THE EFFECT OF HOMOEOPATHIC TREATMENT ON PERCENTAGE GERMINATION OF LETTUCE (*LACTUCA SATIVA*) SEEDS AND THE EFFECT OF A HOMOEOPATHIC ANTIDOTE UPON THESE TREATMENTS

BY

CROFTON RUSSELL HOPKINS

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I, Crofton Russell Hopkins, do hereby declare that this dissertation represents my own work both in concept and execution

Signature of Student

28/05/98

Date of Signature

Approved for final submission

Signature of Supervisor

28/05/98

Date of Signature

Supervisor: Professor A.L.P. Cairns Ph.D. Crop Science

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ABSTRACT

The purpose of this investigation was to evaluate the effects of homoeopathic medicine treatments on Lactuca sativa (lettuce) seed germination. It was hypothesized that Sulphur, Nitric acid and Camphor treatments would effect seed germination and that a combination of the formative two treatments individually combined with Camphor at the same potency levels would have an antidotal effect when compared to the original outcome.

Four experiments were conducted: *Experiment 1* - Germinability trial utilizing high germinability Commander cultivar seed (96% germinability) involving the application of four homoeopathic treatments (Sulphur, Nitric acid, Sulphur/Camphor, Nitric acid/Camphor) at thirty different potency levels (3CH→32CH) and a Control. *Experiment 2* - Germinability trial utilizing 0% germinability Commander cultivar seed involving application of four homoeopathic treatments (Sulphur, Nitric acid, Sulphur/Camphor, and Nitric acid/Camphor) at four different potency levels (3CH, 9CH, 15CH & 30CH) and a Control. *Experiment 3* - Germinability trial utilizing three different cultivars (Greenfield, Great Lakes and Grand Rapids) involving application of five homoeopathic treatments (Sulphur, Nitric acid, Sulphur/Camphor, Nitric acid/Camphor and Camphor) at four different potency levels (3CH, 9CH, 15CH & 30CH). *Experiment 4* - Germinability trial utilizing four different cultivars (Commander, Greenfield, Great Lakes and Grand Rapids) involving one homoeopathic treatment (Camphor 3CH) under four different light and temperature conditions (light @ 15°C; light @ 29°C; dark @ 15°C and dark @ 29°C).

The investigation supported the above hypotheses with clear measurable and statistically significant differences being noted for Sulphur, Nitric acid and Camphor on lettuce seed germination. Camphor showed consistently faster germinability when compared to other treatments independent of cultivar type. Combined treatments of Sulphur/Camphor and Nitric acid/Camphor (in

equivocal potency), as "antidote" treatments were less consistent in their effect in that responses varied across the cultivars. The results also showed that all treatments at 3CH potency consistently provided lower germinability than the other potencies used (9CH, 15CH & 30CH) independent of the cultivar. No significant differences between the other potency levels were observed. Furthermore experiment 4 showed that germinability, involving the four cultivars mentioned, was temperature dependent where germination occurred most favorably at a temperature of 15°C, independent of light or dark conditions.

Although the investigation served to support the employment of germinability trials as a means of assessing effect of homoeopathic medicines further investigation is required to provide conclusive evidence as to mechanisms by which the results may have occurred.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF FIGURES

DEFINITIONS OF TERMS

Antidote

Antidote (homoeopathic) refers to a substance, which by virtue of its similarity in bioenergetic effects, neutralizes the competing substance's field of influence, concealing its effects. The antidoting effect is exerted directly upon the organism, although it takes place indirectly between drugs by neutralization. (Gaier, 1991: 39 – 40.)

Avogadro's hypothesis (Number)

That the number of molecules in one mole of any substance is 6.02554 x 10^{23} as demonstrated by Amedeo Avagadro (1776 – 1856). According to the laws of chemistry, there is a limit to how many serial dilutions can be made without loosing the original substance altogether. Solutions diluted beyond Avogadro's number have no molecules left in solution that can be detected with methods currently available (i.e. potencies equal to and greater the 12CH or 24 DH). (Kayne, 1997: 27; 174.)

Potency

A state of altered remedial activity to which a drug is taken by means of a measured process of deconcentration and the introduction of kinetic energy through succussion or trituration (see below). The rates of deconcentration are used in preparation of homoeopathic potencies. (Gaier, 1991: 432 – 441.)

Centisimal potency

Is a homoeopathic potency scale, introduced by Hahnemann, in which one part of mother tincture (see below) is added to 99 parts of diluent which is subjected to vigorous shaking or grinding known as sucussion or trituration respectively. Each successive Centisimal potency refers to the number of successive 1 in 100 dilutions. (Gaier, 1991: 84,432 – 441.)

Sucussion

The action of shaking up, or the condition of being shaken up vigorously of a liquid dilution of a homoeopathic medicine in its vial or bottle, where each stroke ends with a jolt, usually by pounding the hand engaged in the shaking action against the other palm. (Gaier, 1991: 532.)

Germination

Germination begins with water uptake by the seeds (imbibition) and ends with the start of elongation by the embryonic axis, usually the radicle. It therefore included numerous events e.g. protein hydration, sub-cellular structural changes, respiration, macromolecular synthesis and cell elongation, none of which is itself unique to germination. But their combined effect is to transform a dehydrated, resting embryo with a diminished metabolism into one that has a vigorous metabolism culminating in growth. Germination *sensu stricto* therefore does not include seedling growth, which commences when germination finishes. Germination measurement for the purpose of this experiment will be determined when the axis (in the case the radicle) first emerges through the testa. (Bewley and Black, 1985: 1.)

Quiescent

A seed in which none of the germination processes is taking place (Bewley and Black, 1985: 1.)

Dormancy

Components of the germination process may, however, occur in a seed that does not achieve radicle emergence. Even when conditions are apparently favorable for germination, so that imbibition, respiration synthesis of nucleic acids and proteins, and many other metabolic events all proceed, culminating in cell elongation does not occur, for reasons that are still poorly understood, such a seed expresses dormancy. (Bewley and Black, 1985:1/2.)

Pharmacopoeia

Is an authentic reference work containing monographs of medicines and other therapeutic agents. Specifications of the sources and standards for the strengths and purity of base substances and mother tinctures, formulae and methods of preparation of these substances as well as descriptions of processes for the testing of starting materials. (Frazer, 1992.)

Mother tincture

Liquid preparations resulting from the extraction of constituents from suitable source material with alcoholic or hydroalcoholic solutions, which form the starting point for most homeopathic medicine manufacture. (Gaier, 1991: 354-355.)

Trituration

Is one of the methods of homoeopathic drug preparation. It is the act of prolonged grinding with a mortar and pestle to reduce a homoeopathic drug (usually insoluble) to a fine powder while amalgamating it thoroughly with *Saccharum lactis* (lactose) by rubbing the combination with the pestle in the mortar. (Gaier, 1991: 559.)

Growth chamber (Germination chamber)

Is a specifically designed receptacle used to provide controlled conditions (e.g. temperature and light) for the purpose of seed germination in this particular case.

CHAPTER ONE

INTRODUCTION

Food is one of the basic necessities of life and what sort of food should be eaten has been, and will probably always continue to be, a hotly debated issue. Throughout the years and amongst the theories and themes that have been developed however, the contribution that fresh vegetable produce makes to a healthy diet has seldom been underestimated. None has been more significant to this development than lettuce which has become known as "the king of salad plants" (Shoemaker, 1947: 219). This popular and extensively grown leafy vegetable has increased its prevalence from sparing cultivation by the Persians, as early as 500 BC (Splittstoesser, 1990: 214), to a current international leader. One particular occasion of importance in its development being when the physician of the first Roman emperor prescribed it for the ailing Caesar Augustus. On this occasion Caesar's rapid recovery to good health ensured that both the physician and lettuce enjoyed the success of his cure. (Shoemaker, 1947: 219.)

Lettuce, in its domestic form *L. sativa,* is included in the Compositae family of the plant kingdom, generally being accepted as the off spring of a wild or prickly variety *L. scariola* (Maclay, 1984). Of this large and versatile plant family from which several vegetables are derived only two have outstanding importance L. *sativa* and the globe artichoke *Cynara scolymus L.* (Hayward, 1967: 621). So significant has the former become in the international fresh produce market that it has, for example, become known in California, the most important crop producing region of the United States and internationally one of the most successful vegetable producing regions, as "Green Gold" (Ryder, 1979: 13).

Perhaps the most interesting consideration in this brief description of the development of lettuce would be - why lettuce particularly in the range of fresh

vegetable produce, what ensures its consistent and sustained support by the consumer? The nutritional attributes, and the versatility and aesthetic appeal to the health conscious consumer, are generally agreed to be the pivot points that sustain this market. Nutritional content expressed as g/100g include protein 1.0g, carbohydrate 1.2g, fiber 1.5g and fat 0.4g, while vitamin A and Folic acid are evident in significant quantities - total calorie content is 12 (Brown, 1984: 235). By way of example of this significant contribution to nutritional dependence, in the United States lettuces are ranked fourth after tomatoes, oranges and potatoes, in contribution of nutrients to diet (Wills, Lee, Graham, McGlasson, and Hall, 1989: 13 -14). In South Africa the sales figures for lettuce reflect a similar importance, and sales in 1987 of two cultivars, namely Crisphood and Butterhead, sold to the value of R 7 593 388 and R 86 175 respectively, through 14 national fresh produce markets. This well exceeded the sales of other important vegetables. (Anon, 1987.)

In light of the unique niche of health and consumer appeal which lettuce meets in the fresh vegetable produce market, and the lucrative nature of this industry, attention has turned in more recent years to refining the production of this crop. Extensive research has been focussed on the development and selection of versatile cultivars, and skills and techniques have been honed in the farming and marketing practices.

As with over 90% of all agriculture crops, lettuce is produced from seed (van der Burg and Bruno, 1994). Seed as the propagation material provides the plant breeder the opportunity to select particular genetic properties and the commercial market demand for lettuce has ensured that research and development on lettuce has been extensive. This market requirement has focussed research on the improvement in the quality of the harvested seed, the germination capacity, the germination speed, stress tolerance and disease control (van der Burg and Bino, 1994).

Despite considerable progress in the above fields still relatively is known about the actual processes of lettuce seed germination. Furthermore relatively little

reported investigative research has taken place into the germination process, or indeed any other process, when under homoeopathic treatment with homoeopathic preparations according to homoeopathic principles of application.

Sinha (1976), one of the fore-runners in "Agro-Homeoepathic", was of the opinion that homoeopathic treatment in agriculture, specifically vegetable production, has great potential in providing possibilities to resolve problems of production, poisoning, pollution and health hazards caused by plant protection chemicals. Sinha (1976) developed this opinion through examples of successes that several investigative attempts had reported with exploratory "Agro-Homoeopathy". McIvor (1980) too supported this potential and reported the success of isopathically prepared dilutions in treating fruit trees, including nectarine, plum, and peaches. The research on the use of homoeopathic medicine against some pathogenic fungi that affect seed germination, conducted by Saxena, Pandey, and Gupta, 1988, was favorable too for Homoeopathic treatments in agriculture. Beyond disease protection recent germinability studies conducted by Jharna, Sahila, and Chattpadhyay (1995), showed improved germination and vigor in seeds treated with *Azadirachta indica* leaf powder and iodium (mainly iodine).

The trend that emerges from these studies does indeed support Sinha's opinion of the potential for the use of Homoeopathy in Agriculture. This research aimed to verify whether a measurable biological effect on germination of lettuce seed under homoeopathic treatment could be established. It took the form of an investigation of the effect of homoeopathic treatment on percentage germination of lettuce seeds. In addition to the above the effect of a homoeopathic antidote upon these treatments was also determined, the latter aspect is, to the authors knowledge, novel research. By demonstrating effects to plants, there is no possibility of suggestion (placebo effects) affecting the results (Pelikan and Unger, 1971) and all results are therefore literal according to the experiments.

1.1 The aim of the study

The aim of this investigation was to evaluate the biological effects of homoeopathic medicine treatments on lettuce seed germination.

1.2 The statement of the objectives

1.2.1 The first objective

The first objective was to determine the efficacy of homoeopathic medicines on germinability of different cultivars of lettuce seeds by the application of a range of different potency levels of homoeopathically prepared Sulphur.

1.2.2 The second objective

The second objective was to determine the efficacy of homoeopathic medicines on germinability of different cultivars of lettuce seeds by application of a range of different potency levels of homoeopathically prepared Nitric acid.

1.2.3 The third objective

The third objective was to determine the efficacy of homoeopathic medicines on germinability of different cultivars of lettuce seeds by application of a range of different potency levels of homoeopathically prepared Camphor.

1.2.4 The fourth objective

The fourth objective was to determine the efficacy of homoeopathically prepared Camphor (homoeopathic antidote) on germinability of lettuce seeds when applied in conjugation with the Sulphur and Nitric acid treatments in the

corresponding potencies to the range established for Sulphur and Nitric acid treatments.

1.3 The Hypotheses

1.3.1 Hypothesis one

It is hypothesized that the homoeopathic medicine, Sulphur, prepared in different potencies has a biological effect on lettuce seed germination.

1.3.2 Hypothesis two

It is hypothesized that the homoeopathic medicine, Nitric acid, prepared in different potencies has a biological effect on lettuce seed germination

1.3.3 Hypothesis three

It is hypothesized that the homoeopathic medicine, Camphor, prepared in different potencies has a biological effect on lettuce seed germination.

1.3.4 Hypothesis four

It is hypothesized that homoeopathically prepared Camphor, prepared in the corresponding potencies to the Sulphur and Nitric acid treatments, will nullify the effects on germination that resulted from the Sulphur and Nitric acid treatments.

1.4 Delimitation

1.4.1 Delimitation one

The emphasis of this study is on observed biological activity in terms of germination rate and not on the mechanisms of action of the medicine, or of the germination process.

1.4.2 Delimitation two

This study is limited to observation of biological activity with respect to lettuce seed germination and not the effects on growth.

1.4.3 Delimitation three

This study is limited to the treatment of plants, only the lettuce is utilized, and does not include treatment of animal or human subjects

1.4.4 Delimitation four

This study will not attempt to investigate any other medicines and potencies other than those stipulated.

1.5 The assumptions

1.5.1 The first assumption

It is assumed that the homoeopathic medicines provided are prepared according to the monographs as provided in the Homoeopathic Pharmacopoeia unless stipulated otherwise.

1.5.2 The second assumption

It is assumed that the homoeopathic medicines are functionally active at the time of utilization.

1.5.3 The third assumption

It is assumed that the controlled environmental conditions stipulated in the experiment are effective and efficient over the entire duration of the study.

1.5.4 The fourth assumption

It is assumed that the material upon which and in which the experimental samples are germinated (i.e. filter papers and Petrie dishes) are homoeopathically inert.

1.5.5 The fifth assumption

It is assumed that the viability of the batch of seed utilized is uniform for each sample obtained from the batch.

1.5.6 The sixth assumption

It is assumed that the experimental design will deal with environmental and random errors in the statistical analysis.

1.5.7 The seventh assumption

It is assumed that homoeopathic medicines have obtained specific effects and that their affects are not attributed to "suggestion" commonly known as the placebo effect. This allows an organism to react to an "undistinguishable" remedy, for the effect of a remedy to be independent of the original drug used

for its preparation, for the effects to independent of the experimental models used.

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

2.1 Introduction

The foundation elements to this research are lettuce, lettuce seed germination, Homoeopathy in agriculture and Homoeopathic antidoting. An introductory review on lettuce was provided in Chapter One and in general the information available on this plant is extensive. The author felt that further review of the crop would be superfluous to this research and this literature review is therefore focused on the significant aspects of lettuce seed and the process of germination. As regards Homoeopathy in Agriculture the review first takes up the important aspects of potency and potentisation, and potency and the mechanisms of action because of their applicability and critical role in the accuracy of the preparation of the remedies, and then Homoeopathy in agriculture. Finally Homoeopathic antidoting is reviewed.

2.2 Seed – the reproductive germ of flowering plants

Plants reproduce themselves by sexual and asexual means. Sexual reproduction involves pollination and fertilization, culminating in seed formation. The word seed (mature ovule) is the collective term for the embryo and the tissues that surround the embryo (i.e. the pericarp, the integument and the endosperm). The former two types of tissue serve to protect the embryo and become known as the seed coat or testa. During development of the seed, although there is progressive disorganisation and dissolution of the inner part of both pericarp and integument, the pericarp and integument are brought very closely together by pressure from within. The latter tissue type (endosperm) serves as a food storage area utilised by the embryo before and during germination. (Borthwick and Robbins, 1928.)

"The embryo is the embryonic plant, and it is composed of the hypocotyl, the radicle and the plumule. The hypocotyl is the transition region between the radicle and the plumule, terminating at its lower end, as part of the embryo, in the apical meristem of the radicle and at its upper end in the plumule. The radicle develops from the lower end of the hypocotyl and forms the primary root of the seedling following seed germination. The plumule is the embryonic shoot, developing from the upper end of the hypocotyl and consisting of an apical bud, two tiny leaves, and a short internode called the epicotyl". (Anderson, 1983: 365 – 404; 405 – 428.)

At maturity the seed is the means by which the new "individual" is protected, nourished and dispersed and is therefore a critical component in the life history of the higher plants. The success with which the new "individual' is established – the time, the place and the vigour of the young seedling – is largely determined by the physiological and biochemical features of the seed (internal conditions). The success is however also substantially affected by external conditions (environmental) and can not be discounted. Modern agriculture is exceedingly dependent upon the availability of high quality seed. This implies not only the proper genetic composition but also seed with high viability (internal conditions); the success thereafter depends on the modification of the internal conditions by external treatments (pre-germination seed treatments), and the enhancing of the external conditions that support the process. Hence the expansive interest in successful germination.

2.3 Lettuce seed structure

The lettuce has an achene type of fruit (Esau, 1965: 594). It is derived from an inferior ovary. The achene or seed is spindle or lance shaped with a surface that has a number of longitudinal ribs. (Appendix A)

2.4 Germination

2.4.1 Measurement of germination

By measuring water uptake or respiration one can very roughly determine the extent to which germination has progressed however it only provides a very broad indication of what stage of the germination process has been reached. The only stage of germination that can be timed fairly precisely is it termination i.e. with the emergence of the axis from the seed. This allows recognition as to when germination has gone to completion. In those cases where the axis may grow before it penetrates the surrounding tissues, the completion of germination can be determined as the time when a sustained rise in fresh weight begins. The degree to which germination has been completed in a population is usually expressed as a percentage normally determined at the time intervals over the course of the germination period. (Bewley and Black, 1985: 3.)

2.4.2 Germination curves

The germination curve for a population of lettuce seeds is ordinarily sigmoidal. This indicates early germination of a minority of the seeds in the population, then germination of the majority percentage a rapid process which gives rise to a steep accent of the curve, and finally the relatively few late germinates emerge. The curves are positively skewed because a greater percentage germinates in the first half of the germination period than in the second. A seed population that is highly uniform is one in which individual germination rates are close to the mean rate of germination for the population as a whole. Uniformity can therefore be expressed as the variance of individual times around the mean time to complete germination (i.e. the degree of synchrony of germination). (Bewley and Black, 1985: 4; 229 – 230.)

2.4.3 Germination capacity

Germination capacity of a population of seeds is the proportion of seeds capable of completing germination. This is an internal condition of each seed and is one of the critical factors in the Seed Certification process. Certification of seed has become one of the leading marketing strategies in the production of seed and a supplier with certified seed may, to the cost price benefit, make such label claims for his product. Growers are encouraged to use fresh certified seed (Askew, 1996). Assuming that these seeds are viable, the behaviour of the population could be affected by adaptive internal mechanisms e.g. dormancy or to external conditions e.g. temperature or light, which do not favour germination of most seeds (Bewley and Black, 1985: 4; 229 - 230).

2.5 Lettuce seed germination studies

2.5.1 Internal conditions

Sine qua non to seed germination is proper genetic composition. In its widest sense the accepted genetic composition would be that which would ensure that the seed, and the plant to which it will give rise, are fit for intended use. This is to say that characteristics which are selected during breeding programs, and the evolution process, are those which sustain the seed and ultimately the plant to successful propagation. High viability is sustained by adequate food supply. Another important internal condition regulator is dormancy.

2.5.1.1 Dormancy

The ability of seeds to retain viability for prolonged periods of time without germinating is a vitally important adaptive mechanism of plants. This ensures survival during adverse seasonal conditions and thereby provides a reservoir of ungerminated, but viable, seed for later seasons. Dormancy contributes in evolution by allowing the synchronisation of life processes among members of a

population under the most favourable conditions for the sustenance of life, and between their successive developmental stages and the seasons (Villiers, 1975: 1). However in the pressurised environment of Agriculture dormancy is often regarded, as a failure to germinate in that it results in asynchronous development of the crop. This is not congruous with crop production mechanisation. It is important to mention the state of quiescence where the seed is merely inactive rather than dormant. Dormancy occurs by two main processes. Firstly the non-germination of seeds due to absence of suitable conditions termed imposed dormancy. The most usual cause of this type of dormancy being low moisture content of mature seed. Secondly and of greatest interest, being related to the properties of the seed itself, is organic dormancy (Khan, 1977: 51 - 74). Khan, (1977) quotes the work of Crocker (1916), in the description of organic dormancy as resulting from:

1 Immaturity of the embryo
2 Impermeability of the seed coats to water
3 Mechanical resistance of the seed coat to embryo growth
4 Low permeability of the seed coat to gases
5 A metabolic block within the embryo itself, requiring (I) light, or (ii) chilling for removal
6 Combinations of the above
7 Secondary dormancy

This classification has been utilised extensively for research into organic dormancy-breaking techniques but elaboration of this classification is not perused in this literary review.

Germination is the actuation of an embryo previously either quiescent or dormant. Germination is usually immediate if suitable conditions are available to the quiescent seed (i.e. warm temperatures with water and air). However for the germination of a dormant seed to take place, special treatments are required to break dormancy (Villiers, 1975: 3 - 5). These conditions differ with

the many varieties of seeds, and in broad-spectrum evaluation the requirements as listed below:

1 Dry heat 30°C
2 Wet cold 1 – 8°C
3 Light
4 Dark
5 Low temperatures <10°C
6 High temperatures > 25 – 30 °C
7 Fluctuating temperatures

could be necessary to ensure germination from a dormant state (Cairns, 1994).

2.5.2 External conditions

Of the external conditions affecting germination light and temperature are the most extensively researched and will be elaborated on. Suffice it to say that if there is insufficient of either water or oxygen germination will not occur. The latter is generally more detrimental as it results in the anaerobic degredation of the seed.

2.5.2.1 Light

Flint and McAlister (1935) demonstrated that red light promoted and far red light inhibited lettuce seed germination. Subsequently (Borthwick, Hendricks, Toole and Toole, 1954) fixed the action specific for promoting germination of photosensitive seeds at 660nm (red light) and for inhibiting germination at 735nm (far red light).

The behaviour of seed depends solely upon its relative spectral sensitivity to the red and far-red regions (Soundy, 1989). Borthwick *et. al.* (1954), further showed that the reaction was reversible and postulated a light-pigment reaction

system. Phytochrome, a plant pigment, can take two forms depending upon its exposure to light. Red light converts it to a germination-promoting form, while far-red light or darkness converts it to a germination-inhibiting form. The last radiation exposure determines the pigment state and level of germination. Thus the only difference between dark-germinating seeds and light requiring seeds is in the level of Pfr (far-red absorbing form of phytochrome) maintained in the dark-germinating seeds. Therefore light-requiring seeds would have very low levels of Pfr, or none at all, and would require light to photoconvert Pr (red absorbing) form of phytochrome to Pfr. The dark germinating seeds, on the other hand, would have considerable amounts of Pfr and could only be inhibited by radiation that converts Pfr to Pr. (Smith, 1975: 130 – 136.)

Seed coats have been found to act as light filters that modify both light quality and quantity as the light passed through the coat. The amount of transmissions varied and depended upon hydration, degree of pigmentation and seed coat morphology. (Widdel and Vogelman, 1985.) Previously it was shown that light-germination increased in lettuce seed after removal of the fruit and seed coats, and that the site of light perception appeared in the hypocotyl (Ikuma and Thimann, 1959).

Widdel and Vogelman (1985), managed to relate germination behaviour to seed coat properties by means of transmission spectra, which showed that seed coats may increase the relative proportion of far-red light that enters the seed. The majority of the early work and much of the modern work with seed germination was done with the cultivar Grand Rapids, a leafy type of lettuce grown in greenhouses during winter. Light effects can be modified by chemical additions. Gibberellin overcomes the effect of far-red light (Kahn, 1957; 1960).

Seed moisture content also affects the germination response to phytochrome changes as demonstrated by the work of Hsiao and Vidaver recorded by Ryder (1979: 34), where seed responded to red and far-red changes when the moisture content was 15%, while at 7% no response was obtained.

2.5.2.2 Temperature

Temperature is the other major external factor. The optimum for lettuce seed germination is in the range 18 – 21°C, the optimum for lettuce growing being ±16°C. At 26°C and above germination is inhibited to various degrees, depending upon cultivar type (Borthwick and Robbins, 1928; Ryder and Whitaker, 1980). Borthwick and Robbins (1928), found that seeds will germinate at higher temperatures with coats removed. It was discovered that the innermost structure including the endosperm and a semi-permeable membrane were the most important layers to be removed before germination proceeded normally at higher temperatures. They concluded that there was a possibility that products of metabolism arising and probably accumulating in the endosperm or embryo at high temperatures inhibited initial germination stages. Furthermore this structure also retards gas exchange. In specific studies to investigate high temperature dormancy it was reported that they could be overcome by, by kinetin (Smith, Yen and Lyons, 1968). Harber and Tolbert, (1959) found that a combination of Gibberellin and kinetin was synergistic. It has been found by Gray (1975) that the highest temperature permitting 50% germination of a population of lettuce seed, in seven days, varied among and within lettuce types. Among the Butterheads tested the range was 25,7 – 30,5°C for 16 cultivars. Two Cos cultivars germinated at 31,0°C, while four Crispheads germinated at temperatures ranging from 28,0 – 32,8°C. (Most affective in temperature are the higher temperatures because of the possibility of enzyme destruction and protein coagulation).

Ikuma and Thimann (1964) analysed the physiological properties of germination by exposing seed to a range of temperatures during the different phases of the process. They also conducted germination studies in a nitrogen atmosphere to analyse oxidative properties associated with germination. They concluded from their research that germination occurs in four phases:

1 Pre-inductive phase, when the seed takes up water and prepares for induction by red light.

2 Induction phase, when red light brings about the maximum induction and reversal by far-red is also maximised

3 Post-inductive phase, when the seed undergoes a dark process

4 Phase of visible germination, when the radicle breaks through the surrounding coats.

Subsequent works by Gray (1977), demonstrated that the first hours of inhibitions and the period between the beginnings of mitosis and emergence of the radicle were most sensitive to the pre- and post-induction phases proposed by Ikuma and Thimann (1964).

2.6 Homoeopathic potency and potentisation

Homoeopathy is unique in clinical methodologies and pharmacological preparation of the substances used. Homoeopathic medicines are produced by means of a process of serial dilution and succussion aimed at endowing the solutions with a greater therapeutic effect (dynamisation) (Bellavite and Signorini, 1995: 10). The precise historical development of dynamisation or potentisation results from initial trials performed by Samuel Hahnemann the founder of Homoeopathy. At the outset testing of substances was on an empirical basis, where symptoms were deduced from accidental intoxication. Hahnemann observed that lower doses were sufficient to obtain a positive effect. On the basis of this observation, Hahnemann diluted the medicines in order to discover the curative doses and prevent intoxication. At this stage Hahnemann was only increasing the dilution, which as Vithoulkas (1980: 102 - 104) has commented, is not sufficient to produce the phenomenon. Later he found it necessary to increase the effect of the dilutions by including the process of succussion and/or trituration of the raw materials (according to solubility). This he first documented in his publication the "Organon" in 1831. Hence progressively increasing dilutions were also called potencies and the dilution and succussion process was termed potentisation or dynamisation.

