A COMPARISON OF GROWTH MEDIA ON CYCLAMENS IN A CONTROLLED ENVIRONMENT

by

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DECLARATION:

I, Pierre Adriaanse (ID number 6811015018082), declare that this dissertation entitled, "**A comparison of growth media on cyclamens in a controlled environment**", is my own work, and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references. Prior to the commencement of the research project, both the Unisa Library and I conducted a literature review, and ascertained that no other similar research had been conducted in South Africa, prior to the registration of this project.

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ABSTRACT

Cyclamens are deemed an essential cold season crop for supplementing the income of commercial growers during winter. However, cyclamens have the reputation of being a demanding commercial crop mainly due to difficulty in successful crop cultivation, lengthy production time and production costs. The economic and environmental landscape in South Africa dictates that careful consideration be given to reducing production time and costs, but still improving the quality of the commercial crop for market readiness. Growth medium are considered an important factor contributing significantly to the quality of commercially grown container cyclamens in a controlled environment. The focus of this study was on establishing the most suitable growth medium for commercially grown cyclamens in a South African environment in order to improve the quality of the commercial crop. Only one F1 variety of cyclamen was used as the sample population with a sample size of five plants per growth medium mixture planted according to a randomised block design in a specified area within a greenhouse. Seven commercially available growth medium mixtures, five locally available and two imported, were subjected to a typical production cycle of commercial cyclamens in a controlled greenhouse. The growth medium mixtures for comparison were Cyclamen Mix; 45 Mix; 50% Cyclamen Mix - 50% 45 Mix; 49 Mix; 7 Mix; coarse coir; Klasmann base 4 Substrate mix . The measuring instrument used in the study was adapted from existing instruments used in the comparison of cyclamens and growth medium. It included various measurements and observations: Plant height, plant diameter, plant weight, number of leaves, leaf width, foliage fresh weight, number of flowers, diameter of tuber and root fresh weight. The results obtained in the comparison determine the most suitable growth medium for container cyclamens for South African circumstances. The physical properties of peat retain water for a longer time which is beneficial for the production of container cyclamen. The results of this study therefore indicate that growth mediums containing peat performed better than mediums containing no peat.

Keywords: Coir, container cyclamen, cyclamen, cyclamen production, growth medium, peat, pine bark, perlite.

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GLOSSARY

<u>Definitions (in terms of this study)</u>

Carbon footprint:

Wiedmann and Minx (2008:4) describe carbon footprint as the measure of the direct and indirect total carbon dioxide emissions derived from the activities which are accumulated over the life stages of the product.

Coir:

Coir is an organic waste product derived from coconuts and is used as a growth medium or as part of a growth mixture (Adams, Bamford & Early, 2008:388).

Container cyclamen:

Container cyclamen can be described as cyclamen produced in a container, made of various materials, usually plastic, filled with a growing medium, instead of directly planted in soil. Beyl and Trigiano (2008:49) indicate that containers are anything from individual pots and multi-unit systems which include plugs, inserts, cavity trays and cells.

Controlled environment:

The term "controlled environment" refers to the greenhouse structure which creates a protective and suitable environment for the horticultural crop at a specific time to grow optimally within predetermined parameters (Boodley & Newman, 2009:38).

Cyclamen:

For the purposes of this study, the term "cyclamen" refers to the *Cyclamen persicum, Primulacea* (Boodley & Newman, 2009:449).

Cyclamen production:

Cyclamen production can be described as cyclamen produced in a container in a controlled environment, usually a greenhouse structure of sorts.

Electrical conductivity:

Electrical conductivity (EC) is the measure of the total sum of dissolved salts in the growth medium. It can be measured using an EC meter. A higher EC value means a higher electrical current moving through the solution. The EC value gives the grower insight into the nutrient status of the crop (Beytes & Hamrick, 2003:29).

Fertilization programme:

The aim of any fertilizer application programme is to provide a constant supply of nutrients in sufficient amounts to the plant to ensure the required level of growth (Handreck & Black, 2002:171).

Greenhouse:

The function of a greenhouse is to provide protection and a suitable environment for a specific crop at a specific time which will allow the plants to grow (Boodley & Newman, 2009:38).

Growth medium:

Whitcomb (2003:457) describes a growing medium as a soilless, artificial mixture of a pure material, e.g. pine bark or peat moss, which is used for growing plants in a container.

Lux:

According to Adams *et al*. (2008:113), light energy can be measured in joules/square metres. In practice, light energy is measured according to a given area on which it falls; hence lumens per square metre, which is known as Lux (lx). Brown (2002:69) suggests that a minimum of 500 lx is needed for photosynthesis to take place. Optimum growth takes place. at 10 000 – 15 000 lx.

Pasteurization:

Pasteurization is a process used to kill all harmful organisms and most weed seeds. The most common methods used include steam pasteurization, electrical pasteurization and chemical fumigation (Boodley & Newman, 2009:211).

Peat:

Peat can be described as an acidic organic growth mediuma which consists of plant parts that have accumulated under water over time. Peat is harvested from a peat bog (Boodley & Newman, 2009:781; Whitcomb, 2003:458).

Perlite:

Perlite can be described as a white lightweight mineral granule which has a porous rough texture. Essentially perlite is an inorganic soil alternative used in a growth medium mixture (Adams *et al.*, 2008:389).

pH:

According to Whitcomb (2003:458), pH can be described as a measure of the degree pH values range from 0 to 14, where a value of 7 is neutral, 0 is most acidic and 14 most alkaline.

Pine bark:

Pine bark is the bark of pines and is essentially an organic material used as an alternative to soil as a growth medium (Adams *et al.*, 2008:388).

Sterilization:

Sterilization is a process where all living organisms, including microorganisms, are killed. Microorganisms include bacteria, fungi and any microscopic organisms. The aim of sterilization is to eliminate pathogens which may cause disease to the plant (Boodley & Newman, 2009:211).

TABLE OF CONTENTS

		Page
DECLARATION …………………………………………………………………….		ii
ABSTRACT ………………………………………………………………………		iii
KEYWORDS ……………………………………………………………………...		iii
ACKNOWLEDGEMENTS ……………………………………………………….		iv
GLOSSARY ………………………………………………………………………		v
CHAPTER 1: Introduction …………………………………………………….		16
1.1	Background to the research project …………………………………	16
1.2	Ethical consideration and demarcation ………………………………	16
1.3	Rationale for and benefits derived from the study …………………..	17
1.3.1	Motivation ……………………………………...............................	18
1.3.2	Value of the study ……………... ……………………………………...	19
	1.3.2.1 South African situation	
	1.3.2.2 Benefits to commercial growers of cyclamens	
	1.3.2.3 Environmental context	
1.4	Research aims and objectives.……………………………………….	19
1.5	Significance and contribution of the research ……………………….	20
1.6	Research problem and subproblems …………………………………	20
1.6.1	Research problem statement …………………………………………	20
1.6.2	Research subproblems ………………………………………………...	20
1.7	Research design and methodology …………………………………..	21
1.7.1	Literature review ………………………………………………………..	21
1.7.2	Research methodology ………………………………………………....	21
1.7.3	Experimental design ……………………………………………………	22
1.7.4	Plant population …………………………………………………………	22
1.7.5	Growth medium ……………………………………………………….....	23
1.7.6	Data collection …………………………………………………………..	23
1.7.7	Measuring instrument …………………………………………………..	24
1.8	Research results and analysis ………………………………………...	25
1.9	Conclusions and recommendations …………………………………..	25

1.10	Technical aspects …………………………………………………..	25
1.10.1	Reference and citation management …………………………………	25
1.10.2	Technical care ………………………………………………………..	26

CHAPTER 2: Literature Review ……………………………………………..		27
2.1	Introduction …………………………………………………………..	27
2.2	Controlled environment in greenhouse structures ………………...	29
2.3	Growth medium …………………………………...……………..	30
2.3.1	Soils ……………………………………………………………….	31
2.3.2	Functions of growth medium for the horticulture industry……..…..	31
2.3.3	Sterilization and pasteurization of soils..……………………………	31
2.3.4	Artificial soil as a growth medium…………………………………...	32
2.3.4.1	The need for artificial growth medium	
2.3.4.2	Advantages of artificial growth medium	
2.3.4.3	Content of artificial growth medium	
2.4	Cyclamen ………………………………………………………………	36
2.4.1	Cyclamens as an ornamental horticulture crop ……………………	37
2.4.1.1	Temperature ranges	
2.4.1.2	Pest and disease levels	
2.4.1.3	Growth medium	
2.4.2	Growth medium available in South Africa for cyclamen production..	40
2.4.3	Container cyclamen production at Tuberflora………………………	41
2.4.3.1	Planning phase	
2.4.3.2	Preparation phase	
2.4.3.3	Seedling phase	
2.4.3.4	Transplanting phase	
2.4.3.5	Principal growth phase	
2.4.3.6	Post-production market-ready phase	
2.5	Environmental responsibility and carbon footprint……………….....	49

2.5.1 Existing protocols for horticultural carbon footprint ……………….. 49
2.5.2 The sustainable use of peat as a growth medium………………… 50
2.6 Summary ………………………………………………………………. 52

CHAPTER 3: Research Methodology ……………………………………..... 54
3.1 Introduction……………………………………………………………….. 54
3.2 Motivation for the research ………..…………………………………… 54
3.3 Value of the study ………………………………………………………. 55
3.3.1 Benefits for the South African industry
3.3.2 Benefits to commercial growers of cyclamens
3.4 Problem statement ……………………………………………………… 55
3.4.1 Main problem statement ……………………………………………... 56
3.4.2 Subproblems …………………………………………………………….. 56
3.5 Research design ……………………………………………………..…. 57
3.5.1 Sample plant population ……………………………………………... 60
3.5.2 Trial layout ………………………………………………………………. 60
3.5.3 Physical location …………………………………………………....... 61
3.5.4 Description, characteristics and dimensions of the greenhouse … 61
3.5.5 Production area within the greenhouse …………………………..... 63
3.6 Research instruments ………………………………………………..…. 64
3.6.1 Selection of growth medium for comparison ………………………..……….. 64
3.6.2 Measuring instrument …………………………………………………... 67
3.7 Data collection ………………………………………………………….. 68
3.8 Analysis of data …………………………………………...………….. 69
3.9 Dependent and independent variables ……………………………. 70
3.10 Summary ………………………………………………………………. 70

CHAPTER 4: Results and Analysis ……………………………………………. 71
4.1 Introduction ……………………………………………………………. 71
4.2 Results of comparison of cyclamen growth medium for season 2012 73

4.3	Results of comparison of cyclamen growth medium for season 2013	75
4.4	Comparison of seasons 12 and 2013 …………………….……...	77
4.4.1	Statistical comparisons for seasons 2012 and 2013 ………..........	79
4.4.1.1	Parametric data	
4.4.1.2	Non-parametric data	
4.4.2	Explanations of statistical comparisons for seasons 2012 and 2013	81
4.4.2.1	Plant height	
4.4.2.2	Plant diameter	
4.4.2.3	Fresh plant mass	
4.4.2.4	Number of leaves	
4.4.2.5	Leaf width	
4.4.2.6	Foliage fresh weight	
4.4.2.7	Number of flowers	
4.4.2.8	Diameter of tuber	
4.4.2.9	Root fresh weight	
4.4.3	Graphical presentation of comparison cyclamen sub-parameters of seasons 2012 and 2013…………………………………………	84
4.4.3.1	Comparison of plant height for seasons 2012 and 2013	
4.4.3.2	Comparison of plant diameter for seasons 2012 and 2013	
4.4.3.3	Comparison of plant weight for seasons 2012 and 2013	
4.4.3.4	Comparison of number of leaves for seasons2012 and 2013	
4.4.3.5	Comparison of leaf width for seasons 2012 and 2013	
4.4.3.6	Comparison of foliage fresh weight for seasons 2012 and 2013	
4.4.3.7	Comparison of number of flowers for seasons 2012 and 2013	
4.4.3.8	Comparison of tuber diameter for seasons 2012 and 2013	
4.4.3.9	Comparison of root fresh weight for seasons 2012 and 2013	
4.5	Summary ……………………………………….…………....	89

CHAPTER 5: Conclusions and Recommendations ………………………... 91

5.1 Introduction……………………………………………………………. 91
5.2 Objective 1: Creating a visual measuring instrument……………... 91
5.3 Objective 2: Determining the most suitable growth medium in the production of container cyclamens grown in a controlled environment ……………………………………………………….. 92
5.4 Objective 3: Determining how the commercial cyclamen grower would benefit by using the most suitable growth medium in the production of container cyclamens ………………………………… 93
5.5 Objective 4: Determining whether the carbon footprint of cyclamen production can be reduced by using the most suitable and cost-effective growth medium for container cyclamens …….. 94
5.6 Recommendations ………………………………………….......... 95
5.7 Summary ……………………………………………………….... 96

References ………………………………..……………………......................... 99

FIGURES

Figure 1.1 Research process ………………………………………………………. 21
Figure 2.1 Container cyclamen production phase at Tuberflora ……………. 42
Figure 2.2 Cyclamen production greenhouse in preparation phase at Tuberflora ……………………………………………………………………….... 43
Figure 2.3 Cyclamen plants in seedling phase at Tuberflora …………………. 44
Figure 2.4 Cyclamen seedling plants ready for transplanting ………………... 44
Figure 2.5 Cyclamen plants in principal growth phase at Tuberflora ……….. 47
Figure 2.6 Container cyclamen plants ready for market at Tuberflora …….... 48
Figure 3.1 Question hierarchy …………………………………………….…... 55
Figure 3.2 Cyclamen randomized complete block design ……………………. 59
Figure 3.3 Map to Tuberflora ……………………………………………..……… 61
Figure 3.4 Cyclamen production greenhouse layout ……………………….…. 62
Figure 3.5 Cyclamen production greenhouse at Tuberflora ………………….. 62
Figure 3.6 Locally available growth medium ………………………………….. 64
Figure 4.1 Trial measurements taken during seasons 2012 and 2013 …..…. 72
Figure 4.2 Mean plant height for seasons 2012 and 2013……..…………….... 84
Figure 4.3 Mean plant diameter for seasons 2012 and 2013……...…………. 85
Figure 4.4 Mean plant weight for seasons 2012 and 2013 ……..……………. 85
Figure 4.5 Mean number of leaves for seasons 2012 and 2013 …………….. 86
Figure 4.6 Mean leaf width for seasons 2012 and 2013 …...………………... 87
Figure 4.7 Mean foliage fresh weight for seasons 2012 and 2013 …..……... 87
Figure 4.8 Mean number of flowers for seasons 2012 and 2013…………….. 88
Figure 4.9 Mean tuber diameter for seasons 2012 and 2013………………... 88
Figure 4.10 Mean root fresh weight for seasons 2012 and 2013 ...………..... 89

TABLES

Table 1.1 Summary of citation analysis ……………………………………….. 18
Table 1.2 List of growth mediums………………………………………………… 23
Table 2.1 Summary of growth medium materials as growth medium content 33
Table 3.1 Trial measuring schedule …………………………………………….. 60
Table 3.2 List of selected growth medium for trial …………….……………… 65
Table 3.3 Measuring instrument ………………………………………………... 67
Table 4.1 Mean values of results for season 2012 …………….………….….... 74
Table 4.2 Mean values of results for season 2013 …………….……………… 76
Table 4.3 Mean values of results for seasons 2012 and 2013 combined …... 78
Table 4.4 Measuring instrument parameters ………………………………… 80

ANNEXURES

Annexure A South African legislation ………………………..……………….... 107

Annexure B Letters of permission …………………………………………….. 109

Annexure C List of resources for the study …………………..…………………... 114

Annexure D Information, soil and water sample quote by Eco Analytica …. 116

Annexure E Example of soil and water sample analysis by Eco Analytica .. 119

Annexure F Avonrod spraying programme for cyclamens …………………. 123

Annexure G AVCASA certification ……………………………………………. 125

Annexure H Cyclamen fertilizer programme …………………………………. 126

Annexure I *Cyclamen persicum* F1 – Grandola Deep Rose from Hem Genetics …………………………………………………………………………. 127

Annexure J Schedule for measurement and recording of data……………… 128

Annexure K Basic visual comparison of pilot study ………………………….. 130

Annexure L Cyclamen production cycle records for 2011-2012 and 2012 - 2013 ………………………………………………………………………………. 131

Annexure M Comparison of chemical and physical properties of growth medium …………………..……………………………………………………... 140

CHAPTER 1

INTRODUCTION

1.1 Background to the research project

Cyclamens in general as an ornamental horticulture crop have acquired the international reputation of being difficult to cultivate. According to Beytes and Hamrick (2003:325) and Onofrey (2000:73), advanced growing skills and competencies are required to successfully cultivate cyclamens for commercial purposes. This includes specialized growth specifications, dedicated production space, specialized growth mediums, a disease and pest management programme and a specialized fertilization programme. All these special requirements translate to production costs. However, the present economic decline experienced internationally and locally dictates that commercial nurseries should economize and focus on more cost-effective production strategies. These production strategies involve the cost-effective utilization of available greenhouse production space and the best quality growth mediums for propagation to achieve market competitiveness.

1.2 Ethical consideration and demarcation

This research ethics number 2012/CAES/037 was conducted with strict adherence to the Unisa Research Ethics Policy. The research also adheres to the South African occupational health and safety legislation requirements in terms of human risks, and South African legislation relevant to the use of fertilizers, farm feeds, agricultural remedies and stock remedies in terms of environmental risks. See Annexure A for the relevant South African legislation.

The research was conducted with permission from all stakeholders involved. See letters of permission by Tuberflora, Culterra, Klasmann and MEEGAA in Annexure B. Permission to conduct the research trials using the selected growth mediums during the cyclamen production was obtained from the suppliers of selected growth mediums, Culterra and Greenhouse Technologies, on behalf of Klasmann and MEEGAA. Permission to conduct the study trials at the Tuberflora premises was obtained from

Tuberflora management. This included the utilization of in-house information resources, production resources, staff and equipment. See Annexure C for a list of resources used during the study. The soil (growth mediums) and water sampling for the trial was conducted by Eco Analytica, a specialized laboratory for water and soil sampling in the agricultural sector in South Africa. See Annexures D and E for information on soil and water sampling from Eco Analytica for both seasons.

Tuberflora as a wholesale nursery applies a commercial pesticide and disease management programme purchased from a South African registered plant protection consultant and agent, AVONROD Plant Protection. See Annexure F for the AVONROD Plant Protection spraying programme. The pest and disease management programme designed specifically for cyclamen production was administered by the researcher, currently certified with AVCASA (Association of Veterinary and Crop Associations of South Africa (Reg No 67/02403/08) as a plant protection manager). See Annexure G for the accreditation certificate. Annexure H contains the cyclamen fertilizer programme applied during the trials of seasons 1 and 2. Additional costs such as the purchase of the specialized equipment for temperature and humidity logging, and laboratory analysis were privately financed.

1.3 Rationale for and benefits derived from the study

A citation analysis was conducted using the search string and keywords “comparison of growth mediums on cyclamens” on the citation resources Web of Science, Scopus and Google Scholar. This was also done to identify any possible trends for research possibilities. The keywords identified include:

- growth mediums/substrates
- cyclamen
- comparison

Table 1.1 Summary of citation analysis.

	Citation resources for citation analysis					
	Web of Science		**Scopus**		**Google Scholar**	
	2010-2011	2010-2013	2010-2011	2010-2013	2010-2011	2010-2013
((growth mediums or growth substrate) and cyclamen) and comparison	Two articles (0 articles in 2010-2013)	Six articles (1 article in 2010-2013)	0	0	106 articles (10 articles in 2010-2011)	310 articles (34 articles 2010-2013)
(growth mediums or growth substrate) and cyclamen	33 articles (8 articles in 2010-2011)	37 articles (13 articles in 2010-2013)	5 (most recent article 2010)	5 (most recent article 2010)	159 (14 articles in 2010-2011)	328 articles (36 articles 2010-2013)

The search results included many pertaining to growth mediums on in vitro and tissue culture comparisons on cyclamens. There was low search result retrieval on the comparison of growth mediums for container cyclamens during production in greenhouses with commercial importance. The citation analysis indicated a gap in the South African research on the comparison of growth mediums for cyclamens and also indicated sufficient literature to conduct this research.

1.3.1 Motivation

The motivation for this study is to identify growth mediums most suitable in the commercial production of container cyclamens for the South African environment. Commercial nurseries will be able to make informed decisions. Additionally, knowledge will be available. This study will produce a foundation for future research. See Figure 1.1 for research process.

1.3.2 Value of the study

1.3.2.1 South African situation

The study will emphasize the existing production practices and guidelines for the commercial growing of container cyclamens. New knowledge will be added concerning the most suitable growth mediums for container cyclamens in a South African context in a controlled environment.

1.3.2.2 Benefits to commercial growers of cyclamens

The results of this study will be beneficial to all commercial growers of cyclamens and thus aid in the quality, quantity and improvement of market timing of the commercial production of container cyclamens. Growers will know how to gain a competitive edge and produce a better quality cyclamen in a shorter period for the market.

1.3.2.3 Environmental context

This study will assist in determining whether there are any South African growth mediums alternatives and whether the carbon footprint of the growth mediums can be reduced by using the most suitable mediums for container cyclamens. The study will also help to determine whether South Africa cyclamen growers can reduce the importation of growth mediums for container cyclamen production.

1.4 Research aims and objectives

The first research objective was to determine the most suitable growth mediums for container cyclamens grown in a controlled environment. To do this, plant parameters were compared for container cyclamens grown in various growth mediums. A visual measuring instrument with specific and relevant evaluation criteria was created for measuring plant parameters. The second research objective was to establish a measuring instrument to be used during the study to compare the different plant parameters for cyclamens in different growth medium. The third objective was to establish the benefits to the commercial grower of utilizing the most suitable growth mediums for the commercial production of container cyclamens in a controlled environment. The forth objective was to determining whether the carbon footprint of cyclamen production can be reduced by using the most suitable and cost-effective growth medium for container cyclamens

1.5 Significance and contribution of the research

There are currently no comprehensive industry guidelines for South African cyclamen growers. This study will help to document cyclamen production practices and establish a set of guidelines for the South African environment. This will help commercial cyclamen growers to produce a cyclamen crop of high quality in South Africa.

1.6 Research problem and subproblems

1.6.1 Research problem statement

The following research problem was formulated:

How do the selected growth mediums for cyclamens compare in terms of plant parameters in the production of commercially grown container cyclamens in a South African context in a controlled environment?

1.6.2 Research subproblems

The following subproblems were derived from the problem statement:

- Subproblem 1: Creating a visual measuring instrument.
- Subproblem 2: Determining the most suitable growth mediums in the production of container cyclamens grown in a controlled environment.
- Subproblem 3: Determining how the commercial cyclamen grower would benefit by using the most suitable growth mediums in the production of container cyclamens.
- Subproblem 4: Determining whether the carbon footprint of cyclamen production can be reduced by using the most suitable growth mediums for container cyclamens.

Each of these subproblems translates into research objectives.

