OSTEOSPERMUM: EXTENDING THE SEASON OF PRODUCTION AND ENVIRONMENTAL EFFECTS ON PLANT QUALITY

PART I. EFFECTS OF TEMPERATURES

PART II. EVALUATION OF A RANGE OF PLANT GROWTH REGULATORS

AND

PART III. EVALUATION OF TEMPERATURES, LIGHTING AND PLANT GROWTH REGULATORS

S. PEARSON, A.K. FULLER AND H.M. KITCHENER

Report to the Horticultural Development Council: PC 114

Final Report: November 1996

HDC PC 114

Osteospermum: Extending the season of production and environmental effects on plant quality.

Part I. Effects of temperatures.

Part II. Evaluation of a range of plant growth regulators.

and

Part III. Evaluation of temperature, lighting and plant growth regulators.

S. Pearson[1], A.K. Fuller[2] and H.M. Kitchener[3]

Department of Horticulture[1]. University of Reading, Reading, RG6 6AS
Tel: 01734 318071
Fax: 01734 750630

Horticulture Research International - Efford[2], Lymington, Hampshire, SO41 0LZ
Tel: 01590 673341
Fax: 01590 671553

ADAS Huntingdon[3], Chequers Court, Huntingdon, Cambs, PE18 6LT
Tel: 01480 52161
Fax: 01480 412049

Co-ordinator: Mr R. Oliver

Commenced: February 1995
Completed: June 1996

Key-words: *Osteospermum,* chilling, temperature, flower induction, flower development, cultivars, plant growth regulators, Cycocel, chlormequat, Bonzi, paclobutrazol, Topflor, flurpirimidol, B-Nine, Daminozide, plant growth, flowing, quality.

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Practical Section for Growers

The Grower Relevant Sections from each of the three Parts have been brought to the front to provide an overview of the whole project for ease of reference, in addition to being present in their own Part.

Part I

Effects of Temperature

Relevance to Growers and Practical Application

Application

Two experiments were conducted to examine the effects of chilling and finishing temperatures on the time to flowering and plant quality of *Osteospermum*. Previous research suggested that exposing plants to cool temperatures after pinching may advance time to flowering. Furthermore, high temperatures post chilling may also reduce time to flowering. However, previous research has only been conducted on one variety and comparing the effects of only two temperatures (12 and 22°C). Thus, this HDC work was conducted to confirm whether these effects of temperatures are found in other varieties and to examine the effects of a wider range of more commercially viable temperatures. This work may lead to a more rapid throughput of the crop and the ability to reliably extend the season for *Osteospermum* production.

The first experiment examined the effects three chilling temperatures (9, 12 and 15°C) applied after pinching to two cultivars of *Osteospermum* for 2, 3 or 4 weeks each combined factorially with three different finishing temperatures (12, 15 and 18°C). Time to flowering and plant quality were assessed.

In cultivar Lubutu time to flowering was advanced by 15-22 days when plants were exposed to three weeks at 9°C following pinching compared to the same period at 15°C. Leaf number below the flower was also reduced in chilled (9°C) plants, resulting in reduced plant height. Flowering was slightly delayed if the duration of chilling was only 2 weeks. However, in cv. Sunny Girl the chilling temperature had little effect on time to flowering, however, these plants were pre-pinched by the propagator and may have induced flowers prior to the experiment. This is also suggested by the fact that plants exposed to the coolest chilling temperature had a significantly greater number of flower buds than plants exposed to the warmest temperature. Following chilling plants grown on at 18°C flowered 13 and 11 days earlier compared to 12°C for cv. Lubutu and Sunny Girl, respectively. However, bud numbers were nearly halved when plants were grown on at 18°C compared to 12°C.

The second experiment tested whether the chilling treatments could be applied to plug plants in cold rooms; treatments to potentially remove the need to provide cold temperatures inside glasshouses. If these treatments are successful then it would provide a means to reliably produce the crop during the warmer summer months and reduce the duration required to grow the plant in the glasshouse. Plants of 6 varieties were maintained in growth rooms at either 10 or 20°C, either in the dark or lit at 90μmol $m^{-2}s^{-1}$ for 12 hours for 7, 14 or 21 days. After the treatments, plants were grown on until flowering in a glasshouse at 18°C.

This experiment showed that plants could be chilled to induce flowers at the plug stage. Lit plug plants kept in a cool store at 10°C flowered earlier (by approx. 2 weeks) than those maintained at 20°C. Fastest time to flowering occurred when lit plants were chilled at 10°C for one week. Plants kept at 10°C in the dark also flowered earlier than those lit or unlit at 20°C. However, plants maintained in the dark for more than one week led to high plant losses over the duration of the treatment, limiting the potential of this technique in commercial production. Plants that were lit during chilling at 90μmol $m^{-2}s^{-1}$ suffered minimal losses.

Summary

This project has shown that *Osteospermum* are highly sensitive to temperature. In the limited variety range examined, chilling plants of cv. Lubutu (also known as Buttermilk) at 9°C for 3 weeks significantly advanced time to flowering by up to 3 weeks compared to a commercial 'control' temperature of 15°C. As time to flower initiation was earlier in plants chilled at 9°C, final leaf number below the flower and plant height at flowering were reduced. Suggesting that chilling can be used to control plant growth, as well as flowering.

Pre-pinched plants of cv. Sunny Girl were less sensitive to chilling at 9°C. However, evidence suggested that these plants had partially induced flowers prior to the start of the experiment (plants were pinched on arrival and may have been held at cold temperatures prior to despatch). However, chilling at 9°C for 2 to 4 weeks doubled the final number of initiated flower buds.

In both cultivars higher finishing temperatures (18°C) also considerably reduced time to flowering (by approx. 2 weeks) compared to plants grown on at 12°C. However, the highest finishing temperatures led to a reduction of final bud number by up to 50% compared to plants grown at 12°C.

Experiments suggest that the chilling treatments can be applied to induce flowers in cold rooms. Thereby reducing the time plants require in the glasshouse. However, significant plant losses occur if plants are chilled in the dark for more than one week. At 10°C, if plants are lit no losses occurred.

On the basis of these results we would recommend that chilling cv. Lubutu plants for at least 2 weeks at 9°C after pinching can reduce the duration of crop production and control crop growth, assuming plants are pinched on arrival. In the pre-pinched variety Sunny Girl a brief chilling period may be used to increase bud number without adversely affecting time to flowering.

It should be noted that on the basis of work on other species if plants are pinched *after* chilling then the response may be negated.

Further experiments are now on-going to examine the response of a much wider range of varieties to chilling and whether brief periods of high temperature can negate the response.

Part II

Evaluation of a Range of Plant Growth Regulators

Relevance to Growers and Practical Applications

Application

Three plant growth regulators were evaluated; Cycocel, Bonzi and Topflor, for use on a range of *Osteospermum* cultivars as either a spray or drench application.

A Cycocel drench gave the most reliable and effective control of plant growth in *Osteospermum*. A drench applied when the young shoots are 1-2 cm in length at a rate of 4 ml/l Cycocel (46% ai) (applying 80 ml per 1 litre pot) gave the best results. A second application 2-3 weeks before marketing maintained good plant habit and restricted peduncle stretching in the later stages of production.

Cycocel as a spray also achieved control of growth, but repeated applications were necessary, leaf scorch increased at higher rates >4 ml/l, .

Bonzi was effective as a drench and gave long lasting results, whilst Bonzi as a spray was ineffective. Similarly in an observation with B-Nine either as a spray or drench no obvious control of growth was achieved. Topflor was very effective even at low rates and further work is required to establish both the best application method and the rate which is optimal for *Osteospermum* within this compound.

Summary

In the last few years there has been considerable growth in the market for *Osteospermum* both as a bedding/patio plant and also as a pot plant. The natural habit of many cultivars is to produce a very large plant before flowering, subsequently plant quality can be poor as a result of a `straggly' plant habit which is both unattractive and very difficult to handle during production and at marketing. Trials at Efford in combination with trials on a commercial nursery were carried out to evaluate the use of chemical plant growth regulators: chlormequat (Cycocel), paclobutrazol (Bonzi) and flurprimidol (Topflor). Daminozide as B-Nine was also included as an observation. These chemicals were applied either as a drench or as a spray. Eight *Osteospermum* cultivars were grown in glasshouse compartments at Efford. Young plants were supplied from Denmark and potted in week 4 and in week 15. Thus the effectiveness of each growth regulator was assessed over a range of growing conditions under glass. Records were taken at marketing to compare plant height, pedicel length, flower number etc. In the first trial a set application procedure was adopted using controlled rates of chemical. From these results rates of applied chemical were adjusted in trial 2 as seen necessary.

Part III

Evaluation of Temperatures, Lighting and Plant Growth Regulators

Relevance to Growers and Practical Application

Application

Two temperature and two lighting regimes were evaluated to evaluate the effect on the harvest period.

Plants given 16°C day/night without lighting flowered earlier than those given lighting at 2500 lux for 16 hours a day. The higher temperature may have delayed flowering.

Ambient 9°C temperatures delayed flowering.

Two plant growth regulators were used: Cycocel and Topflor as drenches as required by plant growth.

Topflor delayed flowering.

Summary

Osteospermum grown to a pot plant specification need to be grown with plant growth regulators. Early production of quality product normally has a premium market price.

The commercial trial showed that low/ambient temperatures min. 9°C with no heating delays flowering by 4 weeks and hardens growth.

Growing at 16°C day/night produces plants of good quality in 12 weeks.

The use of assimilation lighting at 2500 lux with 16°C day/night temperature delayed flowering by 5 to 7 days.

All plant growth regulators were applied as drenches. Topflor produced very short compact plants. Cycocel produced good commercial product.

Sunny varieties flowered earlier than the Carl Axel.

Osteospermum Extending the Season of Production and Environmental Effects on Quality

Action Points for Growers

1. Chilling of *Osteospermum* cultivars to 9°C for 3 weeks significantly reduces the time to flowering compared with controlled temperature growth of 15°C day/night. Lower temperatures should be given after the plants are pinched, once the plants are established and before the shoots have developed to any great stage.

2. Chilling at 9°C will also increase the number of final flowers which are initiated.

3. Higher temperatures after initiation i.e. 16/18°C will reduce the time to flowering by up to 14 days compared with plants grown at 12°C.

4. Plant growth regulators should be applied as drenches rather than sprays. Drenches are more effective and give more uniform plants within a batch. Use of ebb and flow systems to apply the drench give even greater uniformity than hand or trickle application.

5. Cycocel as a drench at 4 ml/l and Bonzi at 1.25 ml/l as a drench are the most successful plant growth regulators when used across a range of cultivars. All plant growth regulators should be applied when young shoots are 2-3 cm long and subsequent plant growth regulator applications should be applied as the centre of the young shoots show lighter colour and as long as growth control is needed to meet specification. Application of drenches can be as much as twice or three times per week but it is normal to apply once a week.

6. *Osteospermum* have the best shelf life when marketed with 5-6 flowers open.

7. Low ambient temperatures throughout growth with a minimum of 9°C day/night delays flowering by up to 4 weeks and growth is hardened. The amount of plant growth regulator required is reduced and the number of flowers initiated increased..

8. Growing at 16°C day/night produces plants of good quality from planting in 12 weeks.

9. The use of assimilation lighting at 2,500 lux can delay flowering by up to 7 days due to the rise in temperature of the plants when the lights are on by 1-3°C.

10. High temperatures over 26°C reduce flower initiation and impede flower development. Programming of the crop throughout the summer would require cold storage treatments which may be affected by high summer temperatures, reducing flower count and therefore quality. Growth at high temperatures is rapid and extra plant growth regulator applications are required. All the year round programming to give summer production has not been covered by the trials.

PART I: (1995)

EFFECTS OF TEMPERATURE

FINAL REPORT SEPTEMBER 1996
HDC PC 114

OSTEOSPERMUM:

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S. PEARSON AND J.E.L. WAGSTAFFE
UNIVERSITY OF READING

CO-ORDINATOR: R OLIVER

COMMENCED: FEBRUARY 1995
COMPLETED: JULY 1996

Key words: *Osteospermum*, temperatures, cultivars, plant growth, flowering, quality

PART I

CONTENTS

1.0 RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

1.1 Application

Two experiments were conducted to examine the effects of chilling and finishing temperatures on the time to flowering and plant quality of *Osteospermum*. Previous research suggested that exposing plants to cool temperatures after pinching may advance time to flowering. Furthermore, high temperatures post chilling may also reduce time to flowering. However, previous research has only been conducted on one variety and comparing the effects of only two temperatures (12 and 22°C). Thus, this HDC work was conducted to confirm whether these effects of temperatures are found in other varieties and to examine the effects of a wider range of more commercially viable temperatures. This work may lead to a more rapid throughput of the crop and the ability to reliably extend the season for *Osteospermum* production.

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1.2 Summary

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Further experiments are now on-going to examine the response of a much wider range of varieties to chilling and whether brief periods of high temperature can negate the response.

2.0 MATERIALS AND METHODS

Two experiments were conducted at Reading, the first to investigate the distinct effects of temperature on flower initiation and subsequent flower development. The second experiment investigated whether flowering could be induced by exposing plugs to cool temperatures.

2.1 Introduction

In the last few years there has been considerable interest in the market for *Osteospermum* both as a bedding/patio plant and as a half hardy perennial. In 1993 it was estimated that up to 2 million plants were sold in the UK. Unfortunately the marketing season for *Osteospermum* is largely limited by the fact that most varieties virtually cease flowering during the warmer summer months. The production of earlier or later flowering plants would have great potential for increasing the size of the market. Furthermore, the quality and morphology of finished plants can be variable between batches, with some batches being tall and 'leggy' having initiated many leaves below the flower. In other batches the peduncle length may be so great that the flower collapses prior to sale. Thus, there is a need to understand the factors that control flowering in this species, for season extension and optimisation of production, and to investigate techniques for plant growth regulation.

Due to its relative novelty, very little research has been conducted on this species to investigate the effects of cultural and environmental factors that optimise plant growth and maximise plant quality. An initial study by Pearson *et al.,* (1995) showed that flowering in *Osteospermum* cv. Pink Whirls exposed to at least 2 weeks of cool temperature at 12°C and than 22°C occurred after 5.5 weeks, compared to no flowering occurring, even after 120 days, when plants were maintained at 22°C throughout. Plants kept at 12°C throughout eventually flowered but much later than those given the short period of cool (12°C) followed by a warm temperature (22°C). Thus, a short period of cool temperature apparently speeds up flower initiation and the subsequent duration to flower development is hastened by warm temperatures. However, 22°C was considered too warm to finish the crop, since plants were straggly and flower size and bud number were reduced; those finished at 22°C had 5 flower buds per plant compared to 15 at 12°C. Thus, *Osteospermum* are highly sensitive to temperature but optimal temperatures for producing the crop commercially have not been elucidated, nor have effective growth control strategies.

2.2 Objectives

The commercial objectives of this work were therefore threefold:

To develop strategies that enable the production of plants earlier in the spring and later in the autumn, than currently achieved.

To develop techniques that minimise the duration of production and increase throughput.

Investigate the optimal use of plant growth regulators for growth control and to maximise plant quality.

To fulfil these objectives a number of technical and practical problems require investigation, these include the following questions:

Do all cultivars require a period of cool to induce flowering?
Is 12°C the optimum temperature to promote flower induction?
What is the optimum commercial temperature to finish the crop?
Can the initial period of cool, to induce flowering, be given to cuttings in cold stores?
If this is the case then pre-induced plugs could be sold, such that plants would not require periods of cold temperatures to promote flowering inside the glasshouse. This would shorten the duration of production, by removing the need to chill the plants inside glasshouses. It would also enable the production of *Osteospermum* during the warmer summer months when outside temperatures are too high for glasshouse chilling.
Which plant growth regulator should be used to maximise plant quality and how should it be applied?
Will the PGR strategy need to be modified with later crops?

The financial benefits of any research study are always difficult to quantify, but this project should lead to improved plant quality, through-put and reliable techniques to extend the season. In terms of through-put alone previous studies suggest that time to flowering could be reduced by up 20%, leading to a 20% reduction in the overhead and fuel costs for producing the crop, and the possibility of producing extra crops during periods of high demand for glasshouse space.

This report is divided into three parts. Part I describes the work conducted at Reading on the responses of these plants to temperature. Part II describes semi-commercial trials at Efford on investigations to devise optimal strategies for plant growth regulation. Part III describes the evaluation of temperature, lighting and plant growth regulators on the commercial trial.

2.3 The effects of chilling and finishing temperatures on time to flowering and plant morphology of two *Osteospermum* cv's. Lubutu and Sunny Girl

Two cv's. of *Osteospermum* (Carl Axel Lubutu and Sunny Girl) were obtained as rooted cuttings from Denmark via Anglia Alpines. Plants were immediately potted on into 10 cm pots containing a media of 75:25 SHL potting compost and perlite. Plants of cv. Lubutu were given a soft pinch at potting, cv. Sunny Girl arrived pre-pinched. Plants were left in a greenhouse compartment at 20°C for one week. After that time 45 plants of each variety were transferred into one of 3 Conviron S10H growth cabinets set at 9, 12 and 15°C for 24 hours each day. The cabinets were lit with cool white florescent tubes supplemented with 15% tungsten (calculated on the basis of nominal wattage) at 150μmol $m^{-2}d^{-1}$ for 12 hours each day. After 2, 3 and 4 weeks inside the cabinets a third of the plants of each variety were removed and these were then further sub-divided and placed (30 plants m^{-2}) inside one of 3 different glasshouse compartments set at 12, 15 and 18°C. Thus, the experiment comprised of a factorial combination of 3 'chilling' temperatures maintained for 3 durations and with 3 post chilling finishing temperatures, with 5 replicate plants per treatment. Plants were then grown on until flowering. After the final batch of plants was removed from the cabinets all plants were liquid fed at each watering with a nutrient solution containing Sangral 111 (20N: $20K_2O_5$: $20P_2O_5$) fertiliser diluted to a conductivity of 1500μS. Days to flowering were recorded and at first flowering each individual plant was harvested to assess leaf number below the flower, plant height, flower diameter and flower bud number. Data were analysed using ANOVA.

2.4 The effects of cold temperatures applied to plug plants on subsequent time to flowering and plant quality

Rooted cuttings of cv's. Lubutu, Zulu, Pink Fantasy, Congo, Sunny Girl and Sunny Lady were obtained from HRI Efford, where they were rooted in plugs and not exposed to temperatures below 18°C. Cuttings were initially sourced from Carl Axel and Gaza in Denmark from stock plants maintained at high temperatures (>18°C). Plants were pinched on arrival prior to the treatment application. Plants were maintained in the plugs (P135's) and half of the plants were placed inside one of two growth rooms with temperatures set at 10 and 20°C constant for 24 hours. In each growth roof half of the plants were maintained constantly in the dark and the other half were lit for 16 hours each day at 90μmol $m^{-2}s^{-1}$ using warm white fluorescent tubes supplemented with 6.3% of tungsten (calculated on the basis of nominal wattage). Plants were watered as necessary within the growth rooms. After 7, 14 and 21 days a third of the plants from each treatment were removed from the growth rooms and potted up into 12 cm pots containing a 75:25 mix of SHL potting compost and perlite. Thus, the experiment was a factorial combination of two 'chilling' temperatures, lit and unit and three 'chilling' durations. There were 7 replicate plants for each treatment. Plants were placed inside a glasshouse compartment maintained at 18°C and grown on until flowering. At flowering, of each individual plant, assessments were made of time to flowering and leaf number below the flower.

3.0 RESULTS

3.1 Effects of chilling and finishing temperatures.

3.1.1 Days to flowering

For cv. Lubutu an initial period of cold temperatures at 9°C significantly (P>0.001) advanced time to flowering, whilst in cv. Sunny Girl temperature following pinching (chilling period) had no significant effect on the time to final flowering, see Figure 1.

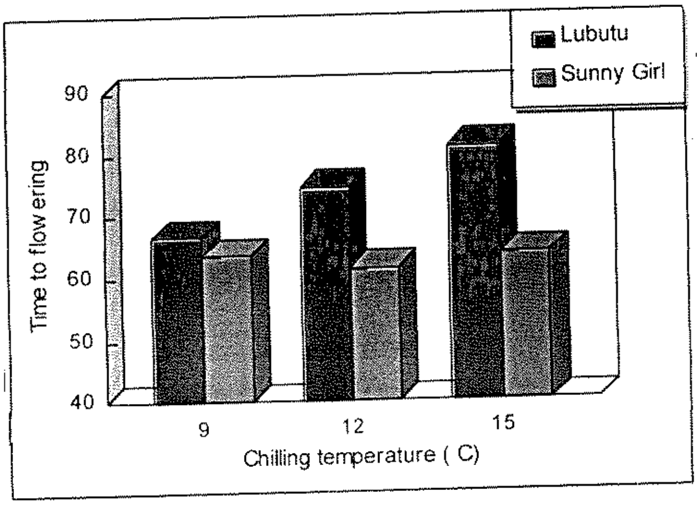


Figure 1. The effects of different chilling temperatures applied after pinching on time to flowering of *Osteospermum* cv. Lubutu (sed = 0.9) and Sunny Girl (sed = 2.1).

Thus, overall, in cv. Lubutu a period of cool temperatures following pinching advanced time to flowering by at least 14 days (comparing the 9 and 15°C treatments). For cv. Sunny Girl the duration of the chilling period also had no significant effect on time to final flowering. The lack of a response to chilling temperature may reflect a 'true' response to temperature or may be because the plants had partially induced flowers prior to the start of the experiment; cuttings were pre-pinched on arrival. However, in cv. Lubutu there was a highly significant interaction (P>0.001) between the chilling temperature and duration of exposure (Table 1).

Table 1 The interaction between the chilling temperature and duration of exposure on time to flowering of cv. Lubutu. The standard error of the difference (sed) to compare two table means was 1.25 days.

Days to Flowering for cv Lubutu	Chilling Temperature			
Chilling Duration	9 C	12 C	15 C	Mean
2 Weeks	68.9	76.4	77.1	74.1
3 Weeks	64.9	74.3	79.9	73.0
4 Weeks	66.3	73.2	86.3	75.3
Mean	66.7	74.6	81.1	

When chilled at 9°C plants flowered significantly (P>0.05) earlier (by 4 days) when the cool temperatures were given over three weeks compared to two. At 12°C plants flowered significantly (P>0.05) earlier by 3.2 days when chilling was given for 4 weeks compared to 2. However, at 15°C flowering was significantly (P>0.001) later when the plants were chilled for 4 compared to two weeks These results reflect the complexity of the chilling response and suggest that two weeks at 9°C does not fully 'quench' the response, whilst prolonged periods at 15°C, a relatively warm temperature, delays flowering; presumably because this temperature is too high to satisfy the plants requirement for cold.

For both cv.s, increasing finishing temperatures significantly (P>0.001) reduced the time to final flowering (Figure 2), and there were no significant interactions between the effects of different chilling temperatures and finishing temperatures. This suggests that the plant has two distinct responses to temperature, one for flower induction and the second for flower development. The response to finishing temperature was considerable, such that for cv. Lubutu and Sunny Girl the time to flowering was advanced by 13 and 11 days, respectively, when plants were finished at 18 compared to 12°C.

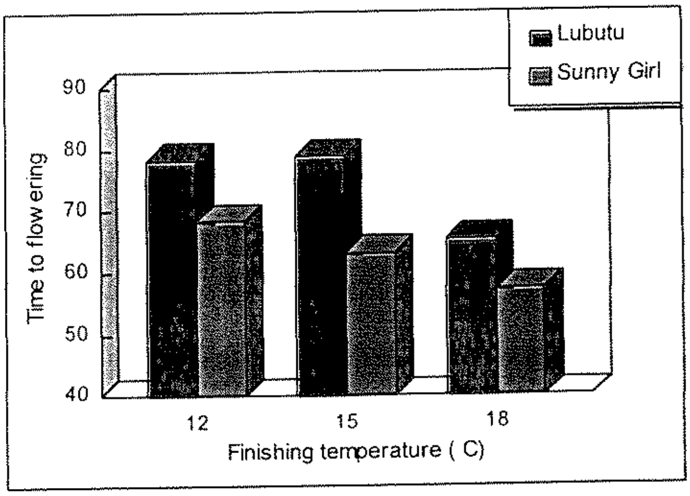


Figure 2. The effects of finishing temperature on the time to flowering of cv. Lubutu (sed = 0.9) and Sunny Girl (sed = 1.25).

3.1.2 Leaf number below the flower.

Information on the leaf number below the flower is of considerable commercial importance as this affects final plant height and morphology For both cv's, the coolest chilling significantly (P>0 001) reduced the leaf number below the flower, though the response of Lubutu was considerably greater than Sunny Girl (Figure 3).

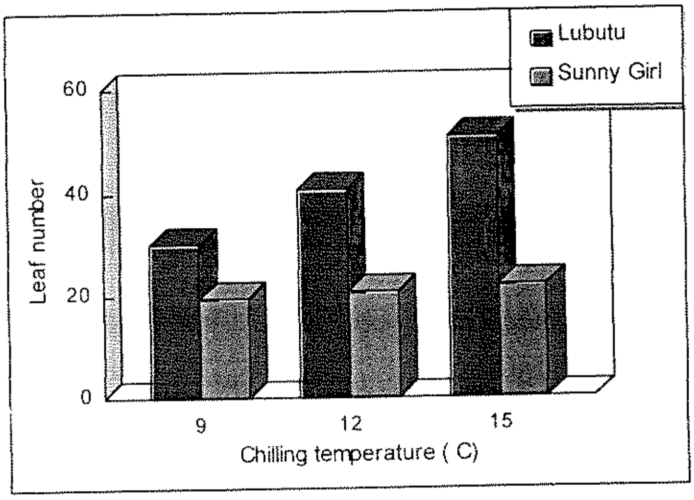


Figure 3. The effects of chilling temperature on the leaf below the flower of cv. Lubutu (sed = 0.9) and Sunny Girl (sed = 0.8).

In cv Sunny Girl finishing temperature and the duration of chilling had no significant effect on time to flowering. However, in cv. Lubutu the coolest finishing temperature also led to a significant (P>0.001) reduction in final leaf number, with 37 leaves being recorded below the flower for plants grown on at 12°C compared to 44 at 18 C. This may reflect that chilling temperatures may induce flowering, but that when induced the final leaf number is not predetermined, i.e. the final number of leaves is dependent on not only when the flower is induced but also environment following induction. There was also a significant interaction between chilling temperature and its duration in cv. Lubutu, such that plants chilled for two weeks produced a significantly (P>0.01) higher leaf number below the flower (33.4) than plants chilled for 3 or 4 weeks (29 and 28.1, respectively). This again reflects the fact that two weeks at 9°C does not quite fully quench the chilling response.

3.1.3 Plant height

Final plant height at flowering is a function of the number of leaves below the flower and internode length. In cv. Sunny Girl all the treatments gave very similar final plant heights at flowering. This may reflect the fact that the treatments had little effect on final leaf number and that this variety has a rather prostrate habit. However, in cv. Lubutu both the chilling temperature and the finishing temperature had significant effects (P>0.001) on final plant height (Figure 4). Plants chilled at 9°C were 22% shorter than those chilled at 15°C, whilst plants grown on at 12°C were 8% taller than those grown on at 18°C. The reduction in height with the coldest chilling treatment reflects the lower leaf number initiated below the flower by these treatments. Whilst the increased plant height with cooler finishing temperature must reflect differences in internode length, since plants grown on at 12°C produced fewer leaves below the flower than those at 18°C.

This reduced plant height with warmer finishing temperatures may be due to the shortened duration of production at high temperature, i.e. the internodes have a shorter time to elongate prior to flowering. Overall, in this variety the shortest plants were produced by chilling the plants at at 9°C followed by 18°C, with an average plant height 39.3cm compared to 59.1 cm for the 15°C chilling / 12°C finishing temperature. The duration of chilling had little overall effect, although it was notable that plants were significantly (P>0.01) shorter when chilled for 3 compared to 2 weeks at 9°C.

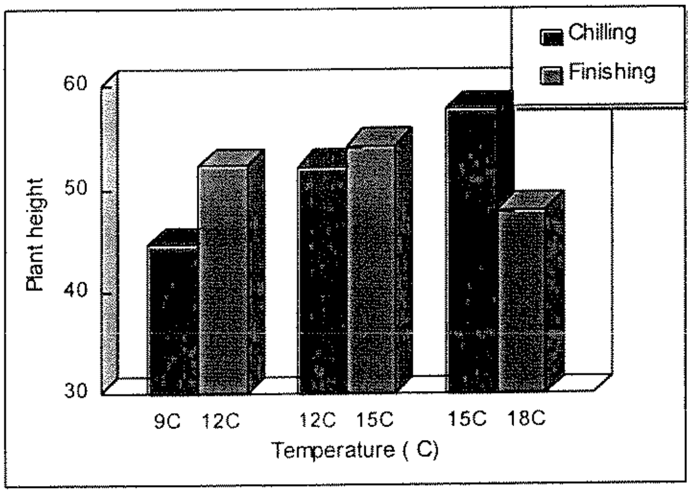
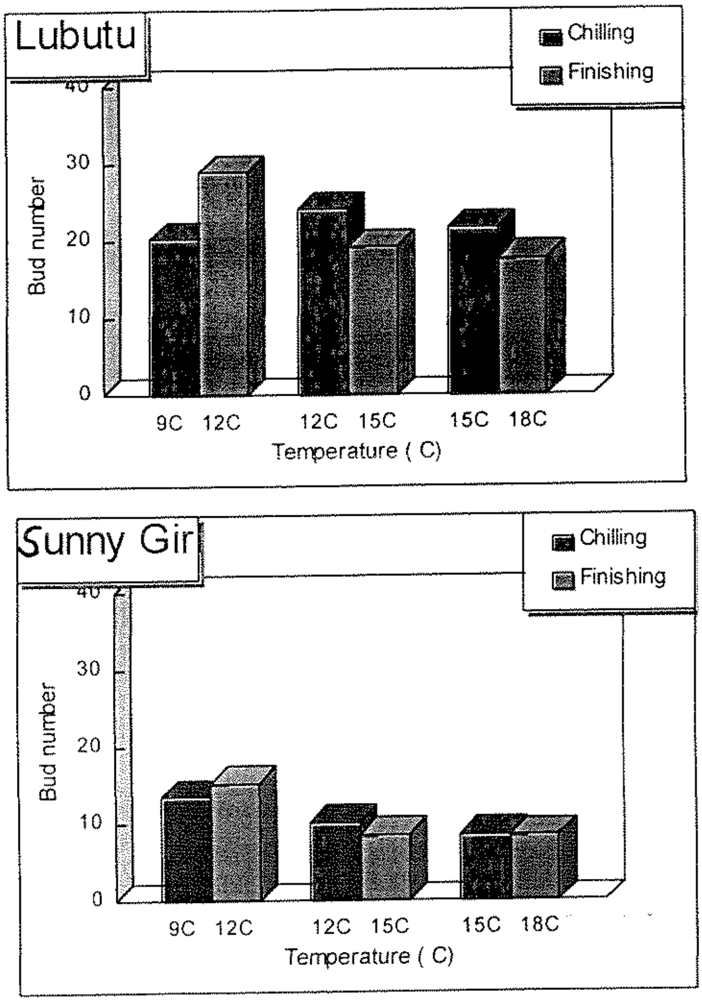


Figure 4. The effects of chilling and finishing temperature on the final plant height of cv. Lubutu (sed = 0.6cm).