Potentisation as devised by Hahnemann, provides three scales of dilution, Centisimal (deconcentration 1 in 100) and Decimal (deconcentration 1 in 10), also attributed to American Homoeopath, Constantine Hering, and potencies based on serial dilutions of 1 in 50000 at each level called either 50 Millesimal potencies, (abbreviated to LM) or Quinquagenimillesimal potencies (abbreviated to Q). Hahnemann initially employed the Centisimal scale of dilution, which are the scales of dilutions upon which this review will focus.

Preparation of homoepathic medicines involves the preparation of Mother tinctures resulting from the extraction of suitable source material with alcohol/water mixtures, which form the starting point for the production of most homoeopathic medicines (Kayne, 1997: 47 - 48). Hahnemann is reported to have preferred preparing substances, even soluble by trituration with lactose (Dellmour, 1994).

The Hahnemann, Centisimal, method of preparation, where one part of a substance (plant, mineral, animal or chemical) is diluted (or triturated/ground, depending on the substance) in 99 parts of diluent (usually distilled water, ethanol/water mixtures and lactose with trituration). The solution or mixture resulting from the admixtures of the two liquids or mixture of the two solids is subjected to vigorous shaking with impact known as succussion and grinding known as trituration in the case of solid mixtures. Each potency level is designated the value of the number of times it has been diluted of that concentration level (i.e. 1CH $\rightarrow$1 in 100; 2CH $\rightarrow$ 1 in 10000 etc.).

After the 12CH (deconcentration 10^{-24} Avogadro's constant ($6{,}023 \times 10^{-23}$) is exceeded indicating that it is highly unlikely that any of the original molecules of the original substances will be present. Thus suggesting that a medicine over the 12th potency (12CH) could not have any physical effect since it is improbable that there are any remaining molecules, still an area of much controversy. (Vithoulkas, 1980: 102 – 103; 105; 165 – 166; Bellavite and Signorini, 1995: 23 and Kayne, 1997: 27, 174 – 175.)

2.7 Potency and mechanisms of action

Various phenomena of Homoeopathy, lacking of scientific explanation, have been severely criticised and have lead to controversy. Scientific elucidation of homoeopathic phenomenon provides the greatest problems and consequently, from a scientist's outlook, the greatest challenge. (Resch and Gutmann, 1987: 14.)

Samuel Hahnemann states in the 6th edition of "The Organon of the Medical Arts", afforism 270 ... " given a medicinal substance which, in its crude state, is only matter (in some cases, unmedicated matter) is subtilized and transformed by these higher and higher dynamisations to becomes a spirit-like medicinal power" (Hahnemann, 1996). To quote Hahnemann again..." that which eventually takes place must at least be possible", which has prompted many homoeopathic practitioners to ask the question as phrased by Vithoulkas (1980: 103),..."what then is actually occurring during the process of potentisation?" In particular those potencies whose dilution level exceeds Avagadro's number (a.k.a. Loschmidt limit) suggestive that no molecules of the original substance are present, as reiterated by Gaier (1991: 47 - 48).

A brief literature overview follows which reflects a need to seek explanations beyond the biochemical interpretations for a more biophysical paradigm, although it has become evident that theorists describe the action of homoeopathic medicines according to their own conceptual framework (Bellavite and Signorini, 1995: 81- 83; 244). Until the 1960s researchers concentrated on demonstrating the presence of original solute in the homoeopathic medicines and for providing evidence of physiological changes that occurred in response to minute quantities of substance. Expositions both biochemical and physiological that suggest why homoeopathic medicines may act (Stephenson, 1955; Stephenson, 1966; Wurmser, 1967), include the use of dielectric strength measurement (Brucato and Stephenson, 1966), surface tension measurements (Kumar and Jussal, 1979) N.M.R. spectroscopy (Smith

and Boericke, 1966; 1968; Young, 1975; Ross, 1997) and ultrasonic studies (Silvio and Arnaldo, 1990), amongst others.

Many of the above mentioned studies lead to the development of the concept of a solvent carrying the "informational content" of the original solute and acting as the medicine rather than the original solute. This concept has been further developed by authors such as Vithoulkas (1980: 60 – 62; 65 – 72; 77 – 78; 85); Jones and Jenkins (1981); Resch and Gutmann (1991: 191 - 213) and Bellavite and Signorini, (1995: 243 - 301), with respect to the importance of succussion and trituration in providing energy to propagate the information.

Jones and Jenkins (1981) were in agreement with Barnard's (1965) suggestion, with respect to the structure of water, that formation of long chain polymers may be occurring during potentisation, although they suggested these water polymers maybe shorter and exist in closed chains of cyclic clusters. These initial theories still provide little knowledge on how the information is passed to and stored in the impregnated pharmaceutical form and the recipient (i.e. organism being treated). As Rawson (1974), postulates three "energy steps":

1 The absorption, the stage in which energy is taken up during preparation of the medicine (endo-ergic stage).
2 The storage of energy within the system
3 The release of stored energy from the system (exo-ergic stage)

Further investigations were undertaken by Singh and Chhabra (1993), with respect to the implication for the mode of action of homoeopathic medicines in ethanol/water systems. Recent interest and hypotheses have arisen concerning imprints which lead to the 'Benveniste controversy", a detailed account of which can be acquired in Michael Schiff's book entitled 'The Memory of Water' (1995).

Resch and Gutmann (1991), reviewed the "system organisation of liquid water" having outlined the "molecular concepts" inadequacies when qualitative

changes are to be understood. A "supermolecular system organisation" and continuous relationship between the molecules is suggested to extend the molecular concept. This conclusion developed from investigations involving the concept that internal vibratory motion of the solvent molecules carries the information content of the solute. Rubik (1989) reported that "specific water polymers are formed during the succussion process with a particular drug substance, and that the configuration of those polymers reflects the information stored in internal molecular nodes as a result of energy transfer from the original drug molecules". However he later also suggested "On the other hand, it may demonstrate that something else is occurring at these very low doses that does not involve molecules (Rubik, 1994).

Similarly Antonchenko and Ilyin (1992) in their review of the physics of water and homoeopathy, discuss the "microstructure" of water as it relates to homoeopathic preparations. They debate that the stability of various "dissipative structures" in water systems is explained by their presence in the earth's electromagnetic field and by the stabilising process of proton transfer along hydrogen bonded chains in these structures. A possible connection between processes occurring in dissipative water structures and the relation characteristics of homoeopathic preparation are demonstrated.

It has been suggested that homoepathic potencies of the same medicine are biochemically identical, but biophysically different forms. Cohen (1993) continues the concept by pointing out the complexity of the "microstructure of water" and its "crystalline nature" of existence giving strength to the idea of "liquid water" being purely an extension of its solid counterpart. Resch and Gutmann (1987) endorse this in the statement "parts of the dynamic aspects of the liquid state are frozen in".

Towsey and Hason (1995) progressed this theory highlighting that dilution has two effects : it progressively removes 'water crystals' containing the solute molecule and it supplies a fresh source of unsaturated water. "The result of repeated succussions and dilutions is the multiplication and growth of 'water

crystals' showing similar structures and vibration characteristics deformed by the original solute molecule which is no longer present". Thus proposing a resolution for the paradox of increasing potency accompanying decreasing solute concentration.

Furthermore they suggest the action of potentised medicines appears to be "biophysical" rather than "biochemical", consisting of 'imprinted' water crystals which intern effect the medicines ability to adsorb and omit coherent radiation. These coherent emissions are suggested to enhance or inhibit enzyme activity. Thus providing a possible scenario to the question of how a homoeopathic medicine releases its effect upon the recipient. Delinick, (1991), also attempted to explain how homoeopathic medicines work on the organism in the explanation of the wave nature of particles.

Bellevite and Signorini (1995: 193 – 198; 245 - 301) document a comprehensive review of the various hypotheses in their book, further investigation with respect to mechanisms of action will not be dealt with in this review. There is still however no conclusion or explanation available in modern physics and chemistry to explain the process of potentisation.

2.8 Homoeopathic agricultural research

The application of Homoeopathy in agriculture is a relatively new subject and has been described by Sinha (1976) as open and having 'great potentiality'. Certain botanical experiments demonstrating the effect of remedies on plants have been performed possibly because there is no possibility of the suggestion affecting the results (placebo effects) (Pelikan and Unger, 1971; Coulter, 1980; Kayne, 1997: 178 - 180).

As a direct result of inspiration as provided by Rudolf Steiner, (founder of the Anthroposophical Movement), in biodynamic farming, Mrs L. Kolisko conducted intensive research (Kolisko and Kolisko, 1978: 10 - 85), to demonstrate the

effect of homoeopathic dilutions predominantly using wheat, however some trials were performed with sunflowers, gladioli, crocuses and a variety of other flowers. This work revealed that lower dilutions promoted growth, higher dilutions inhibited growth and even higher dilutions stimulated growth. Boyd conducted controlled experiments in 1941 and 1942 showing that microdoses of mercuric chloride achieved statistically significant effects on diastase activity (diastase being an enzyme produced during germination of seeds). Comparable studies, by Jones and Jenkins (1983), two British researchers on yeast and wheat seedlings showed that *Pulsatilla* (Windflower), in varying potencies up to 13CH, caused increased growth of yeast and wheat seedlings. Steffan in 1984 attempted to reproduce this work with yeast *Schizosaccharomyces pombe* using electronic particle counters and similar results were not obtained, however later re-analysis of Steffan's work confirmed the work of Jones and Jenkins. Chou (1986), a scholar of the times showed that potentised doses of commercial fertilizer had statistically significant effects on mungbean seed sprouts.

Koffler (1965) and Wannamaker (1966; 1968) conducted experiments testing the effects of potencies of Sulphur and Boron on the growth of onion plants. Although as Scofield (1984) points out, the studies lack statistics and there is no real rational for the study. However Wannamaker claimed both Sulphur and Boron potencies significantly improved weight, dimensions and mineral content. Koffler (1965) demonstrated differences in growth and Sulphur content of seedlings grown in soil treated with Sulphur.

Kolisko's work stimulated more detailed laboratory experiments conducted by Pelikan and Unger (1971). Working with the effect of potentised silver nitrate (decimal dilutions) on the growth of wheat seedlings provided statistically significant evidence that potentised substances do have an effect on plant growth. The above mentioned work prompted Jones and Jenkins (1981) to undertake similar work using silver nitrate (cetesimal dilutions). Minor but significant changes in growth were found with certain of the potencies. Jones and Jenkins conducted further work in 1983 the nature of which is previously

mentioned. Comparison with respect to results obtained by Pelikan and Unger (1971) and Jones and Jenkins (1981) is not really possible as different potency ranges (dilution scales) decimal and Centisimal respectively, were used.

Netien, Boiron and Marin (1966) experimented with seeds obtained from dwarf pea plants sprayed with copper sulphate solution. Half the plants were treated with 15 C (10^{-30}) of copper sulphate and the remaining half with double distilled water. Those treated with copper sulphate 15C had better germination than those receiving double distilled water did. Netien and Graviou (1978) involving *Lepidium sativum* with respect to rhythmic variations in growth. Rhythms of growth were found, the magnitude of which was dependent upon the times of day at which the seeds were germinated. Growth rhythms were reported to change when the growth medium contained potentised copper sulphate at a dilution level of 10^{-30}. Scofield's review 1984 indicated the significance of such findings however suggests that carefully controlled repeated studies with sophisticated statistical evaluation techniques are required to verify such findings.

In the article Agro-Homoeopathy Sinha (1976) reported the use of *Tabacum* 30C as a treatment for virus infected papaya plants (about one year old) where the leaves were mosaiced, curled and closed, however opened within four days of treatment. Medicine selection was the basis of resemblance of tabacco leaf characteristics with those of affected leaves of papaya. The author also claims conducting on-going 'agro-homoeopathy' research on virus-affected tomato (*Lycopersicum esculentum*) and little leaf disease of brinjal (*Solanum melongena*).

Although Haehl (1995: 413 - 415) did not reference his sources he quoted the following authors as having performed the following research:

According to Professor Higo Schultz of Greifswäld, sublimate of mercury, in a 1/20000 dilution destroys or at least arrests the growth of yeast cells, however,

in dilutions 1/50000 and higher, the yeast cells grow more quickly with the sublimate treatment.

According to Löw, uranium salts up to a dilution of 0,05% (5/10000) acts upon young peas and oat plants as a poison, whereas a dilution of 0,01 % (1/10000 = 4th homoeopathic decimal potency) resulted in an increased growth of plants.

Böhn discovered in 1875 that beans could be germinated in spring water but not distilled water. Distilled water being distilled in copper vessels at the time provides a plausible explanation for the phenomenon. Coupin conducted similar experiments using wheat discovering that copper was a very powerful and harmful plant poison, even in a dilution of 1/100000000 (=approximately the 9th homoeopathic potency). Nägeli (a botanist) also proved that copper acted as a plant poison, especially on algae, in a dilution of 1/100000000 (8th homoeopathic decimal potency).

Darwin found that the leafglands of *Drosera rotundifolia* (Sundew) are still stimulated by a dilution of 1/20000000 of ammonium phosphoricum (7th homoeopathic decimal dilution).

Haehl (1995: 413; 415) mentions various other authors as having found significant effects of various dilutions upon various organisms.

A field trial was conducted by Kayne (1991) in which four homoeopathic sprays were applied to rye grass. The aim of the trial being to determine whether any significant effect on growth could be achieved when compared with similar applications of nitrogen fertilizer, and a control. Kayne reports that at the particular dosages and strengths used no effect was perceived, however, that a methodology for the testing of sprays had been established.

Bornoroni (1991) conducted experiments using fragments of oat seedlings (coleoptiles). During the rapid growth phase the coleoptiles were cultured in the presence of IAA (plant growth regulator indoleacetic acid), pretreatment with

homoeopathic dilutions of Calcium carbonate 5C caused statistically significantly increased in growth as compared to those treated with IAA alone.

The effects of certain homoeopathic medicines on incidence of seed-borne fungi and seed germination of *Abelmoschus esculentus* (Saxena *et al*, 1986). The results of which revealed that percentage of seed germination and root-shoot lengths had increased in all treatments in comparison to the control. Five homoeopathic potencies (in different potencies) were used viz. *Thuja* Q 30, 200; Sulphur Q 30, 200; Nitric acid 30, 200; *Calcarea* carbonica *30, 200 and* Tercrium Q were tested. The effect of homoeopathic medicines on germinability of *Vigna radiatal* (L.) Wilczek seed, (Som, Ghosh and Chattopadhyay, 1995), revealed that the dry application of two known and easily available homoeopathic medicines viz. *Iodium* and *Neem* help to sustain the vigor and viability of *Vigna radiata* (L.) Wilzek (also known as greengram or mungbean).

The research of many previously mentioned authors and others not mentioned are critically reviewed and discussed by Schofield (1984) with respect to Homoeopathy in agriculture.

Trials conducted on plants with respect to pathology and spore germination studies are not the focus of this review.

2.9 The phenomenon of Homoeopathic antidoting

"An antidote neutralizes the competing substance's field of influence canceling effects by virtue of its similarity in bioenergetic effects. Boenninghausen observed that" medicines providing similar symptoms are related to each other and are mutually antidotidotal in proportion to the degree of the similarity'" (Gaier, 1991: 39).

"Antidoting in the bioenergetic field (dynamic antidoting) requires that the antidotal substance be pathogenically similar to the poison, but opposite in the direction of the reactive effect produced by it. The antidoting effect is exerted directly upon the organism, although it takes place indirectly between drugs by neutralization in accordance with the law of repulsion of similars (analogous to the electromagnetic laws)" (Gaier, 1991: 39 - 40).

Kayne (1997: 121) describes the action of an antidote as competing for an existing remedy's area of influence by interfering with its effects on the 'vital force'.

Majerus (1991) called for investigation of factors that influence or neutralize the effects of homeopathic potencies. It had been previously recorded that "strong odours" are said to interfere with the 'vibrations' of the homoeopathic medicine, thus having a negative effect on the medicine's action. Hahnemann (1989: 65; 175) cautions against inappropriate homeopathic antidoting. Homeopathic antidotes are usually prescribed when a remedy has not "completely worked" (Kayne, 1997: 121) or when inappropriately prescribed, a homoeopathic physician, may administer a homoeopathic antidote.

The substance Camphor and potencies of Camphor has been written of by many authors but to date little work has been done or been recorded with respect to proving its effectiveness as an antidote to other homoeopathic medicines in potency. Camphor as indicated by Vithoulkas (1980: 253, 264 - 265) can antidote remedies, and as is reiterated by Kayne (1997: 121) is "known as a universal antidote", and should not be used in conjunction with any other remedy (homoeopathic medicine). There is however no record of the antidoting effect of Camphor on other homoeopathic medicines, when administered in potency. Furthermore it remains an enigma as to whether antidotes with respect to Homoeopathy, are affective at all when utilised in organisms such as plants.

It must be noted that Sulphur is antidote to Nitric acid, being one of the treatments of this experiment (Clarke, 1955: 1306).

CHAPTER THREE

METHODS AND MATERIALS

3.1 Experimental procedure (study design)

Four experiments involving homoeopathic treatments of *Lactuca sativa* (Lettuce seed) with respect to germination were conducted.

Germination trials were conducted under controlled laboratory conditions, in growth chambers. The growth chambers were set at a temperature of 15°C with < 1°C temperature fluctuation. Each treatment consisted of three replications of 100 seeds placed in 11cm petri dishes lined with three Whatmann No. 1 filter papers. Five ml of each potency was dispensed into each petri dish prior to incubation. Petri dishes were randomly grouped, placed in plastic bags into which was placed 5ml of double distilled water to preserve moisture and sealed. Germination was recorded by means of 12 hourly counts, representative of the number of germinated seeds, for a period of 7 days. Radical protrusion was used as the criterion for germination.

Experiment 1

Germinability trial utilizing high germinability seed involving the application of five different homoeopathic treatments at thirty different potency levels.

Experiment 2

Germinability trial utilizing low germinability seed involving the application of five different homoeopathic treatments at four different potency levels.

Experiment 3

Germinability trial utilizing three different cultivars of lettuce involving five homoeopathic treatments at four different potency levels.

Experiment 4

Germinability trail utilizing four different cultivars involving one homoeopathic treatment under four different light and temperature conditions.

3.2 Preparation of materials

3.2.1 Setting up of the field trial (technical details)

This trial was run at the Phytotron of the Faculty of Agriculture, University of Pietermaritzburg, Natal. The controlled environment under which lettuce seeds were germinated, consisted of growth chambers set at 15°C (< 1°C fluctuation) with a 12 h photoperiod. Seeds were germinated in 11cm Petri dishes on three Whatmann No. 1 filter papers moistened with 5ml distilled water or test solution. Germination was recorded in 12 h intervals (with the exception of experiment 3 in which the second time measurement was taken after 6 hours) for seven days and expressed as a number of seeds germinated (experiment 1,2, & 4) and in the form of a germination index as described by Walker-Simmons (1988) in experiment 3, refer to Appendix (B).

3.2.2 Apparatus

Growth chamber/Germination chamber - Labcon (Labex), with identification symbols (labeled) University 1, 2 & 3.

Dissecting microscope - Carl Zeiss 4X/ 2.5X in department of Crop Science, University of Natal, Pietermaritzburg. This apparatus was utilized for seed germination counts.

Dispensing pipette (with disposable tip unit) - Socorex (Swiss) 0.5 - 5ml. Utilized to administer above mentioned distilled water and test solutions.

Safe-lamp - 20 watt fluorescent lamp filtered through two layers each of yellow and green cellophane known to produce very little effect on germination of lettuce seeds (Ikuma & Thimann 1959), utilized in experiment 4.

'Dark room' - room in which germination counts were performed under green safe-lamp utilized in experiment 4

Petri dishes - New 11cm (diameter) petri dishes were utilized. All petri dishes were labeled on the exterior of the lid and base of each petri dish.

3.2.3 Materials

3.2.3.1 Seeds

Experiment 1

Commander (96% germinability) gratefully provided by 'Starke Ayres'.

Experiment 2

Commander (very low-0% germinability) gratefully provided by the University of Natal, Pietermaritzburg.

Experiment 3

Greenfield, Great Lakes, Grand Rapids (Molybdenum treated seed) cultivated and provided courtesy of the University of Natal, Pietermaritzburg.

Experiment 4

Commander (96% germinability), source- as above in experiment 1, Greenfield, Great Lakes, Grand Rapids (Molybdenum treated seed, cultivated by the University of Natal).

Seed quantities - 100 seeds of the particular cultivar per Petri dish were used.

Seed counts - All batches of seed were hand counted to ensure accuracy in sample numbers. All batches were checked visually for damaged or deformed seed, which was removed prior to the commencement of the experiment. In addition to the above precautions fresh, supplier certified seed was used as per the recommendations laid out in "Lettuce Production Guidelines" by Askew (1996).

3.2.3.2 Distilled water

All samples of distilled water were obtained from the same source. Samples were taken from a Milli-Q plus Water Purification System (0.22μm filter), within the Department of Biochemistry, University of Natal, Pietermaritzburg.

3.2.3.3 Plastic packets/bags

Two types were utilized:

1 Transparent "String-Tie" 280 x 330mm bags were utilized in experiments 1, 2 & 3.

2 Black/opaque "String-Tie" 280 x 330mm bags were utilized in experiment 4.

3.2.4 Procedures

1 Seed counts were conducted by hand and all batches of counted seed were refrigerated at 4°C (to prevent any possibility of premature germination prior to the commencement of the experiments).

2 Petri dishes were each lined with three Whatmann No.1 filter papers and labeled.

Experiment 1

369 Petri dishes were prepared (one cultivar was used with five treatments, four of which contained thirty different potency levels, the fifth being a control requiring three petri dishes of which all treatments and the control were replicated three times, i.e. ((4 x 30) + 3) x 3 = 369).

Experiment 2

57 Petri dishes were prepared (five treatments, four of which contained four different potency levels, the fifth being a control requiring three petri dishes of which all treatments and the control were replicated three times, i.e. ((4 x 4) + 3) x 3 = 57).

Experiment 3

180 Petri dishes were prepared (three cultivars, using five treatments, containing 4 different potency levels, all of which were replicated three times i.e. (3 x 5 x 4 x 3 = 180)).

Experiment 4

48 Petri dishes were prepared (a single treatment was applied to four different cultivars under four different light/dark/temperature conditions, all treatments were replicated three times i.e. (1 x 4 x 4 x 3 = 48)).

3 One hundred seeds were placed into each petri dish upon the filter paper.

4 Each test solution and distilled water (control experiment 1 & 2) was added by means of a disposable tip-dispensing pipette (to prevent 'contamination' between test solutions).

5 Petri dishes were sealed randomly collected (within each replication) placed one upon the other in 'piles' of approximately 10 and placed into plastic bags (all transparent except for experiment 4 in which black plastic bags were used).

6 Five milliliters of distilled water was placed into each plastic bag (preventing any possibility of desiccation), sealed and placed in the growth chamber.

7 Recording of measurements was performed 12 hourly (except in the case of experiment 3 were one 6 hour measurement was performed) involving physical counts of the number of seeds germinated with the aid of a dissecting microscope. After which the petri dishes were immediately returned to their respective germination chambers.

8 Germination being defined as the first visible protrusion of the radicle through the seed coat. In certain treatments where the cotyledons protruded from the seed coat before the radicles, these seeds were not considered as having germinated and therefore not counted, described as "atypical" germination by Ikuma and Thimann (1963).

3.2.5 Potencies utilized

Experiment 1

Sulphur 3CH→32CH; Nitric Acid 3CH→32CH; Sulphur/Camphor 3CH→32CH; Nitric Acid/Camphor 3CH→32CH and Control.

Experiment 2

Sulphur 3CH, 9CH, 15CH & 30CH; Nitric Acid 3CH, 9CH, 15CH & 30CH; Sulphur/Camphor 3CH, 9CH, 15CH & 30CH; Nitric Acid/Camphor 3CH, 9CH, 15CH & 30CH and Control.

Experiment 3

Sulphur 3CH, 9CH, 15CH & 30CH; Nitric Acid 3CH, 9CH, 15CH & 30CH; Sulphur/Camphor 3CH, 9CH, 15CH & 30CH; Nitric Acid/Camphor 3CH, 9CH, 15CH & 30CH and Camphor 3CH, 9CH, 15CH & 30CH.

Experiment 4

Camphor 3CH.

3.2.6 Dosage levels

All "doses" constituted 5ml test solution or distilled water, directly applied to each sample batch of a hundred (i.e. one petri dish) lettuce seeds. Dosage combinations (e.g. Sulphur/Camphor, Nitric Acid/Camphor) constituted an equivalent total dose quantity, but not of each combined treatment but rather as a summation, using the equivalent potency of each treatment (substance) combined i.e. 2,5ml of Sulphur was added to 2,5ml of Camphor of the equivocal potency, totaling a 5ml dose.

3.3 Preparation of the potencies

3.3.1 Selection of substances utilized

3.3.1.1 Sulphur

1 It has been used more than most as homoeopathic preparations in research, certainly within the field of "Agro-homoeopathy" (Thompson and Kosar, 1939; [lettuce] and Koffler, 1965 and Wannamaker, 1966 [onions]).

2 Sulphur is described as being an antidote to Nitric Acid (Clarke, 1955: 591; Vermeulen, 1994: 929).

3 Sulphur is often described with its action as being homoeopathically centrifugal by nature (Vermeulen, 1994: 920), the effect of this attribute is unknown with respect to lettuce seed germination or even appropriate at all, however, these experiments may throw some light upon this issue.

4 Sulphur has been considered useful for the prevention of 'stress' in plants (Kayne, 1991).

3.3.1.2 Nitric Acid

1 Saxena (1986) has previously utilized Nitric Acid 30CH in homoeopathic research involving seed germination of Abelmoschus esculentus (Musk Mallow) where percentage seed germination and root-shoot lengths were found to have increased when treated.

2 Nitric Acid is antedoted by Sulphur (Vermeulen, 1994: 929)

3.3.1.3 Camphor

1 Recognizably the most generalized, universal homoeopathic antidote (Vithoulkas, 1980: 264; Kayne, 1997: 121)

3.3.2 Selection of potencies utilized

Experiment 1

3CH→32CH (range of thirty potencies)

Experiment 2 & 3

3CH, 9CH, 15CH & 30CH

1 As per recommendation in discussion with Boyer (1994)

2 There is provision for the investigation of two potencies, below (i.e. 3CH & 9CH), and two potencies above (i.e.15CH & 30CH), Avogadro's number with respect to dilution

3 It has been stated by Cook (1984) that the most commonly prescribed Centisimal potencies, based on statistical information on prescriptions dispensed by the principal homoeopathic pharmacies, within the United Kingdom, are: 3CH, 12CH and 30CH

Experiment 4

3CH (in response to data received from experiments 1, 2 & 3).

3.3.3 Methodology of preparation:

1 All potencies (except triturations) prepared were done so using a solvent of double distilled water (refer- Milli-Q plus Water Purification System) so as to avoid any degree of inhibited germination due to the "carry-over" effect of the alcohol from the Mother tincture as has been reported by Jones and Jenkins (1983). Furthermore ethanol has been reported to be toxic to germinating seed causing partial respiratory failure (van der Burg and Bino, 1994). On the contrary low concentrations are stimulatory to germination – especially lettuce (Cairns, 1998).

2 *Camphor(a)* - Prepared according to the monograph as provided by German Homoeopathic Pharmacopoeia (GHP, 1978: 271) using D-Camphor obtained from *Cinnamomum camphora* (*L.*) in compliance of monograph according to German Pharmacopoeia. Potency preparations were in accordance with "Method 5a" (GHP, 1978: 20-21) utilizing purified water as the liquid vehicle. The 'centesimal scale' of dilution was utilized viz. 1 part of the 'Mother tincture' or centesimal solution to 99 parts of the vehicle/solvent ('purified water', according to pharmacopoeia requirements).