1.7 Research design and methodology

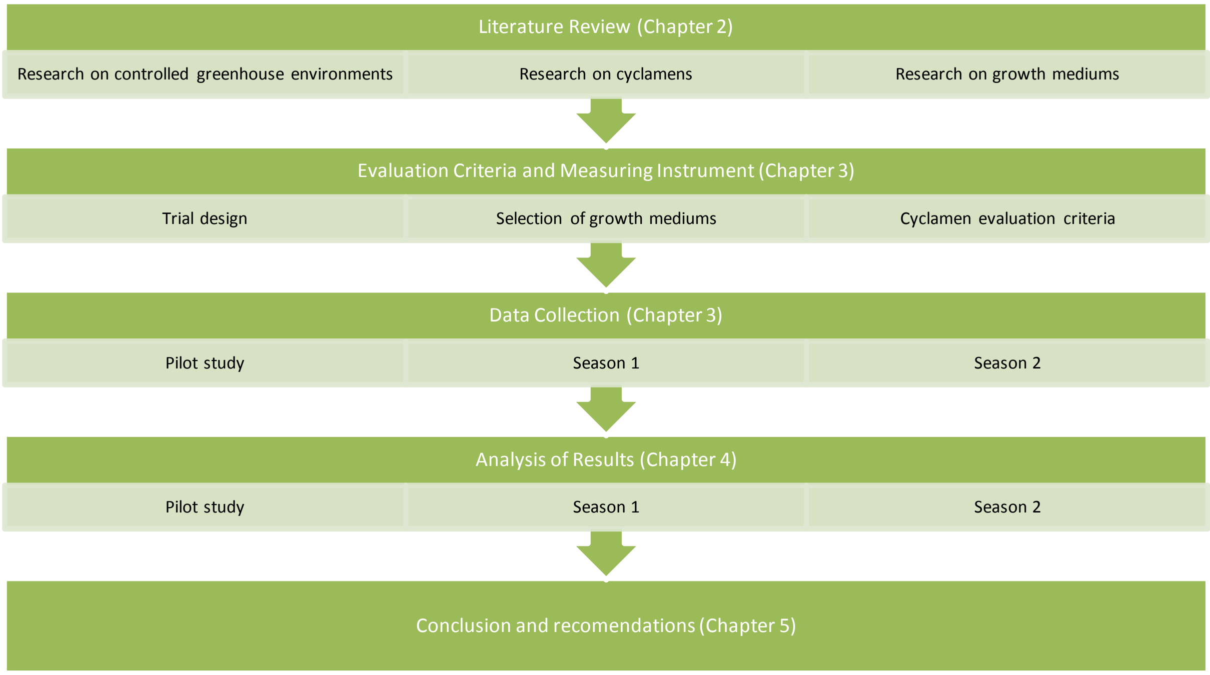


Figure 1.1 Research process

1.7.1 Literature review

In Chapter 2 the theoretical framework for the study is determined and this lays the foundation for the empirical research conducted. This section includes the discussion of the identified subproblems which are contained in the research problem.

1.7.2 Research methodology

The research design for this study is discussed in Chapter 3. The design is based on Pasteur's quadrant of the Stoke quadrant model of scientific research (1997). The research and development processes in this quadrant focus on the search for and understanding of basic research and the consideration of the utilization of the research.

Study was conducted were seven mediums are compared. The trials were conducted on growth mediums selected from the industry and being used by commercial growers in the production of cyclamens in South Africa during 2012 and 2013. The evaluation criteria for growth mediums were determined to develop a visual measuring instrument for the comparison of the cyclamen growth mediums. The experiments were conducted with the consent of Tuberflora management according to Unisa's ethics requirements.

1.7.3 Experimental design

Trials were conducted in a greenhouse on the premises of Tuberflora, a commercial wholesale nursery, located on a plot in Muldersdrift in Gauteng, South Africa. The greenhouse area of 3 072 m^2 (48 m x 64 m) was a pad and fan structure with double-layered clear plastic (polyethylene 200 micron x2). The climate control included a mechanized *40% filter* screen and plastics that allowed for manipulation of light intensity (ideal range *250 - 650 lx*). Temperature was a critical factor. It was essential to have a "cold house" during the production phase. This meant that cyclamen cuttings were transplanted at a cooler temperature during the warm December summers of Gauteng (temp max 39 ˚C using the HUATO S100-TH+ Mini Temperature, humidity and dew point data logger).

The trials were arranged in a randomized complete block design with seven pre-selected growth mediums treatments as suggested by Whitcomb (2003:443), Nelson, Pitchay, Niedziela and Mingis (2010:335) and Widmer (1972:104). There were five plants, each label are randomized place in four blocks in between normal production and two replications (seasonal commercial growth cycles) in a closed environment. The study therefore included a total of 105 plants per replicate are measured and a total of 210 plants over the entire project. See Figure 3.2 and Table 3.1

1.7.4 Plant population

There were 210 plants in the trial. The focus was on only one variety of cyclamen for a homogeneous plant population. It was decided to focus on *Cyclamen persicum* F1 standard, variety Grandola Deep Rose, ref. 20110513.0040, supplied by Hem Genetics.

Each trial container cyclamen was clearly marked with a sticker indicating the plant as part of a trial and not to be sold commercially.

1.7.5 Growth mediums

The growth mediums used for the study are listed in Table 1.2.

Table 1.2 List of growth mediums

Growth mediums	
Mix 1: Cyclamen Mix	This mixture is imported from the Netherlands and commercially sold on the market as a cyclamen mix and is supplied by MEEGAA. It consists of 50% peat moss, 35% coir, 15% perlite and 3 kg Osmocote (16/18 per m^3).
Mix 2: 50% Cyclamen Mix and 50% 45 Mix	This mixture consists of a 50% mixture of the MEEGAA Cyclamen Mix and 45 Mix.
Mix 3: 49 Mix	This mixture is commercially sold on the market as 49 Mix and is supplied by Culterra. It consists of 80% pine bark and 20% coir.
Mix 4: 45 Mix	This mixture is commercially sold on the market as 45 Mix and is supplied by Culterra. It consists of 60% pine bark and 40% coir.
Mix 5: 7 Mix	This mixture is commercially sold on the market as 7 Mix and is supplied by Culterra. It consists of 100% pine bark.
Mix 6: 100% Coir	This mixture consists of 100% coarse coir.
Mix 7: Klasmann 100% peat Substrate 4	This mixture is imported from the Netherlands and is supplied locally by Greenhouse Technologies. It consists of 100% peat. The mixture includes a wetting agent (K–hydro) and extra trace elements 1 EC fertilization.

1.7.6 Data collection

The process of collecting the data was done according to the following guidelines:

- Temperature and humidity were recorded with a data logger on an hourly basis using the HUATO S100-TH+ Mini Temperature, humidity and dew point data logger.
- Light intensity was measured and recorded hourly using a lux data logger TENMARS Data logger light meter TM-203.
- Watering and fertilizing were done as per the programme Annexure H.
- The growth mediums analysis was conducted by Eco Analytica (North West University) Annexure D. The water nutrients were recorded at regular intervals using an EC meter OAKTON Multi- Parameter PCTestr 35 and were administered with the Dosatron D3GL2 system.
- A pest and disease management programme was designed specifically for the cyclamen production, i.e. AVONROD Plant Protection Annexure F, as used by Tuberflora.
- The measuring instrument developed as an evaluation tool was used for the visual observation and measurements of the cyclamens See Table 3.3.
- The visual observations and measurements were recorded over two seasons 2012 and 2013 discuss in Chapter 4 see Table 4.2, 4.3 and 4.4.

The effects of growth mediums were compared on selected plant parameters using the measuring instrument established by identifying evaluation criteria from existing literature sources for cyclamens from season 2012 and season 2013.

1.7.7 Measuring instrument

The measuring instrument criteria included the following measurements and observations: total plant height, plant diameter, fresh plant mass, number of leaves, leaf width, foliage fresh weight, number of flowers, diameter of corm, and root mass.

1.8 Research results and analysis

The results and analysis are discussed in Chapter 4.

The results from the growth mediums comparison for seasons 1 and 2 were analysed and expressed in mean values for each measured variable, and clustered according to production weeks at seven-week intervals, for each of the seven growth mediums mixes. A statistical comparison was made using parametric of the visual measuring instrument for cyclamen growth and non-parametric methods to compare the means in order to identify which mix differed significantly. Explanations were then given for the statistical comparisons.

It became evident during the study that Mix 1 and Mix 7 performed the best as growth mediums for container cyclamens in a controlled environment.

1.9 Conclusions and recommendations

Chapter 5 presents the final conclusions that can be made from this research project. It can be concluded that Mix 1 and Mix 7 are the most suitable growth mediums for container cyclamens for commercial production in a controlled environment. .

1.10 Technical aspects

1.10.1 Reference and citation management

In this section, the reader is given general guidelines on the reference methods and technical layout used in this dissertation. The reference methods applied were derived from using the software programme Refworks, an online reference and citation management resource. It was decided to use the reference output style Adapted Harvard, as prescribed by supervisors and endorsed by the language editor.

1.10.2 Technical care

The dissertation was compiled by using the guidelines given in the Unisa Procedures for Studies for Master's and Doctoral degrees, dated 15 June 2011, Part 5. The thesis was typed, as recommended, with a two-centimetre margin on the left and a one and a half line spacing.

The next chapter covers the literature review for the study.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Container cyclamen *(Cyclamen primulacea)* produced in a controlled environment in South Africa forms part of the winter commercial crop as a cold season plant. Cyclamens are traditionally known as a Christmas crop in the northern hemisphere (Boodley & Newman, 2009:449). They have only recently become an important cold season crop for the South African market.

According to Nell and Barrett (1990:311), until the late 1970s limited research had been conducted on flowering container plants. Publications on cyclamens in general start appearing from 1898 and the production of cyclamens appeared from the early 1950s onwards (The Cyclamen Society, [2013b]:1). Widmer (1972:108) can be credited with publishing the first English scientific research on cyclamens and the comparison of growth mediums in a scholarly journal. Subsequently, more research has been published but on a limited scale regarding the comparison of growth mediums for cyclamens. A limited number of articles on this comparison were retrieved during the literature review for this study, but no articles reported suggestions for growth mediums for the South African environment and circumstances. A lack of scientific journal articles on the production of cyclamens in industry, made it difficult to use as recommendations for the study. A large amount of the information on cyclamen production was located in trade journals and other resources such as Internet websites. Although the information lacked scientific basis, it was deemed sufficient to use within this study.

Cyclamens have acquired the international reputation of being a difficult and demanding ornamental horticultural crop to cultivate and require advanced growing skill and competency to cultivate the successfully for commercial purposes (Beytes & Hamrick, 2003:325; Onofrey, 2000:73). It is suggested that this reputation was established mainly due to difficulty in successful crop cultivation, lengthy production time and high production costs (Beytes & Hamrick, 2003:325; Boodley & Newman, 2009:449). Growing quality container cyclamens in a controlled environment has become a scientific endeavour where technology is indeed harnessed intensively.

The production of cyclamens as a winter crop requires an experienced dedicated grower, dedicated resources such as specialized growth specifications, dedicated production space, specialized growth mediums, a disease and pest management programme and a specialized fertilization programme. Cyclamens have a long growing season of 17 weeks in a production house and are considered an expensive commercial cold season crop to cultivate (Mascarini, Goldberg, Landini, Orden, Vilella & Mascarini, 2001:157; Boodley & Newman, 2009:449).

Many cold season horticultural products such as cyclamens and primulas, although expensive, can be considered an important means of sustaining the income in a commercial wholesale nursery during the cold season. The demand in South Africa for container cyclamens justifies the venture for commercial container cyclamens. Cyclamens are considered an essential plant at Tuberflora and the sales during the cold season indicate increased demand for the next growing season and usually good sales. Although cyclamens are an exotic plant in South Africa, they are considered an important ornamental horticultural plant for the commercial market during winter and a very lucrative business for wholesale nurseries during the winter months. Subsequently, Tuberflora depends largely on the production of cyclamens during the cold season, as an ornamental horticultural product, to supply the South African market with produce and therefore to supplement the summer or hot season income. There are currently only a few wholesale nurseries successfully providing the South African market with container cyclamens. Tuberflora roughly represents 30% of the container cyclamen market in South Africa. The quality, quantity and market timing of the commercial container cyclamens, as a product, ultimately determine the competitive edge in the cyclamen market. These factors will determine whether the crop is lucrative enough to warrant the production of an expensive cold season crop. The present economic scenario dictates that many commercial nurseries economize and focus on more cost-effective production strategies. These strategies involve the cost-effective utilization of available greenhouse production space and of the best quality growth mediums for propagation at competitive prices.

2.2 Controlled environment in greenhouse structures

Controlled greenhouse structures provide the commercial grower with the possibility of producing a large horticultural crop with increased predictability (Giacomelli and Robert, 1993:50). According to Adams, Bamford and Early (2008:12), the advantage of growing a crop in a closed environment, is that growth is maximized by using supplementary light and shade.

The following key principles need to be taken into consideration in a controlled environment:

- Water in a greenhouse structures is considered to be one of the challenges facing a grower in a greenhouse structure. Allen Hammer (2003:83) suggests that there is a science to understanding the relationship between the growth mediums and the application of water to a crop. The right amount of water should be applied at the right time. The site should have access to large volumes of high-quality water. It is also expected that the water should be tested for suitability to grow crops of a high standard. It should also be tested for salinity, alkalinity, pH, hardness, electrical conductivity and mineral content.
- The location of the greenhouse structure is important and would need to be planned carefully. Koske, Hall, Hinson, Pollet and Sanderlin ([s.a.].:4) indicate that the greenhouse structure should be located away from buildings and trees that could shade the structure.
- There are a variety of different structures: gutter-connected greenhouses, A-frames, sawtooth, cold frames, poly tunnels and hot beds to control the environment for

propagation. The crop to be produced would determine the structure to employ as a controlled environment. (Grosser, 2003:7)

- Coverings of such a structure are made of various materials such as polyethylene, fibreglass, reinforced plastic and glass. Each type of covering offers advantages and disadvantages. According to Thompson (2003:3), the materials of the greenhouse structure would determine the greenhouse production costs.
- The heating of greenhouse structures is considered essential to optimize the production of the crop (Rearden, 2003:123). This is usually done burning sun (solar heat) and by fossil fuels such as coal and electricity. All external variables need to be taken into consideration when deciding on the heating of the greenhouse structure.
- Ball (2003:120) and Short (2003:115) consider ventilation in cooling of structures to be essential for ensuring optimum plant growth and quality. Ventilation maintains the temperature, humidity and carbon dioxide levels. The cooling of structures can be done by natural ventilation, fogging systems, pad and fan ventilation, horizontal airflow systems and winter cooling and dehumidifying systems.

Taking all the above mentioned principles into consideration in a greenhouse structure, the grower is able to create a favourable controlled environment in which to grow a commercial horticultural crop. Giacomelli and Roberts (1993:50) suggest that greenhouse structures that are well-designed for maximum efficiency and to be cost-effective, help to predict and achieve a quality crop.

2.3 Growth mediums

Soil was traditionally seen as the essential requirement for a plant to grow (Brown, 2002:139). With the advent of technology and new advances in research, soil is no longer the only growth medium in which ornamental horticultural crops are grown. It is, however, necessary to investigate the role of soils in the growth of a plant.

2.3.1 Soils

Soil is considered an essential requirement for a plant to grow as it provides the plant with anchorage and adequate oxygen, nutrients and water (Brown, 2002:139). Soil was traditionally used as a growth medium in the horticulture industry to produce ornamental crops. However, the maintenance of soils as potting mixes proved to be problematic. These problems included being able to ensure the consistency of the soil quality. There was also inadequate access to a supply of good top soil. It soon became known that potting soil mixes with more than 30% soil resulted in poor aeration and poor water availability (Handreck & Black, 2002:131; Boodley & Newman, 2009:201).

2.3.2 Functions of growth mediums for the horticulture industry

Growth medium plays an essential role in the growth of plants and has various functions. These functions include:

- Mechanical support of the plant for plant stabilization.
- Stores minerals for plant nutrition.
- Stores water for the plant.
- Serves as a home for living organisms. (Boodley & Newman, 2009:181)

Various strategies are needed to ensure that the growth medium creates the best environment for the plant to grow. These strategies include sterilization and pasteurization techniques.

2.3.3 Sterilization and pasteurization of soils

Soil growth medium mixtures require sterilization and pasteurization in order to create an environment conducive for growing and to prevent soil-borne diseases.

2.3.4 Artificial soil as a growth medium

Whitcomb (2003:457) describes a growth medium as a soilless, artificial mixture of a pure material, e.g. pine bark or peat moss, which is used for growing plants in containers.

2.3.4.1 The need for artificial growth medium

Soil-based potting mediums could not satisfy the needs of the horticulture industry as technology advanced. The development of artificial growth mediums became necessary and was an attempt to solve problems experienced by growers and the inadequacy of soil as a growth medium. Artificial soils, as a substitute for soil growth medium, became a necessity for successful growing in the horticulture industry. Growth medium is the accepted term for all traditional and artificial growth medium. This study will therefore refer to “growth medium” (Boodley & Newman, 2009:201).

2.3.4.2 Advantages of artificial growth mediums

The advantages of artificial growth mediums are as follows:

- The materials in the growth mediums have known properties and the grower is aware of these properties.
- The growth mediums are generally easy to use.
- A recipe is used during the preparation of the growth medium, making the medium consistently uniform across seasons.
- The materials as content in the growth mediums, are readily available to the plant.
- The materials have low nutrient levels and therefore allow for the addition of fertilizers to specifications.
- The costs involved in preparing an artificial growth mediums are lower than in preparing soil mixes.

- Artificial growth mediums often do not require sterilization and pasteurization as do soil mixes.
- Artificial growth mediums allow for drainage and aeration, which support good root growth.
- The grower is always aware of the content in soil mixes and artificial growth mediums and this gives consistent results. It therefore allows the grower control over the production of a crop (Boodley & Newman, 2009:201).

In essence, artificial growth mediums eliminate the problems posed by soil as a growing substrate and present known variables into the equation.

2.3.4.3 Content of artificial growth mediums

Beyl and Trigiano (2008:48) mention various materials which are often used in artificial growth medium mixtures.

The types of materials usually found in growth mediums include bark (includes wood by-products), peat, coir, perlite, vermiculite and composts with organic waste. Table 2.1 gives a summary of the content of various growth mediums with specific mention of the origin, pH, aeration porosity (v/v), organic matter, water-holding capacity, nutrient value, slats, size, weight, sustainable resource and availability.

Table 2.1 Summary of growth medium materials as growth medium content (Beyl & Trigiano, 2008:48; Handreck & Black, 2002:122)

Growth medium materials	**Bark**	**Peat**	**Coir**	**Perlite**
Origin	Lumber industry in South Africa	Cool climatic swampy areas in Canada, Northern Europe and Russia	Coconut plantations from tropical areas outside South Africa	Crushed aluminium silicate volcanic rock

pH	3.8 to 6.5 However, 5.0 to 5.5 is usually used	Young peat = pH of 3.5 to 4.0 Old peat = higher pH values	Varies from 5.6 to 6.6 with a mean range of 6.2	Very close to neutral but can vary from 6.5 to 8.4
Aeration porosity (v/v)	30% to 40%	30%	9.5% to 12.5%	High porosity – sealed internal air spaces and increased pore spaces
Organic matter	High percentage organic	90% organic comprising decomposed residue of mosses, reeds and sedges	High percentage organic – wastes of coconut husks	Non-organic
Water-holding capacity	Low Open structure and allows water to run freely	High Holds 10-20 times its weight in water	High	Low Water drains freely
Nutrient value	Low	Little to no nutrient value	Little to no nutrient value	No nutrient value. Is sterile
Salts	Low in salts	None	Soluble salts depend on source	None
Size	0.6 cm to 1 cm mesh scale	n/a	0.05 cm to 0,4 cm	Course grade recommended for propagation purposes
Weight	Light (3 to 4 times the weight of peat)	Very light	Light	Very light
Sustainable resource		Non-renewable resource and limited sustainability		
Availability	Locally available in South Africa	Not locally available in South Africa but imported via suppliers	Locally available from suppliers in South Africa	No locally available in South Africa but imported via suppliers

Growth mediums have different components which give the different biological, physical and chemical properties (Sittig, [2012]:1):

- Biological properties include that the medium is weed free, consists of stable organic material that does not decompose much further and has no pathogenic microbial life.
- Physical properties are that the medium has air-filled porosity (AFP), which is a measure of the amount of air in a potting mix. The AFP is influenced by the size and depth of a container. Water-holding capacity is the medium's ability to hold water. It refers to the number of pores in a medium which can be filled with water. Bulk density refers to the weight of the medium per volume. The higher the bulk density, the heavier the medium will be and the less space will be available for air and water. Shrinkage in a medium of high organic matter, such as sawdust and bark, can be high due to the composting process that continues in the container. Using a stable medium like peat, coir and perlite avoids shrinkage. The wetting and rewetting ability of medium differs. Organic matter in a potting mix such as sawdust and bark is hard to wet and rewet once it has dried out in a pot. Adding coir and peat to bark mix can improve the wettability of the medium.
- Chemical properties determine whether or not the roots are exposed to a suitable concentration of nutrient elements. The pH of the medium is important to determine the solubility and availability of plant nutrients. Electrical conductivity (EC) measures the amount of salts and nutrients in the medium. The cation exchange capacity (CEC) refers to the medium's ability to hold and release nutrients to the plant, and the carbon to nitrogen ratio (C:N ratio) indicates the possibility of the mediums to decompose which causes physical, volume and aeration changes. Mediums such as sawdust and pine have a high C:N ratio.

Laiche and Nash (1986:24) suggest that the availability of material for growing mediums in large quantities is considered fundamental to the Horticulture Industry. The study suggests that a decrease in the organic material and the increase in the price for organic material for growing medium can create the need to source alternatives for growing mediums.

It was decided to focus on bark, peat, coir, combination of coir, peat, perlite mixture and bark coir mixture for the study on the comparison of growth mediums for container cyclamen production.

2.4 Cyclamen

Cyclamen primulacea are herbaceous tuberous perennials which form part of the primrose family. Cyclamens originate from the Mediterranean and central region of Europe and grow naturally in Turkey, Greece, Israel, Syria and Palestine, as well as the Mediterranean islands of Sicily, Cyprus and Rhodes (Morel, 2012:1). The word "cyclamen" is taken from the Greek word *kuklaminos* which is derived from *kuklos* (Morel, 2012:1), meaning "circle", and refers to the tuber/corm which is round and flattened. The cyclamens generally used for cultivation as horticultural crops are *Cyclamen persicum.* Its description differs from the species growing naturally. The "wild" cyclamen have larger flowers with varying shades of colours. The wild cyclamen flowers are usually white, even with light pink or darker pinks. A darker cerise pink colour occurs naturally on the island of Karpathos. The habitat of the "wild" cyclamen includes rocky hills, woodland, abandoned olive groves and graves in old Turkish cemeteries. Cyclamens grow at various altitudes and occur from sea level to a height of 1 200 m (The Cyclamen Society, [2013a]:1).

There are various theories as to when cyclamens were introduced to Europe but the estimation is between the 16th and 17th centuries. Although neglected during the 18th century, cyclamens became a favourite in France, England and Germany during the 19th century (Morel, 2012:1).

Cyclamens have a rounded corm with a flat appearance. Light or dark angular green leaves with mottled greyish irregular spots on the top section of the leaf grow upwards from the corm. The petiole bears a single flower. The colour of the leaves and the flower depends on the variety. The cyclamen flower can last up to four weeks after cutting and is a popular cut flower in Europe (Boodley & Newman, 2009:449). It seems that the container cyclamens are popular. Most of the literature refers to the production of potted or container cyclamens rather than as cut flowers.

2.4.1 Cyclamens as an ornamental horticulture crop

Various growing guidelines are available for the commercial cultivation of container cyclamens which originate from commercial seed suppliers such as Goldsmith Seeds, representing research from the USA and the Netherlands (Goldsmith Seeds, 2008:15; Syngenta, 2011:1).

Despite these growing guidelines, South Africa does not currently have published guidelines in either trade or scholarly literature that is specific to the South African environment. Raviv and Lieth (2007:557) emphasize the importance of choosing the appropriate growth mediums for a specific crop and a specific environmental condition. Tuberflora has experienced that the desired results as predicted by the growing guidelines are not always realized by growers where the environmental conditions are not similar to those described in the growing guidelines. In South Africa, each commercial nursery adheres to its own in-house production strategies which have been adapted from various sources. These strategies are a combination of the existing international guidelines available in literature, formal and informal consultations, advice from commercial cyclamen consultants, in-house experiments and experience. Essentially the growing guidelines and production strategies are important to the success of the cold season crop and are crucial in ensuring the quality, quantity and market timing of the commercial container cyclamen crop. Raviv and Lieth (2007:557) suggest that most research embarked on comparing growth medium does not emphasize the economic consideration of the results and therefore does not result in economically viable options for commercial growers to use during production.

The production strategies and growing guidelines are considered the most crucial in cultivating container cyclamens. An attempt is made in the section below to highlight the growing guidelines and production strategies deemed the most important for Tuberflora during the commercial cultivation of container cyclamens.

2.4.1.1 Temperature ranges

The temperature range that needs to be maintained in the greenhouses, according to literature, is 16 to 22 ˚C (Boonstra, 1985:12; Beytes & Hamrick, 2003:325; Goldsmith Seeds, 2008:14; Boodley & Newman, 2009:449). Most of the literature is a reflection of either European or American environments.

