EFFECTS OF BIOSLURRY AND PLANT BIOSTIMULANT HICURE® ON GROWTH, YIELD AND POSTHARVEST QUALITY OF CARNATION

(*Dianthus caryophyllus* L.)

NIYOKURI NSHUTI ARISTIDE

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EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

DECLARATION

This thesis is my original work and has not been presented in this University or any other for the award of a degree.

Signature ………………………… Date..…………..…………..

Niyokuri Nshuti Aristide

KM14/3663/13

RECOMMENDATION

This thesis has been submitted with our approval as University supervisors.

Signature: ……………………… Date…………………………

Dr. Samuel Nyalala, Ph.D.

Department of Crops, Horticulture and Soils,

Egerton University,

P. O. Box 536-20115, EGERTON

Signature: ……………………….. Date …………………..…….

Dr. Mariam Mwangi, Ph.D.

Department of Crops, Horticulture and Soils,

Egerton University,

P. O. Box 536-20115, EGERTON

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DEDICATION

I dedicate this work to my wife, family, friends and cut flower producers.

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ABSTRACT

Carnation growers heavily use mineral fertilizers and plant growth regulators to obtain desirable stem length, girth and flower head size against Global GAP. This dependency on inorganic fertilizers and synthetic chemicals adversely pollute the environment. While there are limited alternatives to inorganic fertilisers for meeting the nutritional requirements of crops, organic products for regulating plant growth and development are lacking in some crops. The main objective of this study was to contribute to improved production and quality of carnations through application of bioslurry and plant biostimulant, Hicure®. Two greenhouse experiments were conducted in Finlays, Lemotit flower farm, located in Kericho county, Kenya and lying at a latitude of $0^{o}22'$ South and longitude $35^{o}18'$ East. They were laid in split plot embedded in a randomized complete block design with three replications. An established carnation crop planted on soil media at a density of 36 plants per m^2 was used. Four levels of bioslurry: 0, 0.125, 0.25 and 0.5L m^{-2} were applied in the main plot while four levels of Hicure®: 0, 2.0, 2.5 and 3.0L ha^{-1} were used in the sub-plot. All treatments were applied four times at interval of two weeks after pinching. Data were collected from 10 tagged sample plants on vegetative, physiological and flowering parameters and subjected to analysis of variance (ANOVA) using GENSTAT 14th Edition. Separation of means was performed using the Least Significant Difference. Bioslurry or Hicure® did not have a significant effect on flower stem length and diameter ($p \leq 0.05$). However, the interaction of bioslurry and Hicure® at the rate of 0.5L m^{-2} and 3L ha^{-1} significantly improved the flower stem length ($p \leq 0.05$). Application of bioslurry at all the tested rates significantly increased the flower head diameter in trial 2 while all the tested rates of plant biostimulant Hicure® significantly improved the flower head diameter during trial 1. The application of bioslurry and plant biostimulant Hicure® did not have any significant effect on carnation yield and weight although increases in number of stems were observed. Application of bioslurry had no significant effect on the vase life of carnations while Hicure® at the tested rates significantly reduced the vase life. It was concluded that application of bioslurry at the rate of 0.5L m^{-2} and plant biostimulant Hicure® at the rate 3L ha^{-1} can therefore, be adopted for improvement of carnation quality parameters such as stem length and flower head size.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA: Analysis of variance

Ca: Calcium

CBI: Centre for the Promotion of Imports from developing countries

DAP: Di-ammonium phosphate

DM: Dry Matter

EU: European Union

Fe: Iron

FYM: Farm yard manure

HCDA: Horticulture Crops Development Authority

Mg: Magnesium

Mn: Manganese

N.P.K: Nitrogen, Phosphorus, Potassium

PAR: Photosynthetic active radiations

RCBD: Randomized complete block design

CHAPTER ONE
INTRODUCTION

1.1. Background information

Flowers are integral part of human life due to their diversity in beauty, form, texture, colour and fragrance (Ikram *et al.*, 2012). They not only supply aesthetical beauties, but also have become a commercial object (Sönmez *et al.*, 2013). Flowers are purchased as gifts (around 50-60%) for birthdays, Valentine's Day, Mother's Day, Christmas and other festive days. Another 20% is bought for special occasions like weddings and funerals. These figures vary greatly between countries (Rikken, 2010). The cut flower sector has become an important commercial activity in many developed and developing countries, especially after the end of World War II. The total land under ornamental plants reached about 610,000 ha in 2006 and it is known that there are more than 50 countries in the world undertaking cut flower production (Aydinsakir *et al.*, 2011).

Currently, increased flower production, quality of flowers and perfection in the form of plants are the important objectives in bedding and flower production (Moghadam and Shoor, 2013). The present-day flower industry is highly dynamic and international. Significant growth rates have been achieved during the past few decades. Trade is dominated by south-north flows with Europe and North-America housing the world's largest consumer markets, while the producing countries are situated close to the equator (Rikken, 2011). Kenya is the developing country that supplies the largest quantity of cut flowers to the EU. The main importer of Kenyan flowers is the Netherlands and the import value was estimated at € 265 million in 2012 (CBI, 2013) and € 317 million in 2013 (FloraHolland, 2014).

An emerging trend in the European flower trade is the increasing relevance of social and environmental standards. New patterns of consumption, media pressure, and campaigns by non-governmental organisations have generated consumer interest in the conditions under which flowers are produced in the developing countries. Currently the market is characterised by the existence of a multitude of standards in the form of certification schemes, codes of practice and a handful of consumer labels (Rikken, 2011). Flower standards can affect competition in the market by altering the terms of participation (Rikken, 2010). Hence, further growth of flower cultivation in East Africa will largely depend on the ability to adapt to these changing conditions (Rikken, 2011).

The modern carnation (*Dianthus caryophyllus* L.) cultivars offer a diversity of colours, shapes and sizes not available in other flowering plants. Moreover, the cut flower can be produced all over the world in greenhouse. It is commercially produced because it is one of the most used cut flowers by florists for flower arrangement due to its excellent keeping quality, wide range of forms and ability to withstand long distance transportation (Jawaharlal *et al.*, 2009). In 2013, carnation was ranked 16 among the top 25 cut flowers sold in the Dutch auction with a turnover of €24 million. It was fourth among the top ten imported cut flower to the Netherlands after roses, gypsophila and St John's Wort (FloraHolland, 2014). It was also one of the main cut flowers exported by Kenya in 2012 (CBI, 2013). Carnations are among the leading cut flowers locally used in flower arrangements and in value addition of flowers, in form of bouquets. In 2012, carnations contributed 4.9% of the domestic value of floriculture (HCDA, 2013). The total area under carnations production was 252.1 ha producing 30872.2 tons of flowers in 2012. In 2012 carnations acreage increased by 60.5% and yield by 99.8 % as compared to 2011. The major challenges in production of carnations are mainly high costs of investment, high taxation and pests which result in high incidences of interceptions in the EU. However, the potential for growth is immense due to high demand in the domestic and export market (HCDA, 2013).

Carnation not only produces cut flowers but has also become useful in gardening for bedding, edging, borders, pots, and rock gardens. Therefore, paying a great attention to improve both qualitative and quantitative characteristics of carnations is essential. Proper plant nutrition is essential for successful production of floricultural crops in open and also under protected conditions. Quality is one of the most important attributes in the cut flower industry and this is influenced by application of nutrients (Ganesh and Kannan, 2013). In commercial floriculture, flower crops are supplied with the required nutrients through the use of inorganic fertilizers and very few organic fertilizers.

Nevertheless, this continuous and imbalanced use of conventional fertilizers leads to decreased nutrient uptake efficiency of plants resulting in reduced crop yield. It also causes a serious threat to soil health. Problems like leaching, volatilization, denitrification of nitrogen and decomposition of phosphorus in the soil result from heavy use of inorganic fertilizers (Sushma *et* *al.*, 2012). Currently, research is focused on testing the influence of organic fertilizers and biostimulants with non-polluting properties (Violeta *et al*., 2010). It is thought that their application would also reduce the consumption of fossil energy as well as phosphorus and potassium deposits.

The use of compost derived from plant and/or animal wastes as soil amendment or fertilizer additive has been reported in the production of several ornamental plants: marigold (Idan *et al.*, 2014), *Petunia* (Moghadam and Shoor, 2013), *Dahlia* (Ahmed *et al.*, 2004), aster (Balladares *et al.*, 2012) and on tuberose (Padaganur *et al.*, 2005). Bioslurry, the residual manure generated through anaerobic decomposition of various organic materials is considered a quality organic fertilizer (Islam, 2006). About 25 to 30% of organic matter is converted into biogas during the anaerobic fermentation process, while the rest becomes available as manure (bio-slurry). This residual manure is normally rich in macro and micro nutrients (Islam, 2006). Yield responses of vegetable crops to bio-slurry manure application have been reported in different crops including okra (Shahbaz, 2011), maize (*Zea mays*) and cabbage (*Brassica oleracea* var *capitata*) (Karki, 2001) and carrot (*Daucus carota*) (Jeptoo *et al*., 2013).

On the other hand, Hicure®, a biostimulant marketed by Syngenta East Africa Ltd has been tested in Kenya on roses and hypericum and results indicated that by integrating Hicure® in the crop production programs either as a foliar spray or through soil application growers are able to achieve better plant health, longer stem lengths, bigger bud sizes, improved vase life and shorter crop cycles (Syngenta, 2013). This study was therefore conducted to determine the effects of drenching bioslurry and Hicure® on growth, yield and postharvest quality of carnations.

1.2. Statement of the problem

In production of standard carnations, greater number of flower stems is obtained by pinching of young shoots to stimulate branching. Although this practice increases the number of stems, it delays peak flowering. Besides the yield in terms of number of marketable stems, quality of flowers is a key priority for carnation growers. Production of carnations is confronted with many problems that affect quality including calyx splitting and shorter stem length for some varieties. Conventionally, growers obtain the quality parameters such as stem length and girth, flower size and number by heavy application of mineral fertilizers and plant growth regulators. Although this dependency on inorganic fertilizers and synthetic chemicals result in increased production, it adversely affects soil productivity and environmental quality. Moreover, increased enforcement of the European codes of practice on good agricultural practices and environmental standards are affecting cut flower trade in the European market. While there are limited alternatives to inorganic fertilisers for meeting the nutritional requirements of crops, organic products for regulating plant growth and development are lacking in some crops such as carnations.

1.3. Objectives

1.3.1. General objective

The overall objective of the study was to contribute to the improvement of the production and quality of carnations through application of bioslurry and plant biostimulant, Hicure®.

1.3.2. Specific objectives

1. To determine the effect of bioslurry on growth, yield and quality of carnations;
2. To determine the effect of plant biostimulant, Hicure® on growth, yield and quality of carnations;
3. To determine the interactive effect of bioslurry and plant biostimulant, Hicure® on growth, yield and quality of carnations.

1.4. Hypotheses

1. Application of bioslurry has no effect on growth, yield and quality of carnations
2. Application of plant biostimulant, Hicure® has no effect on growth, yield and quality of carnations
3. There are no interactive effects of bioslurry and plant biostimulant, Hicure® on growth, yield and quality of carnations.

1.5. Justification of the study

Higher yield and quality are major priorities for carnations producers. However, to obtain quality of carnations cut flowers with larger size flowers, longer stems and longer vase life, growers resort to mineral fertilizers and plant growth regulators. With increasing environmental concerns, there is an urgent need to reorient the research priorities towards developing alternative systems in crop production. This would be through the elaboration of unconventional and un-pollutant solutions and culture techniques, in stable usage context and focused on testing the action of some fertilizers and biostimulants with non-pollutant properties. Moreover, currently there is a shift towards the reduction of use of fossil energy. For instance at the beginning of 2008, member countries of the European Union signed a document in which they declared to reduce energy consumption by 20% by the year 2020 and, additionally, they undertook a decision that, by the same year, 20% of the consumed energy would be derived from renewable resources. In Rwanda and Kenya, some households have now installed biogas digesters where they use available animal waste to produce clean energy that is used for cooking, lighting, heated baths and room warming. Bioslurry, the residual manure generated through anaerobic decomposition of various organic materials (digested biogas effluent) is considered a quality organic fertilizer and can be used to fertilize crops.

Therefore, bioslurry and Hicure®, a biostimulant produced solely from amino acids and peptides of natural origin, are products that can be used together with mineral fertilizers in carnations production to reduce environmental pollution. However, bioslurry and Hicure® have not been tested on carnations to provide the information on their effects on carnations. Hence, there is a need to determine the effect of bioslurry and Hicure® on growth, yield, and quality; and vase life of carnations. The outcomes of this study would be beneficial to farmers who use the biogas to efficiently utilise the digested biogas effluent (slurry) as organic manure in carnation production and also to obtain improved yield and quality carnation cut flowers through the use of Hicure®. The success of this study would see greenhouse flower producers adopt biogas technology in the production of flowers as source of energy and fertilizers. It would also open opportunities for researchers and cut flower growers to use bioslurry and Hicure® to supplement the imported costly mineral fertilizer for crop production in integrated soil fertility management.

CHAPTER TWO
LITERATURE REVIEW

2.1. Overview on carnations

Carnation (*Dianthus caryophyllus* L.) is grown in several parts of the world and is believed to be a native of the Mediterranean region. The generic name *Dianthus* comes from the writings of Theophratus who lived about 300 B.C. He proposed the word "*Dianthus*" whch comes from the greek words: "*dios*" meaning divine (God); "*anthos*" means flower, that is "the flower of the gods". Linnaeus chose the species name "*caryophyllus*" after the genus of Clove, as the fragrance from Carnation is reminiscent of clove. The common name, Carnation, is likely derived from "*coronation"* as the Greeks wove *Dianthus* flowers into crowns for their athletes (Tah and Mamgain**,** 2013)

The *Dianthus* species are adapted to the cooler alpine regions of Europe and Asia and are also found in the Mediterranean coastal regions. Carnation is not seen in the wild except in some Mediterranean countries. This is consistent with records on floras indicating that the natural distribution of carnation is restricted to the Mediterranean regions of Greece, Italy, Sicily and Sardinia. It has been cultivated for over 2000 years and today commercial cultivation is the result of 200 years of improvement and breeding. It is believed that carnations were cultivated by the Muslims of Africa and introduced to Europe from Tunis in the 13th century (Jawaharlal *et al.*, 2009).

2.1.1. Botany

Carnations belong to order Caryophyllales and the family Caryophyllaceae. Carnation is a semi hardy herbaceous perennial with thick, narrow, linear and succulent leaves. Leaf blades are simple, entire, linear, glaucous, arranged in pairs, keeled and five nerved and their colour varies from green to grey blue or purple. The stems are hardy, shiny and have one to three angles with tumid joints. Each stem produces a terminal flower and hence inflorescence is generally a terminal cyme, sometimes racemiform.

Flowers are bisexual and occasionally unisexual. Carnation flowers are naturally bright pinkish-purple in colour, but other colourful cultivars of this plant have been developed such as carnations with white, red, green, and yellow flowers (Yaacob *et al*., 2013). When grown in gardens, flowers grow between 6 and 8.5 cm in diameter. Some disbudded greenhouse grown plants for exhibition have flowers of up to 10 cm diameter. Petals are broad with frilled margins and the calyx is cylindrical with bracts at the base. The stamens can occur in one or two whorls, in equal number or twice the number of the petals. The fruit is in the form of a capsule and contains many small seeds. The fruit ripens within five weeks of pollination. The fruits contain an average of 40 seeds. On maturity the tubular capsule opens from top and releases the seeds (Jawaharlal *et al.,* 2009).

Present day carnations are the result of continuous genetic improvement and selection by many breeders throughout the world due to which most of them are fully double with their stamens transformed into petaloids. The basic chromosome number in *Dianthus* is 15. Carnations are generally diploids (2n=30), though tetraploid forms (4n= 60) have also been identified. Triploid carnations were produced for commercial purpose, but the resulting plants were mostly aneuploid. The majority of cultivable carnations are diploid. Flower colour in carnation is attributed to the presence of two major pigments: carotenoids and flavonoids. The carotenoids are responsible for colour ranging from yellow to orange. However, many carnation plants do not have carotenoid pigments. Flavonoids are water soluble pigments such as anthocyanins. The major types of anthocyanins which contribute colour to carnation flowers are the cyanidins which are responsible for red or magenta colour and the pelargonidins which are responsible for orange, pink or brick red colour. Carnations do not have blue or mauve flowers because they lack that part of the anthocyanin biosynthetic pathway that produces delphinidins or blue pigments. The fragrance in carnation flower is predominantly due to eugenol, α- caryophyllene and benzoic acid derivatives. The level of these compounds increases during flower development (Jawaharlal *et al.,* 2009).

2.1.2. Types of carnation

Based on the availability of large number of varieties and diversified cultural requirements, carnations are classified as Chabaud or Marguerite, Border and Picotee, Malmaison and Perpetuals (Jawaharlal *et al.,* 2009). Perpetuals are classified into two classes: standard and spray carnations.

a) Standard carnations

Standard carnations produce larger blooms with longer stems, usually a single large flower on an individual stem.

b) Spray carnations

Spray or miniature carnations produce smaller sized blooms with shorter stems in bunches. The flowers are borne on short branches of a single stalk (Jawaharlal *et al.,* 2009).

2.2. Overview on the response of cut flowers to organic fertilizers

2.2.1. Effect of organic fertilizers on vegetative parameters

The yield in most cut flowers will depend on the plant growth during the vegetative stage. For carbohydrate accumulation, environmental conditions must be conducive and water and nutrients must be made available. Hence, organic fertilizers must be good sources of nutrients to effectively stimulate the vegetative growth of cut flowers.

In their experiment to study the effect of urea, farmyard manure and phosphorus on growth and flowering of *Dahlia* cultivars, Ahmed *et al.* (2004) observed significant differences for various fertilizers treatments. The maximum plant height, number of branches and maximum number of leaves were recorded at fertilizer combination of 20 g m^{-2} urea, 40 g m^{-2} DAP and 4 kg m^{-2} farm yard manure and the treatments in which only urea was applied at the rate of 20 g m^{-2}. Minimum plant height was measured in the control treatments and plants which received only farm yard manure at 4 kg m^{-2}. They concluded that the superiority of the former combination over other treatments was due to the availability of N and P from urea and DAP and other minor nutrients from farm yard manure.

In pot experiment carried out during two successive seasons 2009/2010 and 2010 /2011 to investigate the effect of different rates of Nile compost (0,100 and 200g /pot) under different watering intervals (5,7 and 9 days intervals) on growth and chemical constituents of *Matthiola incana* plant. El-Quesni *et al.,* (2012) revealed that all growth parameters: plant height, number of leaves /plant root length, fresh and dry weight of leaves, stems and roots of *Matthiola incana* were significantly affected by Nile compost at 100 and 200 g/pot in sandy soil. Nile compost encouraged all plant growth parameters through the stimulation effect of the meristimatic activity of tissues because of its richness in N, P, K and other minerals which are required for growth.

Moghadam and Shoor (2013) conducted an experiment to study the effect of vermicompost and two bio-fertilizer applications on growth, yield and quality of *Petunia (Petunia hybrida)*. The experiment consisted of 9 treatment combinations composing of vermi-compost, bio-fertilizers and NPK fertilizer. The treatment receiving *Azospirillum* sp. + Phosphate solubilizing bacterium + vermicompost + NPK (25% of recommended dose) recorded the highest plant height, number of branches, plant spread, leaf area index, dry matter accumulation. However, these results were not statistically different from results recorded in the treatment with recommended dose of NPK or in treatment with phosphate solubilizing bacterium + vermicompost.

In an investigation carried out to study the effect of organic and inorganic fertilizers on sprouting, growth, flowering and nutrient status in *Heliconia (Heliconia sp.)* cv. Golden Torch under protected cultivation, Sushma *et al.* (2012) reported that 25:10:20 g NPK + 2 kg m^{-2} farm yard manure was superior with respect to growth parameters like plant height (156.95 cm), number of tillers (19.10), flower yield per plant (3.07) and flower yield per square meter (64.73) followed by treatment (25:10:20 g NPK+ vermicompost 2t ha^{-1}) and treatment with *G. fasciculatum*, *T. harzianum* and other bio-formulations: Panchagavya, Amrit pani plus Agnihothra ash, dry mulch and 2 kg m^{-2} farm yard manure. The least plant height (138.83 cm), number of tillers (9.60) and flowers per plant (2.07) was recorded in treatment with vermicompost 2t ha^{-1}.

The chlorophyll contents such as chlorophyll 'a' , chlorophyll 'b' and total chlorophyll were more (0.83 mg g^{-1}, 0.42 mg g^{-1} and 1.25 mg g^{-1}, respectively) in the plants, which were grown with treatment 25:20:20 g NPK+ 2 kg farm yard manure m^{-2}, which was not statistically different with treatment combining 25: 10: 20 g NPK+ vermicompost 2t ha^{-1}. It was concluded that the increase in chlorophyll content due to nitrogen application could be due to greater availability and uptake of nitrogen and phosphorous by plants. Phosphorus might have increased the uptake of nitrogen by the plants due to which the chlorophyll content increased (Moghadam and Shoor, 2013).

Ikram *et al.* (2012) conducted a study where different potting media were used in different combinations to check their effect on the morphological parameters as well as on the vase life of the tuberose. The different treatments included the combinations of FYM, poultry manure, sand, leaf compost and coconut coir in equivalent ratio. Maximum plant spread, number of leaves and vase life was recorded in sand+FYM. Coconut coir + FYM contributed to the maximum values of plant height, leaf area and spike length. Maximum plantlets were counted for sand+poultry manure.

Research results mentioned above provide evidences that the quality of organic matter used has an effect on vegetative parameters of cut flowers crops. This is justified by the fact that the addition of mineral fertilizers, biofertilizers or solubilizing bacteria improved the parameters. Hence, organic fertilizers with low nutrients content resulted in poor results.

2.2.2. Effects of organic fertilizers on floral characteristics

Moghadam and Shoor (2013) observed significant differences among treatments in *Petunia* for days to first flower bud initiation. In treatment where the plants were supplied with a combination of all treatments (*Azospirillum* sp. + phosphate solubilizing bacterium + vermicompost + NPK 25% of recommended dose), was the first to show visible flower bud which was at par with treatment of phosphate solubilizing bacterium + vermicompost, and recommended NPK dose. However, control treatment was the last to initiate flower bud. The earliness in flowering may be attributed to the presence of biofertilizers especially inoculation with *Azosprillium* and phosphorus solubilizing bacterium which consequently led to flower initiation and more flower duration.

In the study on the effect of urea, FYM and P on growth and flowering of *Dahlia* cultivars reported by Ahmed *et al.* (2004), results showed that when all three fertilizers were mixed and applied, it produced flowers earlier (72 days) than all other treatments. In the control treatments or when urea or farm yard manure was applied singly or when urea and DAP were combined, it took maximum days to flower (between 77.5 to 94.5 days). It indicates that when farm yard manure was applied in combination with urea and DAP, the plants completed their vegetative growth early due to optimum supply of nutrients resulting in early emergence of first flower. While in other treatments the nutrient supply was not optimum which delayed vegetative growth and also flowering.

Moghadam and Shoor (2013) also revealed bio-fertilizers had significant effects on the number of days taken to 50 percent flowering. Between all the treatments, 50 per cent flowering was earliest where plants were supplied with a combination of all treatments (*Azospirillum* sp. + phosphate solubilizing bacterium + vermicompost + NPK 25% of recommended dose) which was significantly similar with treatment of phosphate solubilizing bacterium + vermicompost. Maximum number of days to 50% flowering took place in control.

Idan *et al.* (2014) conducted an investigation aimed at identifying suitable organic manure treatments for marigold cultivation with respect to productivity and quality of cut flowers. The different treatments of organic manures significantly affected the number of flowers per plant. It was evident that among the different treatments, the maximum number and weight of flowers were recorded with poultry manure at 20 t ha^{-1} followed by farm yard manure 20t ha^{-1}, vermicompost 20t ha^{-1}. The minimum number and the lowest weight of flowers per plant were recorded in control treatment.

Ahmed *et al.* (2004) also reported a maximum number of *Dahlia* flowers produced when the combination of 20 g m^{-2} urea, 40 g m^{-2} DAP, 4 kg m^{-2} farm yard manure was applied. In all other treatments significantly less number of flowers was recorded. Minimum number of flowers was recorded in control (no fertilizer used). El-Quesni *et al.* (2012) reported that compost treatment significantly increased flowering parameters of *Matthiola incana* because of the release of N, P and K and some important micro-nutrients which may improve flowering status.

Ahmed *et al.* (2004) observed highly significant differences among various fertilizer treatments. Maximum *Dahlia* flower size was recorded when all three fertilizers were applied in combination, when DAP was applied alone or in combination with urea. Small size flowers were produced in control or when urea or farm yard manure was applied singly. Ahmed *et al.* (2004) opined that *Dahlia* flower size depends upon plant growth and nutrient supply. Where there was shortage of nutrients it resulted in small sized flowers. In an experiment on different potting media on tuberose, Ikram *et al.* (2012) reported that the highest values of tuberose floral diameter and number of flowers per spike were observed in sand+leaf compost potting media.

In an experiment by Saijeen *et al.* (2009)**,** *Gerbera* plants grown in media with farm manure were treated with either organic fertilizer in the form of pig manure extract, or with chemical fertilizer. The plants in the medium without farm manure were treated only with chemical fertilizer. The average leaf number per plant varied significantly for 6-12 and 16-20 weeks old plants. Although at the flowering stage the pot gerbera plants that were treated with chemical fertilizer showed a trend toward greater leaf numbers, no significant differences were found when compared to treatments which were treated with pig manure extract. The days from transplanting to bloom, length of flower stalk and diameter of blooming were not significantly different between treatments. Only the average flower number per pot showed significant differences. All of gerbera treated with chemical fertilizers and some of those treated with organic fertilizers produced a larger flower number per pot.

Mancini and De Lucia (2011) reported that the use of sludge + straw-derived compost induced the highest earliness on the mean flowering period. In any case, the soil supplementation with organic matter, either single or added with mineral fertilisers, increased the yield of cut flowers compared to mineral fertilisation only. The highest value was obtained by applying sludge + stalk-derived compost. The stem quality, notably the total length, spike length and the number of flowers, was positively influenced by the use of both mineral and organic fertilisations; in particular the sludge + stalk-derived compost, either single or mixed with mineral fertilisers. The results obtained seemed to prove the effectiveness of the use of urban wastewater purified sludge composted with different organic matrices in a sustainable floriculture.

Padaganur *et al.* (2005) reported that plants supplied with half recommended dose of fertilizers, control plants and the plants which received only organic matter were early to initiate flowering. Time taken for emergence of spike in days ranged from a minimum of 129.33 days in the treatment where 3 kg m^{-2} vermicompost were applied to a maximum of 162.00 days in treatment where recommended dose of fertilizers was applied alone. Duration of flowering was longer in plants supplied with vermicompost either alone or in combination with 50 per cent recommended dose of fertilizers. Spikes with good quality attributes like spike length, rachis length, spike girth and spike weight were produced by plants which received 50 per cent recommended dose of fertilisers along with 2 and 3 kg vermicompost m^{-2} and recommended dose of fertilisers + recommended dose of farm yard manure. These spikes in turn had increased number of florets with increased length and diameter which in turn increased their fresh weight. Maximum flower yield was observed in plants which received 50 per cent recommended dose of fertilisers along with 3 kg vermicompost $m^{-2,}$ recommended dose of fertilisers + recommended dose of farm yard manure, 50 per cent recommended dose of fertilisers along with 2 kg vermicompost m^{-2}. Padaganur *et al.* (2005) suspected that the significant differences in tuberose flower production when vermicompost was applied along with fertilizers might be due to the fact that it presents the nutrients in most available form, which made it possible for the plants to grow luxuriantly which in turn helped the plants to produce more photosynthates, hence higher flower yields.

Balladares *et al.* (2012) observed that addition of 2.5 kg m^{-2} biowaste compost with or without inorganic fertilizer gave optimum results in terms of increase in height, length and weight of flower stalk and number of secondary and tertiary panicle branches of aster. On the other hand, application of higher dose of compost, 7.5 kg m^{-2} in particular, had detrimental effects on the growth of *Aster* as manifested by the low survival rate, yellowing and narrowing of leaves, and the dwarfing of plants.