3 Nitric Acid (*Acidum nitricum*) - Prepared according to the monograph as provided by German Homoeopathic Pharmacopoeia (GHP, 1978: 89) in compliance of monograph according to German Pharmacopoeia. Potency preparations were in accordance with "Method 5a" (GHP, 1978: 20-21) utilizing purified water as the liquid vehicle. The 'centesimal scale' of dilution was utilized viz. 1 part of the 'Mother tincture' or centesimal solution to 99 parts of the vehicle/solvent ('purified water', according to pharmacopoeia requirements).

4 Sulphur - *Sulphur sublimatum* (Latin); Sublimed Sulphur, Flowers of Sulphur (English). The initial process (i.e.trituration preparations) was performed as directed by Hahnemann (1989: 191, 192) in Aphorism 270 [footnote (a)] of his "Organon of Medicine". One part of flowers of Sulphur (99.5% purity)

was triturated with 99 parts of pure lactose powder to produce the Sulphur 1CH trituration. Having produced the 1CH trituration of Sulphur, an absolutely identical procedure was utilized in preparing the 2CH and 3CH, where the 1 part of Sulphur 1CH and 2CH to 99 parts pure lactose were used respectively. Subsequent liquid Potencies were manufactured as follows, in response to the difficulties as outlined in point 1 (i.e. that all test solutions need to be manufactured in water not alcohol). One part (by weight) Sulphur 3CH was added to 99 parts purified water (by volume), succussed one hundred times, forming Sulphur 4CH. Subsequent potencies require 1 part (by volume) Sulphur 4CH added to 99 parts purified water (by volume), succussed one hundred times, forming the Sulphur 5CH. This procedure was absolutely identical for all proceeding potencies of Sulphur up to Sulphur 32CH. It must be noted that Sulphur 3CH (in liquid form) was obtained from the dissolution of 1 part Sulphur 2CH (triturate) with 99 parts purified water, succussed 100 times, forming Sulphur 3CH. This was a stand alone preparation of the Sulphur 3CH liquid potency. Sulphur 4CH and subsequent ascending potencies were acquired from the Sulphur 3CH (trituration) independent of Sulphur 3CH (liquid form). In preparation neither Sulphur 2CH (triturate) or Sulphur 3CH (triturate) exhibited signs of insolubility, in the form of a presenting sediment.

Note:

1 All glassware was autoclaved at 121°C for 15 minutes before use.

2 All potencies were manufactured under laminar flow (Labair unit with air velocity of 150 Pascals) without the use of fluorescent or ultraviolet lighting.

3 One hundred succussions were used between each dilution of subsequent potencies.

4 Each experiment acquired a 'fresh' batch of final potencies from the same original Mother tinctures.

5 Camphor was neither prepared, administered nor stored in the same environment as potencies of Sulphur and Nitric Acid (similarly for Sulphur and Nitric Acid). In the case of combined treatments (Sulphur/Camphor), Camphor of the corresponding potency was added after the previously mentioned treatments and after having removed the vessels containing those medicines, from the laboratory where treatments and counts were conducted.

3.4 Frequency of application

Test solution and distilled water (control) treatments constitute a single application (i.e. 5ml for each petri dish) at the commencement of the trial. No treatments were repeated during the course of the trail.

3.5 The recording of the data / measurements

Recording measurements was performed 12 hourly (except in the case of experiment 3 where one 6 hour measurement was performed i.e. 18 hours) involving physical counts of the number of seeds germinated with the aid of a dissecting microscope. After which the petri dishes were immediately returned to their respective germination chambers. All counted samples (germinated individual seeds) were removed from the petri dishes to prevent duplicate counts occurring.

3.6 Statistical analysis

3.6.1 Overall multifactor analysis - experiment 1

Experiment 1: Germinability trial utilizing high germinability seed involving the application of five different homoeopathic treatments at thirty different potency levels.

Cultivar - Commander

Treatments - A = Sulphur
B = Nitric Acid
C = Sulphur/Camphor
D = Nitric Acid/Camphor
E = Control

A multifactor analysis of variance was performed using the nested design model. This is a hierarchical nested model containing 5 types of treatments, 5 different "times" and three replications under each of the 5 "times". Replications are nested within "times", and "times" are nested within treatments. This method was used to identify factors responsible for the variation in the rate of germination of seeds. Since this is an unbalanced nested design, nested design analysis of variance could not be performed using the statistical package Statsgraphics. Instead, a multifactor analysis of variance was done.

The statistical model for the method is given as follows:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + \varepsilon_{ijkl}$$

where

μ is the common effect

A_i is the effect of "treatments"

B_j is the effect of "times"

C_k is the effect of "replications"

ε_{ijkl} is the random error

i = 1, . . . , 5 = number of "treatments"

j = 1, . . . , 5 = number of "times"

k = 1, . . . , 3 = number of "replications"

Results from the overall multifactor analysis of variance revealed that:

1 The effect of treatments on germination was significant at the α = 10% level of significance.

2 The effect of "times" was highly significant at the α = 1% level.

3 The effect of replications was significant at the α = 5% level.

3.6.1.1 The one-way analysis of variance, with respect to time - experiment 1

Following the finding in (3.6.1. result 2) above, it was necessary to compare the means of the 5 "times" in the experiment . In other words, the following null hypothesis had to be tested using the one-way analysis of variance method:

H_o: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$ against the alternative hypothesis

H_1: At least 2 of the 5 means differ significantly from each other

$\alpha = 0.05$ = level of significance of test

Decision rule:

At the $\alpha = 0.05$ = level of significance of test,

1 Reject H_o if the P-value $< \alpha/2 = 0.025$

2 Accept H_o if the P-value $\geq \alpha/2 = 0.025$

3.6.1.2 Multiple range tests with respect to time - experiment 1

Results obtained from methods (3.6.1) and (3.6.1.1) of data analysis revealed that most of the variation in the experiment was due to the differences between "times".

Following this finding it was necessary to identify those levels of "times" that differed significantly. Consequently, multiple range tests were used to make pair-wise comparisons between all possible levels of the 5 different "times". Pair-wise comparisons were used using the LSD (least significant difference) method, at the $\alpha = 0.05$ level of significance (Hicks, 1973).

3.6.2 Analysis - experiment 2

Experiment 2: Germinability trial utilizing low germinability seed involving the application of five different homoeopathic treatments at four different potency levels.

The statistical procedure for Experiment 2 is as per procedure outlined in Experiment 3. However at the conclusion of experiment 2 so few seeds had germinated (Appendix C) that statistical analysis was not possible (Dicks, 1987).

3.6.3 Anova (analysis of variance) - experiment 3

Experiment 3: Germinability trial utilizing three different cultivars of lettuce involving five homoeopathic treatments at four different potency levels.

Multifactor Analysis of Variance was performed using Statsgraphics. This technique helps to determine the effects of so-called *factors* on the so-called *response*. In the case of this study the factors were,

1 Dilution levels/potencies (4 levels) - 3CH, 9CH, 15CH & 30CH

2 Medicines (5 levels) - Sulphur, Nitric Acid, Sulphur/Camphor, Nitric Acid/Camphor & Camphor

The response was the GI-index as constructed from the 'time series data'. The data is of a 'repeated measurement' nature. The test was therefore an ANOVA for this type of data.

The pair-wise comparisons used were the so-called LSD-method at a 5% level of significance. (Least significant difference)

3.6.3.1 Statistical technique

To render the data of different varieties more comparable, a GI-index was calculated firstly. The GI-index has an upper bound value of 1. The calculation of the GI-index adds more weight to seeds germinating in the earlier time epochs. If all the seeds germinated in the first time epoch the GI-index would consequently be one. The closer the GI-indices to one therefore, the quicker

the germination process of the seeds was. Calculation of the GI-index encapsulated the 'time effect' of the germination process into the GI-index.

An analysis of variance (ANOVA) was then conducted on the index values of the different types of cultivars of seeds. Pair-wise comparisons of means were concentrated on. This would immediately lift out the importance of the "effects" of:

1 The dilution/potency level and
2 The type of medicine used on the germination process.

The LSD-method of pair-wise comparison was used due to its universal use and known reliability. (LSD = Least significant difference)

A 5% level of significance was used in the multiple range tests (LSD). The Statsgraphics statistical package unfortunately only supplies a difference and limit in the output. No exceedance probabilities are given.

The contrast indicates the pair-wise comparisons that were conducted. The pair-wise test compares means of indicated contrasts (Bowerman and O'Connell, 1990).

3.6.3.2 Results from factorial experiments

The two objectives in this part of the study were to test interaction effects of order 2 and 3 for significance. There were three main effects, three interactions of order 2 and one interaction of order 3.

Part 1

The statistical model is given as follows:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + AB_{ij} + AC_{jk} + BC_{jk} + ABC_{ijk} + \varepsilon_{ijk}$$

where

μ is the overall or common effect

A_i is the effect of cultivar

B_j is the effect of treatments

C_k is the effect of dilution

AB_{ij} is the interaction effect between cultivars and treatments

AC_{jk} is the interaction effect between cultivars and dilution

BC_{jk} is the interaction effect between treatments and dilution

ABC_{ijk} is the three-way interaction effect between cultivars, treatments and dilution

ε_{ijk} is the random error

I = 1, ..., 3 = number of cultivars

j = 1, ..., 5 = number of treatments

k = 1, ..., 4 = number of dilution

The significance of an effect was tested as follows:

The null hypothesis states that the effect in charge is insignificant at the given level of significance.

The alternative hypothesis states that the effect in charge is significant at the given level of significance.

α is the level of significance of test

At the α level of significance,

1 The null hypothesis is rejected if the observed significance level (the P-value) is less than α

2 The null hypothesis is accepted if the observed significance level (the P-value) is greater than or equal to α

The ANOVA (Analysis of Variance) table will be as follows:

SV	DF	SS	MS	Fcal	P-value
A_i	3 - 1	SS (A)	MS (A)	MS (A)/MS Err)	0.001
B_j	5 - 1	SS (B)	MS (B)	MS (B)/MS (Err)	0.001
C_k	4 - 1	SS (C)	MS (C)	MS (C)/ MS (Err)	0.001
Ab_{ij}	8	SS (AB)	MS (AB)	MS (AB)/ MS (Err)	0.001
AC_{ik}	6	SS (AC)	MS (AC)	MS (AC) /MS (Err)	0.001
BC_{jk}	12	SS (BC)	MS (BC)	MS (BC) /MS (Err)	0.001
ABC_{ijk}	24	SS (ABC)	MS (ABC)	MS (ABC)//MS(Err)	0.050
Error	120	SS (Err)	MS (Err)		
Total	180 - 1	SS (Tot)			

Where,

SS (A) is sum of squares for cultivars

SS (B) is sum of squares for treatments

SS (C) is sum of squares for dilutions

SS (Tot) is the total sum of squares

MS (A) = SS (A)/2 is mean squares for cultivars

MS (B) = SS (B)/4 is mean squares for treatments

MS (Err) = SS (Err)/120 is mean squares for the error terms

F-ratio = MS/MS (Err) = the calculated value of the F statistic.

Part 2

The objective is to test the effects of:

1 Cultivars for significance
2 Treatments for significance
3 Dilutions for significance
4 One-way linear effects for significance
5 One-way quadratic effects for significance
6 One-way cubic effects for significance
7 The 3 two-way interaction effects for significance
8 Two-way linear effects for significance
9 Two-way quadratic effects for significance
10 Two-way cubic effects for significance
11 The 2 three-way interaction effects for significance
12 Three-way linear effects for significance
13 Three-way quadratic effects for significance

The statistical model and decision rule, were similar to the model and rule mentioned earlier in this section (Hicks, 1973:161-198).

3.6.4 Nested design multifactor anova and multiple range tests - experiment 4

Experiment 4: Germinability trail utilizing four different cultivars involving one homoeopathic treatment under four different light and temperature conditions.

Cultivars - Commander, Greenfield, Great Lakes & Grand Rapids

Light/ Temperature effects - Light at 15°C, Light at 29°C, Dark at 15°C & Dark at 29°C

$$Y_{ijkl} = \mu + A_i + B_j + C_k + \varepsilon_{ijkl}$$

where

A is the effect of treatments

B is the effect of varieties

C is the effect of light conditions

i = 1,2,3,4 = number of varieties

j = 1,2,3,4 = number of light conditions

k = 1,2,3 = number of replications

l = 1,2,3,4,5,6 = number of observations per replication

The statistical package Statsgraphics is used for both data entry and analyses.

CHAPTER FOUR

RESULTS OF THE STUDY

4.1 The criteria governing the admissibility of the data

The data utilised was observational. Radicle protrusion was the criterion for germination established (refer 3.2.4). The weighted GI – index for experiment 3 is calculated using the observational data (refer 3.2.1 and 3.5).

Key: S = Sulphur; N = Nitric Acid;
S/C = Sulphur/Camphor; N/C = Nitric Acid/Camphor

4.2 Results from the overall multifactor analysis of variance for Experiment 1

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-ratio
Treatment	312.5	4	78.12	2.23	0.06
Time	2010874.9	4	502718.73	14407.47	0.0000
Replications	218.2	2	109.10	3.12	0.0441
Error	63993.62	1834	34.89		
Total	2075399.2	1844			

Table 4.1: Overall Multifactor ANOVA for **Experiment 1**

The above ANOVA table shows that:

a) The effect of treatments on germination was significant at the α = 10% level of significance.

b) The effect of "times" was highly significant at the α = 1% level.

c) The effect of replications was significant at the α = 5% level.

TABLE OF LEAST SQUARES MEANS FOR EXPERIMENT 1					
Level	**Count**	**Average**	**Std. Error**	**95% Confidence for Mean**	
Grand Mean	1845	19.307111	0.2083802	18.898334	19.715888
A: Treatment					
1	450	19.668889	0.2784597	19.122637	20.215141
2	450	19.517778	0.2784597	18.971526	20.064029
3	450	19.511111	0.2784597	18.964859	20.057363
4	450	18.615556	0.2784597	18.069304	19.161807
5	45	19.222222	0.8805670	17.494823	20.949622
B: Time					
1	369	-0.015924	0.3450665	-0.692838	0.660989
2	369	84.875675	0.3450665	84.198761	85.552588
3	369	10.379740	0.3450665	9.702826	11.056653
4	369	1.314699	0.3450665	0.637786	1.991613
5	369	-0.018634	0.3450665	-0.695548	0.658279
C: Replication					
1	615	18.826894	0.2850379	18.267738	19.386050
2	615	19.480553	0.2850379	18.921397	20.039709
3	615	19.613886	0.2850379	19.054730	20.173042

Table 4.2: Least Squares Means for **Experiment 1**

MULTIPLE RANGE ANALYSIS FOR "TREATMENTS"			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
4	450	18.615556	X
5	45	19.222222	XX
3	450	19.511111	X
2	450	19.517778	X
1	450	19.668889	X

Contrast	**Comparison**	**Difference**	**Limit**	**Significant difference**
1 – 2	S Vs N	0.15111	0.77252	
1 – 3	S Vs S/C	0.15778	0.77252	
1 – 4	S Vs N/C	1.05333	0.77252	*
1 – 5	S Vs Control	0.44667	1.81171	
2 – 3	N Vs S/C	0.00667	0.77252	
2 – 4	N Vs N/C	0.90222	0.77252	*
2 – 5	N Vs Control	0.29556	1.81171	
3 – 4	S/C Vs N/C	0.89556	0.77252	*
3 – 5	S/C Vs Control	0.28889	1.81171	
4 – 5	N/C Vs Control	-0.60667	1.81171	

*** Denotes a statistically significant difference**

Table 4.3: LSD tests for **"treatments"** at the α=0,05 level of significance

Conclusion

At the α = 5% level, levels (treatments), 1 and 4, 2 and 4, and, 3 and 4, differ significantly from each other. Sulphur, Nitric Acid and Sulphur/Camphor treatments differ significantly from Nitric Acid/Camphor treatment.

Contrast	95% Confidence intervals for differences between means
1 – 2	[-0.62141, 0.92363]
1 – 3	[-0.61474, 0.9303]
1 – 4	[0.28081, 1.82585]
1 – 5	[-1.36504, 2.25838]
2 – 3	[-0.76585, 0.77919]
2 – 4	[0.1297, 1.67474]
2 – 5	[-1.51615, 2.10727]
3 – 4	[0.12304, 1.66808]
3 – 5	[-1.52282, 2.1006]
4 – 5	[2.41838, 1.20504]

Table 4.4: 95% Confidence Intervals for differences between means with respect to **"treatments"**

MULTIPLE RANGE ANALYSIS FOR "TIME"			
Level	Count	Least Significant Mean	Homogenous groups
5	369	-0.018634	X
1	369	-0.015924	XX
4	369	1.314699	X
3	369	10.379740	X
2	369	84.875675	X

Contrast	Comparison	Difference	Limit	Significant difference
1 – 2	12h Vs 24h	-84.8916	0.85310	*
1 – 3	12h Vs 36h	-10.3957	0.85310	*
1 – 4	12h Vs 48h	-1.33062	0.85310	*
1 – 5	12h Vs 60h	0.00271	0.85310	
2 – 3	24h Vs 36h	74.4959	0.85310	*
2 – 4	24h Vs 48h	83.5610	0.85310	*
2 – 5	24h Vs 60h	84.8943	0.85310	*
3 – 4	36h Vs 48h	9.06504	0.85310	*
3 – 5	36h Vs 60h	10.3984	0.85310	*
4 – 5	48h Vs 60h	1.33333	0.85310	*

*** Denotes a statistically significant difference**

Table 4.5: LSD tests for **"times"** at the α=0,05 level of significance

Conclusion

At the α = 5% level, the following levels of "time" differ significantly from each other.

Contrast	95% Confidence intervals for differences between means
1 – 2	[-85.7447, -84.0385]
1 – 3	[-11.2488, -9.5426]
1 – 4	[-2.18372, -0.47752]
1 – 5	[-0.85039, 0.85581]
2 – 3	[73.6428, 75.349]
2 – 4	[82.7079, 84.4141]
2 – 5	[84.0412, 85.7474]
3 – 4	[8.21194, 9.91814]
3 – 5	[9.5453, 11.2515]
4 – 5	[0.48023, 2.18643]

Table 4.6: 95% Confidence Intervals for differences between means with respect to **"times"**

This indicates that the levels of "time" mutually differ from each other. This makes a subsequent one-way ANOVA with respect to "time" necessary.

MULTIPLE RANGE ANALYSIS FOR "REPLICATIONS"				
Level	Count	Least Significant Mean		Homogenous groups
1	615	18.826894		X
2	615	19.480553		XX
3	615	19.613886		X
Contrast	Comparison	Difference	Limit	Significant difference
1 – 2		-0.65366	0.66081	
1 – 3		-0.78699	0.66081	*
2 – 3		-0.13333	0.66081	

*** Denotes a statistically significant difference**

Table 4.7: LSD tests for **"replications"** at the α=0,05 level of significance

Conclusion

Replications 1 and 3 are significantly different at the α = 5% level.

Contrast	95% Confidence intervals for differences between means
1 – 3	[-1.4478, -0.12618]

Table 4.8: 95% Confidence Intervals for the differences between means with respect to **"replications"**

4.2.1 Results from the one-way analysis of variance with respect to "time"

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Time	577753.81	4	1444380.45	11606.498	0.0000
Error	5537.85	445	12.44		
Total (corrected)	583291.66	449			
0 missing values have been excluded					
All F-ratios are based on the residual mean square error.					

Table 4.9: One-way Analysis of Variance with respect to "time" for **Sulphur**

Conclusion

In using Sulphur, there was a highly significant difference between the 5 "times" at the α=0.05 level of significance.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Time	429934.88	4	107483.72	4227.723	0.0000
Error	11313.478	445	25.423546		
Total (corrected)	441248.36	449			
0 missing values have been excluded					
All F-ratios are based on the residual mean square error.					

Table 4.10: One-way Analysis of Variance with respect to "time" for **Nitric Acid**

Conclusion

In using Nitric acid, there was a highly significant difference between the 5 "times" at the $\alpha = 0.05$ level of significance.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Time	456007.48	4	114001.87	2804.515	0.0000
Error	18088.989	445	40.649413		
Total (corrected)	474096.46	449			
0 missing values have been excluded					
All F-ratios are based on the residual mean square error.					

Table 4.11: One-way Analysis of Variance with respect to "time" for **Sulphur/Camphor**

Conclusion

In using Sulphur / Camphor, there was a highly significant difference between the 5 "times" at the $\alpha = 0.05$ level of significance.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Time	510605.64	4	127651.41	3644.347	0.0000
Error	15587.122	445	35.027241		
Total (corrected)	526192.76	449			
0 missing values have been excluded					
All F-ratios are based on the residual mean square error.					

Table 4.12: One-way Analysis of Variance with respect to "time" for **Nitric Acid /Camphor**

Conclusion

In using Nitric acid / Camphor, there is a highly significant difference between the 5 "times" at the $\alpha = 0.05$ level of significance.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Time	40834.667	4	10208.667	537.927	0.0000
Error	759.11111	40	18.977778		
Total (corrected)	41593.778	44			
0 missing values have been excluded					
All F-ratios are based on the residual mean square error.					

Table 4.13: One-way Analysis of Variance with respect to "time" for **Control**

Conclusion

In the Control group, there was a highly significant difference between the 5 "times" at the $\alpha = 0.05$ level of significance.

4.2.2 LSD tests for the levels of treatments, Sulphur, Nitric Acid, Sulphur/Camphor, Nitric Acid/Camphor and the control at the $\alpha = 0.05$ level of significance.

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	90	0.000000	X
5	90	0.000000	X
4	90	0.700000	X
3	90	6.477778	X
2	90	91.166667	X
Contrast	**Difference**	**Limits**	**Significant difference**
1 – 2	-91.1667	1.03374	*
1 – 3	-6.47778	1.03374	*
1 – 4	-0.70000	1.03374	
1 – 5	0.00000	1.03374	
2 – 3	84.6899	1.03374	*
2 – 4	90.4667	1.03374	*
2 – 5	91.1667	1.03374	*
3 – 4	5.77778	1.03374	*
3 – 5	6.47778	1.03374	*
4 – 5	0.70000	1.03374	

*** Denotes a statistically significant difference**

Table 4.14: LSD tests for the levels of **Sulphur** treatment at the $\alpha = 0.05$ level of significance

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	90	0.000000	X
5	90	0.000000	X
4	90	2.044444	X
3	90	15.266667	X
2	90	80.277778	X

Contrast	**Difference**	**Limits**	**Significant difference**
1 – 2	-80.2778	1.47754	*
1 – 3	-15.2667	1.47754	*
1 – 4	-2.04444	1.47754	*
1 – 5	0.000000	1.47754	
2 – 3	65.0111	1.47754	*
2 – 4	78.2333	1.47754	*
2 – 5	80.2778	1.47754	*
3 – 4	13.2222	1.47754	*
3 – 5	15.2667	1.47754	*
4 – 5	2.04444	1.47754	*

*** Denotes a statistically significant difference**

Table 4.15: LSD tests for the levels of **Nitric acid** at the $\alpha = 0.05$ level of significance

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	90	0.000000	X
5	90	0.000000	X
4	90	1.111111	X
3	90	14.166667	X
2	90	82.266667	X

Contrast	**Difference**	**Limits**	**Significant difference**
1 – 2	-82.2667	1.86830	*
1 – 3	-14.1667	1.86830	*
1 – 4	-1.11111	1.86830	
1 – 5	0.000000	1.86830	
2 – 3	68.1000	1.86830	*
2 – 4	81.1556	1.86830	*
2 – 5	82.2667	1.86830	*
3 – 4	13.0556	1.86830	*
3 – 5	14.1667	1.86830	*
4 – 5	1.11111	1.86830	

*** Denotes a statistically significant difference**

Table 4.16: LSD tests for the levels of **Sulphur / Camphor** at the $\alpha = 0.05$ level of significance

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	90	0.000000	X
5	90	0.000000	X
4	90	1.444444	X
3	90	9.833333	X
2	90	86.53333	X

Contrast	**Difference**	**Limits**	**Significant difference**
1 – 2	-86.5333	1.73430	*
1 – 3	-9.83333	1.73430	*
1 – 4	-1.44444	1.73430	
1 – 5	0.000000	1.73430	
2 – 3	76.7000	1.73430	*
2 – 4	85.0889	1.73430	*
2 – 5	86.5333	1.73430	*
3 – 4	8.38889	1.73430	*
3 – 5	9.83333	1.73430	*
4 – 5	1.44444	1.73430	

*** Denotes a statistically significant difference**

Table 4.17: LSD tests for the levels of **Nitric acid / Camphor** at the $\alpha = 0.05$ level of significance

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	9	0.000000	X
5	9	0.000000	X
4	9	1.666667	X
3	9	16.22222	X
2	9	78.22222	X

Contrast	**Difference**	**Limits**	**Significant difference**
1 – 2	-78.2222	4.15144	*
1 – 3	-16.2222	4.15144	*
1 – 4	-1.66667	4.15144	
1 – 5	0.00000	4.15144	
2 – 3	62.0000	4.15144	*
2 – 4	76.5556	4.15144	*
2 – 5	78.2222	4.15144	*
3 – 4	14.5556	4.15144	*
3 – 5	16.2222	4.15144	*
4 – 5	1.66667	4.15144	

*** Denotes a statistically significant difference**

Table 4.18: LSD tests for the levels of the **Control** at the $\alpha = 0.05$ level of significance

4.3 Results from anova (analysis of variance) for experiment 3

4.3.1 Experimentation using Greenfield Cultivar

4.3.1.1 Calculated GI-index values (cf., appendices)

INDEX REPETITION FOR GREENFIELD CULTIVAR				
Treatment	**Dilution/Potency**	**Index Replication**		
Sulphur		1	2	3
	3	0.65656566	0.66955267	0.68049155
	9	0.66763848	0.6899696	0.68335788
	15	0.64357864	0.65912306	0.68571429
	30	0.66770186	0.66131621	0.68412698
Nitric acid				
	3	0.6257764	0.65922619	0.6552795
	9	0.6359447	0.64893617	0.66261398
	15	0.64577259	0.63081862	0.66165414
	30	0.65223665	0.6730486	0.67391304
Sulphur/Camphor				
	3	0.59937888	0.6075188	0.64285714
	9	0.62444772	0.64431487	0.66613162
	15	0.64506627	0.6442577	0.64213564
	30	0.63165266	0.65873016	0.63723917
Nit.ac./Camphor				
	3	0.63546798	0.67683773	0.66091052
	9	0.65571429	0.67893962	0.6952381
	15	0.67402597	0.66718995	0.68681319
	30	0.68019481	0.66616541	0.695711429
Camphor				
	3	0.65634366	0.67391304	0.63257576
	9	0.68080808	0.70478983	0.66933067
	15	0.68319559	0.70661157	0.70652174
	30	0.69636364	0.6979798	0.70071502

Table 4.19: Calculated GI-index repetitions for **Greenfield** cultivar used in the ANOVA (Analysis of Variance)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Var. Comp.	Percent
Treatments	0.0167789	4	0.0041947	0.000	47.07
Dilutions	0.0078979	15	0.0005265	0.000	14.08
Error	0.0100899	40	.00002522	0.000	38.85
Total (corrected)	0.0347667	59			

Table 4.20: Analysis of Variance - Nested design for **Greenfield** cultivar

4.3.1.2 LSD tests for treatments at the $\alpha = 0.05$ level

MULTIPLE RANGE ANALYSIS FOR GREENFIELD CULTIVAR BY TREATMENTS			
METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
3	12	0.6369916	X
2	12	0.6521017	X
1	12	0.6709578	X
4	12	0.6727677	X
5	12	0.6840957	X

Contrast	Comparison	Difference	Limits	Significant difference
1 – 2	S Vs N	0.01886	0.01318	*
1 – 3	S Vs S/C	0.03397	0.01318	*
1 – 4	S Vs N/C	-0.00181	0.01318	
1 – 5	S Vs C	-0.01314	0.01318	
2 – 3	N Vs S/C	0.01511	0.01318	*
2 – 4	N Vs N/C	-0.02097	0.01318	*
2 – 5	N Vs C	-0.03199	0.01318	*
3 – 4	S/C Vs N/C	-0.03578	0.01318	*
3 – 5	S/C Vs C	-0.04710	0.01318	*
4 – 5	N/C Vs C	-0.01133	0.01318	

*** Denotes a statistically significant difference**

Table 4.21: Multiple range analysis for **Greenfield** cultivar by **"treatments"**

Conclusion

The following significant differences were found:

a) Between the mean index of Sulphur and Nitric Acid; at the 5% level of significance
b) Between the mean index of Sulphur and Sulphur/Camphor; at the 5% level of significance
c) Between the mean index of Nitric Acid and Sulphur/Camphor; at the 5% level of significance
d) Between the mean index of Nitric Acid and Nitric Acid/Camphor; at the 5% level of significance
e) Between the mean index of Nitric Acid and Camphor; at the 5% level of significance
f) Between the mean index of Sulphur/Camphor and Nitric Acid/Camphor; at the 5% level of significance
g) Between the mean index of Sulphur/Camphor and Camphor; at the 5% level of significance

Note: If a contrast shows a negative difference, e.g. -0.01133, it means the first had a smaller mean than the second did. Therefore Treatment using Camphor on average germinated faster than Nitric Acid/Camphor treated seeds.