3.1.4 Bud number

The number of flowers per plant and visible buds were counted at first flowering of each plant. For both varieties, final bud number was significantly (P>0.001) affected by both the chilling and finishing temperatures, with no significant effects of the duration of chilling or interactions (see Figure 5a and b). For cv. Lubutu a chilling temperature of 12°C produced the highest bud number, compared to 9°C for cv. Sunny Girl. The effect of chilling on cv. Sunny Girl bud number does suggest that even this variety responds positively to cool temperatures for flower induction, and that the lack of an effect of chilling on time to flowering may have been because some flowers had been pre induced when the cuttings arrived from Denmark. For both cv.s the warmest finishing temperatures reduced final bud number, indeed for both cv's final bud numbers were nearly halved when plants were finished at 18° compared to 12°C. As time to flowering was delayed with the coolest finishing temperature, a trade off exists between producing plants with high bud numbers and maximising through put.



Figures 5a and 5b. The effects of chilling and finishing temperatures on the bud number of cv. Lubutu (5a, sed = 1.2) and Sunny Girl (5b, sed = 0.8).

3.1.5. Flower diameter

The diameter of the first flower to open on each plant was measured after full expansion. For both varieties flower diameter was only significantly (P>0.01) affected by the finishing temperature (Figure 6).

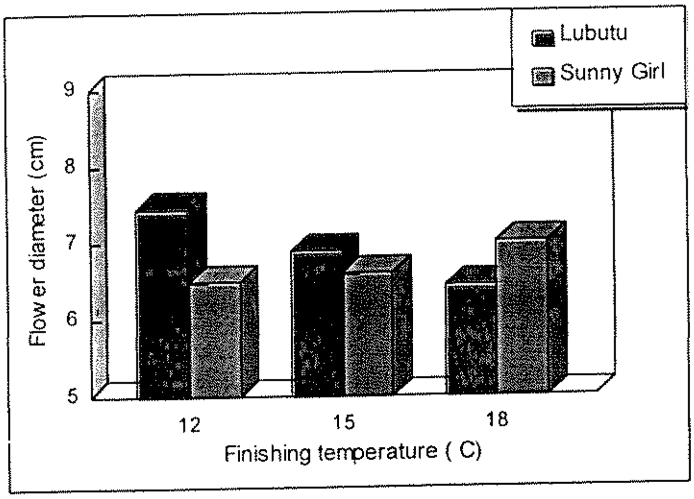


Figure 6. The effects of finishing temperature on the flower diameter of cv's Lubutu (sed = 0.20) and Sunny Girl (sed = 0.13).

For cv Lubutu the highest finishing temperature led to the smallest flower size, whilst the converse was found for cv. Sunny Girl However, effects were generally small

3.2 Prechilling plugs

3.2.1 Time to flowering

This experiment examined whether flowers could be induced by placing plugs in cold stores prior to potting. The effects of a factorial combination of two storage temperatures (10°C plus a 20°C control) combined with a lit or unlit cold store and 3 cold store durations (1, 2 and 3 weeks) were examined. Six different cultivars were also examined, although each gave similar responses. As a consequence the following data are presented as combined means for all the cultivars studied. Figure 7 shows the effects of the treatments on the time to flowering. The data showed that the plants lit and chilled at 10°C flowered on average 10 days earlier (P>0.001) than the lit 20°C controls, for all chilling durations. This confirms that lit plug plants can respond to chilling, even during the first week after pinching. Plants chilled at 10°C in the dark flowered significantly (P>0.01) later than lit plants at 10°C by on average 5.6 days. However, there was an interaction, such that there was no difference in days to flowering between lit and unlit plants at 10°C given one or two weeks chilling, but unlit plants given 3 weeks chilling flowered significantly later than those which were lit. This shows that the chilling response is reduced if the plants are kept in the dark. However, at all times unlit 10°C plants did flower earlier than those kept at 20°C, either lit or unlit.

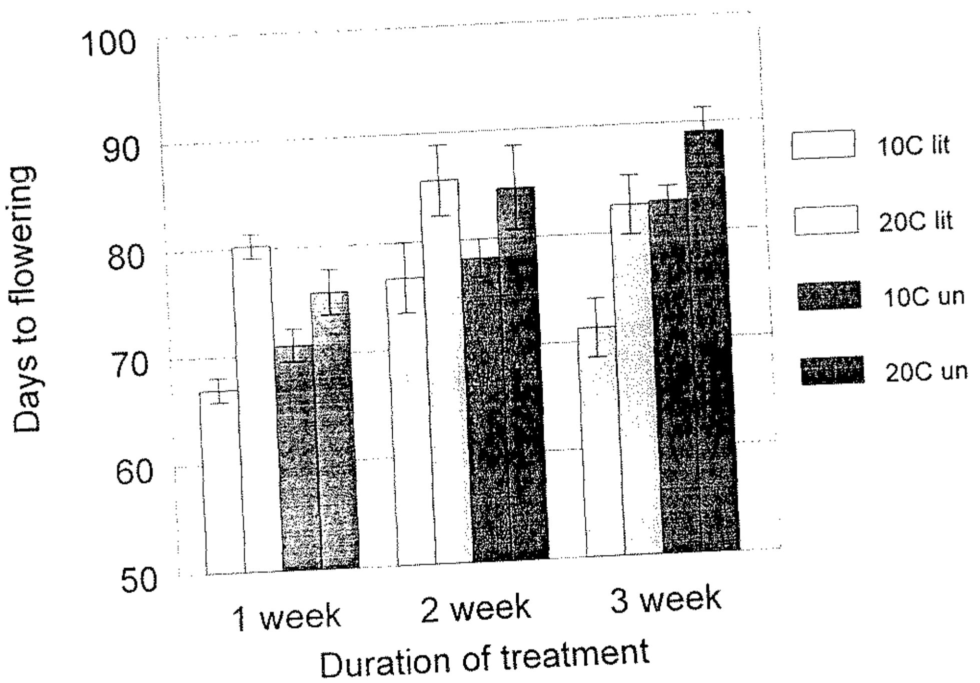
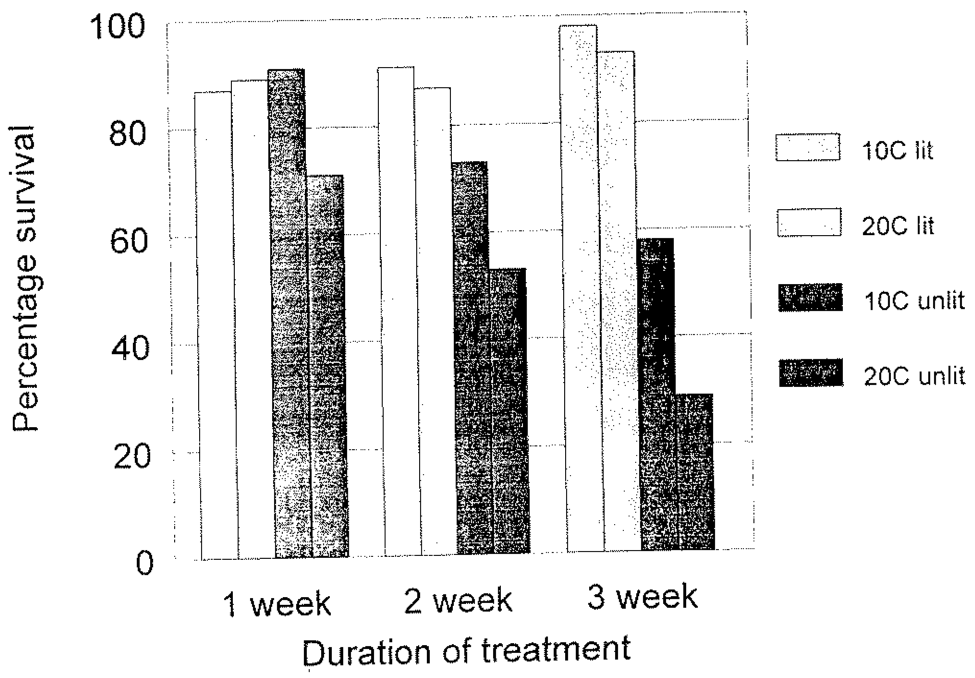


Figure 7. The effects of different chilling treatments, chilling durations imposed after pinching and lighting conditions during chilling on mean time to flowering of six *Osteospermum* cultivars.

Thus, maintaining pinched plug plants in lit cold rooms at 10°C does offer some potential to pre induce flowers. This provides a means to grow *Osteospermums* reliably in the warmer summer months, and could be used to reduce the use of greenhouse space and advance flowering. Furthermore, the chilling could be applied to plants maintained in the dark.

3.2.2 Plant survival

The main draw back with maintaining plants in the dark that they suffered a high degree of losses during chilling, compared to the lit plants (Figure 8).



The losses were greatest for plants maintained unlit for 3 weeks at 20°C. However, there were significant losses for plants maintained at 10°C in the dark for 2 and 3 weeks.

4.0 DISCUSSION AND CONCLUSION

This work has shown that a brief period of chilling can have a profound effect on the growth and flowering of *Osteospermum*. In cv. Lubutu a brief period of chilling at 9°C advanced time to flowering by up to 3 weeks. However, in cv. Sunny Girl the response to chilling was much less in terms of time to flowering, though bud numbers increased with a chilling period with no adverse effect on time to flowering. This effect also suggests that this variety is sensitive to chilling and may have pre-induced flowers after pinching in the plug stage at the propagators. The potential of pre-inducing flowering in plugs was confirmed in the second experiment. This suggests that if *pinched* plugs are bought in then apical dissection to assess whether they have initiated flowers may be useful, the presence of initiated flowers would remove the need for chilling to advance flower induction, though a brief period of chilling may be used to increase the number of flowers. This technique will have drawbacks, since the absence of initiated flowers does not confirm that the plants have been induced to flower, i.e. they could have sensed the period of cold and be in the process of initiating flowers on arrival. Certainly, records of the crops temperature prior to arrival would be useful to growers when deciding whether to chill/not to chill the plants.

In this report, we have emphasised that the chilling treatments were applied post pinching. Although we have no evidence to confirm this on *Osteospermum*, studies on other species suggest that if the plants are pinched after chilling then the response may be removed, this is because the cold stimulus is sensed at the apex.

A further advantage of chilling is that this study has shown in cv. Lubutu that it provides a means to control growth, by reducing the number of leaves initiated below the flower and therefore plant height. This strategy is therefore an adjunct to the use of growth regulators described in Part II of this report.

The drawbacks with this chilling technique is that it will not always be possible to chill the plants when outside ambient temperatures are high. Thus the technique will be limited in commercial production to batches between October and March. Our own previous experience suggests that some varieties (e.g. Zulu) will not flower at all when temperatures are greater than 18°C. However, the second experiment showed that chilling treatments can be applied to plugs in cold rooms, thus establishing a means to extend the season to summer crops. Such treatments will require specialist facilities and if plants are kept in cold stores for too long significant losses could occur.

Further work is now required to establish whether all varieties of *Osteospermum* respond to chilling, and whether brief periods of high temperature in glasshouses negate the response to the cold. Further work is also on-going at Reading to develop mathematical models to predict when the plant has been fully chilled, for example precisely how long the plant requires to commit flowers at a range of temperatures. Such work may help optimise the production of this crop and their chilling responses. This work also raises a further question as to which other crops exhibit a need for chilling. In *Osteospermum* this response was not obvious since the crop will eventually flower even if the plant is grown at a constant 15-16°C. However, time to flowering will be greater than necessary.

5.0 ACKNOWLEDGEMENTS

We would like to thank Ann Parker, Steve Adams and Mannos Kanellos for technical and general support at Reading. As well as to Richard Oliver for supporting and encouraging this research.

6.0 REFERENCES

Pearson, S., Parker, A., Hadley, P. and Kitchener, H.M. (1995). The effect of photoperiod and temperature on reproductive development of Cape daisy (*Osteospermum jucundum* cv. 'Pink Whirls'). *Scientica Horticulturae*, **62**, 225-235.

7.0 COPY OF CONTRACT

See pages 54-63 of Part III of the Report.

PART II: (1995)

EVALUATION OF A RANGE OF PLANT GROWTH REGULATORS

FINAL REPORT SEPTEMBER 1996
HDC PC 114

OSTEOSPERMUM:

EXTENDING THE SEASON OF PRODUCTION AND ENVIRONMENTAL EFFECTS ON QUALITY

A. K. FULLER
HRI EFFORD

CO-ORDINATOR: R. OLIVER

COMMENCED: FEBRUARY 1995
COMPLETED: SEPTEMBER 1995

Key words: *Osteospermum*, cultivars, plant growth regulators, Cycocel, chlormequat, Bonzi, paclobutrazol, Topflor, Flurpirimidol, B-nine, Daminozide, plant growth, flowering, quality

PART III

CONTENTS

1.0 RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

1.1 Application

Three plant growth regulators were evaluated; Cycocel, Bonzi and Topflor, for use on a range of *Osteospermum* cultivars as either a spray or drench application.

A Cycocel drench gave the most reliable and effective control of plant growth in *Osteospermum*. A drench applied when the young shoots are 1-2 cm in length at a rate of 4 ml/l Cycocel (46% ai) (applying 80 ml per 1 litre pot) gave the best results. A second application 2-3 weeks before marketing maintained good plant habit and restricted peduncle stretching in the later stages of production.

Cycocel as a spray also achieved control of growth, but repeated applications were necessary, leaf scorch increased at higher rates >4 ml/l, .

Bonzi was effective as a drench and gave long lasting results, whilst Bonzi as a spray was ineffective. Similarly in an observation with B-Nine either as a spray or drench no obvious control of growth was achieved. Topflor was very effective even at low rates and further work is required to establish both the best application method and the rate which is optimal for *Osteospermum* within this compound.

1.2 SUMMARY

In the last few years there has been considerable growth in the market for *Osteospermum* both as a bedding/patio plant and also as a pot plant. The natural habit of many cultivars is to produce a very large plant before flowering, subsequently plant quality can be poor as a result of a `straggly' plant habit which is both unattractive and very difficult to handle during production and at marketing. Trials at Efford in combination with trials on a commercial nursery were carried out to evaluate the use of chemical plant growth regulators: chlormequat (Cycocel), paclobutrazol (Bonzi) and flurprimidol (Topflor). Daminozide as B-Nine was also included as an observation. These chemicals were applied either as a drench or as a spray. Eight *Osteospermum* cultivars were grown in glasshouse compartments at Efford. Young plants were supplied from Denmark and potted in week 4 and in week 15. Thus the effectiveness of each growth regulator was assessed over a range of growing conditions under glass. Records were taken at marketing to compare plant height, pedicel length, flower number etc. In the first trial a set application procedure was adopted using controlled rates of chemical. From these results rates of applied chemical were adjusted in trial 2 as seen necessary.

1.2.1 METHODOLOGY

1995 - Trial One

Plant material was supplied from Denmark through Anglia Alpines Ltd, Cambs.

	Cultivar	Plant No. (Week 4)	Colour Code
1	Sunny Girl	245	Purple
2	Sunny Lady	245	Yellow
3	Sunny Gustav	245	Orange
4	Karl Axel Lindi	250	Blue
5	Karl Axel Zulu	250	Red
6	Karl Axel Congo	250	Green
7	Karl Axel Lubutu (Buttermilk)	250	White
8	Karl Axel Fantasy (Pink Whirls)	250	Pink

Treatments

Potting Date:

- Week 4 (K.A. Fantasy delay - arrival week 6)

Plant Growth Regulator Treatments:

1) Cycocel - chlormequat 460 g/l a.i.
2) Topflor - Flurprimidol 15 g/l a.i.
3) Bonzi - Paclobutrazol 4 g/l a.i.
4) Water - control
5) B-Nine - Daminozide 850 g/l (observation only).

Rates of Use:

		Drench mg/l^{-1} a.i.	(ml/l)	Spray mg/l^{-1} a.i	(ml/l)
1.	Cycocel	920	(2)	1840	(4)
2.	Topflor	22.5	(1.5)	45	(3)
3.	Bonzi	5	(1.25)	10	(2.5)
4.	Water - control	-	(-)	-	(-)
5.	B-Nine - observation	5000	(5.88)	3000	(3.52)

Application Treatments:

i) Drench - apply 80 ml solution per pot
ii) Spray - apply even spray to all foliage.

Application Treatments:

i) One application per cultivar when shoots were 3-4 cm in length*.
ii) One application as above and second application 21 days later, or as seen necessary.

Cultural Details

Plants were potted into 12 cm pots using VAPO B3 growing media.

Plants remained pot thick for 4 weeks after which plants were spaced to 45 pots/m^2 and at 6 weeks plants were fully spaced to 30 pots/m^2. Plants were grown with a constant heating set point of 16°C with venting at 18°C. No shading was applied, other than after spray application if the weather was very sunny.

Plants were pinched 2-3 weeks after potting (except Sunny cultivars which were delivered already pinched) to 4-5 leaves. Liquid feeding commenced 4 weeks after potting applying a 200 N: 25 P: 200 K_2O: 20 Mg feed at every watering.

1995 - Trial Two

Start Material

Plant material was supplied from Denmark through Anglia Alpines Ltd, Cambs.

	Cultivar	**Plant No. (Week 4)**	**Colour Code**
1.	Sunny Girl	245	Purple
2.	Sunny Lady	245	Yellow
3.	Sunny Gustav	245	Orange
4.	Karl Axel Lindi	250	Blue
5.	Karl Axel Zulu	250	Red
6.	Karl Axel Congo	250	Green
7.	Karl Axel Lubutu (Buttermilk)	250	White
8.	Karl Axel Fantasy (Pink Whirls)	250	Pink

Treatments

Potting Date:

- Week 15

Plant Growth Regulator Treatments:

1) Cycocel - chlormequat 460 g/l a.i.
2) Topflor - Flurprimidol 15 g/l a.i.
3) Bonzi - Paclobutrazol 4 g/l a.i.
4) Water - control

Rates of Use:

		Drench mg/l^{-1} a.i.	(ml/l)	Spray mg/l^{-1} a.i	(ml/l)
1.	Cycocel	1840	(4.0)	1840	(4.0)
2.	Topflor	15	(1.0)	45	(3)
3.	Bonzi	5	(1.25)	20	(5)
4.	Water - control	-	(-)	-	(-)

Application Treatments:

i) Drench - apply 80 ml solution per pot
ii) Spray - apply even spray to all foliage.

Application Treatments:

i) One application per cultivar when shoots were 3-4 cm in length, and repeated applications as required.

Cultural Details

Cultural practices followed the same routines as adopted in Trial One.

Plant growth assessments were taken at flowering (marketing) to assess differences in height, spread, flowering etc. Plants which reached an acceptable marketing stage and quality were then evaluated either in shelf-life or outside in a prepared bed.

1.2.2 RESULTS

- All treatments with the exception of both the B-Nine spray and drench and the Bonzi spray reduced plant growth in comparison to the control plants.

- B-Nine either as a spray or a drench was ineffective.

- Bonzi spray increased plant height slightly in comparison to the control.

- Bonzi drench controlled plant height and there was little difference in plant height between either a single or repeated application. The effect of a drench was long-lasting.

- Topflor either as a spray or a drench considerably reduced plant height and, at the rate used as a drench, growth control was excessive resulting in a stunted plant. The incidence of *botrytis* on these plants was considerably higher, especially in shelf-life.

- Cycocel either as a spray or a drench reduced plant height in comparison to the control, and repeated applications produced further and significant reductions in height. There was some leaf edge `yellowing' as a consequence of spray applications, but this was not thought to be commercially significant at marketing.

- With the exception of the Topflor treatment, there were no significant differences in flower size or colour between treatments.

- Plant growth varied between the two potting dates; the earlier planting had an increased production period (time to flowering), whereas the later planting had a shorter duration of production. PGR treated plants in the second planting reached the marketing stage approximately 5-11 days earlier than the untreated/control.

1.2.3 CONCLUSIONS

- It is recommended to use drench applications of PGRs rather than spray applications. Drenches were more effective and more uniform, and a single drench can be applied in contrast to repeated spray applications.

- The use of Cycocel as a spray or drench (at 4 ml/l) and Bonzi (1.25 ml/l) as a drench were used successfully across the range of cultivars trialled to improve plant habit and quality.

- Topflor was very effective as a growth regulator and rates below those used in this trial should be assessed further. At the rate used, growth control was `severe' and led to increased disease.

- Osteospermums have a relatively good shelf-life when marketed with 5-6 open flowers. Buds present opened successfully but their colour was paler.

2.0 EXPERIMENTAL SECTION

2.1 Introduction

The production of *Osteospermum* as a potted plant for bedding, patio and indoor use has grown rapidly over the last few years, and in 1993 it was estimated that over 2 million plants were sold.

The natural habit of many cultivars is to produce a tall plant before flowering, subsequently plant quality at marketing can be poor as a result of `leggy' plant growth. Chemical plant growth regulators (PGRs) are used widely within the ornamental industry to control plant growth and meet quality specifications. To date, no information is available on the use of PGRs on *Osteospermum*. Therefore trials at Efford in 1995 were carried out to evaluate the use of three PGRs on a range of commercially grown *Osteospermum* cultivars. Using either a drench or spray application, their use was examined on two crops; an early spring potting (late January) and a late spring potting (late April). In the first of the two trials a standard application procedure was maintained to establish the effectiveness of each PGR to control plant growth. In the second trial, the rate of application of each PGR was varied to examine their efficiency and practical use for the grower.

2.2 OBJECTIVES

- To investigate the optimal use of plant growth regulators for growth control to maximise plant quality.
- To evaluate the use of three PGRs on eight *Osteospermum* cultivars at two potting dates; early and late season.
- To examine the use of either a drench or spray application with either a single or repeated application.
- To assess the beneficial/detrimental effects of PGRs upon the shelf-life/garden performance of plants.

2.3 MATERIALS AND METHODS

1995 - Trial One

2.3.1 Site

Three compartments of the multifactorial glasshouse unit, K-Block, were used for the trial.

2.3.2 Start Material

Plant material was supplied from Denmark through Anglia Alpines Ltd, Cambs.

	Cultivar	Plant No. (Week 4)	Colour Code
1.	Sunny Girl	245	Purple
2.	Sunny Lady	245	Yellow
3.	Sunny Gustav	245	Orange
4.	Karl Axel Lindi	250	Blue
5.	Karl Axel Zulu	250	Red
6.	Karl Axel Congo	250	Green
7.	Karl Axel Lubutu (Buttermilk)	250	White
8.	Karl Axel Fantasy (Pink Whirls)	250	Pink

2.3.3 Treatments

Potting Date:

- Week 4 (K.A. Fantasy delay - arrival week 6)

Plant Growth Regulator Treatments:

1) Cycocel - chlormequat 460 g/l a.i.
2) Topflor - Flurprimidol 15 g/l a.i.
3) Bonzi - Paclobutrazol 4 g/l a.i.
4) Water - control
(5) B-Nine - Daminozide 850 g/l (observation only.)

		Drench mg/l^{-1} a.i.	(ml/l)	Spray mg/l^{-1} a.i	(ml/l)
1.	Cycocel	920	(2)	1840	(4)
2.	Topflor	22.5	(1.5)	45	(3)
3.	Bonzi	5	(1.25)	10	(2.5)
4.	Water - control	-	(-)	-	(-)
5.	B-Nine - observation	5000	(5.88)	3000	(3.52)

Application Treatments:

i) Drench - apply 80 ml solution per pot
ii) Spray - apply even spray to all foliage.

Application Treatments:

i) One application per cultivar when shoots were 3-4 cm in length*.
ii) One application as above and second application 21 days later, or as seen necessary*.

* records of dates of application are given in Appendix III.

Shelf-life/Garden Performance:

Plants from each plot which reached the marketing stage were assessed for shelf-life over a 3 week period. Shelf-life Environment: 1000 lux light level for 12 hours a day provided by cool white fluorescent strip lighting, 20°C day and night, 60-65% RH.

In addition, plants from each plot were planted outside in a prepared bed (50 cm x 50 cm spacing).

2.3.4 Experimental Design

8 cultivars
x
4 PGRs (inc. control)
x
2 application techniques (spray or drench)
x
2 applications (one and/or two)
---
128 plots - 12 plants per plot, of which 6 were recorded.

The layout of treatments within the glasshouse compartments are given in Appendix I.

2.3.5 Cultural Details

Plants were potted into 12 cm pots using a VAPO B3 growing media.

Plants remained pot thick for 4 weeks after which plants were spaced to 45 pots/m² and at 6 weeks fully spaced to 30 pots/m². Plants were grown with a constant heating set point of 16°C with venting at 18°C. No shading was applied, other than after spray application if the weather was very sunny.

Plants were pinched 2-3 weeks after potting (except Sunny cultivars which were delivered already pinched) to 4-5 leaves. Liquid feeding commenced 4 weeks after potting applying a 200 N: 25 P: 200 K_2O: 20 Mg feed at every watering.

Liquid feed applied:

Stock Solution	g/l
Mono Ammonium Phosphate	9.0
Potassium Nitrate	87.0
Calcium Nitrate	63.0
Ammonium Nitrate	28.0
Magnesium Nitrate	20.0

applied at 1:200 dilution.

Further details are given in the Crop Diary, Appendix II.

2.3.6 Experimental Records

Plant Growth Records:

Record any visible plant scorch 5 days after each application of PGR.

At marketing per cultivar:

Time to marketing (50% flowering: 3-4 open flowers)
Plant height: pot rim to canopy top
Plant height: pot rim to tallest flower
Plant spread x 2
Flower No./Bud No.
Flower size/diameter
Flower colour
Number of shoots
Plant quality

Shelf-life:

Records weekly for three weeks:
Foliage colour
Flower No./Bud No.
Flower colour
Plant quality

2.4 MATERIALS AND METHODS

1995 - Trial Two

2.4.1 Site

Two compartments of the multifactorial glasshouse unit, K-Block, were used for the trial at Efford.

2.4.2 Start Material

Plant material was supplied from Denmark through Anglia Alpines Ltd, Cambs.

Cultivar	Plant No. (Week 4)	Colour Code
1. Sunny Girl	245	Purple
2. Sunny Lady	245	Yellow
3. Sunny Gustav	245	Orange
4. Karl Axel Lindi	250	Blue
5. Karl Axel Zulu	250	Red
6. Karl Axel Congo	250	Green
7. Karl Axel Lubutu (Buttermilk)	250	White
8. Karl Axel Fantasy (Pink Whirls)	250	Pink

2.4.3 Treatments

Potting Date:

- Week 15

Plant Growth Regulator Treatments:

1) Cycocel - chlormequat 460 g/l a.i.
2) Topflor - Flurprimidol 15 g/l a.i.
3) Bonzi - Paclobutrazol 4 g/l a.i.
4) Water - control

Rates of Use:

		Drench mg/l⁻¹ a.i.	(ml/l)	Spray mg/l⁻¹ a.i	(ml/l)
1.	Cycocel	1840	(4.0)	1840	(4.0)
2.	Topflor	15	(1.0)	45	(3)
3.	Bonzi	5	(1.25)	20	(5)
4.	Water - control	-	(-)	-	(-)

Application Treatments:

i) Drench - apply 80 ml solution per pot
ii) Spray - apply even spray to all foliage.

Application Treatments:

i) One application per cultivar when shoots were 3-4 cm in length, and repeated applications as required*.

* records of dates of application are given in Appendix III.

Shelf-life/Garden Performance:

Plants from each plot which reached marketing stage were assessed for shelf-life over a 3 week period. Shelf-life Environment: 1000 lux light level for 12 hours a day provided by cool white fluorescent strip lighting, 20°C day and night, 60-65% RH.

In addition plants from each plot were planted outside in a prepared bed (50 cm x 50 cm spacing).

2.4.4 Experimental Design

8 cultivars
x
4 PGRs (inc. control)
x
2 application techniques (spray or drench)
---
64 plots - 18 plants per plot, of which 6 were recorded.

The layouts of treatments within the glasshouse compartments are given in Appendix I.

2.4.5 Cultural Details

Cultural practices followed the same routines as adopted in Trial One.

2.4.6 Experimental Records

Plant Growth Records:

Records were made at visible plant scorch 5 days after each application of PGR.

At marketing per cultivar:

Time to marketing (50% flowering: 3-4 open flowers)
Plant height: pot rim to canopy top
Plant height: pot rim to tallest flower
Plant spread x 2
Flower No./Bud No.
Flower size/diameter
Flower colour
Number of shoots
Plant quality

Shelf-life (Garden Performance):

Records weekly for three weeks:
Foliage colour
Flower No./Bud No.
Flower colour
Plant quality

Photographic Records:

At the marketing stage, comparative photographs for each treatment per cultivar were taken.

3.0 Results

3.1 Trial One

Full records of results are given in Appendix IV.

3.1.1 Plant Height

Table 1 shows the percentage reduction in plant height for each PGR treatment. Topflor as either a drench or a spray at the rates used gave in excess of a 60% reduction in height (drench 80%). The only treatment which failed to achieve any control of height was a Bonzi spray which, in the cultivars Sunny Gustav, Sunny Girl, Lindi and Congo, caused a slight increase in final plant height in comparison to the control.

Table 1: Percentage reduction in plant height

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi drench	36	52	13	47	69	42	47	50	**44.5**
Bonzi spray	+13	0	+11	+7	21	+5	145	5	**0**
Cycocel drench	39	41	31	31	23	39	35	39	**34.7**
Cycocel spray	11	28	22	23	29	28	31	15	**23.4**
Topflor drench	-	80	85	77	-	-	-	74	**79.0**
Topflor spray	62	38	73	52	73	67	75	37	**59.6**

3.1.2 Plant Spread

Similar results in plant spread were obtained, Topflor giving the greatest reduction in plant spread (22.5%), whilst Cycocel gave a 13.2% and Bonzi only a 2.7% reduction in plant spread (Table 2).

Table 2: Percentage reduction in plant spread

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi	+9	11	21	24	16	-	-	9	**2.7**
Cycocel	4	14	32	15	-	-	-	13	**13.2**
Topflor	39	40	73	38	10	-	-	36	**22.5**

3.1.3 Pedicel Length

All PGRs achieved some reduction in pedicel length in comparison to the control (Table 3). The cultivars Lindi, Zulu, Fantasy and the Sunny cultivars were more responsive to treatments.

Table 3: Percentage reduction in pedicel length

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi	14	18	11	34	23	13	5	37	**19.4**
Cycocel	30	31	40	34	28	11	20	16	**26.2**
Topflor	34	33	50	55	65	32	66	40	**46.9**

3.1.4 Number of Flowers and Buds

Topflor tended to delay flowering slightly, whilst Bonzi appeared to reduce the overall flowering capacity. There were no consistent differences between Cycocel treated and untreated plants (Table 4).

Table 4: Number of flowers and buds

Cultivar	Sunny Gustav		Sunny Lady		Sunny Girl		Lindi		Zulu	
	Flowers	Buds	Flowers	Buds	Flowers	Buds	Flowers	Buds	Flowers	Buds
Treatment										
Bonzi	2.3	2.2	1.2	2.8	1.3	1.3	3.5	7.5	1.7	4.8
Cycocel	1.5	2.1	1.2	2.7	1.1	1.4	6.0	9.3	2.3	6.6
Topflor	1.5	1.3	1.4	2.3	1.7	1.9	3.9	8.6	0.2	2.9
Control	2.8	4.7	1.4	3.8	1.1	1.4	6.1	6.1	2.9	5.7

Table 4 (Continued): Number of flowers and buds

Cultivar	Congo		Lubutu		Fantasy		Mean	
	Flowers	Buds	Flowers	Buds	Flowers	Buds	Flowers	Buds
Treatment								
Bonzi	2.2	4.0	2.8	4.8	1.5	4.6	**2.1**	**4.0**
Cycocel	2.3	5.0	2.0	5.6	1.8	6.3	**2.3**	**4.9**
Topflor	2.0	5.1	0	2.3	1.7	4.6	**1.3**	**5.4**
Control	2.3	3.8	3.9	5.6	1.8	6.1	**2.8**	**4.6**

3.1.5 Flower Size

There were no large differences in flower size between each treatment with the exception of Cycocel which resulted in a slight increase in flower size in comparison to the control (Table 5).

