, O. 2008. Effect of oxidative treatment on corn seed germination kinetics. *Ozone: Science and Engineering* [online], 30(6):418-422. Available at: www.tandfonline.com [Accessed 6 June 2012].

Vithoulkas, G. 1980. *The science of homoeopathy*. Northhampshire: Thorsons Publishers Limited.

VSN International. 2011. *GenStat for Windows* 14th ed. VSN International, Hemel Hempstead, UK. Available at: http://www.vsni.co.uk/software/genstat?ref=www.genstat.co.uk [Accessed 7 March 2012].

Wahid, A., Gelani, S., Ashraf, M. & Foolad, M.R. 2007. Heat tolerance in plants: an overview. *Environmental and Experimental Botany* [online], 61(3):199-223. Available at: http://.sciencedirect.com. [Accessed 7 March 2012].

Wittig, V.E., Ainsworth, E.A., Naidu, S., Karnosky, D.F. & Long, S.P. 2009. Quantifying the impact of current and future tropospheric ozone on tree biomass, growth, physiology and biochemistry: a quantitative meta-analysis. *Global Change Biology* [online], 15(2):396-424 Available at http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2008.01774.x/full. [Accessed 7 March 2012].

Yasgur, J. 1998. *Homoeopathic dictionary and holistic health reference*. 4th ed. Greenville: Van Hoy Publishers.

Yoshida, S., Kitano, M. & Eguchi, H. 1997 Growth of lettuce plants (*Lactuca Sativa L.*) under control of dissolved O_2 concentration in hydroponics. *Biotronics* [online], 26:39-45. Available at: https://Qir.Kyushu-U.Ac.Jp/Dspace/Bitstream/2324/8228/1/Kj00004506877.Pdf [Accessed 3 March 2012].

Zasoski, R.J. & Burau, R.G. 1977. A rapid Nitric-Perchloric Acid digestion method for multi-element tissue analysis. *Communication in Soil Science and Plant Analysis,* 8(5):425-436.

Zeroni, M., Gale, J. & Ben-Asher, J. 1983. Root aeration in a deep hydroponic system and its effect on growth and yield of tomato. *Scientia Horticulturae* [online], 19(3-4):213-220. Available at: http//:www.sciencedirect.com [Accessed 4 April 2012].

Zheng, Y., Wang, L. & Dixon, M. 2007. An upper limit for elevated root zone dissolved oxygen concentration for tomato. *Scientia Horticulturae* [online], 113(2):162-165. Available at: http://www.sciencedirect.com [Accessed 3 March 2012].

LIST OF APPENDICES

APPENDIX A

Composition and chemical concentration of nutrients added to water to make up the nutrient solution:

- Hygroponic® (Hygrotech Pty. Ltd, South Africa) comprising N (68 mg/kg), P (42 mg/kg), K (208 mg/kg), Mg (30 mg/kg), S (64 mg/kg), Fe (1.254 mg/kg), Cu (0.022 mg/kg), Zn (0.149 mg/kg), Mn (0.299 mg/kg), B (0.373 mg/kg) and Mo (0.037 mg/kg), and;

- Calcium nitrate $(CaNO_3)_2$ comprising N (117 mg/kg) and Ca (166 mg/kg).

APPENDIX B

Data collected for lettuce yield, DO concentration, chlorophyll content, mineral analysis and tip-burn

B1. Lettuce yield

file is Lettuce yield WITHOUT OUTLIER.gen

=== Lettuce yield

April 2012

Identifier	Minimum	Mean	Maximum	Values	Missing
Leaf_fmass	74.38	104.6	145.6	16	0
Noleaves	12.62	14.78	17.00	16	0
Leafarea	925.4	1202	1612	16	0
Leaf_dmass	7.250	8.844	10.38	16	0
Root_fmass	41.12	47.78	55.75	16	0
Root_dmass	6.375	9.094	11.50	16	0
Tip-burn	1.000	5.312	13.00	16	0

Identifier	Values	Missing	Levels
TMT	16	0	4
REP	16	0	4

Analysis of variance

Variate: Leaf_fmass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	1592.0	530.7	1.20	
REP.*Units* stratum					
TMT	3	789.5	263.2	0.59	0.634
Residual	9	3985.2	442.8		
Total	15	6366.7			

Tables of means

Variate: Leaf_fmass

Grand mean 104.6

TMT	a	b	c	d
	108.3	92.5	107.5	110.0

Standard errors of means

Table	TMT
rep.	4
d.f.	9
e.s.e.	10.52

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	33.66

Stratum standard errors and coefficients of variation

Variate: Leaf_fmass

Stratum	d.f.	s.e.	cv%
REP	3	11.52	11.0
REP.*Units*	9	21.04	20.1

Fisher's protected least significant difference test

TMT

Warning 20, code UF 2, statement 159 in procedure AMCOMPARISON

Fisher's protected LSD is not calculated as variance ratio for TMT is not significant.

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	108.3	322.9
b	4	92.5	376.8
c	4	107.5	674.1
d	4	110.0	485.3

TMT	REP	Leaf_fmass	FITTED	RESIDUAL
a	1	115.4	118.5	-3.03
a	2	130.4	106.3	24.12
a	3	95.4	92.9	2.45
a	4	92.1	115.7	-23.53
b	1	118.9	102.7	16.29
b	2	74.4	90.5	-16.09
b	3	94.2	77.1	17.15
b	4	82.5	99.8	-17.34
c	1	101.5	117.7	-16.15
c	2	94.5	105.5	-10.97
c	3	88.4	92.1	-3.67
c	4	145.6	114.8	30.79
d	1	123.0	120.1	2.90
d	2	110.9	107.9	2.95
d	3	78.6	94.6	-15.93
d	4	127.4	117.3	10.08

Analysis of variance

Variate: Noleaves

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	7.508	2.503	1.94	
REP.*Units* stratum					
TMT	3	3.164	1.055	0.82	0.517
Residual	9	11.625	1.292		
Total	15	22.297			

Tables of means

Variate: Noleaves

Grand mean 14.78

TMT	a	b	c	d
	15.47	14.59	14.25	14.81

Standard errors of means

Table	TMT
rep.	4
d.f.	9
e.s.e.	0.568

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	1.818

Stratum standard errors and coefficients of variation

Variate: Noleaves

Stratum	d.f.	s.e.	cv%
REP	3	0.791	5.4
REP.*Units*	9	1.137	7.7

Fisher's protected least significant difference test

TMT

Warning 21, code UF 2, statement 159 in procedure AMCOMPARISON

Fisher's protected LSD is not calculated as variance ratio for TMT is not significant.

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	15.47	1.139
b	4	14.59	1.004
c	4	14.25	0.458
d	4	14.81	3.776

TMT	REP	Noleaves	FITTED	RESIDUAL
a	1	14.62	15.44	-0.8125
a	2	17.00	15.00	2.0000
a	3	14.88	14.84	0.0312
a	4	15.38	16.59	-1.2188
b	1	14.62	14.56	0.0625
b	2	13.88	14.12	-0.2500
b	3	13.88	13.97	-0.0938
b	4	16.00	15.72	0.2812
c	1	14.00	14.22	-0.2188
c	2	13.75	13.78	-0.0312
c	3	14.00	13.62	0.3750
c	4	15.25	15.38	-0.1250
d	1	15.75	14.78	0.9688
d	2	12.62	14.34	-1.7188
d	3	13.88	14.19	-0.3125
d	4	17.00	15.94	1.0625

Analysis of variance

Variate: Leafarea

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	159391.	53130.	1.40	
REP.*Units* stratum					
TMT	3	72340.	24113.	0.64	0.609
Residual	9	340344.	37816.		
Total	15	572076.			

Tables of means

Variate: Leafarea

Grand mean 1202.

TMT	a	b	c	d
	1241.	1087.	1256.	1223.

Standard errors of means

Table	TMT
rep.	4
d.f.	9
e.s.e.	97.2

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	311.1

Stratum standard errors and coefficients of variation

Variate: Leafarea

Stratum	d.f.	s.e.	cv%
REP	3	115.3	9.6
REP.*Units*	9	194.5	16.2

Fisher's protected least significant difference test

TMT

Warning 22, code UF 2, statement 159 in procedure AMCOMPARISON

Fisher's protected LSD is not calculated as variance ratio for TMT is not significant.

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	1241	23468
b	4	1087	23155
c	4	1256	60046
d	4	1223	59910

TMT	REP	Leafarea	FITTED	RESIDUAL
a	1	1203	1262	-58.9
a	2	1467	1196	271.2
a	3	1153	1117	36.2
a	4	1141	1389	-248.5
b	1	1289	1108	180.6
b	2	925	1042	-116.9
b	3	1037	963	73.7
b	4	1098	1236	-137.3
c	1	1131	1277	-146.6
c	2	1219	1211	7.8
c	3	1064	1132	-68.0
c	4	1612	1405	206.8
d	1	1269	1244	24.9
d	2	1016	1178	-162.1
d	3	1057	1099	-41.9
d	4	1550	1371	179.1

Analysis of variance

Variate: Leaf_dmass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	4.0391	1.3464	1.58	
REP.*Units* stratum					
TMT	3	3.2656	1.0885	1.28	0.340
Residual	9	7.6797	0.8533		
Total	15	14.9844			

Tables of means

Variate: Leaf_dmass

Grand mean 8.84

TMT	a	b	c	d
	8.69	8.25	9.50	8.94

Standard errors of means

Table	TMT
rep.	4
d.f.	9
e.s.e.	0.462

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	1.478

Stratum standard errors and coefficients of variation

Variate: Leaf_dmass

Stratum	d.f.	s.e.	cv%
REP	3	0.580	6.6

REP.*Units*	9	0.924	10.4

Fisher's protected least significant difference test

TMT

Warning 23, code UF 2, statement 159 in procedure AMCOMPARISON

Fisher's protected LSD is not calculated as variance ratio for TMT is not significant.

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	8.688	0.3177
b	4	8.250	0.9063
c	4	9.500	0.8646
d	4	8.938	1.8177

TMT	REP	Leaf_dmass	FITTED	RESIDUAL
a	1	8.625	9.469	-0.8438

a	2	9.500	8.406	1.0938
a	3	8.375	8.125	0.2500
a	4	8.250	8.750	-0.5000
b	1	9.500	9.031	0.4688
b	2	7.875	7.969	-0.0938
b	3	8.375	7.688	0.6875
b	4	7.250	8.312	-1.0625
c	1	10.000	10.281	-0.2812
c	2	9.375	9.219	0.1562
c	3	8.250	8.938	-0.6875
c	4	10.375	9.562	0.8125
d	1	10.375	9.719	0.6562
d	2	7.500	8.656	-1.1562
d	3	8.125	8.375	-0.2500
d	4	9.750	9.000	0.7500

Analysis of variance

Variate: Root_fmass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

REP stratum	3	153.34	51.11	4.93	
REP.*Units* stratum					
TMT	3	41.92	13.97	1.35	0.319
Residual	9	93.22	10.36		
Total	15	288.48			

Tables of means

Variate: Root_fmass

Grand mean 47.78

TMT	a	b	c	d
	49.41	45.11	48.58	48.03

Standard errors of means

Table	TMT
rep.	4
d.f.	9
e.s.e.	1.609

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	5.148

Stratum standard errors and coefficients of variation

Variate: Root_fmass

Stratum	d.f.	s.e.	cv%
REP	3	3.575	7.5
REP.*Units*	9	3.218	6.7

Fisher's protected least significant difference test

TMT

Warning 24, code UF 2, statement 159 in procedure AMCOMPARISON

Fisher's protected LSD is not calculated as variance ratio for TMT is not significant.