Note the following significance attached to the values in the contrast column,

1 = S 2 = N 3 = S/C 4 = N/C 5 = C

It follows from the first contrast that the difference in the mean GI-index value between remedy S and remedy N is 0.01886. According to the output the difference was taken as the remedy S minus remedy N, i.e. 1-2. Since the difference is indicated with an asterisk (*), it is concluded that there is a statistically significant difference between the mean GI- index value of remedy S and the mean GI-index of remedy N. It furthermore follows that the mean GI-

index value of S remedy is higher than that of N remedy, because of the fact that the difference in means is positive. It can therefore be concluded that the germination process is faster for the Greenfield cultivar using the S remedy than using the N remedy. (The higher the GI-index the faster the germination process was).

It follows from the second contrast that the difference in the GI-index value between remedies S and S/C is 0.03397. This difference in the mean GI-index value of the remedies S and S/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Greenfield cultivar with remedy S is faster than Greenfield cultivar with remedy S/C.

It follows from the fifth contrast that the difference in the GI-index value between remedies N and S/C is 0.01511. This difference in the mean GI-index value of the remedies N and S/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Greenfield cultivar with remedy N is faster than Greenfield cultivar with remedy S/C.

It follows from the sixth contrast that the difference in the GI-index value between remedies N and N/C is –0.02067. This difference in the mean GI-index value of the remedies N and N/C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Greenfield cultivar with remedy N is slower than Greenfield cultivar with remedy N/C.

It follows from the seventh contrast that the difference in the GI-index value between remedies N and C is -0.03199. This difference in the mean GI-index value of the remedies N and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Greenfield cultivar with remedy N is slower than Greenfield cultivar with remedy C.

It follows from the eighth contrast that the difference in the GI-index value between remedies S/C and N/C is –0.03578. This difference in the mean GI-

index value of the remedies S/C and N/C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Greenfield cultivar with remedy S/C is slower than Greenfield cultivar with remedy N/C.

It follows from the ninth contrast that the difference in the GI-index value between remedies S/C and C is –0.04710. This difference in the mean GI-index value of the remedies S/C and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Greenfield cultivar with remedy S/C is slower than Greenfield cultivar with remedy C.

Finally, it can be concluded from the output that:

The remedies C caused faster germination than remedies N, S/C and N/C. The remedy S caused faster germination than remedies N, S/C. Furthermore, remedy N caused faster germination when compared to S/C but slower than remedy N/C when administered to Greenfield cultivar seed.

Contrast	95% Confidence intervals for differences between means
1 – 2	[0.00568, 0.03204]
1 – 3	[0.02079, 0.04715]
2 – 3	[0.00193, 0.02829]
2 – 4	[-0.03385, -0.00749]
2 – 5	[-0.04517, -0.01881]
3 – 4	[-0.04896, -0.0226]
3 - 5	[-0.06028, -0.03392]

Table 4.22: 95% Confidence Intervals for pair-wise differences with respect to **"treatments"**

4.3.1.3 LSD tests for dilutions at the $\alpha = 0.05$ level

MULTIPLE RANGE ANALYSIS FOR GREENFIELD CULTIVAR BY DILUTIONS			
METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	15	0.6488464	X
3	15	0.6655098	X
2	15	0.6673688	X
4	15	0.6718066	X

Contrast	**Comparison**	**Difference**	**Limits**	**Significant difference**
1 – 2	3 Vs 9	-0.01852	0.01179	*
1 – 3	3 Vs 15	-0.01666	0.01179	*
1 – 4	3 Vs 30	-0.02296	0.01179	*
2 – 3	9 Vs 15	0.00186	0.01179	
2 – 4	9 Vs 30	-0.00444	0.01179	
3 – 4	15 Vs 30	-0.00630	0.01179	

*** Denotes a statistically significant difference**

Table 4.23: Multiple range analysis for **Greenfield** cultivar by **"dilutions"**

Conclusion

The following significant differences were found between the:

a) 3CH and 9CH
b) 3CH and 15CH
c) 3CH and 30CH.

The first contrast indicates a statistically significant difference between the mean GI-index value at dilution 3 and the mean GI-index value at dilution 9. Since the sign of the difference in the mean GI-index values is negative, i.e. –

0.02261, the mean GI-index value at the dilution level of 3 is lower than that of 9. This indicates that the germination process was faster at the higher dilution level.

The second contrast indicates that there is a statistically significant difference between the mean GI-index value at dilution level 3 and the mean GI-index value at dilution level 15. Since the difference between the mean GI-index values is negative, i.e. level 3 minus level 15, it follows that the higher diltuion level caused faster germination.

The third contrast has exactly the same conclusion as the above.

It can therefore be concluded that the higher the dilution level was, the faster the germination process was for the Greenfield cultivar type seed.

Contrast	95% Confidence intervals for differences between means
1 – 2	[-0.03031, -0.00673]
1 – 3	[-0.02845, -0.00487]
1 – 4	[-0.03475, -0.01117]

Table 4.24: 95% Confidence Intervals for pair-wise differences with respect to **"dilutions"**

4.3.2 Experimentation using Great Lakes Cultivar

4.3.2.1 Calculated GI-index values (cf., appendices)

Index Repetition for Great Lakes Cultivar				
Treatment	**Dilution/Potency**	**Index Repetition**		
Sulphur		**1**	**2**	**3**
	3	0.41919192	0.44201031	0.43316832
	9	0.42375	0.44642857	0.44949495
	15	0.4388587	0.43440594	0.45263158
	30	0.453125	0.40801887	0.44072165
Nitric acid				
	3	0.39660494	0.41184211	0.46603261
	9	0.45052083	0.40425532	0.43026316
	15	0.42631579	0.43814433	0.42838542
	30	0.47017045	0.4375	0.42275281
Sulphur/Camphor				
	3	0.30591631	0.23888889	0.28632479
	9	0.3844086	0.40625	0.41447368
	15	0.40494792	0.42582418	0.38306452
	30	0.43548387	0.40521978	0.40206186
Nit.ac./Camphor				
	3	0.26102293	0.29755179	0.17921147
	9	0.46467391	0.35694444	0.41015625
	15	0.41315789	0.42916667	0.41489362
	30	0.42708333	0.39972527	0.40625
Camphor				
	3	0.38621795	0.55889423	0.49437148
	9	0.54081633	0.56492969	0.57349581
	15	0.55222672	0.58413462	0.60242005
	30	0.5659919	0.58312655	0.54898785

Table 4.25: Calculated **GI-index** repetitions for **Great Lakes** cultivar used in the ANOVA (Analysis of Variance)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Var. Comp.	Percent
Treatments	0.2405882	4	0.0601456	0.004	56.13
Dilutions	0.1206272	15	0.0080418	0.002	30.05
Error	0.0427636	40	0.0010691	0.001	13.82
Total (corrected)	0.4039730	59			

Table 4.26: Analysis of Variance - Nested design for **Great Lakes** cultivar

4.3.2.2 LSD tests for treatments at the $\alpha = 0.05$ level

MULTIPLE RANGE ANALYSIS FOR GREAT LAKES CULTIVAR BY TREATMENTS			
METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
4	12	0.3716531	X
3	12	0.3743889	X
2	12	0.4318990	X
1	12	0.4368172	X
5	12	0.5463011	X

Contrast	Comparison	Difference	Limits	Significant difference
1 – 2	**S Vs N**	0.00492	0.03409	
1 – 3	**S Vs S/C**	0.06243	0.03409	*
1 – 4	**S Vs N/C**	0.06516	0.03409	*
1 – 5	**S Vs C**	-0.10948	0.03409	*
2 – 3	**N Vs S/C**	0.05751	0.03409	*
2 – 4	**N Vs N/C**	0.06025	0.03409	*
2 – 5	**N Vs C**	-0.11440	0.03409	*
3 – 4	**S/C Vs N/C**	0.00274	0.03409	
3 – 5	**S/C Vs C**	-0.17191	0.03409	*
4 – 5	**N/C Vs C**	-0.17465	0.03409	*

*** Denotes a statistically significant difference**

Table 4.27: Multiple range analysis for **Great Lakes** cultivar by **"treatments"**

Conclusion

The following significant differences were found:

a) Between the mean index of Sulphur and Sulphur/Camphor; at the 5% level of significance
b) Between the mean index of Sulphur and Nitric Acid/Camphor; at the 5% level of significance
c) Between the mean index of Sulphur and Camphor; at the 5% level of significance
d) Between the mean index of Nitric Acid and Sulphur/Camphor; at the 5% level of significance
e) Between the mean index of Nitric Acid and Nitric Acid/Camphor ; at the 5% level of significance
f) Between the mean index of Nitric Acid and Camphor; at the 5% level of significance
g) Between the mean index of Sulphur/Camphor and Camphor; at the 5% level of significance
h) Between the mean index of Nitric Acid/Camphor and Camphor, at the 5% level of significance

Note the following significance attached to the values in the contrast column,

1 = S 2 = N 3 = S/C 4 = N/C 5 = C

It follows from the second contrast that the difference in the mean GI-index value between remedy S and remedy S/C is 0.06243. According to the output the difference was taken as the remedy S minus remedy S/C, i.e. 1-3. Since the difference is indicated with an asterisk (*), it is concluded that there is a statistically significant difference between the mean GI- index value of remedy S and the mean GI-index of remedy S/C. It furthermore follows that the mean GI-index value of S remedy is higher than that of S/C remedy, because of the fact

that the difference in means is positive. It can therefore be concluded that the germination process is faster for the Great Lakes cultivar using the S remedy than using the S/C remedy. (The higher the GI-index the faster the germination process was.)

It follows from the third contrast that the difference in the GI-index value between remedies S and N/C is 0.06516. This difference in the mean GI-index value of the remedies S and N/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Great Lakes cultivar with remedy S is faster than Great Lakes cultivar with remedy N/C.

It follows from the fourth contrast that the difference in the GI-index value between remedies S and C is -0.10948. This difference in the mean GI-index value of the remedies S and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Great Lakes cultivar with remedy S is slower than Great Lakes cultivar with remedy C.

It follows from the fifth contrast that the difference in the GI-index value between remedies N and S/C is –0.05751. This difference in the mean GI-index value of the remedies N and S/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Great Lakes cultivar with remedy N is faster than Great Lakes cultivar with remedy S/C.

It follows from the sixth contrast that the difference in the GI-index value between remedies N and N/C is 0.06025. This difference in the mean GI-index value of the remedies N and N/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Great Lakes cultivar with remedy N is faster than Great Lakes cultivar with remedy N/C.

It follows from the seventh contrast that the difference in the GI-index value between remedies N and C is –0.11440. This difference in the mean GI-index value of the remedies N and C is statistically significant. Since the difference is

negative, it is concluded that the germination process of the Great Lakes cultivar with remedy N is slower than Greenfield cultivar with remedy C.

It follows from the ninth contrast that the difference in the GI-index value between remedies S/C and C is –0.17191. This difference in the mean GI-index value of the remedies S/C and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Great Lakes cultivar with remedy S/C is slower than Great Lakes cultivar with remedy C.

It follows from the tenth contrast that the difference in the GI-index value between remedies N/C and C is –0.17465. This difference in the mean GI-index value of the remedies N/C and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Great Lakes cultivar with remedy N/C is slower than Great Lakes cultivar with remedy C.

Finally, it can be concluded from the output that:

The remedy C caused faster germination than remedies S, N, S/C and N/C. The remedies S and N caused faster germination than remedies S/C and N/C. Furthermore, remedy S caused faster germination when compared to N but this relationship however is not statistically significant when treating Great Lakes cultivar seed.

Contrast	95% Confidence intervals for differences between means
1 – 3	[0.02834, 0.09649]
1 – 4	[0.03107, 0.09925]
1 – 5	[-0.14357, -0.07539]
2 – 3	[0.02342, 0.0916]
2 – 4	[0.02616, 0.09434]
2 – 5	[-0.14849, -0.08031]
3 – 5	[-0.0206, -0.13782]
4 – 5	[-0.20874 -0.14056]

Table 4.28: 95% Confidence Intervals for pair-wise differences with respect to **"treatments"**

4.3.2.3 LSD tests for dilutions at the $\alpha = 0.05$ level

MULTIPLE RANGE ANALYSIS FOR GREAT LAKES CULTIVAR BY DILUTIONS			
METHOD: 95 PERCENT LSD			
Level	Count	Least Significant Mean	Homogenous groups
1	15	0.3718167	X
2	15	0.4480574	X
4	15	0.4537348	X
3	15	0.4552385	X

Contrast	Comparison	Difference	Limits	Significant difference
1 – 2	3 Vs 9	-0.07624	0.03049	*
1 – 3	3 Vs 15	-0.08342	0.03049	*
1 – 4	3 Vs 30	-0.08192	0.03049	*
2 – 3	9 Vs 15	-0.00718	0.03049	
2 – 4	9 Vs 30	-0.00568	0.03049	
3 – 4	15 Vs 30	0.00150	0.03049	

*** Denotes a statistically significant difference**

Table 4.29: Multiple range analysis for **Great Lakes** cultivar by **"dilutions"**

Conclusion

The following significant differences were found between the:

a) 3CH and 9CH
b) 3CH and 15CH
c) 3CH and 30CH.

The first contrast indicates a statistically significant difference between the mean GI-index value at dilution 3 and the mean GI-index value at dilution 9. Since the sign of the difference in the mean GI-index values is negative, i.e. – 0.02261, the mean GI-index value at the dilution level of 3 is lower than that of 9. This indicates that the germination process was faster at the higher dilution level.

The second contrast indicates that there is a statistically significant difference between the mean GI-index value at dilution level 3 and the mean GI-index value at dilution level 15. Since the difference between the mean GI-index values is negative, i.e. level 3 minus level 15, it follows that the higher diltuion level caused faster germination.

The third contrast has exactly the same conclusion as the above.

It can therefore be concluded that the higher the dilution level was, the faster the germination process was for the Great Lakes cultivar type seed.

Contrast	95% Confidence intervals for differences between means
1 – 2	[-0.10673, -0.04575]
1 – 3	[-0.11389, -0.05293]
1 – 4	[-0.11241, -0.05043]

Table 4.30: 95% Confidence Intervals for pair-wise differences with respect to **"dilutions"**

4.3.3 Experimentation using Grand Rapids cultivar

4.3.3.1 Calculated GI-index values (cf., appendices)

INDEX REPETITION FOR GRAND RAPIDS CULTIVAR				
Treatment	**Dilution/Potency**	**Index Replication**		
Sulphur		**1**	**2**	**3**
	3	0.55	0.57451923	0.5719697
	9	0.56056701	0.57857143	0.59646739
	15	0.57631579	0.5766129	0.5975
	30	0.56182796	0.57608690	0.59078947
Nitric acid				
	3	0.54945055	0.57994186	0.55
	9	0.55357143	0.56182796	0.546875
	15	0.54567308	0.57186869	0.55984043
	30	0.56186869	0.55598958	0.56447368
Sulphur/Camphor				
	3	0.50735294	0.56805556	0.52533784
	9	0.54435484	0.58055556	0.5497449
	15	0.57102273	0.58104396	0.578125
	30	0.55978261	0.56989247	0.57608696
Nit. Ac./Camphor				
	3	0.49350649	0.46348315	0.52298851
	9	0.5577957	0.49311927	0.59375
	15	0.54891304	0.53708791	0.58088235
	30	0.52213542	0.50983146	0.57763158
Camphor				
	3	0.57771261	0.57985258	0.60942761
	9	0.58875805	0.61219793	0.64453524
	15	0.57467532	0.63030303	0.6076555
	30	0.60127592	0.64359504	0.63838384

Table 4.31: Calculated **GI-index** repetitions for **Grand Rapids** cultivar used in the ANOVA (Analysis of Variance)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Var. Comp.	Percent
Treatments	0.0373969	4	0.0093492	0.001	52.31
Dilutions	0.0132344	15	0.0008823	0.000	8.86
Error	0.0209542	40	0.0005239	0.001	38.84
Total (corrected)	0.0715855	59			

Table 4.32: Analysis of Variance - Nested design for **Grand Rapids** cultivar

4.3.3.2 LSD tests for treatments at the $\alpha = 0.05$ level

MULTIPLE RANGE ANALYSIS FOR GRAND RAPIDS CULTIVAR BY TREATMENTS			
METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
4	12	0.5335021	X
2	12	0.5576151	X
3	12	0.5592796	X
1	12	0.5759357	X
5	12	0.6090333	X

Contrast	Comparison	Difference	Limits	Significant difference
1 – 2	**S Vs N**	0.01832	0.01865	
1 – 3	**S Vs S/C**	0.01666	0.01865	
1 – 4	**S Vs N/C**	0.04243	0.01865	* (third contrast)
1 – 5	**S Vs C**	-0.03310	0.01865	*
2 – 3	**N Vs S/C**	-0.00166	0.01865	
2 – 4	**N Vs N/C**	0.02411	0.01865	*
2 – 5	**N Vs C**	-0.05142	0.01865	*
3 – 4	**S/C Vs N/C**	0.02578	0.01865	*
3 – 5	**S/C Vs C**	-0.04975	0.01865	*
4 – 5	**N/C Vs C**	-0.07553	0.01865	*

*** Denotes a statistically significant difference**

Table 4.33: Multiple range analysis for **Grand Rapids** cultivar by **"treatments"**

Conclusion

The following significant differences were found:

a) Between the mean index of Sulphur and Nitric Acid/Camphor; at the 5% level of significance
b) Between the mean index of Sulphur and Camphor; at the 5% level of significance
c) Between the mean index of Nitric Acid and Nitric Acid/Camphor; at the 5% level of significance
d) Between the mean index of Nitric Acid and Camphor; at the 5% level of significance
e) Between the mean index of Sulphur/Camphor and Nitric Acid/Camphor; at the 5% level of significance
f) Between the mean index of Sulphur/Camphor and Camphor; at the 5% level of significance
g) Between the mean index of Nitric Acid/Camphor and Camphor, at the 5% level of significance.

Note the following significance attached to the values in the contrast column,

1 = S 2 = N 3 = S/C 4 = N/C 5 = C

It follows from the third contrast that the difference in the mean GI-index value between remedy S and remedy N/C is 0.04243. According to the output the difference was taken as the remedy S minus remedy N/C, i.e. 1-4. Since the difference is indicated with an asterisk (*), it is concluded that there is a statistically significant difference between the mean GI- index value of remedy S and the mean GI-index of remedy N/C. It furthermore follows that the mean GI-index value of S remedy is higher than that of N/C remedy, because of the fact that the difference in means is positive. It can therefore be concluded that the germination process is faster for the Grand Rapids cultivar using the S remedy

than using the N/C remedy. (The higher the GI-index the faster the germination process was.)

It follows from the fourth contrast that the difference in the GI-index value between remedies S and C is –0.03310. This difference in the mean GI-index value of the remedies S and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Grand Rapids cultivar with remedy S is slower than Grand Rapids cultivar with remedy C.

It follows from the sixth contrast that the difference in the GI-index value between remedies N and N/C is 0.02411. This difference in the mean GI-index value of the remedies N and N/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Grand Rapids cultivar with remedy N is faster than Grand Rapids cultivar with remedy N/C.

It follows from the seventh contrast that the difference in the GI-index value between remedies N and C is –0.05142. This difference in the mean GI-index value of the remedies N and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Grand Rapids cultivar with remedy N is slower than Grand Rapids cultivar with remedy C.

It follows from the eighth contrast that the difference in the GI-index value between remedies S/C and N/C is 0.02578. This difference in the mean GI-index value of the remedies S/C and N/C is statistically significant. Since the difference is positive, it is concluded that the germination process of the Grand Rapids cultivar with remedy S/C is faster than Grand Rapids cultivar with remedy N/C.

It follows from the ninth contrast that the difference in the GI-index value between remedies S/C and C is –0.04975. This difference in the mean GI-index value of the remedies S/C and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Grand

Rapids cultivar with remedy S/C is slower than Grand Rapids cultivar with remedy C.

It follows from the tenth contrast that the difference in the GI-index value between remedies N/C and C is –0.07553. This difference in the mean GI-index value of the remedies N/C and C is statistically significant. Since the difference is negative, it is concluded that the germination process of the Grand Rapids cultivar with remedy N/C is slower than Grand Rapids cultivar with remedy C.

Finally, it can be concluded from the output that the remedies S, N and S/C caused faster germination than remedy N/C. This becomes clear if all the above statistically significant differences have been discussed. Furthermore, remedy C caused the fastest germination of all remedies.

Contrast	95% Confidence intervals for differences between means
1 - 4	[0.02378, 0.06108]
1 - 5	[-0.05175, -0.01445]
2 - 4	[0.00546, 0.04276]
2 - 5	[-0.07007, -0.03277]
3 - 4	[0.00713, 0.04443]
3 - 5	[-0.0684, -0.0311]
4 - 5	[-0.09418, -0.05688]

Table 4.34: 95% Confidence Intervals for pair-wise differences with respect to **"treatments"**

4.3.3.3 LSD tests for dilutions at the $\alpha = 0.05$ level

Multiple range analysis for Grand Rapids cultivar by dilutions Method: 95 Percent LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	15	0.5482399	X
2	15	0.5708479	X
4	15	0.5739768	X
3	15	0.5752280	X

Contrast	Comparison	Difference	Limits	Significant difference
1 – 2	3 Vs 9	-0.02261	0.01668	*
1 – 3	3 Vs 15	-0.02699	0.01668	*
1 – 4	3 Vs 30	-0.02574	0.01668	*
2 – 3	9 Vs 15	-0.00438	0.01668	
2 – 4	9 Vs 30	-0.00313	0.01668	
3 – 4	15 Vs 30	0.00125	0.01668	

*** Denotes a statistically significant difference**

Table 4.35: Multiple range analysis for **Grand Rapids** cultivar by **"dilutions"**

Conclusion

Note the following significance attached to the values in the contrast column,

1 = 3(con) 2 = 9 3 = 15 4 = 30

The following significant differences were found between the:

a) 3CH and 9CH
b) 3CH and 15CH
c) 3CH and 30CH.

The first contrast indicates a statistically significant difference between the mean GI-index value at dilution 3 and the mean GI-index value at dilution 9. Since the sign of the difference in the mean GI-index values is negative, i.e. – 0.02261, the mean GI-index value at the dilution level of 3 is lower than that of 9. This indicates that the germination process was faster at the higher dilution level.

The second contrast indicates that there is a statistically significant difference between the mean GI-index value at dilution level 3 and the mean GI-index value at dilution level 15. Since the difference between the mean GI-index values is negative, i.e. level 3 minus level 15, it follows that the higher diltuion level caused faster germination.

The third contrast has exactly the same conclusion as the above.

It can therefore be concluded that the higher the dilution level was, the faster the germination process was for the Grand Rapids cultivar type seed.

Contrast	95% Confidence intervals for differences between means
1 - 2	[-0.03929, -0.00593]
1 - 3	[-0.04367, -0.01031]
1 - 4	[-0.04242, -0.00906]

Table 4.36: 95% Confidence Intervals for pair-wise differences with respect to **"dilutions"**

4.3.4 The results obtained from factorial experiments are given as follows:

Table 4.37, shows that all effects in the model are significant at the $\alpha = 0.05$ level of significance.

Analysis of variance					
Variate: indicies					
Source of variation	DF	SS	MS	F-ratio	F pr
Cultivar	2	1.6177244	0.8088622	1312.15	< 0.001
Treatment	4	0.1909804	0.0477451	77.45	< 0.001
Dilution	3	0.0592406	0.0197469	32.03	< 0.001
Cultivar.Treatment	8	0.1036010	0.0129501	21.01	< 0.001
Cultivar.Dilution	6	0.0260588	0.0043431	7.05	< 0.001
Treatment.Dilution	12	0.0325670	0.0027139	4.40	< 0.001
Cultivar.Treatment.Dilution	24	0.0237809	0.0009909	1.61	0.050
Residual	120	0.0739729	0.0006164		
Total	179	2.1279261			

Table 4.37: Analysis of variance for factorial experiments of experiment 3

The effect of cultivars is significant at the $\alpha = 0.05$ level. This indicates that there is a significant difference between the three types of cultivars in the experiment, at the $\alpha = 0.05$ level.

The effect of treatments is significant at the $\alpha = 0.05$ level. This indicates that there is a significant difference between the five treatments in the experiment, at the $\alpha = 0.05$ level.

The effect of dilutions is significant at the $\alpha = 0.05$ level. This indicates that there is a significant difference between the four levels of dilution in the experiment, at the $\alpha = 0.05$ level.

The effect of the interaction between cultivars and treatments is significant at the $\alpha = 0.05$ level. This indicates that there is a significant difference between all the interactions between cultivars and treatments in the experiment, at the $\alpha = 0.05$ level.

The effect of the interaction between cultivars and dilutions is significant at the $\alpha = 0.05$ level. This indicates that there is a significant difference between all the interactions between cultivars and dilutions in the experiment, at the $\alpha = 0.05$ level.

The effect of the interaction between treatments and dilutions is significant at the $\alpha = 0.05$ level. This indicates that there is a significant difference between all the interactions between treatments and dilutions in the experiment, at the $\alpha = 0.05$ level.

The effect of the interaction between cultivars, treatments and dilutions is significant at the $\alpha = 0.05$ level (p-value=0.05). This indicates that there is a significant difference between all the interactions between cultivars, treatments and dilutions in the experiment, at the $\alpha = 0.05$ level.