Tuberflora has determined the critical temperature range, by trial and error, which is suitable for the South African environment. This is a range of 6 to 40 ˚C within the South African climate.

2.4.1.2 Pest and disease levels

It is essential to combat pests and diseases and to maintain low levels of these in the greenhouse. Cyclamens are prone to the following diseases: botrytis, fusarium, erwinia, cylindrocarpon (nectria) and gloeosproium (Goldsmith Seeds, 2008:15). Cyclamens are prone to the following pests: aphids, thrips and cyclamen mites (Goldsmith Seeds, 2008:15).

Tuberflora has a dedicated greenhouse for the exclusive production of commercial container cyclamens. Each growing season starts with a strict sanitizing regimen to eradicate all possible pests and diseases. A pest and disease maintenance regime, along with sanitation strategies, is adhered to. All equipment and the greenhouse are sanitized, workers in the greenhouse are required to wash their hands, ground covers are cleaned, new containers are used. The ultimate aim is to prevent contamination.

2.4.1.3 Growth mediums

Cyclamens have been produced commercially at Tuberflora for the last ten years. In the short history of cultivating commercial container cyclamens, Tuberflora has changed the regimen several times in order to find the most suitable growth mediums for the container cyclamens. During the ten years the search for the “right” medium has become a strategic priority due to cyclamen production at Tuberflora providing the main source of income during the cold season months (May-July). Plant quality is dependent on the production process and the choice and quality of growth medium are of cardinal importance. It became necessary to adapt the existing international growth mediums guidelines to the South African climate and environment. The various growth medium experiments remain an in-house venture and the results are rarely recorded correctly and published, as this is seen as a competitive advantage. It remains grey literature only available to the growers at the nursery. The cultivation of cyclamens occurs in silos and information is rarely shared with other growers and it becomes a strategic tool in the production process. The problem is compounded by internationally suggested growth mediums not being freely available in South Africa. These growth mediums are expensive to import and are not readily available locally to purchase when there is an increase in demand for the growth mediums at short notice.

McMahon, Kofranek and Rubatsky (2002:293) suggest that the choice of growth medium for container production should receive primary attention. Using the right medium allows a commercial nursery to supply quality cyclamen plants to the market sooner, thus gaining a competitive edge for sales. The growth medium therefore plays an important and essential role, as a quality medium makes the plant grow faster, reach maximum height and volume earlier in the growing season and start flowering sooner. The maximum number of flowers is an indication of good quality for the market and flowers indicate readiness for market.

In this research it was decided to focus on the problem that growth mediums present to a commercial wholesale nursery and the additional challenge of keeping the cost low while using the best quality of locally available growth mediums for cyclamens. As a commercial grower, Tuberflora endeavours to source and acquire the best growth mediums at a good price while sales are down for container plants during the cold season and therefore lower income is generated then. It is essential to keep costs low while supplementing income during the cold season. Therefore, the growth medium mixture must not only be cost effective on a large scale, but also of high quality to ensure the best production of container cyclamens. An additional priority is to cultivate a flowering cyclamen of the best quality ready for market as soon as possible for a competitive edge and to have stock available first for the market during the winter.

2.4.2 Growth mediums available in South Africa for cyclamen production

This section covers a variety of growth mediums commercially available for cyclamen production in South Africa.

There are a few local suppliers of growth mediums deemed suitable and indeed in use by cyclamen growers in South Africa. These growth mediums include a variety of mixtures. Culterra supplies mostly pine bark, coir and various combinations of the two to the local green industry for growth mediums. Examples of these mixtures include 7 Mix, 45 Mix and 49 Mix. 7 Mix consists of 100% pine bark. According to Laiche and Nash (1986:22), 100% pine bark is a typical growth medium easily available on the local South African market. 45 Mix consists of 60% pine bark and 40% coir. The ingredients of this mixture are readily available in South Africa and can be sourced easily on the market. It was decided to select 45 Mix as the control growth mediums for this study, as it had been in use for cyclamen production at Tuberflora for the last two growing seasons, 49 Mix consists of 80% pine bark and 20% coir. The ingredients of this mixture are readily available in South Africa and on the market. The combination is regularly used as a growth medium in commercial nurseries. Studies by Beyl and Trigiano (2008:48) and Flores-Almaráz, Livera-Muñoz, Colinas-León, Gaytán-Acuña and Muratalla-Lúa (2008:309) suggest coir as a growth medium.

There are commercial growth medium mixtures imported by local suppliers for the green industry for specialized horticulture production. Examples of these growth medium producers are Klasmann and MEEGAA. These growth mediums have specialized growth formulations for specific plant products. The Klasmann TS 4 growth medium mixture was introduced to local suppliers and distributed locally by Greenhouse Technologies, during 2011 for use in the green industry. This imported peat mixture consists of white peat fibres (0-25 mm) and white sod (10-25 mm) peat from Lithuania. The mixture includes wetting agent (K–hydro), extra trace elements 1 EC fertilization and has a pH of 6 (Klasmann, 2012:4). There is one growth medium marketed as a cyclamen mix which has been specifically designed for cyclamen production. The Cyclamen mix consists of 50% peat moss, 35 % Coir, 15 % perlite and 3kg Osmocote (16/18 per m^3). This growth medium by MEEGAA Substrates ™ is supplied locally to South African growers by ALWECO™. These two growth mediums are imported mixtures from Europe and introduce extra cost to production expenses as the growth medium is expensive in relation to the other locally available growth mediums (Klasmann, 2012:4).

2.4.3 Container cyclamen production at Tuberflora

The section contains an overview of the entire production process of the container cyclamens at Tuberflora see Figure 2.1. The production cycle consists of the following phases:

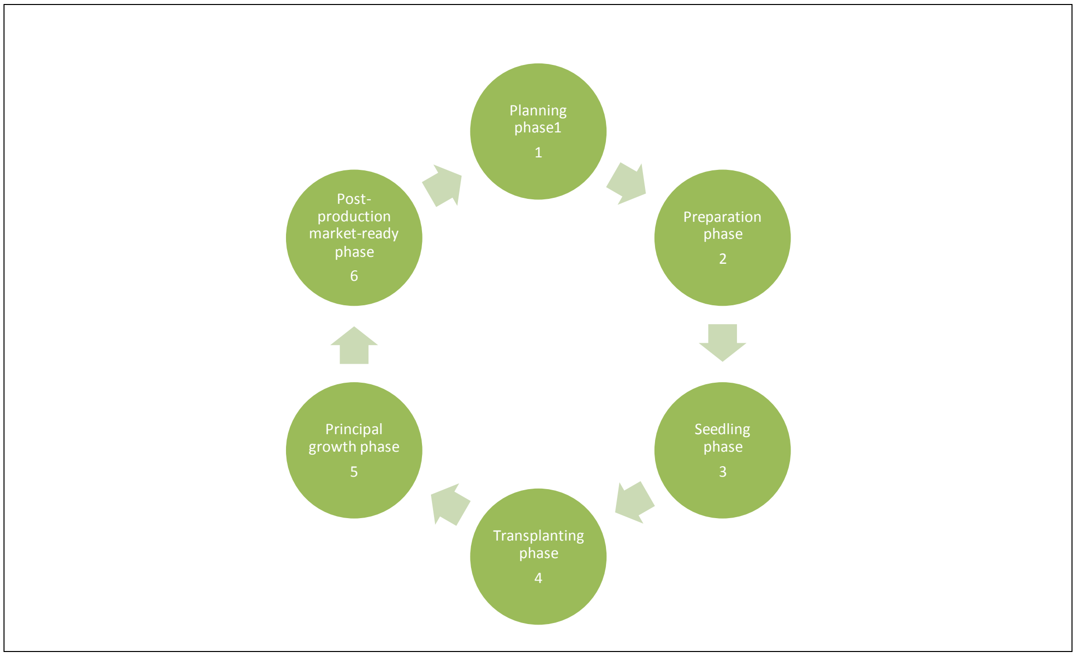


Figure 2.1 Container cyclamen production phase at Tuberflora

2.4.3.1 Planning phase

This phase includes looking at crop size (total number of plants for production), market trends (suitable pot size, new varieties – fashion colour), consignments and orders for the season, budgetary planning, resources planning and production scheduling (timing for market, e.g. Mother's Day).

The planning of the production schedule is crucial and it entails planning the various phases in the production cycle. It includes the schedule for sourcing and purchasing seeds, germinating seeds, transplanting the plants. The production schedule is divided into weeks (52 weeks in a year) and the production schedule starts at week 1 for 1 January and continues to week 52 at the end of December of the same year. Production of cyclamen takes 21 weeks start from week 49 till week 17 of the next year. See Table 3.1

2.4.3.2 Preparation phase

The preparation phase entails the physical preparation of the resources and equipment used in the production of container cyclamens. The greenhouse is prepared for the new season of cyclamen production. This involves the physical production space that will be required. The entire production area is sterilized. See Figure 2.2.This includes the sides, roof and ground covers of the greenhouse. Ground covers, which are used continually, are cleaned and sterilized at the beginning of each production cycle with a solution of 500 ml of BIOX per 100 ℓ of water. Ground covers are replaced when needed based on wear and tear. Cyclamen specialists, Landelijke Cyclamencommissie, in the Netherlands, place a high premium on production hygiene and suggest that prevention is the best strategy (Landelijke Cyclamencommissie, 1997:5).

Figure 2.2 Cyclamen production greenhouse in preparation phase at Tuberflora

2.4.3.3 Seedling phase

The production schedule for the seedling phase starts at week 38 (average) and continues until week 50 (average). The seeds are purchased from Floriseeds, suppliers of

Hem Genetics's cyclamen seeds, which supplies certified seed varieties in South Africa. The cyclamen seedling phase is the responsibility of the seedling grower at Tuberflora. The seeds are sown in 128 cavity trays in a seedling greenhouse, in cyclamen seedling growth medium on premises at Tuberflora. The seedling growth medium mixture used at Tuberflora consists of the following ratios: 45% coir, 28% peat moss and 27% perlite or Klasmann plug mix. The cyclamen seeds are germinated under specific conditions according to the seed supplier and international growing guidelines. As see in Figure 2.3. The guidelines stipulate that a specific fertilization regime be followed and the plants be irrigated on a daily basis as needed. Specified temperature ranges are adhered to, which are from 16 to 26 ˚C. The guidelines suggest a pH range between 6 and 6.8 (Beytes & Hamrick, 2003:325; Goldsmith Seeds, 2008:14; Boodley & Newman, 2009:449; Hem Genetics, 2012:1). The seedling cyclamens are ready for transplanting once the seedling plants have well-established roots.

Figure 2.3 Cyclamen plants in seedling phase at Tuberflora

2.4.3.4 Transplanting phase

The production schedule for the transplanting phase starts at week 51 to 52 (average). The pots are filled with the desired growth medium. At Tuberflora, a pH of 6 is considered necessary for the production of container cyclamens. This is within the range given in the literature for the production of cyclamens (Beytes & Hamrick, 2003:325; Goldsmith Seeds, 2008:14; Boodley & Newman, 2009:449; Hem Genetics, 2012:1). The growth mediums are saturated with water and the seedling cyclamens are planted in the 3 cm handmade holes in the growth medium. The rooted cyclamen seedlings are moved from the seedling greenhouse to the prepared and sterilized cyclamen production greenhouse for transplanting. As see in Figure 2.4.The seedling cyclamens are transplanted manually from the 128 cavity trays to the black 12 cm pots. The plant density is determined by the spacing of the transplanted plants and covers an area of 40 pots/m^2; therefore 2 720 pots per growing area.

Figure 2.4 Cyclamen seedling plants ready for transplanting

The watering regime for the next two weeks consists of water only to help the plants adapt to the new growing environment and establish. Water for irrigation is sourced from a dedicated storage tank outside the greenhouse connected to a Dosatron system. Watering is done manually by hosepipe as part of the Dosatron system on a daily basis. No EC programme is followed during the transplanting phase as only clean water is prescribed during the watering regime.

The roof screen is kept closed for this entire phase so that the light intensity is kept within a specific range (below 650 lx). Care is taken to work within a sterilized environment where hands and equipment are clean and free of contamination. A strict no fertilizer watering regime is conducted.

The plants are drenched with a solution of 200 ml of Previcure N per 100 ℓ of water. This solution ensures the recovery of plants and promotion of root establishment and prevents disease. At Tuberflora the ideal temperature ranges are 19 to 21 ˚C. An average of 20 ˚C is prescribed by growing procedures during these two weeks (WellGro Horti Trading, 2011:2). During the transplanting phase it is essential to reduce the temperature in the greenhouse to between 6 and 22˚ C and to keep it within a specific range, in order for the transplanted cyclamens to establish in the new growing environment. Keeping in mind that the outside temperatures are very high during December, it is necessary to cool the greenhouse considerably to keep within the temperature ranges within the first two weeks.

2.4.3.5 Principal growth phase

The production schedule for the principal growth phase starts at week 1 (average) and continues until the plants are ready for market. During this phase, the flower spikes appear at six months after the seedling generation and the first open flowers appear three to four weeks after the flower spikes appear (*Flowering pot plants*, 1989:30). After the transplanting phase, see Figure 2.5 ,the container cyclamens enter the principal growth phase and the plant density in this phase is determined by the spacing of the established transplanted plants and covers an area of 25 pots/m^2.

Water for irrigation purposes is sourced from the Crocodile River following through the plot, which is pumped to storage dams at the production area. The cyclamen greenhouse has a dedicated storage tank outside the greenhouse connected to a Dosatron system. Watering is done manually by hosepipe as part of the Dosatron system on a daily basis.

Once a week, clean water without nutrients is applied to prevent a build-up of salts in the growth medium.

Figure 2.5 Cyclamen plants in principal growth phase at Tuberflora

Tuberflora consulted a commercial plant protection company, Avonrod Plant Protection, to assist in developing a specific disease and pest prevention programme for cyclamen production at Tuberflora.

An existing fertilization programme is adhered to which has been developed from practical experience and consultation. The EC is measured regularly on watering and an EC reading of 1.2 is considered the ideal EC reading for container cyclamens. Handreck and Black (2002:171) suggest that the best fertilizer programme must be found to suit each species best. McMahon *et al.* (2002:294) claim that EC monitoring in greenhouses helps the growers to make informed decisions about fertigation concentrations, water frequencies and leaching rates. Therefore tracking the EC helps produce superior crops with lower leaching rates and therefore less environmental contamination.

Considerable care is taken to keep the light intensity of the cyclamen greenhouse below 650 lx. Light intensity is measured daily with a lux meter. Temperature management of the cyclamen greenhouse is essential. Week 1 of the production schedule is considered a hot month and the temperature needs to be kept within the range of 6 to 40 ˚C. The temperature is measured daily and additional measures are employed to keep the temperature within the prescribed ranges. The measures include utilizing the pad and fan system, where the fans are started when temperatures increase.

2.4.3.6 Post-production market-ready phase

The post-production market-ready phase starts when the container cyclamens start flowering. Generally when two to six open flowers are present the container cyclamens are ready for the market (Beytes & Hamrick, 2003:327; Nelson *et al*. 2010:354). The container plants are withdrawn from the growing area. Container plastic wrap is placed on the container cyclamens, which are placed on trolleys for removal out of the production greenhouse. See Figure 2.6.

Figure 2.6 Container cyclamen plants ready for market at Tuberflora

2.5 Environmental responsibility and carbon footprint

Climate change is a reality to all – producers, retailers, wholesalers and consumers. The reality of responsibility towards the environment within the horticulture industry has brought about new research being conducted internationally on the effect of horticultural practices and how these affect the environment. Carbon footprint is a concept which encapsulates the human effect on the environment. The need to develop methods of assessing and reducing the carbon footprint in the horticulture industry has become important.

2.5.1 Existing protocols for horticultural carbon footprint

The imperatives to determine and reduce the carbon footprint within the horticulture industry, has produced various protocols and guidelines for all stakeholders in the industry. The PAS2050 Protocol was developed by the British, while the Dutch produced the DHCF2009 Protocol as an alternative to supplement identified gaps (Productschap Tuinbouw, 2009:3). The aim of these protocols was to develop ways of calculating the carbon footprint of specifically horticultural products and to establish best practice regarding reducing the carbon footprint. Similarly, the Australians initiated research with the HAL discussion paper 2 on reduction, mitigation, emissions trading and marketing, to establish the carbon footprint of horticultural products (Deurer, Clothier & Pickering, 2008:2). The focus was on the vegetable industry primarily because of the intensive horticultural practices and higher use of fertilizers. The sophistication of the production practices allows for opportunities to reduce the greenhouse gas emissions and therefore reduce the carbon footprint (Deurer, Clothier & Pickering, 2008:2).

Currently, there are no protocols available for the green and horticulture industries on calculating and reducing the carbon footprint in South Africa. There is clearly a need for such protocols.

2.5.2 The sustainable use of peat as a growth medium

In the literature, using peat as a growth medium is listed as a major concern regarding carbon footprints. The Factsheet for Low Carbon Horticulture (Soil Association, [s.a.]:2) indicates that peat extraction leads to loss of biodiversity and an increase in carbon emissions. The suggestion for low carbon practices is to use alternatives as growth medium such as wood fibre and coir.

According to Clarke (2005:163), the “Wise use” campaign for peat use in the Horticulture Industry is an important step towards the sustainable use of peat. Priority given for countries where peat is extracted to adheres to strict legislation and restoration practices. The companies extracting peat should do it in a responsible and sustainable way.

Growers widely use peat and peat mixtures in the production of greenhouse crops (Caron & Rivière, 2010:68; Rivière, Morel, Michel & Charpentier, 2005:33; Adlam, Rainbow, Wallace & Rayment, 2004:2). Peat has a combination of physical and chemical attributes which make it such a widely used growing medium. The physical attributes include the storage and exchange of air-and-water while the chemical attributes include the pH, salinity and nutrient content

Caron & Rivière, (2010:69) suggest that the following criteria are essential for growing mediums to produce high-quality horticultural crops.

Peat or a mixture of peat as part of the growth mediums, is a favourite to use for the production of horticultural products internationally. Both Adlam, Rainbow, Wallace & Rayment (2004:2), and Clarke (2005:161) argues that peat is valued by the Horticulture Industry and give reasons for the sustained usage of peat by commercial growers. These reasons include:

- Peat is considered the most dependable substrate for production on industrial scale.
- Most growing medium available is a peat mixture.

- The physical and chemical attributes of peat are considered the reason why peat is an essential component of a growing medium. There is speculation that presently, there is no alternative growing medium to peat which can be utilized on an industrial scale and provide the same high-quality production results.

The use of peat as a growth medium has increased due to South Africa being part of the global economy and many products are readily available to use as growth medium. Chavez *et al.* (2008:8083) argues that high quality peat is available at a very high cost which makes it an expensive growing medium. Peat as a non-renewable resource is declining in availability. No new fields are allowed to be harvest from. This makes peat not only a scarce non-renewable resource but an expensive growth medium option.

This study made use of the seven growth mediums which are used as substrates in the greenhouse production of cyclamens internationally. Three of the growth mediums contain peat, an imported product, as it is not available naturally in South Africa (Widmer, 1972:108; Beytes & Hamrick, 2003:325; Onofrey, 2000:73; Boodley & Newman, 2009:449). The designer cyclamen growth mediums containing peat from Klasmann and MEEGAA, which are both international brands, were included in the study due to their availability on the local market. These peat growth medium suppliers have gone to great lengths to practise responsible reporting on their strategies for reducing their carbon footprint. Their adherence to ISO14000 is stated on all branding and marketing material. There is therefore a transparent effort to report environmental responsibility. The South African suppliers of local growth mediums have not reported on their strategy to reduce their carbon footprint and have no transparent strategies regarding environmental responsibility. South African growers are not currently obliged by legislation to practise protocols regarding the reduction of their carbon footprint. No commercial growers are obliged to assess their carbon footprint and to report on strategies to reduce it. Given that carbon footprinting has been reported as a problem in Europe, it might become a problem to supply South African growers with growth mediums containing peat. The uncertain supply of growth mediums with peat might cause peat to be an unsustainable option for commercial growers. More research would be necessary to clarify the sustainability of peat supply to South African commercial growers.

Riviere *et al*. (2005:35) argues that the modern approach to the Horticulture Industry includes a strategy to minimise the usage of non-renewable resources like peat. This is due to the necessity to consider the ecological and environmental implications of horticultural practices. There is social demand for horticultural practices which allow for accountability and sustainability. This strategy also allows for the consideration of re-using and recycling as an alternative to using non-renewable resources.

It is suggested that many countries using peat either do not have peat resources or do not have enough to meet the growing demand. Research is being conducted into finding viable alternatives to peat and peat mixture growing mediums Riviere *et al.* (2005:35). These alternatives include recycling the green waste within the Horticultrual Industry, organic waste and renewable products.

2.6 Summary

It is vital to establish the niche market within which the production of container cyclamens in a controlled environment is positioned. Controlled environments entail specific greenhouse structures and conditions which need to be simulated and adhered to. The literature study helped to define the needs of container cyclamens such as growth mediums and the function and types of growth mediums within the horticulture industry. An attempt was made in this chapter to investigate literature to determine container cyclamen production needs and to discuss existing container cyclamen production at Tuberflora as background information to the study.

The next chapter covers the empirical research of the study and attention is given to the research design, trial design and selection of growth mediums for the study. The chapter also includes a description of how the measuring instrument used during the comparison of the cyclamens in various growth mediums, was developed.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction.

In the previous chapter, the theoretical framework was established in order to lay the foundation for the empirical research. This chapter deals with the research design, the research instruments, data collection, the method for analysing data, limitations of the study and the ethical considerations of the study.

The research aims of the study were to:

- investigate the existing locally available growth medium mixtures mentioned in the literature for the production of container cyclamen in greenhouses
- determine the most suitable cyclamen growth medium mixture, for South African conditions, for wholesale container-grown cyclamens in a controlled environment.

3.2 Motivation for the research

This study will help to identify growth medium most suitable in the commercial production of container cyclamens for the South African environment.

The identification of growth mediums which produce the best quality container-grown cyclamens will inform commercial wholesale cyclamen growers as to which growth mediums are most suitable for commercially grown container cyclamens specific to South African conditions. Additionally, knowledge of container cyclamen cultivation in South Africa under South African conditions will be enhanced. Publishing the newly acquired knowledge will create a platform for sharing it with a wider audience and will establish a scientific foundation for further research on commercially grown cyclamens for the floricultural industry in South Africa. The results of the study will allow commercial nurseries to make informed management decisions on the cultivation of a preferred crop for winter/cold season income supplementation.

3.3 Value of the study

3.3.1 Benefits for the South African industry

There is currently no South African scholarly research on the most suitable growth medium for container cyclamens for South African conditions. A Nexus (NRF database) search was conducted to ascertain any duplication of existing South African research on the comparison of growth mediums for cyclamens. The recording of South African adapted growing guidelines and production strategies will give future generations access to the information. The newly acquired information will also add to the body of knowledge of the ornamental horticulture industry in South Africa.

3.3.2 Benefits to commercial growers of cyclamens

The results of this study will be beneficial to all commercial growers of cyclamens and will thus aid in the quality, quantity and improvement of market timing of the commercial production of container cyclamens.

3.4 Problem statement

The formulation of the research questions for this project followed research done by Emory and Cooper (1995:56). They suggest that the most specific research question be placed before the least specific research question. This concept can be illustrated by Figure 3.1 below.