2.2.3. Effects of organic fertilizers on vase life of cut flowers

Ballardes *et al.* (2012), reported that the end of the decorative or functional life of aster was observed on the 8^{th} day after harvest for plants treated with inorganic fertilizer and with 2.5 kg m^{-2} compost alone or in combination with inorganic fertilizer; the vaselife the other treatments was noted a day earlier. Total moisture loss of the flower stalk was higher in plants under inorganic fertilizer and lower in plants provided with 2.5 kg m^{-2} compost alone. Ikram *et al.* (2012) also observed a maximum of tuberose flowers vaselife were observed in sand+leaf compost potting media.

2.3. Overview on bioslurry

2.3.1. Importance

Bio-slurry is the digested dung that is discharged from the installation after the fermentation process. The fermentation process does not reduce the nutrient value (NPK-value) of the feeding material. In fact, when applied correctly, the fertilizing value of bio-slurry even surpasses that of raw manure. Therefore, bio-slurry is a good organic fertilizer that can replace or reduce the application of chemical fertilizer (Ng'wandu *et al.*, 2009).

Bio-slurry obtained from biogas plant may be considered as quality organic fertilizer. This organic fertilizer is environmental-friendly, has no toxic or harmful effects **(**Gurung, 1997). The slurry can also be used for earthworm, pearl and mushroom cultivation as well as for sprouting seeds. Nutrients from the organic sources are more efficient than those from chemical sources. Bio-slurry is a 100% organic fertilizer most suitable for organic farming of some high value field and horticultural crops including vegetables, fruit, flowering as well as ornamental plants (Islam, 2006). Bioslurry has been also reported to have pesticide properties (de Groot and Bogdanski, 2013).

In his review, Gurung (1997) reported that Biogas slurry applications on wheat, sunflower, hybrid cotton, and groundnut gave an average yield increase of 24% over the control. Application of biogas slurry at the rate of 10 t ha^{-1} in potato, tomato, eggplant, groundnut, sorghum, maize, and okra gave better yields than FYM. (Reports, however, did not indicate the physical form of the slurry used). Seed coating with 50% (w/w of seed), organic nutrient at 2% and biofertilizer at 2% also increased the growth and yield of soybean, blackgram, greengram, and sorghum (Gurung, 1997). Yield increases due to bioslurry application have also been reported for many other crops including peas, mustard, watermelon, cabbage, banana, chillies, bajra, turmeric, sugarcane, deccan hemp, mulberry, tobacco, castor, and onion (Gurung, 1997). Gurung (1997) also reported that a combination of liquid biogas slurry and chemical fertilizer enhanced carbon nitrogen transformation with substantive effect on crop yield. The yields in many instances are reported to be higher than that given by the combination of ordinary FYM and chemical fertilizer.

Yield responses of crops to bio-slurry manure application have been also reported in different crops including okra (Shahbaz, 2011), maize and cabbage (Karki, 2001) and carrot (Jeptoo *et al.,* 2013). However, various studies that focus on the effects of bioslurry as fertilizer, pesticide or fungicide briefly report on the *rate* and/or *quantity* of bioslurry application, yet the exact methodology is often not clear or specified in detail. No study has specifically tested the effects of different application schemes on the various parameters (de Groot and Bogdanski, 2013).

2.3.2. Method of application of bioslurry

Bioslurry can be applied: (i) as a foliar fertiliser, being sprayed onto the crops; (ii) in liquid form (diluted) onto the roots, or; (iii) in dry and composted form (combined with irrigation techniques so that crops have sufficient water). The liquid form can be applied through foliar spraying, a bucket, or irrigation canal. In this way the bioslurry can be applied directly to the crops. It can also be applied to the soil as a basal and/or top dressing. If it is applied to standing crops, it must be diluted at different rates, depending upon the bio-digester type. Otherwise, the high concentration of ammonia and soluble phosphorus in the bioslurry will produce toxic effects on the plant growth and will burn the leaves (Warnars and Oppenoorth, 2014). Experiments by Wenke *et al.* (2008) and Dumitrescu (2013) revealed that bioslurry can be used on soilless media. Results of the study to evaluate the use of compost and biogas residues without and each with 20% additives (Perlite, Styromull, Hygromull, Lecaton, Peat, Cocofiber) as a substitute for peat revealed that biogas residues are suitable potting substrates (Do and Scherer, 2012).

2.3.3. Composition of bioslurry

Solid and liquid forms have different nutrient compositions. According to Debnath *et al*. (1996 cited by Warnars and Oppenoorth, 2014), well-digested bioslurry contains 1.4 – 1.8% N, 1.0 – 2.0% P, 0.8-1.2% K and 25-40% organic carbon. However, the nutrient composition of slurry reported in the study of Singh *et al.*, (2007 cited by Warnars and Oppenoorth, 2014) was for C 55%, N 0.87%, P, 0.65% and K 0.70% while a previous study by Gnanamani and Kasturi-Bai (1991 cited Warnars and Oppenoorth, 2014) recorded the average nutrient composition was 0.8 – 1.5% of nitrogen, 0.5 – 0.75% of phosphate, 0.6- 1.35% of potassium and 31.5 – 45% of total organic carbon. The content of bioslurry varies widely however, as it depends on many variables, such as:

(i) the type of animal manure used as feedstock for the digester, e.g. from pig, cattle or chicken, (ii) additional feedstock for the biogas digester, e.g. different types of crop residues or duckweed, (iii) the animal fodder, in terms of quality and quantity, (iv) the climate, particularly the temperature, in which the biogas digester is operating, i.e. in warm temperatures the digestion rate is higher than in lower temperatures, (v) the biogas digester technology as such. (de Groot and Bogdanski, 2013).

It can be stated that bioslurry is not only rich in mineral and organic dry matter, but also in nutrients like N, P, K, Ca, Mg, Fe, Mn, organic matter, different amino acids and metals like copper and zinc**.** There seems to be a good match between soil N supply and plant N demand of liquid bioslurry (Warnars and Oppenoorth, 2014).

2.4. Overview of biostimulants used in agriculture

"*Plant biostimulants are substances and materials, with the exception of nutrients and pesticides, which, when applied to plant, seeds or growing substrates in specific formulations have the capacity to modify physiological processes of plants in a way that provides potential benefits to growth, development and/or stress response. The term "plant conditioners" is proposed as a synonym, which gives account of the capacity of biostimulants to enhance nutrition efficiency and/or stress response"* (Du Jardin, 2012). The global biostimulants market consists of acid based and extracts based biostimulants. Acid based biostimulants are further classified as humic acid, fulvic acid and amino acids. Extract based biostimulants contains seaweed based biostimulants.

Humic acid has received increasing attention in recent years. Humic substances are naturally occurring organic materials derived from biological sources (decomposed organic matter). They typically are mixtures of several types of chemical compounds, including humic acids, fulvic acids and humins (New Ag International, 2013). Humic acid or humic substances have been reported to enhance some aspect of growth in over 16 species of plants including important agronomic, crops other crops including *Arabidopsis*. It is important to note that the majority of the tests have been conducted in growth chambers or in hydroponic conditions. Promotion of root system development is the most commonly reported initial effect of humic acids on plant growth (Calvo *et al.*, 2014). Humic substances exhibited hormone like effects on plant growth metabolism including auxin-like responses and increased cytokinin level (Nyalala, 2014). Organic acids and humic acids inhibit precipitation of calcium phosphate minerals, enhance phosphorus bioavailability (Nyalala, 2014) and exhibit chelation properties (chelation of micronutrients, such as iron, aids plant uptake and utilization (Calvo *et al.*, 2014)). In addition to increasing overall root growth at early stages of plant development, applications of humic acids have also been reported to increase yield or crop quality in some studies involving full-season growth of plants in greenhouses or field studies (Calvo *et al.*, 2014).

In their review, Calvo *et al*. (2014) revealed that plant growth stimulation and enhanced tolerance to biotic and abiotic stresses have been reported following application of a variety of protein-based products. These plant stimulatory effects appear to be distinct from the nutritional effect of an additional nitrogen source (Ertani *et al*., 2009 cited Calvo *et al.*, 2014). Implicit in these studies is the assumption that plants can readily take up amino acids and peptides. Previous studies by Watson and Fowden (1975 cited Calvo *et al*., 2014), Soldal and Nissen (1978 cited Calvo *et al*., 2014) and Nacry *et al*. (2013 cited Calvo *et al*., 2014) demonstrated that plant roots could take up radio-labelled amino acids. Foliar uptake of amino acids has been reported various studies (Calvo *et al*., 2014). Protein-based products can be divided into two major categories: protein hydrolysates consisting of a mixture of peptides and amino acids of animal or plant origin and individual amino acids such as glutamate, glutamine, proline and glycine betaine (Calvo *et al.*, 2014). Some free amino acids, such as proline, improve osmotic adjustment and water-stress tolerance of plants (New Ag International, 2013). Protein hydrolysates have been shown to stimulate carbon and nitrogen metabolism and to increase nitrogen assimilation (Calvo *et al.,* 2014; Nyalala, 2014). They have been reported also to stimulate plant defence to biotic and abiotic stresses and to enhance plant nutrient uptake and yield (Calvo *et al.,* 2014). Evidences in the study on effect of natural biostimulants on yield and nutritional quality of sweet yellow pepper (*Capsicum annuum* L.) plants were reported by Paradiković *et al.,* (2011). Results showed an overall increase in the pigment content of leaves after biostimulant application, higher total and commercial yields of treated pepper cultivars compared with the control. Their results showed that natural biostimulants had a positive effect on the vitamin C and total phenolic contents in pepper fruits during the hot summer season (Paradiković *et al.,* 2011).

Similarly, results of the study on effect of foliar application of bio-stimulants on growth, yield, components, and storability of garlic (*Allium sativum* L.) indicated that foliar application of Amino Total (1.2 ml L^{-1}) effectively increased plant height compared to all treatments and control. Application of yeast (2 g L^{-1}) or amino total (1.2 ml L^{-1}) produced the heaviest bulb weight (67.7, 72.0 and 69.5, 66.6 g) in the first and second season, respectively. Weight loss of bulbs was lower with the application of ascorbic acid (Shalaby and El-Ramady, 2014).

Results of the study on physiological effect of phenylalanine and tryptophan on the growth and chemical constituents of *Antirrhinum majus* plants showed that, increasing the two amino acids concentrations gradually increased significantly all growth parameters, vegetative and flowering stages (plant height, number of branches, fresh and dry weights of plant as well as length of inflorescence, number of inflorescences/plant and fresh and dry weights of inflorescences/plant), and the contents of the photosynthetic pigments, total soluble sugars and total free amino acids in the leaves. The effect of tryptophan was superior to that of phenylalanine on increasing plant growth at vegetative growth (Nahed *et al*., 2009b).

In an experiment by Ali and Hassan (2013) conducted to evaluate the effect of amino acids applied (Algaefol compound) at 0,1, 2, 3 and 4 ml L^{-1}on vegetative growth, flower parameters, photosynthetic pigments, N, P, K, protein and carbohydrates percentages of marigold. It was observed that Algaefol treatment at 3ml L^{-1} was the best treatments in increasing studied parameters compared to the other levels and control.

Seaweed contains various hormones, vitamins, amino acids, mineral nutrients and other components. Thus, it may affect plants in several ways. However, its stimulating influence-particularly for crops growing under environmental stresses has been attributed to its hormonal activity, especially that of cytokinins and auxins (New Ag International, 2013). A study by

Spann and Little (2011) provided evidences that applications of a commercial extract of the brown seaweed *Ascophyllum nodosum* increases drought tolerance in container-grown 'hamlin' sweet orange nursery trees. Trees treated with seaweed extract and drought-stressed had significantly more total growth than untreated drought-stressed trees for both rootstocks. The maintenance of growth by the seaweed extract under drought stress conditions was unrelated to photosynthesis. However, the seaweed extract treatment did have a significant effect on plant water relations. Soil drench-treated trees had more growth and higher stem water potential than foliar-treated or control trees after 8 weeks of drought stress. Their results indicated that seaweed extract may be a useful tool for improving drought stress tolerance of container-grown citrus trees. Besides, seaweed contains polysaccharides especially laminaran which stimulates natural defence responses in plants (Nyalala, 2014)

2.4.1. Hicure® biostimulant

Hicure® was launched in July 2013 after two years of testing in Kenya. The new product is ecologically produced solely from amino acids and peptides of natural origin. Because of its natural origin, Hicure® is not harmful to the environment and is safe to the crop, greenhouse workers and the spray applicators. Treated crops do not need a withholding period and can be harvested immediately after treatment (Syngenta, 2013). The contents of amino acids, proline and glycine, are higher in Hicure® compared to other biostimulants in the market (Syngenta, 2014). Hicure® contains a balanced mixture of free amino acids and peptides (hydrolysed protein) of natural origin: Amino acids and peptides are 62.5%, total nitrogen, 10.9% and organic carbon is 29.4% (Syngenta, 2013).

Hicure® is easily taken up by leaves and roots and once inside the plant tissues is utilized to synthesize plant proteins essential for vegetative growth and flower formation. Cut flower growers are able to attain longer stem lengths, bigger bud sizes, and a longer post-harvest shelf life by consistently using Hicure® as part of their crop programs (Hortfresh, 2013).

CHAPTER THREE
MATERIALS AND METHODS

3.1. Experimental site description

The study was conducted at Lemotit flower farm of Finlays Horticulture Kenya Ltd situated in Londiani, Kericho County, Kenya. The farm lies at latitude $0^o22'$ South and longitude $35^o18'$ East and an altitude of 2400m with an average annual rainfall of 1386 mm. The annual mean maximum and minimum temperatures range are 24^oC and 9^oC respectively, with an average relative humidity of 85% (Situma *et al.*, 2013). Monthly weather variations during the period of experiments are presented in table 1.

The total amount of rainfall received at the experimental site for trial 1 (September 2014 –March 2015) and Trial 2 (March –August 2015) were 374.8mm and 557.4mm respectively. The mean maximum temperatures for trial 1 and 2 were 24.8^oC and 24.63^oC respectively while the mean minimum temperature for trial 1 and 2 were 8.7^oC and 9.78^oC respectively. The average radiations (PAR) during the experimental period were 851.1 and 801 J cm^{-2} for trial 1 and 2 while humidity levels were 69.7% and 64.7% for trial 1 and 2 respectively.

Table 1: Monthly weather variations during the period of experiment

	2014				2015							
	Sep	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
PAR (J cm^{-2})	880.0	837.5	725.2	777.8	834.8	929.4	973.3	708.3	793.6	716.1	809.5	805.6
Radiation (J cm^{-2})	1144.0	1088.8	942.7	1011.1	1085.2	1208.2	1265.3	920.7	1031.5	930.9	1,052.3	1034.4
Humidity %	69.7	72.4	70.1	67.8	60.3	62.7	64.7	74.3	76.8	79.1	71.1	70.0
Rainfall	71.3	160.8	81.0	39.1	0	15.0	7.6	190.4	130.7	126.8	33.2	68.7
Maximum temperature	24.2	23.9	23.4	22.8	24.9	27.0	27.60	25.0	24.5	23.0	23.6	24.1
Minimum temperature	8.0	9.3	9.5	9.2	7.9	8.2	9.00	10.8	11	10.5	8.5	8.9
Sunshine hours	8.6	8.4	8.5	8.1	8.3	8.7	8.9	8.4	8.7	8.65	8.7	8.79

3.2. Planting materials

Carnation planting materials used in this experiment were the variety Walker bred by Selecta and propagated and rooted by Finlays Horticulture Kenya Ltd-Lemotit Farm. An established carnation crop planted in a greenhouse at a density of 36 plants per m^{-2} was used. Plants used for the first trial were established on 17 September 2014 while plants used in the second trial were established on 16 February 2015. The application of treatments was done after pinching, which was carried out three weeks after transplanting. Both trials were established on soil as the growing media.

3.3. Experimental design and treatment application

The experimental design was a Split- plot embedded in a randomized complete block design (Split plot in RCBD), with 3 replications (Figure 3). The experiment was laid out in an area of 27 m by 5.6 m and each block measured 27 m by 1 m. The main plot measured 5.5 m by 1m ($5.5m^2$) while the sub-sub plot was 1m by 1m ($1m^2$). Inter-plot buffer zone of 0.5 m and 1m buffer zone separating individual main blocks was left. Bioslurry obtained from Tatton Agricultural Park, Egerton University, Kenya was applied at 0, 0.125, 0.25 and 0.5L m^{-2}. It was applied four times at two weeks interval and diluted in 1 litre of irrigation water prior to application. The rate of Hicure® recommended for drench application in flowers and ornamental crops is 2.5L ha^{-1} applied fortnightly (Syngenta, 2013). Levels of Hicure® used were 0, 2.0, 2.5 and 3.0L ha^{-1} applied to the sub-plots and the product were drenched after pinching four times. Prior to application, each level of Hicure® was thoroughly mixed with water at the rate of 5000L ha^{-1}.

Plate 1: Established carnations plants and plots

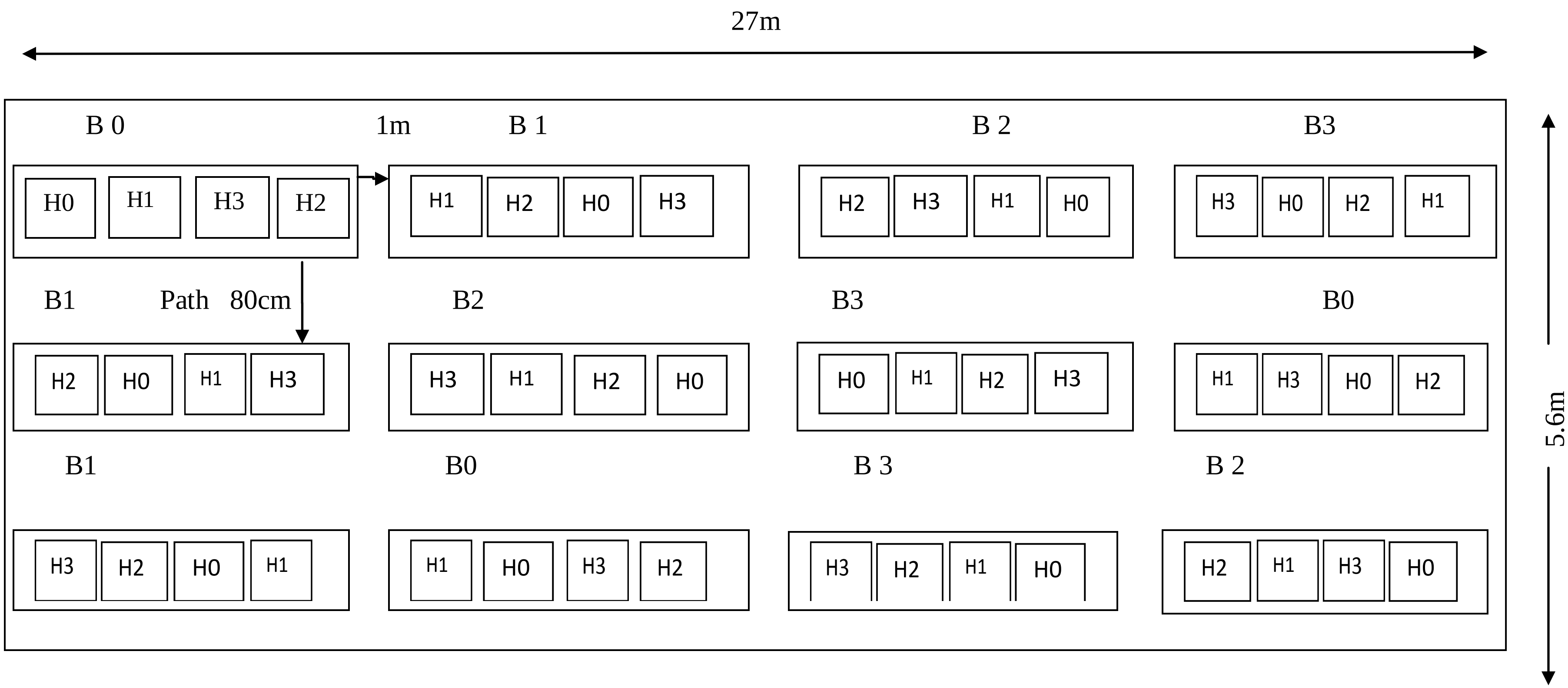

Figure 1: Experimental field layout

Where:

B0: No bioslurry; B 1: Bioslurry 0.125L m^{-2}; B2: Bioslurry 0.25L m^{-2}; B3: Bioslurry 0.5L m^{-2}.

H0: No Hicure; H1: Hicure 2.0 L ha^{-1}, H2: Hicure 2.5 L ha^{-1} and H3: Hicure 3.0L ha^{-1}.

3.4. Bioslurry analysis

Bioslurry was analysed before each application to determine its nutrient composition. The pH was measured using Fisher ACCUMET® pH meter model 610A. Total nitrogen in the bioslurry was determined using Kjeldahl method as described by Watson *et al.*, (2003). Available potassium, calcium and magnesium from the bioslurry were determined by use of Atomic Absorption Spectrophotometer (AAS) as described by Kovar (2003) while available P was determined by colorimetric method using spectrophotometer (Kovar, 2003). All tests were performed at Egerton University Soil Analysis Laboratory. The bioslurry characteristics are summarized in Table 2

Table 2: Bioslurry characteristics

	Trial 1	Trial 2
pH	7.44	7.46
Nitrogen (%)	0.23	0.16
Phosphorus(ppm)	4.58	6.69
Potassium(ppm)	89.3	68.06
Calcium(ppm)	4.31	3.32
Magnesium(ppm)	19.91	19.91
Density	1.0195	1.006

3.5. Crop management practices

Routine management practices included irrigation, fertigation, supporting, weeding, training, disbudding, pest management and harvesting. Water and mineral fertilizers were supplied to experimental plots using drip irrigation system with drip lines running across the experimental plots. The rates used weekly were 3.06 g m^{-2} for N, 3.51 g m^{-2} for P, 5.19 g m^{-2} for K, 1.71 g m^{-2} for Ca and 0.74 g m^{-2} for Mg, plus trace elements. Water was supplied from a storage tank every two days. Supporting was done using strings and bamboo sticks. Manual weeding was done by hand-pulling of weeds and by using small hand hoes to keep the experimental plots weed free. Lateral flower buds were removed on each stem, down to about 6 nodes below the flower bud. When necessary, pest management measures were employed depending on the diseases or insects to be controlled as highlighted in Table 3.

Table 3: List of chemicals used in carnation per category of pest

	Pest			
	Red Spider Mites	**Thrips**	**Rust**	**Caterpillars**
Pesticides used	Diafenthurion	Deltamethrin	Azoxystrobin 250g L^{-1}	Deltamethrin
	Abamectin (1.9%)	Thiocylam hydrogen oxolate 50% w/w	Sulphur	Thiocylam hydrogen oxolate 50% w/w
	Etoxazole	Prosuler oxymatrine 2.4%	Attracker	Flubendiamide
	Abamectin(1.8%)	Lufenuron		Diflubenzuron.
	Clofenezine	Emamectin Benzoate 19.2g L^{-1}		Methoxyfenozide
	Bifenazate	Spinosad		
	Hexythiazox 50%			

Harvesting was done at the paint brush stage when petals started to elongate outside the calyx.

Plate 2: Flowers cut at the paint brush stage

3.6. Data collection

Data were collected from 10 plants from the inner row out of the 36 plants per plot on vegetative, physiological, flowering, flower quality, yield and vase life parameters. The observations on vegetative parameters were recorded every two weeks starting 30 days after pinching.

3.6.1. Vegetative parameters

3.6.1.1. Plant height

The plant height was determined by measuring the plant from the base to the tip of the plant fortnightly using a meter ruler. The average plant height was worked out and expressed in centimetres.

3.6.1.2. Number of shoots

The total number of lateral shoots produced per plant after pinching was recorded fortnightly.

3.6.1.3. Stem base diameter

The diameter of stem base was recorded with the help of vernier callipers at a point just above the ground during growth period and expressed in millimetres.

3.6.1.4. Number of leaves

Number of leaves produced per plant was recorded from the sample plants by counting the number of leaves fortnightly starting from one month after pinching.

3.6.1.5. Leaf area and leaf area index

The leaves from sample plants per plot were used to measure the leaf area (LA). Their lengths and widths were measured using a 30 cm ruler. The leaf area was determined by 0.91xLength x Width (Aydinşakir and Büyüktaş, 2009). Leaf Area Index was computed using average leaf area obtained multiplied by the total number of leaves divided by the ground area from which the leaves were obtained (Pearcy *et al.*, 1989). LAI = leaf area / ground area, m^2 / m^2.

3.6.2. Physiological measurements

3.6.2.1. Stomatal conductance

Leaves were picked from sample plants and used in taking measurements of stomatal conductance in millimoles per square meter per second (mmol $m^{-2}s^{-1}$) using the Decagon SC-1 leaf porometer. Since light is responsible for stomatal opening, measurements were taken during clear part of the day.

3.6.3. Flowering parameters

3.6.3.1. Number of days to flower bud opening

The number of days taken for 50% flower buds opening was recorded by counting the number of days from transplanting up to bud opening. Unfolding of one or two outer petals was considered as bud opening.

3.6.3.3. Duration of flowering

Duration of flowering was recorded by counting the days from first flower bud opening to the harvesting of last flower.

3.6.4. Flower quality parameters

3.6.4.1. Length of flower stem

It was measured from the point just below the bud to the point of origin of branch on the main stem at harvest. Average for the plot was worked out and expressed in centimetres.

3.6.4.2. Diameter of flower stem

Diameter of flower stem was recorded with the help of Vernier callipers at middle of the flower stalk. It was recorded from cut flowers harvested at peak flowering and average was computed and expressed in millimetres.

3.6.4.3. Flower head length

Flower head length was recorded from the point just below the calyx to the upper point of the flower. It was recorded from flowers harvested at peak flowering from each treatment and average was calculated and expressed in millimetres.

3.6.4.4. Flower head diameter

Diameter of flower was recorded at harvest from each harvested cut flower and average was computed and expressed in millimetres.

3.6.5. Yield parameters

3.6.5.1. Number of flower per plant

Number of flowers harvested from the labelled plants was recorded and average was computed.

3.6.5.2. Number of flowers per square meter

Number of flowers per square meter was computed by multiplying the average number of flowers per plant with the number of plants per m^2.

3.6.5.3. Weight of flower

Weight of freshly harvested flowers with stalk per treatment was weighed on weighing balance and average individual flower weight was computed and represented in grams.

3.6.6. Vase life

Immediately after harvesting, flowers were kept in fresh water for two hours to remove the field heat. After that, the flowers were kept in a bucket containing three litres of water and placed in vase life room at 4^oC. Fading of outer row petals was considered as end of vase life of flowers, which was expressed in days.

3.7. Statistical analysis

Data collected were subjected to analysis of variance using the General Linear Model for a split-plot design to obtain the *p* value of the effect of each treatment using GENSTAT 14^{th} edition. The treatments which were found to be significant were separated using Least Significant Difference (LSD) at ($p \leq 0.05$).

The linear model fitted for the experiment was:

$$Y_{ijk} = \mu + \rho_i + \alpha_j + (\rho\alpha)_{ij} + \beta_k + (\alpha\beta)_{jk} + \varepsilon_{ijk}$$

i = 1, 2, 3; j = 1, 2, 3, 4 k = 1,2,3,4

Where, Y_{ijk} - Crop response

μ - grand mean,

ρ_i is i^{th} blocking effect,

α_j is effect of bioslurry level,

$(\rho\alpha)_{ij}$ is main plot error (error a),

β_k is k^{th} effect of Hicure® level,

$(\alpha\beta)_{jk}$ is effect of interaction between Hicure® and Bioslurry levels,

ε_{ijk} is random error component (error b) and γ_{ij} and ε_{ijk} are expected to be normally and independently distributed with zero means with a common variance σ^2.

CHAPTER IV

RESULTS

4.1. Effects of bioslurry and plant biostimulant on vegetative parameters

4.1.1. Effects of bioslurry and plant biostimulant on stem base diameter

The stem base diameter per plant was not statistically different in trial 1 under different levels of bioslurry ($p \leq 0.05$) but was different in trial 2, at 75 days after pinching. Plants treated with 0.25Lm^{-2} had a bigger stem base diameter followed by the control (Figure 2 and 3). Plants where bioslurry at the rate of 0.5L m^{-2} was applied produced thinner stem base. Stem base diameter was influenced differently by the levels of Hicure® manure in both trials. Data collected in trial 2 did not show any significant difference on the effect of bioslurry levels on carnation stem base diameter 30, 45 and 60 days after pinching.