Table of means					
Grand mean	**0.5542**				
Cultivar	**1**	**2**	**3**		
	0.6633	0.4322	0.5672		
Treatment	**1**	**2**	**3**	**4**	**5**
	0.5611	0.5474	0.5235	0.5259	0.6131
Dilution	**3.00**	**9.00**	**15.00**	**30.00**	
	0.5229	0.5620	0.5655	0.5665	
Cultivar.Treatment	**1**	**2**	**3**	**4**	**5**
1	0.6707	0.6521	0.6369	0.6727	0.6841
2	0.4368	0.4319	0.3744	0.3716	0.5463
3	0.5759	0.5584	0.5592	0.5334	0.6090
Cultivar.Dilution	**3.00**	**9.00**	**15.00**	**30.00**	
1	0.6488	0.6672	0.6655	0.6718	
2	0.3718	0.4480	0.4552	0.4537	
3	0.5482	0.5708	0.5758	0.5739	
Treatment.Dilution	**3.00**	**9.00**	**15.00**	**30.00**	
1	0.5552	0.5662	0.5627	0.5604	
2	0.5438	0.5438	0.5453	0.5568	
3	0.4757	0.5349	0.5417	0.5417	
4	0.4656	0.5451	0.5502	0.5427	
5	0.5743	0.6199	0.6275	0.6306	
Cultivar.Treatment.Dilution		**3.00**	**9.00**	**15.00**	**30.00**
1	1	0.6688	0.6803	.6628	0.6710
	2	0.6467	0.6491	0.6460	0.6664
	3	0.6165	0.6449	0.6438	0.6425
	4	0.6577	0.6766	0.6760	0.6806
	5	0.6542	0.6849	0.687	0.6983
2	1	0.4314	0.4398	0.4419	0.4339
	2	0.4248	0.4283	0.4309	0.4434
	3	0.2770	0.4017	0.4046	0.4142
	4	0.2459	0.4105	0.4190	0.4110
	5	0.4798	0.5597	0.5796	0.5660
3	1	0.5655	0.5785	0.5835	0.5762
	2	0.5598	0.5540	0.5591	0.5607
	3	0.5335	0.5582	0.5767	0.5685
	4	0.4933	0.5482	0.5556	0.5365
	5	0.5890	0.6151	0.6042	0.6277

Table 4.38: Table of means for factorial experiments of experiment 3

Standard error of differences of means							
Table	Cultivar	Treatment	Dilution	Cultivar/ Treatment	Cultivar/ Dilution	Treatment/ Dilution	Cultivar/ Treatment/ Dilution
Rep	60	36	45	12	15	9	3
Df	120	120	120	120	120	120	120
Sed	0.00453	0.00585	0.00523	0.01014	0.00907	0.01170	0.02027

Table 4.39: Table of standard error of differences of means for factorial experiments of experiment 3

Stratum standard errors and coefficients of variation			
Variate: indicies	DF	SE	CV%
	120	0.02483	4.5

Table 4.40: Table of stratum standard errors and coefficients of variation for factorial experiments of experiment 3

Part 2

The objective is to test the effects of:

1 Cultivars for significance
2 Treatments for significance
3 Dilutions for significance
4 One-way linear effects for significance
5 One-way quadratic effects for significance
6 One-way cubic effects for significance
7 The 3 two-way interaction effects for significance
8 Two-way linear effects for significance
9 Two-way quadratic effects for significance
10 Two-way cubic effects for significance
11 The 2 three-way interaction effects for significance
12 Three-way linear effects for significance
13 Three-way quadratic effects for significance

The statistical model and decision rule, are similar to the model and rule mentioned earlier in this section.

From Table 4.41, see estimated result for cultivars:

P-value=0.001

α=0.05

Analysis of variance					
Variate: indicies					
Source of variation	DF	SS	MS	F-ratio	F pr
Cultivar	2	1.6177244	0.8088622	1312.15	< 0.001
Treatment	4	0.1909804	0.0477451	77.45	< 0.001
Dilution	3	0.0592406	0.0197469	32.03	< 0.001
Lin	1	0.0293474	0.293474	47.61	< 0.001
Quad	1	0.0251774	0.0251774	40.84	< 0.001
Cub	1	0.0047157	0.0047157	7.65	0.007
Cultivar.Treatment	8	0.1036010	0.0129501	21.01	< 0.001
Cultivar.Dilution	6	0.0260588	0.0043431	7.05	< 0.001
Cultivar.Lin	2	0.0108404	0.0054202	8.79	< 0.001
Cultivar.Quad	2	0.0132150	0.0066075	10.72	< 0.001
Cultivar.Cub	2	0.0020034	0.0010017	1.62	0.201
Treatment.Dilution	12	0.0325670	0.0027139	4.40	< 0.001
Treatment.Lin	4	0.0122762	0.0030691	4.98	< 0.001
Treatment.Quad	4	0.0178498	0.0044624	7.24	< 0.001
Treatment.Cub	4	0.0024410	0.0006103	0.99	0.416
Cultivar.Treatment.Dilution	24	0.0237809	0.0009909	1.61	0.050
Cultivar.Treatment. Lin	8	0.0098224	0.0012278	1.99	0.053
Cultivar.Treatment.Quad	8	0.0102583	0.0012823	2.08	0.043
Deviations	8	0.0037002	0.0004625	0.75	0.647
Residual	120	0.0739729	0.0006164		
Total	179	2.1279261			

Table 4.41: Analysis of variance for linear, quadratic and cubic effects within experiment 3

- Since P < α, the effect for cultivars is significant at the α = 0.05 level of significance.
- Since P < α, the effect for treatments is significant at the α = 0.05 level of significance
- Since P < α, the effect for dilutions is significant at the α = 0.05 level of significance

- Since $P < \alpha$, there is a significant linear effect, $p=0.001$, and $\alpha=0.05$. This means that there is a significant increase or the other way around (a significant decrease).
- Since $P < \alpha$, there is a significant quadratic effect. This means that, there is a significant increase followed by a significant decrease, or the other way around, over a certain period of time, with regard to readings in the experiment [Quadratic: increase →decrease or decrease →increase]
- For the cubic effects, $P = 0.007$, and $\alpha = 0.05$.Since $P < \alpha$, there is a significant cubic effects. This means that, there is a significant increase followed by a significant decrease, followed by a significant increase or the other way around, over a period of time, with regards to readings in the experiment. [Cubic: increase →decrease →increase or decrease →increase →decrease]
- There is a significant linear effect embodied within the cultivars
- There is a significant quadratic effect embodied within the cultivars
- There is no significant cubic effect embodied within cultivars
- There is a significant linear effect embodied within the treatments
- There is a significant quadratic effect embodied within the treatments
- There is no significant cubic effect embodied within treatments
- There is a significant effect between the interaction of cultivars and treatments
- There is a significant effect between the interaction of cultivars and dilutions
- There is a significant effect between the interaction of treatments and dilutions
- There is no significant linear effect embodied within the interaction effect between cultivars and treatments
- There is a significant quadratic effect embodied within the interaction effect between cultivars and treatments
- There is no significant effect between the interaction effects of cultivars, treatments and dilutions.

Table of means					
Variate: indicies					
Grand mean	0.5542				
Cultivar	**1**	**2**	**3**		
	0.6633	0.4322	0.5672		
Treatment	**1**	**2**	**3**	**4**	**5**
	0.5611	0.5474	0.5235	0.5259	0.6131
Dilution	**3.00**	**9.00**	**15.00**	**30.00**	
	0.5229	0.5620	0.5655	0.5665	
Cultivar.Treatment	**1**	**2**	**3**	**4**	**5**
1	0.6707	0.6521	0.6369	0.6727	0.6841
2	0.4368	0.4319	0.3744	0.3716	0.5463
3	0.5759	0.5584	0.5592	0.5334	0.6090
Cultivar.Dilution	**3.00**	**9.00**	**15.00**	**30.00**	
1	0.6488	0.6672	0.6655	0.6718	
2	0.3718	0.4480	0.4552	0.4537	
3	0.5482	0.5708	0.5758	0.5739	
Treatment.Dilution	**3.00**	**9.00**	**15.00**	**30.00**	
1	0.5552	0.5662	0.5627	0.5604	
2	0.5438	0.5438	0.5453	0.5568	
3	0.4757	0.5349	0.5417	0.5417	
4	0.4656	0.5451	0.5502	0.5427	
5	0.5743	0.6199	0.6275	0.6306	
Cultivar.Treatment.Dilution		**3.00**	**9.00**	**15.00**	**30.00**
1	1	0.6688	0.6803	0.6628	0.6710
	2	0.6467	0.6491	0.6460	0.6664
	3	0.6165	0.6449	0.6438	0.6425
	4	0.6577	0.6766	0.6760	0.6806
	5	0.6542	0.6849	0.687	0.6983
2	1	0.4314	0.4398	0.4419	0.4339
	2	0.4248	0.4283	0.4309	0.4434
	3	0.2770	0.4017	0.4046	0.4142
	4	0.2459	0.4105	0.4190	0.4110
	5	0.4798	0.5597	0.5796	0.5660
3	1	0.5655	0.5785	0.5835	0.5762
	2	0.5598	0.5540	0.5591	0.5607
	3	0.5335	0.5582	0.5767	0.5685
	4	0.4933	0.5482	0.5556	0.5365
	5	0.5890	0.6151	0.6042	0.6277

Table 4.42: Table of means for interaction effects of experiment 3

Standard error of differences of means							
Table	Cultivar	Treatment	Dilution	Cultivar/ Treatment	Cultivar/ Dilution	Treatment/ Dilution	Cultivar/ Treatment/ Dilution
Rep	60	36	45	12	15	9	3
Df	120	120	120	120	120	120	120
Sed	0.00453	0.00585	0.00523	0.01014	0.00907	0.01170	0.02027

Table 4.43: Table of standard error of differences of means for interaction effects of experiment 3

Stratum standard errors and coefficients of variation			
Variate: indicies	DF	SE	CV%
	120	0.02483	4.5

Table 4.44: Table of stratum standard errors and coefficients of variation of experiment 3

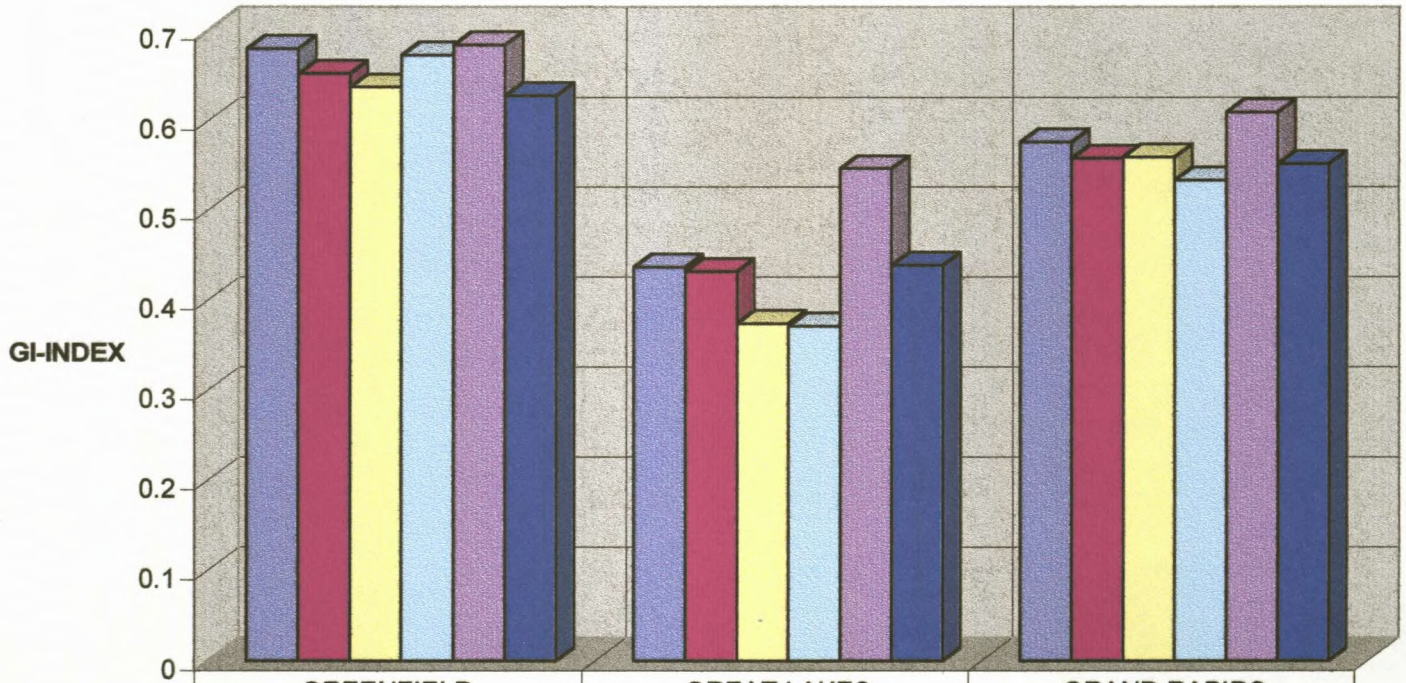
In nested design experiments and multifactor ANOVA, interaction effects of orders 2 and 3 were ignored. However, most of the main effects were shown to be significant at the $\alpha = 0.05$ level.

The factorial experiments used in this section has revealed that presence of significant interaction effects of order 2 or more between the main factors. Moreover, significant linear effects, quadratic effects, and only one cubic effect were obtained.

The barcharts shown in graphs 1 and 2 clearly confirm the above analytical findings.

The statistical package called Genstat Version 5 was used to do data analysis in this part of the study.

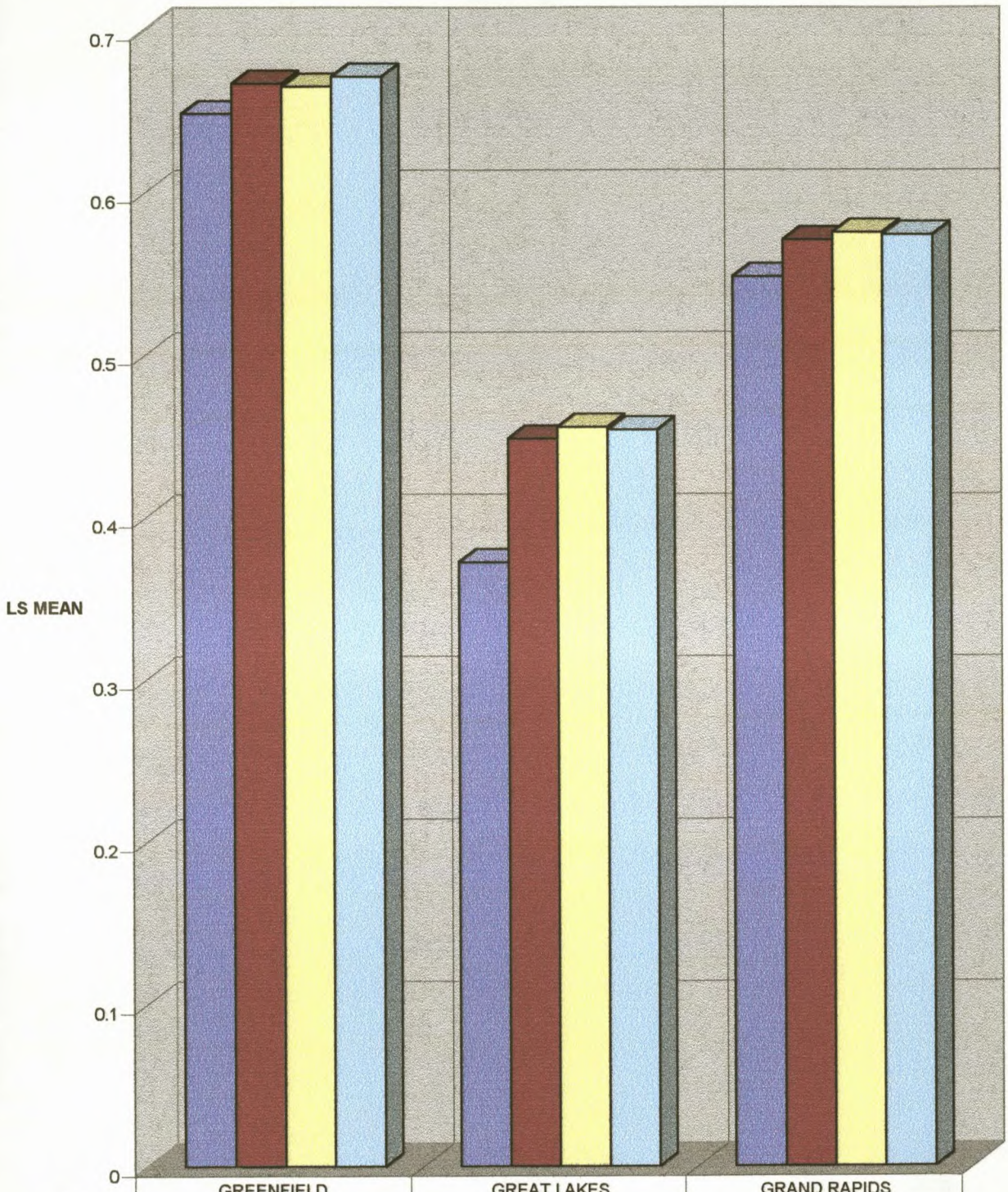
GRAPH 1: EX[ERIMENT 3: EFFECTS OF TREATMENTS



	GREENFIELD	GREAT LAKES	GRAND RAPIDS
SULPHUR	0.6795	0.43681	0.57593
NIT.AC.	0.6521	0.43189	0.55761
SULPHUR/CAMPHOR	0.63699	0.37438	0.55927
NIT. AC./CAMPHOR	0.67276	0.37165	0.5335
CAMPHOR	0.68409	0.5463	0.60903
CONTROL	0.6273	0.4388	0.5518

CULTIVARS

GRAPH 2: EXPERIMENT 3: EFFECTS OF POTENCY LEVELS



	GREENFIELD	GREAT LAKES	GRAND RAPIDS
3CH	0.64884	0.37181	0.54823
9CH	0.66736	0.44805	0.57084
15CH	0.6655	0.45523	0.57522
30CH	0.6718	0.45373	0.57397

CULTIVARS

4.4 Nested design, multifactor anova and multiple range tests for experiment 4

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Var. Comp.	Percent
Cultivar	3203.30	3	1067.76	2.001	0.81
Light	11084.58	12	923.71	51.142	20.60
Replication	101.22	32	3.16	0.000	0.00
Error	46822.66	240	195.09	195.094	78.59
Total (corrected)	61211.77	287			

Table 4.45: Nested design ANOVA results for **Experiment 4**

The above table shows that:

a) The contribution of "cultivars" to the overall variation is 0.81 percent.

b) The contribution of "lights" to the overall variation is 21 percent.

c) The contribution of "replications" to the overall variation is negligible.

This shows that the effect of the "lights" on the response variable is highly significant, while "cultivars" and "replications" have negligible effects on the response variable.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Cultivar	3203.30	3	1067.76	5.937	0.0006
Light	7824.41	3	2608.13	14.502	0.0000
Replication	6.71	2	3.35	0.019	0.9815
Error	50177.34	279	179.84		
Total (corrected)	61211.77	287			

Table 4.46: Multifactor ANOVA results for **Experiment 4**

The above table shows that:

a) The effect of "cultivars" is highly significant at the $\alpha = 0.01$ level.

b) The effect of "lights" is highly significant at the $\alpha = 0.01$ level.

c) The effect of "replications" is insignificant at the $\alpha = 0.05$ level.

This shows that the effects of "cultivars" and "lights" on the response variable are highly significant, while "replications" have a negligible effect on the response variable.

TABLE OF LEAST SQUARES MEANS FOR EXPERIMENT 4					
Level	Count	Average	STD. Error	95% Confidence for mean	
Grand mean	288	5.527778	0.7902336	3.9718561	7.083699
A: Cultivar					
1	72	0.000000	1.5804671	-3.1118433	3.111843
2	72	8.347222	1.5804671	5.2353790	11.459065
3	72	7.958333	1.5804671	4.8464901	11.070177
4	72	5.805556	1.5804671	2.6937123	8.917399
B: Light					
1	72	11.541667	1.5804671	8.4298234	14.653510
2	72	0.666667	1.5804671	-2.4451766	3.778510
3	72	9.861111	1.5804671	6.7492678	12.972954
4	72	0.041667	1.5804671	-3.0701766	3.153510
C: Replication					
1	96	5.458333	1.3687247	2.7663980	8.153269
2	96	5.739583	1.3687247	3.0446480	8.434519
3	96	5.385417	1.3687247	2.6904813	8.080352

Table 4.47: Least Square Means for **Experiment 4**

4.4.1 Results from LSD multiple range tests at the $\alpha = 0.05$ level for experiment 4

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
1	72	0.0000000	X
4	72	5.8055556	X
3	72	7.9583333	X
2	72	8.3472222	X

Contrast	**Comparison**	**Difference**	**Limits**	**Significant difference**
1 – 2	Comm. Vs Greenfield	-8.34722	4.40081	*
1 – 3	Comm. Vs Great Lakes	-7.95833	4.40081	*
1 – 4	Comm. Vs Grand Rapids	-5.80556	4.40081	*
2 – 3	Greenfield Vs Great Lakes	0.38889	4.40081	
2 – 4	Greenfield Vs Grand Rapids	2.54167	4.40081	
3 – 4	Great Lakes Vs Grand Rapids	2.15278	4.40081	

*** Denotes a statistically significant difference**

Table 4.48: LSD multiple range tests at the $\alpha = 0.05$ level of significance for **"cultivars"**

Conclusion:

Greenfield, Great Lakes and Grand Rapids cultivars all germinated more rapidly than the Commander cultivar. However no significant difference occurred between these formative cultivars.

Contrast	95% Confidence intervals for differences between means
1 – 2	[-12.74803, -3.94641]
1 – 3	[-12.35914, -3.55752]
1 – 4	[-10.20637, -1.40475]

Table 4.49: 95% Confidence Intervals for differences between means for **"cultivars"**

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
4	72	0.041667	X
2	72	0.666667	X
3	72	9.861111	X
1	72	11.541667	X

Contrast	Comparison	Difference	Limits	Significant difference
1 – 2	Light/15°C Vs Light/29°C	10.8750	4.40081	*
1 – 3	Light/15°C Vs Dark/15°C	1.68056	4.40081	
1 – 4	Light/15°C Vs Dark/29°C	11.5000	4.40081	*
2 – 3	Light/29°C Vs Dark/15°C	-9.19444	4.40081	*
2 – 4	Light/29°C Vs Dark/29°C	0.62500	4.40081	
3 – 4	Dark/15°C Vs Dark/29°C	9.81944	4.40081	*

Table 4.50: LSD multiple range tests at the $\alpha = 0.05$ level of significance for **"light"**

Conclusion:

Results indicate that there is no significant difference between light and dark treatments. Temperature has a significant effect and in all cases 15 °C is the most favourable.

Contrast	95% Confidence intervals for differences between means
1 – 2	6.47419, 15.27581]
1 – 4	7.09919, 15.90081]
2 – 3	[-13.59525, -4.79363]
3 – 4	[5.41863, 14.22025]

Table 4.51: 95% Confidence Intervals for differences between means for **"light"**

METHOD: 95 PERCENT LSD			
Level	**Count**	**Least Significant Mean**	**Homogenous groups**
3	96	5.3854167	X
1	96	5.4583333	X
2	96	5.7395833	X
Contrast	**Difference**	**Limits**	**Significant difference**
1 – 2	-0.28125	3.81121	None
1 – 3	0.07292	3.81121	None
2 – 3	0.35417	3.81121	None

Table 4.52: LSD multiple range tests at the $\alpha = 0.05$ level of significance for **"replications"**.

CHAPTER FIVE

DISCUSSION

Disorder of the states of an organism result in its failure to act in accordance with its intended function and many factors contribute to this. Understanding the effect of each factor and nullifying the condition substantially enhances performance. Here Homoeopathy has exceptional potential and at the outset of this research it was hypothesised that there will be measurable effects on the germinability of lettuce seed as a result of treatment with homoeopathic medicines, and that antidoting treatments would nullify these effects. All conditions were set as optimal for germination, the measurable criterion being performance with time.

Experiment 1 was set up as a germinability trial involving the application of five different homoeopathic treatments at thirty different potency levels (the factor of treatments being 369 with data harvesting every 12 hours). The remedies were chosen for their attributes as discussed in 3.3.1 and the range of potencies was broad. In statistical analysis the effect of treatments (i.e. remedies and potencies) on germination show significant differences at the α =10% level of significance. The effect of time is highly significant at the α = 1% level of significance. Further evaluation of the treatment data shows significant differences only where Camphor is used in combination with Nitric Acid. In each case the treatment causes a lower germinability for this treatment than for the comparison. This supports the antidote effect of Camphor in this particular combination. This affect becomes a trade mark for the Nitric Acid/Camphor combination throughout Experiment 3 where in almost all cases apart from two results which do not reflect significant differences at the α = 5% level of significance, the Nitric Acid/ Camphor combination significantly decreases the performance of the treated seed. The exceptions in the Greenfield culitvar being when Sulphur is compared with Nitric Acid/ Camphor and Camphor is compared

with Nitric Acid/ Camphor where there is no significant difference. The postulation on these results is taken up later in the discussion. There were no significant differences for the combination Sulphur/ Camphor in experiment 1. However again in experiment 3 the combination Sulphur/Camphor in almost all cases significantly decreases the germinability of seed. The exceptions in the cultivar Grand Rapids being when Sulphur is compared with Sulphur/ Camphor and Nitric Acid is compared to Camphor/Sulphur where there is no significant difference. The postulation on these results is also taken up later in the discussion.

The effect of time being highly significant in experiment 1 warranted further analysis. The multiple range analysis showed significant differences for 12 hours versus 24, 36 and 48 hours in all cases the later times being more significant than 12 hours up until 60 hours when there was no longer this effect. On closer inspection however it was found that between 24 hours and any of the following the significant differences were in support of the former, as was the situation when 36 hours was compared to the later times. This was reflected through all individual treatment analyses with consistent significance for the comparison 12 to 24 and 12 to 36 hours. The real significance of these analyses being that it allowed for the introduction of the six hour count for experiment 3. This meant that data for experiment 3 was also therefore harvested at 18 hours after start. The weight that the significance of time introduced to Experiment 1 meant that the significance of the remedies was to some degree masked. For this reason the GI-index was introduced to experiment 3. The GI index encapsulated the 'time effect' of the germination process (section 3.6.3.1).

No discussion is required for Experiment 2 suffice to say that the seed performed as expected.

This research indicates that there are significant differences between the homoeopathic remedies Sulphur, Nitric Acid and Camphor and the potencies used for this investigation. Experiment 3 consistently shows that between the

Nitric Acid and Camphor treatment Camphor consistently performs best and causes the fastest germination of all the remedies.

As regards the exceptions in the cultivar Greenfields when Sulphur is compared with Nitric Acid/ Camphor and Camphor is compared with Nitric Acid/ Camphor where there is no significant difference between the treatments it is suggested that the antidotal properties may be affected by different cultivars.

As regards the exceptions in the cultivar Grand Rapids when Sulphur is compared with Sulphur/ Camphor and Nitric Acid is compared to Camphor/Sulphur where there is no significant difference between treatments it is suggested that the antidotal properties may be affected by different cultivars. The concept and implementation of antidotal treatments certainly requires further future investigation.

Biological effects upon plants as documented by authors such as (Boyd, 1941 &1942; Koffler, 1965; Wannamaker, 1966 & 1968; Pelikan *et al*, 1971; Sinha, 1976; Kolisko *et al*, 1978; Jones *et al*, 1981 &1983 and Chou, 1986 amongst others (refer to 2.8)), are evident in this research, represented by statistically significant results between treatments.

Statistical differences were noted between different individual treatments with Sulphur treated seed (supporting hypothesis one) also discovered by Saxena *et al* (1986), where Sulphur was effective in percentage seed germination using ***Abelmoschus esculentus***. The work of Thompson *et al* (1939) is echoed although not specifically with respect to dormancy, where Sulphur compounds stimulated germination. Sulphur's mode of action is unknown, and it would be speculative to assume a "prevention of stress" during germination as suggested by Kayne (1991), (refer 3.3.1.1.4), with respect to Sulphur's proposed action upon plants.

Statistically significant differences were noted between Nitric acid treated seed (supporting hypothesis two), Nitric acid having also been found in the 30CH

potency to have been effective in increasing percentage germination of ***Abelmoschus esculentus*** by Saxena *et al* (1986).

Most notably statistically significant differences with Camphor treated seed, exhibiting consistently faster germination (supporting hypothesis three). Experiment 3 also yields significant results for the effect of potency on the germinability. The seed from all three cultivars germinates at a significantly slower rate at the potency 3CH in comparison to 9, 15 and 30CH. There was no significance in comparing the effects of 9CH to 15 or 30CH, nor 15 to 30CH. Evidently Camphor shows a least effective response in the 3CH (10^{-6}) potency, similarly with all of the other treatments in 3CH. According to dilution levels, the 3CH are the least dilute as compared to tested potencies 9CH, 15CH and 30CH.

It is interesting to note that Camphor chemically exists as a ring structure, as do most phenoxy-carboxylic herbicides as illustrated by Anderson (1983:225). Suggesting if mode of action was chemical Camphor 3CH would be least effective in promoting germination, which is true of this case when compared to the corresponding potencies of Camphor. This postulate is not substantiated when considering the mode of action of Sulphur, Nitric acid and combinations thereof in the 3CH potency. It certainly suggests Camphor's effect upon germination in a more concentrated form warrants investigation.