Table 5: Mean Flower Size (mm)

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi	47.0	73.3	80.8	91.5	87.7	78.3	-	59.5	**74.0**
Cycocel	60.4	72.5	81.9	89.0	85.0	78.1	82.8	65.0	**76.8**
Topflor	62.1	66.5	72.7	84.7	-	82.4	-	63.2	**73.6**
Control	63.9	73.1	73.6	86.2	85.6	-	-	63.7	**74.3**
Mean	**58.3**	**71.3**	**60.7**	**87.8**	**86.1**	**79.6**	**82.8**	**62.8**	

3.1.6 Number of Main Shoots

Topflor reduced the number of shoots slightly in comparison to the untreated plants. The cultivars Sunny Gustav, Sunny Lady and Lubutu all had the most shoots - over 3 per plant (Table 6).

Table 6: Mean number of main shoots per plant

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi	4.5	4.0	2.8	1.9	2.7	3.0	3.3	2.3	**3.1**
Cycocel	4.1	4.2	3.0	2.0	2.8	2.5	3.6	2.5	**3.1**
Topflor	3.7	2.8	2.6	2.2	2.7	2.3	2.9	2.0	**2.6**
Control	4.7	4.4	3.4	2.6	2.8	3.2	3.4	2.4	**3.4**
Mean	**4.2**	**3.8**	**2.9**	**2.2**	**2.7**	**2.7**	**3.3**	**2.3**	

3.1.7 Plant Quality

Without the use of PGRs plant growth tended to be very tall, leading to poorer plant quality as a result. The Sunny cultivars were noticeably more compact in their habit, but it is thought that as these plants were received pre-pinched it is likely they had already been treated with a PGR. Cycocel drenching generally gave the best quality plants.

3.2 Trial Two

Full records of results are given in Appendix V and treatment comparisons are shown in colour plates 1 to 9, Appendix VI.

3.2.1 Plant Height

Topflor drench achieved the greatest reduction in height at the rates used in this trial, on average over 58% reduction in height. Drench applications were more effective than sprays, and in some instances spray applications of Bonzi increased final plant height (Sunny Lady and Sunny Gustav). See table 7.

Table 7: Percentage reduction in plant height

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi drench	24	33	35	31	58	9	37	45	**34.0**
Bonzi spray	+25	+15	1	5	28	+3	2	22	**1.2**
Cycocel drench	7	12	17	26	37	59	52	46	**32.0**
Cycocel spray	15	+7	19	12	38	37	42	45	**25.1**
Topflor drench	54	36	58	47	54	72	67	80	**58.5**
Topflor spray	30	2	37	6	60	63	50	61	**38.6**

3.2.2 Plant Spread

Table 8 shows the mean plant spread at marketing for each treatment. Topflor as either a spray or a drench had the greatest effect, reducing plant spread by on average 82 mm and 138 mm respectively. Generally, drench applications were more effective than spray applications.

Table 8: Mean Plant Spread (mm)

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi drench	188	134	176	278	139	412	226	282	**229**
Bonzi spray	245	205	252	332	194	392	270	335	**278**
Cycocel drench	235	148	224	288	178	271	245	288	**234**
Cycocel spray	195	214	239	310	163	328	222	353	**253**
Topflor drench	113	120	133	238	160	153	195	164	**159**
Topflor spray	172	156	166	316	135	266	239	273	**215**
Control	210	227	258	340	228	450	269	395	**297**

3.2.3 Pedicel Length

Bonzi drench brought about the greatest reduction in pedicel length across treatments, by 28.5 mm. A similar reduction was achieved using Topflor as a drench. Spray applications of each PGR gave some control of pedicel length (table 9).

Table 9: Comparison of pedicel length between PGR treatments

Cultivar	**Sunny Gustav**	**Sunny Lady**	**Sunny Girl**	**Lindi**	**Zulu**	**Congo**	**Lubutu**	**Fantasy**	**Mean**
Treatment									
Bonzi drench	46	50	48	59	53	32	63	57	**51.0**
Bonzi spray	66	78	89	88	54	53	82	77	**73.4**
Cycocel drench	39	46	77	42	50	120	69	87	**66.2**
Cycocel spray	67	65	73	44	45	107	62	74	**67.1**
Topflor drench	35	40	29	42	49	95	79	74	**55.4**
Topflor spray	51	63	66	65	43	142	78	87	**74.4**
Control	63	70	98	100	66	88	86	65	**79.5**

3.2.4 Number of Flowers and Buds

There were no consistent differences in either the number of open flowers or buds between treatments. However, Topflor treatments, particularly as a drench, delayed flowering slightly. Cycocel and Topflor, both as a spray, increased the mean number of flower buds at marketing in comparison to the control, untreated plants (Table 10).

Table 10: Number of flowers and buds

Cultivar	Sunny Gustav		Sunny Lady		Sunny Girl		Lindi		Zulu	
	Flowers	Buds	Flowers	Buds	Flowers	Buds	Flowers	Buds	Flowers	Buds
Treatment										
Bonzi drench	6.8	7.8	2.0	4.5	1.5	0.8	3.7	7.8	1.7	9.8
Bonzi spray	4.8	3.5	2.3	3.7	3.0	2.5	4.3	9.8	3.0	13.3
Cycocel drench	3.2	10.0	2.5	5.2	2.5	2.3	3.8	9.5	2.5	10.3
Cycocel spray	7.0	7.2	2.2	4.8	1.5	2.3	4.2	12.7	1.8	11.8
Topflor drench	5.0	10.8	1.7	3.0	2.0	2.0	4.3	11.8	3.5	4.7
Topflor spray	5.2	12.8	3.5	5.3	2.3	4.2	2.8	8.2	1.2	9.8
Control	7.5	9.2	3.0	4.3	2.3	1.8	2.3	8.7	3.3	13.5

Table 10 (Continued): Number of flowers and buds (Continued)

Cultivar	Congo		Lubutu		Fantasy		Mean	
	Flowers	Buds	Flowers	Buds	Flowers	Buds	Flowers	Buds
Treatment								
Bonzi drench	0	7.0	1.8	9.3	1.3	6.5	**2.35**	**6.69**
Bonzi spray	0	2.0	3.2	6.0	1.5	6.0	**2.76**	**5.85**
Cycocel drench	3.3	5.7	1.3	5.3	2.2	6.0	**2.66**	**6.79**
Cycocel spray	2.7	2.8	1.0	8.2	2.7	7.3	**2.88**	**7.14**
Topflor drench	1.3	6.3	1.3	1.3	1.2	3.3	**2.53**	**5.40**
Topflor spray	1.8	3.2	2.8	7.8	1.5	5.7	**2.64**	**7.77**
Control	0.2	2.7	2.8	7.2	0	2.7	**2.67**	**6.26**

3.2.5 Flower Size

There were no differences in flower size between treatments (Table 11).

Table 11: Mean Flower Size (mm) at Marketing

Cultivar	Sunny Gustav	Sunny Lady	Sunny Girl	Lindi	Zulu	Congo	Lubutu	Fantasy	Mean
Treatment									
Bonzi drench	62	70	87	80	72	-	79	64	**73.4**
Bonzi spray	61	73	84	85	79	-	78	63	**74.7**
Cycocel drench	63	72	81	82	80	82	78	66	**75.5**
Cycocel spray	63	72	86	88	71	80	75	70	**75.6**
Topflor drench	64	69	82	85	80	73	85	65	**75.4**
Topflor spray	62	69	85	82	66	83	82	66	**74.4**
Control	62	72	83	82	79	73	79	-	**75.7**

3.2.6 Number of Main Shoots per Plant

There were no differences in the number of main shoots per plant between the different PGR treatments.

3.2.7 Plant Quality

The Sunny cultivars were naturally more compact in their habit, and even without any PGR treatment plants were marketable. All PGR treatments with the exception of Bonzi as a spray restricted plant growth and increased plant quality at marketing. Topflor as a drench produced a 'stunting' effect which led to a reduction in plant quality.

3.2.8 Shelf-life

There were no consistent effects of the treatments during shelf-life or garden performance overwinter, other than that compact plants remained so. Detailed data are therefore not presented further.

4.0 DISCUSSION

Without the use of some method of growth regulation, the natural habit of many *Osteospermum* cultivars is to produce a tall 'leggy' plant of poor marketable quality. Thus this trial at Efford examined the use of different chemical plant growth regulators which could be used by growers; Cycocel, Bonzi, B-Nine and Topflor, although Topflor (flurprimidol) is not registered for use in the UK at present.

Using two potting dates, an early and late spring potting, the effectiveness of treatments was evaluated over different growing conditions. As such in trial one potted in week 4, production time was up to 14-15 weeks in contrast to the later potting in week 15 where plants flowered as early as 8 weeks after potting. Therefore, the rate and application frequency will need to be varied between cultivars and at different times of the year.

In both trials Cycocel applied as a drench at 4 ml/l gave the best uniformity and control of growth. Although spray applications of Cycocel did produce a reduction in plant height, more frequent applications were necessary and their effectiveness was not always as obvious as with a drench. Also, some spray damage was visible at the higher rates of use, 4 ml/l, causing leaf yellowing, although new growth tended to hide earlier leaf damage.

Bonzi only appeared effective as a drench. Using Bonzi as a spray, even at higher than recommended rates (5 ml/l) had a minimal effect and in some cases final plant height increased in comparison to untreated plants. Bonzi drench gave a reduction in final plant height and is a viable option. However, using a drench gave a more 'long lasting' effect, and did cause an excessive reduction in growth in the cultivar Zulu. Overall, Bonzi as a drench appeared to give less flexibility in its use in comparison to Cycocel, although less chemical was required to achieve satisfactory growth control. It may also be possible to reduce the rate used, but this will increase the need for accuracy of application by the grower to ensure all parts receive the same quantity of solution.

Topflor is a relatively new product which is used in continental Europe as a plant growth regulator. There were no recommended rates for this product. The results from both trials showed that Topflor is a very effective growth regulator and even at very low rates of use growth control can be achieved. At only 1 ml/l as a drench plant growth was stunted in all cultivars and the dense canopy resulted in an increased incidence of *botrytis*. As a spray Topflor was used successfully to produce a marketable plant. At a rate of 3 ml/l good control of growth was achieved, although accuracy and uniformity of application is essential to achieve a uniform result. The dramatic reduction in plant growth tended to produce a very compact plant which could be used to create a different product for marketing. Flower size was reduced slightly in some cases, and there appeared to be a delay in reaching the marketing stage (3-4 open flowers) when using Topflor as a drench.

Finally, B-Nine was included in the trial as an observation only. Both as a spray and a drench using recommended rates, it proved ineffective in controlling plant growth to produce a high quality plant at marketing. Further work may be necessary to evaluate higher rates of application, but the increased chemical costs may be uneconomic for commercial use.

In summary, using Cycocel gave the most flexible control of plant growth. A drench application soon after potting when the shoots are only 3-4 cm should be adequate, although further treatments could be applied but no later than 2-3 weeks before sale. This is particularly important if spray application is preferred so as to allow time for any leaf scorch to disappear before sale. Although a rate of 4 ml/l gave good results in these trials it is recommended to test a small number of plants before treating them all to assess the effect. It appeared from this trial that more applications were required earlier in the season when production time was great, whilst less PGRs were required for later pottings which naturally flowered much earlier. In particular, the Sunny cultivars required very little PGR treatment, although it is thought these plants received a PGR drench in the plug tray before plants were received for the trial.

5.0 CONCLUSIONS

- It is recommended to use drench applications of PGRs rather than spray applications. Drenches were more effective and more uniform, and a single drench can be applied in contrast to repeated spray applications.

- The use of Cycocel as a spray or drench (at 4 ml/l) and Bonzi as a drench (at 1.25 ml/l) was used successfully across the range of cultivars trialled to improve plant habit and quality.

- Topflor was very effective as a growth regulator and rates below those used in this trial should be assessed further. At the rates used growth control was `severe' and led to an increased disease risk with a more dense foliage.

- Osteospermums have a relatively good shelf-life when marketed at a later stage with 5-6 open flowers. Buds present successfully opened but their colour was paler.

7.0 COPY OF CONTRACT

See pages 54-63 of Part III of the Report.

PART III: (1995)

COMMERCIAL TRIAL: EVALUATION OF TEMPERATURES, LIGHTING AND PLANT GROWTH REGULATORS

FINAL REPORT SEPTEMBER 1996
HDC PC 114

OSTEOSPERMUM:

EXTENDING THE SEASON OF PRODUCTION AND ENVIRONMENTAL EFFECTS ON QUALITY

H.M. KITCHENER
ADAS HUNTINGDON

CO-ORDINATOR: R. OLIVER

COMMENCED: FEBRUARY 1995
COMPLETED: SEPTEMBER 1995

PART III

CONTENTS

1.0 RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

1.1 Application

Two temperature and two lighting regimes were evaluated to evaluate the effect on the harvest period.

Plants given 16°C day/night without lighting flowered earlier than those given lighting at 2500 lux for 16 hours a day. The higher temperature may have delayed flowering.

Ambient 9°C temperatures delayed flowering.

Two plant growth regulators were used: Cycocel and Topflor as drenches as required by plant growth.

Topflor delayed flowering.

1.2 Summary

Osteospermum grown to a pot plant specification need to be grown with plant growth regulators. Early production of quality product normally has a premium market price.

The commercial trial showed that low/ambient temperatures min. 9°C with no heating delays flowering by 4 weeks and hardens growth.

Growing at 16°C day/night produces plants of good quality in 12 weeks.

The use of assimilation lighting at 2500 lux with 16°C day/night temperature delayed flowering by 5 to 7 days.

All plant growth regulators were applied as drenches. Topflor produced very short compact plants. Cycocel produced good commercial product.

Sunny varieties flowered earlier than the Carl Axel.

2.0 MATERIALS AND METHODS

2.1 Introduction

The production of *Osteospermum* as a pot plant as against a perennial plant in sheltered gardens has increased the number sold in the spring and early summer to two million plus in the UK.

The plant flowers naturally outside in late spring and in the autumn as the soil cools after summer. To produce a pot plant crop programming to specification is important. The habit of the species varies but it is normal for internodes to be long thus the natural shape precludes its use as a pot plant without adaptation.

Commercial production of cuttings in Denmark has indicated that best production of cutting numbers is under long days i.e. 16-18 hours and at temperatures of over 20°C to maintain vegetated production.

The trial was designed to produce commercial product in the minimum of time. The specification was 18-25 cm tall above the pot and 12-18 cm wide with 4 to 5 shoots.

2.2 Objectives

To evaluate the use of two chemical plant growth regulators on six *Osteospermum* cultivars under commercial conditions.

To assess the affect of growing the crop under protection with 3 temperature regimes.

To assess the affects of the treatments on the quality of the harvested plants.

Specification plant 15-18 cm high above the pot, 12-15 cm wide with 4-5 shoots, harvesting when 3 or more flowers are open with plenty of buds to follow.

2.3 Site

Heated and heat assisted glasshouses at Anglia Alpines, St Ives Road, Somersham, Cambs.

2.4 Start Material

Plant material was supplied from Denmark to Anglia Alpines as rooted cuttings.

Cultivars	**Wk**	
Sunny Lady (Lilac)	4	)
Sunny Girl (Rose)	4	) stopped
Sunny Gustav (White)4	4	)
Carl Axel Zulu (Yellow)	4	
Buttermilk	4	
Pink Whirls (Fantasy)	6	

2.5 Treatments

1) Plants were lit with assimilation lighting for 16 hours a day from potting to harvest as required and grown at 16°C day light, ventilation 18°C. Lit till flowering when light level was below 2500 lux.

2) Plants grown without assimilation lighting at 16°C day light, ventilation 18°C.

3) Plants grown at ambient glasshouse temperature without heating as near 9°C as possible.

Two plant growth regulators were used, these were:-

1) Cycocel (Chlormequat) 460 g/l ai

2) Topflor (Flurpirimadol) 15 g/l ai

2.6 Crop Details

<u>Potting Dates - 13 cm pots</u>

Week 3/4:

Sunny Lady
Sunny Girl
Sunny Gustav
Zulu
Buttermilk

Week 6:

Pink Whirls

The plants were potted in week 3 for the cultivars Sunny Lady, Sunny Girl, Sunny Gustav, Zulu and Buttermilk and week 6 Pink Whirls.

The Sunny varieties had already been stopped, Zulu stopped with Buttermilk in week 5 and Pink Whirls at week 7.

The temperatures, lit plants and heated plants, 16°C, ventilation at 18°C day/night throughout the crop's life.

Plants grown at ambient were not heated but the temperature was kept to as near 9°C as possible.

Plant growth regulator application.

Plant Growth Regulator Treatments

Week No. **Variety**	**6**	**7**	**8**	**9**	**10**
Sunny Lady		HL, A	H		
Sunny Girl	HL	A	H		
Sunny Gustav	HL	A	HL		
Carl Axel Zulu		HL			
Buttermilk		HL			
Pink Whirls		HL			

H = Heated
L = Heated and Lit
A = Ambient

Topflor 3 ml/l	5 l/m^2 of solution
Cycocel 5 ml/l	5 l/m^2 of solution

3.0 RESULTS

The plants treated with Topflor were delayed and some suffered badly with Botrytis. The Sunny types flowered earlier than the Carl Axel types.

3.1 Plants heated to 16°C day/night and showing week number, height, width and number of flowers with assimilation lighting 16 hours a day at 2500 lux

Table 1

Heated with assimilation lighting

	Topflor						Cycocel					
	Height		Width		No flowers		Height		Width		No flowers	
Variety	Week 15	Week 17	Week 15	Week 17	Week 15	Week 17	Week 15	Week 17	Week 15	Week 17	Week 15	Week 17
Sunny Lady	14.1	-	13.1	-	1.6	-	18.1	-	22.9	-	4.8	-
Sunny Girl	12.2	-	13.3	-	0.9	-	18.9	-	23.5	-	2.4	-
Sunny Gustav	13.0	-	14.3	-	0.5	-	20.4	-	24.5	-	3.3	-
Zulu	-	7.9	-	6.6	-	-	-	11.7	-	10.0	-	0.7
Buttermilk	-	9.5	-	8.1	-	-	-	30.6	-	18.3	-	2.3
Pink Whirls	-	13.0	-	9.9	-	0.3	-	29.0	-	23.9	-	4.5
Mean	**13.1**	**10.0**	**13.6**	**8.2**	**1.0**	**0.1**	**19.1**	**23.8**	**23.6**	**17.4**	**3.5**	**2.5**

Table 1 shows plants heated 16°C day/night, vent 18°C with lighting 16 hours a day at 2500 lux.

The stopped Sunny varieties flowered 2 weeks earlier than the Carl Axel types, weeks 15 and 17 respectively.

3.2 Plants heated to 16°C day/night vent 18°C without lighting

Table 2

Heated with no assimilation lighting

Variety	Topflor Height Week 14	Topflor Height Week 16	Topflor Width Week 14	Topflor Width Week 16	Topflor No flowers Week 14	Topflor No flowers Week 16	Cycocel Height Week 14	Cycocel Height Week 16	Cycocel Width Week 14	Cycocel Width Week 16	Cycocel No flowers Week 14	Cycocel No flowers Week 16
Sunny Lady	14.7	-	10.9	-	2.9	-	17.1	-	21.7	-	3.9	-
Sunny Girl	11.3	-	14.9	-	0.6	-	12.2	-	20.6	-	2.5	-
Sunny Gustav	10.9	-	14.1	-	0.8	-	16.9	-	21.7	-	2.5	-
Zulu	Botrytis		Botrytis		-	-	-	12.5	-	19.4	-	2.2
Buttermilk	Botrytis		Botrytis		-	-	-	22.1	-	24.1	-	1.4
Pink Whirls	-	12.8	-	9.9	-	0.5	-	24.2	-	21.5	-	4.1
Mean	**12.3**	**12.8**	**13.3**	**9.9**	**1.4**	**0.5**	**15.4**	**19.6**	**21.3**	**21.7**	**3.0**	**2.6**

Table 2 shows that the unlit plants at 16°C flowered weeks 14 and 16 respectively 7 days earlier for each type.

The lit plants were taller but the width was less. The number of flowers open was little changed.

One or two flowers make a saleable plant.

Without the extra heat from the lighting Botrytis was present on the Topflor treatment of non-lit plants.

Topflor made all plants very compact. Moisture formed within the compact plants causing Botrytis to form on soft growth.

3.3 Plants grown at minimum of 9°C

Table 3

Ambient temperatures minimum 9°C

Variety	Topflor Height Week 19	Topflor Height Week 20	Topflor Width Week 19	Topflor Width Week 20	Topflor No flowers Week 19	Topflor No flowers Week 20	Cycocel Height Week 19	Cycocel Height Week 20	Cycocel Width Week 19	Cycocel Width Week 20	Cycocel No flowers Week 19	Cycocel No flowers Week 20
Sunny Lady	10.8	-	11.6	-	2.3	-	14.3	-	17.4	-	4.8	-
Sunny Girl	11.6	-	9.7	-	0.9	-	18.4	-	20.6	-	4.8	-
Sunny Gustav	10.9	-	9.6	-	1.1	-	20.5	-	18.3	-	3.5	-
Zulu	-	21.0	-	14.4	-	0.7	-	25.1	-	16.0	-	0.5
Buttermilk	-	33.7	-	19.6	-	5.1	-	34.9	-	17.8	-	4.7
Pink Whirls												
Mean	**11.1**	**27.4**	**10.3**	**17.0**	**1.4**	**2.9**	**17.7**	**30.0**	**18.8**	**16.9**	**4.4**	**2.6**

Table 3 shows the results from the ambient treatment.

Pink Whirls did not flower before the completion date i.e. week 21.

The effect of Topflor was to make plants more compact whilst Cycocel plants of a more acceptable height.

The ambient treatments were delayed 5 weeks over the heated treatments.

4.0 DISCUSSION

Osteospermum is a very sensitive plant to temperature. The slight rise in temperature of the 16°C lit treatment due to leaf temperature rise due to the lights delayed flowering by one week, when the plants were lit from potting to harvest when required.

The crop grown at ambient 9°C was delayed 5 weeks at harvest compared to the earliest plants in the treatment which was heated and had no assimilation lighting, thus treatment 3 crop grown at ambient 9°C is not considered a commercial option. The cost of delay per m^2 in modern glass is prohibitive. In old glass with little or no heating this could be an option.

Topflor may be effective at lower rates or as a spray.

Cycocel drenches gave the best results but good timing of application is necessary to maintain good plant shape. The timing should be judged against the possible weather in the future and anticipated growth i.e. plants should be held back by early application of a drench with each drench being timed when the shoots show young growth or lighter colour (lighter green) at the shoot tip. Cycocel as with other plant growth regulators tends to darken the foliage. When the plants are coming out of the effect of the plant growth regulator they become lighter in colour at. Final application should be applied of the plant growth regulator as pedicel lengthens when the pedicel is no more than 2-3 cm long.

Temperature at application appears to affect both Cycocel and Topflor on *Osteospermum*. The higher the temperature the greater the effect up to 20°C.

Higher heat temperatures from assimilation lighting may delay flowering at a given air temperature.

5.0 CONCLUSIONS

Osteospermum varieties react differently to plant growth regulators. Each cultivar should be treated as an individual. They are also very temperature sensitive and low temperatures delay flowering whilst high temperatures over 16°C have a similar affect.

All cultivars require plant growth regulators to control height so the plant can be sold as a pot plant.

6.0 ACKNOWLEDGEMENTS

The author of Section 3 would like to thank Anglia Alpines of Somersham, Cambs and the HDC for their support of the work.

7.0 COPY OF CONTRACT

Contract between ADAS, University of Reading and HRI (hereinafter called the "Contractors") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

1. TITLE OF PROJECT

Contract No: PC 114
Contract date: 24.4.95

OSTEOSPERMUM: EXTENDING THE SEASON OF PRODUCTION AND EXAMINATION OF ENVIRONMENTAL EFFECTS ON QUALITY

2. BACKGROUND AND COMMERCIAL OBJECTIVES

Osteospermum is an increasingly popular half hardy ornamental. During 1993, an estimated 2 million plants were sold and the size of the market appears to be increasing rapidly. Unfortunately, the market season for *Osteospermum* is largely limited by the fact that most varieties virtually cease flowering during the warmer summer months. The production of later flowering plants, or even earlier ones, would have great potential for increasing the size of the market. However, to date, there has been little experimental work conducted to determine the optimal cultural for *Osteospermum*, either in the UK or Europe. Some progress has been made in preliminary work at Reading and this needs to be followed-up by more detailed investigation.

The commercial objectives are threefold:

1) The production of plants with minimal heat input for reliable production throughout the early Spring, Summer and Autumn.

2) To develop techniques to minimise the duration of crop production and increase throughput.

3) Investigate the optimal use of plant growth regulators for growth control to maximise plant quality.

3. FINANCIAL BENEFITS TO THE INDUSTRY

The potential benefits to the industry are always difficult to quantify, but may be great in this instance. Increasing the size of the market by 10%, by extending the season would increase production by about 200,000 units, which equates to ≈ £0.5M per annum. It is felt that such a growth is possible because this crop *Osteospermum* has received considerable media attention over the last three years. However, this work will have an additional benefit, since our preliminary experiments have shown that a reduction in the duration of the production from about 10 weeks at present to 6 weeks or less is possible. This would dramatically increase output as well as reducing overheads and fuel costs. If such a gain could be achieved commercially then individual growers could increase output by 20-25%.

4. SCIENTIFIC/TECHNICAL TARGETS

A number of technical and practical problems remain to be solved to fulfil the commercial objectives. These can be summarised as follows in terms of scientific objectives:

1) Do all cultivars require vernalization and if so how long do they need exposure to cold?

2) Is 12°C the optimum commercial temperature for cold exposure?

3) What is the optimum commercial temperature for finishing the crop post-vernalization?

4) Can the vernalization treatment be applied to cold stored cuttings (rooted in plugs)? If such a treatment can be applied then it would have great potential. Firstly, vernalization treatments could be applied easily during the summer when outside temperatures are too warm. Thus, growers would be able to extend the season. Secondly, cold stored treatments would reduce the duration of time required in the greenhouse, thereby reducing costs and increasing output. A small feasibility study to examine the potential of this treatment has been conducted at Reading and it was found that 15 out of 20 Penny Pink plants flowered after 12 days at 12°C, whereas, only 5 out of 20 plants of Blue Streak flowered. The failure of Blue Streak to flower may be due to the fact that the plants were not given a sufficient duration of cold.

5) Which plant growth regulator should be used to maximise plant quality and how should it be applied?

6) Will the PGR application strategy need to be modified with later planted crops?

7) The interactions between the different treatments and *Osteospermum* shelf-life will also be evaluated.

5. CLOSELY RELATED WORK

This proposal arises from more fundamental studies that have been conducted at Reading over the last 2 years. These studies showed that in terms of time to flowering *Osteospermum* cv. Pink Whirls are extremely responsive to temperature and require a period of vernalization prior to flowering. Thus, plants given two weeks of cold (12°C) after potting and thereafter maintained at 22°C flowered after only 5½ weeks. This compares to a typical production time of 8-10 weeks. Plants held at 12°C for only one week never flowered, but merely produced leaves. However, 22°C was considered to be too warm for finishing the crop, since bud number was reduced considerably; plants finished at 22°C had 5 buds, compared to 15 at 12°C. Similarly, producing the crop at the vernalization temperature of 12°C throughout was too cool, since time to flowering was greatly prolonged. High temperatures also considerably reduced quality because plants initiated many leaves and had considerable stem elongation.

Furthermore, to date, there are no reports of the effects of plant growth regulators on *Osteospermum* quality. However, potential for using plant growth regulators exists, since excessive stem elongation of *Osteospermum* is a common commercial problem that reduces plant quality.

6. DESCRIPTION OF THE WORK

To satisfy the objectives 3 experiments and a commercial trial are planned. The first two experiments at Reading, one will investigate optimal production temperatures and the second will investigate the potential for cold storage of cuttings. The third experiment will be conducted at HRI Efford, and will investigate the optimal use of plant growth regulators on different varieties.

<u>Reading</u>

Experiment 1

The effects of different vernalization and finishing temperatures on two cultivars, Zulu and Sunny Girl, will be examined together with any effects on shelf life. This experiment will combine:

3 vernalization temperatures (9, 12, 15°C) *
3 durations of vernalization (2, 3 or 4 weeks) *
3 finishing temperatures (12, 15, 18).

The experiment is therefore a 3 * 3 * 3 factorial with 37 treatment combinations using two cultivars. There will be 8 replicate plants per treatment. Records will be made of time to flowering and plant height, branch number, flower number.

Four plants from each treatment will be transferred to Efford for shelf-life evaluation (216 plants in total). Some treatments may not produce marketable plants and these will be excluded from the shelf-life work. The shelf-life assessments will continue for three weeks and records of plant quality, flower/bud number and foliage colour will be made at receipt and then at 1, 2 and 3 weeks.

Experiment 2

The potential of cold storing cuttings will be examined. Eight cultivars (Zulu, Sunny Girl, Brogette Pink, Sunny Gustav, Sunny Lady, Buttermilk, Pink Whirls and Congo) will be cold stored for 2, 3 or 4 weeks at 10°C and grown on at 16°C or 22°C. The 22°C treatment will confirm whether the plants are induced flower in the cold store; flowering will not occur at this temperature if cold storage had no effect. This is therefore a 3 * 8 * 2 factorial, 48 treatment combinations. Fifteen replicate plants will be used for each treatment. The start date of this experiment will be May, when outside temperatures are high; i.e. the time of year when this treatment may have commercial benefits.

Efford

Experiment 3

The use of chemical Plant Growth Regulators (PGR's) on a range of *Osteospermum* cultivars will be examined together with any long-term effects on shelf-life.

The experimental treatments will be as follows:

Eight Cultivars:	Sunny Boy Sunny Girl Sunny Gustav	Congo Lindi K A Zulu	Buttermilk Pink Whirls
Two Potting Dates:	Week 4 potting Week 16		
Treatments:	Four PGR treatments Cycocel Topflor Bonzi Water (Control) + B-Nine (Observation)		

A single rate will be used for each PGR with either **spray** or **drench** applications.

i. One application when side shoots are 3-4 cm long.

ii. One application, followed by a second application after 25 days.

Rates of each chemical to be discussed with Harry Kitchener, ADAS.

Experiment Design:

8 cultivars x 4 PGR's x 2 application techniques (spray and drench) x 2 applications times = 128 plots.

16 plants per plot, arranged 4 x 4 of which the middle 4 plants will be recorded.

Assessments:

At Potting:	Quality record of plants Compost analysis

At Marketing:	Time to flowering (1 flower open and 2 buds showing colour) Plant height Plant diameter x 2 Flower/Bud count Flower diameter (largest 3 flowers) Flower colour score Uniformity of plot Total No. of shoots and internode length of second shoot Compost analysis

Shelf-life:

Not all plants from each treatment will enter shelf-life because this will lead to unnecessary duplication. Therefore, all the varieties will be evaluated from each of the PGR treatment, but from the two drench applications only. The plants from the first potting date should reach maturity at the same time as the Reading plants and they will undergo a simulated transport run prior to shelf-life assessment for three weeks at the same time as the Reading plants. The shelf-life of the plants from the second potting date will either be assessed using the facilities at Efford or they may be planted-out to assess garden performance if outside conditions are suitable.

Culture:

Plants will be potted into 12 cm pots using a proprietary compost.
Plants will receive a light pinch if necessary.
Plants will be grown throughout a 16°C D/N, vent at 18°C.
No carbon dioxide enrichment.
No supplementary lighting.
Plants will receive appropriate pest/disease biocontrol measures as seen necessary (Fongarid drench at potting, followed by Neamasys drench).
Plants will be liquid fed from two weeks after potting, and then after at every watering N:200 P:30 K:200.
Plants to remain pot thick and will be spaced to 30/m^2 as required.