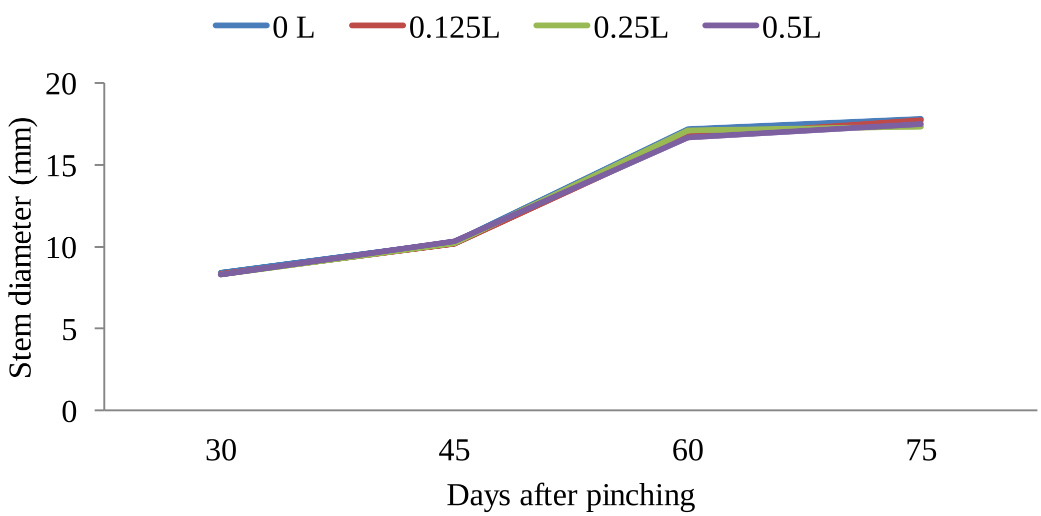

Figure 2: Effect of bioslurry on stem base diameter in trial 1

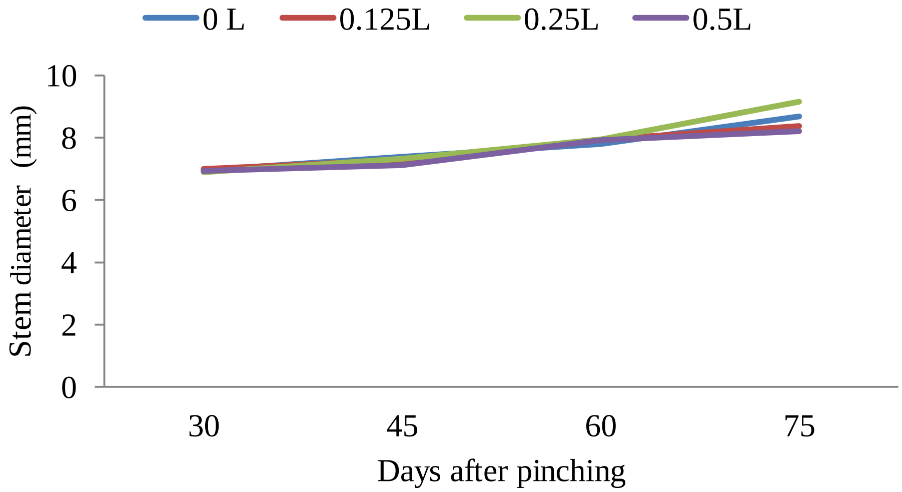

Figure 3: Effect of bioslurry on stem base diameter in trial 2

The application of Hicure® showed mixed effects on carnation stem base diameter (Figure 4 and 5). In trial 1, plants treated with Hicure® at the rate of 3.0L ha^{-1} had bigger stem base diameter 30 days after pinching while the rate of 2.5Lha-1 had a bigger stem diameter 60 days after pinching. Data collected at 45 and 75 days after pinching did not show any significant difference at $p \leq 0.05$. In trial 2, Hicure® at the rate of 2.5L, 2.0L ha^{-1} and the control were not statistically different but significantly different from the plants which were treated with 3.0Lha^{-1}, 60 days after pinching.

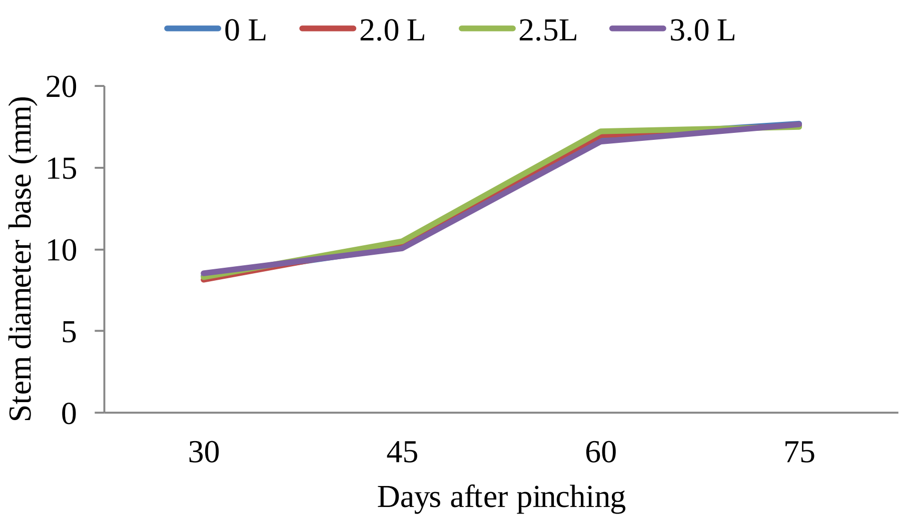

Figure 4: Effect of plant biostimulant Hicure® on stem base diameter in trial 1

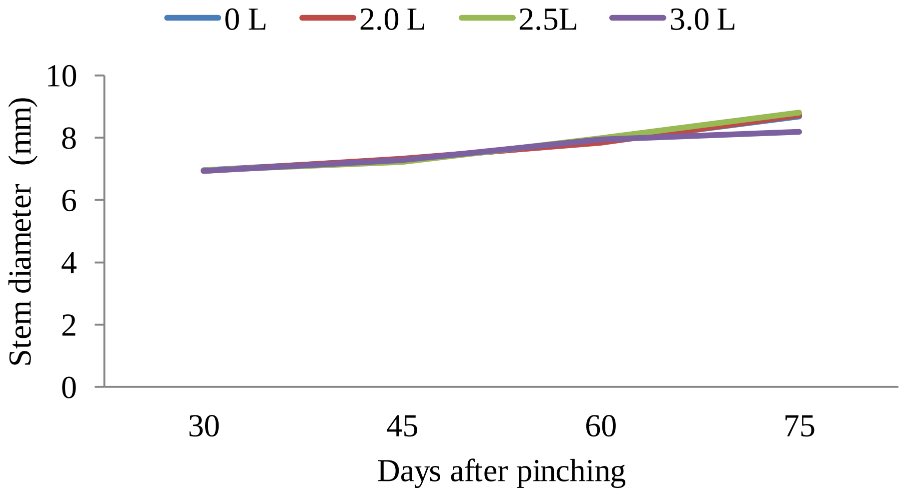

Figure 5: Effect of plant biostimulant Hicure® on stem base diameter in trial 2

There was no interactive effect between levels of bioslurry and different rates of Hicure® on carnation stem base diameter throughout trial 1 (Table 4). However the interaction effect was observed 75 days after pinching during trial 2.

Table 4: Effects of the interaction of bioslurry and plant biostimulant Hicure® on stem base diameter

		Stem diameter in mm							
		Days after pinching							
Level of	**Level of**	**Trial 1**				**Trial 2**			
Bioslurry	**Hicure**	**30**	**45**	**60**	**75**	**30**	**45**	**60**	**75**
0 L m^{-2}	**0L ha^{-1}**	8.40	10.03	17.13	18.24	6.99	7.52	7.84	7.46i*
	2.0L ha^{-1}	8.27	10.60	17.30	18.09	6.98	7.35	7.82	9.34abc
	2.5L ha^{-1}	8.17	10.50	17.64	17.46	6.99	7.33	7.88	9.73a
	3.0L ha^{-1}	8.77	10.07	16.60	17.39	6.89	7.33	7.67	8.24fghij
0.125 L m^{-2}	**0L ha^{-1}**	8.50	9.80	16.90	17.73	6.98	7.28	7.58	8.48defghi
	2.0L ha^{-1}	8.10	10.60	16.93	18.13	7.01	7.33	8.01	8.35efghij
	2.5L ha^{-1}	8.33	10.60	16.77	17.70	7.01	7.24	8.18	7.80jkl
	3.0L ha^{-1}	8.47	9.77	16.47	17.37	6.98	7.26	8.04	8.83cde
0.25 L m^{-2}	**0L ha^{-1}**	8.46	10.23	17.13	17.10	6.85	7.22	8.00	9.72a
	2.0L ha^{-1}	8.13	10.17	17.13	16.80	6.89	7.49	7.73	9.28abc
	2.5L ha^{-1}	8.30	10.43	17.37	17.60	6.88	7.22	7.88	9.53ab
	3.0L ha^{-1}	8.37	9.97	16.73	17.83	6.97	7.39	8.13	8.06hijk
0.5 L m^{-2}	**0L ha^{-1}**	8.17	10.43	16.47	17.60	6.98	7.19	8.00	9.10bc
	2.0L ha^{-1}	8.13	10.07	16.60	17.20	6.89	7.11	7.77	7.95ijkl
	2.5L ha^{-1}	8.37	10.37	17.13	17.24	6.95	7.05	7.95	8.16ghij
	3.0L ha^{-1}	8.47	10.50	16.53	17.98	6.92	7.14	7.96	7.61kl

*Means in the same column with the same letter are not significantly different at $p \leq 0.05$.

4.1.2. Effects of bioslurry and plant biostimulant on plant height

Bioslurry levels had no significant effect on the plant height of carnation ($p \leq 0.05$) in trial 1, while in trial 2; it had effect 75 days after pinching. However for 30, 45, 60 and 90 days after pinching there was no significant differences. Plants that received higher levels (0.125, 0.25 and 0.5L m^{-2}) were not different from each other in the second trial 75 days after pinching but different from control at $p \leq 0.05$. Plants that received higher levels of bioslurry had the highest plant height from 60 days after pinching in trial 2 as opposed to trial 1 where higher levels of bioslurry reduced the plant height (Figure 6 and 7).

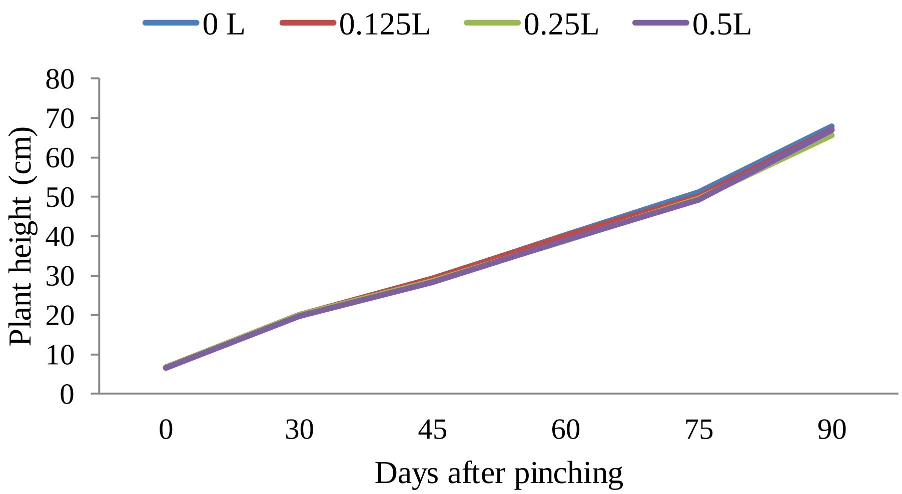

Figure 6: Effect of bioslurry on plant height in trial 1

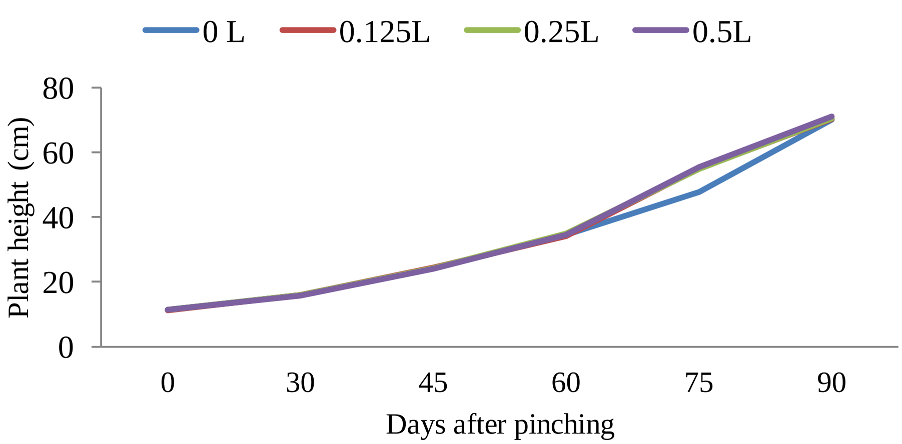

Figure 7: Effect of bioslurry on plant height in trial 2

Both in the trial 1 and 2, the biostimulant Hicure® had no significant effect on the plant height at $p \leq 0.05$ (Figure 8 and 9). The interaction of bioslurry and Hicure® did not have any significant difference at $p \leq 0.05$ for both trial1 and 2 (Table 5).

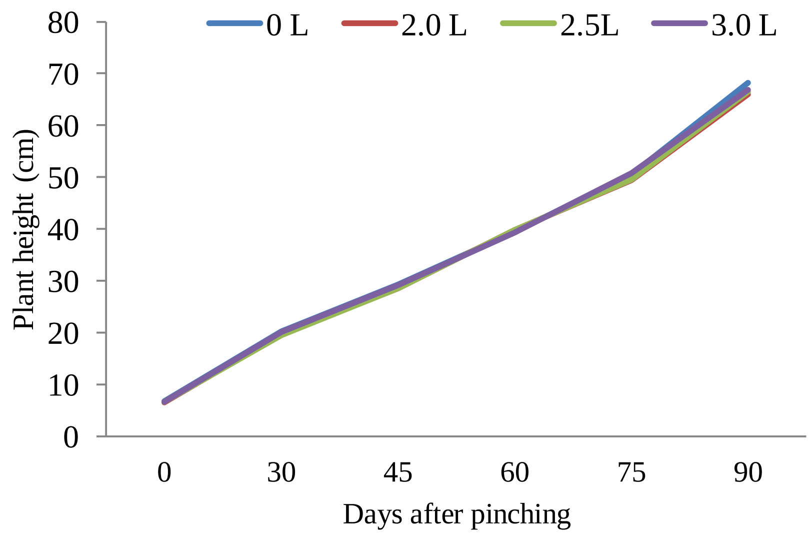

Figure 8: Effect of plant biostimulant Hicure® on plant height in trial 1

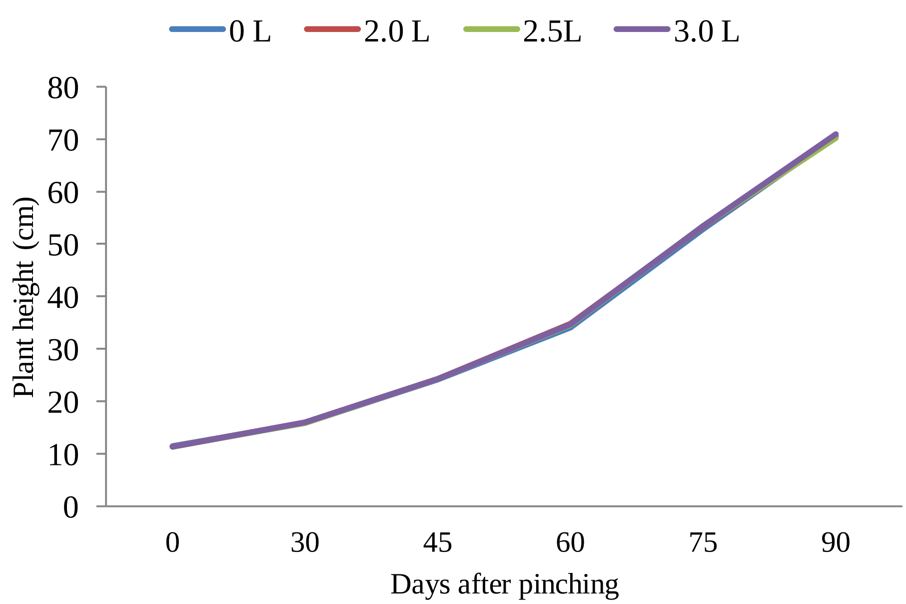

Figure 9: Effect of plant biostimulant Hicure® on plant height in trial 2

Table 5: Effects of the interaction of bioslurry and plant biostimulant Hicure® on plant height

		Plant height in cm											
Level of Bioslurry	**Levels of Hicure**	**Days after pinching**											
		Trial 1						**Trial 2**					
		0	**30**	**45**	**60**	**75**	**90**	**0**	**30**	**45**	**60**	**75**	**90**
0 L m^{-2}	**0L ha^{-1}**	6.87	20.17	28.59	38.54	48.88	67.21	11.77	15.83	24.13	33.87	47.93	69.73
	2.0L ha^{-1}	6.67	20.17	29.34	40.84	51.40	67.88	11.40	15.77	24.60	35.03	47.63	70.27
	2.5L ha^{-1}	6.73	18.80	28.95	40.65	52.40	67.93	11.50	15.87	23.97	34.57	47.60	70.15
	3.0L ha^{-1}	6.73	19.80	29.75	40.94	51.75	68.78	11.00	15.90	24.03	34.40	47.54	69.97
0.125 L m^{-2}	**0L ha^{-1}**	6.94	20.23	30.15	40.39	51.28	68.67	11.37	15.87	24.37	33.17	53.37	70.47
	2.0L ha^{-1}	6.46	19.97	28.78	41.37	49.84	66.66	10.87	16.07	24.40	34.63	55.37	69.77
	2.5L ha^{-1}	6.68	19.43	28.34	38.38	48.37	65.09	11.17	15.94	24.33	34.13	55.17	70.03
	3.0L ha^{-1}	6.78	20.47	29.60	40.45	51.14	67.68	11.37	16.20	24.50	34.37	56.03	71.30
0.25 L m^{-2}	**0L ha^{-1}**	6.64	20.10	29.42	39.21	50.55	68.39	11.20	16.07	24.37	35.30	54.13	70.57
	2.0L ha^{-1}	6.52	19.60	27.59	38.05	48.24	64.03	11.50	15.83	23.87	34.73	54.75	70.08
	2.5L ha^{-1}	6.94	19.93	28.44	40.43	49.57	65.39	11.30	15.87	24.70	34.43	55.63	70.00
	3.0L ha^{-1}	6.46	20.37	28.93	37.64	50.07	64.80	11.63	16.07	24.60	35.47	55.13	71.67
0.5 L m^{-2}	**0L ha^{-1}**	6.58	20.17	28.66	39.65	51.12	68.66	11.47	15.67	23.83	34.03	55.89	71.46
	2.0L ha^{-1}	6.41	19.13	28.25	38.74	48.07	65.40	11.37	16.13	24.07	34.47	55.62	71.47
	2.5L ha^{-1}	6.37	19.53	28.45	39.70	47.77	67.63	11.50	15.70	24.50	35.23	55.40	70.80
	3.0L ha^{-1}	6.65	19.67	27.99	38.01	50.25	66.11	11.30	15.77	23.73	34.47	55.13	70.90

4.1.3. Effects of bioslurry and plant biostimulant on number of leaves

The number of leaves per plant was not statistically different in trial 1 and 2 under different levels of bioslurry and Hicure® at $p \leq 0.05$ (Figure 10, 11, 12 and 13).

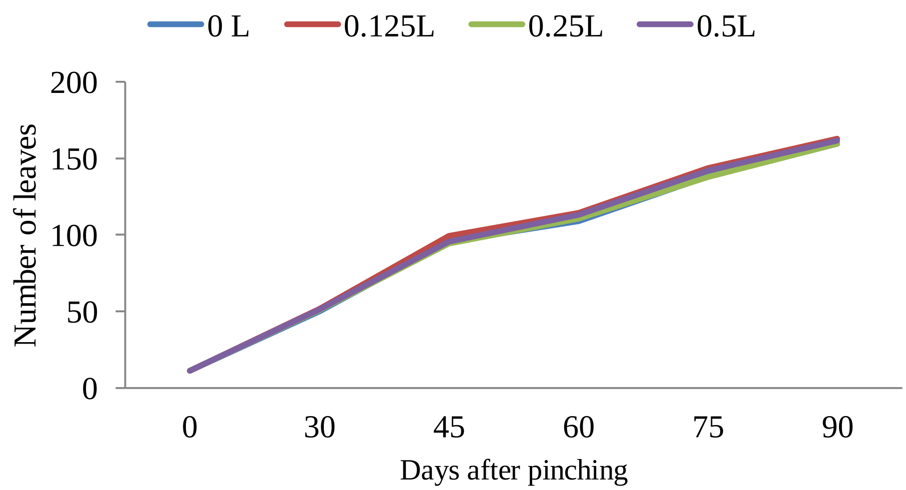

Figure 10: Effect of bioslurry on number of leaves in trial 1

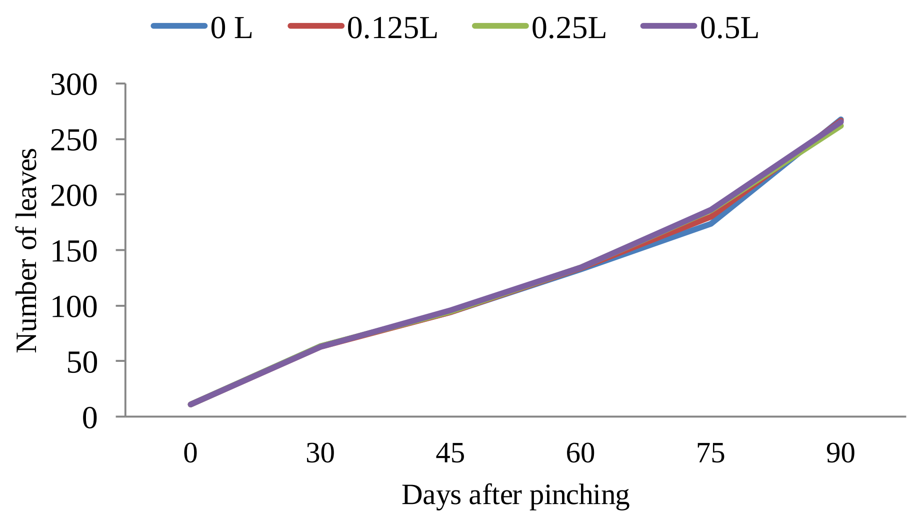

Figure 11: Effect of bioslurry on number of leaves in trial 2

There was no interactive effect between bioslurry levels and Hicure® levels on the number of leaves (Table 6).

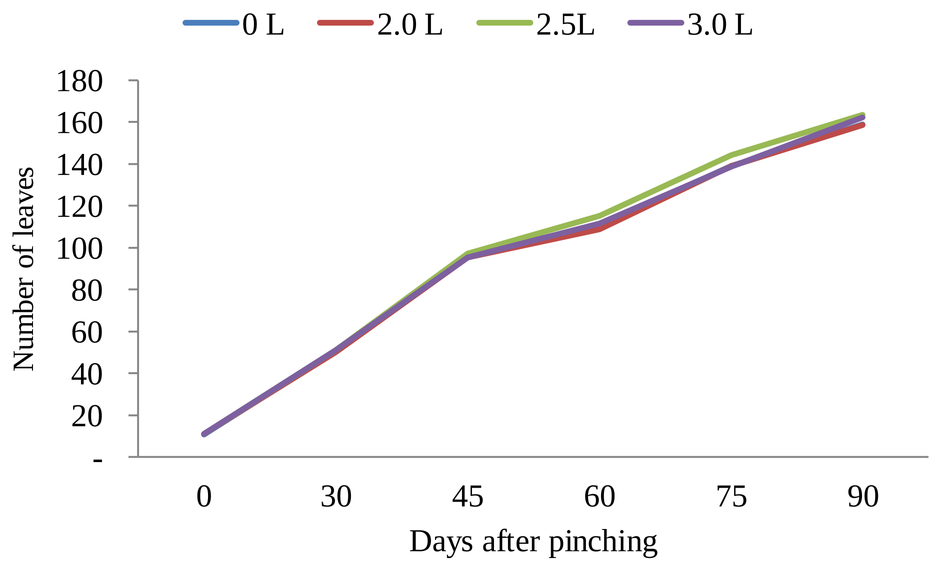

Figure 12: Effect of plant biostimulant Hicure® on number of leaves in trial 1

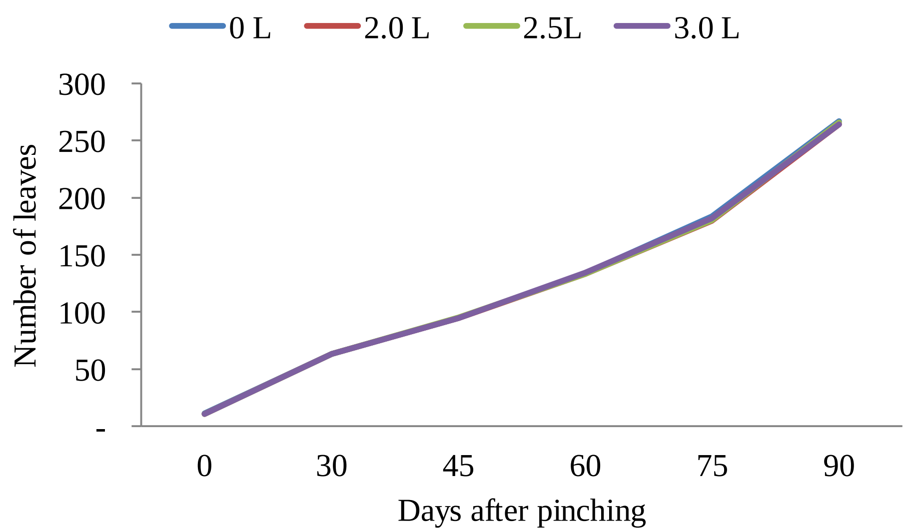

Figure 13: Effect of plant biostimulant Hicure® on number of leaves in trial 2

Table 6: Effects of the interaction of bioslurry and plant biostimulant Hicure® on number of leaves

Level of Bioslurry	Levels of Hicure®	Number of leaves per plant											
		Days after pinching											
		Trial 1						Trial 2					
		0	30	45	60	75	90	0	30	45	60	75	90
0 L m^{-2}	**0L ha^{-1}**	10.97	49.27	93.83	103.83	132.80	152.90	11.00	63.23	93.30	132.87	179.73	267.73
	2.0L ha^{-1}	10.65	48.40	96.83	106.60	139.53	157.13	11.07	63.43	92.80	132.27	171.67	268.30
	2.5L ha^{-1}	10.86	50.97	95.77	112.93	142.06	159.30	11.13	63.50	95.50	131.00	172.07	265.73
	3.0L ha^{-1}	11.32	50.93	95.83	112.40	138.67	168.87	10.93	63.30	94.23	133.83	170.03	268.27
0.125 L m^{-2}	**0L ha^{-1}**	10.83	51.87	98.37	117.37	146.13	163.77	11.17	63.00	93.73	134.03	176.47	267.07
	2.0L ha^{-1}	11.27	51.13	98.10	111.10	141.00	163.43	10.73	62.77	94.00	133.27	180.17	263.07
	2.5L ha^{-1}	10.87	51.00	100.53	118.63	150.70	166.47	10.83	63.13	94.70	132.30	180.13	267.20
	3.0L ha^{-1}	10.78	52.00	99.70	109.67	136.67	157.60	10.90	63.00	93.47	135.53	183.03	268.10
0.25 L m^{-2}	**0L ha^{-1}**	10.90	51.67	95.63	108.50	134.93	157.07	11.13	63.23	95.50	135.03	190.63	266.10
	2.0L ha^{-1}	11.02	49.87	91.57	108.40	135.03	156.25	10.93	63.03	94.00	133.87	183.60	260.07
	2.5L ha^{-1}	10.83	50.97	94.67	113.30	140.00	162.60	11.00	63.50	94.47	134.13	182.37	263.27
	3.0L ha^{-1}	11.10	51.23	95.30	111.30	140.13	162.21	10.70	63.40	95.03	134.17	185.67	259.17
0.5 L m^{-2}	**0L ha^{-1}**	10.85	50.80	98.20	113.17	142.67	162.47	10.97	63.07	95.00	132.27	187.70	267.30
	2.0L ha^{-1}	11.38	51.67	95.53	109.63	140.53	157.70	10.90	63.37	96.77	134.33	182.13	266.07
	2.5L ha^{-1}	11.42	51.70	98.13	115.87	144.73	165.70	10.83	63.03	95.87	136.60	186.60	267.23
	3.0L ha^{-1}	10.88	50.73	90.30	112.83	139.53	159.87	11.13	63.07	95.30	134.30	188.13	261.97

4.1.4. Effects of bioslurry and plant biostimulant on the number of shoots

Number of shoots per plant was less influenced by the application of bioslurry and Hicure® in both trial 1 and 2. The application of bioslurry did not increase significantly the number of shoots during Trial1 (Figure 14). In the second trial the application of bioslurry significantly affected the number of shoots 30 days after pinching with application of 0.25L m^{-2} recording the highest number of shoots per plant followed by the rate of 0.125L m^{-2}. Although there was no significant effect on the number of shoots, the rate of 0.25L m^{-2} of bioslurry recorded the highest number of shoots in trial 2 followed by 0.5L m^{-2} while the control recorded the least number of shoots per plant (Figure 15).