Experiment 4 compared the four cultivars used in this research under the treatment Camphor 3CH. At the outset Commander germinability was known to be 96% and interestingly under this investigation the other three cultivars all germinated more rapidly than Commander did. There were no differences between the other three cultivars. The other dimension to this experiment was the external factors of light and temperature. Only two parameters were used for each condition and of course the seed was treated with Camphor 3CH. The results indicate that under the Camphor treatment germination was not significantly affected by the exposure to light or dark. However in all cases 15°C was significantly more favourable than 29°C, revealing consistent results

when compared to the work of Bewley and Black (1994: 219) as graphically illustrated below.

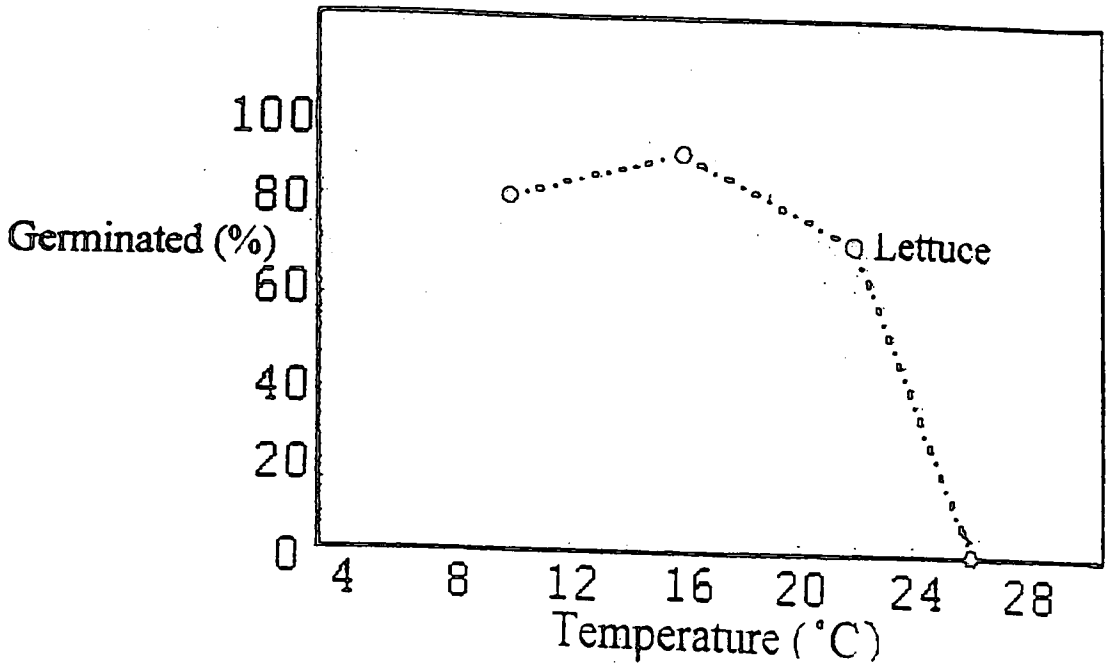


Figure 1. Dormancy in lettuce (Grand Rapids). There is no dormancy in seeds held at temperatures below approximately 15°C, i.e. almost all of the seeds germinate at these low temperatures. Dormancy is expressed as temperatures rise above approximately 15°C and is present in almost all lettuce seeds at 25°C. [Adapted from, Bewley and Black (1994: 219)]

Summary

a) There are clear measurable and statistically significant effects for Sulphur, Nitric Acid and Camphor on lettuce seed germination thus supporting hypotheses 1, 2 & 3 respectively.
b) Camphor showed consistently enhanced germinability when compared to other treatments independent of cultivar.

c) Sulphur/Camphor and Nitric Acid/Camphor as antidote treatments were less consistent in their effect in that responses varied across the cultivars.

d) As regards the potency effect the results show that all treatments at a 3CH consistently show lower germinability than the other potencies used independent of cultivar. There is no significant difference between the other potency levels.

e) "Agro-Homoeopathy" is a developing science and interpretation of results is for the most speculative and will rely on the gradual building of comparable research. The evaluation of antidote effect is novel research and as the nature of Camphor as it responds in "Agro-Homoeopathic" experimentation has no other research to substitute the findings the interpretation of the results are mostly speculative. However for both aspects of the research provide methodology for future investigations.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

It is evident from the results of this study that certain of the homoeopathically prepared medicines employed using germinability trials on *Lactuca sativa* (lettuce seeds) produced distinct biological effects. Statistical differences were noted between individual treatments with the Sulphur treated seed (supporting hypothesis one), with the Nitric acid treated seed (supporting hypothesis two), most notably with the Camphor treated seed a consistently faster germination than the above mentioned treatments occurred (supporting hypothesis three) and also between respective Sulphur/Camphor and Nitric acid/Camphor treated seed, however, only in certain of the cultivars (supporting hypothesis four).

The results also provide evidence of the 3CH potency of the different treatments as having least effect with respect to germination promotion when compared to 9CH, 15CH and 30CH potency levels.

This study certainly serves to support the employment of germinability trials as a possible methodology for testing the efficacy of homoeopathic medicines without ethical implications. Although from the evidence provided in this research it cannot be determined how useful these trials would be if conducted in the field (commercial context). Further research is required to verify the evidence provided in this research before the results can be extrapolated to field scale, for commercial production purposes.

6.2 Recommendations

Kayne (1997: 163) describes two main groups of homoeopathic research, studies involving 'effect' and those concerned with 'efficacy'. This study predominantly focuses upon 'efficacy' due to the inherent difficulties of explanation within current scientific understanding with respect to 'effects', also outlined by Bellavite *et al* (1995: 37-55), however much emphasis in research is required that may lead to theoretical explanation of these 'effects'. In reference to the above, Rubik (1989, 1994) and Kayne (1997: 163-168) encourage the need for refined experimental methodology, replication of phenomena, cooperation between scientific disciplines and communication of all observed phenomena (positive or negative). Replication and refinement of experimental design are an essential in the pursuit of knowledge beyond this research for explanations of the observed phenomena.

6.2.1 Recommendations for further research

1 The establishment of the 'right' substance correct potency and dosage level. Extending the repertoire of substances and potencies may provide greater insights and production potentials. The area of dosage level variation requires further investigation and may throw light on the action of the medicines.

2 An increase in the number and level of potencies used. More accurate evaluation of observed trends would be permitted by extending the range of potencies. Making the opportunity possible for acquisition of optimal effects even from certain potencies infrequently considered in homoeopathic practice.

3 A use of other lettuce cultivars, and plant types. The employment of further lettuce cultivars and other plant types will permit greater reliability if such germinability trials were to be extrapolated into the commercial sector

4 The employment of a control for each cultivar. An increased accuracy may be achieved for each cultivar.

5 The employment of a "placebo" group. The effect of the solvent when potentised without the inclusion of any other substances has to date not been investigated, most authors assuming (correctly or incorrectly) the absence of a 'placebo effect' in plants.

6 An evaluation of medicine manufacture processes.

a Potencies manufactured from medicines utilizing alcohol base and
b Potencies manufactured from medicines utilizing other bases

7 The employment of Camphor in:

a Crude state

Germinability trials testing the effects of Camphor (crude form) against other homoeopathic treatments may provide further information on the effectiveness of Camphor as an antidote, to other homoeopathic medicines in various potencies.

b Camphor at various different potencies tested against a single potency of another substance

8 The employment of other antidotes both generalized and specific (e.g. coffee). Germinability trials may provide direction for which further homoeopathic antidote research upon human subjects, for which, so it would seem, it was originally intended, may occur.

9 The effect of recognized plant growth substances or plant growth regulators when prepared according to homoeopathic principles. Plant growth substances being defined as organic compounds, other than nutrients, that

in small amounts promote, inhibit, or otherwise modify physiological processes in plants (e.g. Auxins (IAA, 2,4-D); Gibberellins (GA); Cytokinins).

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APPENDIX A

The Fruit

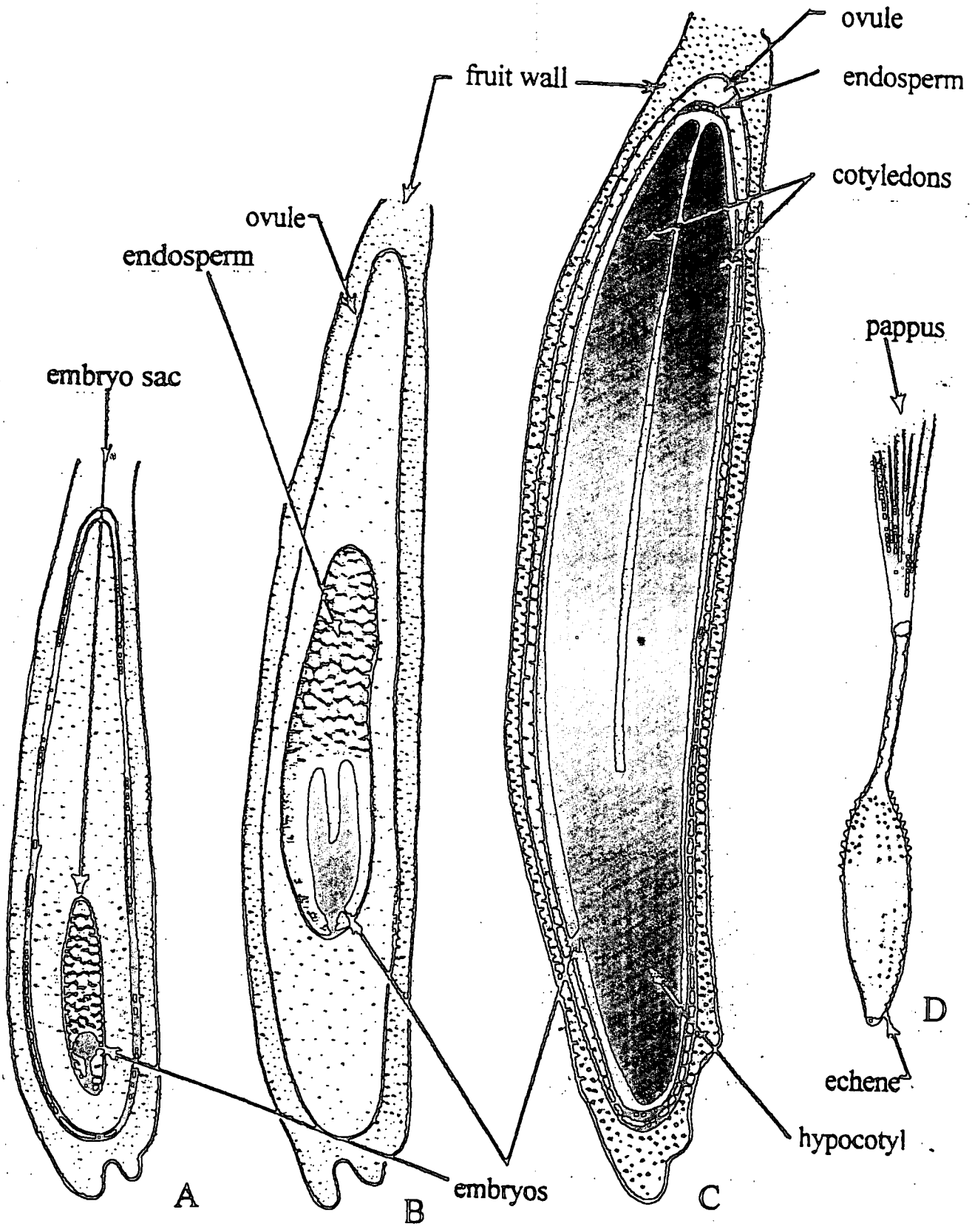

FIGURE 1. Development of embryo and fruit (achene) in *Lactuca sativa* (lettuce). A-C, longitudinal sections of achenes with embryos before (A) and after (B, C) emergence of cotyledons. Details: increase in size of the embryo sac, its encroachment upon ovule, development of endosperm in embryo sac, and replacement of endosperm by embryo. (D) mature achene with pappus. [Adapted from, Esau, 1965, p 594]

APPENDIX B

The GI-index was calculated as follows:

$$GI = \frac{(7 \times n_1 + 6 \times n_2 + 1 \times n_7)}{\text{Total days x total seeds}}$$

Where n_1, n_2 ... n_7 are the number of seeds that germinate on the first, second and subsequent days until seventh day, respectively; 7, 6 ... 1 are weights given to the number germinated on the first, second and subsequent days respectively. The maximum GI is 1.

APPENDIX C

EXPERIMENT 1

Table A- Data- Experiment 1 Sulphur (first replication)
Table B- Data- Experiment 1 Nitric acid (first replication)
Table C- Data- Experiment 1 Sulphur/Camphor (first replication)
Table D- Data- Experiment 1 Nitric acid/Camphor (first replication)
Table E- Data- Experiment 1 Sulphur (second replication)
Table F- Data- Experiment 1 Nitric acid (second replication)
Table G- Data- Experiment 1 Sulphur/Camphor (second replication)
Table H- Data- Experiment 1 Nitric acid/Camphor (second replication)
Table I- Data- Experiment 1 Sulphur (third replication)
Table J- Data- Experiment 1 Nitric acid (third replication)
Table K- Data- Experiment 1 Sulphur/Camphor (third replication)
Table L- Data- Experiment 1 Nitric acid/Camphor (third replication)
Table M- Data- Experiment 1 Control (replications 1,2 & 3)

EXPERIMENT 2

Table N- Data- Experiment 2 (first replication)
Table O- Data- Experiment 2 (second replication)
Table P- Data- Experiment 2 (third replication)

EXPERIMENT 3

Table Q- Experiment 3 Greenfield (repetition 1)
Table R- Experiment 3 Greenfield cumulative (repetition 1)
Table S- Experiment 3 Greenfield (repetition 2)
Table T- Experiment 3 Greenfield Cumulative (repetition 2)
Table U- Experiment 3 Greenfield Calculate 1 (repetition 2)
Table V- Experiment 3 Greenfield Calculate 2 (repetition 2)
Table W- Experiment 3 Greenfield (repetition 3)
Table X- Experiment 3 Greenfield Cumulative (repetition 3)
Table Y- Experiment 3 Greenfield Calculate 1 (repetition 3)
Table Z- Experiment 3 Greenfield Calculate 2 (repetition 3)
Table a- Experiment 3 Great Lakes (repetition 1)
Table b- Experiment 3 Great Lakes Cumulative (repetition 1)
Table c- Experiment 3 Great Lakes Calculate 1 (repetition 1)
Table d- Experiment 3 Great Lakes Calculate 2 (repetition 1)
Table e- Experiment 3 Great Lakes (repetition 2)
Table f- Experiment 3 Great Lakes Cumulative (repetition 2)
Table g- Experiment 3 Great Lakes Calculate 1 (repetition 2)
Table h- Experiment 3 Great Lakes Calculate 2 (repetition 2)
Table i- Experiment 3 Great Lakes (repetition 3)
Table j- Experiment 3 Great Lakes Cumulative (repetition 3)
Table k- Experiment 3 Great Lakes Calculate 1 (repetition 3)
Table l- Experiment 3 Great Lakes Calculate 2 (repetition 3)
Table m- Experiment 3 Grand Rapids (repetition 1)
Table n- Experiment 3 Grand Rapids Cumulative (repetition 1)

Sulphur(1)	12	24	36	48	60	72	84	No Germ
3	0	89	10	1	0	0	0	
4	0	81	16	3	0	0	0	
5	0	58	38	3	0	0	0	1
6	0	87	10	1	0	0	0	2
7	0	91	7	0	0	0	0	2
8	0	89	9	1	0	0	0	1
9	0	86	14	0	0	0	0	
10	0	90	10	0	0	0	0	
11	0	82	16	1	0	0	0	1
12	0	73	19	5	0	0	0	3
13	0	80	20	0	0	0	0	
14	0	92	7	1	0	0	0	
15	0	82	13	1	0	0	0	4
16	0	87	9	0	0	0	0	4
17	0	87	10	0	0	0	0	3
18	0	88	9	0	0	0	0	3
19	0	90	10	0	0	0	0	
20	0	82	12	0	0	0	0	6
21	0	84	15	0	0	0	0	1
22	0	91	7	0	0	0	0	2
23	0	94	6	0	0	0	0	
24	0	82	13	0	0	0	0	5
25	0	89	11	0	0	0	0	
26	0	94	6	0	0	0	0	
27	0	94	6	0	0	0	0	
28	0	89	7	0	0	0	0	4
29	0	97	1	0	0	0	0	2
30	0	87	9	0	0	0	0	4
31	0	89	7	0	0	0	0	4
32	0	88	9	0	0	0	0	3
Table A	Data- Experiment 1		Sulphur	first replication				

Nit.ac.(1)	12	24	36	48	60	72	84	No Germ
3	0	79	17	4	0	0	0	
4	0	85	12	2	0	0	0	1
5	0	86	14	0	0	0	0	
6	0	78	22	0	0	0	0	
7	0	80	14	1	0	0	0	5
8	0	75	23	1	0	0	0	1
9	0	72	26	1	0	0	0	1
10	0	73	26	1	0	0	0	
11	0	76	22	2	0	0	0	
12	0	84	16	0	0	0	0	
13	0	66	28	1	0	0	0	5
14	0	67	27	3	0	0	0	3
15	0	78	22	0	0	0	0	
16	0	66	31	1	0	0	0	2
17	0	71	21	3	0	0	0	5
18	0	77	23	0	0	0	0	
19	0	82	12	4	0	0	0	2
20	0	74	21	0	0	0	0	5
21	0	65	26	6	0	0	0	3
22	0	68	28	0	0	0	0	4
23	0	69	25	2	0	0	0	4
24	0	80	19	0	0	0	0	1
25	0	74	20	6	0	0	0	
26	0	83	10	2	0	0	0	5
27	0	77	18	3	0	0	0	2
28	0	73	26	0	0	0	0	1
29	0	81	15	2	0	0	0	2
30	0	74	21	1	0	0	0	4
31	0	71	19	5	0	0	0	5
32	0	69	29	1	0	0	0	1
Table B	Data- Exp	eriment 1	Nitric acid	first replication				

S/C (1)	12	24	36	48	60	72	84	No Germ
3	0	43	56	0	0	0	0	1
4	0	76	20	1	0	0	0	3
5	0	74	22	0	0	0	0	4
6	0	83	10	4	0	0	0	3
7	0	79	20	1	0	0	0	
8	0	83	15	1	0	0	0	1
9	0	69	24	1	0	0	0	6
10	1	76	18	2	0	0	0	3
11	0	78	20	1	0	0	0	1
12	0	82	15	2	0	0	0	1
13	0	81	9	1	0	0	0	9
14	0	74	23	1	0	0	0	2
15	0	78	22	0	0	0	0	
16	0	79	20	1	0	0	0	
17	0	79	17	4	0	0	0	
18	0	72	26	2	0	0	0	
19	0	68	29	0	0	0	0	3
20	0	78	22	0	0	0	0	
21	0	80	18	1	0	0	0	1
22	0	72	27	0	0	0	0	1
23	0	76	21	0	0	0	0	3
24	0	78	20	1	0	0	0	1
25	0	79	17	0	0	0	0	4
26	0	78	19	1	0	0	0	2
27	0	70	25	3	0	0	0	2
28	0	74	24	2	0	0	0	
29	0	70	25	1	0	0	0	4
30	0	80	16	2	0	0	0	2
31	0	79	16	2	0	0	0	3
32	0	81	19	0	0	0	0	
Table C	Data- Experiment 1		Sulphur/Camphor		first replication			

N/C (1)	12	24	36	48	60	72	84	No Germ
3	0	52	43	0	0	0	0	5
4	0	72	20	2	0	0	0	6
5	0	82	12	1	0	0	0	5
6	0	80	16	3	0	0	0	1
7	0	78	16	4	0	0	0	2
8	0	77	15	1	0	0	0	7
9	0	83	15	0	0	0	0	2
10	0	81	19	0	0	0	0	
11	0	78	18	3	0	0	0	1
12	0	70	24	1	0	0	0	5
13	0	81	16	0	0	0	0	3
14	0	85	4	2	0	0	0	9
15	0	87	5	2	0	0	0	6
16	0	79	15	4	0	0	0	2
17	0	88	9	1	0	0	0	2
18	0	80	16	2	0	0	0	2
19	0	85	11	3	0	0	0	1
20	0	89	9	0	0	0	0	2
21	0	81	5	9	0	0	0	5
22	0	79	16	4	0	0	0	1
23	0	76	14	8	0	0	0	2
24	0	88	12	0	0	0	0	
25	0	79	20	1	0	0	0	
26	0	84	12	1	0	0	0	3
27	0	80	11	3	0	0	0	7
28	0	82	10	3	0	0	0	5
29	0	79	15	1	0	0	0	5
30	0	89	7	1	0	0	0	3
31	0	87	9	2	0	0	0	
32	0	81	12	3	0	0	0	4
Table D	Data- Exp	eriment 1	Nitric acid/Camphor		first replication			

Sulphur(2)	12	24	36	48	60	72	84	No Germ
3	0	98	2	0	0	0	0	
4	0	94	1	1	0	0	0	4
5	0	92	8	0	0	0	0	
6	0	93	3	0	0	0	0	4
7	0	94	3	2	0	0	0	1
8	0	93	2	3	0	0	0	2
9	0	94	4	1	0	0	0	1
10	0	96	3	1	0	0	0	
11	0	93	5	1	0	0	0	1
12	0	88	8	0	0	0	0	4
13	0	96	3	1	0	0	0	
14	0	93	6	0	0	0	0	1
15	0	93	5	0	0	0	0	2
16	0	93	4	0	0	0	0	3
17	0	94	4	1	0	0	0	1
18	0	91	5	1	0	0	0	3
19	0	88	8	2	0	0	0	2
20	0	95	5	0	0	0	0	
21	0	89	6	2	0	0	0	3
22	0	96	2	2	0	0	0	
23	0	93	5	0	0	0	0	2
24	0	91	7	1	0	0	0	1
25	0	90	10	0	0	0	0	
26	0	89	8	2	0	0	0	1
27	0	94	4	1	0	0	0	1
28	0	94	5	1	0	0	0	1
29	0	93	7	0	0	0	0	
30	0	90	3	0	0	0	0	7
31	0	90	8	2	0	0	0	
32	0	97	3	0	0	0	0	
Table E	Data- Experiment 1		Sulphur	second replication				

Nit. ac.(2)	12	24	36	48	60	72	84	No Germ
3	0	77	21	2	0	0	0	
4	0	67	32	0	0	0	0	1
5	0	81	17	2	0	0	0	
6	0	88	5	3	0	0	0	4
7	0	83	7	3	0	0	0	7
8	0	73	13	2	0	0	0	12
9	0	81	17	2	0	0	0	
10	0	75	20	4	0	0	0	1
11	0	85	9	5	0	0	0	1
12	0	75	23	0	0	0	0	2
13	0	69	25	1	0	0	0	5
14	0	80	19	0	0	0	0	1
15	0	73	22	4	0	0	0	1
16	0	80	9	0	0	0	0	11
17	0	79	10	2	0	0	0	9
18	0	82	11	4	0	0	0	3
19	0	84	6	4	0	0	0	6
20	0	66	26	1	0	0	0	7
21	0	69	24	2	0	0	0	5
22	0	71	20	5	0	0	0	4
23	0	85	9	1	0	0	0	5
24	0	71	21	5	0	0	0	3
25	0	72	19	2	0	0	0	7
26	0	76	16	8	0	0	0	
27	0	69	22	6	0	0	0	3
28	0	76	14	4	0	0	0	6
29	0	80	18	2	0	0	0	
30	0	82	14	1	0	0	0	3
31	0	69	21	9	0	0	0	1
32	0	74	14	5	0	0	0	7
Table F	Data- Experiment 1		Nitric acid	second replication				

S/C (2)	12	24	36	48	60	72	84	No Germ
3	0	29	62	9	0	0	0	
4	0	86	8	3	0	0	0	3
5	0	79	16	3	0	0	0	2
6	0	73	20	1	0	0	0	6
7	0	85	14	1	0	0	0	
8	0	78	13	0	0	0	0	9
9	0	78	12	1	0	0	0	9
10	0	76	19	0	0	0	0	5
11	0	85	15	0	0	0	0	
12	0	81	15	1	0	0	0	3
13	0	83	13	0	0	0	0	4
14	0	79	16	0	0	0	0	5
15	0	86	6	1	0	0	0	7
16	0	80	18	1	0	0	0	1
17	0	79	15	0	0	0	0	6
18	0	88	11	0	0	0	0	1
19	0	75	18	3	0	0	0	3
20	0	79	20	0	0	0	0	1
21	0	78	16	2	0	0	0	4
22	0	77	19	1	0	0	0	3
23	0	81	12	2	0	0	0	5
24	0	85	11	1	0	0	0	3
25	0	79	11	4	0	0	0	6
26	0	78	22	0	0	0	0	
27	0	78	18	2	0	0	0	2
28	0	85	9	1	0	0	0	5
29	0	87	10	2	0	0	0	1
30	0	88	11	0	0	0	0	1
31	0	79	10	5	0	0	0	6
32	0	84	12	1	0	0	0	3
Table G	Data- Exp	eriment 1	Sulphur/Camphor		second replication			

N/C (2)	12	24	36	48	60	72	84	No Germ
3	0	47	47	0	0	0	0	6
4	0	85	13	1	0	0	0	1
5	0	80	14	2	0	0	0	4
6	0	81	13	2	0	0	0	5
7	0	86	12	2	0	0	0	
8	0	83	14	2	0	0	0	1
9	0	82	13	2	0	0	0	3
10	0	83	9	2	0	0	0	6
11	0	87	12	0	0	0	0	1
12	0	85	13	2	0	0	0	
13	0	95	5	0	0	0	0	
14	0	86	11	1	0	0	0	2
15	0	89	11	0	0	0	0	
16	0	98	2	0	0	0	0	
17	0	89	10	0	0	0	0	1
18	0	89	8	1	0	0	0	2
19	0	94	5	1	0	0	0	
20	0	92	3	0	0	0	0	5
21	0	92	2	2	0	0	0	4
22	0	87	9	0	0	0	0	4
23	0	91	3	2	0	0	0	4
24	0	88	6	4	0	0	0	2
25	0	86	11	2	0	0	0	1
26	0	92	8	0	0	0	0	
27	0	94	1	0	0	0	0	5
28	0	94	3	0	0	0	0	3
29	0	90	5	4	0	0	0	1
30	0	90	6	3	0	0	0	1
31	0	93	5	2	0	0	0	
32	0	92	6	0	0	0	0	2
Table H	Data- Exp	eriment 1	Nitric acid/Camphor		second replication			

Sulphur(3)	12	24	36	48	60	72	84	No Germ
3	0	97	1	0	0	0	0	2
4	0	99	1	0	0	0	0	
5	0	96	2	1	0	0	0	1
6	0	91	3	2	0	0	0	4
7	0	96	3	1	0	0	0	
8	0	95	2	1	0	0	0	2
9	0	99		0	0	0	0	1
10	0	95	3	0	0	0	0	2
11	0	92	6	0	0	0	0	2
12	0	96	2	0	0	0	0	2
13	0	93	4	1	0	0	0	2
14	0	92	5	1	0	0	0	2
15	0	95	3	2	0	0	0	
16	0	95	1	0	0	0	0	4
17	0	95	3	1	0	0	0	1
18	0	94	3	2	0	0	0	1
19	0	93	2	0	0	0	0	5
20	0	91	4	2	0	0	0	3
21	0	96	4	0	0	0	0	
22	0	95	4	1	0	0	0	
23	0	94	4	0	0	0	0	2
24	0	94	4	2	0	0	0	
25	0	90	7	0	0	0	0	3
26	0	93	6	1	0	0	0	
27	0	96	3	0	0	0	0	1
28	0	95	4	0	0	0	0	1
29	0	95	3	1	0	0	0	1
30	0	91	4	2	0	0	0	3
31	0	93	5	0	0	0	0	2
32	0	93	4	0	0	0	0	3
Table I	Data- Exp	eriment 1	Sulpur	third replication				