NB. Some of the cultural details may be modified following further discussion with grower and the project leader.

Commercial Trial:

A commercial trial will be carried out on a grower's holding to examine whether the treatments applied at Reading and Efford produce results comparable to commercial practice.

Cultivars:	i.	Sunny Gustav	Week 3
	ii.	Sunny Girl	Week 3
	iii.	Sunny Lady	Week 3
	iv.	Zulu	Week 3
	v.	Buttermilk	Week 3
	vi.	Pink Whirls	Week 6

Treatments: 1. Ambient (no heat other than Solar radiation but frost free).
2. Heated to 16-17°C.
3. Heated to 16-17°C ventilate at 23°C plus lighting SONT 2500 lux 7.00 am to 4.00 pm.

Plant growth regulators chloremequat (Cycocel) and flurprimidol (Topflor) at commercial rates, as necessary, to provide plants to specification. As a drench.

Specification 8 cm pot plants, 20/25 cm height above pot.

The trial design will be replicated.

Records

Potting Compost:- Nursery mix for *Osteospermum*
Compost analysis

Marketing:- Time of flowering
Plant height
Plant diameter
Uniformity
No flowers open
Photographs

Culture:- All potted week 13 except Pink Whirls week 6.
Temperature 16/17°C D/N ventilate 23°C except ambient treatment.
No CO_2.

Light one treatment only. 2500 lux.
07.00 to 16.00.

Pest and disease control.

Pot thick then 30 m^2.
Stopping as required per variety.

Pot sizes, composts and other standard cultural details will be standardised throughout and determined following discussions with growers.

7. START DATE, DURATION AND REPORTING

Start date 01.01.95; duration one year.

The experimental leaders will be responsible for producing reports from their own trials. The project leader will collate the separate reports into one final report which will be produced by the end of December.

8. STAFF RESPONSIBILITIES

Project Leader: Harry Kitchener (ADAS)

Experimental Leaders:

Simon Pearson (University of Reading) - Experiments 1 and 2
Andrew Fuller (HRI Efford) - Experiment 3
Harry Kitchener (ADAS) - Commercial trial

9. LOCATION

University of Reading, Efford and grower's holding (Anglia Alpines, Nr Somersham, St Ives, Cambs)

Contract No: PC 114

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature..M.C.. Heath..................

Position. ADAC ACCOUNT MANAGER FOR HDC

Date.............12/5/95.....................

Signed for the Contractor(s)

Signature..
K LOSLEY

Position......INDUSTRIAL CONTRACTS OFFICER UNIVERSITY OF READING

Date..............-7 JUN 1995..................

Signed for the Council

Signature..

Position......CHIEF EXECUTIVE......................

Date..............24.4.95.......................

Signed for the Contractor(s)

Signature..

Position.....CCM Manager HDC.........

Date.........11/1/96.....................

APPENDICES

Osteospermum PGR Trial HDC PC 114

K-Block - K5

N ↑

Topflor - Spray x2

1	5
3	7
2	6
4	8

Bonzi - Drench x2

5	1
7	3
6	2
8	4

Control - Drench x2

5	1
7	3
8	4
6	2

Topflor - Drench x1

3	7
1	5
2	6
4	8

Cycocel - Drench x1

7	3
6	2
8	4
5	1

Control - Spray x1

4	8
3	7
2	6
1	5

Bonzi - Spray x1

5	1
8	4
6	2
7	3

Cycocel - Spray x2

6	2
7	3
8	4
5	1

Varieties:

1 - Sunny Gustav
2 - S. Lady
3 - S. Girl
4 - Karl Axel Lindi
5 - Karl Axel Zulu
6 - K.A Congo
7 - K.A Lubutu (Buttermilk)
8 - Pink Whirls

GLP Ref.No.

Osteospermum PGR Trial HDC PC 114

K-Block - K10

N ↑

Cycocel - Spray x1

6	2
5	1
8	4
7	3

Cycocel - Drench x2

5	1
7	3
6	2
8	4

Bonzi - Drench x1

7	3
5	1
8	4
6	2

Bonzi - Spray x2

5	1
8	4
6	2
7	3

Control - Spray x2

3	7
1	5
4	8
2	6

Topflor - Spray x1

7	3
5	1
8	4
6	2

Topflor - Drench x2

4	8
1	5
3	7
2	6

Control - Drench 1

4	8
3	7
1	5
2	6

Varieties:
1 - Sunny Gustav
2 - S. Lady
3 - S. Girl
4 - Karl Axel Lindi
5 - Karl Axel Zulu
6 - K.A Congo
7 - K.A Lubutu (buttermilk)
8 - Pink Whirls

GLP Ref.No.

N ↑

Osteospermum PGR Trial HDC PC 114

Observation K-Block - K4

Alar - Drench x2

6	3
8	2
5	4
7	1

Alar - Spray x2

5	4
6	1
7	3
8	2

Spare plant material

12°C - 16 days

7	1
5	4
8	2
6	3

Cycocel 12°C - 16 days

8	2
7	3
6	1
5	4

Cycocel - Spray x2

E	D
H	B
F	C
G	A

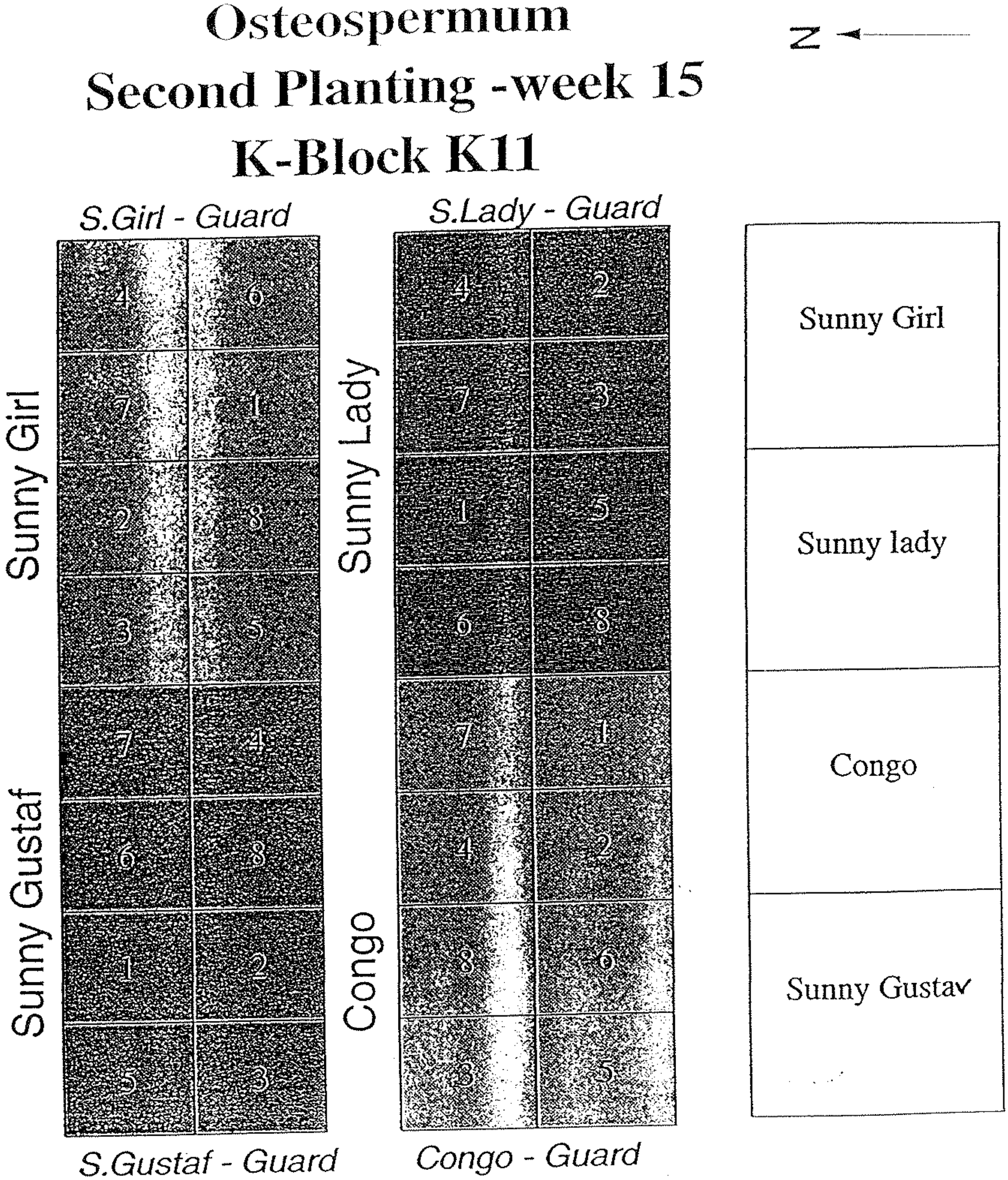
Control - Spray x2

F	C
G	A
E	D
H	B

Varieties:
1 - Sunny Gustav
2 - S. Lady
3 - S. Girl
4 - Karl Axel Lindi
5 - Karl Axel Zulu
6 - K.A Congo
7 - K.A Lubutu (Buttermilk)
8 - Pink Whirls
A - K.A Lusaka
B - K.A Dakar
C - K.A Zambesi
D - K.A Swazi
E - K.A Nairobi
F - K.A Volta
G - K.A Tanga
H - K.A Zimba

GLP Ref.No.

Osteospermum
Second Planting -week 15
K-Block K11

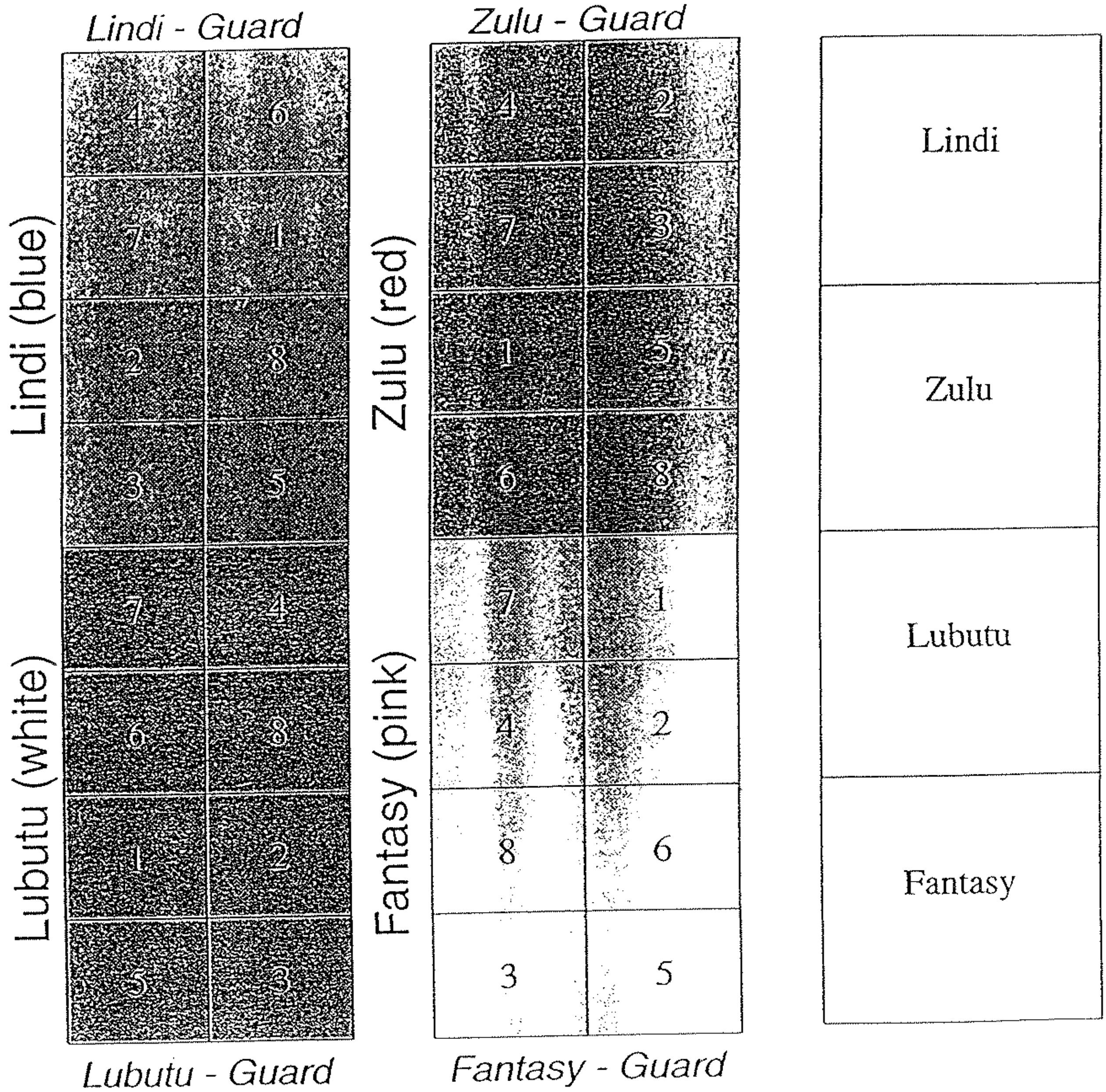


Treatment Codes:

1 = Control Spray
2 = Control Drench
3 = Cycocel Spray
4 = Cycocel Drench
5 = Bonzi Spray
6 = Bonzi Drench
7 = Topflor Spray
8 = Topflor Drench

Osteospermum
Second Planting -week 15
K-Block K12

N ←



Treatment Codes:

1 = Control Spray
2 = Control Drench
3 = Cycocel Spray
4 = Cycocel Drench
5 = Bonzi Spray
6 = Bonzi Drench
7 = Topflor Spray
8 = Topflor Drench

APPENDIX II

Crop Diary (Trial 1)

Date	Operation
27 January	Plants potted
3 February	Fingered drench applied; 1 g/l at 5 l per m² (approx. 80 ml/pot)
7 February	Nemasys applied to all plants
8 February	Plants pinched to 4-5 leaves*
6 March	Commenced liquid feeding
13 March	Plants half spaced
28 March	Plants full spaced

Crop Diary (Trial 2)

Date	Operation
14 April	Plants potted
28 April	Plants pinched to 4-5 leaves*
28 April	Fingered drench applied; 1 g/l at 5 l per m² (approx. 80 ml/pot)
10 May	Plants half spaced
24 May	Plants full spaced

Biological agents employed throughout the trial:

Amblyseius cucumeris
Aphidius colemani
Aphidoletes aphidomyza
Encarsia formosa

* Sunny cultivars were already pinched upon receipt

APPENDIX III

Trial One: record of date of applications

Cultivar	Yellow *S. Lady*	Purple *S. Girl*	Orange *S. Gustav*	Pink *Fantasy*	White *Lubutu*	Green *Congo*	Red *Zulu*	Blue *Lindi*
Treatment								
Con Sp1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Con Sp2	*	*	*	*	*	*	*	*
Con Dr1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Con Dr2	*	*	*	*	*	*	*	*
CCC Sp1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
CCC Sp2	21 Mar	15 Mar	15 Mar	28 Mar	4 Apr	21 Mar	-	4 Apr
CCC Dr1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
CCC Dr2	21 Mar	21 Mar	21 Mar	4 Apr	11 Apr	11 Apr	-	11 Apr
Bon Sp1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Bon Sp2	15 Mar	15 Mar	15 Mar	21 Mar	21 Mar	21 Mar	-	21 Mar
Bon Dr1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Bon Dr2	28 Apr	21 Mar	21 Mar	28 Mar	28 Apr	21 Mar	-	11 Apr
Top Sp1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Top Sp2	28 Apr	28 Mar	28 Mar	28 Apr	28 Apr	28 Mar	-	*
Top Dr1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Top Dr2	-	-	-	-	-	-	-	-
Alar Sp1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Alar Sp2	15 Mar 11 Apr	15 Mar 11 Apr	15 Mar 11 Apr	21 Mar 4 Apr 11 Apr	11 Apr	4 Apr 11 Apr	-	11 Apr
Alar Dr 1	15 Feb	15 Feb	15 Feb	7 Mar	28 Feb	28 Feb	7 Mar	7 Mar
Alar Dr 2	11 Apr	21 Mar 11 Apr	21 Mar 11 Apr	21 Mar 11 Apr	11 Apr	11 Apr	-	11 Apr

NB: Con - Control - plain water
CCC - Cycocel
Bon - Bonzi
Top - Topfloor
Alar - as 'B-Nine'
Dr - Drench
Sp - Spray

APPENDIX III

Trial Two: record of date of applications

Cultivar	Yellow *S. Lady*	Purple *S. Girl*	Orange *S. Gustav*	Pink *Fantasy*	White *Lubutu*	Green *Congo*	Red *Zulu*	Blue *Lindi*
Treatment								
Con Sp	5 May	5 May	5 May	5 May	26 May	5 May	2 Jun	26 May
Con Dr	5 May	5 May	5 May	5 May	26 May	5 May	2 Jun	26 May
CCC Sp	5 May	5 May	5 May	5 May	26 May 6 Jun	5 May 14 Jun 27 Jun	2 Jun	26 May
CCC Dr	5 May	5 May	5 May	5 May	26 May	5 May	2 Jun	26 May
Bon Sp	5 May	5 May	5 May	5 May	26 May 14 Jun 11 Jul	5 May 26 May 14 Jun	2 Jun	26 May 20 Jun
Bon Dr	5 May	5 May	5 May	5 May	26 May 11 Jul	5 May 14 Jun	2 Jun	26 May
Top Sp	5 May	5 May	5 May	5 May	26 May 20 Jun	5 May	2 Jun	26 May
Top Dr	5 May	5 May	5 May	5 May	26 May	5 May	2 Jun	26 May

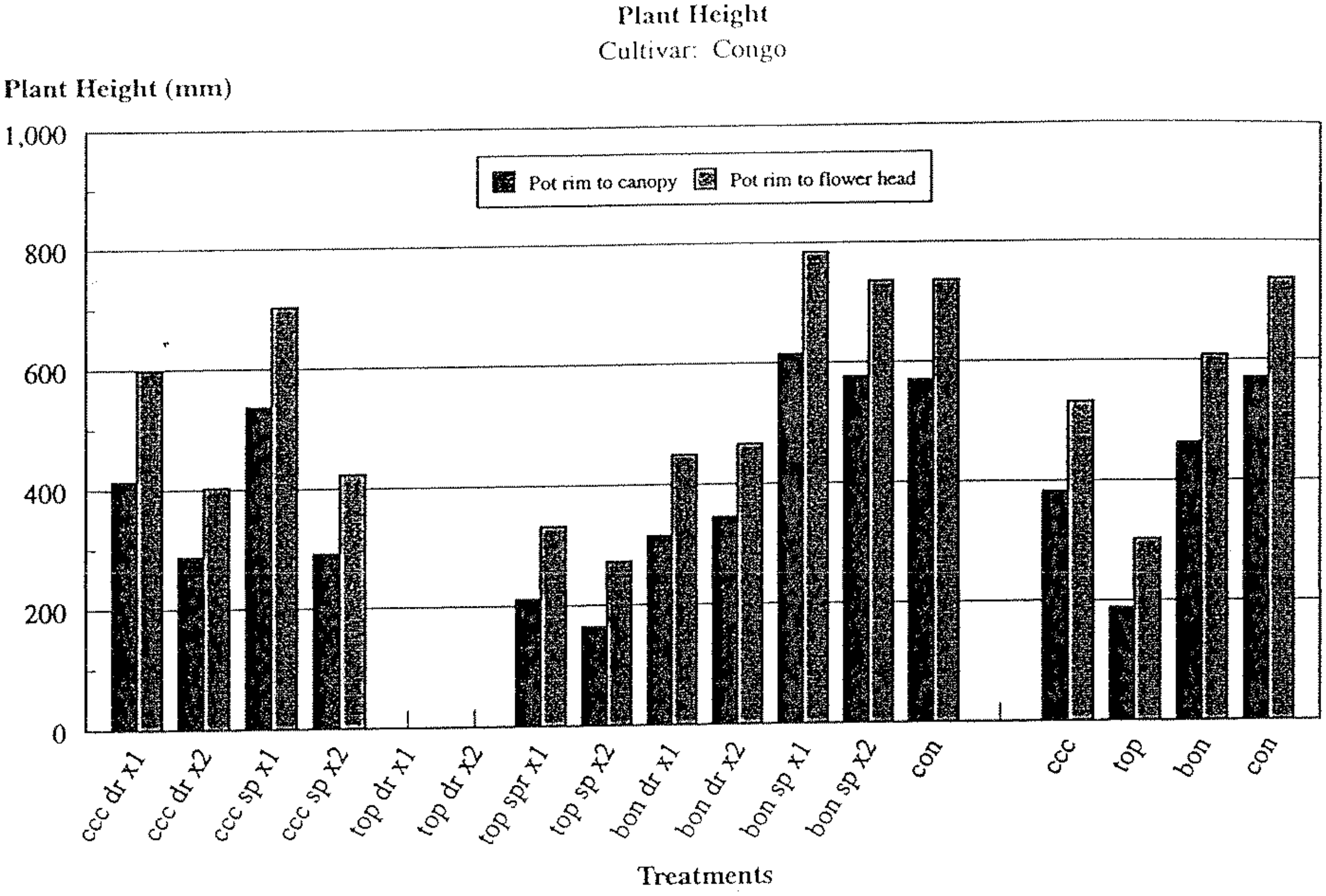
NB: Con - Control - plain water
CCC - Cycocel
Bon - Bonzi
Top - Topflor
Dr - Drench
Sp - Spray

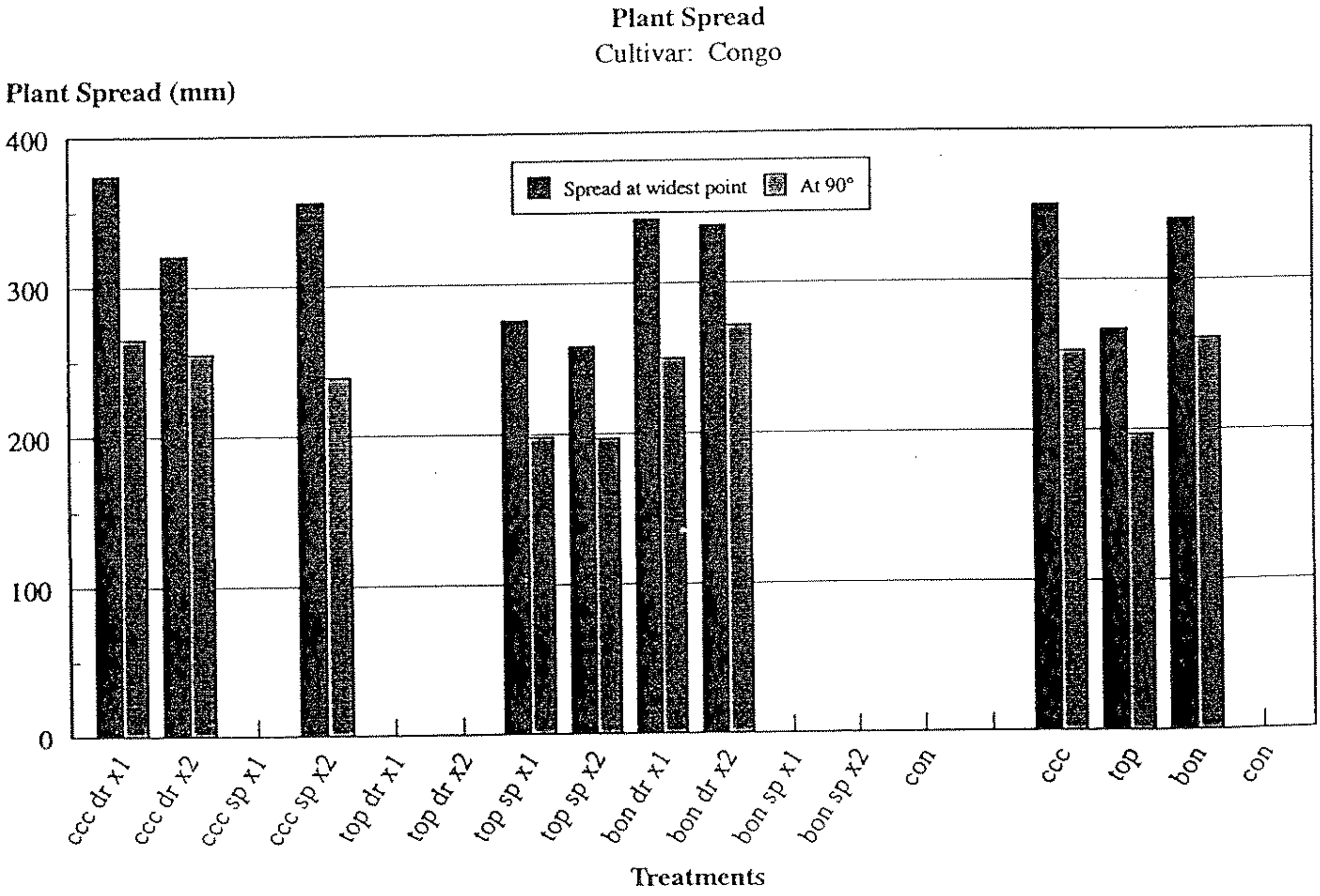
APPENDIX IV

TRIAL ONE - Records of plant growth at marketing

Key:	CCC	=	Cycocel
	Top	=	Topflor
	Bon	=	Bonzi
	Con	=	Control
	Dr	=	Drench
	Sp	=	Spray
	x1/x2	=	Either one or two applications

APPENDIX IV Trial One - Results





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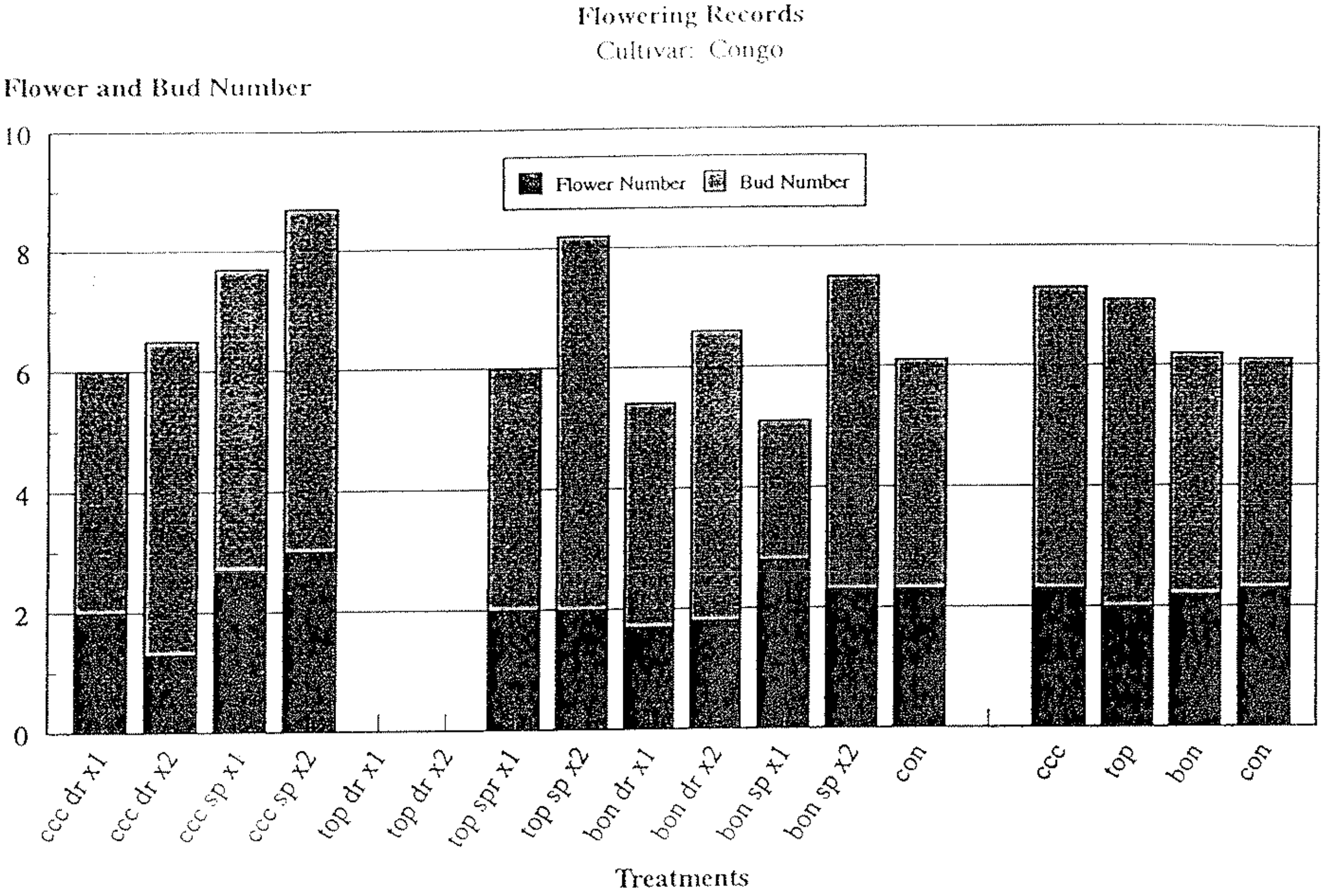