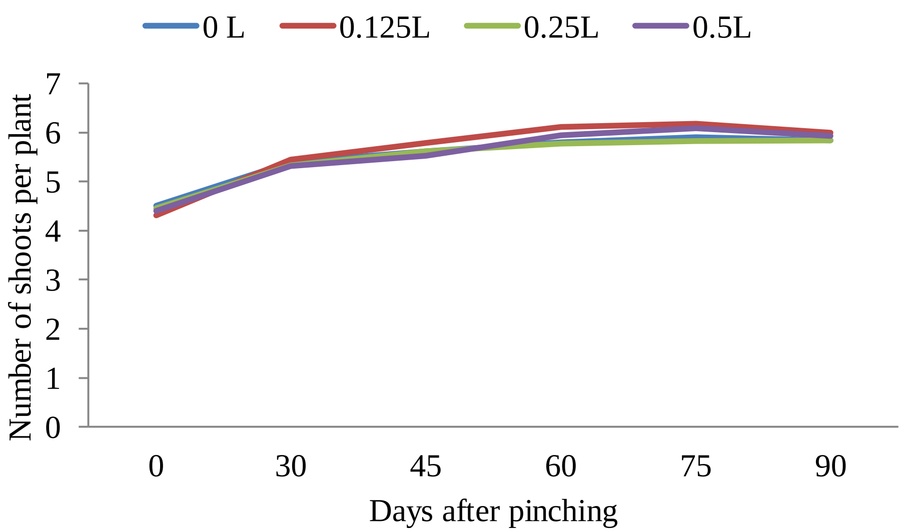

Figure 14: Effect of bioslurry on the number of shoots per plant in trial 1

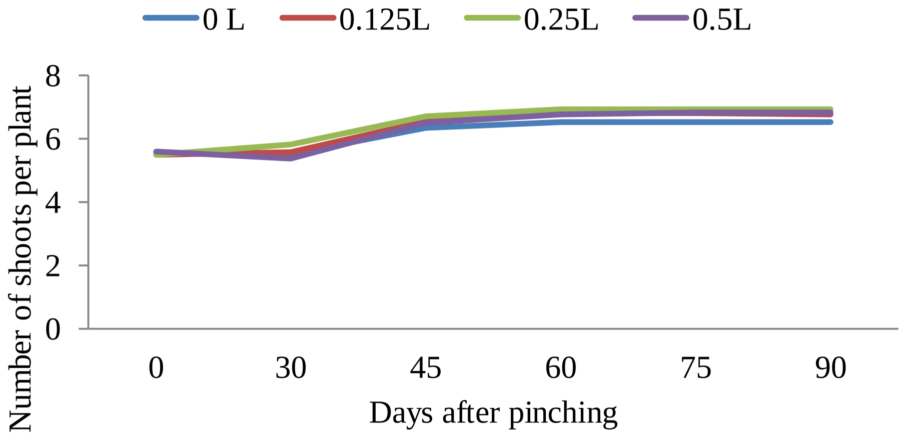

Figure 15: Effect of bioslurry on the number of shoots per plant in trial 2

The application of Hicure in trial 1 significantly affected the number of shoots 45 days after pinching. The application of 2.5L ha^{-1} resulted in a higher number shoots followed by the control while the application of 3L and 2L ha^{-1} resulted in a low number of shoots. Although there were no significant differences amongst different rates of Hicure with regards to number of shoots the same trend remained (Figure 17). The application of different levels of Hicure did not yield any significant result in terms of number of shoots per plant in trial 2 (Figure 18). The only interactive effect between bioslurry and Hicure® was observed 45 days after pinching in trial1 (Table 7).

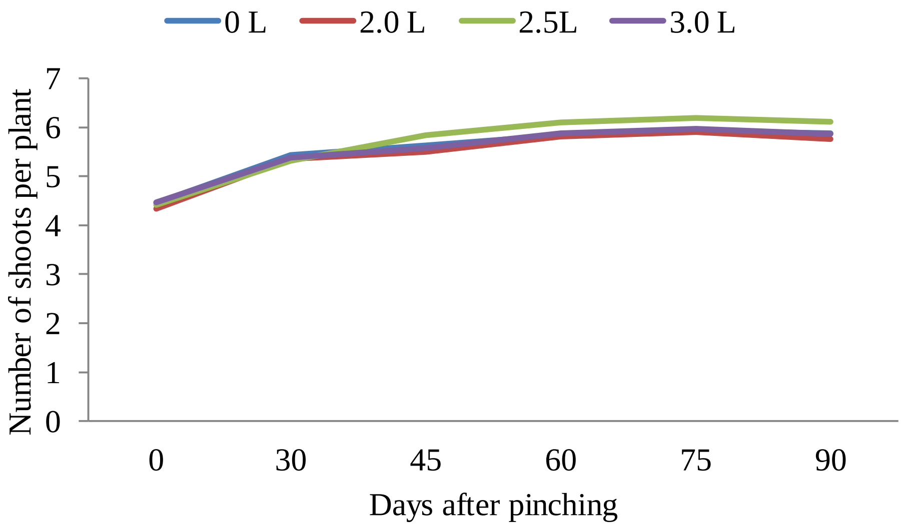

Figure 16: Effect of the plant biostimulant Hicure® on the number of shoots per plant in trial 1

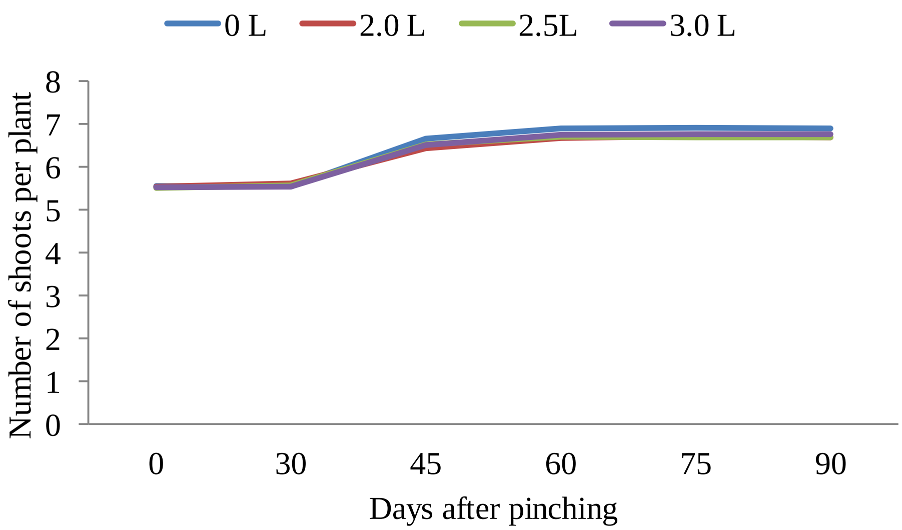

Figure 17: Effect of the plant biostimulant Hicure® on the number of shoots per plant in trial 2

Table 7: Effects of the interaction of bioslurry and plant biostimulant Hicure® on number of shoots

Level of Bioslurry	Levels of Hicure®	Number of shoots per plant											
		Days after pinching											
		Trial 1						Trial 2					
		0	30	45	60	75	90	0	30	45	60	75	90
0L m^{-2}	**0L ha^{-1}**	4.47	5.35	5.33def*	5.37	5.53	5.60	5.57	5.50	6.90	7.17	7.17	7.17
	2.0L ha^{-1}	4.48	5.43	5.47cdef	5.83	5.90	5.73	5.57	5.57	6.10	6.27	6.27	6.27
	2.5L ha^{-1}	4.47	5.27	5.67abcd	6.03	6.17	5.99	5.53	5.37	6.43	6.60	6.57	6.57
	3.0L ha^{-1}	4.63	5.52	5.97a	5.97	6.03	6.03	5.50	5.60	5.97	6.03	6.11	6.11
0.125Lm^{-2}	**0L ha^{-1}**	4.43	5.57	5.83abc	6.30	6.33	6.17	5.53	5.73	6.60	6.80	6.80	6.80
	2.0L ha^{-1}	4.22	5.35	5.80abc	5.93	6.00	5.87	5.53	5.67	6.50	6.77	6.77	6.63
	2.5L ha^{-1}	4.25	5.42	5.90abc	6.43	6.50	6.17	5.43	5.60	6.53	6.83	6.83	6.83
	3.0L ha^{-1}	4.35	5.45	5.63abcd	5.77	5.87	5.80	5.50	5.33	6.53	6.80	6.80	6.77
0.25L m^{-2}	**0L ha^{-1}**	4.42	5.47	5.73abcd	5.70	5.73	5.73	5.50	5.77	6.63	6.83	6.83	6.80
	2.0L ha^{-1}	4.39	5.30	5.70abcd	5.70	5.73	5.63	5.47	5.80	6.77	7.10	7.12	7.12
	2.5L ha^{-1}	4.55	5.28	5.83abc	5.80	5.87	6.10	5.50	5.73	6.83	6.93	6.93	6.93
	3.0L ha^{-1}	4.47	5.28	5.17ef	5.87	5.97	5.87	5.47	5.93	6.60	6.83	6.83	6.83
0.5L m^{-2}	**0L ha^{-1}**	4.48	5.37	5.60abcd	5.97	6.13	6.00	5.60	5.17	6.47	6.77	6.83	6.83
	2.0L ha^{-1}	4.23	5.34	5.03f	5.77	5.97	5.80	5.57	5.40	6.33	6.53	6.67	6.67
	2.5L ha^{-1}	4.42	5.30	5.97a	6.13	6.23	6.17	5.53	5.57	6.30	6.43	6.43	6.43
	3.0L ha^{-1}	4.45	5.25	5.50bcde	5.90	6.00	5.77	5.63	5.30	6.93	7.30	7.30	7.33

*Means in the same column with the same letter are not significantly different.

4.1.5. Effects of bioslurry and plant biostimulant on leaf area and leaf area index

Different rates of bioslurry did not have a significant effect ($p \leq 0.05$) on the leaf area in both trial 1 and 2 (Figure 18 and 19).

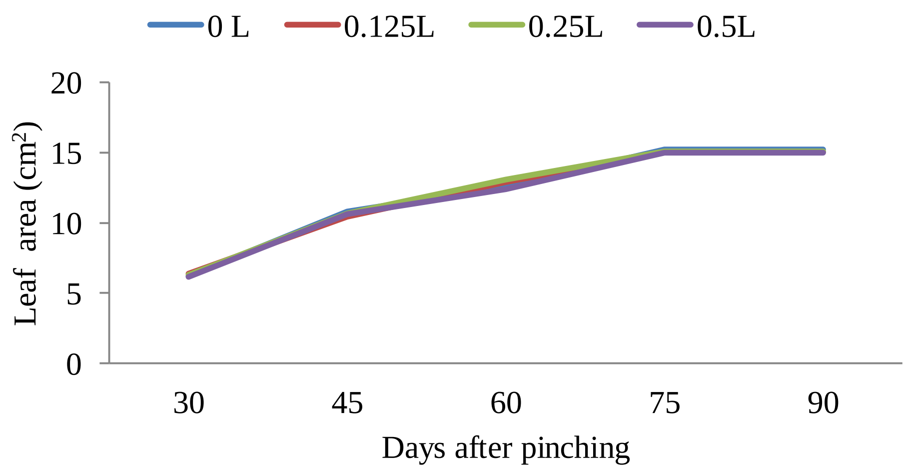

Figure 18: Effect of bioslurry on carnation leaf area in trial 1

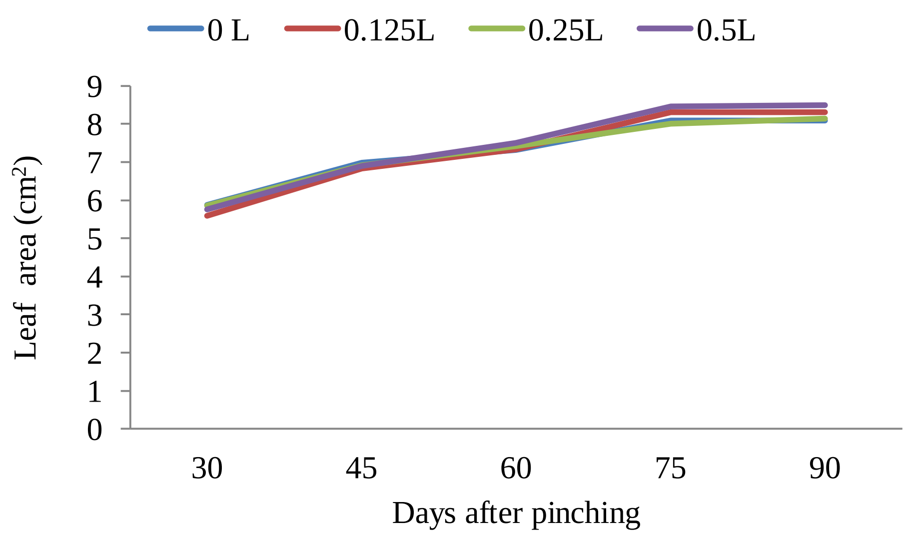

Figure 19: Effect of bioslurry on carnation leaf area in trial 2

On the other hand, different rates of Hicure® had a significant difference on the leaf area in trial1 which was observed 30 days after pinching. The application of Hicure® at the rate of 2L ha^{-1} recorded the biggest leaf area followed by the rate of 2.5L ha^{-1} while the control had the smallest. However, data recorded 45, 60, 75 and 90 did not show any significant difference on the leaf area in trial 1 (Figure 20). In trial 2, different levels of Hicure® did not have a significant effect on the leaf area from 30 to 75 days after pinching. However, on the 90th day after pinching, levels of Hicure® had a significant effect on the leaf area ($p \leq 0.05$). The application of 2.5L and 3L ha^{-1} of Hicure® recorded the biggest leaf area followed by the rate of 2L ha^{-1} while the control had the smallest leaf area (Figure 21).

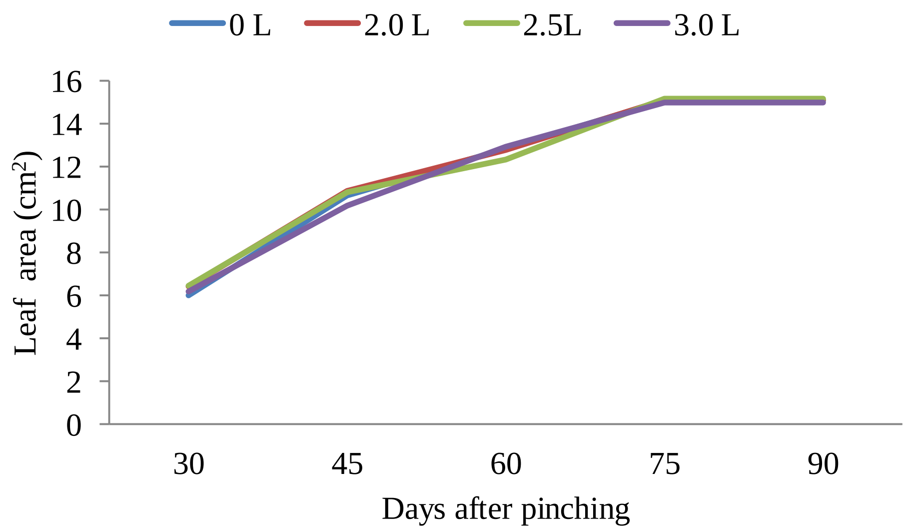

Figure 20: Effect of plant biostimulant Hicure® on carnation leaf area in trial 1

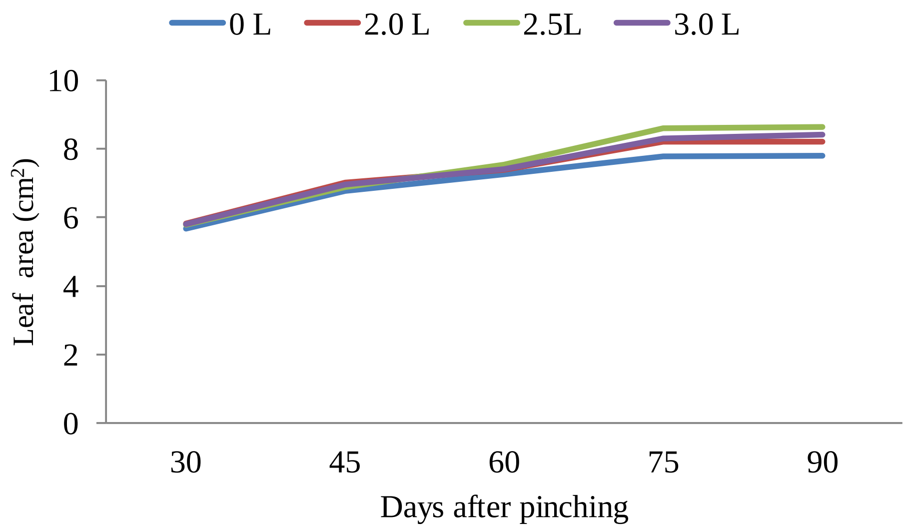

Figure 21: Effect of plant biostimulant Hicure® on carnation leaf area in trial 2

The application of bioslurry did not have a significant effect on leaf area index in both trial 1 and 2 (Figure 22and 23).

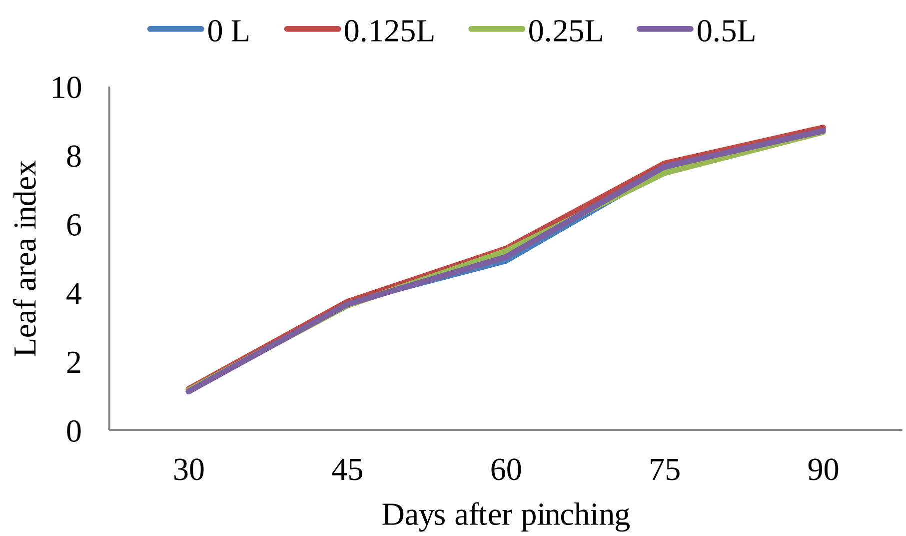

Figure 22: Effect of bioslurry on carnation leaf area index in trial 1

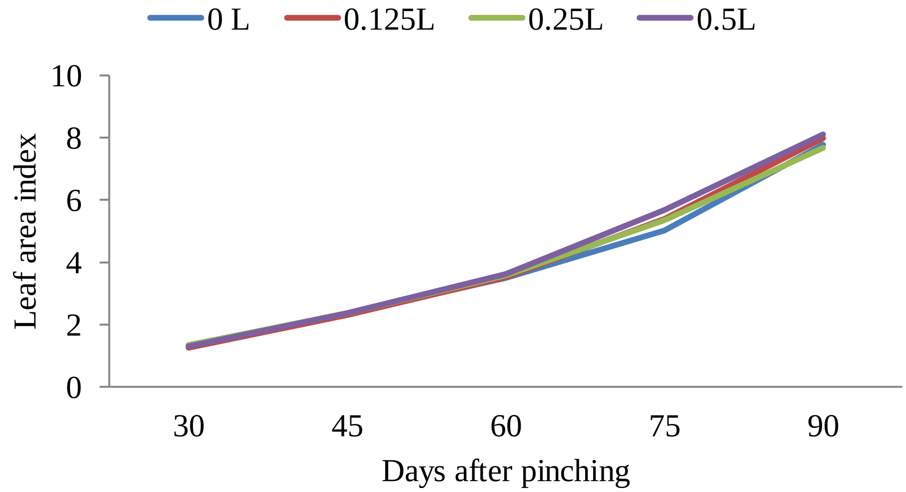

Figure 23: Effect of bioslurry on carnation leaf area index in trial 2

However, different rates of Hicure® significantly affected the leaf area index only 30 days after pinching in trial 1. The application of 2.5L ha^{-1} and 2L ha^{-1} recorded the highest leaf are followed by the rate of 3L ha^{-1} while the control recorded the lowest leaf area index (Figure 24). In trial 2 there was no significant difference on the leaf area of plants which received different application levels of Hicure® (Figure 25).

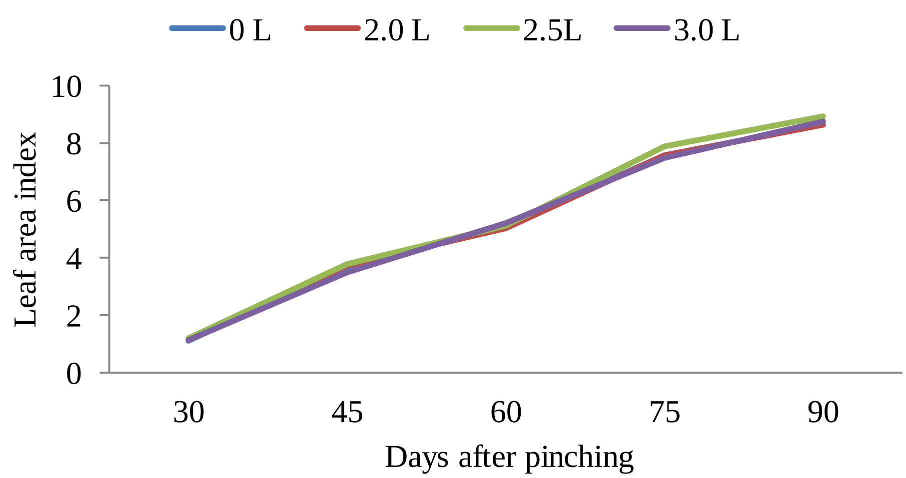

Figure 24: Effect of plant biostimulant Hicure® on carnation leaf area index in trial 1

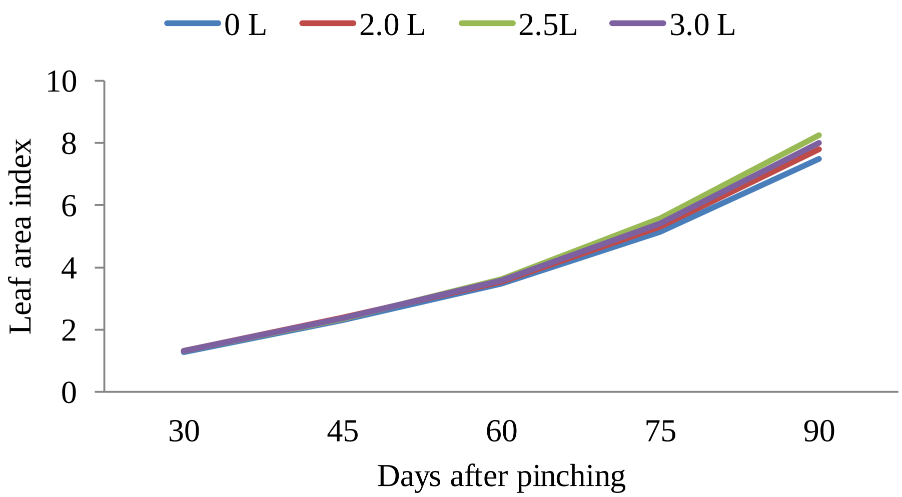

Figure 25: Effect of plant biostimulant Hicure® on carnation leaf area index in trial 2

The interactive effect between different levels of bioslurry and Hicure® was observed on leaf area 30 days after pinching (Table 8) and on leaf area index, 45 days after pinching during trial one. This interactive effect between levels of bioslurry and Hicure® was not significant throughout trial 2 (Table 9).

Table 8: Effects of the interaction of bioslurry and plant biostimulant Hicure® on carnation leaf area

Level of Bioslurry	Level of Hicure	Leaf area in cm^2									
		Days after pinching									
		Trial 1					Trial 2				
		30	45	60	75	90	30	45	60	75	90
0 L m^{-2}	**0L ha^{-1}**	5.60e*	10.55	13.25	15.67	15.67	6.03	7.01	7.28	7.75	7.75
	2.0L ha^{-1}	6.63ab	12.08	12.52	14.91	14.91	5.68	6.74	6.79	7.59	7.59
	2.5L ha^{-1}	6.39abcd	11.23	11.48	15.06	15.06	5.65	7.05	7.61	8.68	8.68
	3.0L ha^{-1}	6.23bcd	9.31	13.00	15.28	15.28	6.15	7.11	7.60	8.35	8.35
0.125 L m^{-2}	**0L ha^{-1}**	6.25bcd	10.43	12.21	14.98	14.98	5.14	6.42	6.82	7.91	7.91
	2.0L ha^{-1}	6.36abcd	10.26	12.97	15.37	15.37	5.57	6.80	7.26	8.24	8.24
	2.5L ha^{-1}	6.81a	10.46	13.20	15.00	15.00	5.94	7.08	7.66	8.58	8.58
	3.0L ha^{-1}	6.17bcd	10.66	13.11	14.74	14.74	5.68	7.07	7.58	8.55	8.55
0.25 L m^{-2}	**0L ha^{-1}**	6.21bcd	11.01	13.33	15.20	15.20	5.85	6.93	7.47	7.65	7.70
	2.0L ha^{-1}	6.40abc	10.57	13.67	15.05	15.05	6.31	7.38	7.84	8.25	8.25
	2.5L ha^{-1}	6.17bcd	10.73	12.49	15.46	15.46	5.74	6.71	7.27	8.51	8.60
	3.0L ha^{-1}	6.45ab	10.29	12.79	14.60	14.60	5.55	6.63	7.14	7.61	8.02
0.5 L m^{-2}	**0L ha^{-1}**	5.94cde	10.67	12.59	14.47	14.47	5.64	6.75	7.44	7.82	7.82
	2.0L ha^{-1}	6.34abcd	10.57	11.96	15.12	15.12	5.73	7.13	7.68	8.74	8.78
	2.5L ha^{-1}	6.38abcd	10.77	12.10	15.13	15.13	5.78	6.72	7.60	8.61	8.66
	3.0L ha^{-1}	5.91de	10.46	12.83	15.26	15.26	5.86	7.01	7.30	8.70	8.70

*Means in the same column with the same letter are not significantly different at $p \leq 0.05$.