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	49.41	27.34
b	4	45.11	23.31
c	4	48.58	26.38
d	4	48.03	5.16

TMT	REP	Root_fmass	FITTED	RESIDUAL
a	1	51.62	54.22	-2.594
a	2	55.75	49.99	5.762

a	3	45.44	46.33	-0.891
a	4	44.81	47.09	-2.278
b	1	52.12	49.92	2.203
b	2	43.94	45.69	-1.753
b	3	43.25	42.03	1.219
b	4	41.12	42.79	-1.669
c	1	55.62	53.39	2.231
c	2	45.26	49.16	-3.900
c	3	44.31	45.50	-1.191
c	4	49.12	46.27	2.859
d	1	51.00	52.84	-1.841
d	2	48.50	48.61	-0.109
d	3	45.81	44.95	0.863
d	4	46.80	45.71	1.087

Analysis of variance

Variate: Root_dmass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

REP stratum	3	6.523	2.174	0.85	
REP.*Units* stratum					
TMT	3	3.164	1.055	0.41	0.749
Residual	9	23.109	2.568		
Total	15	32.797			

Tables of means

Variate: Root_dmass

Grand mean 9.09

TMT	a	b	c	d
	9.12	9.78	8.56	8.91

Standard errors of means

Table	TMT
rep.	4
d.f.	9
e.s.e.	0.801

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	2.563

Stratum standard errors and coefficients of variation

Variate: Root_dmass

Stratum	d.f.	s.e.	cv%
REP	3	0.737	8.1
REP.*Units*	9	1.602	17.6

Fisher's protected least significant difference test

TMT

Warning 25, code UF 2, statement 159 in procedure AMCOMPARISON

Fisher's protected LSD is not calculated as variance ratio for TMT is not significant.

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	9.125	3.344
b	4	9.781	0.389
c	4	8.562	5.505
d	4	8.906	0.639

TMT	REP	Root_dmass	FITTED	RESIDUAL
a	1	9.625	10.156	-0.5312
a	2	11.500	9.156	2.3438

a	3	7.625	8.625	-1.0000
a	4	7.750	8.562	-0.8125
b	1	10.375	10.812	-0.4375
b	2	10.250	9.812	0.4375
b	3	9.125	9.281	-0.1562
b	4	9.375	9.219	0.1562
c	1	11.500	9.594	1.9062
c	2	6.375	8.594	-2.2188
c	3	9.375	8.062	1.3125
c	4	7.000	8.000	-1.0000
d	1	9.000	9.938	-0.9375
d	2	8.375	8.938	-0.5625
d	3	8.250	8.406	-0.1562
d	4	10.000	8.344	1.6562

Analysis of variance

Variate: Tip-burn%

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

REP stratum	3	871.31	290.44	4.49	
REP.*Units* stratum					
TMT	3	862.63	287.54	4.44	0.035
Residual	9	582.68	64.74		
Total	15	2316.62			

Tables of means

Variate: Tip-burn%

Grand mean 22.1

TMT	a	b	c	d
	32.3	25.0	12.5	18.8

Standard errors of means

Table TMT

rep.	4
d.f.	9
e.s.e.	4.02

Least significant differences of means (5% level)

Table	TMT
rep.	4
d.f.	9
l.s.d.	12.87

Stratum standard errors and coefficients of variation

Variate: Tip-burn%

Stratum	d.f.	s.e.	cv%
REP	3	8.52	38.5
REP.*Units*	9	8.05	36.4

Fisher's protected least significant difference test

TMT

	Mean	
a	32.29	a
b	25.00	ab
d	18.75	b
c	12.50	b

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	4	32.29	259.0
b	4	25.00	127.3
c	4	12.50	34.7
d	4	18.75	63.7

TMT	REP	Tip-burn%	FITTED	RESIDUAL
a	1	54.17	41.41	12.760
a	2	25.00	29.95	-4.948

a	3	33.33	36.20	-2.865
a	4	16.67	21.61	-4.948
b	1	29.17	34.11	-4.948
b	2	29.17	22.66	6.510
b	3	33.33	28.91	4.427
b	4	8.33	14.32	-5.990
c	1	16.67	21.61	-4.948
c	2	16.67	10.16	6.510
c	3	12.50	16.41	-3.906
c	4	4.17	1.82	2.344
d	1	25.00	27.86	-2.865
d	2	8.33	16.41	-8.073
d	3	25.00	22.66	2.344
d	4	16.67	8.07	8.594

End of Anthony de Pontes - M.Tech. Homoeopathy, Durban University of Technology. Current data space: 1 block, peak usage 68% at line 47.

GenStat 64-bit Release 14.1 (PC/Windows 7) 04 June 2012 12:50:54

Registered to: ARC Biometry Unit

B2. DO concentration

File is Lettuce dissolved oxygen.gen

======================================= Lettuce dissolved oxygen April 2012

Identifier	Minimum	Mean	Maximum	Values	Missing	
do	5.300	14.83	88.23	864	34	Skew
temp	10.60	21.82	32.83	864	32	

Identifier	Values	Missing	Levels
DATE	864	0	27
TMT	864	0	4
REP	864	0	4
TIME	864	0	2

Analysis of variance

Variate: do

Source of variation d.f. (m.v.) s.s. m.s. v.r. F pr.

REP stratum	3		812.86	270.95	7.02	
REP.TMT stratum						
TMT	3		372.74	124.25	3.22	0.075
Residual	9		347.22	38.58	0.50	
REP.TMT.DATE stratum						
DATE	26		1754.37	67.48	0.87	0.656
TMT.DATE	78		6107.66	78.30	1.01	0.471
Residual	312		24274.19	77.80	1.27	
REP.TMT.DATE.TIME stratum						
TIME	1		306.19	306.19	4.98	0.026
TMT.TIME	3		171.93	57.31	0.93	0.425
DATE.TIME	24	(2)	1703.48	70.98	1.15	0.283
TMT.DATE.TIME	72	(6)	4917.78	68.30	1.11	0.271
Residual	298	(26)	18319.13	61.47		
Total	829	(34)	56861.80			

Tables of means

Variate: do

Grand mean 14.80

TMT	a	b	c	d
	15.78	15.00	14.06	14.38

DATE	01/04/12	02/04/12	03/04/12	04/04/12	05/04/12	06/04/12	07/04/12
	14.03	17.17	14.59	15.29	13.31	12.57	14.58

DATE	08/04/12	09/04/12	10/04/12	11/04/12	12/04/12	13/04/12	14/04/12
	15.14	14.14	16.60	17.98	13.00	16.16	12.77

DATE	15/04/12	20/03/12	21/03/12	22/03/12	23/03/12	24/03/12	25/03/12
	14.94	14.57	11.70	14.01	15.75	15.31	14.18

DATE	26/03/12	27/03/12	28/03/12	29/03/12	30/03/12	31/03/12
	14.03	14.92	16.02	15.52	16.68	14.67

TIME	12pm	8am
	14.21	15.40

TMT	DATE	01/04/12	02/04/12	03/04/12	04/04/12	05/04/12	06/04/12
a		11.41	16.24	18.09	14.52	12.44	11.93
b		16.50	12.21	16.36	18.20	16.20	11.91
c		15.31	16.38	12.34	14.23	12.20	14.76
d		12.88	23.85	11.57	14.22	12.40	11.68

TMT	DATE	07/04/12	08/04/12	09/04/12	10/04/12	11/04/12	12/04/12
a		16.84	13.53	15.06	12.67	14.61	12.49
b		13.25	16.34	11.57	13.75	25.77	12.79
c		11.91	16.48	15.96	19.25	15.93	13.17
d		16.32	14.22	13.95	20.72	15.60	13.56

TMT	DATE	13/04/12	14/04/12	15/04/12	20/03/12	21/03/12	22/03/12
a		16.12	15.99	16.67	17.32	17.55	11.19
b		14.78	11.78	16.24	15.65	9.60	17.90
c		17.58	13.48	15.14	14.56	9.89	11.00
d		16.16	9.83	11.70	10.75	9.79	15.94

TMT	DATE	23/03/12	24/03/12	25/03/12	26/03/12	27/03/12	28/03/12

a		14.35	15.07	14.50	15.83	20.42	21.24
b		22.96	16.75	17.11	14.08	9.01	14.01
c		11.52	12.81	12.52	15.42	15.54	11.47
d		14.17	16.60	12.61	10.81	14.71	17.37

TMT	DATE	29/03/12	30/03/12	31/03/12
a		18.57	22.39	18.91
b		15.37	12.97	11.86
c		10.13	16.83	13.69
d		18.03	14.53	14.23

TMT	TIME	12pm	8am
a		15.70	15.85
b		14.76	15.24
c		13.13	14.98
d		13.24	15.52

DATE	TIME	12pm	8am
01/04/12		12.97	15.08
02/04/12		19.31	15.04
03/04/12		13.05	16.14
04/04/12		12.68	17.91

05/04/12	13.24	13.38
06/04/12	11.20	13.93
07/04/12	13.97	15.19
08/04/12	16.57	13.71
09/04/12	12.82	15.46
10/04/12	15.92	17.27
11/04/12	21.41	14.54
12/04/12	11.46	14.54
13/04/12	17.48	14.83
14/04/12	12.90	12.64
15/04/12	12.43	17.44
20/03/12	13.64	15.50
21/03/12	11.11	12.30
22/03/12	12.47	15.54
23/03/12	15.15	16.35
24/03/12	13.16	17.46
25/03/12	13.17	15.19
26/03/12	11.60	16.47
27/03/12	15.38	14.46
28/03/12	15.57	16.47
29/03/12	15.65	15.40
30/03/12	14.90	18.46

31/03/12		14.32	15.02

TMT	DATE	TIME	12pm	8am
a	01/04/12		10.35	12.47
	02/04/12		17.13	15.35
	03/04/12		13.83	22.36
	04/04/12		13.35	15.69
	05/04/12		11.70	13.18
	06/04/12		9.80	14.06
	07/04/12		17.61	16.08
	08/04/12		14.16	12.89
	09/04/12		14.58	15.54
	10/04/12		9.29	16.05
	11/04/12		16.99	12.23
	12/04/12		10.98	13.99
	13/04/12		18.72	13.51
	14/04/12		19.63	12.35
	15/04/12		13.59	19.75
	20/03/12		16.56	18.09
	21/03/12		17.47	17.62
	22/03/12		10.09	12.29
	23/03/12		14.27	14.43

	24/03/12	13.75	16.39
	25/03/12	15.35	13.64
	26/03/12	12.15	19.51
	27/03/12	28.57	12.27
	28/03/12	23.59	18.88
	29/03/12	20.86	16.29
	30/03/12	17.62	27.16
	31/03/12	21.86	15.97
b	01/04/12	16.71	16.29
	02/04/12	10.39	14.04
	03/04/12	17.38	15.35
	04/04/12	14.52	21.89
	05/04/12	16.15	16.24
	06/04/12	10.80	13.02
	07/04/12	12.70	13.81
	08/04/12	20.27	12.40
	09/04/12	12.17	10.97
	10/04/12	12.38	15.13
	11/04/12	38.55	12.98
	12/04/12	10.08	15.50
	13/04/12	14.38	15.17
	14/04/12	10.48	13.08

	15/04/12	14.54	17.94
	20/03/12	13.42	17.88
	21/03/12	9.36	9.84
	22/03/12	18.28	17.52
	23/03/12	22.72	23.20
	24/03/12	18.12	15.39
	25/03/12	11.69	22.53
	26/03/12	12.20	15.96
	27/03/12	6.90	11.12
	28/03/12	16.60	11.41
	29/03/12	15.63	15.10
	30/03/12	13.34	12.60
	31/03/12	8.68	15.04
c	01/04/12	16.35	14.27
	02/04/12	17.74	15.02
	03/04/12	10.09	14.59
	04/04/12	12.72	15.73
	05/04/12	14.00	10.39
	06/04/12	11.41	18.11
	07/04/12	11.83	12.00
	08/04/12	17.17	15.80
	09/04/12	11.94	19.98

	10/04/12	22.44	16.06
	11/04/12	17.29	14.56
	12/04/12	12.59	13.75
	13/04/12	19.17	15.99
	14/04/12	13.68	13.29
	15/04/12	10.38	19.89
	20/03/12	13.72	15.41
	21/03/12	8.96	10.81
	22/03/12	9.01	12.98
	23/03/12	10.60	12.45
	24/03/12	10.59	15.04
	25/03/12	11.38	13.65
	26/03/12	11.68	19.16
	27/03/12	9.13	21.96
	28/03/12	11.25	11.69
	29/03/12	8.90	11.37
	30/03/12	18.42	15.23
	31/03/12	12.14	15.25
d	01/04/12	8.47	17.28
	02/04/12	31.97	15.73
	03/04/12	10.90	12.25
	04/04/12	10.13	18.31