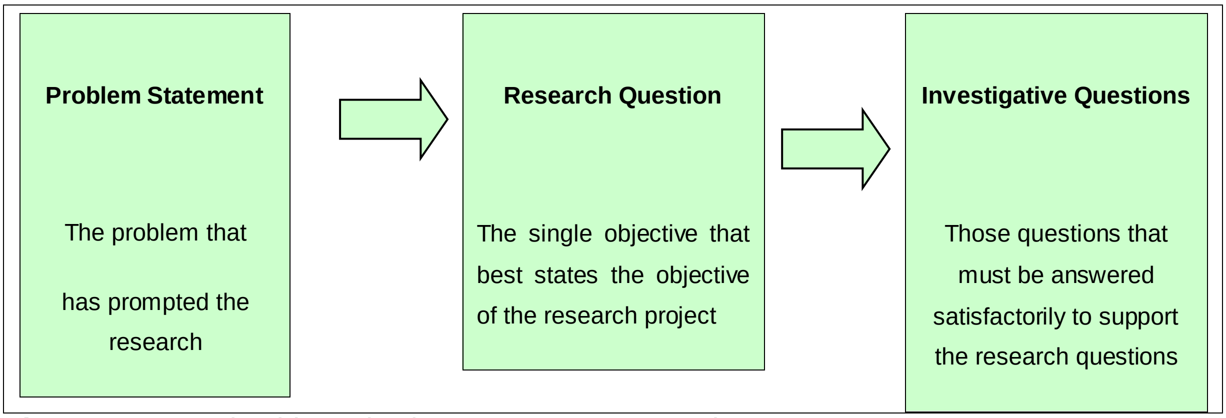


Figure 3.1 Question hierarchy (Emory & Cooper, 1995)

The research question for this study was as follows:

3.4.1 Main problem statement

How do the selected growth mediums for cyclamens compare in terms of quality in the production of commercially grown container cyclamens in a South African context in a controlled environment?

3.4.2 Subproblems

The subproblems identified to support the problem statement was as follows:

- Subproblem 1: Creating a visual measuring instrument
- Subproblem 2: Determining the most suitable growth mediums in the production of container cyclamens grown in a controlled environment
- Subproblem 3: Determining how the commercial cyclamen grower would benefit by using the most suitable growth mediums in the production of container cyclamens
- Subproblem 4: Determining whether the carbon footprint of cyclamen production can be reduced by using the most suitable growth mediums for container cyclamens

3.5 Research design

Research in general can be described as the systematic investigation of materials and sources in order to establish facts and to reach new conclusions regarding the subject being researched (The new Oxford dictionary of English, 1998:995). According to Cooper and Schindler (2001:16), the success of research hinges on the following critical success factors:

- The purpose of the research must be clearly defined.
- The details of the research process must be given.
- The research design should be planned thoroughly.
- Ethical standards must be applied.
- All limitations must be stated.
- All findings should be presented without ambiguity.
- All conclusions must be justified.

The above success factors serve as a guideline to a researcher in the process of conducting research. Stokes (1997) developed a four-quadrant model to classify all research. Each quadrant represents a type of scientific research. The quadrant called Pasteur's quadrant is termed "use-inspired basic research". This type of research aims to do research with the purpose of developing an understanding for the subject on which the research is conducted and also aims to use the research. This type of research aims for both a quest for understanding and consideration to apply the research.

The focus of this study was to conduct research on the different locally available growth mediums in order to gain an understanding of growth mediums for cyclamen and to build on the existing body of knowledge available on greenhouse production of cyclamens. This study also aimed to apply the understanding gained by the research and to apply the knowledge gained for practical use.

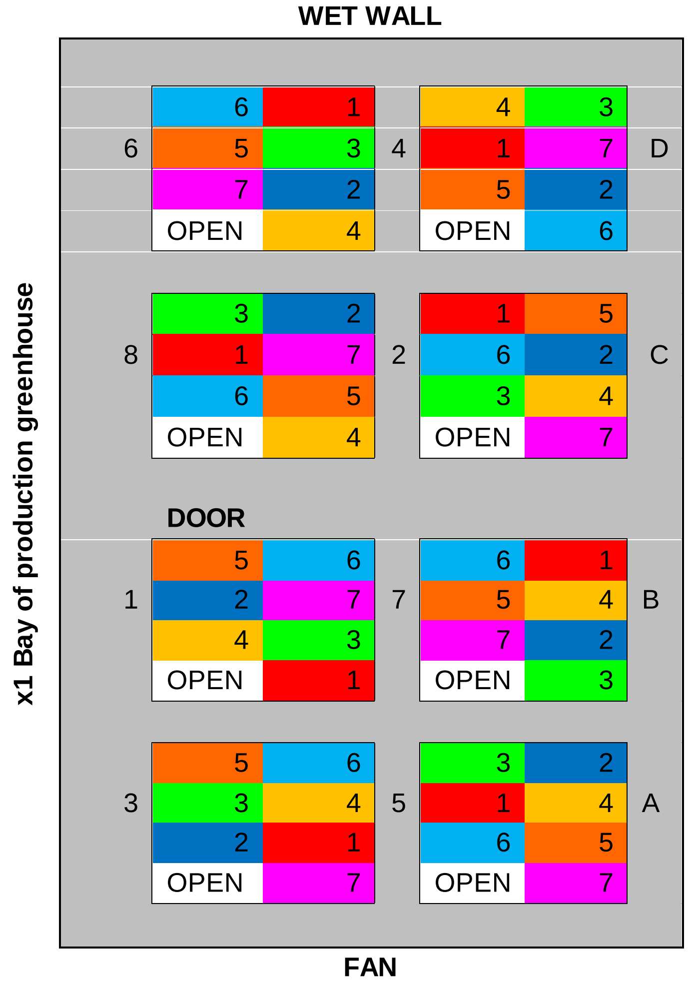
A comparative study was conducted on selected growth mediums in the production of commercially grown cyclamen in order to determine the most suitable growth medium for the production of container cyclamen. To determine a list of suitable growth mediums for this study, it was necessary to apply a selection process. This included determining which growth mediums were suitable for growing cyclamens according to research and which were currently being used by commercial growers in the production of cyclamens in South Africa. The research trials were conducted during 2012 and 2013.

A literature study revealed all growth mediums documented for the production of cyclamens commercially. The information resources were consulted to determine the selection of the growth mediums to be evaluated and compared in the study. The information resources included formal research published in monographs, academic journals and grey literature, and informal information sources not published, such as the commercial growers' in-house information sources. The experiments were conducted with full informed consent of Tuberflora management according to the Unisa ethics guidelines and requirements.

Whitcomb (2003:443) suggests that the most satisfactory method to use for experimentation for plant sciences is the randomized complete block design. The study by Nelson *et al.* (2010:355) applied randomized replicates in blocks as an experimental design and used a sample size of five plants per experimental block. Widmer (1972:104) also suggested using a sample size of five plants per treatment, in his study on the growth of *Cyclamen persicum* in various growth mediums. It was therefore decided to adopt an experimental design with randomized complete block design. Seven pre-selected growth medium treatments were used, with five plants each label are randomized place in four blocks in between normal production per block, and four blocks, see Figure 3.2. with two replications (seasonal commercial growth cycles) in a closed environment (greenhouse). Three readings were taken per season - see Table 3.1 The study therefore included a total of 105 plants per replicate are measured and a total of 210 plants in the entire study

Cyclamen randomized complete block design

Suggested by Whitcomb (2003:443), Nelson *et al.* (2010:355) and Widmer (1972:104)



Legend with mixes	
1	Cyclamen Mix
2	50% Cyclamen / 50% 45
3	49 Mix
4	45 Mix
5	7 Mix
6	100% coir mix
7	Klasmann peat mix

Notes

Seven mixes randomly placed in four blocks for replication
Five plants of each mix label are randomized place in four blocks in between normal production per block

Limitation: Only one bay in the production greenhouse structure was available for trials

1. Block A = 3 & 5
2. Block B = 1 & 7
3. Block C = 8 & 2
4. Block D = 6 & 4

Figure 3.2 Cyclamen randomized complete block design.

3.5.1 Sample plant population

The trial included a plant population of 105 plants, which represented 1.4% of the total container cyclamen population in the cyclamen greenhouse. It was decided to focus on only one variety of cyclamen for a homogeneous plant population, using the seeds *Cyclamen persicum* F1 standard, variety Grandola Deep Rose, ref. 20110513.0040, from a single packet from the supplier, Hem Genetics of the Netherlands. See Annexure I for packaging details of the cyclamen seeds used in this study. Each trial container cyclamen was clearly marked with a sticker indicating the plant as part of a trial and not for sale commercially (Hem Genetics, 2012:1).

3.5.2 Trial layout

The trials were conducted by the researcher, who was the head grower at Tuberflora with the responsibility, see Table 3.1, of growing container cyclamens for the local South African market. The trials focused on the primary growth production phase of the container cyclamens. However, for the trial to be successful, the production cycle was followed and documented in its entirety for accuracy and authenticity of results. See Annexure J for the measuring and data recording schedule.

Table 3.1 Trial measuring schedule.

Trial measuring schedule according to production weeks for seasons 2012 and 2013																		
	Season 2012									**Season 2013**								
	Week	**Mix**								**Week**	**Mix**							
		1	2	3	4	5	6	7	Total		1	2	3	4	5	6	7	Total
Date of planting	49									47								
First measurement	3	5	5	5	5	5	5	5	35	1	5	5	5	5	5	5	5	35
Second measurement	10	5	5	5	5	5	5	5	35	8	5	5	5	5	5	5	5	35
Third measurement	17	5	5	5	5	5	5	5	35	15	5	5	5	5	5	5	5	35
Total									105									105
Note: Production weeks differ by 2 weeks from 2012 to 2013 due to planning schedules at Tuberflora																		

3.5.3 Physical location

The trials took place on the premises of Tuberflora, a commercial wholesale nursery, located on a plot in Muldersdrift in Gauteng, South Africa, GPS co-ordinates S 26˚02.539 E 27˚51.503, at an altitude of 1 642 m.

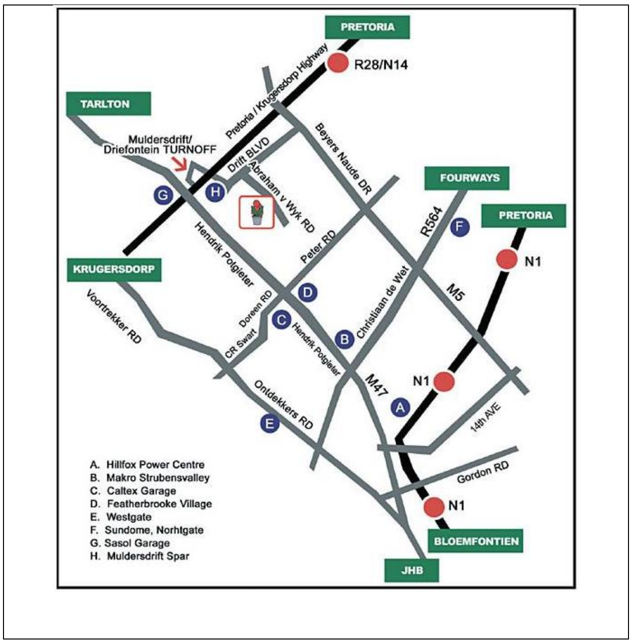


Figure 3.3 Map to Tuberflora (Tuberflora, 2011:1)

The study took place in an environmentally controlled industrial greenhouse that was suitable for the production of container cyclamens on the premises of Tuberflora.

3.5.4 Description, characteristics and dimensions of the greenhouse

The greenhouse at Tuberflora covers an area of 3 072 m^2 (48 m x 64 m). The roof structure is divided into eight bays or spans, each being 8 m wide, and therefore allowing each span to create a designated growing area. No artificial lighting is supplied to the greenhouse.

The greenhouse is a pad and fan structure made of galvanized steel, 48 m from pad to fan. The roof and sides of the greenhouse are covered in a double-layered clear plastic (polyethylene 200 micron x2) supplied and manufactured by Gundle Plastics. The double layer of plastic allows for the roof and sides to be inflated with air, which creates a buffer for temperature control. The greenhouse has a mechanized screen between the roof and the floor of the greenhouse, which can open and close by means of a control panel. See Fig 3.4 and 3.5.

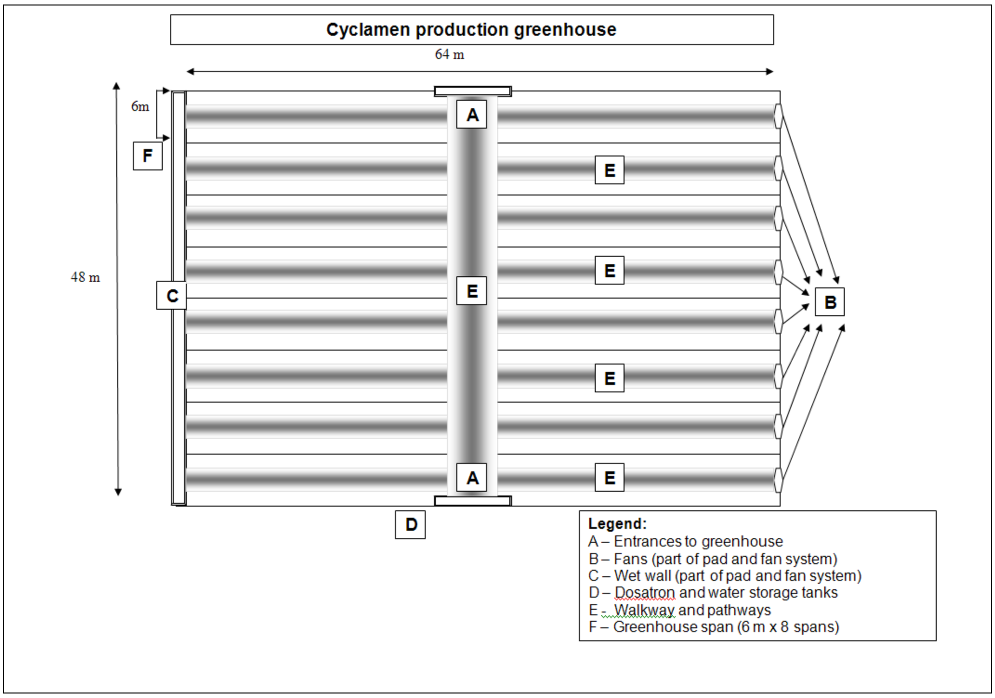


Figure 3.4 Cyclamen production greenhouse layout

Figure 3.5 Cyclamen production greenhouse at Tuberflora

The specific greenhouse is ideal for the production of cyclamens with the ability to control the climate within the greenhouse. The physical characteristics of the greenhouse allow for manipulation of temperature and lux ranges .

- Temperature

The double-layered plastic structure of the greenhouse creates an air pocket which functions as an insulation buffer between the outdoor and indoor temperature. During the production phase it is critical to keep the transplanted cyclamens at a cooler temperature in the warm December summers of Gauteng which can have temperature maximums of up to 39 ˚C. It is therefore referred to as a “cold house” (temperature between 6 and 25 ˚C) compared to the other greenhouses at the nursery. Additionally, a generator which supplies the greenhouse with constant guaranteed electricity during the warm Decembers in Gauteng ensures the running of the fans and more effective temperature control in order to keep the specific temperature range of 6 to 25 ˚C during the establishment of the cyclamen plants in the transplanting phase of the cyclamens.

- Lux

The clear plastic and screen allow for the filtering of light intensity of above 2 000 lx outside the greenhouse, measured on a typical summer’s day in Gauteng. The screen, a 40% filter screen, allows for further manipulation of light intensity inside the greenhouse where a lux variation of 250 lx (screen closed) and 650 lx (screen open) can be experienced.

3.5.5 Production area within the greenhouse

The cyclamens are grown in black PC pots, with a diameter of 12 cm at ground level on ground covers. The prepared production area consists of the following layers: Ground/soil, corrugated fibreglass panels and gravel, covered in black Evedeck soil covers. The production areas on the ground are separated by pathways constructed of cement, which allow for easy access to the cyclamens in pots for watering, spraying and scouting for disease and pests. Each span accommodates two beddings. One bedding can accommodate 2 720 plants.

3.6 Research instruments

It was necessary to develop a measuring instrument to compare the container cyclamens planted in the various growth mediums. This process involved firstly selecting growth mediums to use for the study and then developing a measuring instrument which could be used to compare the container cyclamens growing in the selected growth mediums.

3.6.1 Selection of growth mediums for comparison

It was decided to select growth mediums locally and readily available with maximum porosity. Cyclamen mix and Klasmann Mix are imported and locally available. See Figure 3.6.

Imported Cyclamen Mix

Imported Klasmann TS 4

Coir

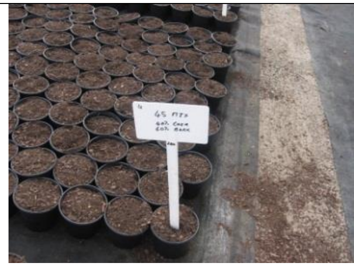
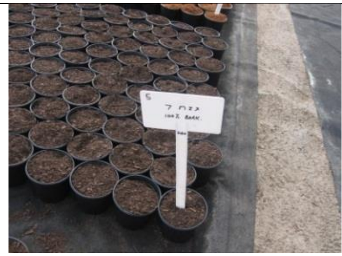
Bark mix

Figure 3.6 Locally available growth mediums

It was decided to restrict the growth mediums for the study to those listed in Table 3.2.

Table 3.2 List of selected growth mediums for trial

Growth mediums		
Mix 1: Cyclamen Mix	This mixture is commercially sold on the market as a cyclamen mix and is supplied by MEEGAA. It consists of 50% peat moss, 35% coir, 15% perlite and 3 kg Osmocote (16/18 per m^3).	
Mix 2: 50% Cyclamen Mix and 50% 45 Mix	This mixture consists of a 50% mixture of the MEEGAA Cyclamen Mix and 50% of 45 Mix.	
Mix 3: 49 Mix	This mixture is commercially sold on the market as 49 Mix and is supplied by Culterra. It consists of 80% pine bark and 20% coir.	

Mix 4: 45 Mix	This mixture is commercially sold on the market as 45 Mix and is supplied by Culterra. It consists of 60% pine bark and 40% coir.	
Mix 5: Pine bark	This mixture is commercially sold on the market as 7 Mix and is supplied by Culterra. It consists of 100% pine bark.	
Mix 6: 100% coir	This mixture consists of 100% coarse coir.	
Mix 7: Klasmann 100% peat Substrate 4	This mixture is imported from the Netherlands and is supplied locally by Greenhouse Technologies. It consists of 100% peat. The mixture includes a wetting agent (K–hydro) and extra trace elements 1 EC fertilization.	

3.6.2 Measuring instrument

Trials were arranged in a randomized complete block design as suggested by Whitcomb (2003:443) and Ingram, Vince-Prue and Gregory (2008:314). This would allow for each growth medium to be well represented in each random block. See Table 3.3.

Table 3.3 Measuring instrument

	Parameters/criteria	**Subparameters**	**Source**
1	**Total plant**	Plant height (canopy height) mm	Widmer (1972:108) Van der Gaag, Van Noort, Stapel-Cuijpers, De Kruij, Termorshuizen, Van Rijn, Zmora-Nahum & Chen (2007:296) Nelson *et al.* (2010:354) Cativello, Della Donna & Pantanali (1997:444) Mao, Han & Zhang (2006:543)
		Plant diameter mm	Widmer (1972:109) Cativello *et al.* (1997:444) Van der Gaag *et al.* (2007:296) Trelka & Szczepaniak (2009:3) Nelson *et al.* (2010:354)
		Fresh plant weight (tuber) g	Cativello *et al.* (1997:444) Van der Gaag *et al.* (2007:296) Trelka & Szczepaniak (2009:3) Nelson *et al.* (2010:354)
2	**Leaves**	Number of leaves	Mao *et al.* (2006:543) Trelka & Szczepaniak (2009:3) Nelson *et al.* (2010:354)
		Leaf width mm	Mao *et al.* (2006:543)

		Foliage fresh weight g	Cativello *et al.* (1997:444)
3	**Flowers**	Number of flowers	Cativello *et al.* (1997:444) Van der Gaag *et al.* (2007:296) Nelson *et al.* (2010:354)
4	**Tubers**	Diameter of tuber mm	Mao *et al.* (2006:543) Trelka & Szczepaniak (2009:3)
5	**Roots**	Root weight g	Cativello *et al.* (1997:444)

3.7 Data collection

An Excel spread sheet was used to capture the data for analysis. The data was sourced from various measuring instruments:

- Temperature and humidity were measured and recorded at regular intervals (daily) using the HUATO S100-TH+ Mini Temperature, humidity and dew point data logger.
- The light intensity of the greenhouse was measured using a lux meter TENMARS Data logger light meter TM-203.
- pH of growth medium analysis were conducted at a reputable laboratory at North West University Annexure D.
- The nutrients were measured and recorded at regular intervals (daily) on watering intervals using an EC meter OAKTON Multi- Parameter PCTestr 35.
- The water used for irrigation was analysed by the Eco Analytica see Annexure E.
- The Dosatron D3GL2 system was set on the required EC measurement.
- A pest and disease management programme designed specifically for the cyclamen production, AVONROD Plant Protection, see Annexures F, is the regime currently employed at Tuberflora and this was continued and accurate records were kept.

It was decided to evaluate the growth mediums by comparing the quality of the plants ready for market by using a measuring instrument. This instrument included a visual observation evaluation tool. Using the measuring instrument, visual observations and measurements of the trial population were recorded at the point of the production cycle where the first cyclamens were deemed ready for market. The evaluation with the measuring instrument was initiated when plants had six flowers per plant as prescribed by Nelson *et al.* (2010:354). Using the measuring instrument, the following data was captured on the data capturing spread sheet using the determined parameters:

<u>Total plant:</u>

- Plant: Plant height (canopy height), plant diameter (canopy diameter), fresh plant weight (with tuber)
- Leaves: Number of leaves, leaf width, foliage fresh weight
- Flowers: Number of flowers
- Tubers: Diameter of tuber
- Roots: Roots weight

The data was then presented and the results documented. The findings of the study were then presented for analysis and discussion. All conclusions and possible recommendations for future research were documented.

3.8 Analysis of data

The analysis of the results obtained from the comparison of selected growth mediums in the production of commercially grown cyclamen includes two sets of results from two growth seasons: season 2012 and season 2013. Statistical analysis was conducted using both parametric and non-parametric methods to compare the means. The parametric methods used included ANOVA and Tukey HSD (Larson-Hall, 2010:283). Non-parametric methods used included the Mann-Whitney U test and the Kruskal-Wallis test (Larson-Hall, 2010:393).

3.9 Dependent and independent variables

The identified dependent variable was the growth mediums for container cyclamen. This study focused on comparing the growth mediums during the primary production phase of the production cycle. It represents a snapshot in time of the production cycle of cyclamens during 2011-2012 for the first cycle and 2012-2013 for the second cycle, thus representing the “current state” of container cyclamen production at Tuberflora across two growing seasons.

The study was restricted to the container cyclamen varieties grown commercially at Tuberflora. It was decided to only focus on one variety out of the many grown at Tuberflora to limit the variables in the study to the seven different growth mediums.

3.10 Summary

The main problem statement and four subproblems were identified. The research instruments, data collection, the method for analysing data, limitations of the study and the ethical considerations were to be established for the study.

The next chapter contains the results obtained in the study.

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Introduction

This chapter provides a discussion of the results and analysis of the data collected during the comparison of the growth medium for container cyclamens in a controlled environment. See table 4.1, 4.2, 4.3 and 4.4 for results.

Three growth mediums for container cyclamens in a controlled environment were used. The three growth mediums mixes used were Mix 45, Cyclamen Mix and a mixture containing 50% of Mix 45 and 50% of Cyclamen Mix. See Figure 4.1 a basic visual measuring instrument need to be developed. The plants in Cyclamen Mix appeared to be larger in size and to have a stronger root system compared with the other two growth mediums. See the basic visual comparison of the pilot study in Annexure K. This discovery lead to the study of comparison of growth medium on cyclamens in a controlled environment.

The following recommendations were made based on the results of the pilot study:

- A visual measuring instrument using three growth mediums was not sufficient to compare cyclamens in different growth mediums.
- A more comprehensive growth medium measuring instrument would need to be developed using research documented in literature.
- It was therefore decided to use seven growth mediums instead of only three growth mediums.

The recommendations from the pilot study were used to amend the selection of growth medium and the measuring instrument used to evaluate the cyclamen growth mediums in a controlled environment. The new selection of growth medium included seven locally available mixes instead of only three and the new measuring instrument included specific evaluation criteria used in previous research on cyclamen growth medium evaluation which was obtained from an extensive literature review. It was decided to use Mix 45 as the control mix for the study. The comprehensive evaluation criteria are presented in table form - see Chapter 3 table 3.1. Annexure L provides the cyclamen production cycle records derived from the schedule for measurement and recording of data during seasons 2012 and 2013. This includes data for watering, spraying and the temperature, humidity and lux readings for both seasons 2012 and 2013. See Annexure M for a comparison of the chemical and physical properties of the growth medium used during the study for both seasons 2012 and 2013. The measurements were recorded according to the trial measuring schedule in Table 3.1 in Chapter 3. The figure below indicates the trial measurements taken during seasons 2012 and 2013.