Table 9: Effects of the interaction of bioslurry and plant biostimulant Hicure® on carnation leaf area index

		Leaf area index									
Level of Bioslurry	**Level of Hicure**	**Days after pinching**									
		Trial 1					**Trial 2**				
		30	**45**	**60**	**75**	**90**	**30**	**45**	**60**	**75**	**90**
0 L m^{-2}	**0L ha^{-1}**	1.00	3.57bc*	4.97	7.50	8.64	1.37	2.35	3.48	5.01	7.48
	2.0L ha^{-1}	1.16	4.21a	4.82	7.51	8.47	1.30	2.25	3.23	4.66	7.30
	2.5L ha^{-1}	1.17	3.87ab	4.67	7.70	8.64	1.29	2.42	3.59	5.38	8.25
	3.0L ha^{-1}	1.14	3.22c	5.28	7.63	9.31	1.40	2.41	3.67	5.08	8.06
0.125 L m^{-2}	**0L ha^{-1}**	1.17	3.69bc	5.15	7.87	8.83	1.17	2.17	3.29	5.01	7.61
	2.0L ha^{-1}	1.17	3.63bc	5.18	7.81	9.05	1.26	2.29	3.48	5.35	7.79
	2.5L ha^{-1}	1.25	3.79ab	5.64	8.14	9.00	1.35	2.41	3.65	5.56	8.24
	3.0L ha^{-1}	1.16	3.83ab	5.18	7.25	8.36	1.29	2.38	3.70	5.63	8.26
0.25 L m^{-2}	**0L ha^{-1}**	1.15	3.79ab	5.22	7.42	8.64	1.33	2.38	3.63	5.24	7.33
	2.0L ha^{-1}	1.15	3.48bc	5.36	7.31	8.46	1.43	2.50	3.77	5.46	7.74
	2.5L ha^{-1}	1.13	3.66bc	5.08	7.79	9.04	1.31	2.28	3.51	5.59	8.17
	3.0L ha^{-1}	1.19	3.53bc	5.14	7.37	8.53	1.26	2.27	3.45	5.08	7.49
0.5 L m^{-2}	**0L ha^{-1}**	1.09	3.76ab	5.13	7.44	8.48	1.28	2.30	3.54	5.28	7.50
	2.0L ha^{-1}	1.18	3.63bc	4.76	7.66	8.60	1.30	2.48	3.71	5.76	8.37
	2.5L ha^{-1}	1.19	3.81ab	5.05	7.88	9.02	1.31	2.32	3.74	5.79	8.31
	3.0L ha^{-1}	1.08	3.40bc	5.22	7.67	8.79	1.33	2.40	3.52	5.89	8.24

*Means in the same column with the same letter are not significantly different at $p \leq 0.05$.

4.2. Effects of bioslurry and plant biostimulant on leaf stomatal conductance

In both trial 1 and 2, there were no statistical ($p \leq 0.05$) differences in the influence of bioslurry levels on leaf stomatal conductance 60, 75, 90 and 105 days after pinching. The peak leaf stomatal conductance was recorded 90 days after pinching for all levels except for the control where it was recorded on after 105 days after pinching in trial 1. In trial 1, bioslurry manure at 0.5L m^{-2} gave the highest leaf stomatal conductance at 90th day after pinching, followed by the 0.25L m^{-2} and the least were observed from plants that were under control (Figure 26). In contrast, bioslurry at the rate of 0.125 L m^{-2} recorded the highest leaf stomatal conductance 90 days after pinching in trial 2 followed by the control (Figure 27).

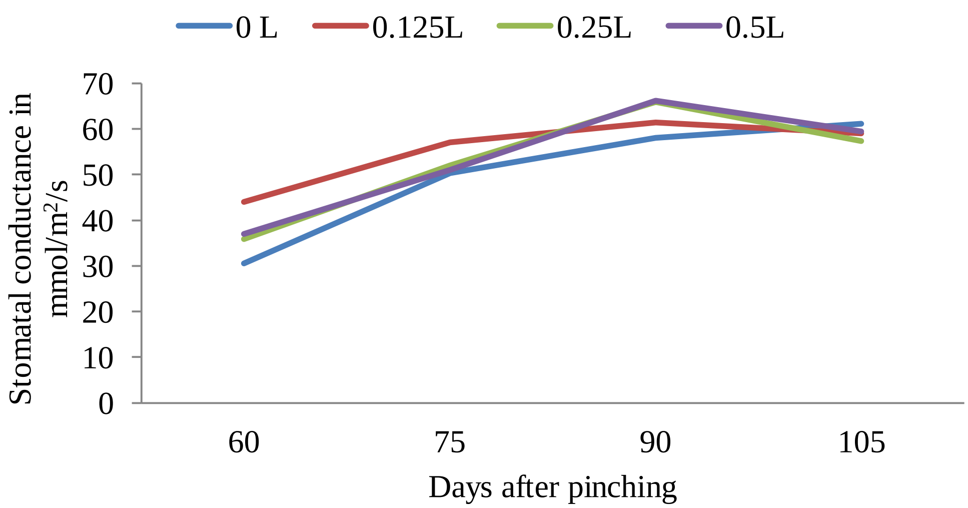

Figure 26: Effect of bioslurry on leaf stomatal conductance in trial 1

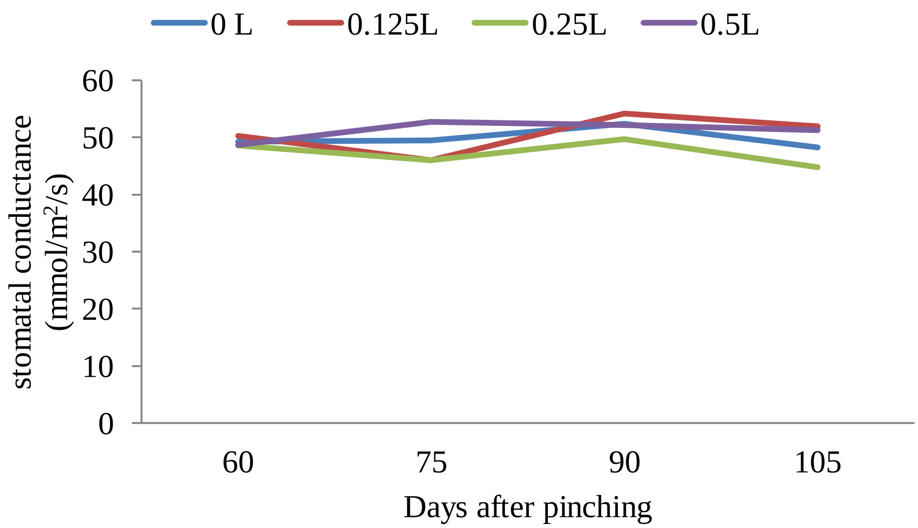

Figure 27: Effect of bioslurry on leaf stomatal conductance in trial 2

Similarly, in both trial 1 and 2, there were no statistical ($p \leq 0.05$) differences in the influence of Hicure® levels on leaf stomatal conductance 60, 75, 90and 105 days after pinching (Figure 28 and 29).

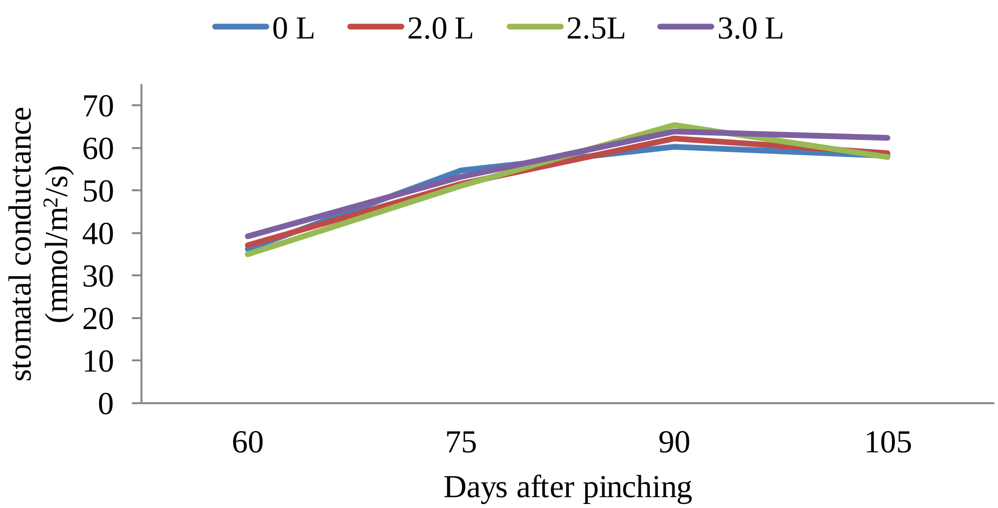

Figure 28: Effect of plant biostimulant Hicure® on stomatal conductance in trial 1

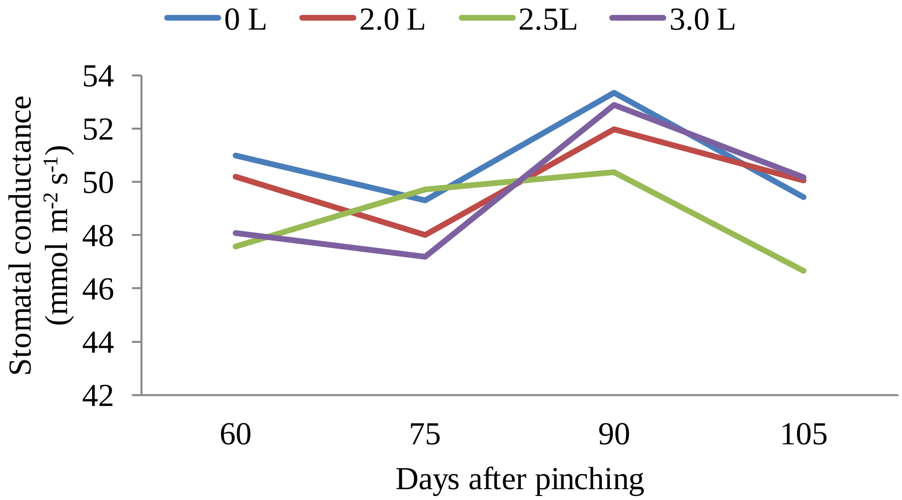

Figure 29: Effect of plant biostimulant Hicure® on stomatal conductance in trial 2

The interactive effect of bioslurry levels and Hicure® levels on leaf stomatal conductance was not observed at all intervals of data collection (Table 10).

Table 10: Effects of the interaction of bioslurry and plant biostimulant Hicure® on leaf stomatal conductance

Stomatal conductance in mmol m^{-2} s^{-1}									
		Days after pinching							
Level of Bioslurry	Level of Hicure	Trial 1				Trial 2			
		60	75	90	105	60	75	90	105
0 L m^{-2}	**0L ha^{-1}**	23.69	46.82	53.73	61.19	53.95	46.78	52.41	45.34
	2.0L ha^{-1}	35.64	54.79	55.36	61.32	55.16	54.87	55.72	47.62
	2.5L ha^{-1}	28.90	48.44	60.83	64.21	46.74	52.42	49.43	47.11
	3.0L ha^{-1}	34.07	51.51	62.33	57.79	41.10	44.00	52.17	53.00
0.125 L m^{-2}	**0L ha^{-1}**	45.40	59.47	54.01	55.66	51.08	44.81	51.18	52.09
	2.0L ha^{-1}	38.56	51.05	65.46	57.15	50.45	46.20	53.14	56.28
	2.5L ha^{-1}	41.46	54.37	61.55	57.99	48.66	47.16	54.92	51.75
	3.0L ha^{-1}	50.44	63.62	64.70	65.31	51.01	45.68	57.55	47.67
0.25 L m^{-2}	**0L ha^{-1}**	42.51	53.11	68.66	58.68	52.00	47.30	57.04	44.41
	2.0L ha^{-1}	36.01	52.86	66.99	60.84	47.21	42.24	49.93	46.20
	2.5L ha^{-1}	30.12	52.45	66.44	50.70	45.52	46.37	41.95	40.78
	3.0L ha^{-1}	34.89	49.43	61.83	59.35	49.68	48.04	50.07	47.85
0.5 L m^{-2}	**0L ha^{-1}**	33.32	59.24	64.72	56.78	46.95	58.38	52.81	55.88
	2.0L ha^{-1}	38.11	47.29	61.21	55.54	47.99	48.71	49.10	50.08
	2.5L ha^{-1}	39.32	49.20	72.37	58.44	49.40	52.87	55.13	47.06
	3.0L ha^{-1}	37.12	48.32	66.40	67.04	50.55	51.02	51.79	52.18

4.3. Effects of bioslurry and plant biostimulant on flowering parameters

4.3.1. Effects of bioslurry and plant biostimulant on flower bud opening

During both trial 1 and 2, the application of various levels of bioslurry and the plant biostimulant did not have any significant effect on the number of days to 50% flower bud opening (Table 11 and 12). There was no noticeable effect of the interaction between bioslurry and the plant biostimulant Hicure® levels on flower bud opening in both trial 1 and 2 (Table13).

Table 11: Effects of bioslurry on flowering parameters

Level of Bioslurry	Days to 50% flower bud opening		Duration of flowering	
	Trial 1	Trial 2	Trial 1	Trial 2
0 L m^{-2}	147	148	56.58	64.08
0.125 L m^{-2}	149	148	58.17	65.25
0.25 L m^{-2}	148	147	55.75	66.42
0.5 L m^{-2}	148	148	56.17	63.08

Table 12: Effects of plant biostimulant Hicure® on flowering parameters

Levels of Hicure®	Days to 50% flower bud opening		Duration of flowering	
	Trial 1	Trial 2	Trial 1	Trial 2
0 L ha^{-1}	147	147	57.58	64.42
2 L ha^{-1}	148	148	56.50	64.17
2.5L ha^{-1}	149	147	57.33	65.75
3 Lha^{-1}	148	149	55.25	64.50

4.3.2. Effects of bioslurry and plant biostimulant on duration of flowering

The application of bioslurry and plant biostimulant Hicure® did not have any significant effect on the duration of flowering in both trials ($p \leq 0.05$). Moreover in both cases, there was no uniform trend which was maintained in both trial 1 and 2 (Table 11 and 12). There was no interactive effect of levels of bioslurry and different rates of the plant biostimulant on the duration of carnation flowering in both trials at $p \leq 0.05$ (Table 13).

Table 13: Effects of the interaction of bioslurry and plant biostimulant Hicure® on flowering parameters

Level of Bioslurry	Level of Hicure	Days to 50% Flower bud opening		Flowering duration (days)	
		Trial 1	Trial 2	Trial 1	Trial 2
0 L m^{-2}	**0L ha^{-1}**	149.67	147.67	59.00	62.33
	2.0L ha^{-1}	146.00	147.67	57.00	65.67
	2.5L ha^{-1}	146.33	147.67	58.33	60.67
	3.0L ha^{-1}	146.33	148.00	52.00	67.67
0.125 L m^{-2}	**0L ha^{-1}**	148.00	147.33	60.00	63.33
	2.0L ha^{-1}	148.33	148.67	58.67	65.00
	2.5L ha^{-1}	149.00	146.33	55.67	67.00
	3.0L ha^{-1}	149.00	148.67	58.33	65.67
0.25 L m^{-2}	**0L ha^{-1}**	145.33	146.67	59.33	71.67
	2.0L ha^{-1}	149.67	147.00	51.00	61.67
	2.5L ha^{-1}	149.33	146.67	57.67	68.33
	3.0L ha^{-1}	148.67	149.33	55.00	64.00
0.5 L m^{-2}	**0L ha^{-1}**	145.00	147.67	52.00	60.33
	2.0L ha^{-1}	149.33	149.00	59.33	64.33
	2.5L ha^{-1}	150.00	147.00	57.67	67.00
	3.0L ha^{-1}	148.00	148.00	55.67	60.67

4.4. Effects of bioslurry and plant biostimulant on flower quality parameters

4.4.1. Flower stem length

There was no significant effect of bioslurry and Hicure® on flower stem length in both trial one and two (Table 14). In trial one the application of 0.125L m^{-2} of bioslurry recorded the highest flower stem length of 65.92 cm followed by the rate of 0.5L m^{-2} with 65.83 cm while the control had 65.1cm. In trial two, the trend was reversed as the control recorded a flower stem length of 69.63 followed with the rate of 0.125L m^{-2} which recorded 69.57 and the rate of 0.5L m^{-2} had the lowest flower stem length with 69.46 (Table 14). The application of Hicure® in trial one resulted in slight but non-significant decrease of the stem length with the control recording length of 66.07cm followed by the rate of 3.0L ha^{-1} with 65.64cm and the rate of 2.0L ha^{-1} had the lowest stem length of 65.34. In trial two, however, the application of Hicure® at the rate 3L ha^{-1} resulted in longer flower stems with 69.76cm followed by the control with 69.61cm while the rate of 2.0L ha^{-1} recorded the shortest flower stems with 69.36 cm (Table 15). The interaction between different levels of bioslurry and those levels of Hicure® did not have significant differences in trial 1 while there was a significant difference in trial 2 ($p \leq 0.05$). The combination of the rate of 0.5L m^{-2} of bioslurry and 3.0L ha^{-1} of Hicure® recorded the longest flower stems with 70.53 while the combination of 0.5L m^{-2} with Hicure® at the rate of 2.5L ha^{-1} recorded the shortest flower stems with 68.12cm (Table16).

Table 14: Effect of bioslurry on carnation flower quality

	Trial 1				Trial 2			
Bioslurry levels	**SL (cm)**	**SD (mm)**	**HD (mm)**	**HL (mm)**	**SL (cm)**	**SD (mm)**	**HD (mm)**	**HL (mm)**
0 L m^{-2}	65.10	5.78	22.15	39.39	69.63	5.30	21.09c*	40.34b*
0.125 L m^{-2}	65.92	5.76	22.38	39.52	69.57	5.36	21.68b	40.96a
0.25 L m^{-2}	65.62	5.77	22.29	39.55	69.54	5.32	21.81ab	40.97a
0.5 L m^{-2}	65.83	5.77	22.32	39.42	69.46	5.30	21.90a	40.88a

*Means in the same column with the same letter are not significantly different at $p \leq 0.05$

SL: Stem length, SD: Stem diameter; HL: Flower head length, HD: Flower head diameter

Table 15: Effect of plant biostimulant Hicure® on carnation flower quality

	Trial 1				Trial 2			
Levels of Hicure®	**SL (cm)**	**SD (mm)**	**HD (mm)**	**HL (mm)**	**SL (cm)**	**SD (mm)**	**HD (mm)**	**HL (mm)**
0 L ha^{-1}	66.07	5.78	22.12b*	39.49	69.61	5.36	21.59	40.70
2 L ha^{-1}	65.34	5.75	22.32a	39.57	69.48	5.30	21.55	40.94
2.5L ha^{-1}	65.43	5.78	22.30a	39.36	69.36	5.31	21.67	40.62
3 Lha^{-1}	65.64	5.76	22.40a	39.46	69.76	5.32	21.65	40.89

Means in the same column with the same letter are not significantly different at $p \leq 0.05$

SL: Stem length, SD: Stem diameter; HL: Flower head length, HD: Flower head diameter

4.4.2. Flower stem diameter

The application of different rates of bioslurry and those of Hicure® did not significantly affect the flower stem diameter (Table 14 and 15). There was no interactive effect of bioslurry and Hicure® on the flower stem diameter (Table16).

4.4.3. Flower head size

4.4.3.1. Flower head length

The application of different rate of bioslurry did not significantly increase the flower head length in trial one but it had a significant effect in trial 2. The application of 0.125, 0.25 and 0.5L m^{-2} significantly improved the flower head length compared to the control ($p \leq 0.05$) (Table 14). In trial one the application of bioslurry at the rate of 0.25L m^{-2} recorded 39.55mm followed by 0.125Lm^{-2} with 39.52mm while the control had 39.39 mm and in trial two they respectively recorded 40.97mm, 40.96mm and 40.34mm. On the other hand, the application different rates of Hicure® did not have a significant effect on the flower head length. In both trial 1 and 2, the application of Hicure® at the rate of 2Lha^{-1} recorded the highest value respectively 39.59mm and 40.94mm while the rate of 2.5Lha^{-1}recorded the lowest head length in both experiment one and two with 39.36mm and 40.61mm respectively (Table 15). There was no interactive effect between levels of bioslurry and levels of Hicure® in trial 1 while there was a significant effect in trial 2 (Table 16).

4.4.3.2. Flower head diameter

There were mixed effects of different rates of bioslurry and of plant biostimulant Hicure® on the flower head diameter. In the first trial, the application of different levels of bioslurry did not have a significant effect on flower head diameter. The application of bioslurry at the rate of 0.125L m^{-2} recorded the highest diameter with 22.38mm followed by the rate 0.5L m^{-2} with 22.32mm while the control recorded the lowest with 22.15mm. Meanwhile, there was a significant ($p \leq 0.05$) difference between different rates of bioslurry on the flower head diameter in the second trial. In trial 2, the lower rate which was the control recorded the lowest value of 21.09 mm while the biggest flower head diameter of 21.90 mm was obtained in plots that received 0.5Lm^{-2}(Table 14). On the other hand, the application of various levels of Hicure® had a significant effect on the flower head diameter in the first trial while there was no significant difference on the effect of different rates of Hicure® on the flower head diameter ($p \leq 0.05$) in the second trial. In trial 1, the thinner flower head was recorded in the control wit 22.12mm while the rate 3L ha^{-1} resulted in carnations with flower head diameter of an average 22.40mm. Though, there was no significant differences among various levels of Hicure® in trial 2, it can be noted that the trend was not maintained as the application of Hicure® at the rate of 2.5 L ha^{-1} recorded the highest value of 21.67mm followed by the rate of 3Lha^{-1} with 21.65mm while the lowest value (21.55mm) was recorded in plots which received 2.0L of Hicure® per hectare (Table 15). There was no interactive effect between levels of bioslurry and different levels of Hicure® (Table 16).

Table 16: Effects of the interaction of bioslurry and plant biostimulant Hicure® on flowering parameters

Level of Bioslurry	Level of Hicure	Trial 1				Trial 2			
		SL(cm)	SD(mm)	HD(mm)	HL(mm)	SL(cm)	SD(mm)	HD(mm)	HL(mm)
0 L m^{-2}	**0L ha^{-1}**	65.30	5.79	21.63	39.34	69.42ab*	5.33	21.22	40.21de*
	2.0L ha^{-1}	65.20	5.76	22.25	39.44	69.85a	5.30	20.78	40.23cde
	2.5L ha^{-1}	64.92	5.77	22.28	39.40	69.95a	5.27	21.20	40.54abcde
	3.0L ha^{-1}	64.99	5.80	22.46	39.36	69.32abc	5.31	21.15	40.36bcde
0.125 L m^{-2}	**0L ha^{-1}**	66.56	5.79	22.32	39.58	69.99a	5.40	21.65	41.01ab
	2.0L ha^{-1}	65.24	5.74	22.38	39.66	68.74bc	5.33	21.61	41.02ab
	2.5L ha^{-1}	65.28	5.78	22.41	39.49	69.98a	5.36	21.59	40.89abc
	3.0L ha^{-1}	66.60	5.73	22.42	39.35	69.57ab	5.33	21.85	40.89abc
0.25 L m^{-2}	**0L ha^{-1}**	66.19	5.79	22.21	39.55	69.77ab	5.43	21.70	40.88abcd
	2.0L ha^{-1}	65.63	5.76	22.28	39.60	69.38abc	5.22	21.71	41.15a
	2.5L ha^{-1}	65.63	5.79	22.39	39.46	69.39abc	5.37	22.00	40.96ab
	3.0L ha^{-1}	65.03	5.73	22.27	39.56	69.60ab	5.27	21.81	40.90abc
0.5 L m^{-2}	**0L ha^{-1}**	66.23	5.77	22.32	39.48	69.25abc	5.28	21.78	40.69abcde
	2.0L ha^{-1}	65.28	5.74	22.36	39.57	69.94a	5.33	22.10	41.35a
	2.5L ha^{-1}	65.88	5.79	22.14	39.07	68.12c	5.22	21.91	40.07e
	3.0L ha^{-1}	65.92	5.78	22.44	39.57	70.53a	5.36	21.79	41.40a

*Means in the same column with the same letter are not significantly different at $p \leq 0.05$.

SL: Stem length, SD: Stem diameter; HL: Flower head length, HD: Flower head diameter

4.5. Effects of bioslurry and plant biostimulant on yield parameters

4.5.1. Effects of bioslurry and plant biostimulant Hicure® on the number of flowers per plant and per m^2

There were no significant differences in the effect of bioslurry levels on number of flowers per plant and per m^2 in trial 1 and in trial 2. However, bioslurry rates of 0.5 and 0.125L m^{-2} increased the number of stems in trial 1; while in trial 2, the addition of any level of bioslurry increased the number of stems per m^2 compared to the control (Table 17). Similarly, the application of the biostimulant Hicure® did not increase the number of flowers significantly although slight increases were recorded on plant which received this biostimulant at the rate of 3L ha^{-1} in both trial1 and 2 (Table 18) . There were no significant interaction effects on carnation number of flowers per plant and per m^2 in all the combination of bioslurry and Hicure® biostimulant (Table19).

Table 17: Effect of bioslurry on the number of flowers per plant and per m^2

	Flowers per plant		**Flowers per m^2**	
Level of bioslurry	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
0 L m^{-2}	5.62	6.38	202.33	229.56
0.125 L m^{-2}	5.63	6.54	202.80	235.46
0.25 L m^{-2}	5.41	6.76	194.70	243.28
0.5 L m^{-2}	5.64	6.43	203.10	231.47

Table 18: Effect of plant biostimulant Hicure® on number of flowers per plant and per m^2

	Flowers per plant		**Flowers per m^2**	
Levels of Hicure®	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
0 L ha^{-1}	5.44	6.60	195.73	237.70
2 L ha^{-1}	5.49	6.38	197.70	229.60
2.5L ha^{-1}	5.63	6.50	202.80	234.12
3 Lha^{-1}	5.74	6.62	206.70	238.34

Table 19: Effects of the interaction of bioslurry and plant biostimulant Hicure® on the number of flowers per plant and per m^2

		Flower yield per plant		Flower yield m^{-2}	
Level of Bioslurry	**Level of Hicure**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
0 L m^{-2}	**0L ha^{-1}**	5.48	6.79	197.33	244.38
	2.0L ha^{-1}	5.30	6.19	190.80	222.80
	2.5L ha^{-1}	5.80	6.47	208.80	232.98
	3.0L ha^{-1}	5.90	6.06	212.40	218.06
0.125 L m^{-2}	**0L ha^{-1}**	5.73	6.50	206.40	234.00
	2.0L ha^{-1}	5.57	6.34	200.40	228.23
	2.5L ha^{-1}	5.60	6.71	201.60	241.50
	3.0L ha^{-1}	5.63	6.61	202.80	238.11
0.25 L m^{-2}	**0L ha^{-1}**	5.33	6.69	192.00	240.80
	2.0L ha^{-1}	5.17	6.88	186.00	247.70
	2.5L ha^{-1}	5.53	6.93	199.20	249.60
	3.0L ha^{-1}	5.60	6.53	201.60	235.00
0.5 L m^{-2}	**0L ha^{-1}**	5.20	6.44	187.20	231.60
	2.0L ha^{-1}	5.93	6.10	213.60	219.67
	2.5L ha^{-1}	5.60	5.90	201.60	212.40
	3.0L ha^{-1}	5.83	7.28	210.00	262.20

4.5.2. Flower weight

Application of bioslurry did not have any significant effect on flower weight in both trial 1 and 2 at $p \leq 0.05$ (Table 20). However, the weight of flowers decreased as the number of flowers per plant increased following bioslurry application particularly in trial 2 (Figure 30). Application of plant biostimulant, Hicure® did not have any significant effect on flower weight in both trial 1 and 2 at $p \leq 0.05$ (Table 21). There was no noticeable interactive effect of levels of bioslurry and Hicure on the weight of flower (Table 22).