05/04/12	11.11	13.69
06/04/12	12.80	10.55
07/04/12	13.76	18.89
08/04/12	14.69	13.76
09/04/12	12.58	15.33
10/04/12	19.59	21.84
11/04/12	12.83	18.38
12/04/12	12.20	14.91
13/04/12	17.65	14.67
14/04/12	7.83	11.84
15/04/12	11.22	12.18
20/03/12	10.88	10.62
21/03/12	8.65	10.92
22/03/12	12.50	19.38
23/03/12	13.03	15.31
24/03/12	10.19	23.02
25/03/12	14.29	10.94
26/03/12	10.38	11.25
27/03/12	16.91	12.50
28/03/12	10.85	23.89
29/03/12	17.23	18.82
30/03/12	10.22	18.85

31/03/12	14.63	13.83	

Standard errors of means

Table	TMT	DATE	TIME
rep.	216	32	432
d.f.	9	312	298
e.s.e.	0.423	1.559	0.377

Table	TMT	TMT	DATE
	DATE	TIME	TIME
rep.	8	108	16
e.s.e.	3.089	0.681	2.086
d.f.	319.98	56.22	604.62

Except when comparing means with the same level(s) of

TMT	3.119	0.754	
d.f.	312	298	
DATE			1.960
d.f.			298

Table	TMT

	DATE TIME
rep.	4
e.s.e.	4.151
d.f.	614.76

Except when comparing means with the same level(s) of

TMT	4.172
d.f.	604.62
TMT.DATE	3.920
d.f.	298
TMT.TIME	4.172
d.f.	604.62

(Not adjusted for missing values)

Least significant differences of means (5% level)

Table	TMT	DATE	TIME
rep.	216	32	432
d.f.	9	312	298
l.s.d.	1.352	4.339	1.050

Table	TMT	TMT	DATE
	DATE	TIME	TIME
rep.	8	108	16
l.s.d.	8.595	1.928	5.794
d.f.	319.98	56.22	604.62

Except when comparing means with the same level(s) of

TMT	8.678	2.100	
d.f.	312	298	
DATE			5.455
d.f.			298

Table	TMT
	DATE
	TIME
rep.	4
l.s.d.	11.527
d.f.	614.76

Except when comparing means with the same level(s) of

TMT	11.588
d.f.	604.62
TMT.DATE	10.911

d.f.	298
TMT.TIME	11.588
d.f.	604.62

(Not adjusted for missing values)

Stratum standard errors and coefficients of variation

Variate: do

Stratum	d.f.	s.e.	cv%
REP	3	1.120	7.6
REP.TMT	9	0.845	5.7
REP.TMT.DATE	312	6.237	42.1
REP.TMT.DATE.TIME	298	7.841	53.0

========== Summary of original data =========

	Mean	s.d.
TIME		
12pm	14.14	9.282

8am	15.52	7.087

	Mean	s.d.
TMT		
a	15.77	9.133
b	14.95	8.653
c	14.13	6.162
d	14.47	8.800

DATE	TMT	REP	TIME	do	FITTED	RESIDUAL
20/03/12	a	1	8am	21.73	23.28	-1.550
20/03/12	a	1	12pm	23.30	21.75	1.550
20/03/12	d	1	8am	11.60	12.04	-0.436
20/03/12	d	1	12pm	12.73	12.29	0.436
20/03/12	c	1	8am	8.53	12.04	-3.515
20/03/12	c	1	12pm	13.87	10.36	3.515
20/03/12	b	1	8am	21.20	17.40	3.802
20/03/12	b	1	12pm	9.13	12.93	-3.802
20/03/12	a	2	8am	16.80	15.57	1.235
20/03/12	a	2	12pm	12.80	14.04	-1.235
20/03/12	b	2	8am	19.57	18.85	0.718
20/03/12	b	2	12pm	13.67	14.39	-0.718

20/03/12	d	2	8am	10.93	10.79	0.144
20/03/12	d	2	12pm	10.90	11.04	-0.144
20/03/12	c	2	8am	14.20	13.24	0.955
20/03/12	c	2	12pm	10.60	11.55	-0.955
20/03/12	b	3	8am	10.23	19.53	-9.303
20/03/12	b	3	12pm	24.37	15.07	9.303
20/03/12	c	3	8am	28.67	18.20	10.475
20/03/12	c	3	12pm	6.03	16.51	-10.475
20/03/12	a	3	8am	20.03	22.37	-2.335
20/03/12	a	3	12pm	23.17	20.84	2.335
20/03/12	d	3	8am	10.17	11.31	-1.136
20/03/12	d	3	12pm	12.70	11.56	1.136
20/03/12	d	4	8am	9.77	8.34	1.429
20/03/12	d	4	12pm	7.17	8.60	-1.429
20/03/12	b	4	8am	20.53	15.75	4.782
20/03/12	b	4	12pm	6.50	11.28	-4.782
20/03/12	c	4	8am	10.23	18.15	-7.915
20/03/12	c	4	12pm	24.37	16.45	7.915
20/03/12	a	4	8am	13.80	11.15	2.650
20/03/12	a	4	12pm	6.97	9.62	-2.650
21/03/12	a	1	8am	*	21.63	*
21/03/12	a	1	12pm	21.47	21.47	0.000

21/03/12	d	1	8am	*	8.61	*
21/03/12	d	1	12pm	6.33	6.33	0.000
21/03/12	c	1	8am	*	9.45	*
21/03/12	c	1	12pm	7.60	7.60	0.000
21/03/12	b	1	8am	*	7.68	*
21/03/12	b	1	12pm	7.20	7.20	0.000
21/03/12	a	2	8am	*	28.36	*
21/03/12	a	2	12pm	28.20	28.20	0.000
21/03/12	b	2	8am	*	7.25	*
21/03/12	b	2	12pm	6.77	6.77	0.000
21/03/12	d	2	8am	*	12.81	*
21/03/12	d	2	12pm	10.53	10.53	0.000
21/03/12	c	2	8am	*	13.02	*
21/03/12	c	2	12pm	11.17	11.17	0.000
21/03/12	b	3	8am	*	11.65	*
21/03/12	b	3	12pm	11.17	11.17	0.000
21/03/12	c	3	8am	*	11.82	*
21/03/12	c	3	12pm	9.97	9.97	0.000
21/03/12	a	3	8am	*	12.56	*
21/03/12	a	3	12pm	12.40	12.40	0.000
21/03/12	d	3	8am	*	14.01	*
21/03/12	d	3	12pm	11.73	11.73	0.000

21/03/12	d	4	8am	*	8.28	*
21/03/12	d	4	12pm	6.00	6.00	0.000
21/03/12	b	4	8am	*	12.78	*
21/03/12	b	4	12pm	12.30	12.30	0.000
21/03/12	c	4	8am	*	8.95	*
21/03/12	c	4	12pm	7.10	7.10	0.000
21/03/12	a	4	8am	*	7.96	*
21/03/12	a	4	12pm	7.80	7.80	0.000
22/03/12	a	1	8am	16.90	14.60	2.300
22/03/12	a	1	12pm	10.10	12.40	-2.300
22/03/12	d	1	8am	14.57	17.81	-3.236
22/03/12	d	1	12pm	14.17	10.93	3.236
22/03/12	c	1	8am	14.87	13.07	1.796
22/03/12	c	1	12pm	7.30	9.10	-1.796
22/03/12	b	1	8am	11.73	11.81	-0.075
22/03/12	b	1	12pm	12.63	12.55	0.075
22/03/12	a	2	8am	9.67	10.80	-1.130
22/03/12	a	2	12pm	9.73	8.60	1.130
22/03/12	b	2	8am	10.40	8.48	1.925
22/03/12	b	2	12pm	7.30	9.22	-1.925
22/03/12	d	2	8am	12.53	13.04	-0.506
22/03/12	d	2	12pm	6.67	6.16	0.506

22/03/12	c	2	8am	17.80	14.65	3.146
22/03/12	c	2	12pm	7.53	10.68	-3.146
22/03/12	b	3	8am	38.90	39.26	-0.360
22/03/12	b	3	12pm	40.37	40.01	0.360
22/03/12	c	3	8am	8.10	10.69	-2.589
22/03/12	c	3	12pm	9.30	6.71	2.589
22/03/12	a	3	8am	9.23	9.60	-0.370
22/03/12	a	3	12pm	7.77	7.40	0.370
22/03/12	d	3	8am	38.90	33.77	5.129
22/03/12	d	3	12pm	21.77	26.90	-5.129
22/03/12	d	4	8am	11.50	12.89	-1.386
22/03/12	d	4	12pm	7.40	6.01	1.386
22/03/12	b	4	8am	9.07	10.56	-1.490
22/03/12	b	4	12pm	12.80	11.31	1.490
22/03/12	c	4	8am	11.17	13.52	-2.354
22/03/12	c	4	12pm	11.90	9.55	2.354
22/03/12	a	4	8am	13.37	14.17	-0.800
22/03/12	a	4	12pm	12.77	11.97	0.800
23/03/12	a	1	8am	10.47	10.47	0.000
23/03/12	a	1	12pm	*	10.31	*
23/03/12	d	1	8am	22.47	22.47	0.000
23/03/12	d	1	12pm	*	20.19	*

23/03/12	c	1	8am	10.23	10.23	0.000
23/03/12	c	1	12pm	*	8.38	*
23/03/12	b	1	8am	48.47	48.47	0.000
23/03/12	b	1	12pm	*	47.99	*
23/03/12	a	2	8am	14.43	14.43	0.000
23/03/12	a	2	12pm	*	14.27	*
23/03/12	b	2	8am	9.93	9.93	0.000
23/03/12	b	2	12pm	*	9.45	*
23/03/12	d	2	8am	18.37	18.37	0.000
23/03/12	d	2	12pm	*	16.09	*
23/03/12	c	2	8am	12.87	12.87	0.000
23/03/12	c	2	12pm	*	11.02	*
23/03/12	b	3	8am	12.43	12.43	0.000
23/03/12	b	3	12pm	*	11.95	*
23/03/12	c	3	8am	11.30	11.30	0.000
23/03/12	c	3	12pm	*	9.45	*
23/03/12	a	3	8am	8.97	8.97	0.000
23/03/12	a	3	12pm	*	8.81	*
23/03/12	d	3	8am	8.90	8.90	0.000
23/03/12	d	3	12pm	*	6.62	*
23/03/12	d	4	8am	11.50	11.50	0.000
23/03/12	d	4	12pm	*	9.22	*

23/03/12	b	4	8am	21.97	21.97	0.000
23/03/12	b	4	12pm	*	21.49	*
23/03/12	c	4	8am	15.40	15.40	0.000
23/03/12	c	4	12pm	*	13.55	*
23/03/12	a	4	8am	23.83	23.83	0.000
23/03/12	a	4	12pm	*	23.67	*
24/03/12	a	1	8am	9.63	10.59	-0.956
24/03/12	a	1	12pm	8.90	7.94	0.956
24/03/12	d	1	8am	51.00	35.33	15.671
24/03/12	d	1	12pm	6.83	22.50	-15.671
24/03/12	c	1	8am	22.87	18.45	4.425
24/03/12	c	1	12pm	9.57	13.99	-4.425
24/03/12	b	1	8am	12.10	9.40	2.696
24/03/12	b	1	12pm	9.43	12.13	-2.696
24/03/12	a	2	8am	35.60	25.14	10.464
24/03/12	a	2	12pm	12.03	22.49	-10.464
24/03/12	b	2	8am	25.07	23.27	1.796
24/03/12	b	2	12pm	24.20	26.00	-1.796
24/03/12	d	2	8am	13.57	18.21	-4.644
24/03/12	d	2	12pm	10.03	5.39	4.644
24/03/12	c	2	8am	12.70	13.06	-0.360
24/03/12	c	2	12pm	8.97	8.61	0.360