Nit.ac. (3)	12	24	36	48	60	72	84	No Germ
3	0	80	13	2	0	0	0	5
4	0	84	11	2	0	0	0	3
5	0	88	8	2	0	0	0	2
6	0	91	9	0	0	0	0	
7	0	85	9	0	0	0	0	6
8	0	91	4	1	0	0	0	4
9	0	92	6	1	0	0	0	1
10	0	84	14	0	0	0	0	2
11	0	88	8	1	0	0	0	3
12	0	87	11	1	0	0	0	1
13	0	79	13	1	0	0	0	7
14	0	89	9	0	0	0	0	2
15	0	88	9	1	0	0	0	2
16	0	87	7	1	0	0	0	5
17	0	93	4	3	0	0	0	
18	0	91	7	2	0	0	0	
19	0	90	6	1	0	0	0	3
20	0	88	8	1	0	0	0	3
21	0	94	6	0	0	0	0	
22	0	89	7	3	0	0	0	1
23	0	89	10	1	0	0	0	
24	0	93	5	0	0	0	0	2
25	0	94	4	1	0	0	0	1
26	0	91	5	3	0	0	0	1
27	0	92	4	2	0	0	0	2
28	0	87	11	0	0	0	0	2
29	0	89	7	3	0	0	0	1
30	0	89	6	1	0	0	0	4
31	0	86	8	3	0	0	0	3
32	0	85	8	6	0	0	0	1
Table J	Data- Experiment 1		Nitric acid	third replication				

S/C (3)	12	24	36	48	60	72	84	No Germ
3	0	82	17	1	0	0	0	
4	0	92	5	2	0	0	0	1
5	0	93	3	0	0	0	0	4
6	0	92	5	1	0	0	0	2
7	0	93	4	0	0	0	0	3
8	0	97	1	0	0	0	0	2
9	0	93	4	1	0	0	0	2
10	0	88	8	0	0	0	0	4
11	0	96	2	0	0	0	0	2
12	0	88	10	2	0	0	0	
13	0	90	7	1	0	0	0	2
14	0	88	8	1	0	0	0	3
15	0	91	7	0	0	0	0	2
16	0	95	4	0	0	0	0	1
17	0	97	3	0	0	0	0	
18	0	95	4	0	0	0	0	1
19	0	91	6	2	0	0	0	1
20	0	98	2	0	0	0	0	
21	0	94	3	0	0	0	0	3
22	0	93	4	1	0	0	0	2
23	0	92	6	0	0	0	0	2
24	0	89	7	1	0	0	0	3
25	0	92	8	0	0	0	0	
26	0	93	6	0	0	0	0	1
27	0	90	7	2	0	0	0	1
28	0	93	4	2	0	0	0	1
29	0	92	6	0	0	0	0	2
30	0	92	4	1	0	0	0	3
31	0	91	5	0	0	0	0	4
32	0	87	8	2	0	0	0	3
Table K	Data- Experiment1		Sulphur/Camphor		third replication			

N/C (3)	12	24	36	48	60	72	84	No Germ
3	0	50	61	3	0	0	0	6
4	0	93	5	0	0	0	0	2
5	0	95	3	0	0	0	0	2
6	0	90	6	1	0	0	0	3
7	0	96	3	0	0	0	0	1
8	0	92	2	2	0	0	0	4
9	0	94	4	2	0	0	0	
10	0	91	2	2	0	0	0	5
11	0	91	3	1	0	0	0	5
12	0	92	5	2	0	0	0	1
13	0	93	3	0	0	0	0	4
14	0	97	3	0	0	0	0	
15	0	95	3	0	0	0	0	2
16	0	95	3	2	0	0	0	
17	0	94	5	1	0	0	0	
18	0	92	7	0	0	0	0	1
19	0	91	7	2	0	0	0	
20	0	91	3	2	0	0	0	4
21	0	90	6	2	0	0	0	2
22	0	91	5	0	0	0	0	4
23	0	95	5	0	0	0	0	
24	0	93	5	1	0	0	0	1
25	0	94	3	0	0	0	0	3
26	0	92	6	0	0	0	0	2
27	0	91	5	3	0	0	0	1
28	0	94	5	1	0	0	0	
29	0	95	4	0	0	0	0	1
30	0	95	3	0	0	0	0	2
31	0	98	1	0	0	0	0	1
32	0	96	3	0	0	0	0	1
Table L	Data- Exp	eriment 1	Nitric acid/Camphor		third replication			

Control 1	12	24	36	48	60	72	84	No Germ
1	0	70	28	0	0	0	0	2
2	0	77	13	5	0	0	0	5
3	0	73	23	1	0	0	0	3
Control 2								
1	0	75	22	1	0	0	0	2
2	0	77	19	3	0	0	0	1
3	0	75	17	2	0	0	0	6
Control 3								
1	0	85	11	2	0	0	0	2
2	0	86	6	1	0	0	0	7
3	0	86	7	0	0	0	0	7
Table M	Data- Exp	eriment	Control with replications 1, 2 & 3					

Replication (1)								
Sulphur	12	24	36	48	60	72	84	No Germ
3	0	0	1	0	0	0	0	99
9	0	0	1	0	1	0	0	98
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
Nitric acid								
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
S/C								
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
N/C								
3	0	0	0	0	0	0	0	100
9	0	0	1	0	0	0	0	99
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
Control								
1	0	0	2	0	0	0	0	98
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Temp	14.5	15	15	15	15	15	15	
Table N	Data- Experiment 2		[first replication]					

Replication (2)								
Sulphur	12	24	36	48	60	72	84	No Germ
3	0	0	2	0	0	0	0	98
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
Nitric acid								
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	1	0	0	0	0	99
30	0	0	0	0	0	0	0	100
S/C								
3	0	0	0	0	0	0	0	100
9	0	0	0	1	0	0	0	99
15	0	0	1	0	0	0	0	99
30	0	0	0	0	0	0	0	100
N/C								
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
Control								
1	0	0	0	0	0	0	0	100
2	0	0	0	0	1	0	0	99
3	0	0	0	0	0	0	0	100
Temp	15	15	15	15	15	15	15	
Table O	Data- Experiment 2		[second replication]					

Replication 3								
Sulphur	12	24	36	48	60	72	84	No Germ
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
Nitric acid								
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
S/C								
3	0	0	0	0	0	0	0	100
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
N/C								
3	0	0	0	2	0	0	0	98
9	0	0	0	0	0	0	0	100
15	0	0	0	0	0	0	0	100
30	0	0	0	0	0	0	0	100
Control								
1	0	0	0	0	0	0	0	100
2	0	0	0	1	1	0	0	98
3	0	0	0	0	0	0	0	100
Temp	15	15	15	15	15	15	15	
Table P	Data- Experiment 2		[third replication]					

GREENFIELD (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	71	22	2	2	2	0	0	0	0	0	0
	9	0	2	74	16	2	2	2	0	0	0	0	0	0
	15	0	1	64	23	7	3	1	0	0	0	0	0	0
	30	0	1	66	21	2	2	0	0	0	0	0	0	0
NITRIC ACID	3	0	0	45	40	4	3	0	0	0	0	0	0	0
	9	0	0	50	38	3	1	1	0	0	0	0	0	0
	15	0	1	57	33	6	1	0	0	0	0	0	0	0
	30	0	0	58	39	2	0	0	0	0	0	0	0	0
S/C	3	0	0	29	56	5	0	2	0	0	0	0	0	0
	9	0	0	51	36	6	3	1	0	0	0	0	0	0
	15	0	0	52	43	2	0	0	0	0	0	0	0	0
	30	0	0	54	41	4	2	1	0	0	0	0	0	0
N/C	3	0	0	53	23	8	3	0	0	0	0	0	0	0
	9	0	0	75	16	4	3	2	0	0	0	0	0	0
	15	0	8	74	20	6	1	1	0	0	0	0	0	0
	30	0	1	75	6	3	2	1	0	0	0	0	0	0
CAMPHOR	3	0	0	0	42	39	4	2	2	2	0	0	0	0
	9	0	0	0	67	12	6	1	3	0	0	1	0	0
	15	0	0	0	72	17	5	2	1	1	1	0	0	0
	30	0	0	1	78	15	3	1	0	1	1	0	0	0

TABLE Q: EXPERIMENT 3 GREENFIELD (REPETITION 1)

GREENFIELD CUMULATIVE (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	71	93	95	97	99	99	99	99	99	99	99
	9	0	2	76	92	94	96	98	98	98	98	98	98	98
	15	0	1	65	88	95	98	99	99	99	99	99	99	99
	30	0	1	67	88	90	92	92	92	92	92	92	92	92
NITRIC ACID	3	0	0	45	85	89	92	92	92	92	92	92	92	92
	9	0	0	50	88	91	92	93	93	93	93	93	93	93
	15	0	1	58	91	97	98	98	98	98	98	98	98	98
	30	0	0	58	97	99	99	99	99	99	99	99	99	99
S/C	3	0	0	29	85	90	90	92	92	92	92	92	92	92
	9	0	0	51	87	93	96	97	97	97	97	97	97	97
	15	0	0	52	95	97	97	97	97	97	97	97	97	97
	30	0	0	54	95	99	101	102	102	102	102	102	102	102
N/C	3	0	0	53	76	84	87	87	87	87	87	87	87	87
	9	0	0	75	91	95	98	100	100	100	100	100	100	100
	15	0	8	82	102	108	109	110	110	110	110	110	110	110
	30	0	1	76	82	82	87	88	88	88	88	88	88	88
CAMPHOR	3	0	0	0	42	81	85	87	87	91	91	91	91	91
	9	0	0	0	67	79	85	86	89	89	89	89	89	89
	15	0	0	0	72	89	94	96	97	98	99	99	99	99
	30	0	0	1	79	94	97	98	98	99	100	100	100	100

TABLE R : EXPERIMENT 3 GREENFIELD CUMULATIVE (REPETITION 1)

GREENFIELD (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	73	23	2	0	1	0	0	0	0	0	0
	9	0	6	70	14	4	0	0	0	0	0	0	0	0
	15	0	1	75	16	4	4	1	0	0	0	0	0	0
	30	0	2	62	17	6	2	0	0	0	0	0	0	0
NITRIC ACID	3	0	2	59	31	4	0	0	0	0	0	0	0	0
	9	0	0	58	32	2	1	1	0	0	0	0	0	0
	15	0	0	46	36	5	2	0	0	0	0	0	0	0
	30	0	1	75	16	2	3	0	0	0	0	0	0	0
S/C	3	0	0	34	55	2	4	0	0	0	0	0	0	0
	9	0	0	56	38	2	2	0	0	0	0	0	0	0
	15	0	0	62	33	4	3	0	0	0	0	0	0	0
	30	0	0	59	28	2	1	0	0	0	0	0	0	0
N/C	3	0	5	75	18	2	2	1	0	0	0	0	0	0
	9	0	9	68	12	4	3	1	0	0	0	0	0	0
	15	0	9	59	11	8	4	0	0	0	0	0	0	0
	30	0	1	75	10	4	5	0	0	0	0	0	0	0
CAMPHOR	3	0	0	0	47	41	0	1	3	0	1	0	0	0
	9	0	0	0	71	20	0	2	0	0	1	1	0	0
	15	0	0	0	78	5	2	1	2	0	0	0	0	0
	30	0	0	0	72	12	3	1	0	2	1	0	0	0

TABLE S : EXPERIMENT 3 GREENFIELD (REPETITION 2)

GREENFIELD CUMULATIVE (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	73	96	98	98	99	99	99	99	99	99	99
	9	0	6	76	90	94	94	94	94	94	94	94	94	94
	15	0	1	76	90	96	100	101	101	101	101	101	101	101
	30	0	2	64	81	87	89	89	89	89	89	89	89	89
NITRIC ACID	3	0	2	61	92	96	96	96	96	96	96	96	96	96
	9	0	0	58	90	92	93	94	94	94	94	94	94	94
	15	0	0	46	82	87	89	89	89	89	89	89	89	89
	30	0	1	76	92	94	97	97	97	97	97	97	97	97
S/C	3	0	0	34	89	91	95	95	95	95	95	95	95	95
	9	0	0	56	94	96	98	98	98	98	98	98	98	98
	15	0	0	62	95	99	102	102	102	102	102	102	102	102
	30	0	0	59	87	89	90	90	90	90	90	90	90	90
N/C	3	0	5	80	98	100	102	103	103	103	103	103	103	103
	9	0	9	77	89	93	96	97	97	97	97	97	97	97
	15	0	9	68	79	87	91	91	91	91	91	91	91	91
	30	0	1	76	86	90	95	95	95	95	95	95	95	95
CAMPHOR	3	0	0	0	47	88	88	89	92	92	93	93	92	92
	9	0	0	0	71	91	91	93	93	93	94	95	93	93
	15	0	0	0	78	83	85	86	88	88	88	88	88	88
	30	0	0	0	72	84	87	88	88	90	91	91	90	90

TABLE T: EXPERIMENT 3 GREENFIELD CUMULATIVE (REPETITION 2)

GREENFIELD CALCULATE 1 (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
NITRIC ACID	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
S/C	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
N/C	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
CAMPHOR	3	11	10	9	8	7	6	5	4	3	2	1	0	-1
	9	11	10	9	8	7	6	5	4	3	2	1	0	-1
	15	11	10	9	8	7	6	5	4	3	2	1	0	-1
	30	11	10	9	8	7	6	5	4	3	2	1	0	-1

TABLE U: EXPERIMENT GREENFIELD CALCULATE 1 (REPETITION 2)

GREENFIELD CALCULATE 2 (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	365	92	6	0	1	0	0	0	0	0	0
	9	0	36	350	56	12	0	0	0	0	0	0	0	0
	15	0	6	375	64	12	8	1	0	0	0	0	0	0
	30	0	12	310	68	18	4	0	0	0	0	0	0	0
NITRIC ACID	3	0	12	295	124	12	0	0	0	0	0	0	0	0
	9	0	0	290	128	6	2	1	0	0	0	0	0	0
	15	0	0	230	144	15	4	0	0	0	0	0	0	0
	30	0	6	375	64	6	6	0	0	0	0	0	0	0
S/C	3	0	0	170	220	6	8	0	0	0	0	0	0	0
	9	0	0	280	152	6	4	0	0	0	0	0	0	0
	15	0	0	610	132	12	6	0	0	0	0	0	0	0
	30	0	0	295	112	6	2	0	0	0	0	0	0	0
N/C	3	0	30	275	72	6	4	0	0	0	0	0	0	0
	9	0	54	340	48	12	6	1	0	0	0	0	0	0
	15	0	54	295	44	24	8	1	0	0	0	0	0	0
	30	0	6	375	40	12	10	0	0	0	0	0	0	0
CAMPHOR	3	0	0	0	376	287	0	5	12	0	2	0	0	0
	9	0	0	0	568	140	0	10	0	0	2	1	0	0
	15	0	0	0	624	35	12	5	8	0	0	0	0	0
	30	0	0	0	576	84	18	5	0	6	2	0	0	0

TABLE V: EXPERIMENT 3 GREENFIELD CALCULATE 2 (REPETITION 2)

GREENFIELD (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	75	16	0	2	0	0	0	0	0	0	0
	9	0	3	77	13	2	1	1	0	0	0	0	0	0
	15	0	5	74	12	0	4	0	0	0	0	0	0	0
	30	0	4	72	8	4	1	1	0	0	0	0	0	0
NITRIC ACID	3	0	0	58	31	2	1	0	0	0	0	0	0	0
	9	0	0	63	29	1	1	0	0	0	0	0	0	0
	15	0	0	65	25	5	0	0	0	0	0	0	0	0
	30	0	0	73	14	4	0	1	0	0	0	0	0	0
S/C	3	0	0	53	38	5	0	0	0	0	0	0	0	0
	9	0	0	65	20	2	2	0	0	0	0	0	0	0
	15	0	0	67	24	1	4	3	0	0	0	0	0	0
	30	0	0	60	18	5	4	2	0	0	0	0	0	0
N/C	3	0	4	61	17	7	1	1	0	0	0	0	0	0
	9	0	12	79	7	3	3	1	0	0	0	0	0	0
	15	0	12	73	10	6	2	1	0	0	0	0	0	0
	30	0	5	83	8	2	2	0	0	0	0	0	0	0
CAMPHOR	3	0	0	0	44	29	7	8	3	5	2	0	0	0
	9	0	0	0	60	18	5	4	1	3	0	1	0	0
	15	0	0	5	73	7	3	3	1	0	0	0	0	0
	30	0	0	0	77	6	1	3	1	1	0	0	0	0

TABLE W: EXPERIMENT 3 GREENFIELD (REPETITION 3)

GREENFIELD CALCULATE 1 (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
NITRIC ACID	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
S/C	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
N/C	3	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	9	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	15	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
	30	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5
CAMPHOR	3	11	10	9	8	7	6	5	4	3	2	1	0	-1
	9	11	10	9	8	7	6	5	4	3	2	1	0	-1
	15	11	10	9	8	7	6	5	4	3	2	1	0	-1
	30	11	10	9	8	7	6	5	4	3	2	1	0	-1

TABLE Y: EXPERIMENT 3 GREENFIELD CALCULATE 1 (REPETITION 3)

GREENFIELD CALCULATE 2 (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	375	64	0	4	0	0	0	0	0	0	0
	9	0	18	385	52	6	1	1	0	0	0	0	0	0
	15	0	30	370	48	0	8	0	0	0	0	0	0	0
	30	0	24	360	32	12	2	1	0	0	0	0	0	0
NITRIC ACID	3	0	0	290	124	6	2	0	0	0	0	0	0	0
	9	0	0	315	116	3	2	0	0	0	0	0	0	0
	15	0	0	325	100	15	0	0	0	0	0	0	0	0
	30	0	0	365	56	12	0	1	0	0	0	0	0	0
S/C	3	0	0	265	152	15	0	0	0	0	0	0	0	0
	9	0	0	325	80	6	4	0	0	0	0	0	0	0
	15	0	0	335	96	3	8	3	0	0	0	0	0	0
	30	0	0	300	72	15	8	2	0	0	0	0	0	0
N/C	3	0	24	305	68	21	2	1	0	0	0	0	0	0
	9	0	72	395	28	9	6	1	0	0	0	0	0	0
	15	0	72	365	40	18	4	1	0	0	0	0	0	0
	30	0	30	415	32	6	4	0	0	0	0	0	0	0
CAMPHOR	3	0	0	0	352	203	42	40	12	15	0	0	0	0
	9	0	0	0	480	126	30	20	4	9	0	0	0	0
	15	0	0	45	584	49	18	15	4	0	0	0	0	0
	30	0	0	0	616	42	6	15	4	3	0	0	0	0

TABLE Z: EXPERIMENT 3 GREENFIELD CALCULATE 2 (REPETITION 3)

GREAT LAKES (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	2	46	39	9	3	0	0	0	0	0
	9	0	0	0	2	49	38	8	3	0	0	0	0	0
	15	0	0	0	2	48	38	3	1	0	0	0	0	0
	30	0	0	0	3	61	27	3	2	0	0	0	0	0
NITRIC ACID	3	0	0	0	0	30	40	6	5	0	0	0	0	0
	9	0	0	0	0	63	30	1	2	0	0	0	0	0
	15	0	0	0	0	52	33	7	3	0	0	0	0	0
	30	0	0	0	0	70	16	1	1	0	0	0	0	0
S/C	3	0	0	0	0	8	22	8	21	18	0	0	0	0
	9	0	0	0	0	35	39	10	9	0	0	0	0	0
	15	0	0	0	0	45	35	10	6	0	0	0	0	0
	30	0	0	0	3	44	42	3	1	0	0	0	0	0
N/C	3	0	0	0	0	2	12	9	21	17	7	0	0	0
	9	0	0	0	3	63	24	1	1	0	3	0	0	0
	15	0	0	0	4	38	41	7	5	2	2	0	0	0
	30	0	0	0	4	46	37	4	5	0	0	0	0	0
CAMPHOR	3	0	0	0	0	0	3	17	22	21	18	7	4	5
	9	0	0	0	0	5	39	31	13	5	0	3	1	1
	15	0	0	0	0	0	57	23	6	2	2	2	2	1
	30	0	0	0	0	4	47	34	7	1	0	0	0	2

TABLE a: EXPERIMENT 3 GREAT LAKES (REPETITION 1)

GREAT LAKES CUMULATIVE (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	98	108	120	132	144
SULPHUR	3	0	0	0	2	48	87	96	99	99	99	99	99	99
	9	0	0	0	2	51	89	97	100	100	100	100	100	100
	15	0	0	0	2	50	88	91	92	92	92	92	92	92
	30	0	0	0	3	64	91	94	96	96	96	96	96	96
NITRIC ACID	3	0	0	0	0	30	70	76	81	81	81	81	81	81
	9	0	0	0	0	63	93	94	96	96	96	96	96	96
	15	0	0	0	0	52	85	92	95	95	95	95	95	95
	30	0	0	0	0	70	86	87	88	88	88	88	88	88
S/C	3	0	0	0	0	8	30	38	59	59	77	77	77	77
	9	0	0	0	0	35	74	84	93	93	93	93	93	93
	15	0	0	0	0	45	80	90	96	96	96	96	96	96
	30	0	0	0	3	47	89	92	93	93	93	93	93	93
N/C	3	0	0	0	0	2	14	23	46	46	63	63	63	63
	9	0	0	0	2	66	90	91	92	92	92	92	92	92
	15	0	0	0	4	42	83	90	95	95	95	95	95	95
	30	0	0	0	4	50	87	91	96	96	96	96	96	96
CAMPHOR	3	0	0	0	0	0	3	20	42	42	63	63	91	96
	9	0	0	0	0	5	44	75	88	88	96	96	97	98
	15	0	0	0	0	0	57	80	86	86	88	88	94	95
	30	0	0	0	0	4	51	85	92	92	93	93	93	95

TABLE b: EXPERIMENT 3 GREAT LAKES CUMULATIVE (REPETITION 1)

GREAT LAKES CALCULATE 1 (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
NITRIC ACID	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
S/C	3	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
N/C	3	9	8	7	6	5	4	3	2	2	0	-1	-2	-3
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
CAMPHOR	3	13	12	11	10	9	8	7	6	5	4	3	2	1
	9	13	12	11	10	9	8	7	6	5	4	3	2	1
	15	13	12	11	10	9	8	7	6	5	4	3	2	1
	30	13	12	11	10	9	8	7	6	5	4	3	2	1

TABLE c: EXPERIMENT 3 GREAT LAKES CALCULATE 1 (REPETITION 1)

GREAT LAKES CALCULATE 2 (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	10	184	117	18	3	0	0	0	0	0
	9	0	0	0	10	196	114	16	3	0	0	0	0	0
	15	0	0	0	10	192	114	6	1	0	0	0	0	0
	30	0	0	0	15	244	81	6	2	0	0	0	0	0
NITRIC ACID	3	0	0	0	0	120	120	12	5	0	0	0	0	0
	9	0	0	0	0	252	90	2	2	0	0	0	0	0
	15	0	0	0	0	208	99	14	3	0	0	0	0	0
	30	0	0	0	0	280	48	2	1	0	0	0	0	0
S/C	3	0	0	0	0	40	88	24	42	18	0	0	0	0
	9	0	0	0	0	140	117	20	9	0	0	0	0	0
	15	0	0	0	0	180	105	20	6	0	0	0	0	0
	30	0	0	0	15	176	126	6	1	0	0	0	0	0
N/C	3	0	0	0	0	10	48	27	46	17	0	0	0	0
	9	0	0	0	15	252	72	2	1	0	0	0	0	0
	15	0	0	0	20	152	123	14	5	0	0	0	0	0
	30	0	0	0	20	184	111	8	5	0	0	0	0	0
CAMPHOR	3	0	0	0	0	0	24	119	132	105	68	21	8	5
	9	0	0	0	0	45	312	217	78	25	0	9	2	1
	15	0	0	0	0	0	456	161	36	10	8	6	4	1
	30	0	0	0	0	36	376	238	42	5	0	0	0	2

TABLE d: EXPERIMENT 3 GREAT LAKES CALCULATE 2 (REPETITION 1)

GREAT LAKES (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	2	60	27	4	4	0	0	0	0	0
	9	0	0	0	8	52	27	10	1	0	0	0	0	0
	15	0	0	0	7	50	28	16	0	0	0	0	0	0
	30	0	0	0	6	43	33	21	3	0	0	0	0	0
NITRIC ACID	3	0	0	0	1	40	41	12	1	0	0	0	0	0
	9	0	0	0	2	37	41	9	5	0	0	0	0	0
	15	0	0	0	0	55	36	6	0	0	0	0	0	0
	30	0	0	0	1	45	37	2	1	0	0	0	0	0
S/C	3	0	0	0	0	4	3	4	13	16	0	0	0	0
	9	0	0	0	2	37	38	12	3	0	0	0	0	0
	15	0	0	0	3	40	41	5	2	0	0	0	0	0
	30	0	0	0	1	37	40	9	4	0	0	0	0	0
N/C	3	0	0	0	0	10	9	5	22	13	0	0	0	0
	9	0	0	0	2	15	46	22	5	0	0	0	0	0
	15	0	0	0	2	41	41	6	0	0	0	0	0	0
	30	0	0	0	1	37	38	9	6	0	0	0	0	0
CAMPHOR	3	0	0	0	0	4	2	13	11	25	17	16	6	3
	9	0	0	0	0	2	45	30	9	5	2	2	0	2
	15	0	0	0	0	1	59	25	3	6	4	2	1	1
	30	0	0	0	0	2	53	27	7	3	4	0	0	1

TABLE e: EXPERIMENT 3 GREAT LAKES (REPETITION 2)

GREAT LAKES CUMULATIVE (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	2	62	89	93	97	97	97	97	97	97
	9	0	0	0	8	60	87	97	98	98	98	98	98	98
	15	0	0	0	7	57	85	101	101	101	101	101	101	101
	30	0	0	0	6	49	82	103	106	106	106	106	106	106
NITRIC ACID	3	0	0	0	1	41	82	94	95	95	95	95	95	95
	9	0	0	0	2	39	80	89	94	94	94	94	94	94
	15	0	0	0	0	55	91	97	97	97	97	97	97	97
	30	0	0	0	1	46	83	85	86	86	86	86	86	86
S/C	3	0	0	0	0	4	7	11	24	40	40	40	40	40
	9	0	0	0	2	39	77	89	92	92	92	92	92	92
	15	0	0	0	3	43	84	89	91	91	91	91	91	91
	30	0	0	0	1	38	78	87	91	91	91	91	91	91
N/C	3	0	0	0	0	10	19	24	46	59	59	59	59	59
	9	0	0	0	2	17	63	85	90	90	90	90	90	90
	15	0	0	0	2	43	84	90	90	90	90	90	90	90
	30	0	0	0	1	38	76	85	91	91	91	91	91	91
CAMPHOR	3	0	0	0	0	4	6	19	30	55	72	88	61	64
	9	0	0	0	0	2	47	77	86	91	93	95	91	93
	15	0	0	0	0	1	60	85	88	94	98	100	95	96
	30	0	0	0	0	2	55	82	89	92	96	96	92	93

TABLE f: EXPERIMENT 3 GREAT LAKES CUMULATIVE (REPETITION 2)

GREAT LAKES CALCULATE 1 (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
NITRIC ACID	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
S/C	3	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
N/C	3	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
CAMPHOR	3	13	12	11	10	9	8	7	6	5	4	3	2	1
	9	13	12	11	10	9	8	7	6	5	4	3	2	1
	15	13	12	11	10	9	8	7	6	5	4	3	2	1
	30	13	12	11	10	9	8	7	6	5	4	3	2	1

TABLE g: EXPERIMENT 3 GREAT LAKES CALCULATE 1 (REPETITION 2)