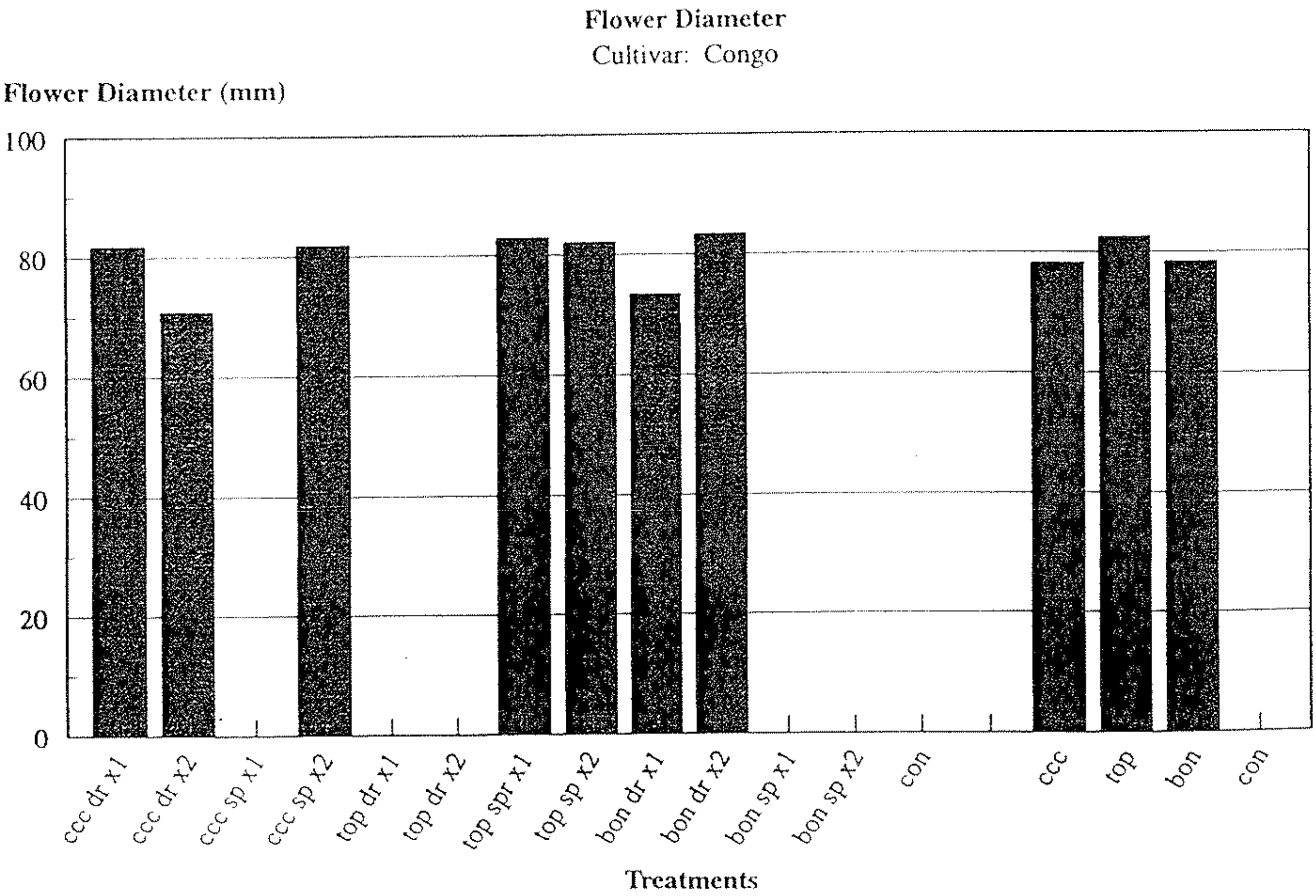

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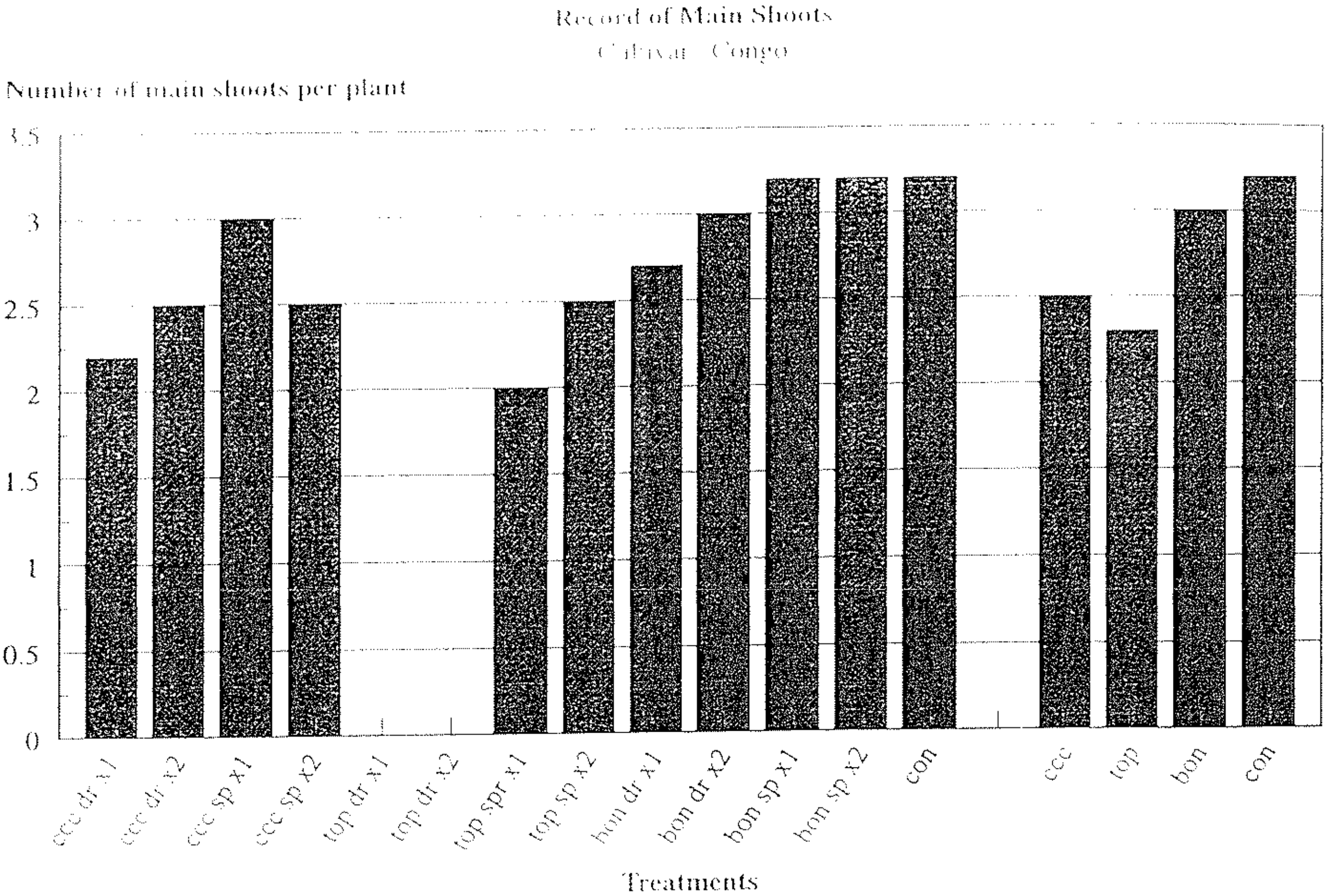

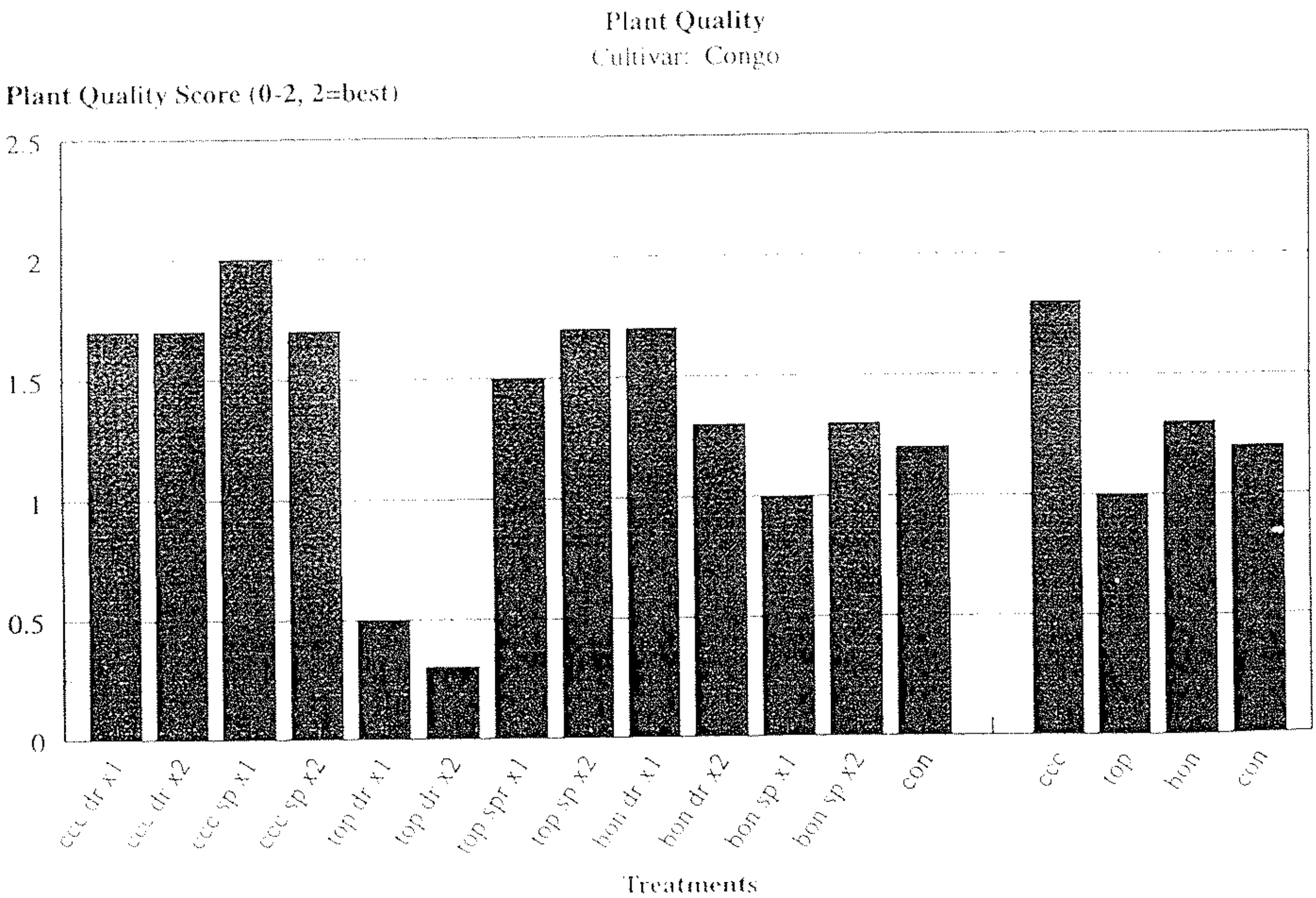

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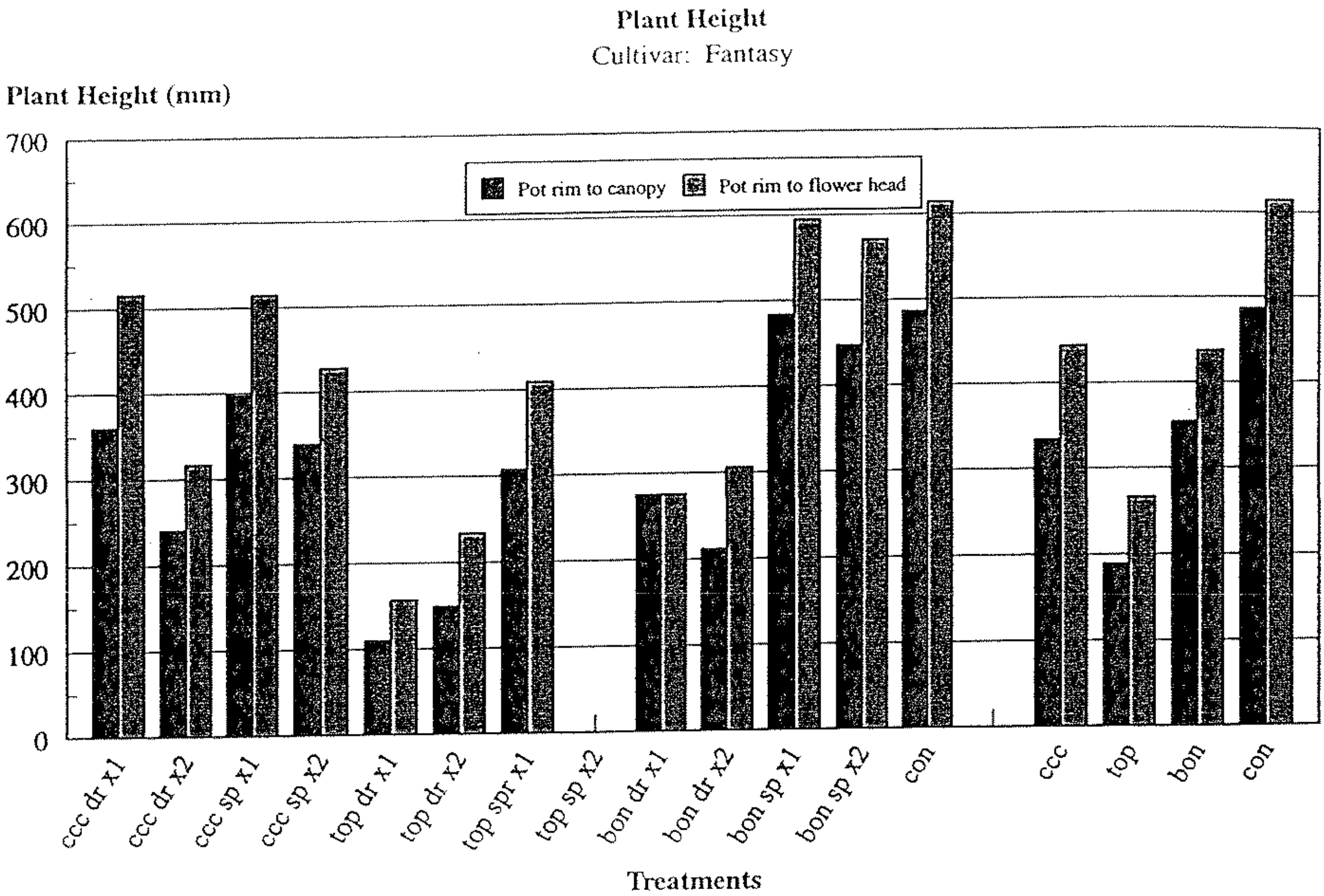

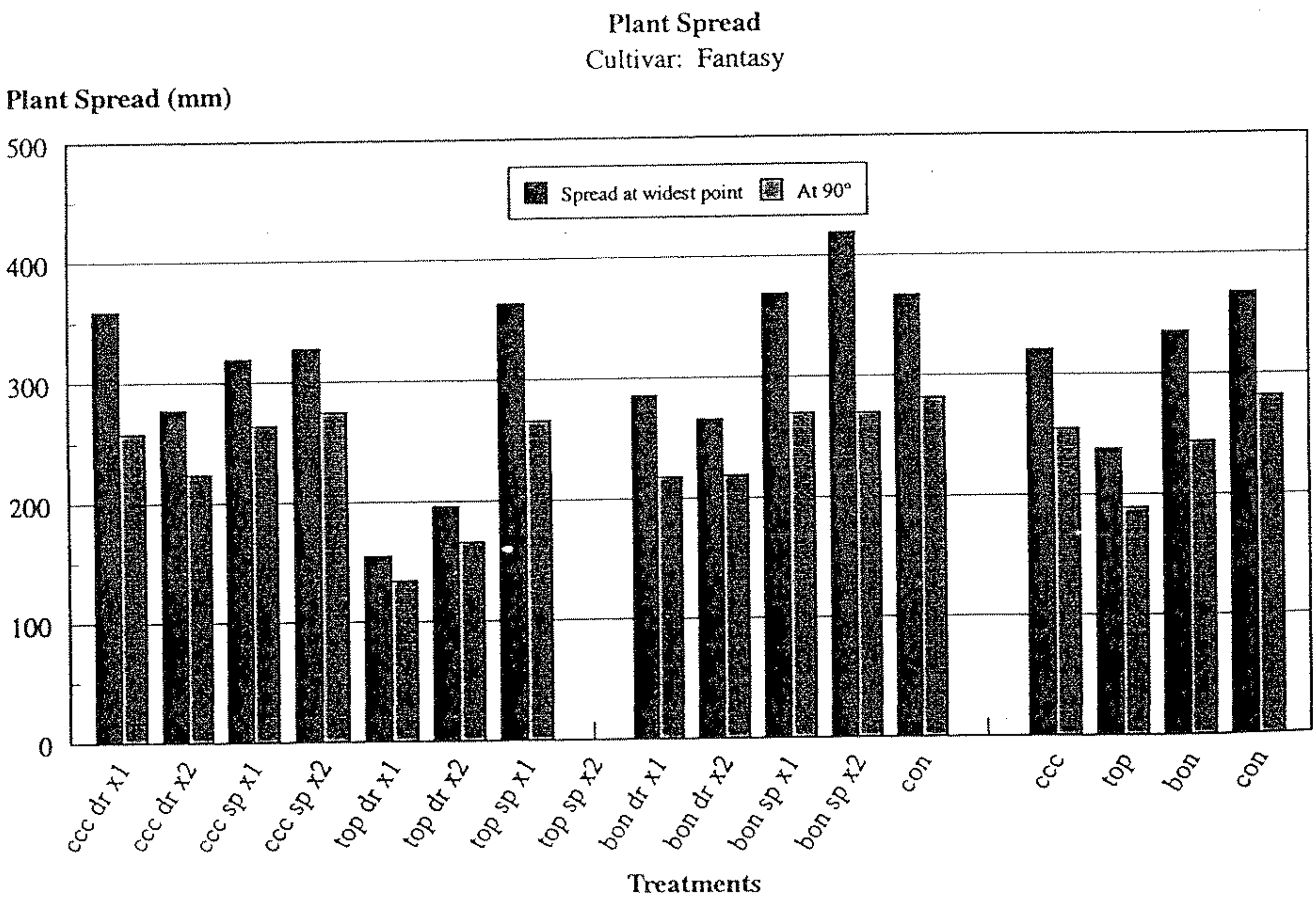

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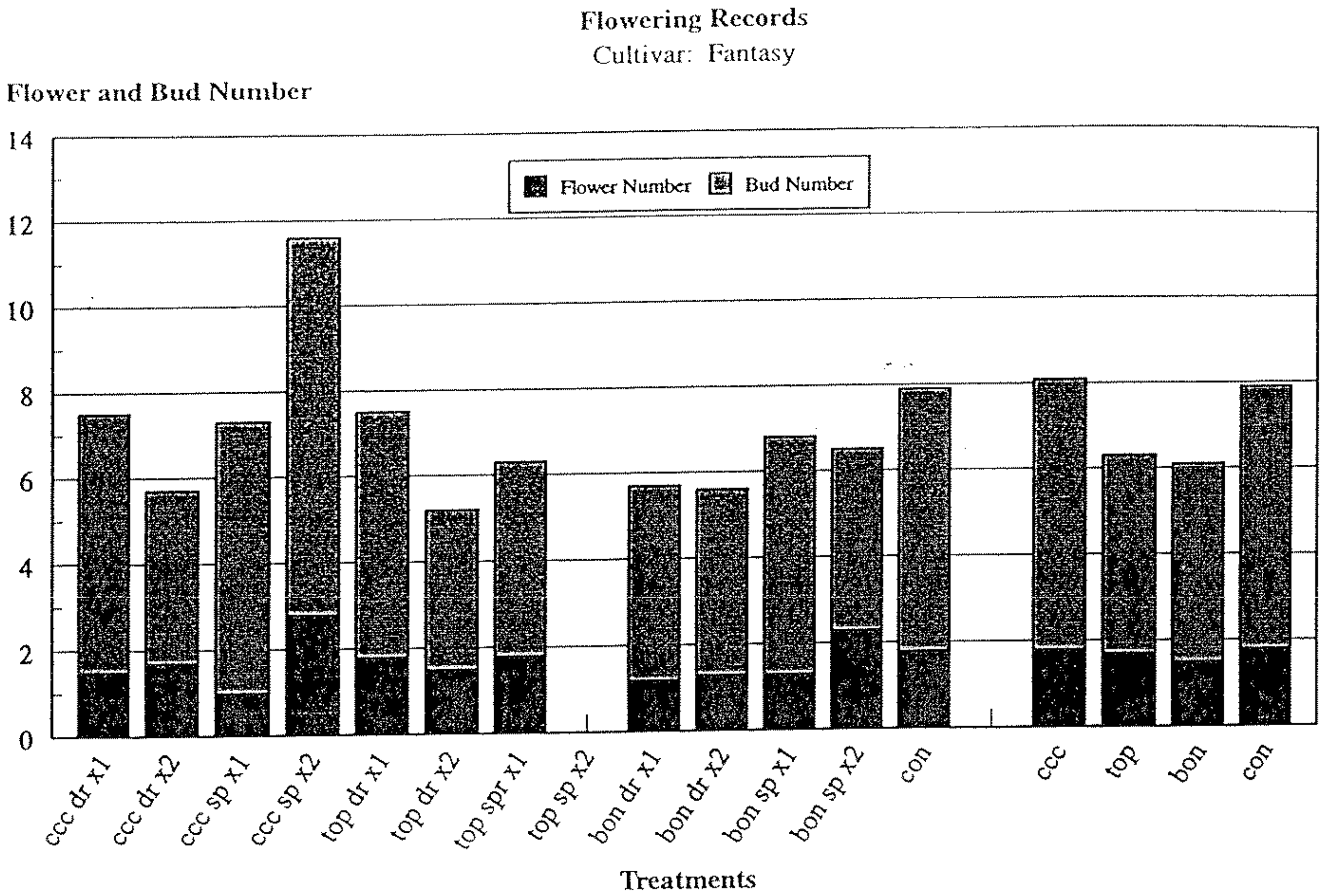