24/03/12	b	3	8am	13.53	19.52	-5.989
24/03/12	b	3	12pm	28.23	22.24	5.989
24/03/12	c	3	8am	15.07	17.12	-2.055
24/03/12	c	3	12pm	14.73	12.68	2.055
24/03/12	a	3	8am	9.97	19.21	-9.236
24/03/12	a	3	12pm	25.80	16.56	9.236
24/03/12	d	3	8am	17.13	22.79	-5.664
24/03/12	d	3	12pm	15.63	9.97	5.664
24/03/12	d	4	8am	10.37	15.73	-5.364
24/03/12	d	4	12pm	8.27	2.91	5.364
24/03/12	b	4	8am	10.87	9.37	1.496
24/03/12	b	4	12pm	10.60	12.10	-1.496
24/03/12	c	4	8am	9.50	11.51	-2.010
24/03/12	c	4	12pm	9.07	7.06	2.010
24/03/12	a	4	8am	10.37	10.64	-0.271
24/03/12	a	4	12pm	8.27	8.00	0.271
25/03/12	a	1	8am	17.87	17.27	0.604
25/03/12	a	1	12pm	18.37	18.97	-0.604
25/03/12	d	1	8am	12.47	7.81	4.656
25/03/12	d	1	12pm	6.50	11.16	-4.656
25/03/12	c	1	8am	10.90	10.62	0.278
25/03/12	c	1	12pm	8.07	8.35	-0.278

25/03/12	b	1	8am	10.93	18.34	-7.409
25/03/12	b	1	12pm	14.90	7.49	7.409
25/03/12	a	2	8am	14.50	13.63	0.869
25/03/12	a	2	12pm	14.47	15.34	-0.869
25/03/12	b	2	8am	36.67	29.26	7.411
25/03/12	b	2	12pm	11.00	18.41	-7.411
25/03/12	d	2	8am	9.50	9.83	-0.329
25/03/12	d	2	12pm	13.50	13.17	0.329
25/03/12	c	2	8am	19.07	14.42	4.648
25/03/12	c	2	12pm	7.50	12.15	-4.648
25/03/12	b	3	8am	10.70	15.91	-5.209
25/03/12	b	3	12pm	10.27	5.06	5.209
25/03/12	c	3	8am	11.67	13.36	-1.688
25/03/12	c	3	12pm	12.77	11.08	1.688
25/03/12	a	3	8am	12.50	12.21	0.289
25/03/12	a	3	12pm	13.63	13.92	-0.289
25/03/12	d	3	8am	11.30	14.61	-3.314
25/03/12	d	3	12pm	21.27	17.96	3.314
25/03/12	d	4	8am	10.50	11.51	-1.014
25/03/12	d	4	12pm	15.87	14.86	1.014
25/03/12	b	4	8am	31.83	26.62	5.206
25/03/12	b	4	12pm	10.57	15.78	-5.206

25/03/12	c	4	8am	12.97	16.21	-3.238
25/03/12	c	4	12pm	17.17	13.93	3.238
25/03/12	a	4	8am	9.70	11.46	-1.761
25/03/12	a	4	12pm	14.93	13.17	1.761
26/03/12	a	1	8am	41.93	34.51	7.424
26/03/12	a	1	12pm	19.73	27.15	-7.424
26/03/12	d	1	8am	9.20	10.47	-1.272
26/03/12	d	1	12pm	10.87	9.60	1.272
26/03/12	c	1	8am	21.70	18.76	2.944
26/03/12	c	1	12pm	8.33	11.27	-2.944
26/03/12	b	1	8am	26.80	18.81	7.986
26/03/12	b	1	12pm	7.07	15.06	-7.986
26/03/12	a	2	8am	9.37	12.38	-3.006
26/03/12	a	2	12pm	8.03	5.02	3.006
26/03/12	b	2	8am	12.93	12.73	0.201
26/03/12	b	2	12pm	8.77	8.97	-0.201
26/03/12	d	2	8am	12.50	11.79	0.713
26/03/12	d	2	12pm	10.20	10.91	-0.713
26/03/12	c	2	8am	31.43	24.91	6.524
26/03/12	c	2	12pm	10.90	17.42	-6.524
26/03/12	b	3	8am	12.07	20.48	-8.409
26/03/12	b	3	12pm	25.13	16.72	8.409

26/03/12	c	3	8am	14.93	21.51	-6.576
26/03/12	c	3	12pm	20.60	14.02	6.576
26/03/12	a	3	8am	13.03	15.06	-2.026
26/03/12	a	3	12pm	9.73	7.70	2.026
26/03/12	d	3	8am	11.57	11.74	-0.167
26/03/12	d	3	12pm	11.03	10.86	0.167
26/03/12	d	4	8am	11.73	11.00	0.727
26/03/12	d	4	12pm	9.40	10.13	-0.727
26/03/12	b	4	8am	12.03	11.81	0.221
26/03/12	b	4	12pm	7.83	8.05	-0.221
26/03/12	c	4	8am	8.57	11.46	-2.891
26/03/12	c	4	12pm	6.87	3.98	2.891
26/03/12	a	4	8am	13.70	16.09	-2.391
26/03/12	a	4	12pm	11.13	8.74	2.391
27/03/12	a	1	8am	10.73	0.56	10.165
27/03/12	a	1	12pm	6.70	16.87	-10.165
27/03/12	d	1	8am	12.10	8.56	3.542
27/03/12	d	1	12pm	9.43	12.97	-3.542
27/03/12	c	1	8am	41.13	32.81	8.315
27/03/12	c	1	12pm	11.67	19.99	-8.315
27/03/12	b	1	8am	10.07	10.58	-0.508
27/03/12	b	1	12pm	6.87	6.36	0.508

27/03/12	a	2	8am	9.63	3.23	6.400
27/03/12	a	2	12pm	13.13	19.53	-6.400
27/03/12	b	2	8am	10.07	10.58	-0.508
27/03/12	b	2	12pm	6.87	6.36	0.508
27/03/12	d	2	8am	10.60	6.71	3.892
27/03/12	d	2	12pm	7.23	11.12	-3.892
27/03/12	c	2	8am	12.37	17.39	-5.015
27/03/12	c	2	12pm	9.57	4.55	5.015
27/03/12	b	3	8am	15.93	13.16	2.773
27/03/12	b	3	12pm	6.17	8.94	-2.773
27/03/12	c	3	8am	14.90	18.05	-3.150
27/03/12	c	3	12pm	8.37	5.22	3.150
27/03/12	a	3	8am	13.23	42.58	-29.350
27/03/12	a	3	12pm	88.23	58.88	29.350
27/03/12	d	3	8am	17.60	25.86	-8.257
27/03/12	d	3	12pm	38.53	30.27	8.257
27/03/12	d	4	8am	9.70	8.88	0.822
27/03/12	d	4	12pm	12.47	13.29	-0.822
27/03/12	b	4	8am	8.40	10.16	-1.758
27/03/12	b	4	12pm	7.70	5.94	1.758
27/03/12	c	4	8am	19.43	19.58	-0.150
27/03/12	c	4	12pm	6.90	6.75	0.150

27/03/12	a	4	8am	15.50	2.71	12.785
27/03/12	a	4	12pm	6.23	19.02	-12.785
28/03/12	a	1	8am	9.70	21.76	-12.060
28/03/12	a	1	12pm	38.53	26.47	12.060
28/03/12	d	1	8am	10.07	19.25	-9.184
28/03/12	d	1	12pm	15.40	6.22	9.184
28/03/12	c	1	8am	14.23	11.72	2.510
28/03/12	c	1	12pm	8.77	11.28	-2.510
28/03/12	b	1	8am	13.20	22.64	-9.440
28/03/12	b	1	12pm	37.27	27.83	9.440
28/03/12	a	2	8am	16.37	15.67	0.705
28/03/12	a	2	12pm	19.67	20.38	-0.705
28/03/12	b	2	8am	9.37	6.34	3.030
28/03/12	b	2	12pm	8.50	11.53	-3.030
28/03/12	d	2	8am	13.03	17.90	-4.869
28/03/12	d	2	12pm	9.73	4.86	4.869
28/03/12	c	2	8am	13.70	12.63	1.065
28/03/12	c	2	12pm	11.13	12.20	-1.065
28/03/12	b	3	8am	11.37	6.44	4.930
28/03/12	b	3	12pm	6.70	11.63	-4.930
28/03/12	c	3	8am	9.63	12.15	-2.520
28/03/12	c	3	12pm	14.23	11.71	2.520

28/03/12	a	3	8am	34.53	27.89	6.635
28/03/12	a	3	12pm	25.97	32.61	-6.635
28/03/12	d	3	8am	26.97	23.57	3.401
28/03/12	d	3	12pm	7.13	10.53	-3.401
28/03/12	d	4	8am	45.47	34.82	10.651
28/03/12	d	4	12pm	11.13	21.78	-10.651
28/03/12	b	4	8am	11.70	10.22	1.480
28/03/12	b	4	12pm	13.93	15.41	-1.480
28/03/12	c	4	8am	9.20	10.25	-1.055
28/03/12	c	4	12pm	10.87	9.81	1.055
28/03/12	a	4	8am	14.93	10.21	4.720
28/03/12	a	4	12pm	10.20	14.92	-4.720
29/03/12	a	1	8am	11.57	9.02	2.553
29/03/12	a	1	12pm	11.03	13.58	-2.553
29/03/12	d	1	8am	11.73	11.36	0.368
29/03/12	d	1	12pm	9.40	9.77	-0.368
29/03/12	c	1	8am	12.10	10.52	1.582
29/03/12	c	1	12pm	6.47	8.05	-1.582
29/03/12	b	1	8am	9.60	8.15	1.451
29/03/12	b	1	12pm	7.23	8.68	-1.451
29/03/12	a	2	8am	20.93	27.42	-6.487
29/03/12	a	2	12pm	38.47	31.98	6.487

29/03/12	b	2	8am	9.70	13.37	-3.669
29/03/12	b	2	12pm	17.57	13.90	3.669
29/03/12	d	2	8am	26.80	17.73	9.068
29/03/12	d	2	12pm	7.07	16.14	-9.068
29/03/12	c	2	8am	12.93	12.08	0.848
29/03/12	c	2	12pm	8.77	9.62	-0.848
29/03/12	b	3	8am	12.03	20.20	-8.169
29/03/12	b	3	12pm	28.90	20.73	8.169
29/03/12	c	3	8am	13.23	12.96	0.267
29/03/12	c	3	12pm	10.23	10.50	-0.267
29/03/12	a	3	8am	26.37	19.85	6.517
29/03/12	a	3	12pm	17.90	24.42	-6.517
29/03/12	d	3	8am	17.93	23.80	-5.868
29/03/12	d	3	12pm	28.07	22.20	5.868
29/03/12	d	4	8am	18.83	22.40	-3.568
29/03/12	d	4	12pm	24.37	20.80	3.568
29/03/12	b	4	8am	29.07	18.68	10.386
29/03/12	b	4	12pm	8.83	19.22	-10.386
29/03/12	c	4	8am	7.20	9.90	-2.697
29/03/12	c	4	12pm	10.13	7.43	2.697
29/03/12	a	4	8am	6.30	8.88	-2.583
29/03/12	a	4	12pm	16.03	13.45	2.583

30/03/12	a	1	8am	29.63	31.90	-2.271
30/03/12	a	1	12pm	24.63	22.36	2.271
30/03/12	d	1	8am	44.63	30.53	14.099
30/03/12	d	1	12pm	7.80	21.90	-14.099
30/03/12	c	1	8am	16.03	18.67	-2.639
30/03/12	c	1	12pm	24.50	21.86	2.639
30/03/12	b	1	8am	12.70	16.79	-4.094
30/03/12	b	1	12pm	21.63	17.54	4.094
30/03/12	a	2	8am	37.17	29.37	7.799
30/03/12	a	2	12pm	12.03	19.83	-7.799
30/03/12	b	2	8am	7.97	10.41	-2.444
30/03/12	b	2	12pm	13.60	11.16	2.444
30/03/12	d	2	8am	10.87	15.05	-4.181
30/03/12	d	2	12pm	10.60	6.42	4.181
30/03/12	c	2	8am	12.10	9.17	2.931
30/03/12	c	2	12pm	9.43	12.36	-2.931
30/03/12	b	3	8am	11.83	11.33	0.501
30/03/12	b	3	12pm	11.57	12.07	-0.501
30/03/12	c	3	8am	18.27	14.02	4.246
30/03/12	c	3	12pm	12.97	17.22	-4.246
30/03/12	a	3	8am	16.83	18.00	-1.171
30/03/12	a	3	12pm	9.63	8.46	1.171