Table 20: Effect of bioslurry on flower weight

	Weight of flower in grams	
Levels of bioslurry	**Trial 1**	**Trial 2**
0L m^{-2}	39.25	32.46
0.125L m^{-2}	39.29	32.23
0.25 L m^{-2}	39.97	32.07
0.5 L m^{-2}	38.55	32.42

Table 21: Effect of plant biostimulant Hicure® on flower weight

	Weight of flower in grams	
Levels of Hicure®	**Trial 1**	**Trial 2**
0 L ha^{-1}	38.96	33.03
2 L ha^{-1}	39.02	33.29
2.5L ha^{-1}	39.46	31.03
3 Lha^{-1}	39.61	31.83

Table 22: Effects of the interaction of bioslurry and plant biostimulant Hicure® on flower fresh weight

		Trial 1	Trial 2
Level of Bioslurry	**Level of Hicure**	**Weight (g)**	**Weight (g)**
0 L m^{-2}	**0L ha^{-1}**	37.96	33.27
	2.0L ha^{-1}	41.53	33.56
	2.5L ha^{-1}	38.19	32.23
	3.0L ha^{-1}	39.31	30.78
0.125 L m^{-2}	**0L ha^{-1}**	36.99	34.27
	2.0L ha^{-1}	39.40	32.39
	2.5L ha^{-1}	40.23	30.25
	3.0L ha^{-1}	40.53	32.00
0.25 L m^{-2}	**0L ha^{-1}**	41.76	33.58
	2.0L ha^{-1}	38.73	31.41
	2.5L ha^{-1}	40.67	31.08
	3.0L ha^{-1}	38.71	32.19
0.5 L m^{-2}	**0L ha^{-1}**	39.13	30.98
	2.0L ha^{-1}	36.42	35.80
	2.5L ha^{-1}	38.75	30.58
	3.0L ha^{-1}	39.88	32.33

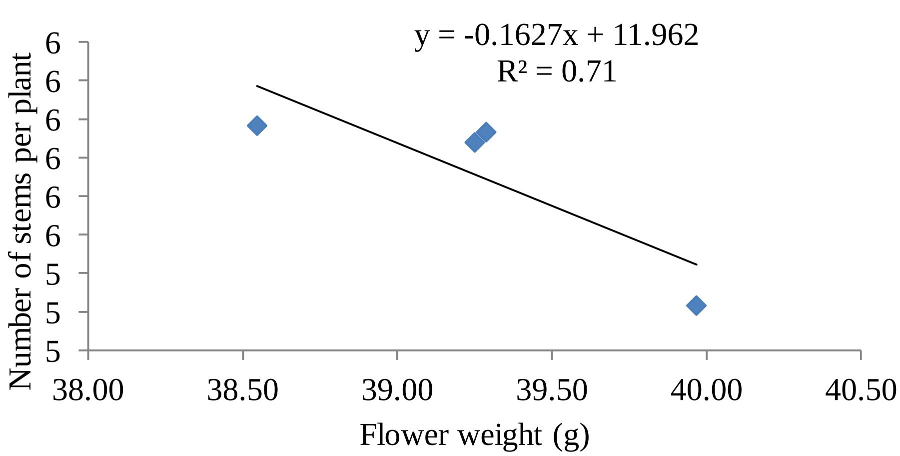

Figure 30: Correlation of number flowers and flower weight following bioslurry application in trial 1

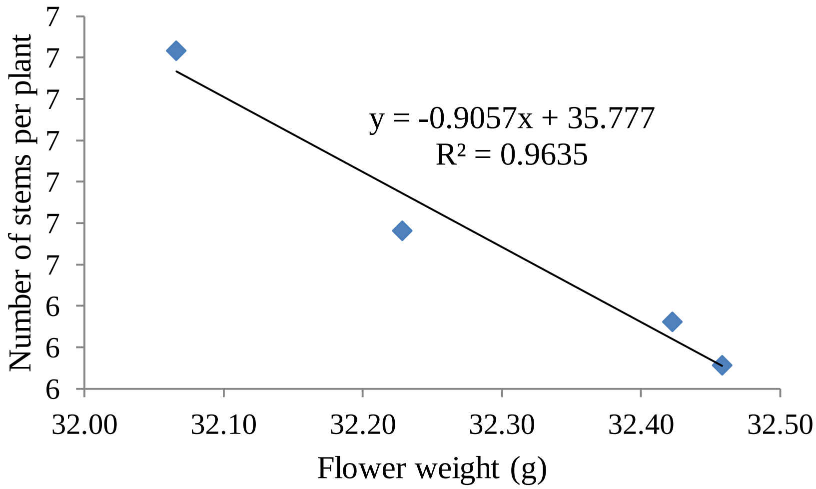

Figure 31: Correlation of number flowers and flower weight following bioslurry application in trial 2

4.1.6. Vase life

Bioslurry application did not significantly ($p \leq 0.05$) affect the vase life of cut carnation. However, the application of bioslurry 0.125, 0.25 and 0.5L m^{-2} reduced the vase life as compared to the control in both trial 1 and 2 (Table 23). On the other hand, the application of Hicure® significantly reduced the vase life. The rate of 2, 2.5 and 3L ha^{-1} did not differ significantly but had a reduced vase life compared to the control which recorded a longer vase life in both trials (Table 24). Data collected in both trial 1 and 2 did not, however, show any significant interactive effect between levels of bioslurry and the plant biostimulant Hicure® on the vase life of carnations (Table 25).

Table 23: Effect of bioslurry on vase life

	Vaselife (days)	
Level of bioslurry	**Trial 1**	**Trial 2**
0L m^{-2}	19.42	16.05
0.125L m^{-2}	18.25	15.33
0.25 L m^{-2}	17.75	15.71
0.5 L m^{-2}	17.42	15.91

Table 24: Effect of plant biostimulant Hicure® on vase life

Level of Hicure®	Vase life (days) Trial 1	Trial 2
0 L ha^{-1}	19.83a*	16.41a
2 L ha^{-1}	17.58b	15.79b
2.5L ha^{-1}	17.67b	15.36b
3 Lha^{-1}	17.75b	15.44b

Means in the same column with the same letter are not significantly different at $p \leq 0.05$

Table 25: Effects of the interaction of bioslurry and plant biostimulant Hicure® on vase life

		Trial 1	Trial 2
Level of Bioslurry	**Level of Hicure**	**Vase life (in days)**	**Vase life (in days)**
0 L m^{-2}	**0L ha^{-1}**	21.67	16.77
	2.0L ha^{-1}	18.33	15.97
	2.5L ha^{-1}	18.67	16.00
	3.0L ha^{-1}	19.00	15.47
0.125 L m^{-2}	**0L ha^{-1}**	20.67	16.00
	2.0L ha^{-1}	17.00	15.33
	2.5L ha^{-1}	18.00	15.00
	3.0L ha^{-1}	17.33	15.00
0.25 L m^{-2}	**0L ha^{-1}**	19.67	16.10
	2.0L ha^{-1}	18.33	15.87
	2.5L ha^{-1}	16.33	15.67
	3.0L ha^{-1}	16.67	15.20
0.5 L m^{-2}	**0L ha^{-1}**	17.33	16.77
	2.0L ha^{-1}	16.67	16.00
	2.5L ha^{-1}	17.67	14.77
	3.0L ha^{-1}	18.00	16.10

CHAPTER FIVE
DISCUSSION

5.1. Effect of bioslurry

5.1.1. Effect of bioslurry on growth and development of carnations

The application of bioslurry had mixed effect on carnations growth and development in both trials. For instance a significant effect on stem diameter was recorded in trial 2. This is possibly due to increased supply of phosphorus, which the plant greatly needs at the beginning of the developmental stage (Mengel and Kirkby, 2001). The application of bioslurry did not have an impact on stem diameter in trial 1 possibly because of low phosphorus content in bioslurry applied. The difference observed in two trials was possibly due to the reaction of plants to soil, the stress of propagation, climatic conditions during trial 2 particularly the high light during growth period after recovering from stress of pinching (Table 2) and the severity of fusarium wilt which occurred throughout trial 2. This is in agreement with Mastalerz (1983 cited by Kazaz *et al.,* 2011), who reported the high light increased the stem diameter in carnation.

The addition of bioslurry, though did not significantly increase the number of shoots, recorded a significant increase during early days of trial 2. This depicts that carnation was able to efficiently use nutrients from bioslurry for more shoots development. This indicates that the timing was crucial and also highlights the importance of supplying enough phosphorus at early stages of plant development (Mengel and Kirkby, 2001).

The application of the bioslurry showed a slight increase on number of leaves in trial 1 and the effect was almost absent in trial 2. The increase in trial 1 was because of slightly higher nitrogen content in trial 1. The abundance of carnation leaves coupled with a lower content in nitrogen somehow made the effect of bioslurry nitrogen undetectable in trial 2. However this may be controlled environmental factors such as temperature (Islam *et al.,* 2010). The difference between the maximum and minimum temperature increased during trial 2(Table 2). The addition of bioslurry did not affect the plant height in trial 1 as opposed to trial 2 where a slight effect was recorded throughout and a significant effect at 75 days after pinching. The application of bioslurry increased the leaf area as observed in trial 1. However, it was not observed in trial 2. This is because of nitrogen which widely influences the growth of leaves. This increase observed on different parameters may be due to the nutrients that were supplied particularly phosphorus which was higher in bioslurry applied in trial 2. In addition, this period coincided with higher LAI and Leaf area. Phosphate compounds act as an energy currency in plants, and play an important role in photosynthesis and the metabolism of carbohydrates; they are also stored for subsequent growth (Islam *et al*., 2010). The absence of bioslurry effect on leaf area observed in trial 2 is probably because of the increase of number of leaves. This large number of leaves shared the small amount of nutrients, leading to insignificant effect due to increased carnations leaf area. This is not in line with results reported on carrot by Jeptoo *et al.* (2013) who concluded that higher plant heights and leaf numbers obtained in their study could also be attributed to better levels of major nutrients (N, P, and K) in the bio-slurry manure. However, some positive effects recorded on growth parameters of carnations in this study can be attributed to improved nutrients uptake following bioslurry application. Results reported by Shahbaz *et al.* (2014) proved that the application of bioslurry improved the nutrients use efficiency on okra. This was also observed by Islam *et al.* (2010) who reported that increasing the level of slurry nitrogen presumably increased the availability of soil nitrogen, and that of other macro and micronutrients, which might have enhanced meristematic growth.

Application of bioslurry did not significantly influence the stomatal conductance probably because of equal supply of water. In the first experiment, the addition of bioslurry increased the stomatal conductance and reached the peak at 90 days after pinching while the control reached its peak 105 days after pinching. This suggests that nutrients added by bioslurry application positively affected the stomatal conductance. This was confirmed in trial 2 when the application of 0.5L m^{-2} resulted in peak stomatal conductance at 75 days after pinching and maintained it at that level. However, other levels dropped their stomatal conductance levels possibly due to the large number of leaves which lead to competition for light. The effect of easiness of absorption and dilution was observed in the first trial as the level 0.125L m^{-2}started with a higher stomatal conductance level while 0.25 and 0.5 L m^{-2} had a somehow equal stomatal conductance.

Bioslurry application did not affect the 50% flower bud opening and flowering duration as all treatment flowered almost at the same time. These results are not in agreement with previous studies by Moghadam and Shoor (2013) on marigold and Ahmed *et al.* (2004) on *Dahlia* who reported a reduction of number of days to flower bud opening when inorganic fertilizers where supplemented with organic fertilizers. They suspected that the nutrient supply was not optimum which delayed vegetative growth and also flowering. The absence of effect is probably that the supply of nutrients was optimized in all treatments.

5.1.2 Effect of bioslurry on yield, flower quality and vase life of carnation

The application of bioslurry had opposite trends in affecting the flower stem length in the two trials. This can be attributed to the fact that the application of bioslurry recorded a very slight increase of number of stems per plant in the first trial as opposed to the second. This implies that the allocated dry matter was somehow shared by many stems in the second trial leading to a decrease in stem length as opposed to the first trial. However it was noted that application of bioslurry improved the flower head size of carnation although it was only significant in trial 2. This is probably due to increased supply of phosphorus in the second trial. In fact, phosphorus in cowdung slurry and poultry manure slurry is released in higher amount compared to their original state (Haque *et al.,* 2015). According to Islam *et al.* (2010), phosphate compounds act as an energy currency in plants, play an important role in photosynthesis and the metabolism of carbohydrates; they are also stored for subsequent growth and reproductive processes therefore directed to flowers. This is probably the reason for the increase of flower head size. It has also been reported by Zubair and Wazir (2007) that phosphorus significantly improved all floral characters in gladiolus. The other probable reason is the efficiency in uptake of nutrients in reproductive organs as previously revealed by Shahbaz *et al.* (2014) in Okra. This efficiency in uptake of nutrients is a result of the application of bioslurry as organic amendment along with inorganic fertilizers which could be attributed to improvement in soil and water conservation, increase microbial population, buffering capacity, exchange capacity of the soil (Muhmood *et al.,* 2014; Ahmad *et al.,* 2014).

Application of bioslurry also slightly increased the number of flower stems per m^2 as compared to control. This increase however, affected the stem weight as the increased number of stems reduced the weight per stem. This is probably because the application of bioslurry adds more nutrients during early days when shoots are forming and they compete for the nutrients supplied by the inorganic fertilizer through fertigation. This justifies why stems in the control had more weight than those where bioslurry was applied (Figure 30).

Bioslurry application also reduced the vase life, even though there was no significant difference. This is would may be interpreted as the effect of bigger flower size which is a heavy sink during vase life. Therefore the bigger the size the shorter the vase life as they deplete the dry matter quickly. The weight of stems coupled with the flower head size played a significant role in reducing the vase life as they act as heavy sinks during vase life and the deplete stored reserves faster. The other possibility is that the increased nitrogen reduces the vase life as previously revealed on tuberose (Khalaj *et al.*, 2012) and Sandersonia (Clark and Burge, 1999). It has been revealed by Shahbaz *et al.* (2014) the application of organic fertilizers improves nutrient uptake particularly nitrogen. This was also reported by Islam *et al.* (2010) who observed that increasing the level of slurry nitrogen presumably increased the availability of soil nitrogen.

5.2. Effect of plant biostimulant Hicure®

5.2.1. Effect of plant biostimulant Hicure® on growth and development of carnations

The application of Hicure had mixed effects on growth parameters such as number of shoots, stem diameter and leaf area during growth stages of development. However no significant response was observed on plant height, number of leaves, leaf area index, stomatal conductance, flower bud opening and flowering duration. These results are different from those obtained on *Gladiolus grandflorum* (Nahed *et al.*, 2009a), *Antirrhinum majus* (Nahed *et al.*, 2009b), marigold (Ali and Hassan, 2013) showing that amino acids significantly increased vegetative growth.

Given the nature of components of the plant biostimulant Hicure®, which are mainly glycine and proline, it can be suspected that soil drenching did not favour their rapid uptake and use and therefore resulted in insignificant effect on growth. A study on wheat confirmed the preferences of plants to uptake inorganic nitrogen over organic nitrogen (Gioseffi *et al.*, 2012). Several studies have shown that amino acids can be taken up by plants, however many of them were conducted on foliar application of amino acids. This would imply that there was a reduced uptake of the biostimulant possibly because of the optimum supply of nutrients, the influence of soil buffer capacity in regulating the uptake of nutrients and the regulation of nitrogen uptake by the plant itself. The latter has been shown in a study by Gioseffi *et al.* (2012) on wheat where the co-provision of 1mµ glycine and 3mMNO^{-3} resulted in a down-regulation of NO^{-3} uptake while that of glycine was unaffected. In this study, glycine uptake was not down-regulated in the presence of NO^{-3}, and it was concluded that plants may be able to maintain a similar total nitrogen uptake (Gioseffi *et al.*, 2012). This therefore may justify the absence of significant difference observed in both trials for several parameters. This may be emphasized by the fact that the source of nitrogen used during the study included ammonium. Ammonium has been reported to down regulate amino acids (Henry and Jefferies, 2003 cited by Gioseffi *et al.,* 2012; Thornton and Robinson, 2005 cited by Gioseffi *et al.,* 2012).

The other probable reasons are may be the rate and frequency of application of plant biostimulant in this study. For instance a study on roses showed an effect when amino acids were applied weekly for 5 months (Di Benedetto *et al.,* 2006). However, this may be speculative as the fate of amino acids base biostimulant has not been explored under several soil conditions.

5.2.2. Effect of plant biostimulant Hicure® on yield, flower quality and vase life of carnations

As observed on growth parameters, the application of plant biostimulant did not show results with similar trends in the two trials. For instance it recorded the highest number of stems and heavier stem in trial 1 and not in trial 2. It also recorded significantly increased flower head diameter in trial 1 and not in trial 2. This would imply that the effect of biostimulant is not observed in all growing conditions. It may be possible that prevailing climatic conditions have an effect on its uptake. Possibly as stated above, the uptake of the biostimulant, the regulatory mechanisms of soil and plant and the optimum supply of nutrients through fertigation may have led to the absence of the effect. The only uniform trend observed was on vase life as the application of Hicure significantly reduced the vase life. This may be considered to be a result of increased nitrogen as it has been previously reported on tuberose (Khalaj *et al*., 2012) and on *Sandersonia* (Clark and Burge, 1999).

5.3. Effects of the interaction of bioslurry and plant biostimulant Hicure®

5.3.1. Effects of the interaction of bioslurry and plant biostimulant Hicure® on growth and development of carnations

During growth and development, some significant interactions were observed on the stem diameter, number of shoots, leaf area and leaf area index in early days after pinching. This was a result of synergy between the bioslurry and the plant biostimulant. This interaction was probably because of the action of bioslurry in improving the uptake of nitrogen from the biostimulant or the action of biostimulant in facilitating the transport of nutrients. This was confirmed by

Shahbaz *et al.* (2014) on okra and Islam *et al.* (2010) who reported that the addition of bioslurry improved the availability and the efficiency of other soil nutrients.

The absence of effects on other growth and development parameters was probably because of reasons stated in above paragraphs such as the control mechanisms by the soil and the plant itself, the timing of application, frequency and rates. Moreover, the mode of application which was used may not have favoured the uptake.

5.3.2. Effects of the interaction of bioslurry and plant biostimulant Hicure® on yield, flower quality and vase life of carnation

The interactive effect of bioslurry rates and plant biostimulant rates was mainly observed on flower stem length and on flower head height. The fact that biostimulant has a nutrient chelating effect, improves nutrient transport; and the role of bioslurry in improving the uptake of nutrients may have played a big role. The fact that the significant effect was observed in trial 2 suggests that there was a synergy of bioslurry and plant biostimulant in efficiently improving the uptake of phosphorus which improves floral characters. This is not in accordance with findings of Van Dyke *et al.* (2009) who reported that phosphorus uptake was not influenced by organic acid treatments, but several other tissue nutrient levels were significantly affected; including potassium, calcium, copper, zinc, manganese and sodium. It was not clear what mechanism was responsible for these effects, but they may relate to the chelating properties of the organic acids used. Van Dyke *et al.* (2009) suspected that addition of organic acids may not have improved uptake of P because grasses are already efficient at obtaining phosphorus. This, however, emphasizes the statement that probably phosphorus was mainly important in improving the flower head size and the flower stalk. Moreover, results of a study on *Leucospermum cordifolium* revealed that treatment with greater quantities of nitrogen and amino acids resulted in increased N, P, Ca, Mg, Fe and Mn nutrient removal by the harvested flowers (Hernández *et al*., 2014).

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

This study had the main objective of contributing to the improvement of the production and quality of carnations through application of plant biostimulant and bioslurry. Based on the results the following conclusions were formulated:

(i) Bioslurry application did not significantly improve growth and yield of carnation in this study. However, application of bioslurry at the tested rates significantly improved the flower head size.

(ii) There was no significant effect of plant biostimulant Hicure® on growth and yield of carnations but rates of 2.0, 2.5 and 3.0L ha^{-1} of plant biostimulant Hicure® showed a significant increase in flower head diameter. Nevertheless, application of plant biostimulant Hicure® negatively affected the vase life.

(iii) The interaction between bioslurry and plant biostimulant Hicure® did not affect the growth and yield of carnation. However, bioslurry at 0.5L m^{-2} and plant biostimulant Hicure® at 3.0L ha^{-1} significantly increased the flower stem length and flower head diameter.

6.2. Recommendations

Upon completion of this study, the following recommendations were formulated:

a. For carnation growers

(i) Bioslurry at 0.5L m^{-2} in combination with plant biostimulant, Hicure® at 3.0L ha^{-1} can be used to enhance quality parameters such as flower stem length and flower head diameter.

b. For future research:

(i) Further studies can be conducted using foliar application of the plant biostimulant to explore whether the medium did not affect its uptake. It would be necessary to study the application of both products under lower rates of inorganic fertilizers or without fertigation;

(ii) Studies should extend over many production flushes to find out whether both bioslurry and Hicure® have residual effect;

(iii) Further studies should focus on using other forms of bioslurry: dried or composted to obtain the effect from more concentrated nutrients;

(iv) Further studies should also focus on varying the timing of application to optimize the solo and interactive effect.

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APPENDICES

Appendix 1: Raw data for stem base diameter

			Trial 1				Trial 2			
			Days after pinching							
Bioslurry	**Hicure**	**Blocks**	**30**	**45**	**60**	**75**	**30**	**45**	**60**	**75**
B0	H0	1	8.60	10.30	17.30	18.82	7.10	8.17	7.99	7.70
B0	H0	2	7.70	9.80	17.40	18.18	6.91	7.16	7.95	7.70
B0	H0	3	8.90	10.00	16.70	17.73	6.97	7.23	7.57	6.98
B0	H1	1	8.70	11.00	17.70	19.09	7.11	7.67	7.25	9.31
B0	H1	2	7.70	10.70	17.60	17.55	6.94	7.30	8.07	9.37
B0	H1	3	8.40	10.10	16.60	17.64	6.90	7.08	8.13	9.34
B0	H2	1	8.20	9.80	18.00	17.82	7.08	7.59	8.15	9.68
B0	H2	2	7.90	10.70	18.22	17.10	6.98	7.29	7.93	9.89
B0	H2	3	8.40	11.00	16.70	17.45	6.92	7.12	7.57	9.61
B0	H3	1	9.40	10.30	17.10	18.55	6.90	7.49	7.49	8.18
B0	H3	2	7.90	10.30	16.80	17.45	6.96	7.32	7.94	8.34
B0	H3	3	9.00	9.60	15.90	16.18	6.81	7.18	7.58	8.20
B1	H0	1	8.70	10.10	17.30	18.90	7.05	7.34	7.53	8.48
B1	H0	2	8.20	10.00	17.20	17.40	6.95	7.31	7.47	8.68
B1	H0	3	8.60	9.30	16.20	16.90	6.93	7.20	7.73	8.28
B1	H1	1	8.30	10.40	17.50	18.40	7.12	7.36	7.88	8.33
B1	H1	2	7.70	11.50	16.70	18.40	6.90	7.18	8.30	8.50
B1	H1	3	8.30	9.90	16.60	17.60	7.01	7.45	7.84	8.21
B1	H2	1	8.20	11.50	17.50	18.40	7.14	7.59	8.29	7.80
B1	H2	2	8.10	11.00	16.90	17.30	6.95	7.01	8.35	7.71
B1	H2	3	8.70	9.30	15.90	17.40	6.93	7.14	7.89	7.88
B1	H3	1	8.90	9.30	17.40	18.40	7.04	7.47	8.39	9.36
B1	H3	2	8.20	10.30	16.10	17.30	6.98	7.09	8.04	8.75
B1	H3	3	8.30	9.70	15.90	16.40	6.91	7.23	7.69	8.38
B2	H0	1	8.40	10.40	17.60	16.60	6.97	7.19	7.86	10.43

B2	H0	2	8.40	11.00	17.10	17.50	6.77	7.26	8.15	9.44
B2	H0	3	8.58	9.30	16.70	17.20	6.82	7.21	8.00	9.28
B2	H1	1	8.00	10.90	17.90	17.60	6.88	7.83	7.59	9.58
B2	H1	2	8.40	9.90	16.50	17.00	6.88	7.35	7.83	9.04
B2	H1	3	8.00	9.70	17.00	15.80	6.90	7.29	7.76	9.22
B2	H2	1	8.40	11.10	17.90	18.10	6.99	7.27	7.87	9.60
B2	H2	2	8.00	10.20	17.80	17.60	6.80	7.23	7.88	9.40
B2	H2	3	8.50	10.00	16.40	17.10	6.84	7.18	7.89	9.59
B2	H3	1	8.30	10.30	17.60	18.50	7.05	7.80	7.93	7.97
B2	H3	2	8.60	10.00	16.80	17.50	6.96	7.14	7.96	7.52
B2	H3	3	8.20	9.60	15.80	17.50	6.91	7.22	8.50	8.68
B3	H0	1	8.80	11.30	16.70	16.70	7.02	7.19	7.85	9.45
B3	H0	2	8.00	10.20	16.50	18.00	7.02	7.12	7.73	8.99
B3	H0	3	7.70	9.80	16.20	18.10	6.90	7.26	8.42	8.85
B3	H1	1	8.30	10.40	17.30	17.20	6.99	6.85	7.64	8.12
B3	H1	2	8.00	10.40	16.40	17.30	6.75	7.14	7.90	7.31
B3	H1	3	8.10	9.40	16.10	17.10	6.91	7.33	7.77	8.43
B3	H2	1	8.10	10.50	17.10	17.22	7.01	6.91	7.79	8.20
B3	H2	2	8.30	10.90	17.40	17.40	6.92	7.22	7.84	8.02
B3	H2	3	8.70	9.70	16.90	17.11	6.92	7.02	8.23	8.26
B3	H3	1	9.10	10.60	16.90	16.33	6.94	7.12	7.78	7.92
B3	H3	2	8.30	10.70	17.10	18.20	6.93	7.17	8.17	7.49
B3	H3	3	8.00	10.20	15.60	19.40	6.89	7.15	7.92	7.43

Appendix 2: Raw data for plant height

			Trial 1						Trial 2					
			Days after pinching											
Bioslurry	**Hicure**	**Blocks**	**0**	**30**	**45**	**60**	**75**	**90**	**0**	**30**	**45**	**60**	**75**	**90**
B0	H0	1	7.16	22.30	28.75	42.56	55.04	70.30	12.50	15.90	24.10	33.10	48.00	62.60
B0	H0	2	6.72	20.10	29.18	36.87	45.40	64.84	11.80	16.10	23.60	34.10	49.20	73.50
B0	H0	3	6.73	18.10	27.83	36.19	46.20	66.50	11.00	15.50	24.70	34.40	46.60	73.10
B0	H1	1	7.04	20.90	29.42	42.15	54.01	70.30	11.40	16.10	24.60	33.30	47.80	62.00
B0	H1	2	6.34	20.00	28.89	40.74	51.20	65.04	11.50	15.70	24.90	35.60	47.60	75.00
B0	H1	3	6.63	19.60	29.71	39.62	49.00	68.30	11.30	15.50	24.30	36.20	47.50	73.80
B0	H2	1	7.44	18.70	29.63	42.42	54.36	70.15	11.80	15.90	24.20	35.40	47.80	63.60
B0	H2	2	6.32	18.70	28.74	40.21	51.36	67.57	11.40	16.00	23.80	34.00	48.10	73.40
B0	H2	3	6.44	19.00	28.47	39.31	51.50	66.08	11.30	15.70	23.90	34.30	46.89	73.44
B0	H3	1	7.33	21.50	30.10	44.39	55.31	69.70	11.20	15.80	23.60	34.30	47.33	62.11
B0	H3	2	5.90	19.50	30.17	38.68	48.14	68.43	10.70	16.10	24.30	34.90	47.50	73.60
B0	H3	3	6.98	18.40	28.98	39.75	51.80	68.20	11.10	15.80	24.20	34.00	47.80	74.20
B1	H0	1	6.96	20.80	30.15	42.54	52.81	69.10	11.20	16.10	24.40	33.00	52.80	64.90
B1	H0	2	6.47	19.40	29.72	38.47	49.32	67.80	11.40	15.80	23.80	33.40	55.80	73.30
B1	H0	3	7.39	20.50	30.57	40.16	51.70	69.10	11.50	15.70	24.90	33.10	51.50	73.20
B1	H1	1	6.85	19.30	27.42	37.25	45.31	62.21	11.00	16.40	25.00	34.60	55.30	62.70
B1	H1	2	6.09	20.00	29.02	42.79	52.10	68.78	10.80	16.40	24.10	34.60	55.50	73.00
B1	H1	3	6.46	20.60	29.90	44.07	52.10	69.00	10.80	15.40	24.10	34.70	55.30	73.60
B1	H2	1	7.40	18.30	27.82	37.35	47.20	65.00	11.20	15.70	24.80	34.10	55.30	63.20
B1	H2	2	6.63	19.40	28.46	40.05	50.90	66.67	11.20	15.90	24.30	33.50	54.80	72.90
B1	H2	3	6.01	20.60	28.75	37.74	47.00	63.60	11.10	16.20	23.90	34.80	55.40	74.00
B1	H3	1	6.54	20.00	29.74	41.16	53.12	69.36	11.10	16.40	24.60	32.80	56.10	63.80
B1	H3	2	6.11	19.00	27.46	37.22	45.80	63.89	11.80	16.00	24.60	36.10	56.00	73.70
B1	H3	3	7.70	22.40	31.59	42.96	54.50	69.80	11.20	16.20	24.30	34.20	56.00	76.40
B2	H0	1	6.78	20.30	30.55	42.70	53.90	71.40	11.40	16.30	23.70	35.80	52.20	64.10