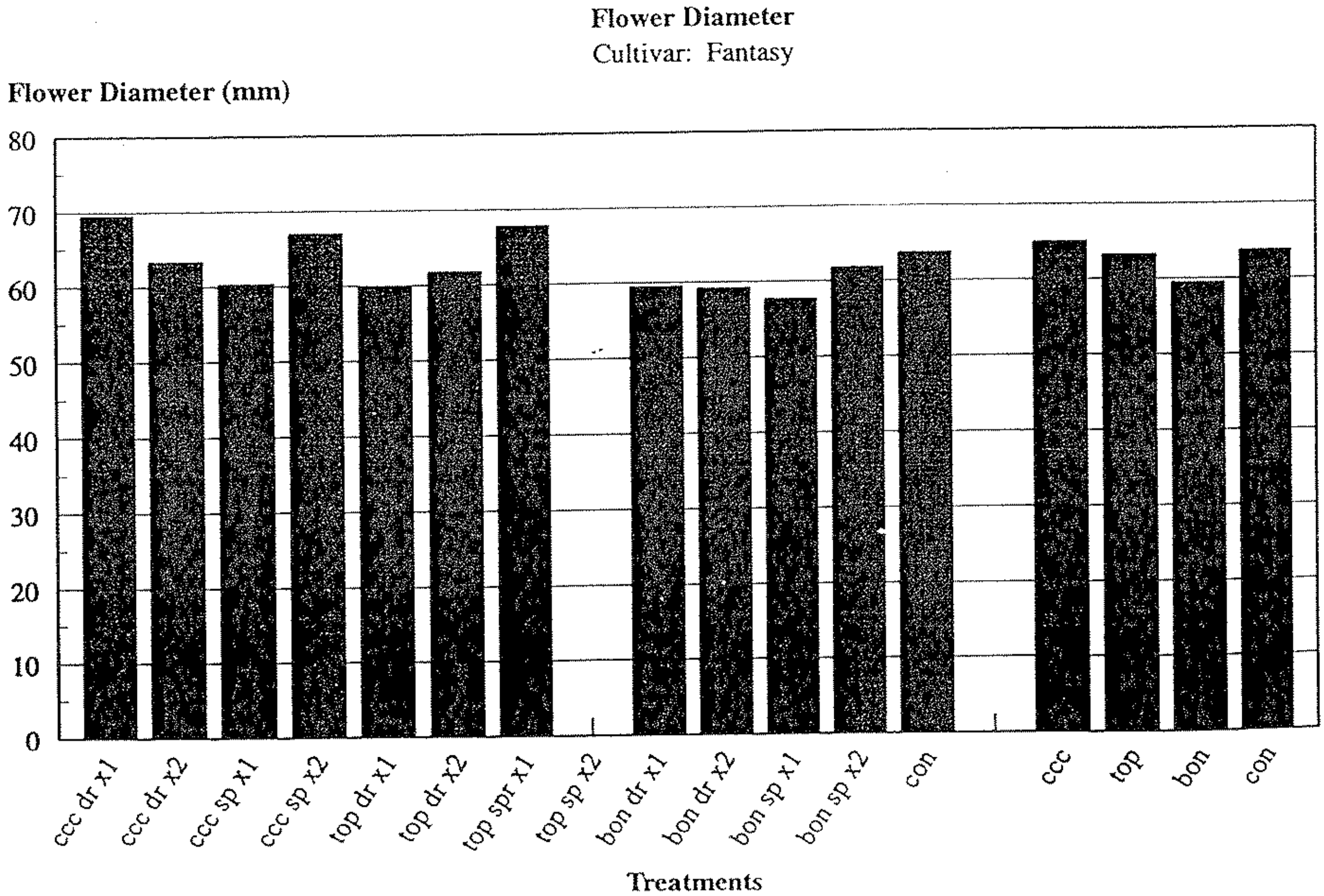

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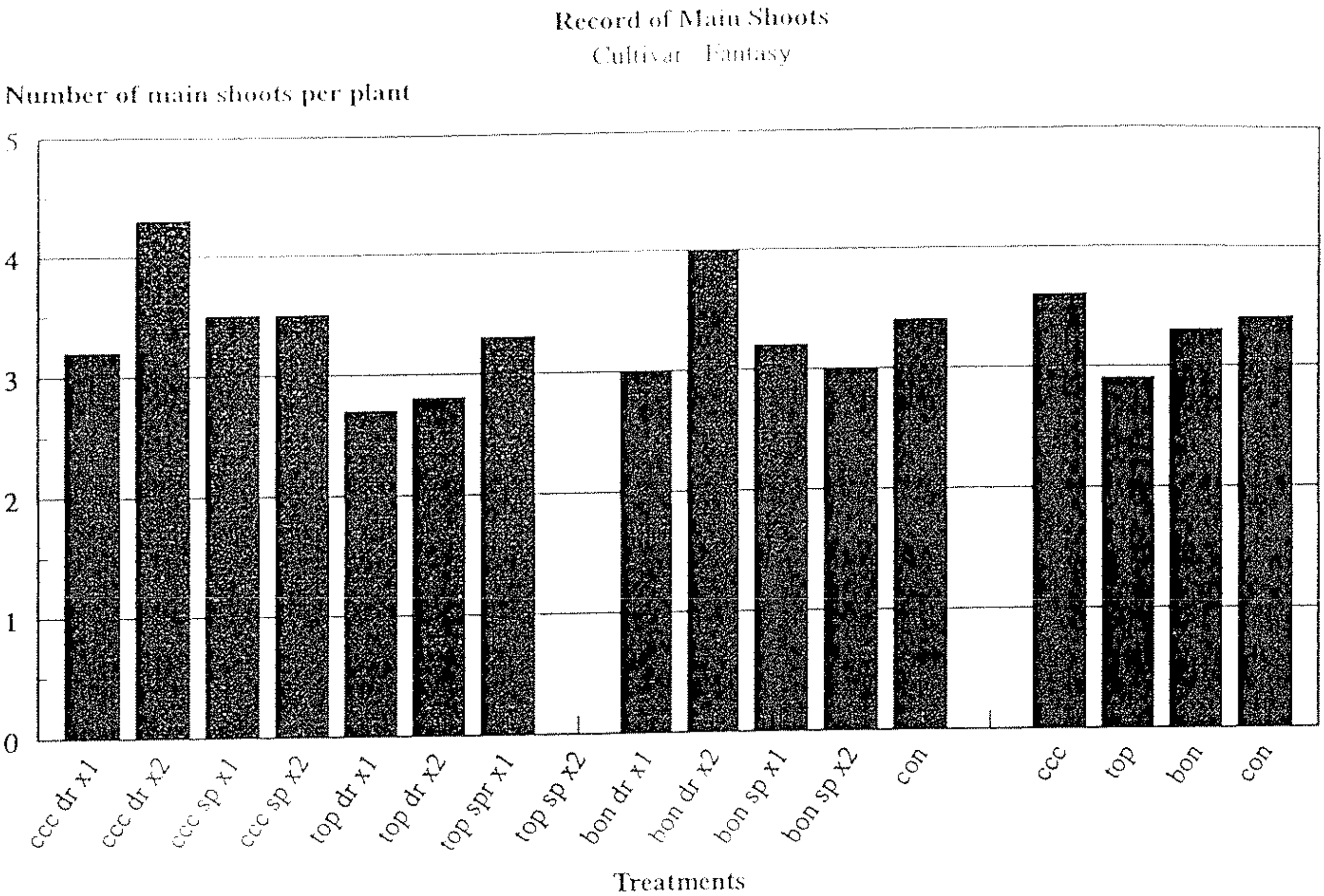
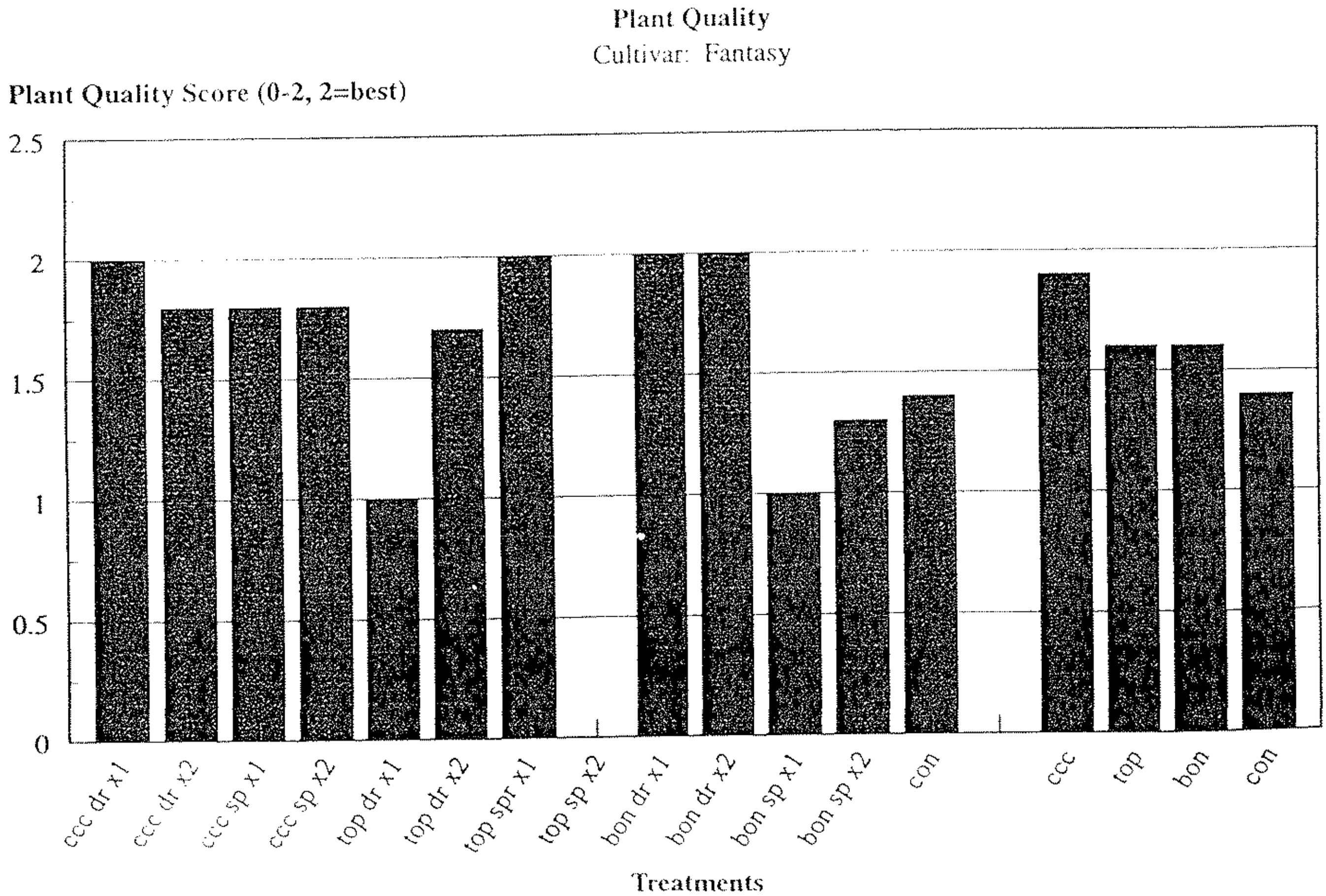
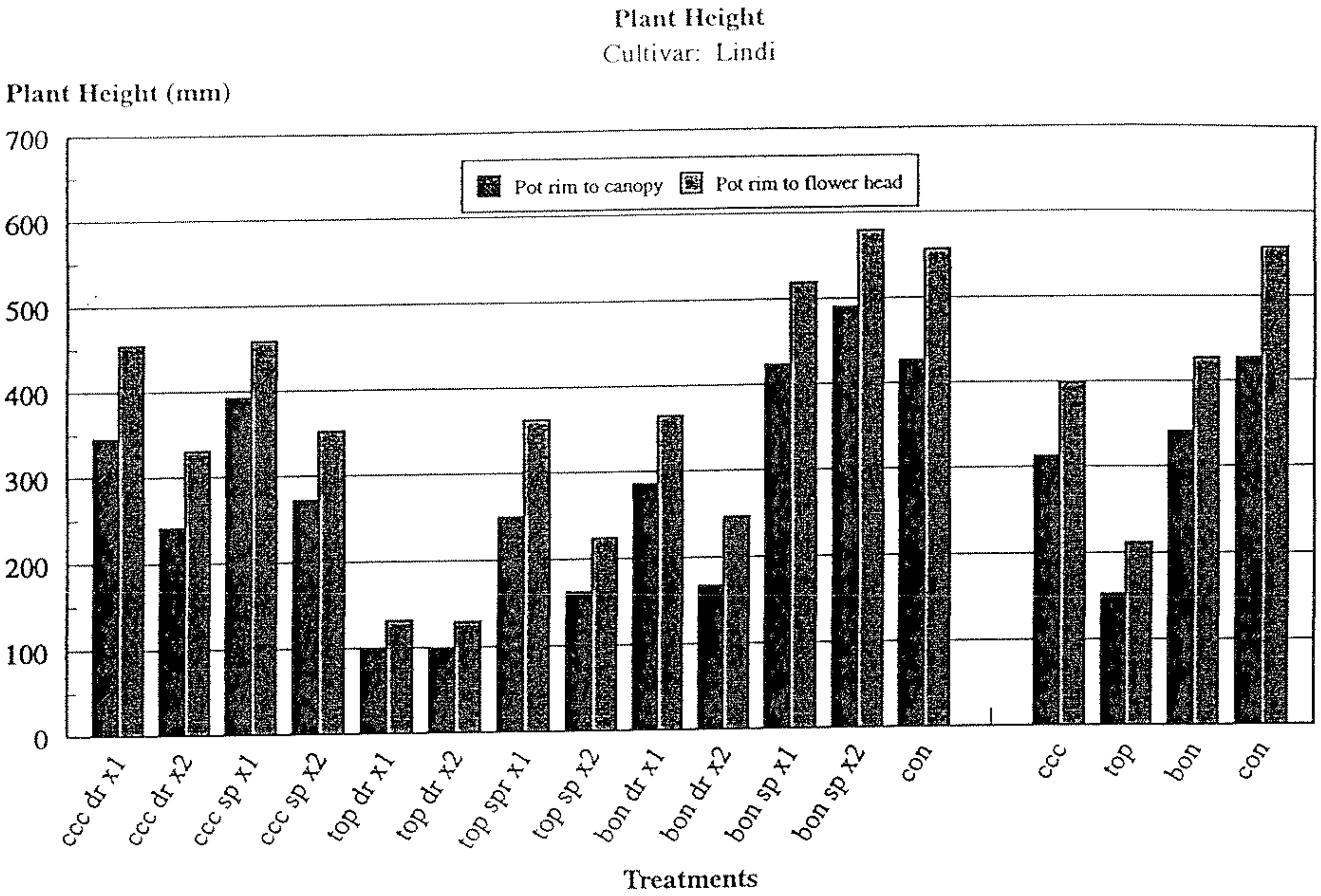
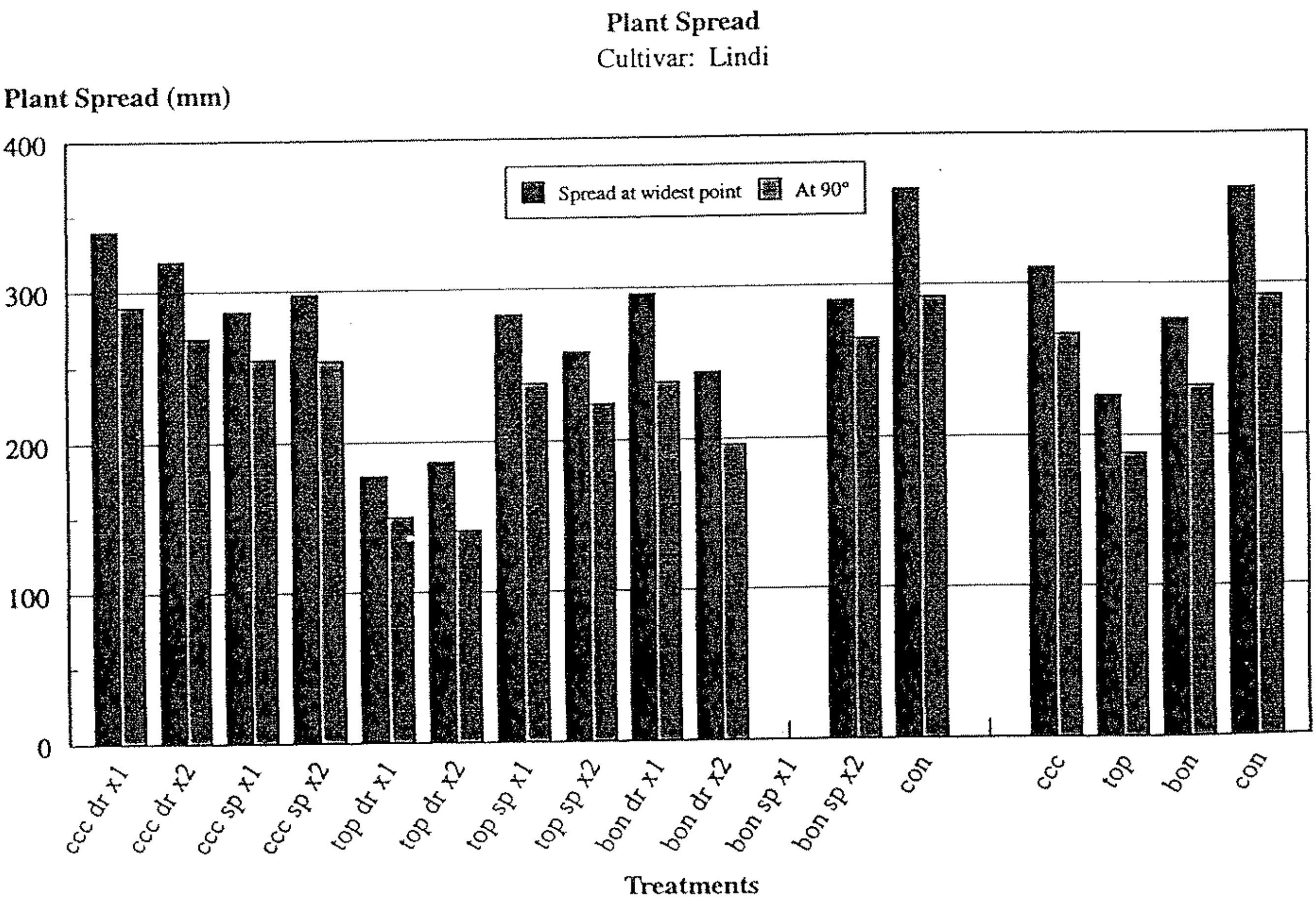
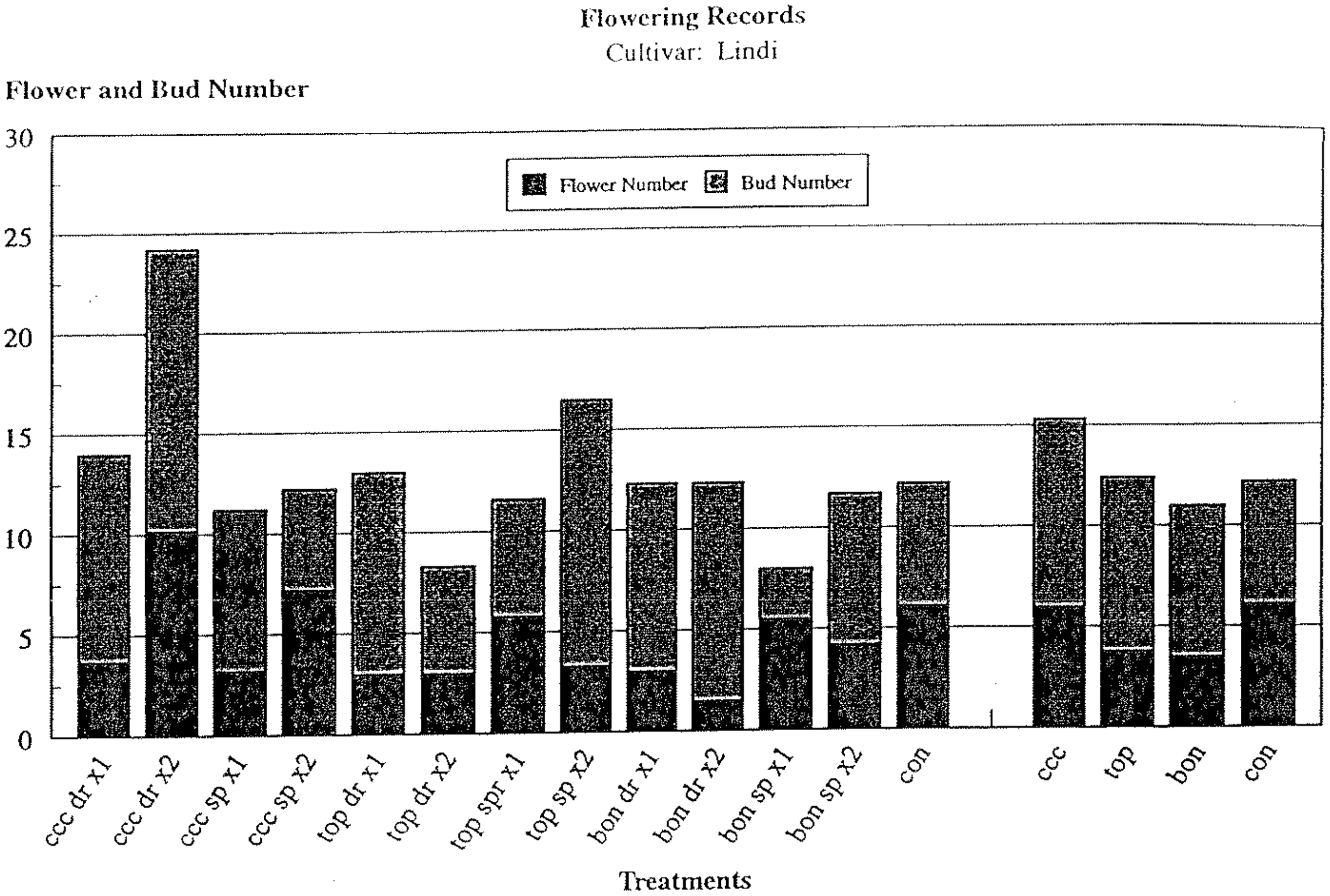


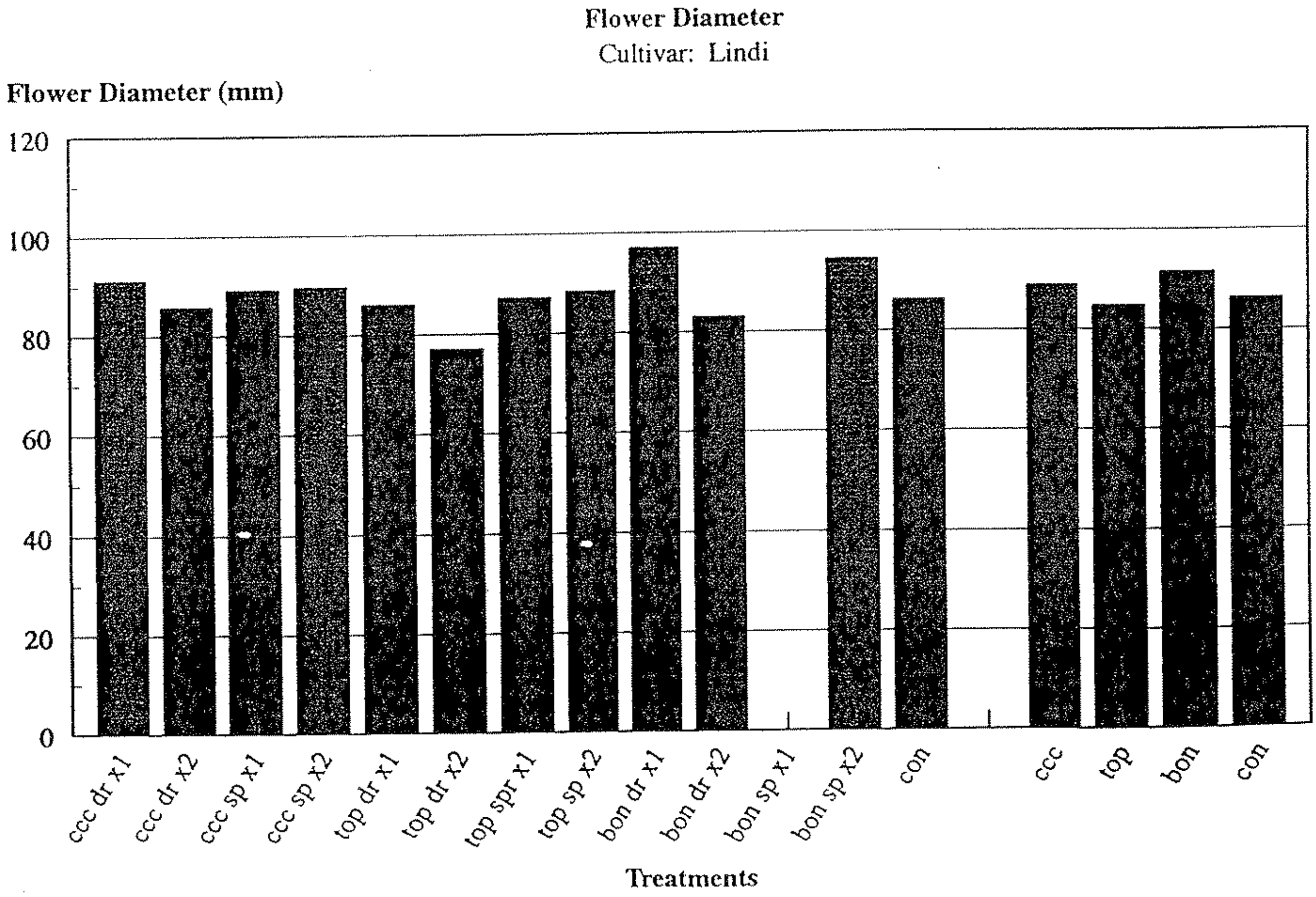



Plant Height
Cultivar: Lindi
Plant Height (mm)
700
600
500
400
300
200
100
0
Pot rim to canopy
Pot rim to flower head
ccc dr x1
ccc dr x2
ccc sp x1
ccc sp x2
top dr x1
top dr x2
top spr x1
top sp x2
bon dr x1
bon dr x2
bon sp x1
bon sp x2
con
ccc
top
bon
con
Treatments


Plant Spread
Cultivar: Lindi
Plant Spread (mm)
400
300
200
100
0
Spread at widest point
At 90°
ccc dr x1
ccc dr x2
ccc sp x1
ccc sp x2
top dr x1
top dr x2
top sp x1
top sp x2
bon dr x1
bon dr x2
bon sp x1
bon sp x2
con
ccc
top
bon
con
Treatments

APPENDIX IV Trial One - Results





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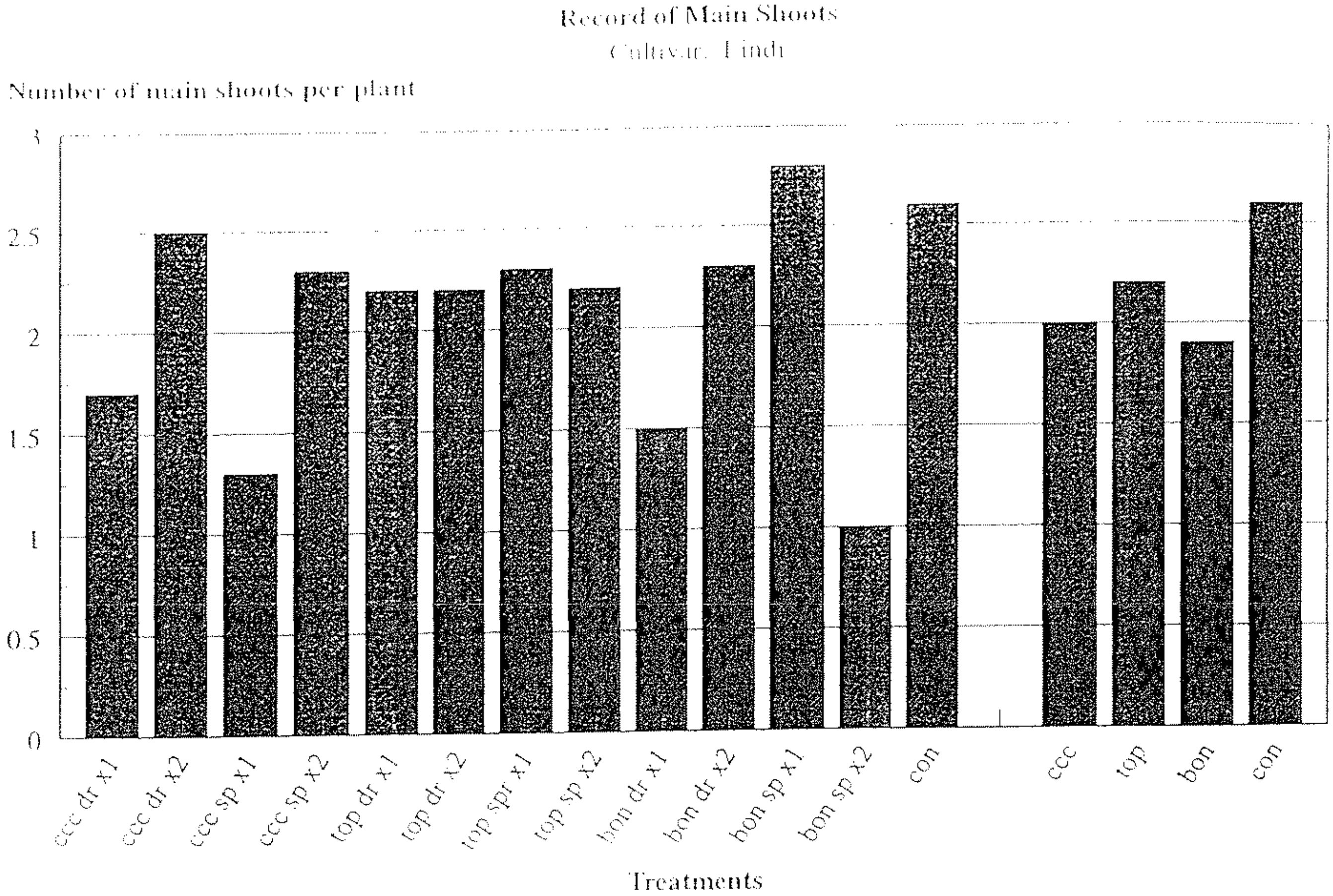
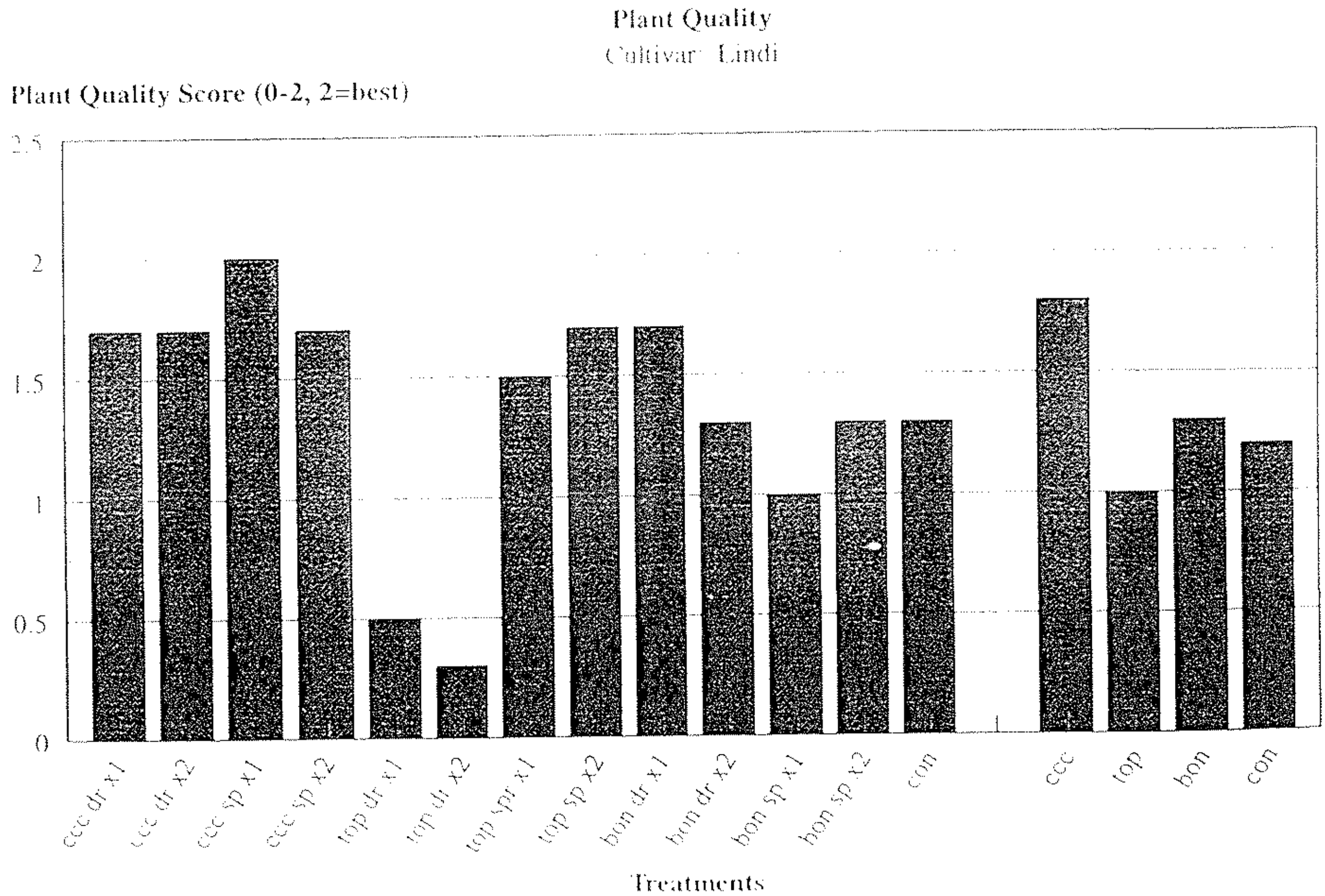
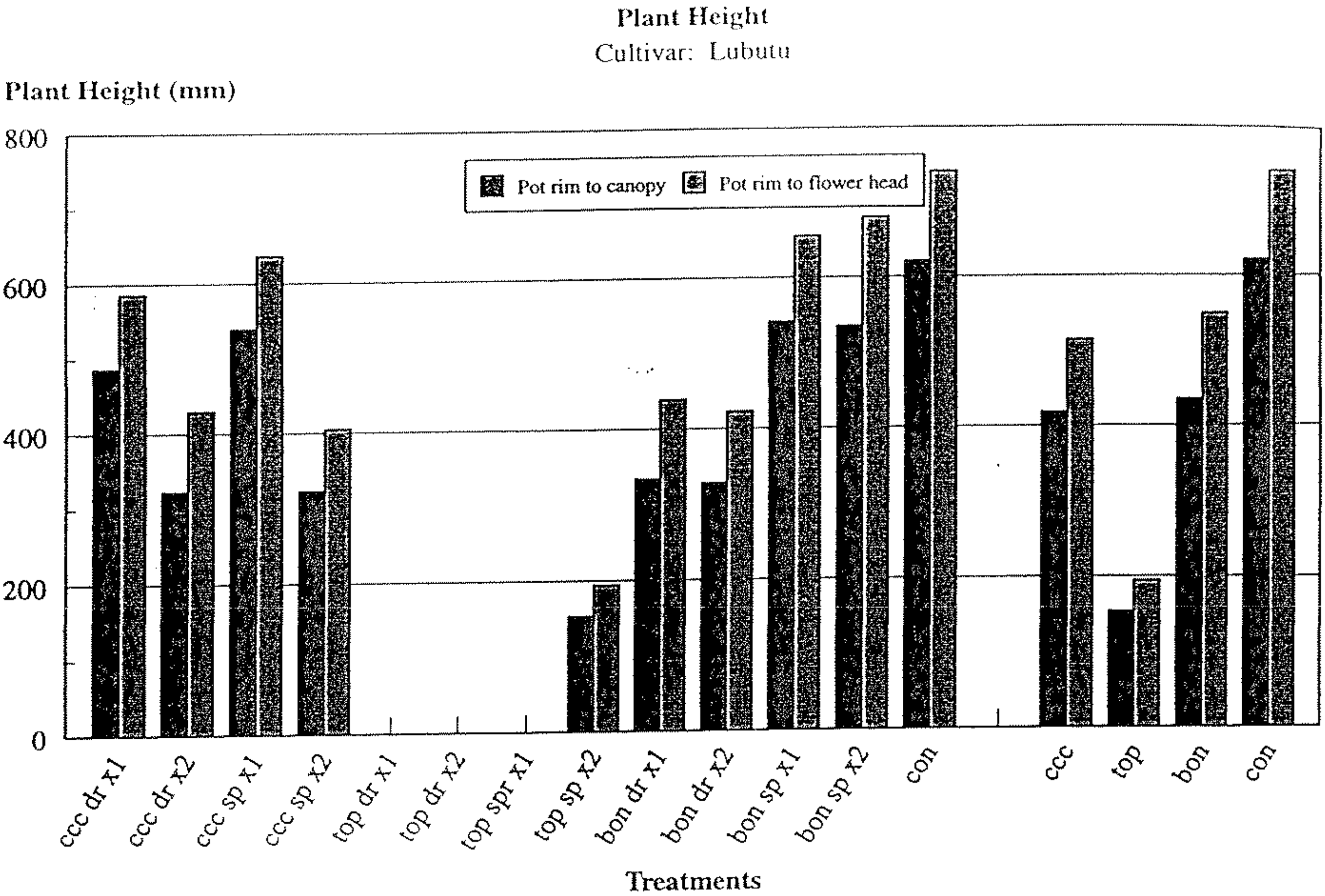
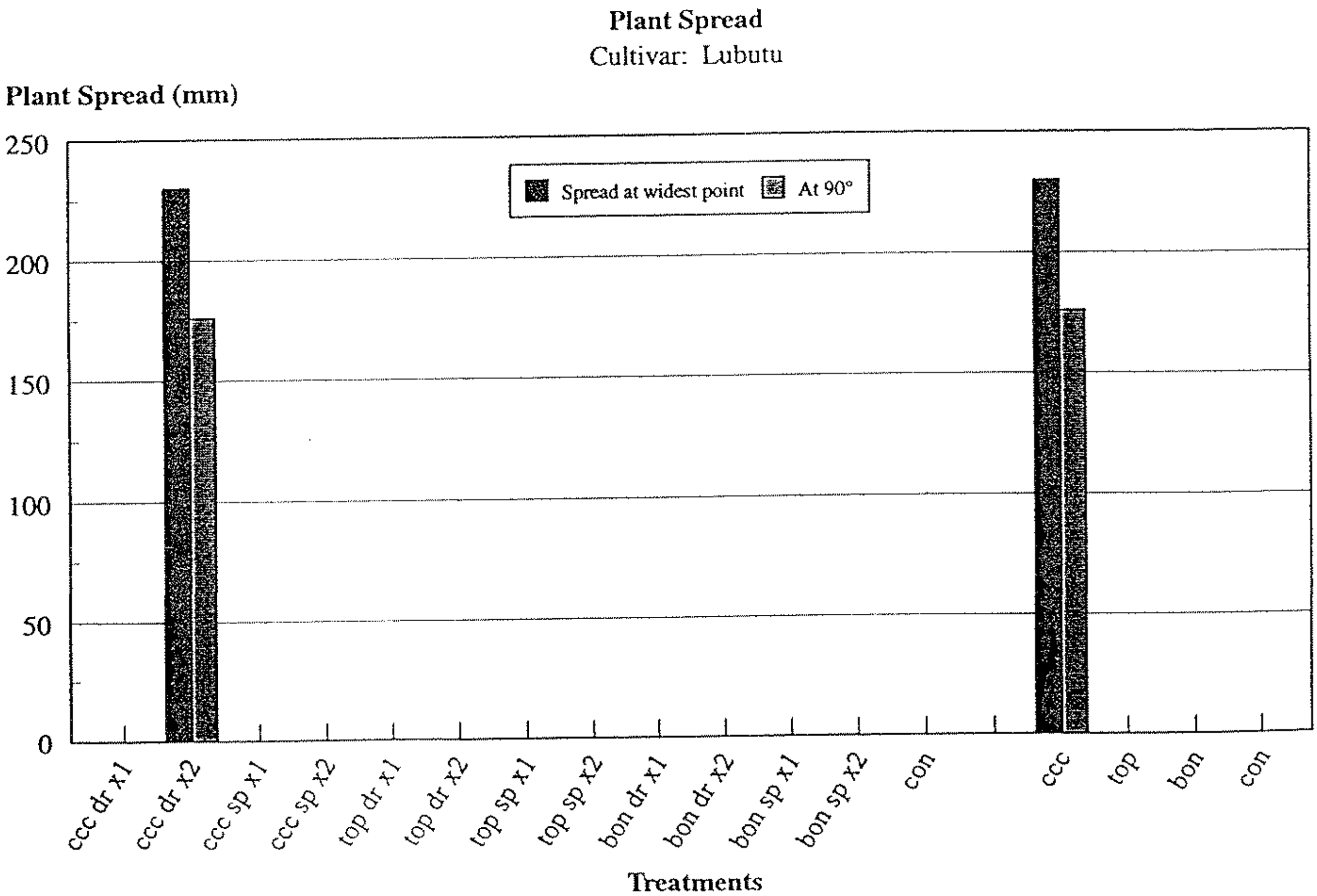