30/03/12	d	3	8am	9.60	14.42	-4.816
30/03/12	d	3	12pm	10.60	5.78	4.816
30/03/12	d	4	8am	10.30	15.40	-5.101
30/03/12	d	4	12pm	11.87	6.77	5.101
30/03/12	b	4	8am	17.90	11.86	6.036
30/03/12	b	4	12pm	6.57	12.61	-6.036
30/03/12	c	4	8am	14.53	19.07	-4.539
30/03/12	c	4	12pm	26.80	22.26	4.539
30/03/12	a	4	8am	25.03	29.39	-4.356
30/03/12	a	4	12pm	24.20	19.84	4.356
31/03/12	a	1	8am	17.13	11.33	5.795
31/03/12	a	1	12pm	11.43	17.23	-5.795
31/03/12	d	1	8am	11.43	11.63	-0.204
31/03/12	d	1	12pm	12.63	12.43	0.204
31/03/12	c	1	8am	8.10	10.26	-2.159
31/03/12	c	1	12pm	9.30	7.14	2.159
31/03/12	b	1	8am	10.40	12.03	-1.634
31/03/12	b	1	12pm	7.30	5.67	1.634
31/03/12	a	2	8am	11.17	8.59	2.580
31/03/12	a	2	12pm	11.90	14.48	-2.580
31/03/12	b	2	8am	11.50	12.30	-0.799
31/03/12	b	2	12pm	6.73	5.93	0.799

31/03/12	d	2	8am	8.10	8.30	-0.204
31/03/12	d	2	12pm	9.30	9.10	0.204
31/03/12	c	2	8am	14.87	12.64	2.226
31/03/12	c	2	12pm	7.30	9.53	-2.226
31/03/12	b	3	8am	11.80	14.23	-2.434
31/03/12	b	3	12pm	10.30	7.87	2.434
31/03/12	c	3	8am	13.37	12.68	0.691
31/03/12	c	3	12pm	8.87	9.56	-0.691
31/03/12	a	3	8am	10.17	9.00	1.165
31/03/12	a	3	12pm	13.73	14.89	-1.165
31/03/12	d	3	8am	23.83	25.37	-1.539
31/03/12	d	3	12pm	27.70	26.16	1.539
31/03/12	d	4	8am	11.97	10.02	1.946
31/03/12	d	4	12pm	8.87	10.82	-1.946
31/03/12	b	4	8am	26.47	21.60	4.866
31/03/12	b	4	12pm	10.37	15.24	-4.866
31/03/12	c	4	8am	24.67	25.43	-0.759
31/03/12	c	4	12pm	23.07	22.31	0.759
31/03/12	a	4	8am	25.40	34.94	-9.540
31/03/12	a	4	12pm	50.37	40.83	9.540
01/04/12	a	1	8am	12.00	12.15	-0.146
01/04/12	a	1	12pm	10.17	10.02	0.146

01/04/12	d	1	8am	16.57	16.45	0.115
01/04/12	d	1	12pm	7.53	7.65	-0.115
01/04/12	c	1	8am	12.80	15.73	-2.927
01/04/12	c	1	12pm	20.73	17.80	2.927
01/04/12	b	1	8am	11.97	10.93	1.042
01/04/12	b	1	12pm	10.30	11.34	-1.042
01/04/12	a	2	8am	9.20	11.11	-1.911
01/04/12	a	2	12pm	10.90	8.99	1.911
01/04/12	b	2	8am	12.50	11.14	1.358
01/04/12	b	2	12pm	10.20	11.56	-1.358
01/04/12	d	2	8am	31.43	25.57	5.860
01/04/12	d	2	12pm	10.90	16.76	-5.860
01/04/12	c	2	8am	12.93	17.99	-5.062
01/04/12	c	2	12pm	25.13	20.07	5.062
01/04/12	b	3	8am	21.27	17.79	3.477
01/04/12	b	3	12pm	14.73	18.21	-3.477
01/04/12	c	3	8am	11.73	11.14	0.588
01/04/12	c	3	12pm	12.63	13.22	-0.588
01/04/12	a	3	8am	16.33	14.61	1.719
01/04/12	a	3	12pm	10.77	12.49	-1.719
01/04/12	d	3	8am	12.00	14.32	-2.320
01/04/12	d	3	12pm	7.83	5.51	2.320

01/04/12	d	4	8am	9.13	12.79	-3.655
01/04/12	d	4	12pm	7.63	3.97	3.655
01/04/12	b	4	8am	19.43	25.31	-5.877
01/04/12	b	4	12pm	31.60	25.72	5.877
01/04/12	c	4	8am	19.63	12.23	7.402
01/04/12	c	4	12pm	6.90	14.30	-7.402
01/04/12	a	4	8am	12.37	12.03	0.339
01/04/12	a	4	12pm	9.57	9.91	-0.339
02/04/12	a	1	8am	29.67	23.06	6.610
02/04/12	a	1	12pm	18.23	24.84	-6.610
02/04/12	d	1	8am	8.97	8.66	0.307
02/04/12	d	1	12pm	24.60	24.91	-0.307
02/04/12	c	1	8am	10.57	14.29	-3.721
02/04/12	c	1	12pm	20.73	17.01	3.721
02/04/12	b	1	8am	11.80	12.88	-1.079
02/04/12	b	1	12pm	10.30	9.22	1.079
02/04/12	a	2	8am	9.90	17.91	-8.010
02/04/12	a	2	12pm	27.70	19.69	8.010
02/04/12	b	2	8am	11.97	11.71	0.256
02/04/12	b	2	12pm	7.80	8.06	-0.256
02/04/12	d	2	8am	25.40	47.34	-21.942
02/04/12	d	2	12pm	85.53	63.59	21.942

02/04/12	c	2	8am	24.67	22.51	2.159
02/04/12	c	2	12pm	23.07	25.23	-2.159
02/04/12	b	3	8am	*	14.13	*
02/04/12	b	3	12pm	10.47	10.47	-0.002
02/04/12	c	3	8am	9.33	9.69	-0.361
02/04/12	c	3	12pm	12.77	12.41	0.361
02/04/12	a	3	8am	11.67	9.38	2.290
02/04/12	a	3	12pm	8.87	11.16	-2.290
02/04/12	d	3	8am	11.97	2.98	8.992
02/04/12	d	3	12pm	10.23	19.22	-8.992
02/04/12	d	4	8am	16.57	3.93	12.642
02/04/12	d	4	12pm	7.53	20.17	-12.642
02/04/12	b	4	8am	18.27	17.45	0.821
02/04/12	b	4	12pm	12.97	13.79	-0.821
02/04/12	c	4	8am	15.50	13.58	1.924
02/04/12	c	4	12pm	14.37	16.29	-1.924
02/04/12	a	4	8am	10.17	11.06	-0.890
02/04/12	a	4	12pm	13.73	12.84	0.890
03/04/12	a	1	8am	43.33	31.30	12.034
03/04/12	a	1	12pm	10.73	22.76	-12.034
03/04/12	d	1	8am	15.50	16.94	-1.441
03/04/12	d	1	12pm	17.03	15.59	1.441

03/04/12	c	1	8am	23.03	17.83	5.196
03/04/12	c	1	12pm	8.13	13.33	-5.196
03/04/12	b	1	8am	18.87	13.13	5.735
03/04/12	b	1	12pm	9.43	15.17	-5.735
03/04/12	a	2	8am	21.27	21.89	-0.616
03/04/12	a	2	12pm	13.97	13.35	0.616
03/04/12	b	2	8am	15.97	13.04	2.935
03/04/12	b	2	12pm	12.13	15.07	-2.935
03/04/12	d	2	8am	9.13	8.81	0.324
03/04/12	d	2	12pm	7.13	7.45	-0.324
03/04/12	c	2	8am	10.40	11.19	-0.789
03/04/12	c	2	12pm	7.47	6.68	0.789
03/04/12	b	3	8am	13.27	18.80	-5.535
03/04/12	b	3	12pm	26.37	20.84	5.535
03/04/12	c	3	8am	9.87	13.72	-3.854
03/04/12	c	3	12pm	13.07	9.22	3.854
03/04/12	a	3	8am	11.40	19.40	-8.001
03/04/12	a	3	12pm	18.87	10.87	8.001
03/04/12	d	3	8am	12.87	12.36	0.509
03/04/12	d	3	12pm	10.50	11.01	-0.509
03/04/12	d	4	8am	11.50	10.89	0.609
03/04/12	d	4	12pm	8.93	9.54	-0.609

03/04/12	b	4	8am	13.27	16.41	-3.135
03/04/12	b	4	12pm	21.57	18.43	3.135
03/04/12	c	4	8am	15.07	15.62	-0.554
03/04/12	c	4	12pm	11.67	11.12	0.554
03/04/12	a	4	8am	13.43	16.85	-3.416
03/04/12	a	4	12pm	11.73	8.31	3.416
04/04/12	a	1	8am	25.57	19.57	5.999
04/04/12	a	1	12pm	11.23	17.23	-5.999
04/04/12	d	1	8am	26.23	22.09	4.137
04/04/12	d	1	12pm	9.77	13.91	-4.137
04/04/12	c	1	8am	13.93	14.72	-0.788
04/04/12	c	1	12pm	12.50	11.71	0.788
04/04/12	b	1	8am	13.57	19.66	-6.086
04/04/12	b	1	12pm	18.37	12.28	6.086
04/04/12	a	2	8am	13.70	12.16	1.544
04/04/12	a	2	12pm	8.27	9.81	-1.544
04/04/12	b	2	8am	27.23	26.20	1.029
04/04/12	b	2	12pm	17.80	18.83	-1.029
04/04/12	d	2	8am	15.37	16.29	-0.922
04/04/12	d	2	12pm	9.03	8.11	0.922
04/04/12	c	2	8am	16.43	14.03	2.397
04/04/12	c	2	12pm	8.63	11.03	-2.397

04/04/12	b	3	8am	29.63	23.49	6.144
04/04/12	b	3	12pm	9.97	16.11	-6.144
04/04/12	c	3	8am	15.13	14.67	0.463
04/04/12	c	3	12pm	11.20	11.66	-0.463
04/04/12	a	3	8am	11.07	17.21	-6.136
04/04/12	a	3	12pm	21.00	14.86	6.136
04/04/12	d	3	8am	21.47	21.16	0.307
04/04/12	d	3	12pm	12.67	12.98	-0.307
04/04/12	d	4	8am	10.17	13.69	-3.522
04/04/12	d	4	12pm	9.03	5.51	3.522
04/04/12	b	4	8am	17.13	18.22	-1.086
04/04/12	b	4	12pm	11.93	10.84	1.086
04/04/12	c	4	8am	17.43	19.50	-2.073
04/04/12	c	4	12pm	18.57	16.50	2.073
04/04/12	a	4	8am	12.43	13.84	-1.406
04/04/12	a	4	12pm	12.90	11.49	1.406
05/04/12	a	1	8am	10.00	12.03	-2.025
05/04/12	a	1	12pm	12.57	10.54	2.025
05/04/12	d	1	8am	11.23	13.51	-2.276
05/04/12	d	1	12pm	13.20	10.92	2.276
05/04/12	c	1	8am	10.37	7.55	2.822
05/04/12	c	1	12pm	8.33	11.15	-2.822

05/04/12	b	1	8am	11.23	12.56	-1.330
05/04/12	b	1	12pm	13.80	12.47	1.330
05/04/12	a	2	8am	17.43	16.55	0.875
05/04/12	a	2	12pm	14.20	15.07	-0.875
05/04/12	b	2	8am	19.57	18.34	1.225
05/04/12	b	2	12pm	17.03	18.26	-1.225
05/04/12	d	2	8am	12.07	15.63	-3.556
05/04/12	d	2	12pm	16.60	13.04	3.556
05/04/12	c	2	8am	8.83	14.18	-5.348
05/04/12	c	2	12pm	23.13	17.78	5.348
05/04/12	b	3	8am	17.63	19.16	-1.530
05/04/12	b	3	12pm	20.60	19.07	1.530
05/04/12	c	3	8am	11.70	9.11	2.587
05/04/12	c	3	12pm	10.13	12.72	-2.587
05/04/12	a	3	8am	16.07	13.01	3.060
05/04/12	a	3	12pm	8.47	11.53	-3.060
05/04/12	d	3	8am	9.53	10.72	-1.191
05/04/12	d	3	12pm	9.33	8.14	1.191
05/04/12	d	4	8am	21.93	14.91	7.024
05/04/12	d	4	12pm	5.30	12.32	-7.024
05/04/12	b	4	8am	16.53	14.89	1.635
05/04/12	b	4	12pm	13.17	14.81	-1.635