	The first set of measurements were taken in week 49 for season 2012 and week 47 for season 2013.
	The second set of measurements were taken in week 3 for season 2012 and week 1 for season 2013.
	The third set of measurements were taken in week 17 for season 2012 and week 15 for season 2013.

Figure 4.1 Trial measurements taken during seasons 1 and 2.

Mean values were taken for each measured variable, clustered according to the production weeks at seven-week intervals, for each of the seven growth mediums mixes. The analysis of the results is presented in Chapter 3 Table 3.3 in the same order as taken with the measuring instrument.

4.2 Results of comparison of cyclamen growth mediums for season 2012

This section presents the results and analysis of the findings made based on the measuring instrument developed for the study and applied to the seven growth mediums mixes according to the research design in Chapter 3 Table 3.3.

Table 4.1 Mean values of results for 2012 season.

Growth mediums mix comparison								
Measuring schedule per production week	**Mix 1: Cyclamen Mix**	**Mix 2: 50% Cyclamen Mix and 50% 45 Mix**	**Mix 3: 49 Mix**	**Mix 4: 45 Mix**	**Mix 5: Pine bark**	**Mix 6: 100% coir mix**	**Mix 7: Peat Klasmann mix**	
First measurement								
Plant height mm	7.3	5	5.3	4	3.7	3.5	5.2	
Plant diameter mm	12.6	10.9	11.4	9.5	9.8	10	12.8	
Plant weight g	32	28.8	19.8	10.4	18	25	56.2	
Number of leaves	15.4	13.2	11.6	8	12.4	11.2	19.6	
Leaf width mm	5.7	13.2	5.1	4.6	4.5	5.1	5.4	
Foliage fresh weight g	20.2	5.5	9.6	5.4	8	8	20.4	
Number of flowers	*	*	*	*	*	*	*	
Diameter of tuber mm	1.5	1.8	1.5	1.4	1.9	1.9	1.7	
Roots fresh weight g	7.8	11.4	7	3.6	5.4	14.9	32.4	
Second measurement								
Plant height mm	12.8	9.4	9.3	9.5	8.6	10.3	10.4	
Plant diameter mm	22	21.4	17.8	21.2	17.5	20.6	19.8	
Plant weight g	123	1158	67	111	74.8	118	157	
Number of leaves	30.6	37.6	22.6	30.2	28.6	36.5	29.2	
Leaf width mm	8.3	7.5	8.4	8.6	7.3	8.1	7.8	
Foliage fresh weight g	80.6	73	43.2	56.4	37.4	50.4	56.2	
Number of flowers	17.2	16.2	14.2	18	15.6	15.2	19.4	
Diameter of tuber mm	1.5	2	1.9	2	2.2	1.8	1.8	
Roots fresh weight g	32.4	30.8	20.2	41.4	27.2	43	86.4	
Third measurement								
Plant height mm	16.2	10.4	11	12.4	9.6	10	13.8	
Plant diameter mm	28.8	21.8	20.8	22	14.8	18.6	27	
Plant weight g	430.4	274.6	154.8	211.4	79	103.8	502.8	
Number of leaves	35.6	37	26	42	20.8	32.8	49.2	
Leaf width mm	10.6	8.5	8.5	8	6.6	6.9	8.5	
Foliage fresh weight g	126	76.4	49.8	57.8	38.4	43.6	77.4	
Number of flowers	22.6	20.4	15.8	19.2	9.8	12.8	20	
Diameter of tuber mm	1.8	2.2	2.3	2.2	1.9	1.8	1.8	
Roots fresh weight g	220.2	130.2	31.8	104.8	39.8	41.4	355.8	

* No flowers present

4.3 Results of comparison of cyclamen growth medium for season 2013.

This section presents the results of the findings made based on the measuring instrument developed for the study and applied to the seven growth mediums mixes according to the research design in Chapter 3 Table 3.3.

Table 4.2 Mean values of results for 2013 season.

Growth mediums mix comparison								
Measuring schedule per production week	**Mix 1: Cyclamen Mix**	**Mix 2: 50% Cyclamen Mix and 50% 45 Mix**	**Mix 3: 49 Mix**	**Mix 4: 45 Mix**	**Mix 5: Pine bark**	**Mix 6: 100% coir mix**	**Mix 7: Peat Klasmann mix**	
First measurement								
Plant height mm	5.1	5.1	3.5	3.2	4.3	4.5	4.5	
Plant diameter mm	12.7	13.3	10.7	11.5	11.2	11.2	12	
Plant weight g	37.6	32.4	28.4	38.6	33.4	47.4	50.9	
Number of leaves	19.4	20.4	18.2	17.2	20.4	16	20.3	
Leaf width mm	6.1	5.6	5	5.5	5.1	6	6.3	
Foliage fresh weight g	18.2	16.6	11.6	16.4	15.8	16	18.4	
Number of flowers	*	*	*	*	*	*	*	
Diameter of tuber mm	1.5	1.5	1.7	1.7	1.5	1.6	1.5	
Roots fresh weight g	14.2	11	10.6	15.2	12.2	26.2	26	
Second measurement								
Plant height mm	11.1	9.4	5.4	6.2	5.8	7.6	9	
Plant diameter mm	24.8	19.8	14.6	14.2	13.5	18.5	20	
Plant weight g	145.4	115	51	44.2	41.4	126.6	281	
Number of leaves	27.2	29.2	19.2	19.2	21.6	20.8	25.8	
Leaf width mm	8.7	8.7	6.7	7.2	6.6	9	9.5	
Foliage fresh weight g	71.2	66.6	24.4	26.2	25.6	45.5	59.4	
Number of flowers	18.8	15.8	9	9.4	10.8	12.4	14.8	
Diameter of tuber mm	2.3	2.3	5.8	1.9	1.7	2	1.9	
Roots fresh weight g	39	23.6	14.6	10	10	60	160	
Third measurement								
Plant height mm	13.8	13.2	10.4	10.5	9.2	12	11	
Plant diameter mm	27.4	24.4	19.8	21.8	19.2	23	22	
Plant weight g	317.2	253.2	162.8	194.8	124	219	280	
Number of leaves	65	56.4	40.4	48.6	31.8	38.2	51.8	
Leaf width mm	8.9	8.9	8.1	8.1	8.2	10.4	9	
Foliage fresh weight g	180	145.8	79.6	110.4	67.2	128	118.4	
Number of flowers	33.5	33.2	26.4	28.2	19	22.6	34.6	
Diameter of tuber mm	2	2.8	2.5	2.4	2.1	2.4	1.9	
Roots fresh weight g	50.8	44	38.4	32.4	18.4	40.6	133.5	

* No flowers present

4.4 Comparison of seasons 2012 and 2013

The results include the visual observations and measurements recorded during three separate sessions of two growing seasons. This section also contains the statistical comparisons made.

Table 4.3 Mean values of results for seasons 2012 and 2013 combined

Growth medium mix comparison								
Measuring schedule per production week	**Mix 1: Cyclamen Mix**	**Mix 2: 50% Cyclamen Mix and 50% 45 Mix**	**Mix 3: 49 Mix**	**Mix 4: 45 Mix**	**Mix 5: Pine bark**	**Mix 6: 100% coir mix**	**Mix 7: Peat Klasmann mix**	
First measurement								
Plant height mm	6.2	5.1	4.4	4	4	4	4.9	
Plant diameter mm	17	17	15	13	16	14	20	
Plant weight g	12.6	12.1	11	10.5	10.5	10.6	12.4	
Number of leaves	35	31	24	25	26	36	53	
Leaf width mm	5.9	9.4	5	5	4.8	5.5	5.8	
Foliage fresh weight g	18.9	10.9	10.6	10.9	11.9	12	19.4	
Number of flowers	*	*	*	*	*	*	*	
Diameter of tuber mm	1.5	1.7	1.6	1.5	1.7	1.7	1.6	
Roots fresh weight g	11	11	9	9	9	20	29	
Second measurement								
Plant height mm	12	9.4	7.4	7.9	7.2	9	9.8	
Plant diameter mm	29	33	21	25	25	29	28	
Plant weight g	23.4	20.6	16.2	17.7	15.5	19.5	20	
Number of leaves	134	115	59	78	58	122	200	
Leaf width mm	8.5	8.2	7.5	7.9	6.9	8.4	8.2	
Foliage fresh weight g	75.9	69.8	33.8	41.3	31.5	47.8	57.8	
Number of flowers	18	16	12	14	13	14	17	
Diameter of tuber mm	1.9	2.1	2	1.9	1.9	1.9	1.9	
Roots fresh weight	36	27	17	26	19	52	123	
Third measurement								
Plant height mm	15	14.3	10.7	11.4	9.5	11	12.4	
Plant diameter mm	28.1	23.1	20.3	21	17	20.8	24.5	
Plant weight g	373.8	263.8	158.8	203.4	101.5	161	391.4	
Number of leaves	50.3	46.5	33.2	45.3	26.3	30.5	50.5	
Leaf width mm	9.75	8.7	8.3	8	7.4	8.6	8.7	
Foliage fresh weight g	153	115.6	64.7	88.1	52.8	85.8	98	
Number of flowers	28.5	26.8	21.1	23.7	14.4	17.7	27.3	
Diameter of tuber mm	1.9	2.5	2.2	2.3	2	2.1	1.8	
Roots fresh weight g	135.5	87.1	35.1	68.6	29.1	41	244.5	

* No flowers present

4.4.1 Statistical comparisons for seasons 2012 and 2013.

Parametric and non-parametric methods were used to compare mix means and were followed up with post hoc analysis to identify.

The assumptions of normality, constant variance and independence were tested. The alpha levels were 0.05.

4.4.1.1 Parametric data

Parametric data, namely plant height, diameter of tuber, number of leaves and leaf width, was used for group comparisons Kruskal wallis and Tukey HSD for the post hoc analysis. The data collected for the variables/parameters that are termed "parametric data" – follow a relatively normal distribution

4.4.1.2 Non-parametric data

Non-parametric data, namely plant diameter, plant mass, number of flowers, root fresh weight and foliage fresh weight, were tested using the Kruskall-Wallis test for a comparison of mix means, followed by the Mann-Whitney U test for the post hoc analysis. The data collected from the "non-parametric" parameters do not follow a normal distribution. Observations done using QQ-Plots to accommodate the objective of the research, the post hoc tests were conducted using a top-down approach. The mean values were ranked and the highest mix mean was compared with the second highest value until a significant difference was obtained. The objective was to report where the first observed significant mean difference within each parameter was found. As an example:

2013 – Plant Height Mix 1 & 3 {Tukey HSD p = 0.014} The mean values for each treatment were ranked from highest to lowest. In this scenario, there was a significant difference between Mix 1 & 3 – There would therefore also be significant difference between Mix 1 and any mean equal to or lower than Mix 3 – Refer to table 4.2 to see which means are lower than Mix 3. For the illustration of mixes with significant differences see Table 4.4

Table 4.4 Measuring instrument parameters

Measuring instrument parameters	Sub-parameters	2012			2013		
Total plant	1. Plant height	ANOVA p = 0.00232	Mix 1&2	Tukey HSD p = 0.03	ANOVA p = 0.014	Mix 1&3	Tukey HSD p = 0.014
	2. Plant diameter	Kruskal-Wallis p = 0.056	Mix 1&5	Mann-Whitney p = 0.01	Kruskal-Wallis p = 0.005	Mix 1&7	Mann-Whitney p = 0.039
	3. Fresh plant mass	Kruskal-Wallis p = 0.026	Mix 7&6	Mann-Whitney p = 0.024	Kruskal-Wallis p = 0.007	Mix 7&4	Mann-Whitney p = 0.01
Leaves	4. Number of leaves	ANOVA p = 0.07			ANOVA p = 0.107		
	5. Leaf width	ANOVA p = 0.0003020244	Mix 2&3	Tukey HSD p = 0.041	ANOVA p = 0.011	Mix 6&3	Tukey HSD p = 0.051
	6. Foliage fresh weight	Kruskal-Wallis p = 0.032	Mix 1&2	Mann-Whitney p = 0.126	Kruskal-Wallis p = 0.118		
Flowers	7. Number of flowers	Kruskal-Wallis p = 0.293			Kruskal-Wallis p = 0.651		
Tubers	8. Diameter of tuber	ANOVA p = 0.005	Mix 2&5		ANOVA p = 0.015	Mix 2&5	Tukey HSD p = 0.059
Root	9. Weight	Kruskal-Wallis p = 0.005	Mix 1&7	Mann-Whitney p = 0.05	Kruskal-Wallis p = 0	Mix 7&6	Mann-Whitney p = 0.018

4.4.2 Explanations of statistical comparisons for seasons 2012 and 2013

4.4.2.1 Plant height

2012 ANOVA compare p = 0.00232 Mix 1 & 2 Tukey HSD p = 0.03
2013 ANOVA compare p = 0.014 Mix 1 & 3 Tukey HSD p = 0.014

In both 2012 and 2013, the plant height differed significantly between the mix means only for the mixes mentioned. In 2012, plant height was significantly more in Mix 1 compared with Mix 2. The means of Mix 1 were less than those of Mix 2. In 2013, plant height was also significantly more for Mix 1 compared with Mix 3, with the means of Mix 1 less than those of Mix 3.

4.4.2.2 Plant diameter

2012 Kruskal-Wallis compare p = 0.056 Mix 1 & 5 Mann-Whitney p = 0.01
2013 Kruskal-Wallis compare p = 0.005 Mix 1 & 7 Mann-Whitney p = 0.039

In both 2012 and 2013, the plant diameter differed significantly between the mix means only for the mixes mentioned. In 2012, plant diameter was significantly larger in Mix 1 compared with Mix 5. The means of Mix 1 were less than those of Mix 5. In 2013, plant diameter was also significantly larger for Mix 1 compared with Mix 7, with the means of Mix 1 less than those of Mix 7.

4.4.2.3 Fresh plant mass

2012 Kruskal-Wallis compare p = 0.026 Mix 7 & 6 Mann-Whitney p = 0.024
2013 Kruskal-Wallis compare p = 0.007 Mix 7 & 4 Mann-Whitney p = 0.01

In both 2012 and 2013, the fresh plant mass differed significantly between the mix means only for the mixes mentioned. In 2012 fresh plant mass was significantly more in Mix 7 compared with Mix 6. The means of Mix 7 were less than those of Mix

6. In 2013, fresh plant mass was also significantly more for Mix 7 compared with Mix 4, with the means of Mix 7 less than those of Mix 4.

4.4.2.4 Number of leaves

2012 ANOVA p = 0.07

2013 ANOVA p = 0.107

No significant difference in number of leaves was found between treatments in both 2012 and 2013 when using an alpha value of 0.05. However, using an alpha value of 0.1 a significant difference was observed only for the mixes mentioned. The three highest mean values for 2012 (treatment 7, 2, 1) and 2013 (treatment 1, 7, 2) were the same. This was the only comment for the parameter and it was deemed worthy for inclusion.

4.4.2.5 Leaf width

2012 ANOVA compare p = 0.00030244 Mix 2 & 3 Tukey HSD p = 0.041

2013 ANOVA compare p = 0.011 Mix 6 & 3 Tukey HSD p = 0.051

In both 2012 and 2013, the leaf width differed significantly between the mix means, only for the mixes mentioned. In 2012, leaf width was significantly larger in Mix 2 compared with Mix 3. The means of Mix 2 were less than those of Mix 3. In 2013, leaf width was also significantly larger for Mix 6 compared with Mix 3, with the means of Mix 6 less than those of Mix 3.

4.4.2.6 Foliage fresh weight

2012 Kruskal-Wallis compare p = 0.032 Mix 1 & 2 Mann-Whitney p = 0.126

2013 Kruskal-Wallis compare p = 0.118 Mix 1 & 2

In both 2012 and 2013, the foliage fresh weight differed significantly between the mix means only for the mixes mentioned. In 2012, foliage fresh weight was significantly more in Mix 1 compared with Mix 2. The means of Mix 1 were less than those of Mix 2. In 2013, foliage fresh weight was also more for Mix 1 compared with Mix 2, with the means of Mix 1 less than those of Mix 2.

4.4.2.7 Number of flowers

2012 Kruskal-Wallis compare $p = 0.293$
2013 Kruskal-Wallis compare $p = 0.651$

No significant difference in number of flowers was found between treatments in both 2012 and 2013 only for the mixes mentioned.

The results of the comparison of mean number of flowers indicate that Mix 1 performed the best. The largest mean number of flowers was recorded with Mix 1.

4.4.2.8 Diameter of tuber

2012 ANOVA compare $p = 0.005$ Mix 1 significantly smaller than Mix 2 & 5
2013 ANOVA compare $p = 0.015$ Mix 2 & 5 Tukey HSD $p = 0.059$

In both 2012 and 2013, the diameter of the tuber differed significantly between the mix means only for the mixes mentioned. In 2012, tuber diameter was significantly smaller in Mix 1 compared with Mix 2 and 5. The means of Mix 1 were greater than those of Mix 2 and 5. In 2013, tuber diameter was also significantly larger for Mix 2 compared with Mix 5, with the means of Mix 2 less than those of Mix 5.

4.4.2.9 Root fresh weight

2012 Kruskal-Wallis compare p = 0.005 Mix 1 & 7 Mann-Whitney p = 0.05

2013 Kruskal-Wallis compare p = < 0.05 Mix 7 & 6 Mann-Whitney p = 0.018

In both 2012 and 2013, the root fresh weight differed significantly between the mix means only for the mixes mentioned. In 2012, root fresh weight was significantly more in Mix 1 compared with Mix 7. The means of Mix 1 were less than those of Mix 7. In 2013, root fresh weight was also significantly more for Mix 7 compared with Mix 6, with the means of Mix 7 less than those of Mix 6.

4.4.3 Graphical presentation of comparison cyclamen sub-parameters of seasons 2012 and 2013

4.4.3.1 Comparison of plant height for seasons 2012 and 2013

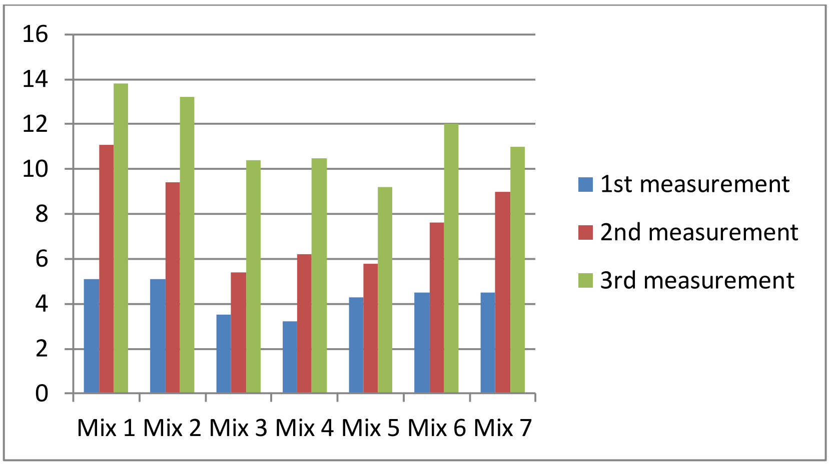


Figure 4.2 Mean plant height measure in mm for seasons 2012 and 2013

The results of the comparison of mean plant height measure in mm indicate that Mix 1 performed the best in seven growth medium across the two seasons. The tallest plant height was recorded with Mix 1.

4.4.3.2 Comparison of plant diameter for seasons 2012 and 2013

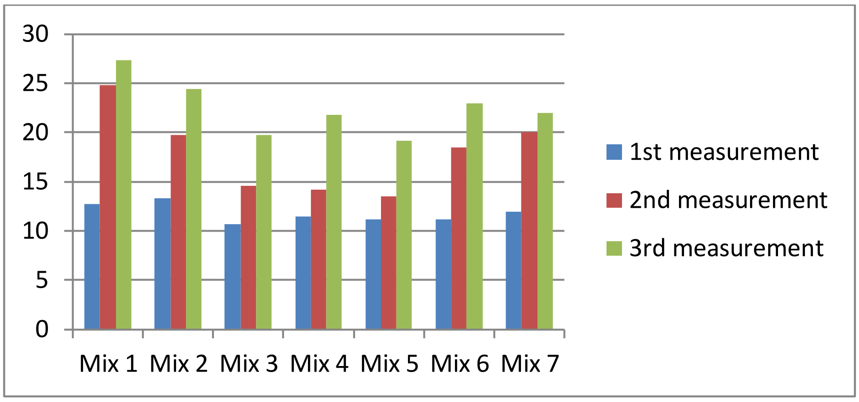


Figure 4.3 Mean plant diameter measure in mm for seasons 2012 and 2013

The results of the comparison of mean plant diameter measure in mm indicate that Mix 1 performed the best in seven growth medium across the two seasons. The largest plant diameter was recorded with Mix 1.

4.4.3.3 Comparison of plant weight for seasons 2012 and 2013

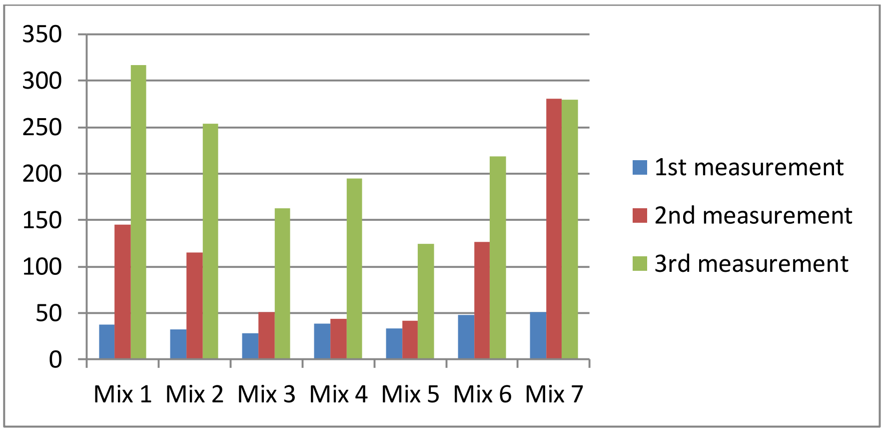


Figure 4.4 Mean plant weight measure in grams for seasons 2012 and 2013

The results of the comparison of mean plant weight measure in grams indicate that Mix 7 performed the best in seven growth medium across the two seasons. The highest mean plant mass was recorded with Mix 7.

4.4.3.4 Comparison of number of leaves for seasons 2012 and 2013

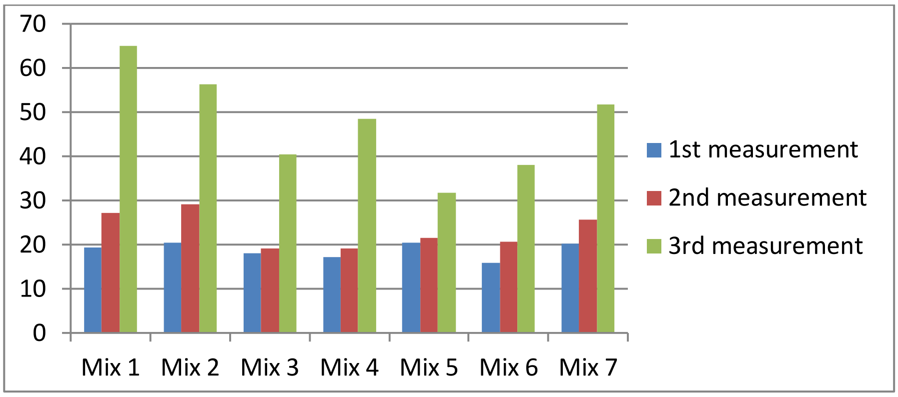


Figure 4.5 Mean number of leaves for seasons 2012 and 2013

The results of the comparison of mean number of leaves indicate that Mix 1 performed the best in seven growth medium across the two seasons. The most number of leaves was recorded with Mix 1. This could possibly be because Mix 1 had the highest fertilizer content in the medium of all the growth mediums mixes.