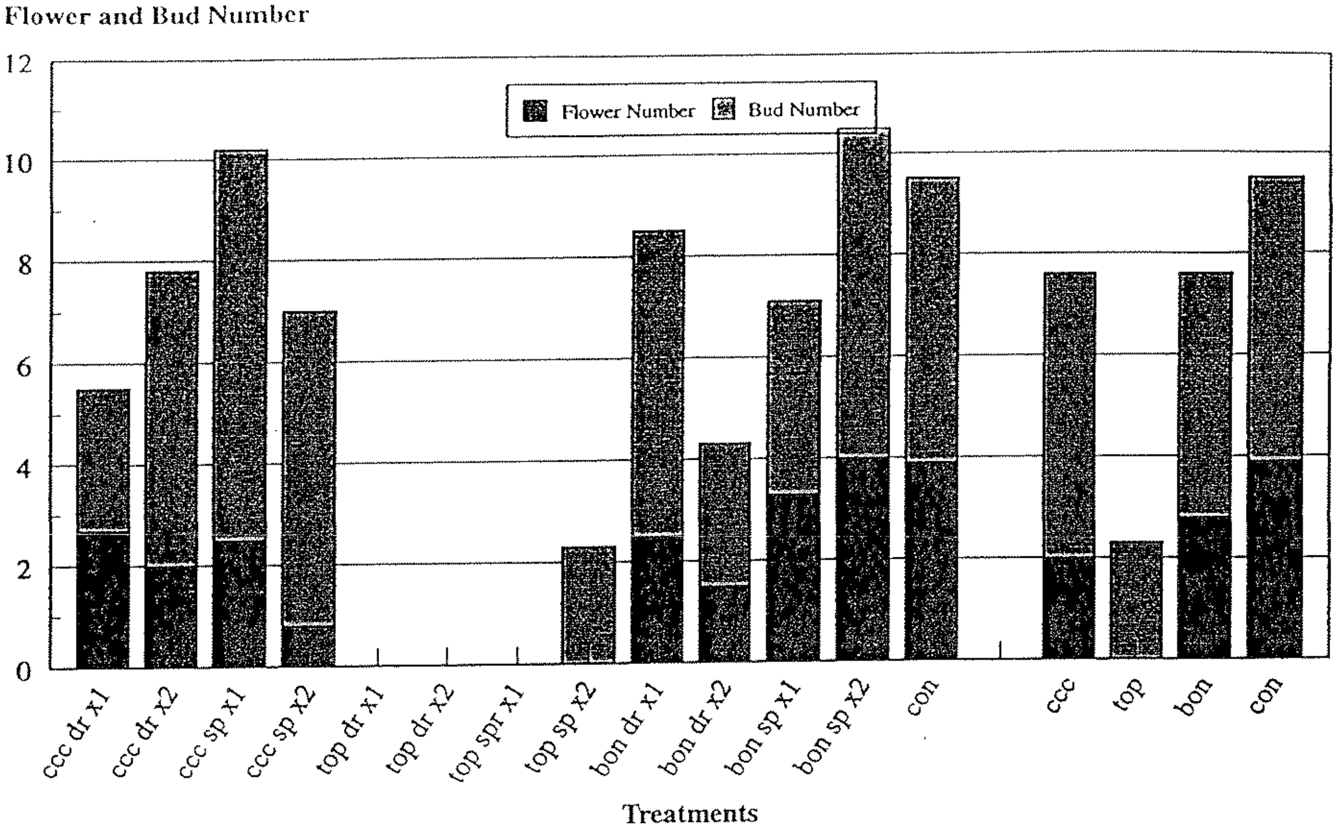
APPENDIX IV Trial One - Results



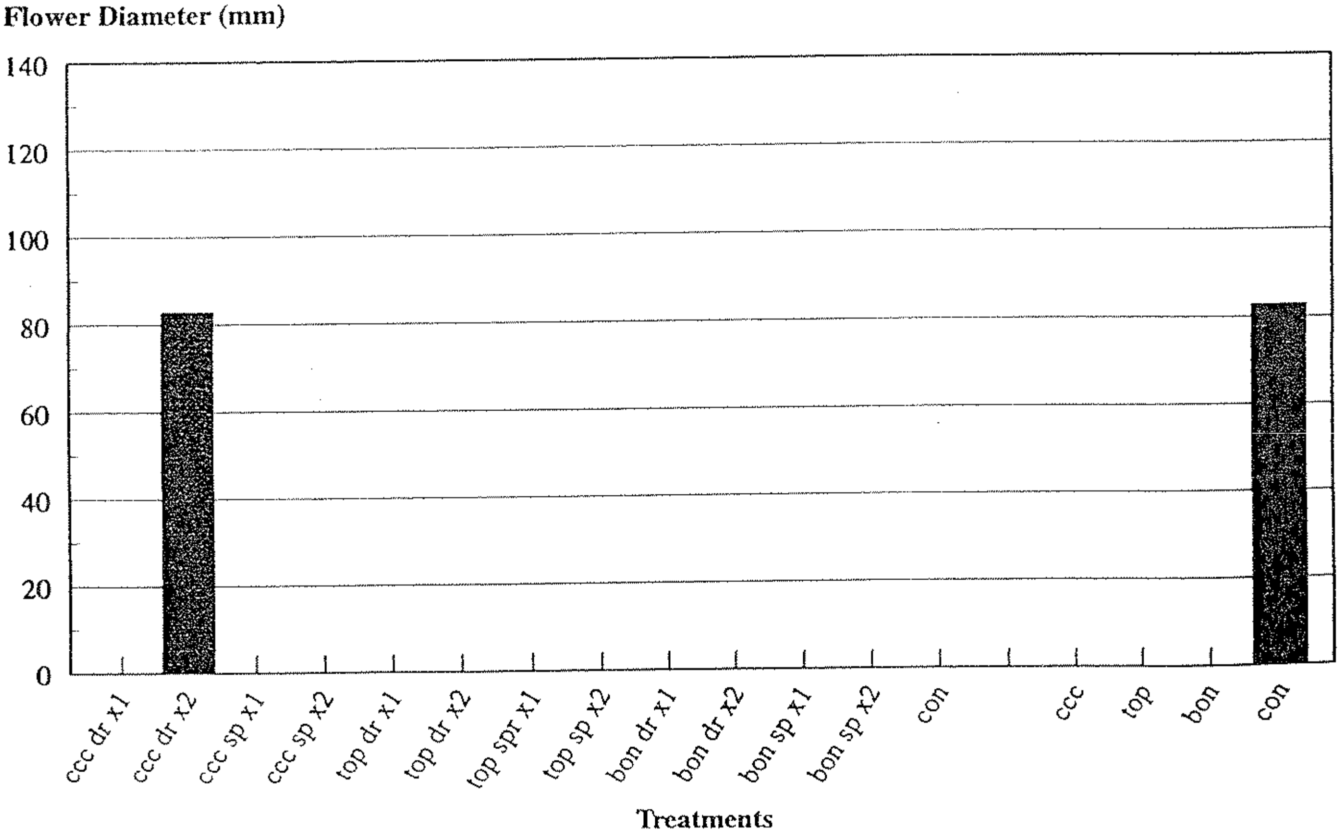


APPENDIX IV Trial One - Results

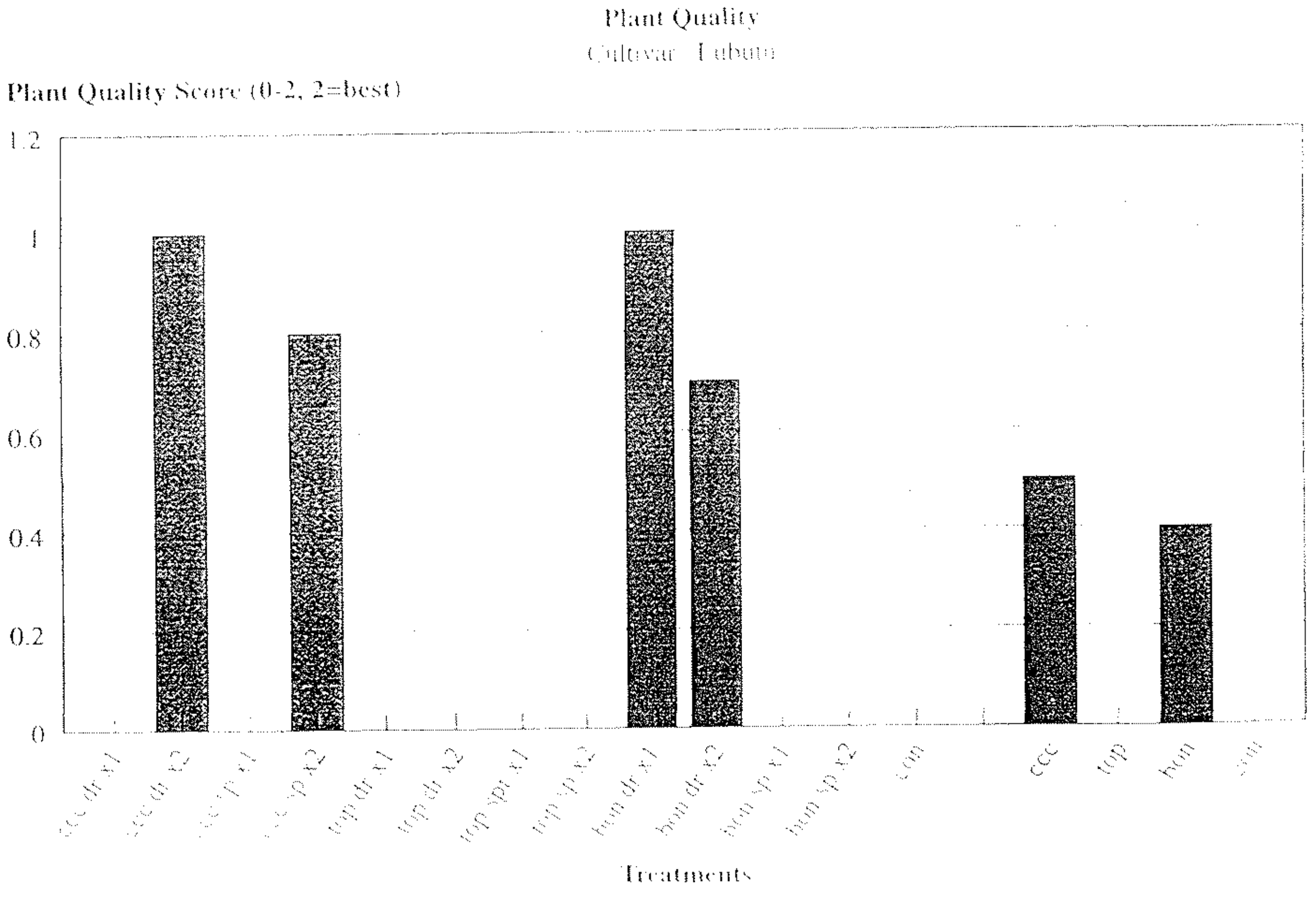
Flowering Records
Cultivar: Lubutu



Flower Diameter
Cultivar: Lubutu

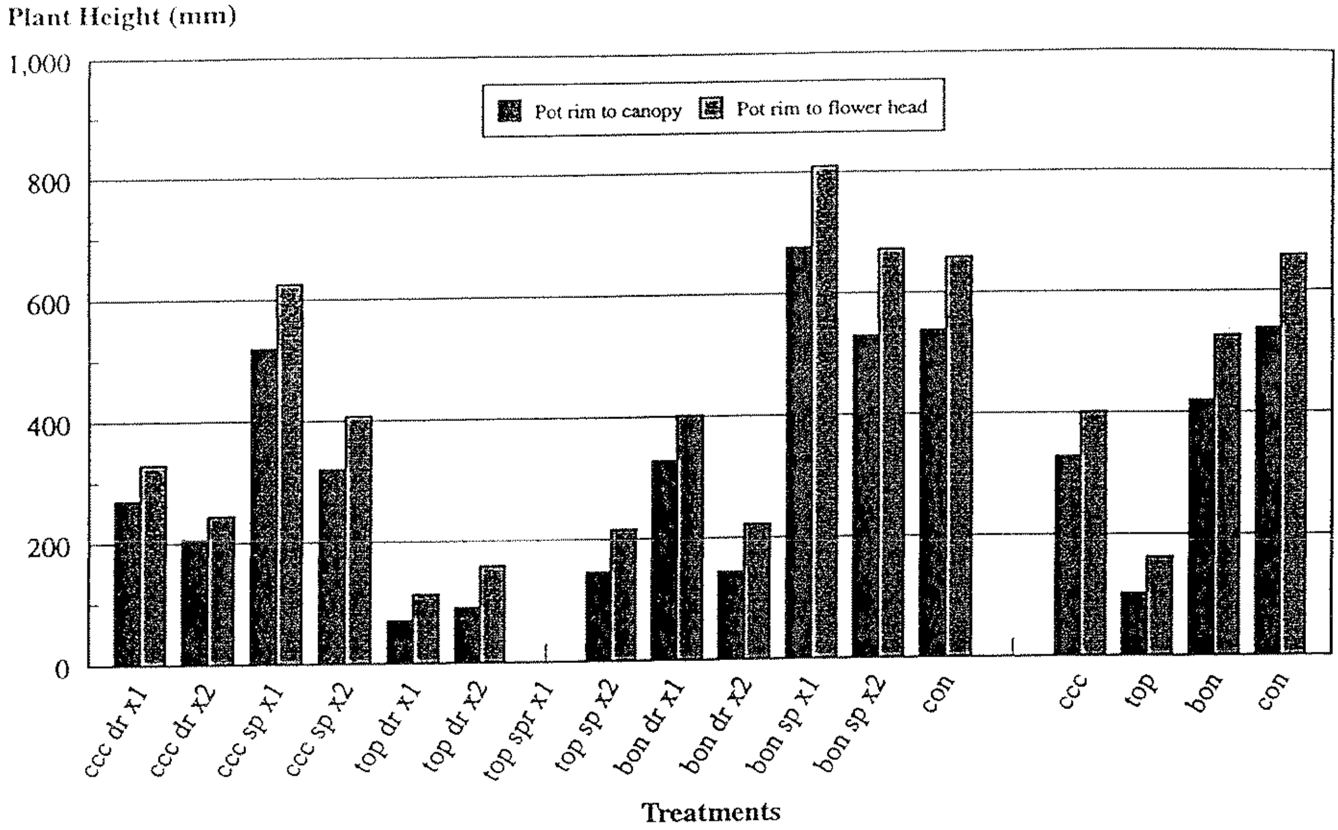


APPENDIX IV Trial One - Results

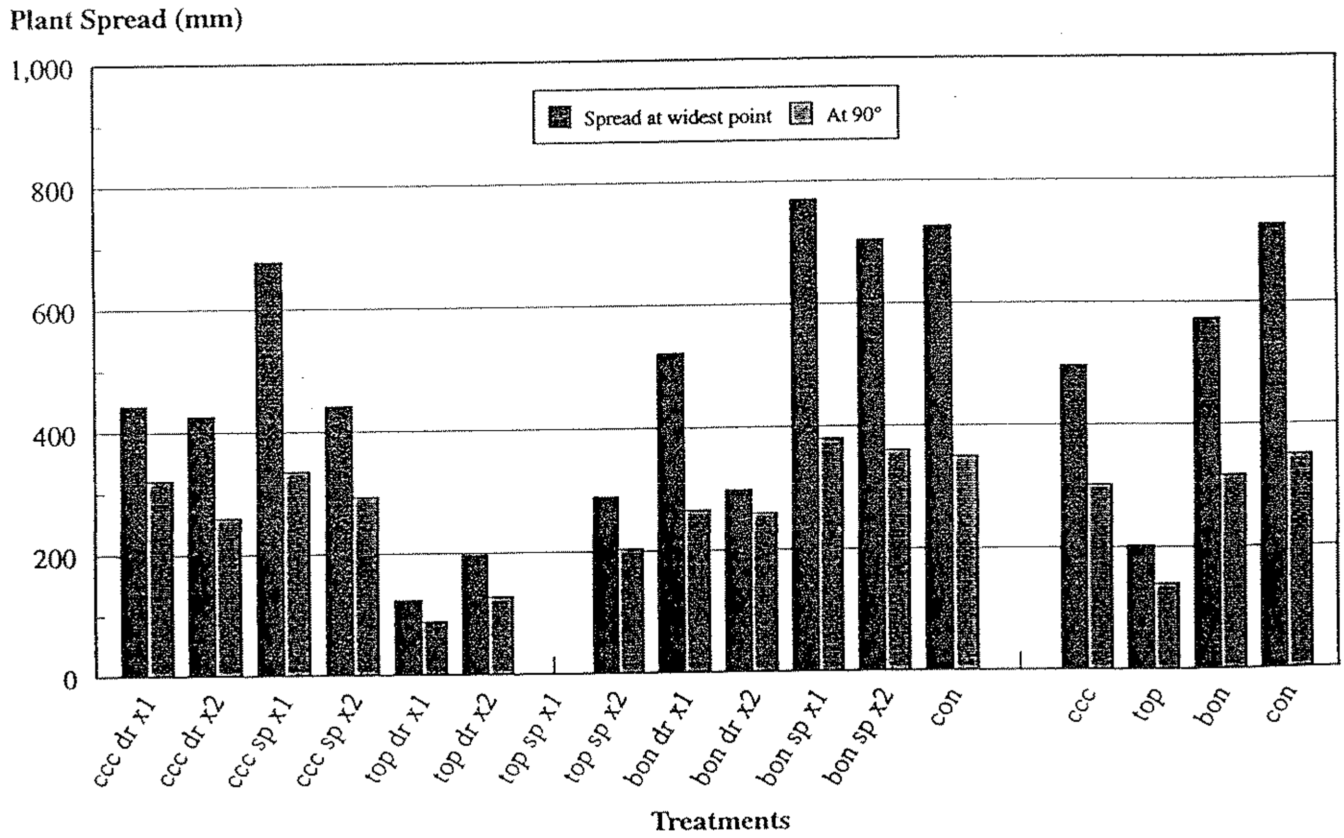


APPENDIX IV Trial One - Results

Plant Height
Cultivar: Sunny Girl

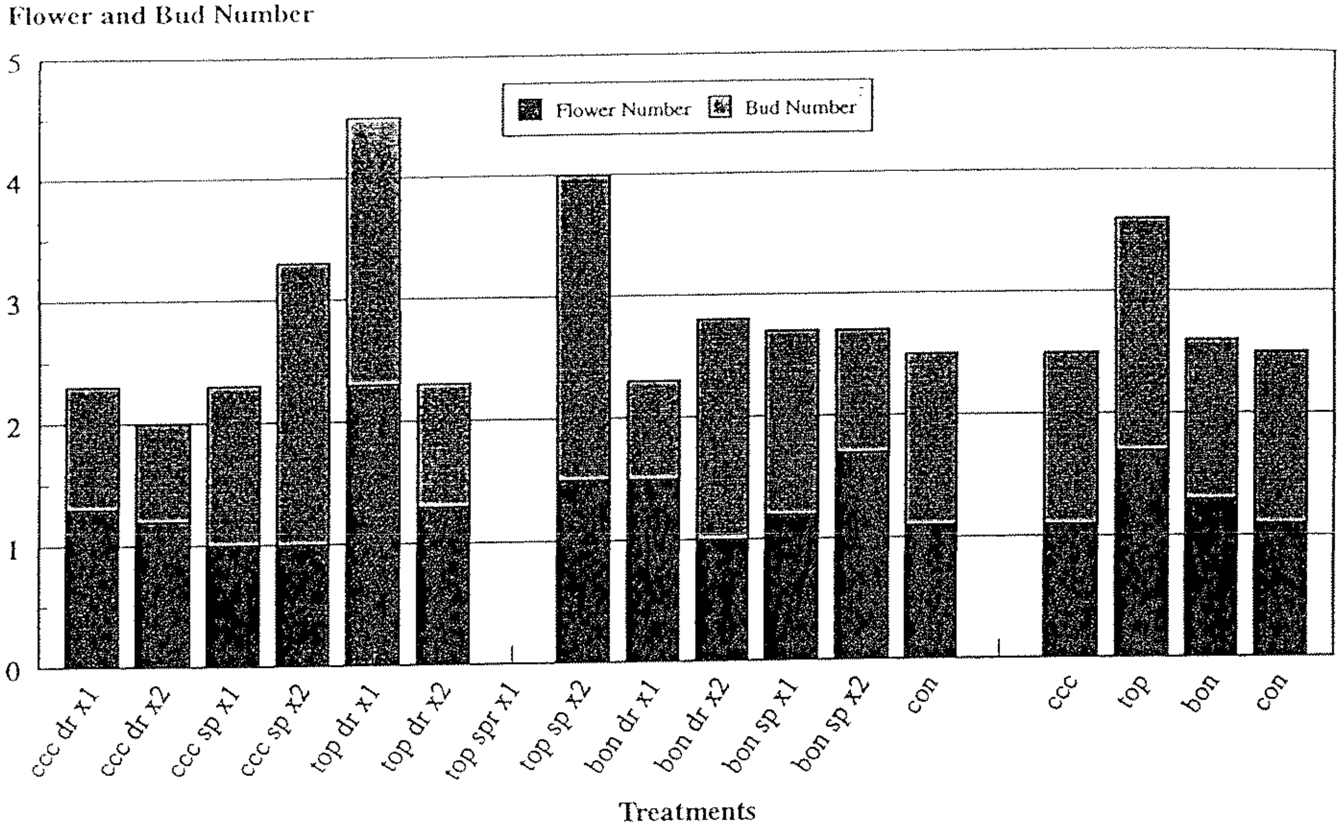


Plant Spread
Cultivar: Sunny Girl

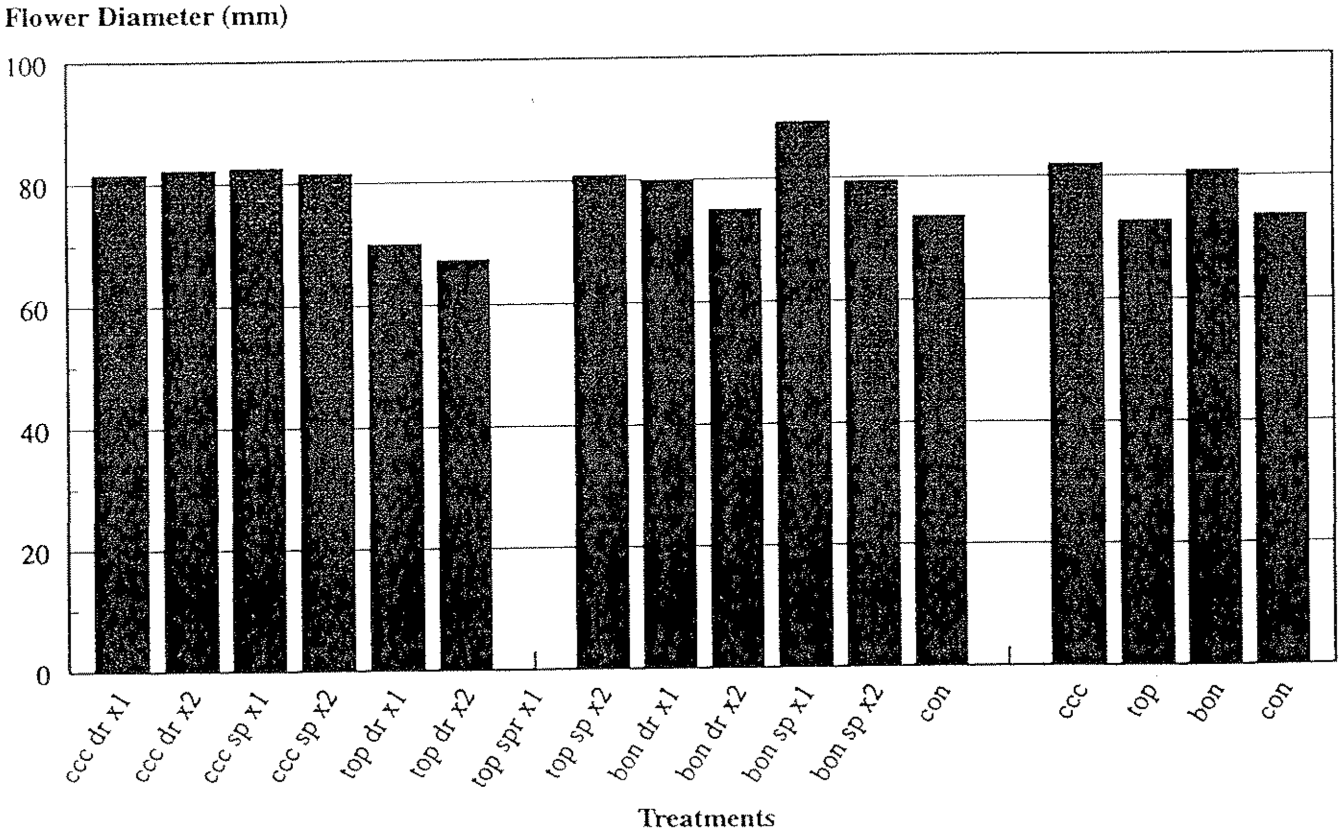


APPENDIX IV Trial One - Results

Flowering Records
Cultivar: Sunny Girl

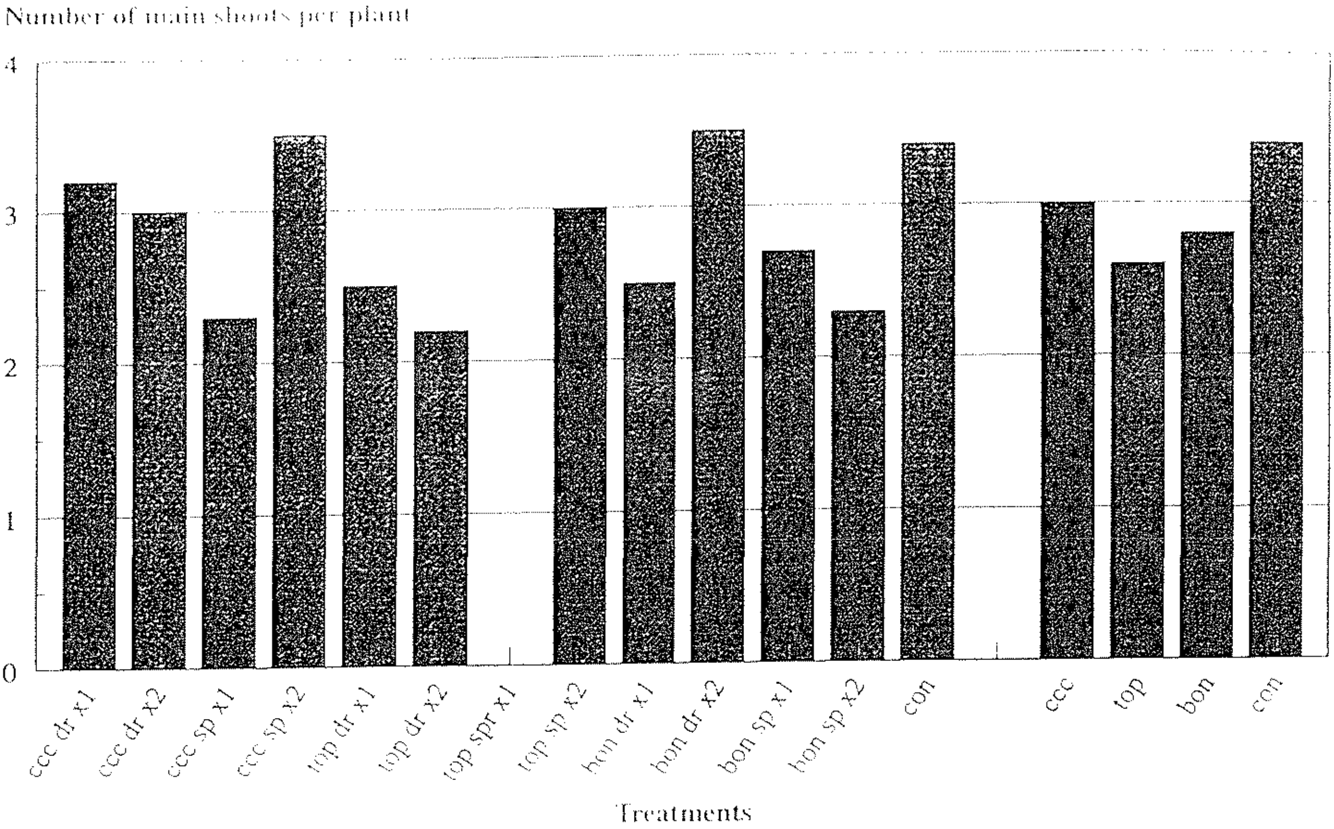


Flower Diameter
Cultivar: Sunny Girl

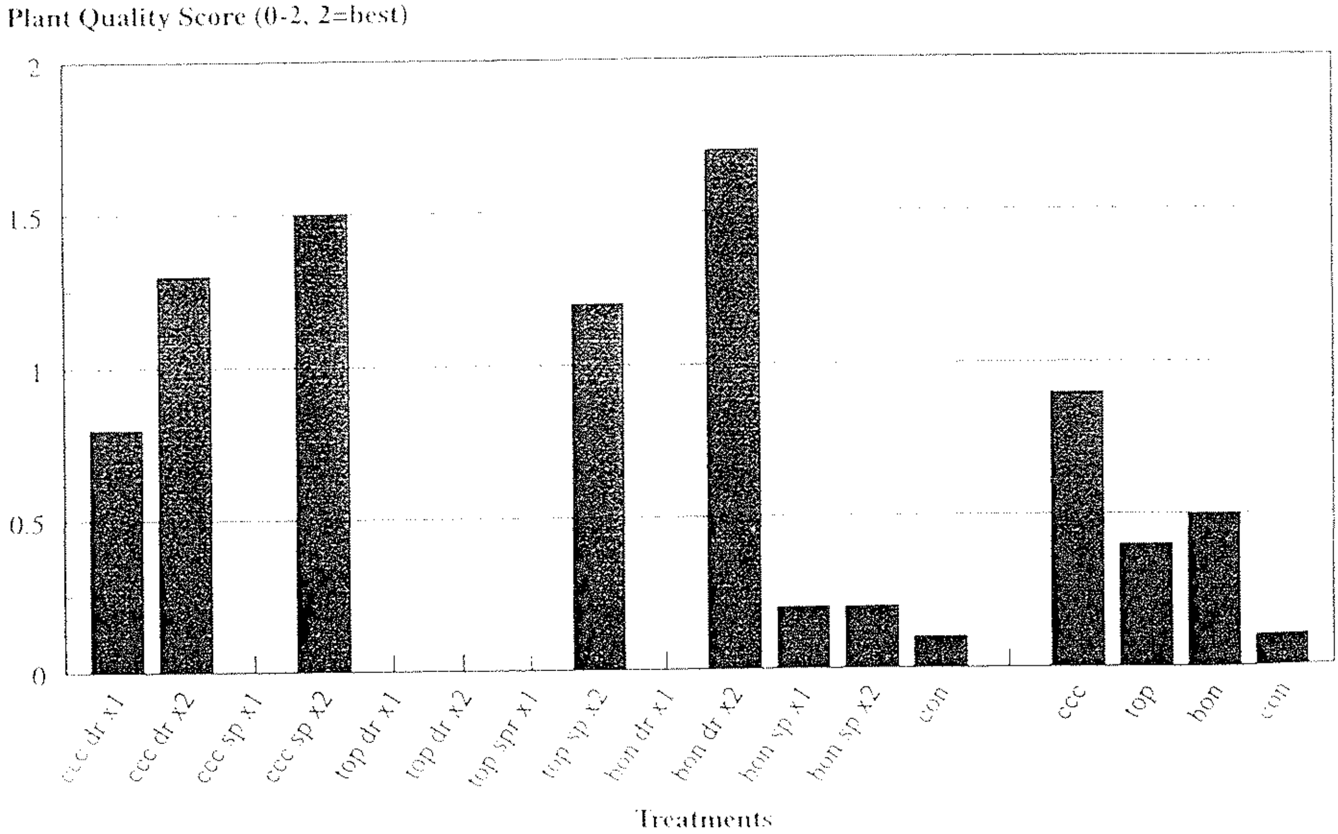


APPENDIX IV Trial One - Results

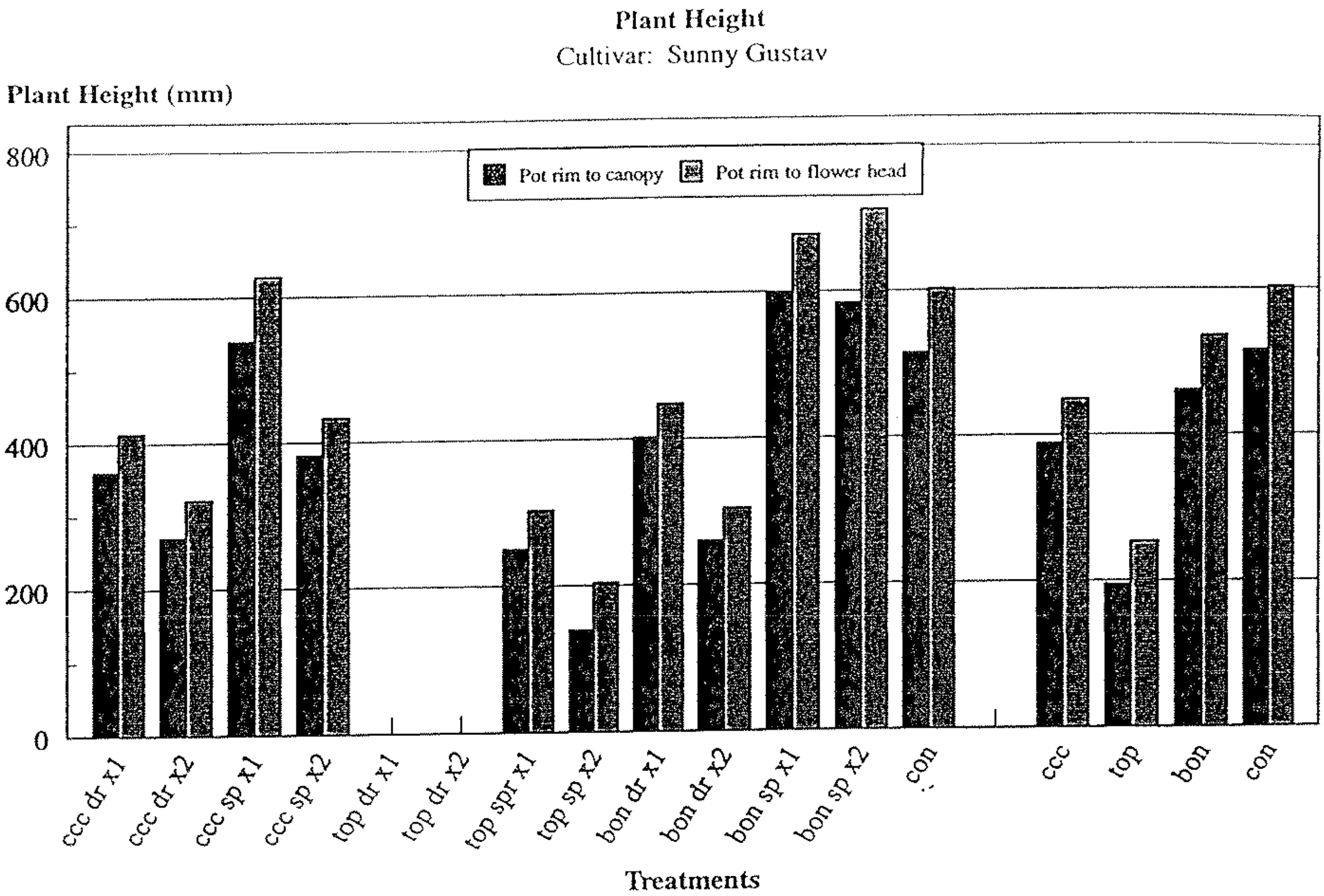
Record of Main Shoots
Cultivar: Sunny Girl