05/04/12	c	4	8am	10.67	10.73	-0.062
05/04/12	c	4	12pm	14.40	14.34	0.062
05/04/12	a	4	8am	9.23	11.14	-1.910
05/04/12	a	4	12pm	11.57	9.66	1.910
06/04/12	a	1	8am	14.87	14.96	-0.093
06/04/12	a	1	12pm	10.80	10.71	0.093
06/04/12	d	1	8am	11.10	10.94	0.158
06/04/12	d	1	12pm	13.03	13.19	-0.158
06/04/12	c	1	8am	24.67	19.62	5.049
06/04/12	c	1	12pm	7.87	12.92	-5.049
06/04/12	b	1	8am	11.90	11.09	0.808
06/04/12	b	1	12pm	8.07	8.88	-0.808
06/04/12	a	2	8am	11.50	11.31	0.188
06/04/12	a	2	12pm	6.87	7.06	-0.188
06/04/12	b	2	8am	13.00	12.84	0.157
06/04/12	b	2	12pm	10.47	10.63	-0.157
06/04/12	d	2	8am	12.67	9.63	3.042
06/04/12	d	2	12pm	8.83	11.87	-3.042
06/04/12	c	2	8am	16.87	15.39	1.484
06/04/12	c	2	12pm	7.20	8.68	-1.484
06/04/12	b	3	8am	15.70	16.89	-1.192
06/04/12	b	3	12pm	15.87	14.68	1.192

06/04/12	c	3	8am	18.57	21.80	-3.231
06/04/12	c	3	12pm	18.33	15.10	3.231
06/04/12	a	3	8am	16.13	15.53	0.602
06/04/12	a	3	12pm	10.67	11.27	-0.602
06/04/12	d	3	8am	9.47	10.48	-1.007
06/04/12	d	3	12pm	13.73	12.72	1.007
06/04/12	d	4	8am	8.97	11.16	-2.192
06/04/12	d	4	12pm	15.60	13.41	2.192
06/04/12	b	4	8am	11.47	11.24	0.227
06/04/12	b	4	12pm	8.80	9.03	-0.227
06/04/12	c	4	8am	12.33	15.63	-3.301
06/04/12	c	4	12pm	12.23	8.93	3.301
06/04/12	a	4	8am	13.73	14.43	-0.697
06/04/12	a	4	12pm	10.87	10.17	0.697
07/04/12	a	1	8am	16.50	12.59	3.913
07/04/12	a	1	12pm	10.20	14.11	-3.913
07/04/12	d	1	8am	13.43	19.93	-6.498
07/04/12	d	1	12pm	21.30	14.80	6.498
07/04/12	c	1	8am	10.97	11.02	-0.052
07/04/12	c	1	12pm	10.90	10.85	0.052
07/04/12	b	1	8am	14.93	12.18	2.746
07/04/12	b	1	12pm	8.33	11.08	-2.746

07/04/12	a	2	8am	20.13	19.52	0.612
07/04/12	a	2	12pm	20.43	21.04	-0.612
07/04/12	b	2	8am	10.30	16.20	-5.904
07/04/12	b	2	12pm	21.00	15.10	5.904
07/04/12	d	2	8am	12.27	14.28	-2.013
07/04/12	d	2	12pm	11.17	9.16	2.013
07/04/12	c	2	8am	10.93	11.29	-0.358
07/04/12	c	2	12pm	11.47	11.11	0.358
07/04/12	b	3	8am	16.27	15.52	0.746
07/04/12	b	3	12pm	13.67	14.42	-0.746
07/04/12	c	3	8am	17.13	16.47	0.662
07/04/12	c	3	12pm	15.63	16.29	-0.662
07/04/12	a	3	8am	15.33	22.70	-7.373
07/04/12	a	3	12pm	31.60	24.23	7.373
07/04/12	d	3	8am	22.97	20.53	2.437
07/04/12	d	3	12pm	12.97	15.41	-2.437
07/04/12	d	4	8am	26.87	20.80	6.073
07/04/12	d	4	12pm	9.60	15.67	-6.073
07/04/12	b	4	8am	13.73	11.32	2.411
07/04/12	b	4	12pm	7.80	10.21	-2.411
07/04/12	c	4	8am	8.97	9.22	-0.252
07/04/12	c	4	12pm	9.30	9.05	0.252

07/04/12	a	4	8am	12.37	9.52	2.848
07/04/12	a	4	12pm	8.20	11.05	-2.848
08/04/12	a	1	8am	14.03	14.01	0.015
08/04/12	a	1	12pm	15.27	15.29	-0.015
08/04/12	d	1	8am	15.40	14.42	0.979
08/04/12	d	1	12pm	14.37	15.35	-0.979
08/04/12	c	1	8am	12.40	17.17	-4.766
08/04/12	c	1	12pm	23.30	18.53	4.766
08/04/12	b	1	8am	12.47	18.39	-5.918
08/04/12	b	1	12pm	32.17	26.25	5.918
08/04/12	a	2	8am	15.43	13.66	1.765
08/04/12	a	2	12pm	13.17	14.94	-1.765
08/04/12	b	2	8am	10.60	9.42	1.182
08/04/12	b	2	12pm	16.10	17.28	-1.182
08/04/12	d	2	8am	14.40	14.19	0.214
08/04/12	d	2	12pm	14.90	15.11	-0.214
08/04/12	c	2	8am	14.10	10.05	4.049
08/04/12	c	2	12pm	7.37	11.42	-4.049
08/04/12	b	3	8am	13.97	12.70	1.268
08/04/12	b	3	12pm	19.30	20.57	-1.268
08/04/12	c	3	8am	25.07	21.89	3.184
08/04/12	c	3	12pm	20.07	23.25	-3.184

08/04/12	a	3	8am	10.93	11.73	-0.800
08/04/12	a	3	12pm	13.80	13.00	0.800
08/04/12	d	3	8am	13.13	14.09	-0.956
08/04/12	d	3	12pm	15.97	15.01	0.956
08/04/12	d	4	8am	12.10	12.34	-0.236
08/04/12	d	4	12pm	13.50	13.26	0.236
08/04/12	b	4	8am	12.57	9.10	3.468
08/04/12	b	4	12pm	13.50	16.97	-3.468
08/04/12	c	4	8am	11.63	14.10	-2.466
08/04/12	c	4	12pm	17.93	15.46	2.466
08/04/12	a	4	8am	11.17	12.15	-0.980
08/04/12	a	4	12pm	14.40	13.42	0.980
09/04/12	a	1	8am	27.37	20.02	7.355
09/04/12	a	1	12pm	11.70	19.05	-7.355
09/04/12	d	1	8am	12.17	13.36	-1.191
09/04/12	d	1	12pm	11.80	10.61	1.191
09/04/12	c	1	8am	17.00	20.19	-3.186
09/04/12	c	1	12pm	15.33	12.14	3.186
09/04/12	b	1	8am	15.37	13.55	1.822
09/04/12	b	1	12pm	12.93	14.75	-1.822
09/04/12	a	2	8am	10.43	10.13	0.300
09/04/12	a	2	12pm	8.87	9.17	-0.300

09/04/12	b	2	8am	8.30	11.36	-3.062
09/04/12	b	2	12pm	15.63	12.57	3.062
09/04/12	d	2	8am	19.37	15.80	3.574
09/04/12	d	2	12pm	9.47	13.04	-3.574
09/04/12	c	2	8am	11.47	15.41	-3.936
09/04/12	c	2	12pm	11.30	7.36	3.936
09/04/12	b	3	8am	10.63	10.73	-0.097
09/04/12	b	3	12pm	12.03	11.93	0.097
09/04/12	c	3	8am	41.37	30.09	11.279
09/04/12	c	3	12pm	10.77	22.05	-11.279
09/04/12	a	3	8am	12.00	12.99	-0.995
09/04/12	a	3	12pm	13.03	12.04	0.995
09/04/12	d	3	8am	18.30	19.98	-1.676
09/04/12	d	3	12pm	18.90	17.22	1.676
09/04/12	d	4	8am	11.47	12.18	-0.706
09/04/12	d	4	12pm	10.13	9.42	0.706
09/04/12	b	4	8am	9.57	8.23	1.337
09/04/12	b	4	12pm	8.10	9.44	-1.337
09/04/12	c	4	8am	10.10	14.26	-4.156
09/04/12	c	4	12pm	10.37	6.21	4.156
09/04/12	a	4	8am	12.37	19.03	-6.660
09/04/12	a	4	12pm	24.73	18.07	6.660

10/04/12	a	1	8am	23.70	20.47	3.231
10/04/12	a	1	12pm	10.47	13.70	-3.231
10/04/12	d	1	8am	38.40	31.16	7.241
10/04/12	d	1	12pm	21.67	28.91	-7.241
10/04/12	c	1	8am	19.80	19.77	0.029
10/04/12	c	1	12pm	*	26.12	*
10/04/12	b	1	8am	15.23	16.36	-1.129
10/04/12	b	1	12pm	14.73	13.60	1.129
10/04/12	a	2	8am	10.37	12.75	-2.384
10/04/12	a	2	12pm	8.37	5.99	2.384
10/04/12	b	2	8am	12.90	12.28	0.621
10/04/12	b	2	12pm	8.90	9.52	-0.621
10/04/12	d	2	8am	12.80	13.37	-0.574
10/04/12	d	2	12pm	11.70	11.13	0.574
10/04/12	c	2	8am	18.67	16.83	1.839
10/04/12	c	2	12pm	21.37	23.21	-1.839
10/04/12	b	3	8am	19.43	18.04	1.386
10/04/12	b	3	12pm	13.90	15.29	-1.386
10/04/12	c	3	8am	10.90	15.68	-4.776
10/04/12	c	3	12pm	26.83	22.05	4.776
10/04/12	a	3	8am	14.37	15.20	-0.834
10/04/12	a	3	12pm	9.27	8.44	0.834

10/04/12	d	3	8am	22.93	29.60	-6.674
10/04/12	d	3	12pm	34.03	27.36	6.674
10/04/12	d	4	8am	13.23	13.22	0.006
10/04/12	d	4	12pm	10.97	10.98	-0.006
10/04/12	b	4	8am	12.97	13.85	-0.879
10/04/12	b	4	12pm	11.97	11.09	0.879
10/04/12	c	4	8am	14.87	11.96	2.909
10/04/12	c	4	12pm	15.43	18.34	-2.909
10/04/12	a	4	8am	15.77	15.78	-0.014
10/04/12	a	4	12pm	9.03	9.02	0.014
11/04/12	a	1	8am	14.87	9.06	5.811
11/04/12	a	1	12pm	8.00	13.81	-5.811
11/04/12	d	1	8am	14.20	13.82	0.375
11/04/12	d	1	12pm	7.90	8.28	-0.375
11/04/12	c	1	8am	11.00	16.28	-5.284
11/04/12	c	1	12pm	24.30	19.02	5.284
11/04/12	b	1	8am	12.87	32.80	-19.932
11/04/12	b	1	12pm	78.30	58.37	19.932
11/04/12	a	2	8am	13.50	11.42	2.076
11/04/12	a	2	12pm	14.10	16.18	-2.076
11/04/12	b	2	8am	13.10	0.22	12.883
11/04/12	b	2	12pm	12.90	25.78	-12.883