B2	H0	2	6.47	20.00	29.10	39.27	52.52	71.56	10.90	15.70	24.40	34.40	55.20	74.30
B2	H0	3	6.69	20.00	28.60	35.67	45.23	62.20	11.30	16.20	25.00	35.70	55.00	73.30
B2	H1	1	6.51	18.50	26.51	39.99	50.00	64.60	11.40	15.90	23.80	34.90	54.56	63.44
B2	H1	2	6.23	20.10	27.28	36.09	48.30	66.10	11.90	15.90	23.60	34.80	55.30	73.80
B2	H1	3	6.81	20.20	28.97	38.08	46.42	61.40	11.20	15.70	24.20	34.50	54.40	73.00
B2	H2	1	7.46	19.00	29.36	43.59	53.60	67.50	11.20	16.20	24.00	34.90	54.30	63.30
B2	H2	2	6.82	21.10	29.10	44.33	52.30	68.50	11.70	15.80	24.20	33.90	56.20	73.40
B2	H2	3	6.54	19.70	26.85	33.38	42.80	60.17	11.00	15.60	24.70	34.50	56.40	73.30
B2	H3	1	6.26	21.40	29.21	41.88	51.70	67.50	11.50	15.70	24.50	35.70	53.60	65.00
B2	H3	2	6.17	19.20	28.80	40.02	52.60	68.30	11.70	16.40	24.60	35.10	55.40	75.10
B2	H3	3	6.95	20.50	28.78	31.01	45.90	58.61	11.70	16.10	24.70	35.60	56.40	74.90
B3	H0	1	6.66	20.10	30.18	42.45	53.80	71.30	11.60	16.20	23.50	33.80	56.56	63.89
B3	H0	2	6.42	20.60	27.35	36.71	48.06	66.12	11.20	15.50	23.80	33.20	55.30	75.80
B3	H0	3	6.66	19.80	28.44	39.80	51.50	68.56	11.60	15.30	24.20	35.10	55.80	74.70
B3	H1	1	7.00	20.50	29.06	40.16	52.90	67.24	11.30	16.50	23.70	33.90	55.60	65.30
B3	H1	2	5.73	18.30	27.28	37.88	45.81	66.40	11.70	16.00	24.00	34.20	56.25	74.00
B3	H1	3	6.50	18.60	28.41	38.17	45.50	62.56	11.10	15.90	24.50	35.30	55.00	75.11
B3	H2	1	6.45	20.90	28.78	45.65	57.90	76.10	11.50	16.00	24.90	33.90	54.90	63.70
B3	H2	2	5.90	19.10	27.94	37.06	44.10	62.80	12.30	15.50	24.20	34.80	56.00	73.90
B3	H2	3	6.78	18.60	28.63	36.38	41.30	64.00	10.70	15.60	24.40	37.00	55.30	74.80
B3	H3	1	6.71	20.00	27.66	41.41	52.70	70.00	11.40	15.90	23.40	34.80	55.30	64.10
B3	H3	2	6.14	19.30	28.55	37.32	51.70	68.00	11.40	15.70	23.60	33.80	55.70	73.90
B3	H3	3	7.11	19.70	27.75	35.31	46.36	60.33	11.10	15.70	24.20	34.80	54.40	74.70

Appendix 3: Raw data for number of leaves

			Trial 1						Trial 2					
			Days after pinching											
Bioslurry	Hicure	Blocks	0	30	45	60	75	90	0	30	45	60	75	90
B0	H0	1	10.60	47.90	86.60	108.10	139.60	167.10	10.50	64.70	88.50	132.60	186.10	237.60
B0	H0	2	11.05	51.30	100.80	104.20	132.00	157.40	11.30	63.00	95.10	136.10	181.90	281.30
B0	H0	3	11.25	48.60	94.10	99.20	126.80	134.20	11.20	62.00	96.30	129.90	171.22	284.30
B0	H1	1	9.70	49.30	100.30	119.60	149.70	177.80	11.20	63.80	89.90	130.30	181.10	240.10
B0	H1	2	11.30	47.60	95.80	104.70	133.10	148.20	11.00	63.70	93.90	134.90	187.30	281.00
B0	H1	3	10.95	48.30	94.40	95.50	135.80	145.40	11.00	62.80	94.60	131.60	146.60	283.80
B0	H2	1	10.50	50.00	99.60	121.90	154.30	174.60	11.30	63.80	92.80	133.80	176.30	235.60
B0	H2	2	10.44	51.70	93.70	111.78	138.67	156.89	11.00	63.80	96.30	130.10	184.50	280.00
B0	H2	3	11.65	51.20	94.00	105.10	133.20	146.40	11.10	62.90	97.40	129.10	155.44	281.56
B0	H3	1	11.30	50.60	98.80	118.40	148.40	187.10	10.70	64.50	93.60	137.50	170.67	239.22
B0	H3	2	11.10	50.40	97.80	107.50	129.00	162.00	11.00	62.30	94.00	134.10	189.60	282.60
B0	H3	3	11.55	51.80	90.90	111.30	138.60	157.50	11.10	63.10	95.10	129.90	149.80	283.00
B1	H0	1	10.55	52.80	98.50	115.30	142.00	163.90	11.40	63.70	92.00	136.70	183.40	238.20
B1	H0	2	10.53	50.60	99.00	115.10	143.80	162.40	10.90	62.50	95.90	133.20	183.90	283.80
B1	H0	3	11.40	52.20	97.60	121.70	152.60	165.00	11.20	62.80	93.30	132.20	162.10	279.20
B1	H1	1	10.95	52.60	101.20	114.80	146.80	170.70	10.30	63.10	91.10	133.10	179.20	231.70
B1	H1	2	11.45	51.00	96.30	115.10	144.40	162.20	10.70	63.00	95.10	130.00	186.70	280.70
B1	H1	3	11.40	49.80	96.80	103.40	131.80	157.40	11.20	62.20	95.80	136.70	174.60	276.80
B1	H2	1	11.30	49.60	99.60	117.10	146.60	174.20	10.80	63.80	91.80	135.40	173.70	245.10
B1	H2	2	10.30	52.40	100.80	128.20	163.30	174.40	10.70	63.30	95.70	130.60	181.40	277.80
B1	H2	3	11.00	51.00	101.20	110.60	142.20	150.80	11.00	62.30	96.60	130.89	185.30	278.70
B1	H3	1	10.55	53.60	100.50	119.30	149.60	174.20	11.00	63.20	92.20	135.00	183.00	239.70
B1	H3	2	11.20	52.20	98.30	101.40	128.20	148.20	10.80	63.50	94.40	137.00	185.80	283.20
B1	H3	3	10.60	50.20	100.30	108.30	132.20	150.40	10.90	62.30	93.80	134.56	180.30	281.40
B2	H0	1	10.45	49.60	99.40	113.90	145.00	170.70	11.20	63.30	96.00	135.70	186.50	233.20

B2	H0	2	11.05	53.20	96.70	114.10	140.20	162.40	11.20	63.60	94.60	135.10	187.30	282.50
B2	H0	3	11.20	52.20	90.80	97.50	119.60	138.11	11.00	62.80	95.90	134.30	198.10	282.60
B2	H1	1	10.55	49.40	96.10	118.60	146.90	169.20	11.00	62.70	92.40	135.10	177.67	221.56
B2	H1	2	11.00	49.80	90.50	107.80	133.60	145.00	10.80	63.50	94.70	133.00	186.20	276.00
B2	H1	3	11.50	50.40	88.10	98.80	124.60	154.56	11.00	62.90	94.90	133.50	186.90	282.60
B2	H2	1	10.65	50.60	96.70	110.30	138.40	160.40	11.00	64.20	93.30	135.60	177.20	229.40
B2	H2	2	10.55	51.40	93.70	108.40	136.60	166.00	10.80	63.50	95.70	132.20	183.60	277.70
B2	H2	3	11.30	50.90	93.60	121.20	145.00	161.40	11.20	62.80	94.40	134.60	186.30	282.70
B2	H3	1	10.90	52.60	96.80	120.10	150.00	169.40	10.40	63.60	94.50	134.80	180.80	225.90
B2	H3	2	10.70	51.40	96.10	109.00	136.00	164.56	11.00	63.50	95.30	132.20	183.40	274.30
B2	H3	3	11.70	49.70	93.00	104.80	134.40	152.67	10.70	63.10	95.30	135.50	192.80	277.30
B3	H0	1	10.70	52.20	104.10	117.80	148.00	177.00	10.60	63.00	94.50	132.50	185.56	245.78
B3	H0	2	10.80	51.60	98.60	109.10	141.00	155.90	11.10	62.50	95.90	129.60	183.80	275.30
B3	H0	3	11.05	48.60	91.90	112.60	139.00	154.50	11.20	63.70	94.60	134.70	193.70	280.80
B3	H1	1	11.40	52.80	102.90	122.00	157.00	181.00	10.50	63.60	96.90	135.20	197.20	239.60
B3	H1	2	11.30	51.80	94.90	105.00	133.40	148.20	11.00	63.00	97.70	132.90	184.00	275.00
B3	H1	3	11.45	50.40	88.80	101.90	131.20	143.89	11.20	63.50	95.70	134.90	165.22	283.56
B3	H2	1	11.10	52.10	98.30	118.50	146.90	169.90	11.00	62.70	95.90	138.90	186.70	241.90
B3	H2	2	11.30	52.00	101.20	120.40	150.30	172.60	10.50	62.80	96.50	135.40	188.00	281.60
B3	H2	3	11.85	51.00	94.90	108.70	137.00	154.60	11.00	63.60	95.20	135.50	185.10	278.20
B3	H3	1	10.20	52.20	90.40	114.40	143.80	169.60	10.80	62.90	96.10	135.70	194.40	234.00
B3	H3	2	10.80	50.00	93.50	116.00	142.40	159.30	11.40	63.70	95.00	137.20	185.90	273.10
B3	H3	3	11.65	50.00	87.00	108.10	132.40	150.70	11.20	62.60	94.80	130.00	184.10	278.80

Appendix 4: Raw data for number of shoots

			Trial 1						Trial 2					
			Days after pinching											
Bioslurry	**Hicure**	**Blocks**	**Nodes**	**30**	**45**	**60**	**75**	**90**	**Nodes**	**30**	**45**	**60**	**75**	**90**
B0	H0	1	4.50	5.85	5.60	5.70	5.90	6.10	5.40	5.50	6.20	6.50	6.50	6.50
B0	H0	2	4.30	4.90	5.20	5.30	5.40	5.80	5.70	5.50	7.30	7.40	7.40	7.40
B0	H0	3	4.60	5.30	5.20	5.10	5.30	4.90	5.60	5.50	7.20	7.60	7.60	7.60
B0	H1	1	4.65	6.10	5.60	6.50	6.50	6.50	5.70	5.70	6.20	6.60	6.60	6.60
B0	H1	2	4.00	4.95	5.40	5.30	5.50	5.40	5.50	5.30	6.70	6.80	6.80	6.80
B0	H1	3	4.80	5.25	5.40	5.70	5.70	5.30	5.50	5.70	5.40	5.40	5.40	5.40
B0	H2	1	4.50	5.80	5.60	6.70	6.80	6.90	5.60	5.60	6.10	6.50	6.50	6.50
B0	H2	2	4.17	4.72	5.70	5.89	6.00	5.67	5.50	5.50	7.00	7.10	7.10	7.10
B0	H2	3	4.75	5.30	5.70	5.50	5.70	5.40	5.50	5.00	6.20	6.20	6.11	6.11
B0	H3	1	4.65	6.40	5.50	6.30	6.50	6.50	5.50	5.90	5.90	6.00	6.22	6.22
B0	H3	2	4.60	4.85	6.20	5.70	5.70	5.80	5.50	5.50	6.40	6.50	6.50	6.50
B0	H3	3	4.65	5.30	6.20	5.90	5.90	5.80	5.50	5.40	5.60	5.60	5.60	5.60
B1	H0	1	4.30	6.25	6.10	6.10	6.10	6.20	5.40	5.80	6.60	7.10	7.10	7.10
B1	H0	2	4.05	4.95	5.70	6.20	6.30	6.10	5.50	5.50	6.50	6.70	6.70	6.70
B1	H0	3	4.95	5.50	5.70	6.60	6.60	6.20	5.70	5.90	6.70	6.60	6.60	6.60
B1	H1	1	4.40	5.85	6.00	6.20	6.30	6.30	5.60	5.90	6.50	6.80	6.80	6.40
B1	H1	2	3.80	5.30	5.70	6.20	6.20	5.60	5.40	5.30	6.20	6.60	6.60	6.60
B1	H1	3	4.45	4.90	5.70	5.40	5.50	5.70	5.60	5.80	6.80	6.90	6.90	6.90
B1	H2	1	4.70	6.00	6.10	6.30	6.30	6.40	5.40	5.70	6.50	7.00	7.00	7.00
B1	H2	2	4.15	5.50	5.80	7.10	7.20	6.60	5.40	5.40	6.10	6.20	6.20	6.20
B1	H2	3	3.90	4.75	5.80	5.90	6.00	5.50	5.50	5.70	7.00	7.30	7.30	7.30
B1	H3	1	4.55	6.25	5.70	6.40	6.50	6.50	5.60	5.20	7.00	7.70	7.70	7.60
B1	H3	2	3.85	5.10	5.60	5.30	5.50	5.40	5.50	5.80	6.20	6.20	6.20	6.20
B1	H3	3	4.65	5.00	5.60	5.60	5.60	5.50	5.40	5.00	6.40	6.50	6.50	6.50
B2	H0	1	4.20	5.65	5.80	6.10	6.20	6.30	5.40	5.80	6.60	7.10	7.10	7.00

B2	H0	2	4.70	5.45	5.70	6.00	6.00	6.00	5.60	5.50	6.40	6.50	6.50	6.50
B2	H0	3	4.35	5.30	5.70	5.00	5.00	4.90	5.50	6.00	6.90	6.90	6.90	6.90
B2	H1	1	4.20	5.30	5.90	6.30	6.30	6.30	5.50	6.00	7.00	7.50	7.56	7.56
B2	H1	2	4.63	5.30	5.60	5.70	5.70	5.40	5.40	5.50	6.70	7.10	7.10	7.10
B2	H1	3	4.35	5.30	5.60	5.10	5.20	5.20	5.50	5.90	6.60	6.70	6.70	6.70
B2	H2	1	4.50	5.40	6.10	5.80	5.80	6.10	5.50	5.80	6.80	6.90	6.90	6.90
B2	H2	2	4.60	5.45	5.70	5.70	5.80	6.20	5.50	5.90	7.30	7.50	7.50	7.50
B2	H2	3	4.55	5.00	5.70	5.90	6.00	6.00	5.50	5.50	6.40	6.40	6.40	6.40
B2	H3	1	4.35	5.75	5.50	6.40	6.40	6.40	5.60	5.70	6.60	7.10	7.10	7.10
B2	H3	2	4.45	5.00	5.00	5.70	5.80	5.80	5.40	6.00	6.10	6.20	6.20	6.20
B2	H3	3	4.60	5.10	5.00	5.50	5.70	5.40	5.40	6.10	7.10	7.20	7.20	7.20
B3	H0	1	4.65	5.70	5.80	6.40	6.50	6.60	5.60	4.70	6.10	6.70	6.89	6.89
B3	H0	2	4.25	5.35	5.50	5.70	6.00	5.70	5.60	5.50	6.10	6.20	6.20	6.20
B3	H0	3	4.55	5.05	5.50	5.80	5.90	5.70	5.60	5.30	7.20	7.40	7.40	7.40
B3	H1	1	4.40	5.91	6.00	6.50	6.80	7.00	5.60	5.60	7.00	7.70	7.70	7.70
B3	H1	2	3.85	5.05	4.60	5.50	5.60	5.40	5.50	5.00	6.30	6.30	6.75	6.75
B3	H1	3	4.45	5.05	4.50	5.30	5.50	5.00	5.60	5.60	5.70	5.60	5.56	5.56
B3	H2	1	4.65	5.41	5.70	6.30	6.40	6.40	5.60	5.30	5.60	5.80	5.80	5.80
B3	H2	2	4.10	5.40	6.10	6.40	6.50	6.40	5.50	5.60	6.30	6.30	6.30	6.30
B3	H2	3	4.50	5.10	6.10	5.70	5.80	5.70	5.50	5.80	7.00	7.20	7.20	7.20
B3	H3	1	4.35	5.40	5.50	6.10	6.20	6.10	5.60	5.30	7.10	7.80	7.80	7.90
B3	H3	2	4.20	5.35	5.50	5.90	6.00	5.70	5.70	5.40	6.70	6.90	6.90	6.90
B3	H3	3	4.80	5.00	5.50	5.70	5.80	5.50	5.60	5.20	7.00	7.20	7.20	7.20

Appendix 5: Raw data for leaf area

			Trial 1					Trial 2				
			Days after pinching									
Bioslurry	**Hicure**	**Blocks**	**30**	**45**	**60**	**75**	**90**	**30**	**45**	**60**	**75**	**90**
B0	H0	1	5.34	10.41	14.64	15.90	15.90	6.06	7.09	7.49	7.57	7.57
B0	H0	2	5.61	10.57	12.86	15.82	15.82	6.31	7.09	7.09	7.41	7.41
B0	H0	3	5.86	10.66	12.26	15.29	15.29	5.71	6.84	7.25	8.27	8.27
B0	H1	1	6.68	11.65	13.29	15.97	15.97	6.51	7.48	7.19	8.07	8.07
B0	H1	2	6.94	12.05	11.88	14.65	14.65	5.12	5.79	5.89	6.54	6.54
B0	H1	3	6.28	12.54	12.40	14.10	14.10	5.42	6.96	7.29	8.15	8.15
B0	H2	1	6.44	11.80	11.36	15.14	15.14	6.48	7.93	8.93	9.61	9.61
B0	H2	2	6.49	12.30	12.05	15.31	15.31	4.90	6.07	6.32	8.24	8.24
B0	H2	3	6.24	9.59	11.04	14.72	14.72	5.56	7.14	7.57	8.19	8.19
B0	H3	1	6.20	10.32	14.83	15.81	15.81	6.60	7.68	8.22	8.35	8.35
B0	H3	2	6.21	9.28	12.00	15.38	15.38	6.32	7.02	7.64	7.79	7.79
B0	H3	3	6.29	8.33	12.16	14.64	14.64	5.54	6.63	6.95	8.90	8.90
B1	H0	1	5.94	11.25	12.80	15.83	15.83	4.91	6.22	6.44	7.67	7.67
B1	H0	2	6.00	10.61	12.24	15.01	15.01	5.73	6.82	7.37	7.85	7.85
B1	H0	3	6.81	9.42	11.60	14.11	14.11	4.79	6.21	6.65	8.20	8.20
B1	H1	1	6.19	11.50	12.49	15.77	15.77	6.06	7.33	7.91	8.45	8.45
B1	H1	2	6.55	9.93	13.11	15.47	15.47	6.29	7.31	7.62	8.71	8.71
B1	H1	3	6.33	9.34	13.32	14.88	14.88	4.36	5.75	6.25	7.55	7.55
B1	H2	1	6.25	10.51	13.58	15.52	15.52	6.37	7.14	8.51	8.85	8.85
B1	H2	2	7.30	11.42	12.78	15.15	15.15	6.25	7.25	7.69	9.30	9.30
B1	H2	3	6.88	9.46	13.25	14.32	14.32	5.21	6.86	6.78	7.59	7.59
B1	H3	1	6.04	10.83	13.57	14.63	14.63	5.92	7.15	7.76	8.25	8.25
B1	H3	2	6.30	10.13	13.24	14.80	14.80	5.44	6.42	6.93	8.35	8.35
B1	H3	3	6.17	11.02	12.52	14.79	14.79	5.69	7.64	8.05	9.04	9.04
B2	H0	1	6.42	10.49	13.55	15.52	15.52	6.46	7.37	8.19	8.35	8.35
B2	H0	2	5.97	11.30	13.57	16.18	16.18	6.09	7.09	7.53	7.78	7.78
B2	H0	3	6.24	11.25	12.87	13.90	13.90	5.00	6.34	6.68	6.82	6.96

B2	H1	1	6.27	10.41	14.66	15.04	15.04	6.32	7.31	7.72	7.87	7.87
B2	H1	2	6.41	10.42	13.37	15.14	15.14	6.74	7.56	8.42	8.99	8.99
B2	H1	3	6.52	10.87	12.98	14.96	14.96	5.87	7.28	7.37	7.88	7.88
B2	H2	1	6.19	10.58	14.13	16.36	16.36	5.02	6.47	6.96	8.12	8.12
B2	H2	2	6.07	10.57	12.04	14.60	14.60	6.29	6.76	7.57	9.36	9.63
B2	H2	3	6.25	11.04	11.30	15.42	15.42	5.90	6.91	7.28	8.05	8.05
B2	H3	1	6.17	10.38	13.70	14.71	14.71	5.77	6.80	7.21	7.96	7.96
B2	H3	2	6.71	9.68	12.97	14.64	14.64	5.49	6.61	7.17	7.33	8.58
B2	H3	3	6.48	10.80	11.70	14.45	14.45	5.38	6.49	7.05	7.53	7.53
B3	H0	1	6.04	9.53	12.80	15.02	15.02	6.46	7.45	8.34	8.50	8.50
B3	H0	2	6.23	11.42	13.10	14.56	14.56	5.57	6.67	7.07	7.13	7.13
B3	H0	3	5.54	11.06	11.88	13.84	13.84	4.89	6.12	6.90	7.83	7.83
B3	H1	1	6.05	10.10	13.64	15.44	15.44	5.92	7.48	8.23	9.62	9.62
B3	H1	2	6.72	11.54	10.85	15.35	15.35	5.56	6.42	6.89	8.65	8.78
B3	H1	3	6.26	10.08	11.39	14.56	14.56	5.71	7.49	7.91	7.95	7.95
B3	H2	1	6.34	10.96	12.14	15.19	15.19	6.56	7.78	9.21	9.22	9.22
B3	H2	2	6.28	10.67	12.13	14.76	14.76	5.50	5.67	6.45	9.30	9.30
B3	H2	3	6.53	10.69	12.04	15.45	15.45	5.28	6.70	7.14	7.32	7.46
B3	H3	1	5.65	9.87	13.23	15.54	15.54	5.41	6.54	7.05	7.92	7.92
B3	H3	2	6.41	10.58	13.35	15.02	15.02	5.87	6.63	6.71	9.89	9.89
B3	H3	3	5.68	10.94	11.92	15.23	15.23	6.29	7.86	8.14	8.30	8.30

Appendix 6: Raw data for leaf area index

			Trial 1					Trial 2				
			Days after pinching									
Bioslurry	**Hicure**	**Blocks**	**30**	**45**	**60**	**75**	**90**	**30**	**45**	**60**	**75**	**90**
B0	H0	1	0.92	3.25	5.70	7.99	9.57	1.41	2.26	3.58	5.07	6.48
B0	H0	2	1.04	3.84	4.82	7.52	8.96	1.43	2.43	3.47	4.85	7.50
B0	H0	3	1.03	3.61	4.38	6.98	7.38	1.27	2.37	3.39	5.10	8.46
B0	H1	1	1.19	4.21	5.72	8.61	10.22	1.50	2.42	3.37	5.26	6.97
B0	H1	2	1.19	4.16	4.48	7.02	7.82	1.17	1.96	2.86	4.41	6.61
B0	H1	3	1.09	4.26	4.26	6.89	7.38	1.22	2.37	3.45	4.30	8.33
B0	H2	1	1.16	4.23	4.99	8.41	9.52	1.49	2.65	4.30	6.10	8.15
B0	H2	2	1.21	4.15	4.85	7.64	8.65	1.12	2.10	2.96	5.47	8.30
B0	H2	3	1.15	3.24	4.18	7.06	7.76	1.26	2.50	3.52	4.58	8.30
B0	H3	1	1.13	3.67	6.32	8.44	10.65	1.53	2.59	4.07	5.13	7.19
B0	H3	2	1.13	3.27	4.65	7.14	8.97	1.42	2.37	3.69	5.31	7.92
B0	H3	3	1.17	2.73	4.87	7.31	8.30	1.26	2.27	3.25	4.80	9.07
B1	H0	1	1.13	3.99	5.31	8.09	9.34	1.13	2.06	3.17	5.06	6.57
B1	H0	2	1.09	3.78	5.07	7.77	8.78	1.29	2.36	3.53	5.20	8.02
B1	H0	3	1.28	3.31	5.08	7.75	8.38	1.08	2.09	3.17	4.78	8.24
B1	H1	1	1.17	4.19	5.16	8.33	9.69	1.38	2.40	3.79	5.45	7.05
B1	H1	2	1.20	3.44	5.43	8.04	9.03	1.43	2.50	3.57	5.86	8.81
B1	H1	3	1.14	3.26	4.96	7.06	8.43	0.98	1.98	3.07	4.74	7.52
B1	H2	1	1.12	3.77	5.73	8.19	9.73	1.46	2.36	4.15	5.53	7.81
B1	H2	2	1.38	4.14	5.90	8.90	9.51	1.42	2.50	3.62	6.08	9.30
B1	H2	3	1.26	3.45	5.28	7.33	7.77	1.17	2.38	3.19	5.07	7.62
B1	H3	1	1.17	3.92	5.83	7.88	9.18	1.35	2.37	3.77	5.43	7.12
B1	H3	2	1.18	3.58	4.83	6.83	7.90	1.24	2.18	3.42	5.59	8.51
B1	H3	3	1.12	3.98	4.88	7.04	8.01	1.28	2.58	3.90	5.87	9.15
B2	H0	1	1.15	3.75	5.56	8.10	9.54	1.47	2.55	4.00	5.61	7.01
B2	H0	2	1.14	3.93	5.57	8.17	9.46	1.39	2.41	3.66	5.25	7.91
B2	H0	3	1.17	3.68	4.52	5.98	6.91	1.13	2.19	3.23	4.87	7.08

B2	H1	1	1.12	3.60	6.26	7.95	9.16	1.43	2.43	3.75	5.04	6.28
B2	H1	2	1.15	3.40	5.19	7.28	7.90	1.54	2.58	4.03	6.03	8.93
B2	H1	3	1.18	3.45	4.62	6.71	8.32	1.33	2.49	3.54	5.30	8.02
B2	H2	1	1.13	3.68	5.61	8.15	9.45	1.16	2.17	3.40	5.18	6.71
B2	H2	2	1.12	3.57	4.70	7.18	8.72	1.44	2.33	3.60	6.18	9.62
B2	H2	3	1.15	3.72	4.93	8.05	8.96	1.33	2.35	3.53	5.40	8.19
B2	H3	1	1.17	3.62	5.93	7.94	8.97	1.32	2.31	3.50	5.18	6.47
B2	H3	2	1.24	3.35	5.09	7.17	8.67	1.25	2.27	3.41	4.84	8.47
B2	H3	3	1.16	3.62	4.41	6.99	7.94	1.22	2.23	3.44	5.23	7.52
B3	H0	1	1.13	3.57	5.43	8.00	9.57	1.46	2.53	3.98	5.68	7.52
B3	H0	2	1.16	4.05	5.14	7.39	8.17	1.25	2.30	3.30	4.71	7.06
B3	H0	3	0.97	3.66	4.82	6.93	7.70	1.12	2.08	3.35	5.46	7.92
B3	H1	1	1.15	3.74	5.99	8.73	10.06	1.35	2.61	4.01	6.83	8.30
B3	H1	2	1.25	3.94	4.10	7.37	8.19	1.26	2.26	3.29	5.73	8.70
B3	H1	3	1.14	3.22	4.18	6.88	7.54	1.30	2.58	3.84	4.73	8.12
B3	H2	1	1.19	3.88	5.18	8.03	9.29	1.48	2.69	4.60	6.20	8.03
B3	H2	2	1.18	3.89	5.26	7.98	9.17	1.24	1.97	3.15	6.29	9.43
B3	H2	3	1.20	3.65	4.71	7.62	8.60	1.21	2.30	3.48	4.88	7.47
B3	H3	1	1.06	3.21	5.45	8.04	9.49	1.23	2.26	3.44	5.54	6.67
B3	H3	2	1.15	3.56	5.57	7.70	8.61	1.35	2.27	3.31	6.62	9.73
B3	H3	3	1.02	3.43	4.64	7.26	8.26	1.42	2.68	3.81	5.50	8.33