4.4.3.5 Comparison of leaf width for seasons 2012 and 2013

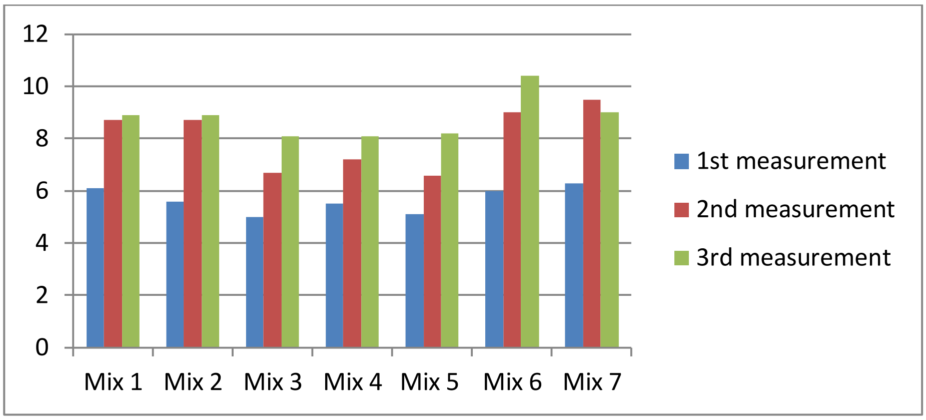


Figure 4.6 Mean leaf width measure in mm for seasons 2012 and 2013

The results of the comparison of mean leaf width measure in mm indicate that Mix 7 performed the best in seven growth medium across the two seasons. The largest leaf width was recorded with Mix 7.

4.4.3.6 Comparison of foliage fresh weight for seasons 2012 and 2013

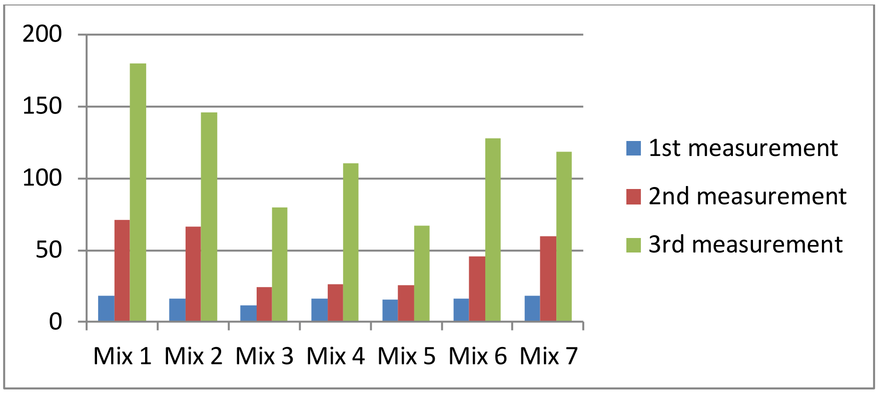


Figure 4.7 Mean foliage fresh weight measure in grams for seasons 2012 and 2013

The results of the comparison of mean foliage fresh weight measure in grams indicate that Mix 1 performed the best in seven growth medium across the two seasons. The highest mean foliage fresh weight was recorded with Mix 1.

4.4.3.7 Comparison of number of flowers for seasons 2012 and 2013

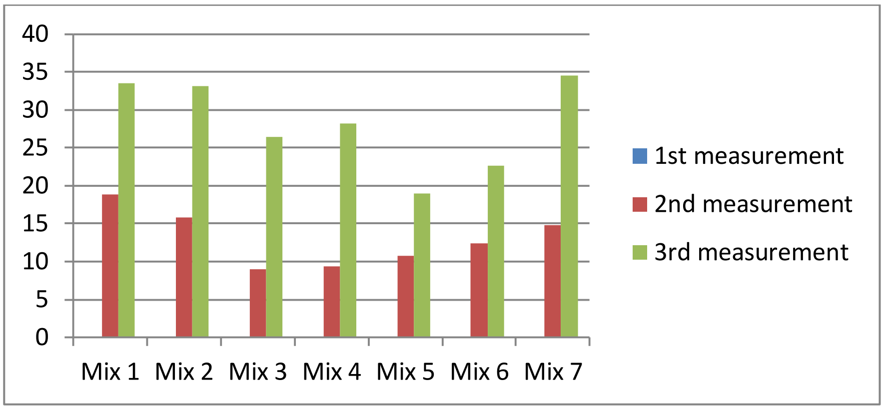


Figure 4.8 Mean number of flowers for seasons 2012 and 2013

The results of the comparison of mean number of flowers indicate that Mix 1 performed the best in seven growth medium across the two seasons. The highest mean number of flowers was recorded with Mix 1.

4.4.3.8 Comparison of tuber diameter for seasons 2012 and 2013

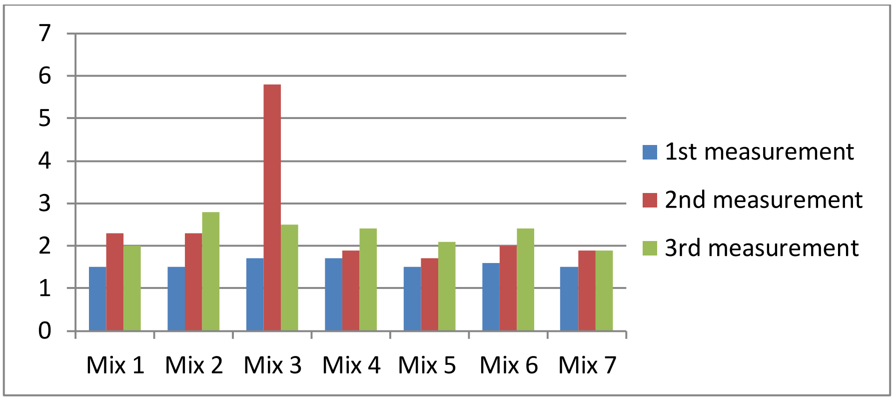


Figure 4.9 Mean tuber diameter measure in mm for seasons 2012 and 2013

The results of the comparison of mean tuber diameter measure in mm indicate that Mix 3 performed the best in seven growth medium across the two seasons. The largest mean tuber diameters were recorded with Mix 3.

4.4.3.9 Comparison of root fresh weight for seasons 2012 and 2013

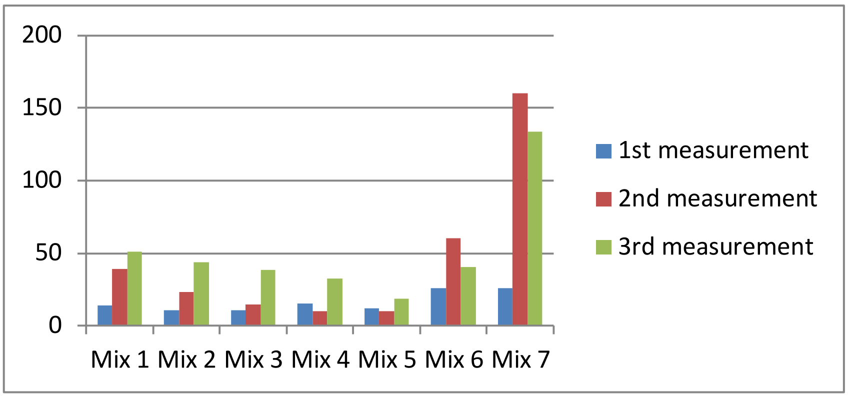


Figure 4.10 Mean root fresh weight measure in grams for seasons 2012 and 2013

The results of the comparison of mean root fresh weight measure in grams indicate that Mix 7 performed the best in seven growth medium across the two seasons. The highest mean root fresh weight was recorded with Mix 7.

4.5 Summary

The analysis of the results from seasons 2012 and 2013 indicate that two mixes, Mix 1 and Mix 7, were the best performing growth mediums for container cyclamens in a controlled environment. The best performing growth medium, all contained peat. This result was supported by various research projects. A study conducted by Emmel (2005:173) concluded that peat, as growing medium, produces better results in the production of ornamental horticulture crops. A study by Waste and Resources action programme (Adlam, Rainbow, Wallace & Rayment, 2004:2) found that peat-based growing medium produced plants of better quality than using alternative growing mediums which contained Green compost and bark. Widmer (1972:112) suggested cyclamen grown in a medium of 100% or 80% peat mixture presented with a greater plant size. Tuber size indicated a possibility of the plant being in stress and that the growth medium was not supplying enough water for foliage and leaf growth but rather tuber growth. The next chapter contains the conclusion to the study and possible recommendations will be made.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The conclusions reached after the analysis of the data collected during the comparison of the growth mediums for container cyclamens in a controlled environment are discussed in this chapter. Each subproblem identified from the research problem statement translated into research objectives. These research objectives are discussed separately in order to determine whether the research objectives identified in the subproblems have been achieved during the study.

The following research objectives were identified from the subproblems:
Subproblem 1: Creating a visual measuring instrument
Subproblem 2: Determining the most suitable growth medium in the production of container cyclamens grown in a controlled environment
Subproblem 3: Determining how the commercial cyclamen grower would benefit by using the most suitable growth medium in the production of container cyclamens
Subproblem 4: Determining whether the carbon footprint of cyclamen production can be reduced by using the most suitable and cost-effective growth medium for container cyclamens

5.2 Objective 1: Creating a visual measuring instrument

Research has been published on the comparison of growth medium for cyclamens. However, it focuses on comparative studies of certain aspects of cyclamen growth medium and no comprehensive evaluation criteria are available to be used as a practical guideline for growers during the production of container cyclamens for a controlled environment (Widmer (1972:108); Van der Gaag *et al.* (2007:296); Nelson *et al.* (2010:354); Cativello *et al.* (1997:444); Trelka & Szczepaniak (2009:3); Mao *et al.* (2006:543).

The need therefore arose to establish such guidelines for cyclamen growers to use in evaluating cyclamen growth medium. It was necessary to peruse the literature for available research on existing comparisons of growth mediums for cyclamens and to identify a set of comprehensive evaluation criteria which would help create the measuring instrument for the comparison of growth. The comprehensive evaluation criteria were used to create a visual measuring instrument for the study to compare various growth mediums and their influence on container cyclamens. The visual instrument functions as a practical guideline and industry standard for growers for the production of container cyclamens in South Africa. The measuring instrument enabled the study to determine the most suitable growth medium for container cyclamens within a South African context with the commercially available growth mediums. The objective to create a visual instrument with comprehensive evaluation criteria for the comparison of growth medium for container-grown cyclamens was therefore achieved. This is a new contribution to the pool of knowledge.

5.3 Objective 2: Determining the most suitable growth medium in the production of container cyclamens grown in a controlled environment

Seven growth mediums for cyclamens were selected based on the literature and availability of the medium on South African markets. The results in Chapter 4 of the comparison of the growth mediums of seasons 2012 and 2013 indicate that Mix 1 and Mix 7 were the best performing growth mediums. The researcher observed the following during the study:

- The best performing growth mediums all contained peat. This result was supported by various research projects. Emmel (2008:173) concluded that peat produces better results in the production of ornamental horticulture crops. The study by Waste and Resources action programme (Adlam, Rainbow, Wallace & Rayment, 2004:2), found that peat-based growing mediums produced plants of better quality than using alternative growing mediums which contained Green compost and bark. Widmer (1972:106) suggested cyclamen grown in a medium of 100% or 80% peat mixture presented with a greater plant size.

- Tuber size indicated a possibility of the plant being in stress and that the growth medium was not supplying enough water for foliage and leaf growth but rather tuber growth.

The objective to determine the most suitable growth medium for container-grown cyclamens in a controlled environment was therefore achieved.

5.4 Objective 3: Determining how the commercial cyclamen grower would benefit by using the most suitable growth medium in the production of container cyclamens

The first benefit for commercial growers in using the most suitable growth medium is that they will be able to produce a quality product which reaches market readiness as early as possible in the production cycle. The first cyclamens to reach the market fetch a higher price at the market and product sales are assured.

The second benefit of using a growth medium that has been well researched the carbon footprint of the producer can be traced and reduced where possible. Most companies extracting peat in Europe are adhering to the peat "Wise use" campaign which translates to peat extraction that is sustainable and responsible (Clark, 2005:163).

There are disadvantages to using peat and peat mixtures as growing medium for the production of container cyclamen. It is expensive to use peat as a growth medium as indicated by Chavez et al. (2008:8083). The cost is increased by the necessity to import the growing medium consisting of peat from Europe as South Africa has no peat resources. More research in South Africa is necessary to find growth medium alternatives to peat which would be able to produce the same plant quality as peat and peat mixtures to serve as an alternative to peat as a growing medium. This study would like to recommend that South Africa also establishes a peat "Wise use" campaign however the initiative would need support from the Green Industry. This study has found peat to deliver the most suitable growth medium for cyclamens which contradicts the "Wise use" campaign. The objective to how the commercial cyclamen grower would benefit by using the most suitable growth medium in the production of container cyclamen was therefore achieved

5.5 Objective 4: Determining whether the carbon footprint of cyclamen production can be reduced by using the most suitable growth mediums for container cyclamens

The results of this study indicate that the best performing growth medium for container cyclamens were the ones containing peat. The local growth medium mixes without peat did not deliver the same performance results as the mixes with peat. As indicated in Chapter 2, protocols developed for the horticulture industry regarding the reduction of the carbon footprint suggest that the utilization of non-peat growth medium reduces the carbon footprint. The protocols suggest the utilization of peat alternatives in order to decrease the carbon footprint during the production of a horticultural crop.

Given the findings, in this study, the best performing growth medium for container cyclamens did not reduce the carbon footprint during cyclamen production, as they contained peat.

The imported growth medium mixes sourced from local suppliers are specifically designed for the production of container cyclamens in controlled environments. These “designer” growth mixes contain peat. Commercial growers will be faced with the dilemma of either using a growth medium which produces the best quality container cyclamens with early market delivery, but which increases the carbon footprint, or using non-peat growth medium and compromising on quality and delayed market delivery of the container cyclamens.

Importing growth mediums containing peat entails transport from the source of the peat, which is Europe, and any transport, by air or sea, increases the carbon footprint of a product. Therefore importing growth mediums specifically for cyclamens, which contain peat, increases the carbon footprint. The objective to determine whether the carbon footprint of cyclamen production can be reduced for the production of container cyclamen was not achieved. This is an important finding.

5.6 Recommendations

This study, based on the conclusions made from the findings, therefore recommends that a growth mediums which contains peat be used in the commercial production of cyclamens. This would help produce container cyclamens of a high quality and promote the early delivery of the product to the market. The presence of a minimum of six flowers would show that the plant is market ready. Commercial growers must be made aware of the increased carbon footprint that accompanies the use of growth mediums containing peat. It is also recommended that further research be conducted on new growth mediums mixtures.

5.7 Summary

The commercial growers in South Africa deem the production of container cyclamens to be an important source of supplementing winter income during the cold season. However, the greenhouse production of cyclamens is considered a high maintenance effort due to the length of the production season and the degree of expertise needed to produce a quality crop for the market. During a cold season, greenhouse production costs are higher than during the summer season and therefore careful planning of commercial crops is required, as the greenhouse structures need to be heated, which adds to the costs of production. Commercial growers, in general, must constantly look for innovative methods of growing products to improve their return on investment and quality of the final product. The aim of this study was to compare locally available growth mediums for the greenhouse production of cyclamens in order to determine which medium gives the optimal return on investment. With the introduction of new designer growth medium which have become available on the market locally, commercial growers are faced with determining which growth medium are the most suitable and will help reduce production costs.

The research problem formulated for this study was how to select the most suitable growth medium for the production of container cyclamens by comparing, in terms of quality, the production of commercially grown container cyclamens in a controlled environment. The result of the study has helped produce guidelines for the green industry on the selection of suitable growth mediums for container cyclamens. There is currently no comprehensive industry guideline or best practice specifications for the South African growers of container cyclamens. This gap in the South African research on the comparison of the growth mediums for cyclamen has now been reduced through this study.

The aim of this study was to determine the most suitable growth mediums for container cyclamens in a controlled environment. The objectives were to establish a measuring instrument which can be used to compare the growth medium for the production of container cyclamens, to determine the most suitable growth medium in the production of container cyclamens, to determine the benefits to the commercial growers and to determine whether the carbon footprint of cyclamen production can be reduced by using the most suitable and cost-effective growth medium for container cyclamens. The significance of this study is that growers know which medium produces the optimal growth result.

A comparative study has been conducted to determine the optimal growth medium. This was conducted and repeated over two seasons, 2012 and 2013, at Tuberflora, a wholesale nursery in Gauteng, South Africa.

The mediums used were selected from what industry is currently using. The focus was only on one variety of cyclamen from a homogeneous plant population. The seeds were *Cyclamen persicum* F1 standard variety Grandola Deep Rose ref. 20110513.0040 from a single packet from the suppliers Hem Genetics.

Whitcomb (2003:443) suggests that the most satisfactory method to use for experimentation for plant sciences is the “randomized complete block design”. The study by Nelson et al. (2010:355) also applied randomized replicates in blocks as an experimental design and used a sample size of five plants per experimental block. In the current study, there were 105 plants per season repeated in 2012 and 2013, constituting a total of 210 plants in the trial.

The study involved creating and applying a visual observation measuring instrument for container cyclamens. This instrument was created from existing measuring instruments used to compare the growth mediums of cyclamens in literature.

The measuring instrument criteria included the following measurements and observations: Total plant height, plant diameter, fresh plant mass, number of leaves, leaf width, foliage fresh weight, number of flowers, diameter of corm and root mass. A measuring instrument for the selection of growth medium for cyclamens was created successfully. The measuring instrument can be used as a guideline for commercial growers interested in selecting the most suitable growth mediums for a commercial container cyclamen crop for greenhouse production.

Based on the results analyses of the comparison of the combined season 2012 and season 2013, it was found that the most suitable growth medium for container cyclamens for South African circumstances would contain peat. Therefore commercial growers using growth medium with peat and peat mixtures would not only have a better quality product for market, but the minimum number of flowers deemed necessary for market readiness would be present. Plants would be ready for the market sooner than when using growth medium without peat. The study was able to determine suitable growth medium for container cyclamens in a controlled greenhouse structure. The study also highlighted the benefits to commercial growers, such as a to produce a quality product, faster production cycle and earlier market-ready container cyclamen delivery to the market.

The study determined, that although the growth mediums containing peat delivered the best quality product, that carbon footprint of these growth mediums are high. Commercial growers will need to make a decision as to whether environmental considerations weigh more heavily than the quality of the product, i.e. container cyclamens. This study allows commercial growers or nurseries to make an informed management decision on the cultivation of cyclamen in a controlled environment. This study was conducted only on the mediums available in Gauteng, South Africa, and further research would need to be conducted on new growth mediums mixtures entering the market. Publishing the results will create a platform for sharing information and will lead to a scientific foundation for further research on commercially grown cyclamen for the floriculture industry in South Africa.

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ANNEXURES

A. SOUTH AFRICAN LEGISLATION

South African Occupational Health and Safety legislation

labour

Department:
Labour
REPUBLIC OF SOUTH AFRICA

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Documents

Legislation

Fraud Hotline
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Amended Occupational Health and Safety Act

by Lloyd Ramutloa — last modified 2008-05-30 16:14

Amended Occupational Health and Safety Act

Occupational Health and Safety Act (No. 85 of 1993)

Summary: To provide for the health and safety of persons at work and for the health and safety of persons in connection with the use of plant and machinery; the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work; to establish an advisory council for occupational health and safety; and to provide for matters connected therewith.

Be it enacted by the Parliament of the Republic of South Africa as follows:-

Table of Contents

1. Definitions
2. Establishment of Advisory Council for Occupational Health and Safety
3. Functions of Council
4. Constitution of Council
5. Period of office and remuneration of members of Council
6. Establishment of technical committees of Council
7. Health and safety policy

News

→ Speech by the honourable Minister of Labour, Mildred Oliphant, MP; Inspectors Conference, CTICC, Cape Town
2013-09-12
12 September 2013

→ Social dialogue is crucial for labour inspectors – Department's indaba told
2013-09-12
12 September 2013

→ Department urges employers to comply with Health and Safety law
2013-09-11
11 September 2013

→ Department faces huge ICT wage bill
2013-09-11
10 September 2013

→ Quest for new

Sourced from http://www.labour.gov.za/DOL/legislation/acts/occupational-health-and-safety/read-online/amended-occupational-health-and-safety-act

South African legislation relevant to use of fertilizers, farm feeds, agricultural remedies and stock remedies acts and regulations

Regulation Title	PEST CONTROL OPERATOR REGULATIONS - GN R98/2011 (FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT 36 OF 1947)
Commencement Date	20110218
Date Modified by Sabinet	2011-03-08
SEARCH	across this Act and its Regulations

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FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT 36 OF 1947

PEST CONTROL OPERATOR REGULATIONS

Published under Government Notice R 98 in *Government Gazette* 34020 of 18 February 2011.

The Minister for Agriculture, Forestry and Fisheries has under Section 23 of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947), made the regulations in the Schedule.

Sourced from http://0-discover.sabinet.co.za.oasis.unisa.ac.za/document/NTL10047

FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT 36 OF 1947

[ASSENTED TO 3 JUNE 1947] [DATE OF COMMENCEMENT: 1 JUNE 1948]

(Afrikaans text signed by the Governor-General)

as amended by

Fertilizers, Farm Feeds, Seeds and Remedies Amendment Act 48 of 1950

Seeds Act 28 of 1961

Fertilizers, Farm Feeds and Remedies Amendment Act 60 of 1970

Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Amendment Act 17 of 1972

Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Amendment Act 24 of 1977

Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Amendment Act 4 of 1980

General Law Amendment Act 49 of 1996

Regulations under this Act

EXCLUSION OF CERTAIN FARM FEEDS FROM THE OPERATION OF CERTAIN PROVISIONS OF THE ACT

FARM FEEDS, REGULATIONS RELATING TO

GRANTING OF CERTAIN POWERS TO THE SECRETARY FOR AGRICULTURE REGARDING THE ACQUISITION, DISPOSAL OR USE OF FARM FEEDS

PROHIBITION OF THE SALE, ACQUISITION, DISPOSAL OR USE OF AGRICULTURAL REMEDIES AND STOCK REMEDIES [CHLORDANE]

PROHIBITION OF THE SALE, ACQUISITION, DISPOSAL OR USE OF AGRICULTURAL REMEDIES AND

Sourced from http://www.nda.agric.za/doaDev/sideMenu/ActNo36_1947/Act%2036%20of%201947.pdf

B. Letters of permission from stakeholders: Tuberflora, Culterra, Klasmann and MEEGAA

Tuberflora

CC/BK No. 1990/016399/23 "Just add water"

P.O. Box 141 Muldersdrift 1747 Tel. (011) 662-1954/9 Fax 662-1966

Tuberflora Management
POBox 141, Mukdersdrift, 1747
Plot 45, Abraham van Wyk Rd, Muldersdrift, 1747
Tel: 011 662 1954/5/9/65
Fax 086 508 4139
Cell 083 674 0151 & 078 800 6037
Email: info@tuberflora.co.za

Dear Sir / Madam,

Hereby permission is given to commence and complete the planned research which is to be conducted in the form of a research dissertation.

Title: **A COMPARISON OF GROWTH MEDIA ON CYCLAMENS IN A CONTROLLED ENVIRONMENT.**
Name: **Mr. Pierre Adriaanse**
Qualification: **MSc Ornamental Horticulture**
Tertiary institution: **School of Environmental Sciences at Unisa (University of South Africa)**

Tuberflora has no objection to the publishing of scholarly articles which may emanate out of the research conducted during the study in popular Green Industry Trade or scholarly peer-reviewed journals.

Kind regards

(A. DE JONG)
Tuberflora Management

Vervaardigers van Organiese Misstowwe en Grondmengsels
Beton Produkte, Stadig Vrystellende en Chemiese Kunsmis

Manufacturers of Organic Fertilizers and Soil Mixtures.
Concrete products, Slow Release and Chemical Fertilizers.