11/04/12	d	2	8am	16.33	17.34	-1.010
11/04/12	d	2	12pm	12.80	11.79	1.010
11/04/12	c	2	8am	14.67	14.12	0.551
11/04/12	c	2	12pm	16.30	16.85	-0.551
11/04/12	b	3	8am	12.17	20.89	-8.718
11/04/12	b	3	12pm	55.17	46.45	8.718
11/04/12	c	3	8am	15.57	13.07	2.501
11/04/12	c	3	12pm	13.30	15.80	-2.501
11/04/12	a	3	8am	9.73	12.67	-2.944
11/04/12	a	3	12pm	20.37	17.43	2.944
11/04/12	d	3	8am	15.20	21.23	-6.025
11/04/12	d	3	12pm	21.70	15.67	6.025
11/04/12	d	4	8am	27.77	21.11	6.660
11/04/12	d	4	12pm	8.90	15.56	-6.660
11/04/12	b	4	8am	13.80	-1.97	15.767
11/04/12	b	4	12pm	7.83	23.60	-15.767
11/04/12	c	4	8am	17.00	14.77	2.231
11/04/12	c	4	12pm	15.27	17.50	-2.231
11/04/12	a	4	8am	10.83	15.77	-4.944
11/04/12	a	4	12pm	25.47	20.53	4.944
12/04/12	a	1	8am	20.63	15.19	5.445
12/04/12	a	1	12pm	6.73	12.17	-5.445

12/04/12	d	1	8am	10.43	12.94	-2.508
12/04/12	d	1	12pm	12.73	10.22	2.508
12/04/12	c	1	8am	18.17	17.75	0.421
12/04/12	c	1	12pm	16.17	16.59	-0.421
12/04/12	b	1	8am	9.57	13.26	-3.694
12/04/12	b	1	12pm	11.53	7.84	3.694
12/04/12	a	2	8am	12.50	12.52	-0.020
12/04/12	a	2	12pm	9.53	9.51	0.020
12/04/12	b	2	8am	13.47	14.80	-1.329
12/04/12	b	2	12pm	10.70	9.37	1.329
12/04/12	d	2	8am	13.30	14.39	-1.092
12/04/12	d	2	12pm	12.77	11.68	1.092
12/04/12	c	2	8am	12.80	12.71	0.086
12/04/12	c	2	12pm	11.47	11.56	-0.086
12/04/12	b	3	8am	17.97	16.63	1.336
12/04/12	b	3	12pm	9.87	11.21	-1.336
12/04/12	c	3	8am	10.93	10.46	0.471
12/04/12	c	3	12pm	8.83	9.30	-0.471
12/04/12	a	3	8am	11.07	14.19	-3.120
12/04/12	a	3	12pm	14.30	11.18	3.120
12/04/12	d	3	8am	18.23	16.94	1.293
12/04/12	d	3	12pm	12.93	14.22	-1.293

12/04/12	d	4	8am	17.70	15.39	2.307
12/04/12	d	4	12pm	10.37	12.68	-2.307
12/04/12	b	4	8am	21.00	17.31	3.686
12/04/12	b	4	12pm	8.20	11.89	-3.686
12/04/12	c	4	8am	13.10	14.08	-0.979
12/04/12	c	4	12pm	13.90	12.92	0.979
12/04/12	a	4	8am	11.77	14.07	-2.305
12/04/12	a	4	12pm	13.37	11.06	2.305
13/04/12	a	1	8am	13.50	9.08	4.424
13/04/12	a	1	12pm	9.87	14.29	-4.424
13/04/12	d	1	8am	19.33	15.72	3.606
13/04/12	d	1	12pm	15.10	18.71	-3.606
13/04/12	c	1	8am	16.97	27.16	-10.190
13/04/12	c	1	12pm	40.53	30.34	10.190
13/04/12	b	1	8am	11.60	14.36	-2.757
13/04/12	b	1	12pm	16.33	13.57	2.757
13/04/12	a	2	8am	15.10	21.63	-6.526
13/04/12	a	2	12pm	33.37	26.84	6.526
13/04/12	b	2	8am	18.37	16.06	2.307
13/04/12	b	2	12pm	12.97	15.28	-2.307
13/04/12	d	2	8am	15.47	10.64	4.826
13/04/12	d	2	12pm	8.80	13.63	-4.826

13/04/12	c	2	8am	24.20	19.61	4.590
13/04/12	c	2	12pm	18.20	22.79	-4.590
13/04/12	b	3	8am	13.67	17.13	-3.458
13/04/12	b	3	12pm	19.80	16.34	3.458
13/04/12	c	3	8am	12.30	8.33	3.975
13/04/12	c	3	12pm	7.53	11.51	-3.975
13/04/12	a	3	8am	10.30	7.56	2.744
13/04/12	a	3	12pm	10.03	12.77	-2.744
13/04/12	d	3	8am	13.27	18.74	-5.474
13/04/12	d	3	12pm	27.20	21.73	5.474
13/04/12	d	4	8am	10.60	13.56	-2.959
13/04/12	d	4	12pm	19.50	16.54	2.959
13/04/12	b	4	8am	17.03	13.12	3.908
13/04/12	b	4	12pm	8.43	12.34	-3.908
13/04/12	c	4	8am	10.50	8.88	1.625
13/04/12	c	4	12pm	10.43	12.05	-1.625
13/04/12	a	4	8am	15.13	15.77	-0.641
13/04/12	a	4	12pm	21.63	20.99	0.641
14/04/12	a	1	8am	16.77	10.68	6.086
14/04/12	a	1	12pm	11.87	17.96	-6.086
14/04/12	d	1	8am	12.47	12.29	0.178
14/04/12	d	1	12pm	8.10	8.28	-0.178

14/04/12	c	1	8am	13.53	10.25	3.276
14/04/12	c	1	12pm	7.37	10.65	-3.276
14/04/12	b	1	8am	12.93	11.16	1.769
14/04/12	b	1	12pm	6.80	8.57	-1.769
14/04/12	a	2	8am	13.37	10.46	2.906
14/04/12	a	2	12pm	14.83	17.74	-2.906
14/04/12	b	2	8am	14.07	12.92	1.154
14/04/12	b	2	12pm	9.17	10.32	-1.154
14/04/12	d	2	8am	9.83	10.36	-0.528
14/04/12	d	2	12pm	6.87	6.34	0.528
14/04/12	c	2	8am	13.27	12.57	0.696
14/04/12	c	2	12pm	12.27	12.97	-0.696
14/04/12	b	3	8am	13.17	16.60	-3.426
14/04/12	b	3	12pm	17.43	14.00	3.426
14/04/12	c	3	8am	16.17	13.32	2.846
14/04/12	c	3	12pm	10.87	13.72	-2.846
14/04/12	a	3	8am	9.80	21.28	-11.479
14/04/12	a	3	12pm	40.03	28.55	11.479
14/04/12	d	3	8am	15.33	13.49	1.842
14/04/12	d	3	12pm	7.63	9.47	-1.842
14/04/12	d	4	8am	9.73	11.22	-1.492
14/04/12	d	4	12pm	8.70	7.21	1.492

14/04/12	b	4	8am	12.13	11.63	0.504
14/04/12	b	4	12pm	8.53	9.03	-0.504
14/04/12	c	4	8am	10.17	16.99	-6.819
14/04/12	c	4	12pm	24.20	17.38	6.819
14/04/12	a	4	8am	9.47	6.98	2.486
14/04/12	a	4	12pm	11.77	14.26	-2.486
15/04/12	a	1	8am	15.37	21.77	-6.395
15/04/12	a	1	12pm	22.00	15.61	6.395
15/04/12	d	1	8am	14.20	16.14	-1.941
15/04/12	d	1	12pm	17.13	15.19	1.941
15/04/12	c	1	8am	15.87	17.15	-1.284
15/04/12	c	1	12pm	8.93	7.65	1.284
15/04/12	b	1	8am	16.87	21.62	-4.750
15/04/12	b	1	12pm	22.97	18.22	4.750
15/04/12	a	2	8am	23.27	21.15	2.120
15/04/12	a	2	12pm	12.87	14.99	-2.120
15/04/12	b	2	8am	11.60	13.85	-2.250
15/04/12	b	2	12pm	12.70	10.45	2.250
15/04/12	d	2	8am	10.77	9.73	1.044
15/04/12	d	2	12pm	7.73	8.77	-1.044
15/04/12	c	2	8am	32.83	26.77	6.061
15/04/12	c	2	12pm	11.20	17.26	-6.061

15/04/12	b	3	8am	28.27	22.54	5.735
15/04/12	b	3	12pm	13.40	19.13	-5.735
15/04/12	c	3	8am	14.63	16.97	-2.339
15/04/12	c	3	12pm	9.80	7.46	2.339
15/04/12	a	3	8am	26.27	20.96	5.305
15/04/12	a	3	12pm	9.50	14.80	-5.305
15/04/12	d	3	8am	13.93	12.51	1.424
15/04/12	d	3	12pm	10.13	11.55	-1.424
15/04/12	d	4	8am	9.80	10.33	-0.526
15/04/12	d	4	12pm	9.90	9.37	0.526
15/04/12	b	4	8am	15.00	13.74	1.265
15/04/12	b	4	12pm	9.07	10.33	-1.265
15/04/12	c	4	8am	16.23	18.67	-2.439
15/04/12	c	4	12pm	11.60	9.16	2.439
15/04/12	a	4	8am	14.10	15.13	-1.030
15/04/12	a	4	12pm	10.00	8.97	1.030

End of Anthony de Pontes - M.Tech. Homoeopathy, Durban University of Technology. Current data space: 1 block, peak usage 33% at line 1001.

GenStat 64-bit Release 14.1 (PC/Windows 7) 02 May 2012 12:08:34

B3. Chlorophyll content

file is Lettuce chlorophyll.gen

================================== Lettuce chlorophyll

April 2012

Identifier	Minimum	Mean	Maximum	Values	Missing	
Plant1	1.200	18.98	51.50	96	0	
Plant2	4.800	18.65	50.40	96	0	
Plant3	4.600	17.80	48.30	96	0	
Plant4	5.500	18.88	63.50	96	0	Skew
Chlorophyl	5.850	18.58	38.88	96	0	

Identifier	Values	Missing	Levels
DATE	96	0	6
TMT	96	0	4
REP	96	0	4

Analysis of variance

Variate: Chlorophyl

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	153.96	51.32	2.29	
REP.TMT stratum					
TMT	3	174.30	58.10	2.60	0.117
Residual	9	201.48	22.39	0.42	
REP.TMT.DATE stratum					
DATE	5	372.19	74.44	1.39	0.241
TMT.DATE	15	503.17	33.54	0.63	0.842
Residual	60	3215.95	53.60		
Total	95	4621.06			

Tables of means

Variate: Chlorophyl

Grand mean 18.58

TMT	a	b	c	d
	19.65	19.89	16.50	18.27

DATE	02/04/12	05/04/12	10/04/12	11/04/12	13/04/12	30/03/12
	19.30	21.21	19.58	16.56	15.40	19.40

TMT	DATE	02/04/12	05/04/12	10/04/12	11/04/12	13/04/12	30/03/12
a		24.07	25.34	17.42	17.79	17.44	15.83
b		21.21	20.31	20.41	18.68	16.40	22.32
c		13.11	16.70	19.67	17.36	13.51	18.68
d		18.83	22.48	20.83	12.41	14.27	20.79

Standard errors of means

Table	TMT	DATE	TMT DATE
rep.	24	16	4
e.s.e.	0.966	1.830	3.478
d.f.	9	60	67.31

Except when comparing means with the same level(s) of

TMT	3.661
d.f.	60

Stratum standard errors and coefficients of variation

Variate: Chlorophyl

Stratum	d.f.	s.e.	cv%
REP	3	1.462	7.9
REP.TMT	9	1.932	10.4
REP.TMT.DATE	60	7.321	39.4

========== Summary of original data =========

	Nobservd	Mean	Variance
TMT			
a	24	19.65	41.82
b	24	19.89	70.30
c	24	16.50	30.00
d	24	18.27	51.22