Appendix 7: Raw data for stomatal conductance

			Trial 1				Trial 2			
			Days after pinching							
Bioslurry	**Hicure**	**Blocks**	**60**	**75**	**90**	**105**	**60**	**75**	**90**	**105**
B0	H0	1	27.86	52.05	53.48	56.30	45.84	38.75	49.70	35.59
B0	H0	2	18.74	45.44	56.16	69.80	65.79	59.52	58.83	51.20
B0	H0	3	24.48	42.98	51.54	57.47	50.22	42.06	48.71	49.23
B0	H1	1	37.28	73.07	59.78	61.16	59.59	54.92	50.02	41.96
B0	H1	2	37.72	45.56	54.53	66.39	58.23	74.55	63.00	56.79
B0	H1	3	31.92	45.73	51.78	56.41	47.66	35.14	54.13	44.12
B0	H2	1	35.84	53.49	66.54	68.03	48.51	58.87	52.86	40.75
B0	H2	2	28.88	41.16	56.08	68.52	53.08	62.16	42.91	59.16
B0	H2	3	21.98	50.66	59.87	56.09	38.64	36.24	52.51	41.42
B0	H3	1	19.82	58.38	56.60	64.02	33.45	41.15	51.98	45.99
B0	H3	2	47.47	42.33	70.89	61.18	55.71	54.28	60.19	70.76
B0	H3	3	34.93	53.82	59.50	48.17	34.15	36.57	44.33	42.25
B1	H0	1	47.58	79.11	59.71	67.59	71.93	47.39	40.29	54.00
B1	H0	2	45.40	49.88	61.33	59.25	45.64	52.28	57.07	52.04
B1	H0	3	43.22	49.41	40.99	40.14	35.68	34.75	56.19	50.23
B1	H1	1	46.40	64.55	67.66	61.55	63.69	49.79	39.64	55.79
B1	H1	2	33.70	40.82	64.51	56.19	50.77	55.31	66.21	57.87
B1	H1	3	35.58	47.79	64.21	53.71	36.88	33.50	53.56	55.19
B1	H2	1	56.42	61.03	63.56	66.35	50.45	49.16	37.34	49.23
B1	H2	2	40.52	40.04	66.30	52.31	48.94	60.11	67.37	62.98
B1	H2	3	27.43	62.05	54.79	55.31	46.58	32.22	60.05	43.03
B1	H3	1	45.20	62.96	74.85	69.01	55.41	45.81	39.33	46.25
B1	H3	2	63.55	55.41	53.23	55.68	50.28	46.63	73.18	56.28
B1	H3	3	42.57	72.48	66.02	71.25	47.35	44.61	60.13	40.47
B2	H0	1	58.77	58.89	74.49	48.57	35.76	35.38	50.00	46.59
B2	H0	2	45.63	55.97	63.03	59.56	66.21	57.71	70.32	33.49
B2	H0	3	23.13	44.47	68.46	67.90	54.04	48.80	50.81	53.16

B2	H1	1	58.08	70.08	64.15	55.17	37.59	43.13	50.08	57.05
B2	H1	2	23.57	38.67	75.56	64.27	63.55	46.72	67.09	39.37
B2	H1	3	26.37	49.84	61.25	63.09	40.49	36.86	32.63	42.17
B2	H2	1	31.15	53.86	67.11	61.50	45.25	40.72	39.82	40.06
B2	H2	2	36.62	49.82	58.75	41.96	49.83	61.42	47.45	37.75
B2	H2	3	22.58	53.66	73.47	48.65	41.48	36.96	38.58	44.52
B2	H3	1	56.77	71.31	60.84	55.77	41.27	43.90	51.15	50.92
B2	H3	2	26.97	44.79	73.02	61.39	57.19	48.91	54.86	40.27
B2	H3	3	20.93	32.18	51.62	60.88	50.57	51.32	44.21	52.37
B3	H0	1	58.20	64.69	76.35	54.66	42.07	62.40	48.46	50.30
B3	H0	2	18.70	55.38	58.52	52.93	57.21	58.64	57.24	59.37
B3	H0	3	23.05	57.66	59.29	62.76	41.58	54.10	52.74	57.96
B3	H1	1	51.23	46.03	65.25	51.69	47.83	49.33	47.62	38.58
B3	H1	2	42.73	46.34	65.37	64.73	60.60	51.79	52.96	62.67
B3	H1	3	20.38	49.49	53.01	50.20	35.53	45.01	46.71	48.99
B3	H2	1	56.78	61.85	83.81	65.56	41.96	50.27	52.71	46.44
B3	H2	2	35.37	41.99	65.24	58.25	58.32	52.73	54.13	45.63
B3	H2	3	25.82	43.75	68.05	51.51	47.93	55.62	58.54	49.12
B3	H3	1	56.47	56.29	76.24	70.33	35.43	43.69	56.06	57.67
B3	H3	2	25.85	41.04	66.61	62.17	71.00	57.79	58.67	48.88
B3	H3	3	29.05	47.62	56.35	68.63	45.22	51.58	40.63	49.99

Appendix 8: Raw data for flowering parameters

			Trial 1		Trial 2	
Bioslurry	**Hicure**	**Blocks**	**Flower bud opening**	**Duration of flowering**	**Flower bud opening**	**Duration of flowering**
B0	H0	1	149	67	149	63
B0	H0	2	151	56	146	56
B0	H0	3	149	54	148	68
B0	H1	1	149	67	148	65
B0	H1	2	145	57	148	70
B0	H1	3	144	47	147	62
B0	H2	1	145	49	148	62
B0	H2	2	149	66	148	58
B0	H2	3	145	60	147	62
B0	H3	1	144	51	147	71
B0	H3	2	146	49	148	62
B0	H3	3	149	56	149	70
B1	H0	1	149	67	148	64
B1	H0	2	146	50	147	63
B1	H0	3	149	63	147	63
B1	H1	1	154	60	148	58
B1	H1	2	145	64	150	66
B1	H1	3	146	52	148	71
B1	H2	1	151	65	146	70
B1	H2	2	145	57	147	63
B1	H2	3	151	45	146	68
B1	H3	1	146	72	148	63
B1	H3	2	150	48	152	62
B1	H3	3	151	55	146	72
B2	H0	1	146	60	147	72
B2	H0	2	145	55	146	70

B2	H0	3	145	63	147	73
B2	H1	1	149	60	148	61
B2	H1	2	151	47	144	62
B2	H1	3	149	46	149	62
B2	H2	1	146	52	148	72
B2	H2	2	151	61	144	71
B2	H2	3	151	60	148	62
B2	H3	1	151	51	148	62
B2	H3	2	149	54	148	62
B2	H3	3	146	60	152	68
B3	H0	1	145	44	148	62
B3	H0	2	145	45	148	62
B3	H0	3	145	67	147	57
B3	H1	1	145	56	147	69
B3	H1	2	149	66	152	62
B3	H1	3	154	56	148	62
B3	H2	1	146	54	150	62
B3	H2	2	158	58	147	67
B3	H2	3	146	61	144	72
B3	H3	1	146	58	149	60
B3	H3	2	144	54	146	62
B3	H3	3	154	55	149	60

Appendix 9: Raw data for Flower quality parameters

			Trial 1				Trial 2			
Bioslurry	Hicure	Blocks	Stem Length (cm)	Stem Diameter (mm)	Head Diameter (mm)	Head Height (mm)	Stem Length (cm)	Stem Diameter (mm)	Head Diameter (mm)	Head Height (mm)
B0	H0	1	66.16	5.89	21.74	39.19	69.10	5.26	20.94	40.13
B0	H0	2	65.31	5.75	21.74	39.35	69.65	5.43	21.29	40.02
B0	H0	3	64.44	5.72	21.41	39.49	69.50	5.29	21.44	40.48
B0	H1	1	65.03	5.85	22.47	39.17	68.43	5.13	20.75	39.62
B0	H1	2	66.15	5.70	22.34	39.53	71.24	5.40	20.64	40.47
B0	H1	3	64.43	5.74	21.94	39.62	69.89	5.37	20.96	40.61
B0	H2	1	64.60	5.79	22.71	39.60	68.66	5.17	20.88	40.63
B0	H2	2	63.95	5.75	21.88	39.03	69.75	5.21	21.32	40.25
B0	H2	3	66.21	5.78	22.24	39.58	71.44	5.42	21.40	40.73
B0	H3	1	66.28	5.78	22.53	38.98	68.44	5.22	20.86	39.93
B0	H3	2	66.00	5.76	22.37	39.48	69.67	5.42	21.48	40.78
B0	H3	3	62.69	5.85	22.48	39.63	69.84	5.30	21.10	40.36
B1	H0	1	68.11	5.85	22.13	39.59	69.29	5.30	21.54	41.07
B1	H0	2	65.10	5.74	22.52	39.61	70.23	5.39	21.80	41.22
B1	H0	3	66.46	5.78	22.30	39.53	70.44	5.51	21.60	40.74
B1	H1	1	66.24	5.73	22.37	39.37	68.45	5.39	21.55	40.81
B1	H1	2	64.17	5.72	22.51	39.97	68.30	5.35	21.83	41.54
B1	H1	3	65.30	5.77	22.25	39.63	69.46	5.26	21.45	40.71
B1	H2	1	66.94	5.78	22.38	39.33	69.65	5.24	21.40	40.84
B1	H2	2	63.05	5.75	22.46	39.66	70.44	5.36	21.57	41.01
B1	H2	3	65.85	5.81	22.39	39.47	69.84	5.49	21.80	40.83
B1	H3	1	66.26	5.76	22.37	39.33	69.11	5.26	21.67	40.66
B1	H3	2	66.13	5.68	22.32	39.30	69.00	5.25	21.90	41.01
B1	H3	3	67.40	5.76	22.58	39.41	70.60	5.47	21.99	41.01

B2	H0	1	65.73	5.79	22.37	39.50	69.11	5.37	21.70	40.75
B2	H0	2	67.56	5.80	22.42	39.61	70.60	5.45	21.36	41.01
B2	H0	3	65.29	5.79	21.84	39.55	69.60	5.46	22.05	40.89
B2	H1	1	67.89	5.70	22.14	39.57	69.18	5.05	21.37	41.27
B2	H1	2	67.24	5.78	22.39	39.34	70.43	5.49	22.07	41.07
B2	H1	3	61.77	5.81	22.31	39.90	68.54	5.13	21.68	41.11
B2	H2	1	63.21	5.74	22.29	39.42	69.18	5.34	21.92	40.67
B2	H2	2	67.51	5.85	22.33	39.58	70.38	5.43	21.90	41.16
B2	H2	3	66.17	5.77	22.55	39.39	68.62	5.34	22.18	41.04
B2	H3	1	65.46	5.79	22.52	39.52	69.83	5.20	21.63	40.89
B2	H3	2	67.16	5.70	22.06	39.52	69.03	5.39	21.96	40.77
B2	H3	3	62.48	5.71	22.24	39.65	69.94	5.22	21.85	41.03
B3	H0	1	67.10	5.79	22.30	39.45	69.18	5.36	21.72	40.72
B3	H0	2	65.73	5.72	22.42	39.81	69.03	5.32	21.69	40.60
B3	H0	3	65.85	5.79	22.24	39.19	69.55	5.17	21.94	40.76
B3	H1	1	66.53	5.69	22.43	39.33	69.50	5.25	21.82	41.47
B3	H1	2	64.46	5.77	22.37	39.59	70.19	5.43	22.31	41.27
B3	H1	3	64.85	5.77	22.28	39.79	70.14	5.32	22.17	41.32
B3	H2	1	68.35	5.79	22.38	39.58	67.97	5.28	21.58	40.62
B3	H2	2	66.53	5.75	22.43	39.44	67.36	5.03	22.58	38.89
B3	H2	3	62.77	5.82	21.61	38.19	69.03	5.36	21.56	40.70
B3	H3	1	66.31	5.72	22.36	39.59	70.54	5.32	21.55	41.16
B3	H3	2	66.03	5.84	22.40	39.59	70.85	5.29	21.90	41.36
B3	H3	3	65.42	5.78	22.57	39.54	70.21	5.48	21.92	41.67

Appendix 10: Raw data for Yield and postharvest parameters

			Trial 1				Trial 2			
Bioslurry	Hicure	Blocks	Stems yield/plant	Stems yield /m^2	Weight	Vase Life	Stems yield/plant	Stems yield /m^2	Weight	Vase Life
B0	H0	1	5.70	205.20	44.20	22	6.29	226.29	36.33	17.0
B0	H0	2	6.44	232.00	36.86	21	6.86	246.86	35.38	16.3
B0	H0	3	4.30	154.80	32.83	22	7.22	260.00	28.1	17.0
B0	H1	1	6.40	230.40	45.60	15	6.50	234.00	32.88	16.3
B0	H1	2	4.80	172.80	36.00	21	6.67	240.00	34.60	15.3
B0	H1	3	4.70	169.20	43.00	19	5.40	194.40	33.2	16.3
B0	H2	1	6.50	234.00	40.20	15	6.43	231.43	30.25	16.0
B0	H2	2	6.20	223.20	37.78	22	6.88	247.50	33.63	16.3
B0	H2	3	4.70	169.20	36.60	19	6.11	220.00	32.8	15.7
B0	H3	1	6.10	219.60	41.83	17	6.29	226.29	29.86	16.7
B0	H3	2	5.50	198.00	37.50	19	6.29	226.29	29.57	15.0
B0	H3	3	6.10	219.60	38.60	21	5.60	201.60	32.9	14.7
B1	H0	1	6.40	230.40	38.80	21	6.20	223.20	35.20	17.0
B1	H0	2	5.90	212.40	33.00	22	6.70	241.20	35.71	16.0
B1	H0	3	4.90	176.40	39.17	19	6.60	237.60	31.9	15.0
B1	H1	1	6.00	216.00	40.00	19	6.29	226.29	37.00	15.7
B1	H1	2	6.00	216.00	40.00	17	5.83	210.00	29.38	16.0
B1	H1	3	4.70	169.20	38.20	15	6.90	248.40	30.8	14.3
B1	H2	1	5.90	212.40	38.86	19	6.63	238.50	31.14	16.0
B1	H2	2	5.70	205.20	37.00	17	6.20	223.20	31.00	15.3
B1	H2	3	5.20	187.20	44.83	18	7.30	262.80	28.6	13.7
B1	H3	1	6.70	241.20	38.00	19	7.14	257.14	33.71	16.3
B1	H3	2	5.70	205.20	37.83	15	6.20	223.20	30.00	15.0
B1	H3	3	4.50	162.00	45.75	18	6.50	234.00	32.3	13.7
B2	H0	1	6.40	230.40	40.40	22	6.67	240.00	30.71	16.3

B2	H0	2	5.50	198.00	46.67	22	6.50	234.00	37.13	16.0
B2	H0	3	4.10	147.60	38.20	15	6.90	248.40	32.9	16.0
B2	H1	1	5.70	205.20	37.20	17	7.17	258.00	33.25	15.3
B2	H1	2	5.50	198.00	42.50	21	7.10	255.60	30.38	17.0
B2	H1	3	4.30	154.80	36.50	17	6.38	229.50	30.6	15.3
B2	H2	1	5.20	187.20	39.33	14	6.90	248.40	32.00	16.0
B2	H2	2	5.30	190.80	43.50	19	7.50	270.00	29.75	16.3
B2	H2	3	6.10	219.60	39.17	16	6.40	230.40	31.5	14.7
B2	H3	1	6.20	223.20	40.33	16	6.75	243.00	34.00	14.0
B2	H3	2	5.80	208.80	41.00	18	5.83	210.00	28.57	15.3
B2	H3	3	4.80	172.80	34.80	16	7.00	252.00	34.0	16.3
B3	H0	1	6.00	216.00	41.40	20	6.89	248.00	33.14	16.0
B3	H0	2	4.80	172.80	36.33	17	5.29	190.29	32.00	17.0
B3	H0	3	4.80	172.80	39.67	15	7.13	256.50	27.8	17.3
B3	H1	1	6.60	237.60	39.00	17	7.00	252.00	36.17	16.3
B3	H1	2	5.70	205.20	35.67	16	5.75	207.00	34.83	15.7
B3	H1	3	5.50	198.00	34.60	17	5.56	200.00	36.4	16.0
B3	H2	1	6.20	223.20	40.25	19	5.00	180.00	31.43	14.0
B3	H2	2	5.70	205.20	37.17	18	5.50	198.00	27.80	14.3
B3	H2	3	4.90	176.40	38.83	16	7.20	259.20	32.5	16.0
B3	H3	1	6.90	248.40	41.17	21	7.75	279.00	33.30	17.0
B3	H3	2	5.80	208.80	39.63	15	6.90	248.40	32.00	15.3
B3	H3	3	4.80	172.80	38.83	18	7.20	259.20	31.7	16.0

Appendix 11: Analysis of variance for stem base diameter

a) First trial

Analysis of variance for stem base diameter 30 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	1.62190	0.81095	3.02	
Blocks.Bios stratum					
Bios	3	0.09025	0.03008	0.11	0.950
Residual	6	1.61112	0.26852	2.98	
Blocks.Bios.Hicu stratum					
Hicu	3	0.81858	0.27286	3.03	0.049
Bios.Hicu	9	0.49741	0.05527	0.61	0.773
Residual	24	2.16073	0.09003		
Total	47	6.79999			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.225	2.7
Blocks.Bios	6	0.259	3.1
Blocks.Bios.Hicu	24	0.300	3.6

Analysis of variance for stem base diameter 60 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	9.9451	4.9725	32.73	
Blocks.Bios stratum					
Bios	3	2.0463	0.6821	4.49	0.056
Residual	6	0.9115	0.1519	1.23	
Blocks.Bios.Hicu stratum					
Hicu	3	2.5506	0.8502	6.87	0.002
Bios.Hicu	9	1.0095	0.1122	0.91	0.535
Residual	24	2.9690	0.1237		
Total	47	19.4318			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.557	3.3
Blocks.Bios	6	0.195	1.2
Blocks.Bios.Hicu	24	0.352	2.1

b) Second trial

Analysis of variance for stem base diameter 30 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.143324	0.071662	42.44	
Blocks.Bios stratum					
Bios	3	0.061724	0.020575	12.18	0.006
Residual	6	0.010132	0.001689	0.50	
Blocks.Bios.Hicu stratum					
Hicu	3	0.002309	0.000770	0.23	0.876
Bios.Hicu	9	0.061879	0.006875	2.04	0.079
Residual	24	0.080930	0.003372		
Total	47	0.360297			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.06692	1.0
Blocks.Bios	6	0.02055	0.3
Blocks.Bios.Hicu	24	0.05807	0.8

Analysis of variance for stem base diameter 75 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.58126	0.29063	2.06	
Blocks.Bios stratum					
Bios	3	6.20286	2.06762	14.65	0.004
Residual	6	0.84670	0.14112	1.49	
Blocks.Bios.Hicu stratum					
Hicu	3	2.85050	0.95017	10.03	<.001
Bios.Hicu	9	17.08207	1.89801	20.03	<.001
Residual	24	2.27376	0.09474		
Total	47	29.83715			

Stratum standard errors and coefficients of variation

Stratum	**d.f.**	**s.e.**	**cv%**
Blocks	2	0.135	1.6
Blocks.Bios	6	0.188	2.2
Blocks.Bios.Hicu	24	0.308	3.6

Appendix 12: Analysis of variance for plant height 75 days after pinching in second trial

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Blocks stratum	2	5.4622	2.7311	1.93	
Blocks.Bios stratum					
Bios	3	503.1642	167.7214	118.32	<.001
Residual	6	8.5048	1.4175	2.10	
Blocks.Bios.Hicu stratum					
Hicu	3	3.2126	1.0709	1.58	0.219
Bios.Hicu	9	13.2746	1.4750	2.18	0.062
Residual	24	16.2307	0.6763		
Total	47	549.8492			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.413	0.8
Blocks.Bios	6	0.595	1.1
Blocks.Bios.Hicu	24	0.822	1.5

Appendix 13: Analysis of variance for number of shoots, 45 days after pinching in the first trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.52542	0.26271	5.85	
Blocks.Bios stratum					
Bios	3	0.45667	0.15222	3.39	0.095
Residual	6	0.26958	0.04493	0.59	
Blocks.Bios.Hicu stratum					
Hicu	3	0.78833	0.26278	3.47	0.032
Bios.Hicu	9	2.14833	0.23870	3.15	0.012
Residual	24	1.81833	0.07576		
Total	47	6.00667			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.128	2.3
Blocks.Bios	6	0.106	1.9
Blocks.Bios.Hicu	24	0.275	4.9

Appendix 14: Analysis of variance for number of shoots, 30 days after pinching in second trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.06542	0.03271	0.60	
Blocks.Bios stratum					
Bios	3	1.26563	0.42188	7.76	0.017
Residual	6	0.32625	0.05438	0.67	
Blocks.Bios.Hicu stratum					
Hicu	3	0.03562	0.01187	0.15	0.930
Bios.Hicu	9	0.66188	0.07354	0.91	0.531
Residual	24	1.93500	0.08062		
Total	47	4.28979			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.0452	0.8
Blocks.Bios	6	0.1166	2.1
Blocks.Bios.Hicu	24	0.2839	5.1

Appendix 15: Analysis of variance for leaf area and leaf are index in the first trial

a) Analysis of variance for Leaf area 30 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.50564	0.25282	2.91	
Blocks.Bios stratum					
Bios	3	0.43786	0.14595	1.68	0.270
Residual	6	0.52176	0.08696	1.22	
Blocks.Bios.Hicu stratum					
Hicu	3	1.60890	0.53630	7.55	0.001
Bios.Hicu	9	1.62289	0.18032	2.54	0.033
Residual	24	1.70407	0.07100		
Total	47	6.40111			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.126	2.0
Blocks.Bios	6	0.147	2.4
Blocks.Bios.Hicu	24	0.266	4.3

b) Analysis of variance for Leaf area 45 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.9343	0.4671	0.46	
Blocks.Bios stratum					
Bios	3	0.7035	0.2345	0.23	0.872
Residual	6	6.0905	1.0151	2.11	
Blocks.Bios.Hicu stratum					
Hicu	3	3.4909	1.1636	2.42	0.091
Bios.Hicu	9	10.0554	1.1173	2.32	0.048
Residual	24	11.5439	0.4810		
Total	47	32.8185			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.171	1.6
Blocks.Bios	6	0.504	4.7
Blocks.Bios.Hicu	24	0.694	6.5

c) Analysis of variance for Leaf area index 30 days after pinching

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Blocks stratum	2	0.019546	0.009773	3.32	
Blocks.Bios stratum					
Bios	3	0.032977	0.010992	3.73	0.080
Residual	6	0.017688	0.002948	0.83	
Blocks.Bios.Hicu stratum					
Hicu	3	0.047708	0.015903	4.49	0.012
Bios.Hicu	9	0.067018	0.007446	2.10	0.071
Residual	24	0.084992	0.003541		
Total	47	0.269929			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.02471	2.2
Blocks.Bios	6	0.02715	2.4
Blocks.Bios.Hicu	24	0.05951	5.2

d) Leaf area index 45 days after pinching

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.63923	0.31962	3.78	
Blocks.Bios stratum					
Bios	3	0.11565	0.03855	0.46	0.723
Residual	6	0.50722	0.08454	1.14	
Blocks.Bios.Hicu stratum					
Hicu	3	0.58595	0.19532	2.63	0.073
Bios.Hicu	9	1.56069	0.17341	2.34	0.047
Residual	24	1.78009	0.07417		
Total	47	5.18884			

Stratum standard errors and coefficients of variation

Stratum	**d.f.**	**s.e.**	**cv%**
Blocks	2	0.1413	3.8
Blocks.Bios	6	0.1454	4.0
Blocks.Bios.Hicu	24	0.2723	7.4

Appendix 16: Analysis of variance for Leaf area 90 days after pinching in second trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	1.7483	0.8742	0.93	
Blocks.Bios stratum					
Bios	3	1.1999	0.4000	0.42	0.743
Residual	6	5.6591	0.9432	2.24	
Blocks.Bios.Hicu stratum					
Hicu	3	4.5315	1.5105	3.59	0.028
Bios.Hicu	9	1.8425	0.2047	0.49	0.869
Residual	24	10.0928	0.4205		
Total	47	25.0740			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.234	2.8
Blocks.Bios	6	0.486	5.9
Blocks.Bios.Hicu	24	0.648	7.9

Appendix 17: Analysis of variance for flower stems length

a) First trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	16.756	8.378	1.58	
Blocks.Bios stratum					
Bios	3	4.772	1.591	0.30	0.825
Residual	6	31.841	5.307	2.68	
Blocks.Bios.Hicu stratum					
Hicu	3	3.847	1.282	0.65	0.591
Bios.Hicu	9	5.109	0.568	0.29	0.972
Residual	24	47.436	1.977		
Total	47	109.761			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.724	1.1
Blocks.Bios	6	1.152	1.8
Blocks.Bios.Hicu	24	1.406	2.1

b) Second trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	4.8182	2.4091	2.75	
Blocks.Bios stratum					
Bios	3	0.1823	0.0608	0.07	0.974
Residual	6	5.2516	0.8753	2.14	
Blocks.Bios.Hicu stratum					
Hicu	3	1.0445	0.3482	0.85	0.479
Bios.Hicu	9	12.9067	1.4341	3.51	0.007
Residual	24	9.8132	0.4089		
Total	47	34.0165			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.388	0.6
Blocks.Bios	6	0.468	0.7
Blocks.Bios.Hicu	24	0.639	0.9

Appendix 18: Analysis of variance for flower head height

a)First trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.11227	0.05614	0.50	
Blocks.Bios stratum					
Bios	3	0.20327	0.06776	0.61	0.634
Residual	6	0.66797	0.11133	1.53	
Blocks.Bios.Hicu stratum					
Hicu	3	0.27462	0.09154	1.26	0.310
Bios.Hicu	9	0.45127	0.05014	0.69	0.711
Residual	24	1.74404	0.07267		
Total	47	3.45345			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.059	0.2
Blocks.Bios	6	0.167	0.4
Blocks.Bios.Hicu	24	0.270	0.7

b) Trial 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.2357	0.1179	0.52	
Blocks.Bios stratum					
Bios	3	3.3046	1.1015	4.87	0.048
Residual	6	1.3582	0.2264	2.01	
Blocks.Bios.Hicu stratum					
Hicu	3	0.8495	0.2832	2.51	0.083
Bios.Hicu	9	3.0670	0.3408	3.02	0.015
Residual	24	2.7079	0.1128		
Total	47	11.5231			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.086	0.2
Blocks.Bios	6	0.238	0.6
Blocks.Bios.Hicu	24	0.336	0.8

Appendix 19: Analysis of variance for flower head diameter

a) First trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.17743	0.08872	1.96	
Blocks.Bios stratum					
Bios	3	0.32602	0.10867	2.40	0.166
Residual	6	0.27174	0.04529	0.95	
Blocks.Bios.Hicu stratum					
Hicu	3	0.50842	0.16947	3.55	0.029
Bios.Hicu	9	0.89874	0.09986	2.09	0.072
Residual	24	1.14639	0.04777		
Total	47	3.32875			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.074	0.3
Blocks.Bios	6	0.106	0.5
Blocks.Bios.Hicu	24	0.219	1.0

b) Second trial

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.82343	0.41172	14.08	
Blocks.Bios stratum					
Bios	3	4.75414	1.58471	54.21	<.001
Residual	6	0.17540	0.02923	0.54	
Blocks.Bios.Hicu stratum					
Hicu	3	0.11707	0.03902	0.72	0.550
Bios.Hicu	9	0.76739	0.08527	1.57	0.180
Residual	24	1.30021	0.05418		
Total	47	7.93764			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.160	0.7
Blocks.Bios	6	0.085	0.4
Blocks.Bios.Hicu	24	0.233	1.1

Appendix 20: Analysis of variance for vaselife

a) Trial 1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	11.542	5.771	0.43	
Blocks.Bios stratum					
Bios	3	27.583	9.194	0.69	0.592
Residual	6	80.292	13.382	4.11	
Blocks.Bios.Hicu stratum					
Hicu	3	42.417	14.139	4.34	0.014
Bios.Hicu	9	27.917	3.102	0.95	0.501
Residual	24	78.167	3.257		
Total	47	267.917			

Stratum standard errors and coefficients of variation

Stratum	d.f.	s.e.	cv%
Blocks	2	0.601	3.3
Blocks.Bios	6	1.829	10.0
Blocks.Bios.Hicu	24	1.805	9.9

b) Trial 2

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Blocks stratum	2	2.0046	1.0023	0.56	
Blocks.Bios stratum					
Bios	3	3.5440	1.1813	0.66	0.605
Residual	6	10.6991	1.7832	3.60	
Blocks.Bios.Hicu stratum					
Hicu	3	8.3032	2.7677	5.59	0.005
Bios.Hicu	9	3.9468	0.4385	0.89	0.552
Residual	24	11.8889	0.4954		
Total	47	40.3866			

Stratum standard errors and coefficients of variation

Stratum	**d.f.**	**s.e.**	**cv%**
Blocks	2	0.25	1.6
Blocks.Bios	6	0.67	4.2
Blocks.Bios.Hicu	24	0.70	4.5