GREAT LAKES CALCULATE 2 (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	10	240	81	8	4	0	0	0	0	0
	9	0	0	0	40	208	81	20	1	0	0	0	0	0
	15	0	0	0	35	200	84	32	0	0	0	0	0	0
	30	0	0	0	30	172	99	42	3	0	0	0	0	0
NITRIC ACID	3	0	0	0	5	160	123	24	1	0	0	0	0	0
	9	0	0	0	10	148	123	18	5	0	0	0	0	0
	15	0	0	0	0	220	108	12	0	0	0	0	0	0
	30	0	0	0	5	180	111	4	1	0	0	0	0	0
S/C	3	0	0	0	0	20	12	12	26	16	0	0	0	0
	9	0	0	0	10	148	114	24	3	0	0	0	0	0
	15	0	0	0	15	160	123	10	2	0	0	0	0	0
	30	0	0	0	5	148	120	18	4	0	0	0	0	0
N/C	3	0	0	0	0	50	36	15	44	13	0	0	0	0
	9	0	0	0	10	60	138	44	5	0	0	0	0	0
	15	0	0	0	10	164	123	12	0	0	0	0	0	0
	30	0	0	0	5	148	114	18	6	0	0	0	0	0
CAMPHOR	3	0	0	0	0	36	16	91	66	125	68	48	12	3
	9	0	0	0	0	18	360	210	54	25	8	6	0	2
	15	0	0	0	0	9	472	175	18	30	16	6	2	1
	30	0	0	0	0	18	424	189	42	15	16	0	0	1

TABLE h: EXPERIMENT 3 GREAT LAKES CALCULATE 2 (REPETITION 2)

GREAT LAKES (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	2	54	36	7	2	0	0	0	0	0
	9	0	0	0	3	59	32	4	1	0	0	0	0	0
	15	0	0	0	2	56	36	1	0	0	0	0	0	0
	30	0	0	0	2	58	29	5	3	0	0	0	0	0
NITRIC ACID	3	0	0	0	1	65	26	0	0	0	0	0	0	0
	9	0	0	0	1	47	42	3	2	0	0	0	0	0
	15	0	0	0	2	45	43	4	2	0	0	0	0	0
	30	0	0	0	0	49	31	3	6	0	0	0	0	0
S/C	3	0	0	0	0	2	9	2	5	9	0	0	0	0
	9	0	0	0	1	40	44	8	2	0	0	0	0	0
	15	0	0	0	0	36	37	10	10	0	0	0	0	0
	30	0	0	0	1	45	30	16	5	0	0	0	0	0
N/C	3	0	0	0	2	3	7	7	2	20	21	0	0	0
	9	0	0	0	1	46	34	9	6	0	0	0	0	0
	15	0	0	0	1	41	42	7	3	0	0	0	0	0
	30	0	0	0	2	39	34	14	3	0	0	0	0	0
CAMPHOR	3	0	0	0	0	0	10	22	21	26	7	2	0	3
	9	0	0	0	0	5	60	22	7	5	1	0	1	1
	15	0	0	0	0	2	60	18	5	4	5	1	0	0
	30	0	0	0	0	0	56	20	10	3	1	0	5	1

TABLE I: EXPERIMENT 3 GREAT LAKES (REPETITION 3)

GREAT LAKES CUMULATIVE (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	2	56	92	99	101	101	101	101	101	101
	9	0	0	0	3	62	94	98	99	99	99	99	99	99
	15	0	0	0	2	58	94	95	95	95	95	95	95	95
	30	0	0	0	2	60	89	94	97	97	97	97	97	97
NITRIC ACID	3	0	0	0	1	66	92	92	92	92	92	92	92	92
	9	0	0	0	1	48	90	93	95	95	95	95	95	95
	15	0	0	0	2	47	90	94	96	96	96	96	96	96
	30	0	0	0	0	49	80	83	89	89	89	89	89	89
S/C	3	0	0	0	0	2	10	12	17	26	26	26	26	26
	9	0	0	0	1	41	85	93	95	95	95	95	95	95
	15	0	0	0	0	36	73	83	93	93	93	93	93	93
	30	0	0	0	1	46	76	92	97	97	97	97	97	97
N/C	3	0	0	0	2	5	12	19	21	41	62	62	62	65
	9	0	0	0	1	47	81	90	96	96	96	96	96	96
	15	0	0	0	1	42	84	91	94	94	94	94	94	94
	30	0	0	0	2	41	75	89	92	92	92	92	92	92
CAMPHOR	3	0	0	0	0	0	10	32	53	79	86	88	79	82
	9	0	0	0	0	5	65	87	94	99	100	100	100	101
	15	0	0	0	0	2	62	80	85	89	94	95	89	89
	30	0	0	0	0	0	56	76	86	89	90	90	94	95

TABLE j: EXPERIMENT 3 GREAT LAKES CUMULATIVE (REPETITION 3)

GREAT LAKES CALCULATE 1 (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
NITRIC ACID	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
S/C	3	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
N/C	3	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
CAMPHOR	3	13	12	11	10	9	8	7	6	5	4	3	2	1
	9	13	12	11	10	9	8	7	6	5	4	3	2	1
	15	13	12	11	10	9	8	7	6	5	4	3	2	1
	30	13	12	11	10	9	8	7	6	5	4	3	2	1

TABLE k: EXPERIMENT 3 GREAT LAKES CALCULATE 1 (REPETITION 3)

GREAT LAKES CALCULATE 2 (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	10	216	108	14	2	0	0	0	0	0
	9	0	0	0	15	236	96	8	1	0	0	0	0	0
	15	0	0	0	10	224	108	2	0	0	0	0	0	0
	30	0	0	0	10	232	87	10	3	0	0	0	0	0
NITRIC ACID	3	0	0	0	5	260	78	0	0	0	0	0	0	0
	9	0	0	0	5	188	126	6	2	0	0	0	0	0
	15	0	0	0	10	180	129	8	2	0	0	0	0	0
	30	0	0	0	0	196	93	6	6	0	0	0	0	0
S/C	3	0	0	0	0	10	32	6	10	9	0	0	0	0
	9	0	0	0	5	160	132	16	2	0	0	0	0	0
	15	0	0	0	0	144	111	20	10	0	0	0	0	0
	30	0	0	0	5	180	90	32	5	0	0	0	0	0
N/C	3	0	0	0	12	15	28	21	4	20	0	0	0	0
	9	0	0	0	5	184	102	18	6	0	0	0	0	0
	15	0	0	0	5	164	126	14	3	0	0	0	0	0
	30	0	0	0	10	156	102	28	3	0	0	0	0	0
CAMPHOR	3	0	0	0	0	0	80	154	126	130	28	6	0	3
	9	0	0	0	0	45	480	154	42	25	4	0	2	1
	15	0	0	0	0	18	480	126	30	20	20	3	0	0
	30	0	0	0	0	0	448	140	60	15	4	0	10	1

TABLE I: EXPERIMENT 3 GREAT LAKES CALCULATE 2 (REPETITION 3)

GRAND RAPIDS (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	42	38	3	1	1	0	0	0	0	0
	9	0	0	2	65	18	4	6	2	0	0	0	0	0
	15	0	0	1	70	16	4	2	2	0	0	0	0	0
	30	0	0	0	62	21	5	4	1	0	0	0	0	0
NITRIC ACID	3	0	0	0	58	21	5	4	3	0	0	0	0	0
	9	0	0	0	60	27	6	3	2	0	0	0	0	0
	15	0	0	0	59	33	5	5	2	0	0	0	0	0
	30	0	0	0	67	22	5	2	3	0	0	0	0	0
S/C	3	0	0	0	37	29	11	3	5	0	0	0	0	0
	9	0	0	0	57	23	5	5	3	0	0	0	0	0
	15	0	0	0	62	17	6	3	0	0	0	0	0	0
	30	0	0	0	60	23	4	3	2	0	0	0	0	0
N/C	3	0	0	0	30	21	21	2	3	0	0	0	0	0
	9	0	0	0	65	12	12	2	2	0	0	0	0	0
	15	0	0	0	55	21	14	1	1	0	0	0	0	0
	30	0	0	0	56	16	15	3	6	0	0	0	0	0
CAMPHOR	3	0	0	0	2	66	10	7	0	4	2	2	0	0
	9	0	0	0	19	59	9	6	7	4	1	2	0	0
	15	0	0	0	13	17	15	4	1	5	1	0	0	0
	30	0	0	0	15	72	10	9	3	3	2	0	0	0

TABLE m: EXPERIMENT 3 GRAND RAPIDS (REPETITION 1)

GRAND RAPIDS CUMULATIVE (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	42	80	83	84	85	85	85	85	85	85
	9	0	0	2	67	85	89	95	97	97	97	97	97	97
	15	0	0	1	71	87	91	93	95	95	95	95	95	95
	30	0	0	0	62	83	88	92	93	93	93	93	93	93
NITRIC ACID	3	0	0	0	58	79	84	88	91	91	91	91	91	91
	9	0	0	0	60	87	93	96	98	98	98	98	98	98
	15	0	0	0	59	92	97	102	104	104	104	104	104	104
	30	0	0	0	67	89	94	96	99	99	99	99	99	99
S/C	3	0	0	0	37	66	77	80	85	85	85	85	85	85
	9	0	0	0	57	80	85	90	93	93	93	93	93	93
	15	0	0	0	62	79	85	88	88	88	88	88	88	88
	30	0	0	0	60	83	87	90	92	92	92	92	92	92
N/C	3	0	0	0	30	51	72	74	77	77	77	77	77	77
	9	0	0	0	65	77	89	91	93	93	93	93	93	93
	15	0	0	0	55	76	90	91	92	92	92	92	92	92
	30	0	0	0	56	72	87	90	96	96	96	96	96	96
CAMPHOR	3	0	0	0	2	68	78	85	85	89	91	93	93	93
	9	0	0	0	19	78	87	93	100	104	105	107	107	107
	15	0	0	0	13	30	45	49	50	55	56	56	56	56
	30	0	0	0	15	87	97	106	109	112	114	114	114	114

TABLE n: EXPERIMENT 3 GRAND RAPIDS CUMULATIVE (REPETITION 1)

GRAND RAPIDS CALCULATE 1 (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
NITRIC ACID	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
S/C	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
N/C	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
CAMPHOR	3	11	10	9	8	7	6	5	4	3	2	1	0	-1
	9	11	10	9	8	7	6	5	4	3	2	1	0	-1
	15	11	10	9	8	7	6	5	4	3	2	1	0	-1
	30	11	10	9	8	7	6	5	4	3	2	1	0	-1

TABLE o: EXPERIMENT 3 GRAND RAPIDS CALCULATE 1 (REPETITION 1)

GRAND RAPIDS CALCULATE 2 (REPETITION 1)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	0	210	152	9	2	1	0	0	0	0	0
	9	0	0	12	325	72	12	12	2	0	0	0	0	0
	15	0	0	6	350	64	12	4	2	0	0	0	0	0
	30	0	0	0	310	84	15	8	1	0	0	0	0	0
NITRIC ACID	3	0	0	0	290	84	15	8	3	0	0	0	0	0
	9	0	0	0	300	108	18	6	2	0	0	0	0	0
	15	0	0	0	295	132	15	10	2	0	0	0	0	0
	30	0	0	0	335	88	15	4	3	0	0	0	0	0
S/C	3	0	0	0	185	116	33	6	5	0	0	0	0	0
	9	0	0	0	285	92	15	10	3	0	0	0	0	0
	15	0	0	0	310	68	18	6	0	0	0	0	0	0
	30	0	0	0	300	92	12	6	2	0	0	0	0	0
N/C	3	0	0	0	150	84	63	4	3	0	0	0	0	0
	9	0	0	0	325	48	36	4	2	0	0	0	0	0
	15	0	0	0	275	84	42	2	1	0	0	0	0	0
	30	0	0	0	280	64	45	6	6	0	0	0	0	0
CAMPHOR	3	0	0	0	16	462	60	35	0	12	4	2	0	0
	9	0	0	0	152	413	54	30	28	12	2	2	0	0
	15	0	0	0	104	119	90	20	4	15	2	0	0	0
	30	0	0	0	120	504	60	45	12	9	4	0	0	0

TABLE p: EXPERIMENT 3 GRAND RAPIDS CALCULATE 2 (REPETITION 1)

GRAND RAPIDS (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	3	74	16	6	3	2	0	0	0	0	0
	9	0	0	2	76	18	5	3	1	0	0	0	0	0
	15	0	0	1	68	15	5	4	0	0	0	0	0	0
	30	0	0	0	71	10	8	2	1	0	0	0	0	0
NITRIC ACID	3	0	0	0	64	16	4	1	1	0	0	0	0	0
	9	0	0	0	66	17	4	2	4	0	0	0	0	0
	15	0	0	0	68	19	8	1	3	0	0	0	0	0
	30	0	0	0	69	9	12	4	2	0	0	0	0	0
S/C	3	0	0	0	63	18	6	1	2	0	0	0	0	0
	9	0	0	0	69	14	5	0	2	0	0	0	0	0
	15	0	0	0	70	13	5	3	0	0	0	0	0	0
	30	0	0	0	68	16	4	3	2	0	0	0	0	0
N/C	3	0	0	0	33	021	20	6	9	0	0	0	0	0
	9	0	0	0	57	7	33	6	6	0	0	0	0	0
	15	0	0	0	61	10	11	4	5	0	0	0	0	0
	30	0	0	0	58	4	9	12	6	0	0	0	0	0
CAMPHOR	3	0	0	0	4	48	8	3	6	5	1	0	0	0
	9	0	0	0	23	35	9	3	5	4	1	0	0	0
	15	0	0	0	21	54	5	2	4	4	4	2	0	0
	30	0	0	0	21	56	6	1	1	3	3	3	0	0

TABLE q: EXPERIMENT 3 GRAND RAPIDS (REPETITION 2)

GRAND RAPIDS CUMULATIVE (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	3	77	93	99	102	104	104	104	104	104	104
	9	0	0	2	78	96	101	104	105	105	105	105	105	105
	15	0	0	1	69	84	89	93	93	93	93	93	93	93
	30	0	0	0	71	81	89	91	92	92	92	92	92	92
NITRIC ACID	3	0	0	0	64	80	84	85	86	86	86	86	86	86
	9	0	0	0	66	83	87	89	93	93	93	93	93	93
	15	0	0	0	68	87	95	96	99	99	99	99	99	99
	30	0	0	0	69	78	90	94	96	96	96	96	96	96
S/C	3	0	0	0	63	81	87	88	90	90	90	90	90	90
	9	0	0	0	69	83	88	88	90	90	90	90	90	90
	15	0	0	0	70	83	88	91	91	91	91	91	91	91
	30	0	0	0	68	84	88	91	93	93	93	93	93	93
N/C	3	0	0	0	33	54	74	80	89	89	89	89	89	89
	9	0	0	0	57	64	97	103	109	109	109	109	109	109
	15	0	0	0	61	71	82	86	91	91	91	91	91	91
	30	0	0	0	58	62	71	83	89	89	89	89	89	89
CAMPHOR	3	0	0	0	4	52	60	63	69	74	75	75	74	74
	9	0	0	0	23	58	67	70	75	79	80	80	79	79
	15	0	0	0	21	75	80	82	86	90	94	96	90	90
	30	0	0	0	21	77	83	84	85	88	91	94	88	88

TABLE r: EXPERIMENT 3 GRAND RAPIDS CUMULATIVE (REPETITION 2)

GRAND RAPIDS CALCULATE 1 (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
NITRIC ACID	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
S/C	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
N/C	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
CAMPHOR	3	11	10	9	8	7	6	5	4	3	2	1	0	-1
	9	11	10	9	8	7	6	5	4	3	2	1	0	-1
	15	11	10	9	8	7	6	5	4	3	2	1	0	-1
	30	11	10	9	8	7	6	5	4	3	2	1	0	-1

TABLE s: EXPERIMENT 3 GRAND RAPIDS CALCULATE 1 (REPETITION 2)

GRAND RAPIDS CALCULATE 2 (REPETITION 2)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	18	370	64	18	6	2	0	0	0	0	0
	9	0	0	12	380	72	15	6	1	0	0	0	0	0
	15	0	0	6	340	60	15	8	0	0	0	0	0	0
	30	0	0	0	355	40	24	4	1	0	0	0	0	0
NITRIC ACID	3	0	0	0	320	64	12	2	1	0	0	0	0	0
	9	0	0	0	330	68	12	4	4	0	0	0	0	0
	15	0	0	0	340	76	24	2	3	0	0	0	0	0
	30	0	0	0	345	36	36	8	2	0	0	0	0	0
S/C	3	0	0	0	315	72	18	2	2	0	0	0	0	0
	9	0	0	0	345	56	15	0	2	0	0	0	0	0
	15	0	0	0	350	52	15	6	0	0	0	0	0	0
	30	0	0	0	340	64	12	6	2	0	0	0	0	0
N/C	3	0	0	0	165	84	60	12	9	0	0	0	0	0
	9	0	0	0	285	28	99	12	6	0	0	0	0	0
	15	0	0	0	305	40	33	8	5	0	0	0	0	0
	30	0	0	0	290	16	27	24	6	0	0	0	0	0
CAMPHOR	3	0	0	0	32	336	48	15	24	15	2	0	0	0
	9	0	0	0	184	245	54	15	20	12	2	0	0	0
	15	0	0	0	168	378	30	10	16	12	8	2	0	0
	30	0	0	0	168	392	36	5	4	9	6	3	0	0

TABLE t: EXPERIMENT 3 GRAND RAPIDS CALCULATE 2(REPETITION 2)

GRAND RAPIDS (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	1	76	11	4	4	3	0	0	0	0	0
	9	0	0	3	73	11	3	1	1	0	0	0	0	0
	15	0	0	4	81	9	2	3	1	0	0	0	0	0
	30	0	0	2	72	17	2	1	1	0	0	0	0	0
NITRIC ACID	3	0	0	0	63	13	15	2	2	0	0	0	0	0
	9	0	0	0	69	13	18	0	4	0	0	0	0	0
	15	0	0	0	67	16	4	3	4	0	0	0	0	0
	30	0	0	0	64	19	10	1	1	0	0	0	0	0
S/C	3	0	0	0	41	16	10	5	2	0	0	0	0	0
	9	0	0	0	67	16	8	1	6	0	0	0	0	0
	15	0	0	0	62	10	5	2	1	0	0	0	0	0
	30	0	0	0	70	13	6	1	2	0	0	0	0	0
N/C	3	0	0	0	57	8	9	7	6	0	0	0	0	0
	9	0	0	0	88	10	3	2	1	0	0	0	0	0
	15	0	0	0	69	7	6	1	2	0	0	0	0	0
	30	0	0	0	77	6	8	2	2	0	0	0	0	0
CAMPHOR	3	0	0	0	8	60	3	3	2	5	1	1	0	0
	9	0	0	0	31	42	9	3	2	2	2	2	0	0
	15	0	0	0	2	58	6	5	2	3	2	4	0	0
	30	0	0	0	17	60	8	2	1	2	3	2	0	0

TABLE u: EXPERIMENT 3 GRAND RAPIDS (REPETITION 3)

GRAND RAPIDS CUMULATIVE (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	1	77	88	92	96	99	99	99	99	99	99
	9	0	0	3	76	87	90	91	92	92	92	92	92	92
	15	0	0	4	85	94	96	99	100	100	100	100	100	100
	30	0	0	2	74	91	93	94	95	95	95	95	95	95
NITRIC ACID	3	0	0	0	63	76	91	93	95	95	95	95	95	95
	9	0	0	0	69	82	100	100	104	104	104	104	104	104
	15	0	0	0	67	83	87	90	94	94	94	94	94	94
	30	0	0	0	64	83	93	94	95	95	95	95	95	95
S/C	3	0	0	0	41	57	67	72	74	74	74	74	74	74
	9	0	0	0	67	83	91	92	98	98	97	98	98	98
	15	0	0	0	62	72	77	79	80	80	80	80	80	80
	30	0	0	0	70	83	89	90	92	92	92	92	92	92
N/C	3	0	0	0	57	65	74	81	87	87	87	87	87	87
	9	0	0	0	88	98	101	103	104	104	104	104	104	104
	15	0	0	0	69	76	82	83	85	85	85	85	85	85
	30	0	0	0	77	83	91	93	95	95	95	95	95	95
CAMPHOR	3	0	0	0	8	68	71	74	76	81	82	83	81	81
	9	0	0	0	31	73	82	85	87	89	91	93	89	89
	15	0	0	0	2	60	66	71	73	76	78	82	76	76
	30	0	0	0	17	77	85	87	88	90	93	95	90	90

TABLE v: EXPERIMENT 3 GRAND RAPIDS CUMULATIVE (REPETITION 3)

GRAND RAPIDS CALCULATE 1 (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
NITRIC ACID	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
S/C	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
N/C	3	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	15	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
	30	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4
CAMPHOR	3	11	10	9	8	7	6	5	4	3	2	1	0	-1
	9	11	10	9	8	7	6	5	4	3	2	1	0	-1
	15	11	10	9	8	7	6	5	4	3	2	1	0	-1
	30	11	10	9	8	7	6	5	4	3	2	1	0	-1

TABLE w: EXPERIMENT 3 GRAND RAPIDS CALCULATE 1 (REPETITION 3)

GRAND RAPIDS CALCULATE 2 (REPETITION 3)														
Time		12	18	24	36	48	60	72	84	96	108	120	132	144
SULPHUR	3	0	0	6	380	44	12	8	3	0	0	0	0	0
	9	0	0	18	365	44	9	2	1	0	0	0	0	0
	15	0	0	24	405	36	6	6	1	0	0	0	0	0
	30	0	0	12	360	68	6	2	1	0	0	0	0	0
NITRIC ACID	3	0	0	0	315	52	45	4	2	0	0	0	0	0
	9	0	0	0	345	52	54	0	4	0	0	0	0	0
	15	0	0	0	335	64	12	6	4	0	0	0	0	0
	30	0	0	0	320	76	30	2	1	0	0	0	0	0
S/C	3	0	0	0	205	64	30	10	2	0	0	0	0	0
	9	0	0	0	335	64	24	2	6	0	0	0	0	0
	15	0	0	0	310	40	15	4	1	0	0	0	0	0
	30	0	0	0	350	52	18	2	2	0	0	0	0	0
N/C	3	0	0	0	285	32	27	14	6	0	0	0	0	0
	9	0	0	0	440	40	9	4	1	0	0	0	0	0
	15	0	0	0	345	28	18	2	2	0	0	0	0	0
	30	0	0	0	385	24	24	4	2	0	0	0	0	0
CAMPHOR	3	0	0	0	64	420	18	15	8	15	2	1	0	0
	9	0	0	0	248	294	54	15	8	6	4	2	0	0
	15	0	0	0	16	406	36	25	8	9	4	4	0	0
	30	0	0	0	136	420	48	10	4	6	6	2	0	0

TABLE x: EXPERIMENT 3 GRAND RAPIDS CALCULATE 2 (REPETITION 3)

		12	18	24	36	48	60	72	84
Greenfield	A	0	0	54	28	10	3	1	0
	B	0	4	64	26	6	2	1	0
	C	0	0	37	44	2	4	2	0
Great lakes	A	0	0	0	1	51	23	6	3
	B	0	0	0	2	55	30	7	0
	C	0	0	0	2	58	29	9	2
University	A	0	0	0	52	29	6	2	2
	B	0	0	0	55	32	9	1	2
	C	0	0	0	60	30	3	0	4

TABLE y: EXPERIMENT 3 CONTROL

		12	18	24	36	48	60	72	84
Greenfield	A	0	0	54	82	92	95	96	96
	B	0	4	68	94	100	102	103	103
	C	0	0	37	81	83	87	89	89
Great lakes	A	0	0	0	1	52	75	81	84
	B	0	0	0	2	57	87	94	94
	C	0	0	0	2	60	89	98	100
University	A	0	0	0	52	81	87	89	91
	B	0	0	0	55	87	96	97	99
	C	0	0	0	60	90	93	93	97

TABLE z: EXPERIMENT 3 CONTROL CUMULATIVE

		12	18	24	36	48	60	72	84
Greenfield	A	7	6	5	4	3	2	1	0
	B	7	6	5	4	3	2	1	0
	C	7	6	5	4	3	2	1	0
Great lakes	A	8	7	6	5	4	3	2	1
	B	8	7	6	5	4	3	2	1
	C	8	7	6	5	4	3	2	1
University	A	8	7	6	5	4	3	2	1
	B	8	7	6	5	4	3	2	1
	C	8	7	6	5	4	3	2	1

TABLE a1: EXPERIMENT 3 CONTROL CALCULATE 1

		12	18	24	36	48	60	72	84
Greenfield	A	0	0	270	112	30	6	1	0
	B	0	24	320	104	18	4	1	0
	C	0	0	185	176	6	8	2	0
Great lakes	A	0	0	0	5	204	69	12	3
	B	0	0	0	10	220	90	14	0
	C	0	0	0	10	232	87	18	2
University	A	0	0	0	260	116	18	4	2
	B	0	0	0	275	128	27	2	2
	C	0	0	0	300	120	9	0	4

TABLE a2: EXPERIMENT 3 CONTROL CALCULATE 2

		GI Index
Greenfield	A	0.6235119
	B	0.65325936
	C	0.60513644
Great Lakes	A	0.4360119
	B	0.44414894
	C	0.43625
University	A	0.54945055
	B	0.5479798
	C	0.55798969

TABLE a3: CONROL GI INDEX

COMMANDER CULTIVAR								
Light 15C	12	24	36	48	60	72	84	No Germ
1	0	0	0	0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Light 29C								
1	0	0	0	0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Dark 15C								
1	0	0	0	0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Dark 29C								
1	0	0	0	0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Table a4	Data- Experiment 4		Commander Cultivar		[using four different lighting conditions]			

GREENFIELD CULTIVAR								
Light 15C	12	24	36	48	60	72	84	No Germ
1	0	74	5	2	4	8	0	8
2	0	84	10	1	3	2	0	0
3	0	69	6	0	3	1	0	21
Light 29C								
1	0	5	[RI] 2	1	0	0	0	92
2	4	8	[RI] 2	0	0	0	0	86
3	0	21	[RI] 2	0	0	0	0	77
Dark 15C								
1	0	18	65	4	0	1	0	12
2	0	24	60	9	0	0	0	7
3	0	31	63	4	2	0	0	0
Dark 29C								
1	0	0	0	[RI]	0	0	0	100
2	0	1	0	[RI]	0	0	0	99
3	1	0	1	[RI]	0	0	0	98
(RI=Unidentified fungal infection)								
Table a5	Data- Experiment 4		Greenfield Cultivar		[using four different lighting conditions]			

GREAT LAKES CULTIVAR								
Light 15C	12	24	36	48	60	72	84	No Germ
1	0	0	4	62	24	7	0	3
2	0	0	2	54	35	1	0	8
3	0	0	4	45	32	7	0	12
Light 29C								
1	0	0	0	[RI] 0	3	0	0	97
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Dark 15C								
1	0	0	0	0	67	30	0	3
2	0	0	0	0	44	56	0	0
3	0	0	0	3	53	40	0	4
Dark 29C								
1	0	0	0	[RI] 0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
(RI=Unidentified fungal infection)								
Table a6	Data- Experiment 4		Great Lakes cultivar		[using four different lighting conditions]			

GRAND RAPIDS CULTIVAR								
Light 15C	12	24	36	48	60	72	84	No Germ
1	0	28	34	16	15	2	0	5
2	0	16	57	12	11	4	0	100
3	0	8	51	12	12	4	0	13
Light 29C								
1	0	0	0	0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Dark 15C								
1	0	0	0	16	17	10	0	57
2	0	0	2	18	25	6	0	54
3	0	0	2	12	22	6	0	58
Dark 29C								
1	0	0	0	0	0	0	0	100
2	0	0	0	0	0	0	0	100
3	0	0	0	0	0	0	0	100
Table a7	Data- Experiment 4		Grand Rapids cultivar		[using four different lighting conditions]			