TMT	REP	Chlorophyl	FITTED	RESIDUAL
a	1	16.20	16.03	0.169
d	1	35.95	22.06	13.891
c	1	21.35	18.16	3.191
b	1	29.35	26.47	2.880
a	2	25.98	14.45	11.527
b	2	19.55	20.35	-0.803
d	2	22.65	18.21	4.445
c	2	14.28	17.16	-2.889
b	3	10.55	19.48	-8.932
c	3	23.10	19.48	3.620
a	3	10.53	14.15	-3.627
d	3	13.43	22.65	-9.222
d	4	11.15	20.26	-9.114
b	4	29.82	22.97	6.855
c	4	15.97	19.90	-3.922
a	4	10.62	18.69	-8.069
d	1	14.28	20.09	-5.816
a	1	19.52	24.27	-4.750
c	1	10.10	12.59	-2.491
b	1	19.35	25.36	-6.007
a	2	18.70	22.69	-3.992

b	2	32.05	19.24	12.809
d	2	9.12	16.24	-7.111
c	2	16.80	11.59	5.205
b	3	8.65	18.37	-9.720
c	3	9.80	13.91	-4.111
a	3	25.02	22.40	2.629
d	3	22.48	20.68	1.797
d	4	29.43	18.29	11.130
b	4	24.77	21.86	2.918
c	4	15.72	14.33	1.397
a	4	33.05	26.94	6.112
a	1	23.38	25.54	-2.169
d	1	15.45	23.74	-8.291
c	1	12.47	16.18	-3.709
b	1	27.30	24.46	2.843
a	2	20.65	23.96	-3.310
b	2	14.65	18.34	-3.691
d	2	20.23	19.89	0.339
c	2	13.80	15.19	-1.389
b	3	16.88	17.47	-0.595
c	3	19.93	17.51	2.420
a	3	24.15	23.66	0.485

d	3	32.98	24.33	8.647
d	4	21.25	21.94	-0.695
b	4	22.40	20.96	1.443
c	4	20.60	17.92	2.678
a	4	33.20	28.21	4.994
a	1	13.15	17.62	-4.469
d	1	21.98	22.10	-0.122
c	1	17.57	19.15	-1.578
b	1	18.15	24.56	-6.407
a	2	18.20	16.04	2.165
b	2	21.70	18.44	3.259
d	2	17.80	18.24	-0.443
c	2	10.72	18.16	-7.432
b	3	25.82	17.57	8.255
c	3	30.38	20.47	9.901
a	3	21.50	15.74	5.760
d	3	22.45	22.68	-0.234
d	4	21.10	20.30	0.799
b	4	15.95	21.06	-5.107
c	4	20.00	20.89	-0.891
a	4	16.82	20.28	-3.456
a	1	22.30	17.99	4.306

d	1	17.23	13.68	3.547
c	1	23.98	16.84	7.134
b	1	38.88	22.83	16.043
a	2	14.38	16.41	-2.035
b	2	10.05	16.72	-6.666
d	2	11.00	9.82	1.176
c	2	20.20	15.84	4.355
b	3	10.15	15.84	-5.695
c	3	5.85	18.16	-12.311
a	3	9.80	16.11	-6.315
d	3	11.18	14.27	-3.091
d	4	10.25	11.88	-1.632
b	4	15.65	19.33	-3.682
c	4	19.40	18.58	0.822
a	4	24.70	20.66	4.044
a	1	24.55	17.64	6.913
d	1	12.32	15.53	-3.209
c	1	10.45	13.00	-2.547
b	1	11.20	20.55	-9.351
a	2	11.70	16.05	-4.354
b	2	9.53	14.43	-4.909
d	2	13.28	11.68	1.595

c	2	14.15	12.00	2.149
b	3	30.25	13.56	16.686
c	3	14.80	14.32	0.482
a	3	16.82	15.76	1.067
d	3	18.23	16.12	2.103
d	4	13.25	13.74	-0.489
b	4	14.62	17.05	-2.426
c	4	14.65	14.73	-0.084
a	4	16.68	20.30	-3.625

End of Anthony de Pontes - M.Tech. Homoeopathy, Durban University of Technology. Current data space: 1 block, peak usage 48% at line 148.

GenStat 64-bit Release 14.1 (PC/Windows 7) 02 May 2012 11:57:24

Registered to: ARC Biometry Unit

B4. Mineral content

ANALYSIS REPORT: ARC –

INSTITUTE FOR SOIL, CLIMATE AND WATER

ONTLEDINGSVERSLAG: LNR –

INSTITUUT VIR GROND KLIMAAT EN WATER

600 Belvedere Street, Arcadia, Pretoria.

P. Bag X79, Pretoria, 0001.

Telephone: (012) 310 2500   Telefax (012) 323 1157

Report Number: PLANT 2012/13-1255

Report on: Analysis of Dry Lettuce from A de Pontes

Lab No.	Sender No.	Tot N %	Mg %	K %	Fe mg/kg	Ca %
P23	Rep 1 tx a	5.53	0.489	5.986	417.9	1.478
P24	Rep 1 tx b	5.65	0.494	5.723	405.4	1.505
P25	Rep 1 tx c	5.60	0.515	5.608	419.7	1.627
P26	Rep 1 tx d	5.04	0.478	5.784	520.9	1.378
P27	Rep 2 tx a	5.64	0.523	5.852	470.8	1.457
P28	Rep 2 tx b	5.54	0.459	4.941	332.5	1.448

P29	Rep 2 tx c	5.56	0.504	6.283	338.8	1.454
P30	Rep 2 tx d	5.49	0.485	5.630	375.4	1.464
P31	Rep 3 tx a	5.35	0.448	5.264	277.9	1.480
P32	Rep 3 tx b	5.36	0.460	5.391	339.5	1.383
P33	Rep 3 tx c	5.26	0.461	5.358	277.4	1.397
P34	Rep 3 tx d	5.17	0.488	5.214	387.3	1.439
P35	Rep 4 tx a	5.70	0.458	5.345	391.4	1.480
P36	Rep 4 tx b	4.96	0.444	5.115	360.7	1.388
P37	Rep 4 tx c	5.68	0.462	5.829	533.9	1.322
P38	Rep 4 tx d	5.32	0.456	5.824	296.4	1.324

APPENDIX C

Description of NA 1500 Nitrogen Carbon Sulphur analyser

The instrument is a Carlo Erba NA 1500 Nitrogen Carbon Sulphur Analyser. It uses Gas Chromatography (GC) to separate the gases, ie N (in the form of N_2), C (in the form of CO_2) and S (in the form of SO_2), using a He carrier gas and a thermal conductivity detector (TCD). The two main modes of the unmodified instrument are:-

1. C & N only (or N only if a CO_2 trap is installed), using both furnaces with a combustion column in the first furnace at very high temp. (1020° C) and a reduction column, packed with Cu, in the second furnace at a lower temp. (540° C). The combustion column is packed with a chrome (Cr) oxide catalyst above a layer of silvered cobalt (Co) oxide, with the top half of the column empty (to allow the sample in its tin capsule to fall into the middle of the column). The silvered cobalt oxide absorbs (or reacts with) any S and halogens present.

2. C, N & S mode, where only one furnace and one column, for combustion and reduction, is used. The Cu for reduction is packed in the bottom quarter of this column, below a tungsten (W) on aluminium oxide catalyst (instead of the chrome oxide). Obviously no silvered cobalt oxide is used.

Since mid 2008, we have been using PeakNet software (Dionex Corporation, May 1998), with an external A/D interface (UI20 Universal Interface, Dionex). This software allows non-linear calibrations, but only polynomial (eg quadratic), use of peak height or peak area, smoothing out of high frequency noise and flexibility in peak integration. We have found that peak area is by far the best for the narrow C and N peaks, while for the broader S peak, peak area is usually still slightly better, but peak height is very similar in accuracy and occasionally better. For very low N in the presence of high C, peak height may be more accurate than peak area for the very small N peak.

Compliled by M.F. Philpott B.Sc (Hons) (Chem.) (UCT), Dip. Dat. (UNISA), MBA (Wits)

Appendix D: Ozone proving

by Anne Schadde (Grimes, 2006)

Mind

• Euphoric sensation, as if on speed, as if tipsy.

• Feeling of ease.

• Very quiet and calm, relaxed.

• Positive feeling, conspicuous loss of tension.

going as far as a

• Floating sensation.

• Notable cheerfulness.

progressing to feelings such as

• Mood is not constant, it is unsteady, it can change at any moment.

going as far as

• Increased sensitivity.

• Feeling of tension.

and up to

• Totally worked up, irritated and cross.

• Aggressive with swearing and feeling overtaxed.

as far as

• maliciousness without feeling guilty.

The following symptoms show even more clearly the process on another level.

• **Sensation of floating.**

• As if without contact, offer no chance of approach with a feeling of

• standing beside myself, not participating

• as if I were surrounded by a layer.

• Feeling as if wandering beneath a glass dome, separated from others.

and up to

• Indifference, inner coldness, unemotional.

• Feeling of inner emptiness.

• Feeling as if I were a dead, unfeeling stone.

The effects on the intellectual level are accordingly, from

• Very concentrated, need for mental occupation.

• Communicative.

• Clear perception: as if something is disengaging from the heaviness of the body.

up to

• Difficulty in concentration.

• Fairly absent-minded.

• Mistakes when writing.

• Forgetfulness.

• Missing words, I feel as if separated from myself.

• Distortion of sensation of time.

The colour of ozone is responsible for the dark blue evening skies. On the other hand the colour of oxygen effects the blue daytime skies. This is also explicable in the symptoms of the remedy proving.

• The evening sky is blue-black in colour, darkness is approaching, nighttime.

In gaseous form ozone is blue, in fluid state (boiling point - 110.5ºC) violet-blue and in solid form (melting point - 192.5ºC) black-violet. Regarding this it is interesting to observe the materia medica symptoms:

• Fear and panic, heaven has turned against me.

• My situation is more and more hopeless.

• Fear in the dark, my final hour has struck.

• Hopelessness and despair.

• I want to die.

• I feel connected to the dark forces and am attracted to the colour black.

• I imagine that the countryside is covered with a black, soft, warm layer of snow.

In accordance with the hermetic principle "As above, so below" the ozone topic also has to manifest itself on the physical level. We gain insight into this:

Vertigo

• Feeling as if passing out

Head

• Clear and active in mind.

• Sensation of lightness in head, as if brain were not getting enough oxygen.

and up to

• Dullness in head.

• Feeling of numbness in head.

• Feeling of heaviness, a dazed state.

and as for headaches

• Headache like a cap, a ring, a wrench.

• Headache combined with a stiff neck (one cannot move one´s head anymore!!) .

Eyes

• Sensation as if the cornea is covered with a milky layer.

• Sensation as if something was deposited in the corner of one´s eye.

• Vision as if looking through fog.

• Vision as if looking through a white curtain.

Hearing

• As if through cottonwool.

• As if the ears were shut off.

Nose

• Sensitive to smell, especially repelled by the smell of petrol and chlorine in the indoor swimming pool.

• Smells are intensely perceived.

• Stuffed nose, permanent cold.

• Urge to sneeze.

Face

• Tired, worn-out, pale.

• **Change in pigmentation** (see further on under "Skin").

Stomach

• Burping.

• Nausea.

• Desire for alcohol, sweets.

The remedy proving provided interesting symptoms:

Mouth

• Dryness of mucous membranes.

Throat

• Aching pain in the throat.

• Sensation of lump.

Larynx

• Hoarseness.

Respiration

• Natural.

• Difficulty in breathing. Shortness of breath.

• Nervous cough.

Skin

• Vitiligo (bleached patches!!).

A general symptom experienced by almost all provers was the

• Extreme tiredness,

• a feeling of exhaustion.

• Heaviness, as if from a lead apron.

Naturally these subjects have to show up in the dreams. Just how "fertile", i. e. positive such an undertaking can prove to be is depicted by the following:
A female prover dreamt at the start of the proving of "birth". Her thoughts in the dream were: "does something want to be born by means of the remedy?". Nine months later she gave birth to twins. (Both father and mother of these twins participated in the proving) .

Other selected subjects of dreams were:
• of childhood;
• of snakes;
• of elephants;
• of a house made of glass, crystal, marble;
• of sloppy looking and filthy houses, totally dusty attics,
• soiled and shabby huts;
• of toilets;
• of mountains and mountain peaks, where heaven is closer to earth;
• of travels and foreign places (Peking, Russia, Iceland);
• of unfortunate undertakings;
• of danger, of being threatened;
• of illegality;
• of black (!) stains on white and white stains on black;
• of poisonous industrial snow;
• of gas masks and radioactivity;
• of death and farewells and separation.