CULTERRA (EDMS)BPK./(Pty) Ltd
Reg. No. [illegible]
982 Muldersdrif 1747 RSA
☎: (011) 300 9913/4/5
Fax: 0866 196 698 / 0866 980 684
Cel: 072 591 9848; 082 555 4880; 082 901 2624
e-mail: culterra@mweb.co.za
web: www.culterra.co.za

11/11/2011

Dear Mr P. Adriaanse,

Culterra™ notes your intention to conduct a research study at Tuberflora™ using the following growth media from Culterra™:

- Mix No 7 100% pine bark
- Mix No 49 80% pine bark and 20% coir
- Mix No 45 60% pine bark and 40% coir
- Mix 100% course coir

The above mentioned mixtures are commercially available on order at the Culterra depot. We support your research and are happy to be associated with the study; namely

Title: **A COMPARISON OF THE EFFECT OF GROWTH MEDIA ON THE PRODUCTION OF CYCLAMENS IN A CONTROLLED ENVIRONMENT.**
Name: **Mr. Pierre Adriaanse**
Qualification: **MSc Ornamental Horticulture**
Tertiary institution: **School of Environmental Sciences at Unisa (University of South Africa)**

Kind regards

Culterra

Cnr. Vickers Rd & Fig Place
City Deep, Johannesburg
Tel: +27(0)11 613 3103/2580
Fax: +27(0)11 613 2095
www.ghtech.co.za
francois@ghtech.co.za

17 February 2012

Dear Mr. P. Adriaanse,

Greenhouse Technologies notes your intention to conduct a research study at Tuberflora™ using the following growth media from Greenhouse Technologies:

- Klasmann Deilmann Peat Moss

The above mentioned mixtures are commercially available on order at the Greenhouse Technologies depot. We support your research and are happy to be associated with the study; namely

Title: A COMPARISON OF THE EFFECT OF GROWTH MEDIA ON THE PRODUCTION OF CYCLAMENS IN A CONTROLLED ENVIRONMENT.

Name: **Mr. Pierre Adriaanse**

Qualification: **MSc Ornamental Horticulture**

Tertiary institution: **School of Environmental Sciences at Unisa (University of South Africa)**

Kind Regards,

Francois de Kock

Managing Director

MEGA substrates

MeeGaa substrates bv
Postadres: Westgaag 4aa
3155 DE Maasland
Tel. +31(0)15 - 2143055
Fax +31(0)10 - 5926035
E-mail info@meegaa.nl
internet www.meegaa.nl
Rek. nr. 13.27.32.432
IBAN NL43RABO0132732432
Swift adres RABONL2U
BTW nr. NL8186.94.385.B01

Maasland, January 15th 2013

To whom it may concern,

We, the undersigned, herewith declare that we give permission to:

Mr. Pierre Adriaanse
Working for Tuberflora
Plot 45, Abraham van Wyk Rd
Muldersdrift 1747
South Africa

to use our Medium "Potting soil Cyclamen mix" in his trials for his master degree in horticulture at UNISA. This medium will be used for his topic *"a comparison of growth media on Cyclamen in a controlled environment"*.

Yours faithfully,

MeeGaa Substrates B.V.

C. van Gils

MeeGaa Substrates B.V.
Westgaag 4aa
3155 DE Maasland
Tel:+31(0)10-7144920 Fax:+31(0)10-5926035
info@meegaa.nl
OB nr.: NL818694385B01 K.v.K.nr.: 27307956

MeeGaa Substrates B.V.
Shakti Cocos

Alweco Scherminstalaties Int B.V
Kind attn.: Danie
Honderdland 103
2676 LT Maasdijk
dani@alweco.za.co

Your reference	Our reference	Date
	O12ALW013	03 December 2012

Dear Danie,

According to our conversation on the phone we herewith send you our quotation for Cyclamen-mixture.

Product
Cyclamen-Mixture
- 20% peatmoss fraction 2
- 30% peatmoss fraction 1,5
- 20% cocos crush
- 15% Irish Coarse
- 15% perlite 3
- lime for pH 6
- 1 kg PG-mix / m3
- 3 kg Osmocote 16/18 per m3

Approx 4EN-M^3 per BigBale.
Stock available.
LEAD TIME ± 3 WEEKS if stock not AVAIL

C. LIST OF RESOURCES FOR THE STUDY

Resources	Details
Infrastructure Resources: Greenhouse for cyclamen production Seeding room Germination room Ground cover Seeds AVONROD spray programme – Pest and disease Tuberflora - Fertilizer programme	 Tuberflora's property
Equipment: Lux meter Temperature and humidity data logger EC meter pH Meter Hosepipe with Dosatron for fertilizer - watering Spraying cart	 Tuberflora's property
Consumables: 12 cm plastic pots 128 trays Substrates (growth medium): 1. Cyclamen mix - a commercially imported mixture consisting of 90% coir and 10% perlite; 2. 50% Cyclamen mix - 50% 45 Mix; 3. 49 Mix - a mixture of 80% pine bark and 20% coir; 4. 45 Mix - a mixture of 60% pine bark and 40% coir; 5. 7 Mix - 100% pine bark; 6. 100% course coir; and 7. Klasmann 4 substrate - a commercially imported mixture consisting of 100% peat. Fertilizers as per fertilizer programme – Appendix H	

Commercial products for pest and disease programme – as per prescription by AVONROD	
Stationary: Paper Printer Ink DVD's for back-ups and data storage	

D. Information, soil and water quotes by Eco Analytica

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOMKAMPUS

Posbus 19140
NOORDBRUG
2522

NFA: Omgewingswetenskappe & -Bestuur
Tel: 018-293 3900
Faks: 018-294 5740
E-pos: yvonne.visagie@nwu.ac.za

TELEFAKS/TELEFAX

Faks no./Fax no.: **Datum/Date:** **7 September 2011**

AAN/TO : **Tuberflora**

VIR AANDAG/FOR ATTENTION : **Pierre**

Bladsye insluitend hierdie een/Pages including this one: 1

BOODSKAP/MESSAGE:

Goeie dag
Hiermee die kwotasie soos aangevra: **Verwys / Ref No:**

Tipe Analise	Aantal	Prys per monster (BTW uitgesluit)	TOTAAL (BTW ingesluit)
1:2 Ekstraksie sonder P-Bray 1	1	262.35	**299.08**
1:2 Ekstraksie met P-Bray 1	1	281.20	**320.57**
Water analise	1	232.45	**264.99**
Chemiese analise	1	170.70	**194.60**
Sand, Slik en Klei (SSK)	1	60.70	**69.20**
Aanbeveling	1	275.00	**313.50**
TOTAAL (BTW ingesluit)			**1461.94**

Bankbesonderhede : Absa Bank Kerkstraat
Tak nommer : 335-138
Rekening nommer : 405-9896-660
Rekening naam : Noordwes-Universiteit - Eco Analytica
Faks asb. 'n bewys van inbetaling (deposito strokie of elektroniese oorbetaling) deur.
Ontleding van monsters kan nie begin alvorens bewys van inbetaling ontvang is nie.

Fisiese koerier adres: Eco Analytica
Vyfhoek Plot 491
Thabo Mbeki Drive (R501)
Uit op die Carletonville pad
Potchefstroom

WAGENINGEN UNIVERSITY

WAGENINGEN UR

For quality of li

WEPAL

North-West University
Eco Analytica
C/o Terina Vermeulen, Senior Laboratory Technician
P.O. Box 19140
2522 Noordbrug
Noordbrug

February 13, 2012

Participation WEPAL Programme

WU12-L-030

Minke van Veldhuizen

+31 371 48 23 37

Dear member of WEPAL,

Your institute is a member of the Wageningen Evaluating Programmes for Analytical Laboratories starting the year 1994.

You participate in Programme	: ISE
Your participate in period(s)	: all 4 periods
Your client number is	: 231
Your code name is	: XIAL
Your lab number is	: 233

Sincerely yours,

Mr. Drs. A. Eijgenraam
Manager WEPAL

P.O. Box 8005
NL 6700 EC Wageningen
The Netherlands

Building number 112
Bornsesteeg 10
6721 NG Bennekom

+31 317 48 23 37

+31 317 48 56 86

www.wepal.nl

AGRI LABORATORY ASSOCIATION OF SOUTHERN AFRICA

AGRI LABORATORIUM ASSOSIASIE VAN SUIDELIKE AFRIKA

CERTIFICATE OF MEMBERSHIP

Presented to:

ECO ANALYTICA, NORTH-WEST UNIVERSITY, POTCHEFSTROOM

01 January 2012

MEMBER

To remain in good standing by fulfilling the responsibilities of membership

....

President

E. Example of soil and water sample analysis by Eco Analytica

NORTH-WEST UNIVERSITY
ECO-ANALYTICA

Eco Analytica
P.O. Box 19140
NOORDBRUG 2522
Tel: (018) 293 3900

PIERRE ADRIAANSE

20/1/2012

Nutrient Status

Sample no.	Ca	Mg	K	Na	P	$pH(H_2O)$	pH(KCl)	EC
	(mg/kg)							(mS/m)
1	4122.0	1368.0	1517.0	350.5	211.4	5.68	5.26	154
2	2102.0	566.5	962.0	216.5	52.6	5.42	4.65	95
3	2038.5	542.5	1030.0	220.0	52.0	5.32	4.44	85
4	1736.5	407.5	860.5	234.5	37.5	5.27	4.38	80
5	2377.0	735.0	919.5	205.0	35.2	5.85	5.09	95
6	3079.0	1203.0	2097.0	425.0	63.6	5.74	5.03	137
7	5195.0	435.0	97.0	145.5	4.5	4.76	3.88	25

Exchangeable cations

Sample no.	Ca	Mg	K	Na	CEC	S-value	Base saturation (%)	$pH(H_2O)$	pH(KCl)
	(cmol(+)/kg)								
1	20.57	11.26	3.89	1.52	37.11	37.24	100.35	5.68	5.26
2	10.49	4.66	2.47	0.94	31.03	18.56	59.80	5.42	4.65
3	10.17	4.47	2.64	0.96	30.91	18.23	58.99	5.32	4.44
4	8.67	3.35	2.21	1.02	27.48	15.25	55.48	5.27	4.38
5	11.86	6.05	2.36	0.89	30.17	21.16	70.15	5.85	5.09
6	15.36	9.90	5.38	1.85	37.75	32.49	86.07	5.74	5.03
7	25.92	3.58	0.25	0.63	56.24	30.38	54.02	4.76	3.88

HANDBOOK OF STANDARD SOIL TESTING METHODS FOR ADVISORY PURPOSES

Exchangeable cations: 1M NH_4-Asetaat pH=7
CEC: 1M NH_4-Asetaat pH=7
Extractable, Exchangeable micro-elements: 0.02M $(NH_4)_2$ EDTA.H_2O

EC: Saturated Extraction
pH H_2O/KCl: 1:2.5 Extraction
Phosphorus: P-Bray 1 Extraction

This laboratory participares in the following quality control schemes:
1. Agricultural Laboratory Association of Southern Africa.
2. International Soil-Analytical Exchange (ISE), Wageningen, Nederland.

No responsibility is accepted by North-West University for any losses due to the use of this data

Soil Samples 1-5 and Water Samples 15 December 2011

Cyclamen Mix

1:1,5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY I
15/12/2011	*millimol per liter*										*mikromol per liter*						*mS/cm*	*DPM*
1	0.38	0.50	2.25	1.02	0.68	0.97	0.95	0.32	0.37	0.10	12.99	1.09	1.12	3.06	25	5.40	0.54	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$	1 : 0.4			K:Ca	1 : 0.2			K:Mg	1 : 0.2		Ca:Mg		1 : 1.3		

50% Cyclamen Mix and 50% 45 Mix

1:1,5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY I
15/12/2011	*millimol per liter*										*mikromol per liter*						*mS/cm*	*DPM*
2	0.19	0.18	1.85	1.03	0.12	0.64	0.18	0.01	1.82	0.05	24.90	0.93	0.72	0.62	8	4.84	0.37	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$	1 : 0.1			K:Ca	1 : 0.1			K:Mg	1 : 0.1		Ca:Mg		1 : 0.9		

49 Mix (20% Coir and 80% Pine Bark)

1:1,5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY I
15/12/2011	*millimol per liter*										*mikromol per liter*						*mS/cm*	*DPM*
3	0.12	0.06	1.64	0.82	0.08	0.34	0.12	0.01	1.74	0.05	28.26	0.24	1.07	0.58	4	4.59	0.29	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$	1 : 0.1			K:Ca	1 : 0.1			K:Mg	1 : 0.0		Ca:Mg		1 : 0.5		

45 Mix (40% Coir and 60% Pine Bark)

1:1.5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY 1
15/12/2011	millimol per liter										mikromol per liter						mS/cm	DPM
4	0.13	0.07	1.42	0.82	0.03	0.34	0.13	0.02	1.71	0.05	22.42	0.57	0.94	0.40	8	4.64	0.27	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$	1 : 0.1			K:Ca	1 : 0.1			K:Mg	1 : 0.0		Ca:Mg		1 : 0.5		

7 Mix (100% Pine Bark)

1:1.5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY 1
15/12/2011	millimol per liter										mikromol per liter						mS/cm	DPM
5	0.19	0.14	1.79	0.79	0.04	0.42	0.18	0.02	2.01	0.10	21.02	1.86	1.01	0.51	3	5.22	0.33	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$	1 : 0.1			K:Ca	1 : 0.1			K:Mg	1 : 0.1		Ca:Mg		1 : 0.7		

100% Course Coir

1:1.5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY 1
15/12/2011	millimol per liter										mikromol per liter						mS/cm	DPM
6	0.20	0.26	3.00	1.48	0.06	0.91	0.12	0.01	3.20	0.05	26.98	3.95	0.98	0.45	7	5.00	0.55	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$	1 : 0.0			K:Ca	1 : 0.1			K:Mg	1 : 0.1		Ca:Mg		1 : 1.3		

Klasmann Base Substrate 4

1:1,5 EKSTRAK	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY 1
15/12/2011	*millimol per liter*										*mikromol per liter*						*mS/cm*	*DPM*
7	0.07	0.02	0.08	0.27	0.01	0.21	0.09	0.16	0.14	0.00	7.10	0.54	0.12	0.19	<1	4.20	0.07	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$ 1 : 1.1				K:Ca 1 : 0.9				K:Mg 1 : 0.3			Ca:Mg 1 : 0.3				

Water Gkasshouse No 16

WATER	Ca	Mg	K	Na	PO_4	SO_4	NO_3	NH_4	Cl	HCO_3	Fe	Mn	Cu	Zn	B	pH	EG	P-BRAY 1
15/12/2011	*millimol per liter*										*mikromol per liter*						*mS/cm*	*DPM*
CH16	0.75	0.59	0.07	0.91	0.01	0.25	1.35	0.02	0.67	1.10	3.76	1.07	1.25	2.30	<1	6.83	0.37	
EVALUASIE																		
NORM																		
Vorige																		
			$K:NO_3$ 1 : 19.3				K:Ca 1 : 10.7				K:Mg 1 : 8.4			Ca:Mg 1 : 0.8				

F. AVONROD SPRAYING PROGRAMME FOR CYCLAMEN

AVONROD PLANTPROTECTION cc 1
Supplier of horticultural chemicals, biologicals & spray equipment.
PO Box 671 Fourways 2055
12/269 Woburn Ave Chartwell North Estates Jhb. South Africa.
Tel: 011 460 1901 Fax: 011 460 0174
Cell: 082 891 8399 E-mail: avonrod@mweb.co.za

Cyclamen.sp

AVONROD SPRAY PROGRAM FOR CYCLAMEN

CLIENT Tuba Flora

EDITION: 03 / 2012

AREA

VARIETIES

PROGRAM No. 5701 B

REF: Cyclamen.sp
DATE of Issue 29/3/2012

The program consists of a 3 week cycle (Preventative) and several SPECIAL MIXES This program is based on the assumption that the amount of spray mix applied is approximately 600 Lt to 800 Lt per. Ha. (Depending on the height and density of the foliage --- Ensure good penetration of foliage by using fine spray droplets and adequate pressure) - If using "conventional spray methods" Knapsack mist blowers are not recommended!

Please notify us, should you observe any "Phytotoxcisity" resulting from this program.

When in doubt contact me immediately, any time, day or night --- within reason!

The chemicals used to compile this program have proved to be compatible with each other and safe within reason, if used in the right sequence and at our recommended dosage rates. However, other factors may influence the effect the chemicals have on the plants, i.e. spray water, climate, soil, nutrient status of soil, age of chemicals and storage conditions __ spray technique is also critical. We have recommended certain brand names; we take no responsibility if "**generics**" are substituted. There are vast differences in the quality of chemicals with the same active ingredient, but of different origin (manufacture).

This spray program is suggested in good faith, we aim to simplify spray management. The program consists of a 3 week cycle (Preventative) and several Special Mixes that are only sprayed when an "outbreak" has occurred or when weather conditions are favourable for the development of the pest or disease. Scout regularly for pests that may escape the preventative spray program, then implement one of the "SPECIAL MIXES", should the need arise. These Special Mixes should be implemented on their own but in the same week, with a few days interval between sprays.

Nº 5701 B

SPRAY PROGRAM 3 WEEK CYCLE (Preventative)

Mix 1	Octave	80 g	Per 100 Lt. Water
	Orthene	100 g	
	Silwet	10 ml	
Mix 2	Benomyl	100 ml	Per 100 Lt. Water
	Bandit / Kohinor	50 ml	
	Silwet	10 ml	
Mix 3	Bravo	200 ml	Per 100 Lt. Water
	Seizar	40 ml	
	Silwet	10 ml	

Treat young plants or seedlings before or after transplanting with ;-

Drench;-	Benomyl	100 g	
	Proplant / Previcure N	200 ml	Per 100 Lt. Water
	Octave	15 g	

One week after the above chemical treatment,

Drench;- Trichotech *Trichoderma harzianum* 125 g Per Ha (10000 M^2 area.)
Trichoderma will protect the plants against fungal infection.

Treatment when root rots break out.

Drench;- *Streptomyces griseoviridis* 200 – 500 ml Per 1Ha (10000 M^2
This treatment has proved to be very successful.
However *Trichoderma harzianum* will also be destroyed, and will have to be reapplied at a later stage.

G. AVCASA CERTIFICATION

AVCASA

Association of Veterinary And Crop Associations of South Africa
Reg No. 67/02403/08

SUID-AFRIKAANSE POLISIE DIENS
MULDERSDRIFT
STASIE BEVELVOERDER
17 MAR 2012
MULDERSDRIFT
STATION COMMANDER
SOUTH AFRICAN POLICE SERVICE

Certificate

For the successful completion of the AVCASA Plant Protection Course

Issued to

PIERRE ADRIAANSE
681101 5018 082

Completion Date

MAY 2007

Executive Director

30/07/2007
Date

H. CYCLAMEN FERTILIZER PROGRAMME

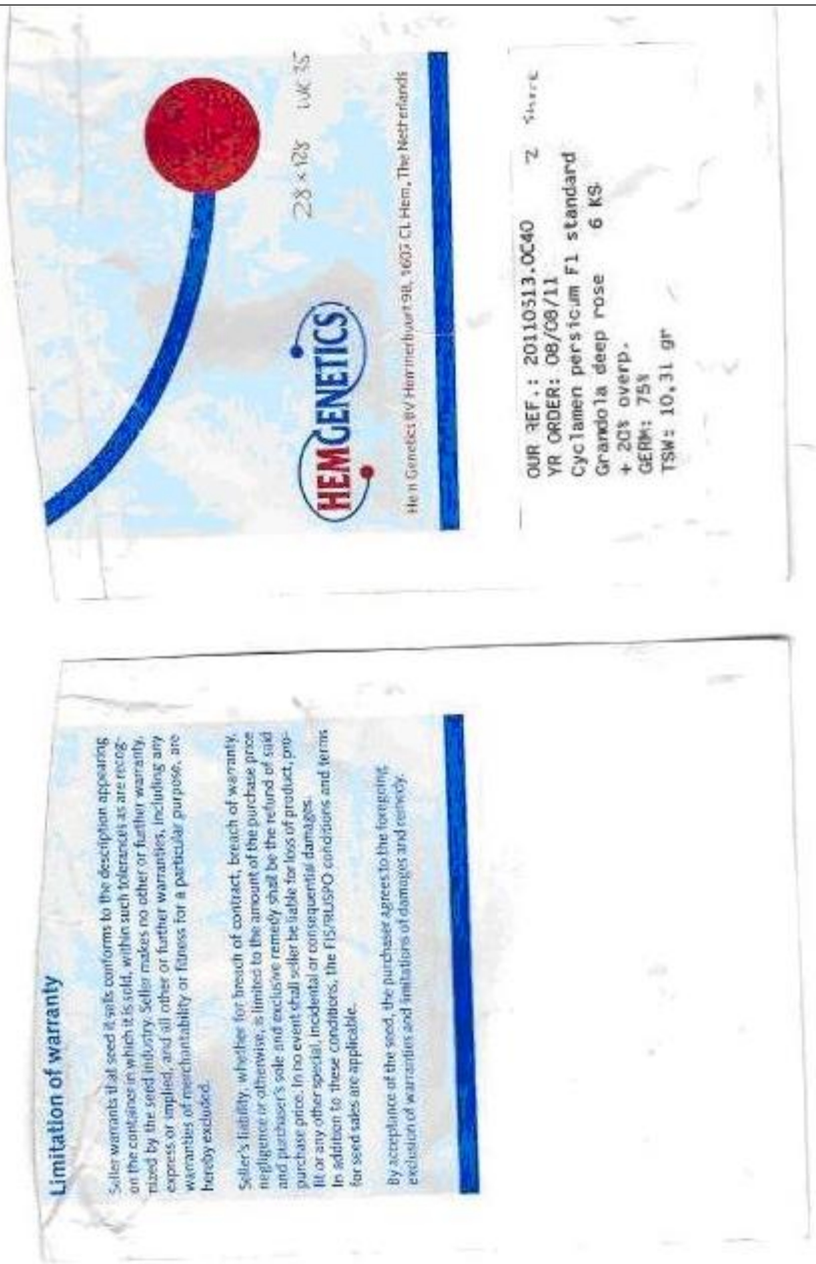
<u>Cyclamen Fertilizer programme</u>

Schedule sequence for the production phase

	Group 1	Date
1	Calcium Nitrate	
2	Multifeed	
3	Calcium Nitrate	
4	Multifeed	
5	Calcium Nitrate	
6	Multifeed	
7	Calcium Nitrate	
8	Multifeed	
9	Calcium Nitrate	
10	Multifeed	
11	Calcium Mix	
12	Calcium Nitrate	
13	Potassium Nitrate	
14	Calcium Nitrate	
15	Calcium Mix	
16	Multifeed	
17	Potassium Nitrate	
18	Calcium Nitrate	
19	Multifeed	
20	Potassium Nitrate	
21	Superfeed	
22	Multifeed	
23	Potassium Nitrate	

Multifeed = a product by Plaaschem™
Superfeed = a product of Plaaschem™

I. CYCLAMEN PERSICUM F1 – GRANDOLA DEEP ROSE FROM HEMGENETIC™



J. SCHEDULE FOR MEASUREMENT AND RECORDING OF DATA

Note: Actual schedule
It was for continuity, a field work diary would be kept for the entire production process although the study focuses only on the production phase of the cyclamen which would coincide with the production process. The visual observations and evaluations will take place on regular basis (every 7 weeks) according to a schedule using various equipment and tools such as data loggers for accuracy and continuity, the following is envisaged that visual observations and evaluations as listed below will be undertaken:

1. Soil samples
2. Water samples
3. Planning Phase:
4. Preparation phase:
    - Dates greenhouse cleaned & sterilized etc.
5. Seed phase:
    - Dates seeds arrived,
    - Seeds sowed germinated,
    - Temperature and humidity data and
6. Germination phase:
    - Dates plants arrive in germination room
    - Temperature and humidity
7. Seedling phase:
    - Dates plants arrive in production greenhouse,
    - Temperature and humidity data
    - Other notes e.g. dates and details of Previcure application
    - Pest and disease programme - AVONROD Plant Protection®
8. Production phase
    - Dates plants arrive in production greenhouse,
    - EC details – remember to once a week clean out with no nutrients
    - pH details
    - Lux measurements
    - Temperature and humidity data
    - Pest and disease programme - AVONROD Plant Protection®
    - Other notes e.g.
        a. Apply the following parameters as part of measuring instrument every 7 weeks:
            i. Plant diameter
            ii. Number of leaves
            iii. Diameter of corm
        b. Date of spacing of pots (to prevent leaves touching)

9. Post-production phase
    - Date of cyclamens leaving production floor
    - Other notes

10. General observations and evaluations every 7 weeks:
    - Ambient temperatures - season
    - Fertigation programme

- Spraying programme
- Problems experienced – notes on power cuts, strikes etc.
- Dosatron® system calibration

K. BASIC VISUAL COMPARISON OF PILOT STUDY

<table>
<tr><th>Pilot Study results</th><th>Basic Visual measuring instrument:</th></tr>
<tr><td>
</td><td>The plant diameter in the cyclamen Mix appeared to be larger in size and have more leaves as compared to Mix 45.</td></tr>
<tr><td>
</td><td>The plants in the Mix 45 appeared to be smaller in size and to have a weaker root system – note less white roots.</td></tr>
<tr><td>
</td><td>The plants in the cyclamen Mix appeared to be larger in size and to have a stronger root system note more white roots.</td></tr>
</table>

L. CYCLAMEN PRODUCTION CYCLE RECORDS FOR 2011-2012 AND 2012-2013

Cyclamen production cycle records for 2011-2012

Week		Watering	Spraying	Temperature Min	Temperature Max	Humidity Max	Humidity Min	Lux reading
49	1	Cleaning						
	2	Disinfect						
	3	Filling pots						
	4	Start Planting		17.2	21.1	94.2	92.2	400 Lux
	5	Planting		17.8	25.4	63.2	96.2	400 Lux
	6			16.6	33.2	41.3	96.3	
	7			16	40.2	35.2	92.4	
50	1	Clean water		17.1	35.2	42.2	97.6	400 Lux
	2			18.1	36.1	48.3	95.4	500 Lux
	3			18	35.7	38.2	97.3	500 Lux
	4			18.6	34.3	33.7	96.2	400 Lux
	5	Clean water		17	36.3	34.4	96.3	350 Lux
	6			17.4	38.4	33.6	96.3	
	7			16.3	39.4	35.6	96.3	
51	1	Clean water		18.3	37.7	35.6	96.3	450 Lux
	2			18.6	38.5	36.6	86.5	400 Lux
	3		Biox 500 ml / 100 L	17.6	34.5	39.7	95.6	500 Lux
	4			18.4	34.4	58.5	96.5	500 Lux
	5	Clean water		19.4	26.6	41.4	96.3	500 Lux
	6			18.9	33.3	36.6	95.2	
	7			18.4	25.5	47.3	95.2	
52	1	Cano3		18.3	32.4	48.7	96.2	500 Lux
	2			18.7	40.4	58.4	97.5	500 Lux
	3	Multifeed	Benomyl 50 g / 100 L	19.4	34.3	52.9	98.3	450 Lux
	4		Mospilan 50g / 100 L	18.3	27.5	36.3	96.2	450 Lux
	5	Cano3		17.4	35.7	48.3	96.8	500 Lux
	6			16.5	35.7	63.2	96.8	
	7	Clean water		15.4	37.7	50.5	96.8	
1	1			17.3	39	38.6	95.6	450 Lux
	2	Multifeed	Bravo 100ml / 100 L	17.2	37.6	40.7	96.6	400 Lux
	3		Seizar 40ml / 100 L	17.7	39.4	36.7	96.7	500 Lux
	4	Cano3		17.5	38.4	40.7	96.4	500 Lux
	5		Biox 500 ml / 100 L	16.5	40.2	34.2	95.4	500 Lux
	6	Multifeed		18.3	26.7	40.3	95.9	
	7			17.1	34.4	35.5	96.4	
2	1	Cano3		17.2	43.1	56.7	96.5	500 Lux

	2		Benomyl 50 g / 100 L	15.9	33.7	43.2	95.5	550 Lux
	3	Multifeed	Mospilan 50g / 100 L	17.6	33.4	31.9	94.6	500 Lux
	4			20.5	27.9	48.7	85.9	400 Lux
	5	Cano3	Biox 500 ml / 100 L	17.7	28.3	58.7	95.8	400 Lux
	6			19	41.3	33.3	96.7	
	7	Clean water		19.1	35.5	42.7	95.4	
3	1	Multifeed		17.1	38.3	37.9	96.7	500 Lux
	2			16.8	35.4	41.9	95.5	500 Lux
	3	Cano3		17.5	33.8	40.7	95.7	500 Lux
	4			17.4	37.2	40.5	96.6	500 Lux
	5	Multifeed	Biox 500 ml / 100 L	16.2	29.5	38.7	97.9	450 Lux
First measuring	6			16.3	34.6	43.9	95.5	
	7	Clean water		19.4	35.1	43.6	95.5	
4	1			19.6	37.9	46.3	96.8	550 Lux
	2	Cano3		19.2	38.3	38.9	96.6	500 Lux
	3		Drench	17.4	38.5	44.1	96.7	500 Lux
	4	Cano3		17.3	37.2	40.3	95.6	450 Lux
	5		Biox 500 ml / 100 L	18.2	35.3	39.6	98.6	450 Lux
	6			16.8	36.9	49.1	98.7	
	7			17.5	40.2	40.3	98.6	
5	1	Potassium Nitrate		15.1	37.9	40.3	97.6	450 Lux
	2		Drench	16.3	38.3	44.7	98.1	400 Lux
	3	Cano3		17.4	38.5	38.2	96.1	500 Lux
	4			19.3	37.7	44.1	95.9	500 Lux
	5	Cano3	Biox 500 ml / 100 L	18.2	35	40.9	98.2	500 Lux
	6			16.8	36.9	39.1	98.1	
	7			17.5	40.2	49.1	98.6	
6	1	Multifeed		15.1	40.2	40.7	97.2	500 Lux
	2		Bravo 100ml / 100 L	16.3	37.5	33.5	98.9	500 Lux
	3	Potassium Nitrate	Seizar 40ml / 100 L	17.7	38.2	33.2	96.6	350 Lux
	4			19.1	36.2	43.2	96.5	350 Lux
	5	Cano3	Biox 500 ml / 100 L	20.1	30	38.2	96.5	400 Lux
	6			18.6	38.3	44.1	95.2	
	7			19.4	39.6	60.5	96.1	
7	1			19.2	29.1	41.2	96.4	450 Lux
	2	Multifeed	Octave 80 g / 100 L	18.4	23.1	42.6	97.2	400 Lux
	3		Orthene 80 g /100 L	20.1	34.8	73.6	96.1	500 Lux
	4			20.5	39.6	83.1	98.1	500 Lux
	5	Potassium Nitrate	Drench	19.8	40.2	46	97.5	500 Lux
	6			13.3	38.1	23.3	93.6	
	7			13.8	35.4	33.3	96.4	

8	1	Superfeed		18.5	34.5	42.2	96.2	400 Lux
	2		Drench	17.3	35.1	50.7	95.8	500 Lux
	3	Multifeed		17.3	36.9	48.1	96.1	500 Lux
	4			17.4	31.3	64.1	96	400 Lux
	5	Potassium Nitrate	Biox 500 ml / 100 L	18.1	34.2	50.6	91.4	350 Lux
	6			17.7	36	54	97.2	
	7			16.9	33	42	95.6	
9	1		Bravo 100ml / 100 L	17.2	38.1	45.6	91.4	450 Lux
	2	Multifeed	Seizar 40ml / 100 L	15.3	26	41.8	94.1	400 Lux
	3			16.1	29	36.3	93.2	500 Lux
	4	Potassium Nitrate		16.7	39.2	66.1	91.2	500 Lux
	5		Biox 500 ml / 100 L	16.2	39.4	50.8	91.8	500 Lux
	6			14.7	43.6	23.4	93.2	
	7			13.2	33.5	32.3	92	
10	1			16.2	26.9	29.8	90	500 Lux
	2	Superfeed	Octave 80 g / 100 L	19	33.2	51.7	90.7	550 Lux
	3		Orthene 80 g /100 L	15.8	32.9	76.8	91.4	500 Lux
	4	Potassium Nitrate		16.3	33.7	48	96.2	400 Lux
	5			15.3	37.2	45	94.4	400 Lux
Second Measuring	6		Drench	17.3	35.1	40.9	88	
	7			16.3	37.1	39.7	96.2	
11	1	Superfeed		14.1	38	39.3	96.8	500 Lux
	2		Benomyl 50 g / 100 L	13.9	21.8	36.3	93.1	500 Lux
	3		Mospilan 50g / 100 L	15.1	24.5	34.8	92.4	350 Lux
	4	Potassium Nitrate		18	36.2	84.5	87.4	350 Lux
	5			16.1	35.5	76.8	97.2	400 Lux
	6			15	40.1	39.8	97.6	
	7			12.5	37	40.4	98.5	
12	1	Superfeed	Bravo 100ml / 100 L	16	36.1	32.4	97.2	500 Lux
	2		Seizar 40ml / 100 L	14.4	34.1	36.7	97.3	550 Lux
	3			15.5	39.9	42.2	94.2	500 Lux
	4	Potassium Nitrate		14.1	32.9	39.4	95.9	400 Lux
	5		Proplant Drench	15	30.2	37.5	96.2	400 Lux
	6			15	34.7	44.5	95.7	
	7			14.1	31.3	41.1	93.6	
13	1	Superfeed	Octave 80 g / 100 L	13.5	33.7	41.2	93.4	500 Lux
	2		Orthene 80 g /100 L	15.7	34	40.6	96.2	550 Lux
	3			17.9	20.7	43	95.1	500 Lux
	4	Potassium Nitrate		17.1	27.7	44.8	96.8	400 Lux

	5		Biox 500 ml / 100 L	18	30.8	95.7	96.8	400 Lux
	6			16.1	34	43.7	96.1	
	7			13.3	23.3	49.5	95.6	
14	1	Superfeed	Benomyl 50 g / 100 L	14.7	32.4	37.8	97.1	400 Lux
	2		Mospilan 50g / 100 L	13.1	34.7	65.9	99.3	500 Lux
	3			12.9	33	39.6	96	500 Lux
	4	Cano3		0.5	32.2	31.2	96.8	400 Lux
	5		Proplant Drench	12.5	35.6	13.4	95.3	350 Lux
	6			11.5	32.4	30.4	94.3	
	7			11.8	30.8	33.4	94.7	
15	1	Superfeed	Bravo 100ml / 100 L	12.7	30.5	29.8	94.8	450 Lux
	2		Seizar 40ml / 100 L	8.7	30.3	22.2	91.5	400 Lux
	3			8.4	30.6	35.4	94.7	500 Lux
	4	Potassium Nitrate		10.5	30.6	36.1	95.6	500 Lux
	5		Biox 500 ml / 100 L	11.9	30.1	43.2	94.1	500 Lux
	6	Cano3		11.2	23.7	37.4	92.8	
	7			11.1	24.7	59.1	95.1	
16	1		Octave 80 g / 100 L	12.3	23.8	39.3	96.8	400 Lux
	2	Potassium Nitrate	Orthene 80 g /100 L	14	25.8	36.3	93.1	500 Lux
	3			12.2	30.8	34.8	92.4	500 Lux
	4			13.4	30.5	84.5	87.4	400 Lux
	5	Superfeed	Drench	12.9	29.5	76.8	97.2	350 Lux
	6			12.5	30	39.8	97.6	
	7			13.5	29.1	40.4	98.5	
17	1		Benomyl 50 g / 100 L	12.3	27	32.4	97.2	500 Lux
	2	Multifeed		12.6	27.9	36.7	97.3	500 Lux
	3			12.5	24.6	42.2	94.2	350 Lux
	4			12.3	25.7	39.4	95.9	350 Lux
	5	Potassium Nitrate	Biox 500 ml / 100 L	12.7	27	37.5	96.2	400 Lux
Third Measuring	6			12.6	27.5	44.5	95.7	
	7			12.7	30.5	41.1	93.6	

Cyclamen production cycle records for 2012-2013

Week		Watering	Spraying	Temperature Min	Temperature Max	Humidity Max	Humidity Min	Lux reading
47	1	Cleaning						
	2	Disinfect						
	3	Fulling pots						
	4	Start Planting		17.2	21.1	94.2	92.2	300 Lux
	5	Planting		17.8	25.4	63.2	96.2	450 Lux
	6			16.6	33.2	41.3	96.3	
	7			16	40.2	35.2	92.4	
48	1	Clean water		17.1	35.2	42.2	97.6	400 Lux
	2			18.1	36.1	48.3	95.4	550 Lux
	3			18	35.7	38.2	97.3	500 Lux
	4			18.6	34.3	33.7	96.2	400 Lux
	5	Clean water		17	36.3	34.4	96.3	350 Lux
	6			17.4	38.4	33.6	96.3	
	7			16.3	39.4	35.6	96.3	
49	1	Clean water		18.3	37.7	35.6	96.3	450 Lux
	2			18.6	38.5	36.6	86.5	400 Lux
	3		Biox 500 ml / 100 L	17.6	34.5	39.7	95.6	550 Lux
	4			18.4	34.4	58.5	96.5	550 Lux
	5	Clean water		19.4	26.6	41.4	96.3	500 Lux
	6			18.9	33.3	36.6	95.2	
	7			18.4	25.5	47.3	95.2	
50	1	Cano3		18.3	32.4	48.7	96.2	500 Lux
	2			18.7	40.4	58.4	97.5	500 Lux
	3	Multifeed	Benomyl 50 g / 100 L	19.4	34.3	52.9	98.3	450 Lux
	4		Mospilan 50g / 100 L	18.3	27.5	36.3	96.2	450 Lux
	5	Cano3		17.4	35.7	48.3	96.8	500 Lux
	6			16.5	35.7	63.2	96.8	
	7	Clean water		15.4	37.7	50.5	96.8	
51	1			17.3	39	38.6	95.6	450 Lux
	2	Multifeed	Bravo 100ml / 100 L	17.2	37.6	40.7	96.6	400 Lux
	3		Seizar 40ml / 100 L	17.7	39.4	36.7	96.7	500 Lux
	4	Cano3		17.5	38.4	40.7	96.4	500 Lux
	5		Biox 500 ml / 100 L	16.5	40.2	34.2	95.4	500 Lux
	6	Multifeed		18.3	26.7	40.3	95.9	
	7			17.1	34.4	35.5	96.4	

52	1	Cano3		17.2	43.1	56.7	96.5	500 Lux
	2		Benomyl 50 g / 100 L	15.9	33.7	43.2	95.5	550 Lux
	3	Multifeed	Mospilan 50g / 100 L	17.6	33.4	31.9	94.6	500 Lux
	4			20.5	27.9	48.7	85.9	400 Lux
	5	Cano3	Biox 500 ml / 100 L	17.7	28.3	58.7	95.8	400 Lux
	6			19	41.3	33.3	96.7	
	7	Clean water		19.1	35.5	42.7	95.4	
1	1	Multifeed		17.1	38.3	37.9	96.7	500 Lux
	2			16.8	35.4	41.9	95.5	500 Lux
	3	Cano3		17.5	33.8	40.7	95.7	500 Lux
	4			17.4	37.2	40.5	96.6	500 Lux
	5	Multifeed	Biox 500 ml / 100 L	16.2	29.5	38.7	97.9	450 Lux
First measuring	6			16.3	34.6	43.9	95.5	
	7	Clean water		19.4	35.1	43.6	95.5	
2	1			19.6	37.9	46.3	96.8	550 Lux
	2	Cano3		19.2	38.3	38.9	96.6	500 Lux
	3		Drench	17.4	38.5	44.1	96.7	550 Lux
	4	Cano3		17.3	37.2	40.3	95.6	450 Lux
	5		Biox 500 ml / 100 L	18.2	35.3	39.6	98.6	450 Lux
	6			16.8	36.9	49.1	98.7	
	7			17.5	40.2	40.3	98.6	
3	1	Potassium Nitrate		15.1	37.9	40.3	97.6	450 Lux
	2		Drench	16.3	38.3	44.7	98.1	400 Lux
	3	Cano3		17.4	38.5	38.2	96.1	500 Lux
	4			19.3	37.7	44.1	95.9	550 Lux
	5	Cano3	Biox 500 ml / 100 L	18.2	35	40.9	98.2	500 Lux
	6			16.8	36.9	39.1	98.1	
	7			17.5	40.2	49.1	98.6	
4	1	Multifeed		15.1	40.2	40.7	97.2	500 Lux
	2		Bravo 100ml / 100 L	16.3	37.5	33.5	98.9	500 Lux
	3	Potassium Nitrate	Seizar 40ml / 100 L	17.7	38.2	33.2	96.6	350 Lux
	4			19.1	36.2	43.2	96.5	350 Lux
	5	Cano3	Biox 500 ml / 100 L	20.1	30	38.2	96.5	400 Lux
	6			18.6	38.3	44.1	95.2	
	7			19.4	39.6	60.5	96.1	
5	1			19.2	29.1	41.2	96.4	450 Lux

	2	Multifeed	Octave 80 g / 100 L	18.4	23.1	42.6	97.2	400 Lux
	3		Orthene 80 g /100 L	20.1	34.8	73.6	96.1	500 Lux
	4			20.5	39.6	83.1	98.1	550 Lux
	5	Potassium Nitrate	Drench	19.8	40.2	46	97.5	500 Lux
	6			13.3	38.1	23.3	93.6	
	7			13.8	35.4	33.3	96.4	
6	1	Superfeed		18.5	34.5	42.2	96.2	400 Lux
	2		Drench	17.3	35.1	50.7	95.8	500 Lux
	3	Multifeed		17.3	36.9	48.1	96.1	500 Lux
	4			17.4	31.3	64.1	96	400 Lux
	5	Potassium Nitrate	Biox 500 ml / 100 L	18.1	34.2	50.6	91.4	350 Lux
	6			17.7	36	54	97.2	
	7			16.9	33	42	95.6	
7	1		Bravo 100ml / 100 L	17.2	38.1	45.6	91.4	450 Lux
	2	Multifeed	Seizar 40ml / 100 L	15.3	26	41.8	94.1	400 Lux
	3			16.1	29	36.3	93.2	500 Lux
	4	Potassium Nitrate		16.7	39.2	66.1	91.2	500 Lux
	5		Biox 500 ml / 100 L	16.2	39.4	50.8	91.8	500 Lux
	6			14.7	43.6	23.4	93.2	
	7			13.2	33.5	32.3	92	
8	1			16.2	26.9	29.8	90	500 Lux
	2	Superfeed	Octave 80 g / 100 L	19	33.2	51.7	90.7	550 Lux
	3		Orthene 80 g /100 L	15.8	32.9	76.8	91.4	500 Lux
	4	Potassium Nitrate		16.3	33.7	48	96.2	400 Lux
	5			15.3	37.2	45	94.4	400 Lux
Second Measuring	6		Drench	17.3	35.1	40.9	88	
	7			16.3	37.1	39.7	96.2	
9	1	Superfeed		14.1	38	39.3	96.8	500 Lux
	2		Benomyl 50 g / 100 L	13.9	21.8	36.3	93.1	500 Lux
	3		Mospilan 50g / 100 L	15.1	24.5	34.8	92.4	350 Lux
	4	Potassium Nitrate		18	36.2	84.5	87.4	350 Lux
	5			16.1	35.5	76.8	97.2	400 Lux
	6			15	40.1	39.8	97.6	

	7			12.5	37	40.4	98.5	
10	1	Superfeed	Bravo 100ml / 100 L	16	36.1	32.4	97.2	500 Lux
	2		Seizar 40ml / 100 L	14.4	34.1	36.7	97.3	550 Lux
	3			15.5	39.9	42.2	94.2	500 Lux
	4	Potassium Nitrate		14.1	32.9	39.4	95.9	400 Lux
	5		Proplant Drench	15	30.2	37.5	96.2	400 Lux
	6			15	34.7	44.5	95.7	
	7			14.1	31.3	41.1	93.6	
11	1	Superfeed	Octave 80 g / 100 L	13.5	33.7	41.2	93.4	500 Lux
	2		Orthene 80 g /100 L	15.7	34	40.6	96.2	550 Lux
	3			17.9	20.7	43	95.1	500 Lux
	4	Potassium Nitrate		17.1	27.7	44.8	96.8	400 Lux
	5		Biox 500 ml / 100 L	18	30.8	95.7	96.8	400 Lux
	6			16.1	34	43.7	96.1	
	7			13.3	23.3	49.5	95.6	
12	1	Superfeed	Benomyl 50 g / 100 L	14.7	32.4	37.8	97.1	450 Lux
	2		Mospilan 50g / 100 L	13.1	34.7	65.9	99.3	500 Lux
	3			12.9	33	39.6	96	500 Lux
	4	Cano3		0.5	32.2	31.2	96.8	400 Lux
	5		Proplant Drench	12.5	35.6	13.4	95.3	350 Lux
	6			11.5	32.4	30.4	94.3	
	7			11.8	30.8	33.4	94.7	
13	1	Superfeed	Bravo 100ml / 100 L	12.7	30.5	29.8	94.8	450 Lux
	2		Seizar 40ml / 100 L	8.7	30.3	22.2	91.5	400 Lux
	3			8.4	30.6	35.4	94.7	500 Lux
	4	Potassium Nitrate		10.5	30.6	36.1	95.6	500 Lux
	5		Biox 500 ml / 100 L	11.9	30.1	43.2	94.1	500 Lux
	6	Cano3		11.2	23.7	37.4	92.8	
	7			11.1	24.7	59.1	95.1	
14	1		Octave 80 g / 100 L	12.3	23.8	39.3	96.8	450 Lux
	2	Potassium Nitrate	Orthene 80 g /100 L	14	25.8	36.3	93.1	500 Lux
	3			12.2	30.8	34.8	92.4	550 Lux
	4			13.4	30.5	84.5	87.4	400 Lux

	5	Superfeed	Drench	12.9	29.5	76.8	97.2	350 Lux
	6			12.5	30	39.8	97.6	
	7			13.5	29.1	40.4	98.5	
15	1		Benomyl 50 g / 100 L	12.3	27	32.4	97.2	500 Lux
	2	Multifeed		12.6	27.9	36.7	97.3	550 Lux
	3			12.5	24.6	42.2	94.2	350 Lux
	4			12.3	25.7	39.4	95.9	350 Lux
	5	Potassium Nitrate	Biox 500 ml / 100 L	12.7	27	37.5	96.2	400 Lux
Third Measuring	6			12.6	27.5	44.5	95.7	
	7			12.7	30.5	41.1	93.6	

M. A COMPARISON OF THE CHEMICAL AND PHYSICAL PROPERTIES OF THE GROWTH MEDIUMS

Growth medium	Composition	*EC 2012	2013	*pH 2012	2013	AFP 2012	2013
1. Cyclamen mix	This mixture is commercially sold in the market as a cyclamen mix and is supplied by MEEGAA™. It consists of 50 peat moss, 35% coir, 15% perlite and 3kg Osmocote (16/18 per m^3)	0.54	0.8	5.4	7.6	700	700
2. Mix 2	This mixture consists of a 50 % mixture of the MEEGAA™ Cyclamen mix and 45 Mix.	0.37	0.6	4.84	5.9	650	650
3. 49 Mix	This mixture is commercially sold in the market as 49 Mix and supplied by Culterra™. It consists of 80% pine bark and 20% coir.	0.29	0.24	4.59	6.18	500	500
4. 45 Mix	This mixture is commercially sold in the market as 45 Mix and supplied by Culterra™. It consists of 60% pine bark and 40% coir	0.27	0.4	4.64	6.4	600	600
5. Pine Bark	This mixture is commercially sold in the market as 7 Mix and supplied by Culterra™. It consists of 100% pine bark	0.33	0.37	5.22	6.2	500	500
6. Coir	This mixture consists of 100 % Course Coir.	0.55	0.4	5	5.6	550	550
7. Klasmann Peat	This mixture is imported from the Nederland's and is supplied locally by and Greenhouse Technologies™, Green Technologies. It consists of 100% peat and the mixture includes wetting agent (K–hydro), extra trace elements 1 EC fertilization	0.07	0.2	4.2	5.7	700	700

*The growth mediums used during this study was the growth mediums commercially available and differences in EC and pH can occur between the various batches.