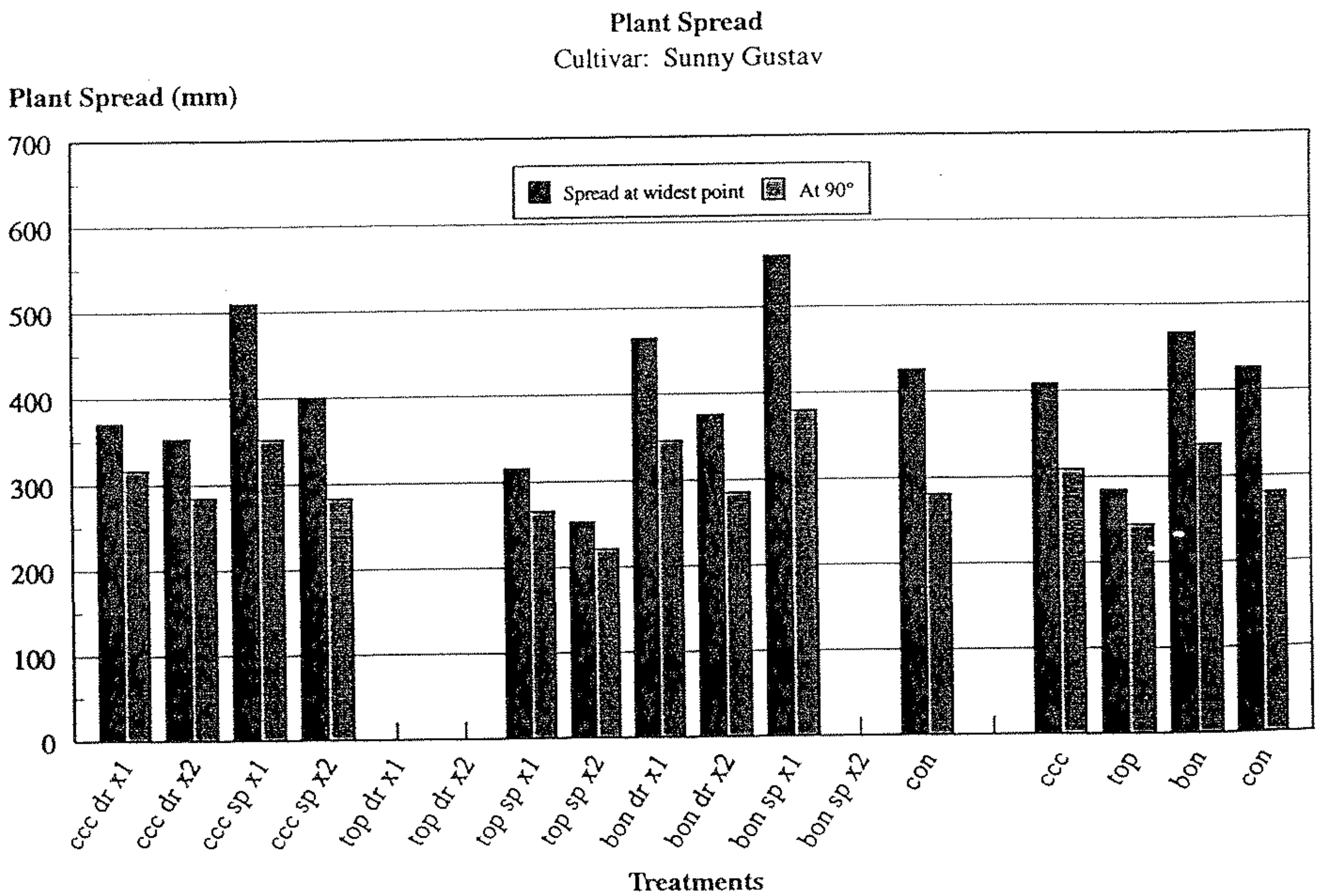


Plant Quality
Cultivar: Sunny Girl

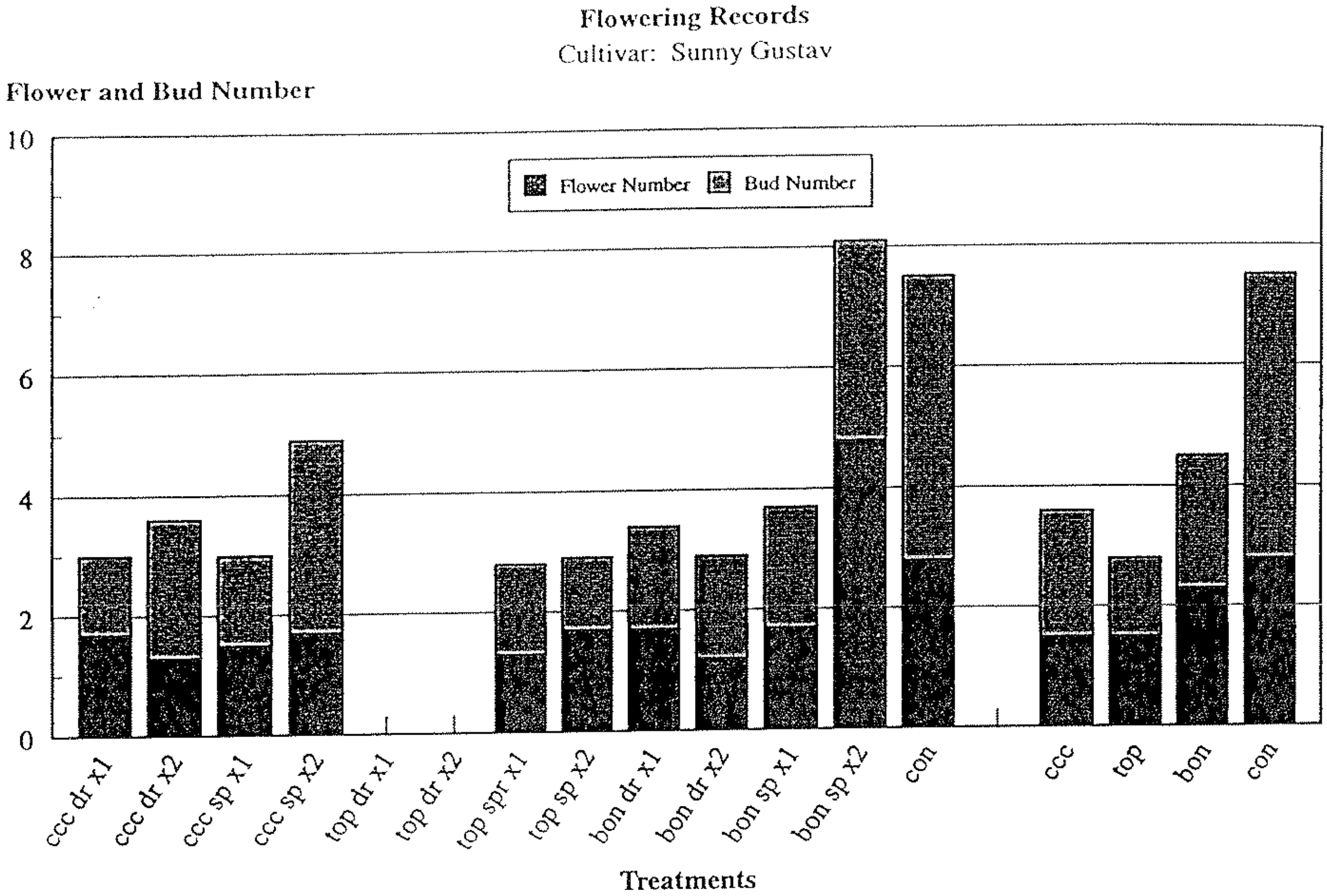


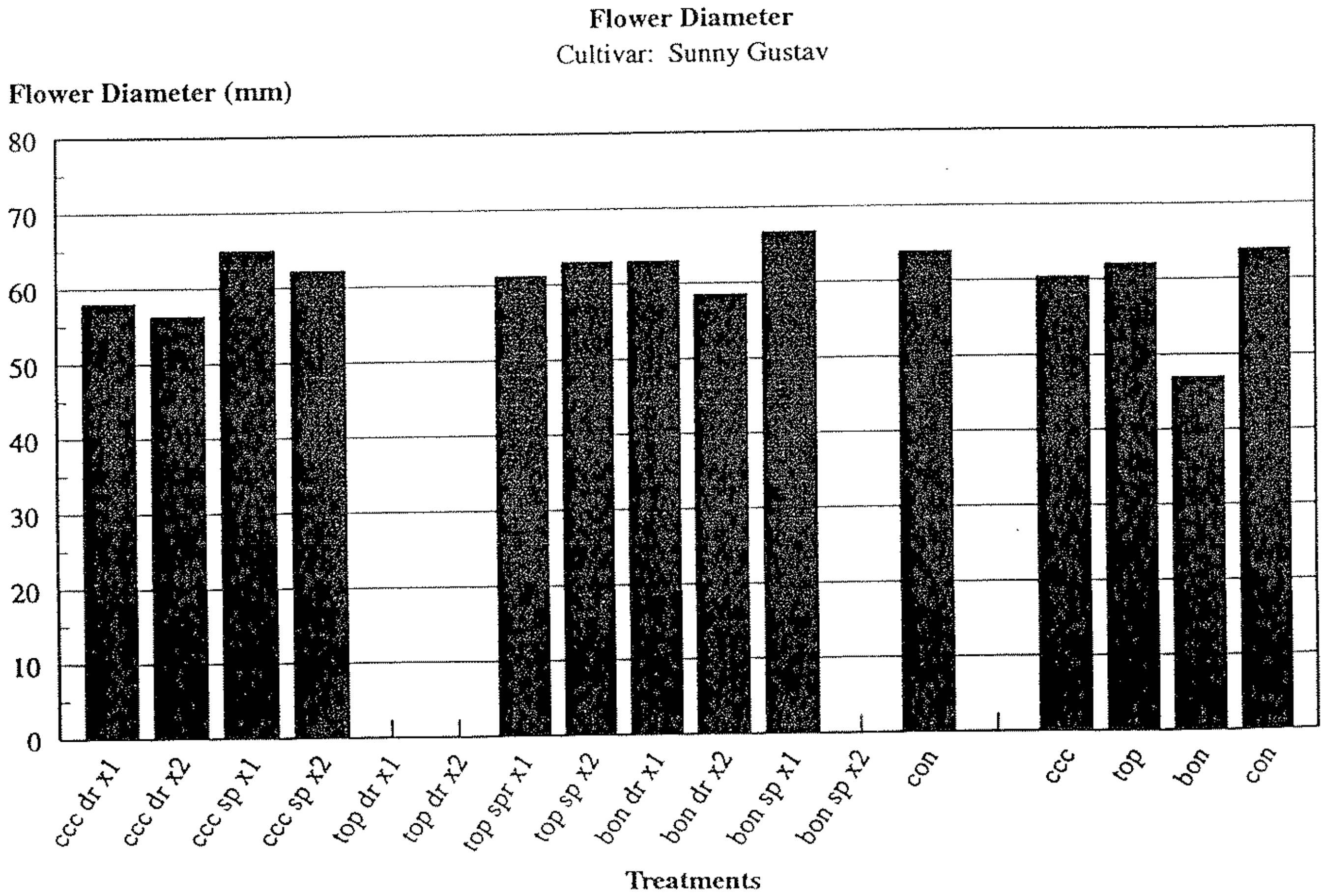
APPENDIX IV Trial One - Results





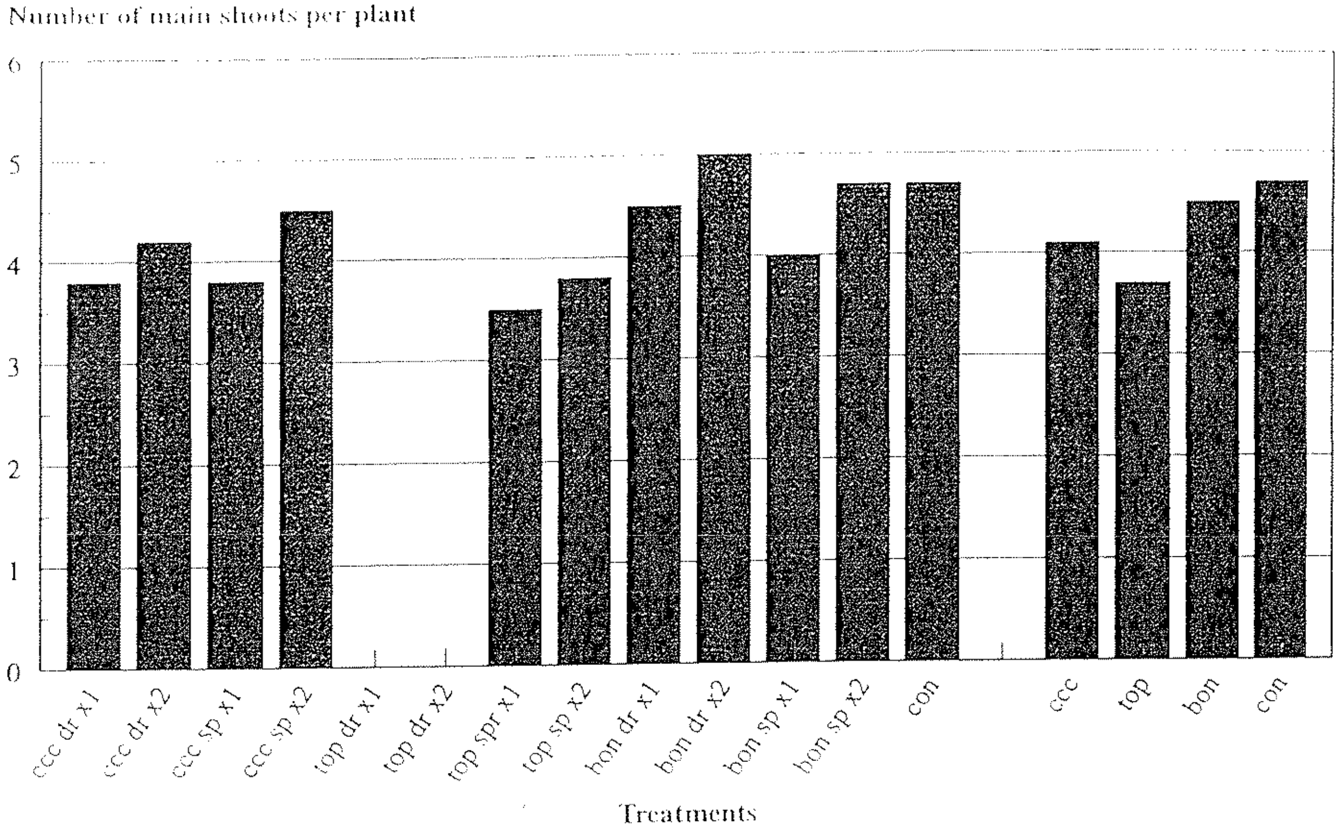
APPENDIX IV Trial One - Results



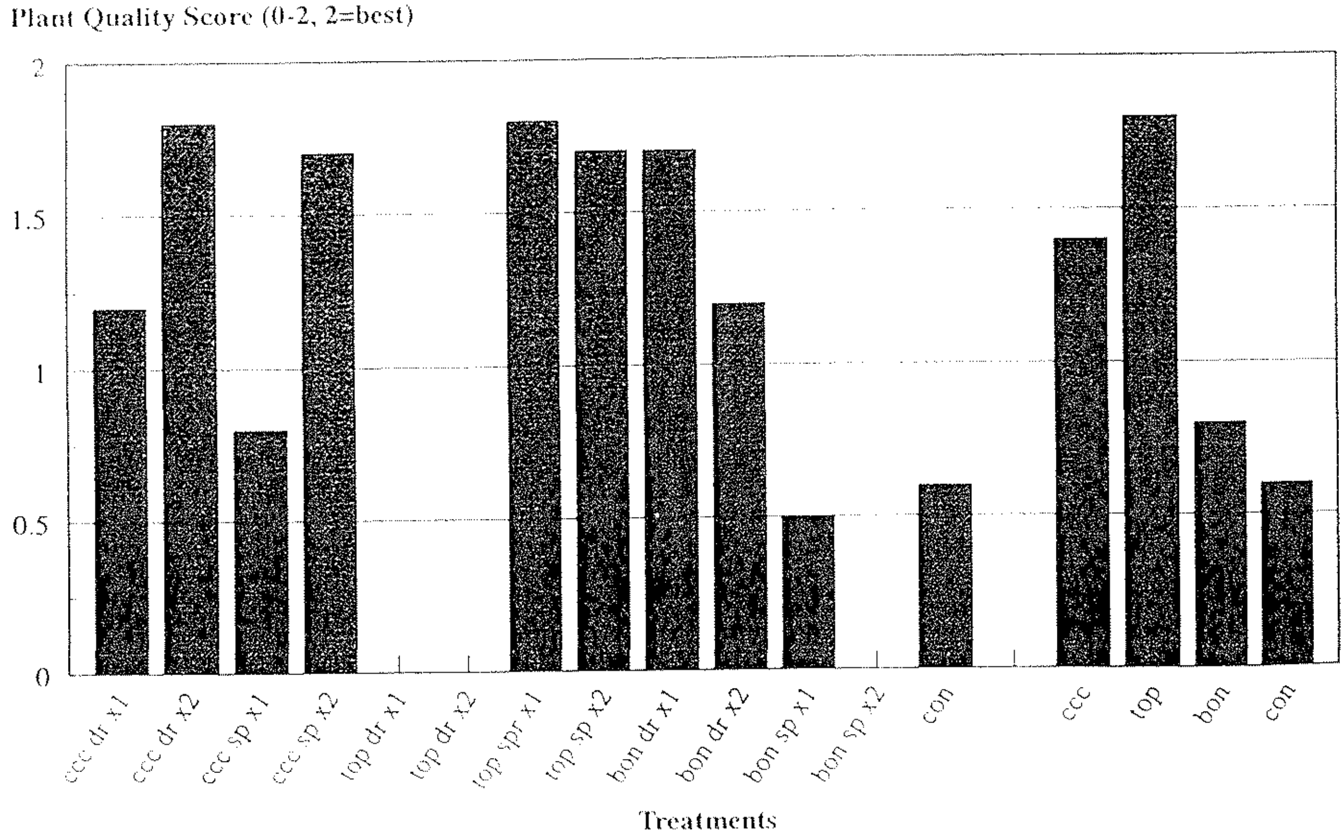


APPENDIX IV Trial One - Results

Record of Main Shoots
Cultivar: Sunny Gustav

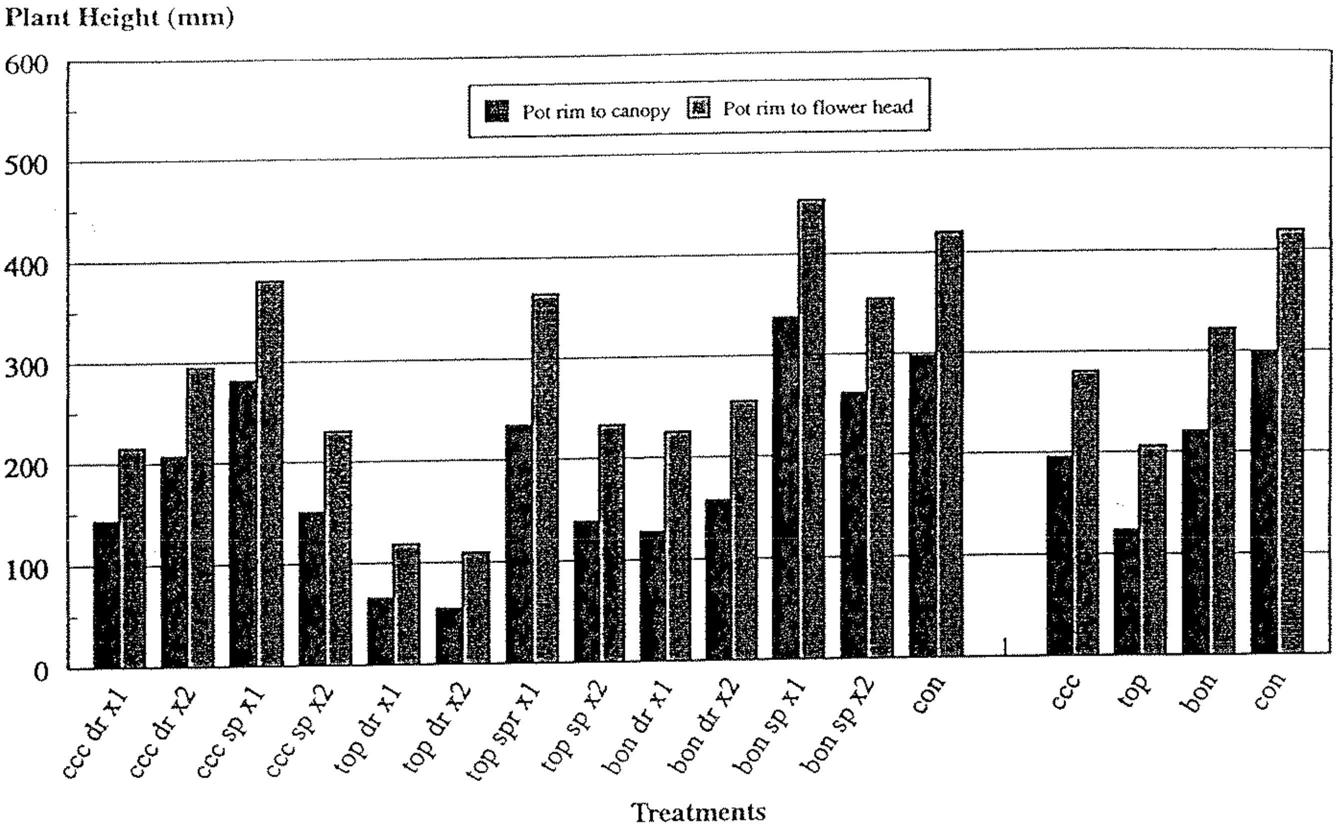


Plant Quality
Cultivar: Sunny Gustav

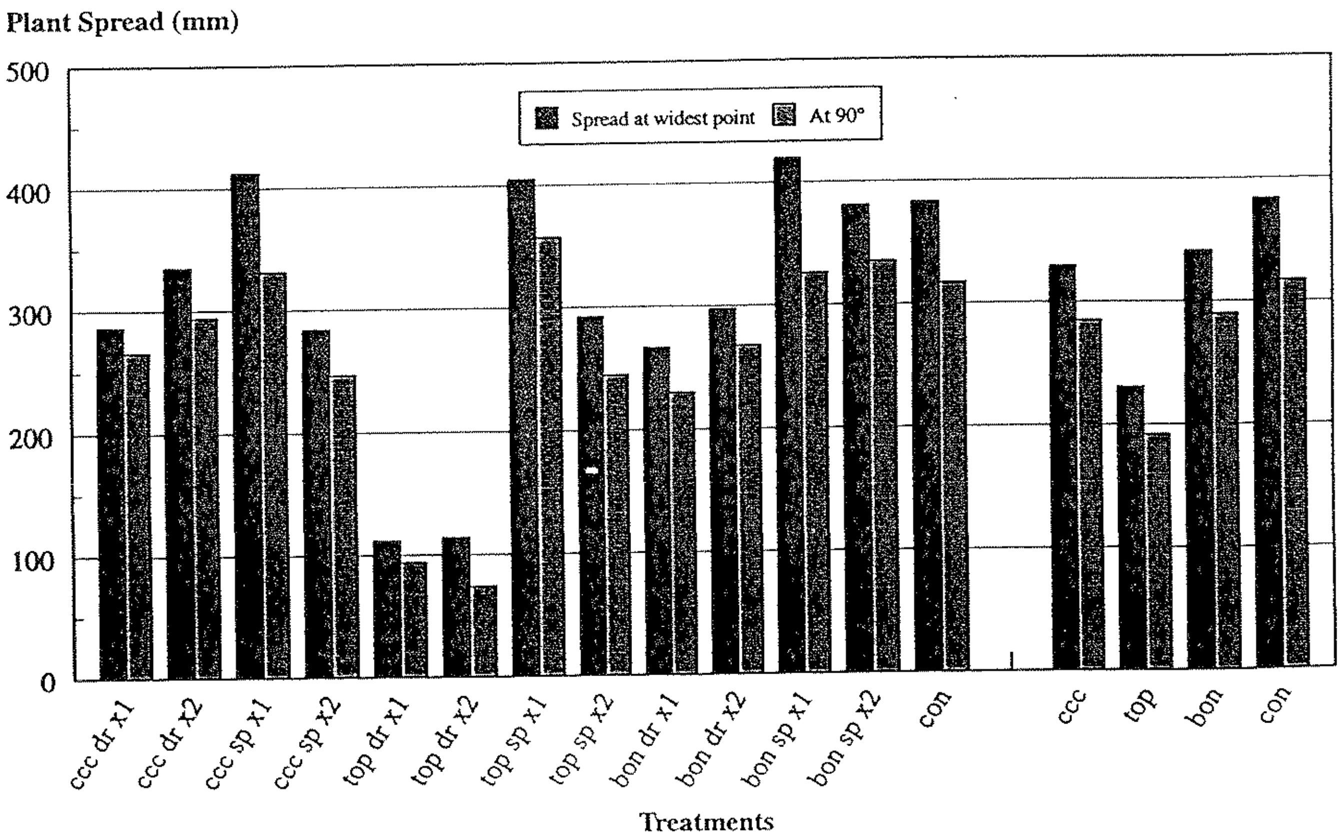


APPENDIX IV Trial One - Results

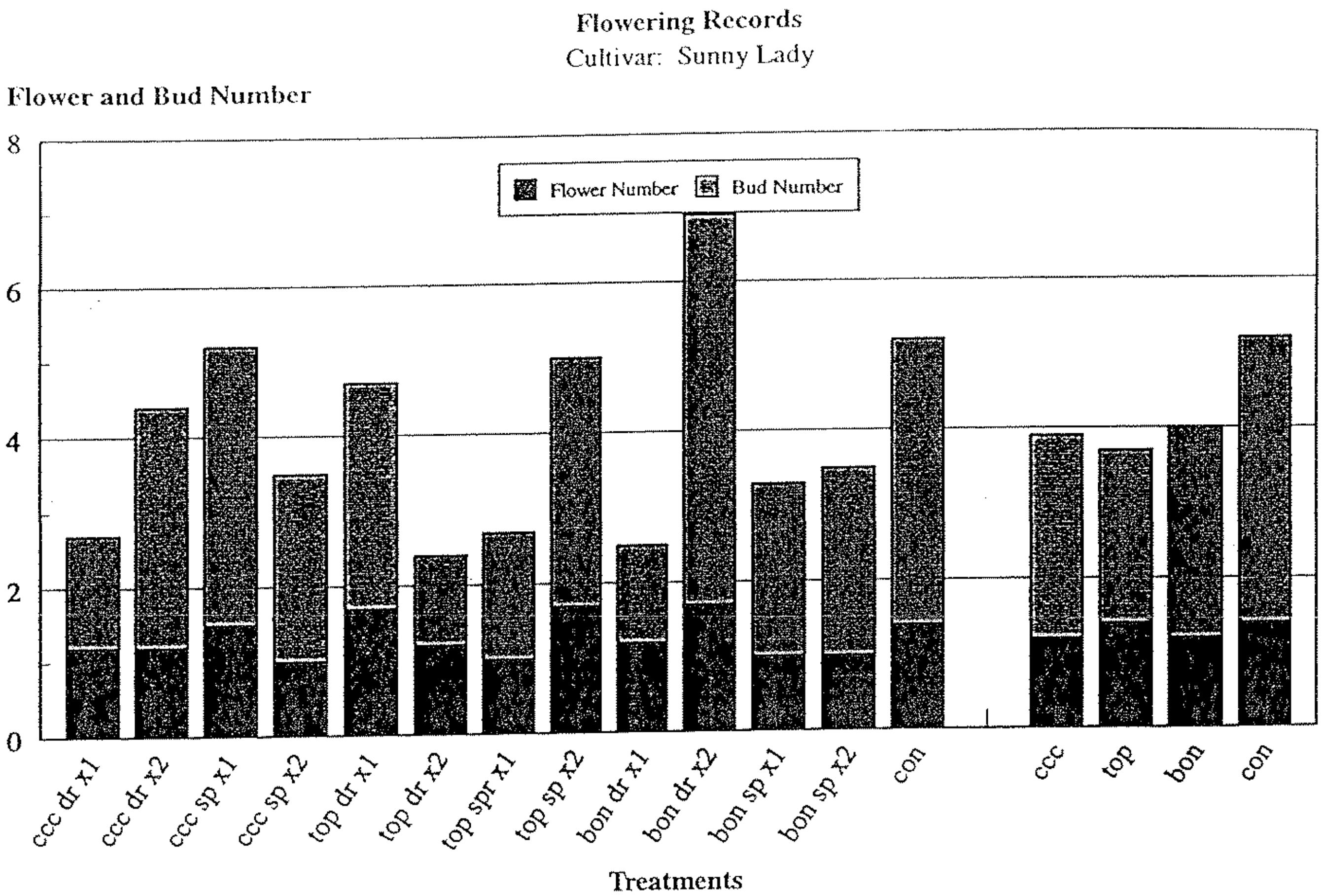
Plant Height
Cultivar: Sunny Lady

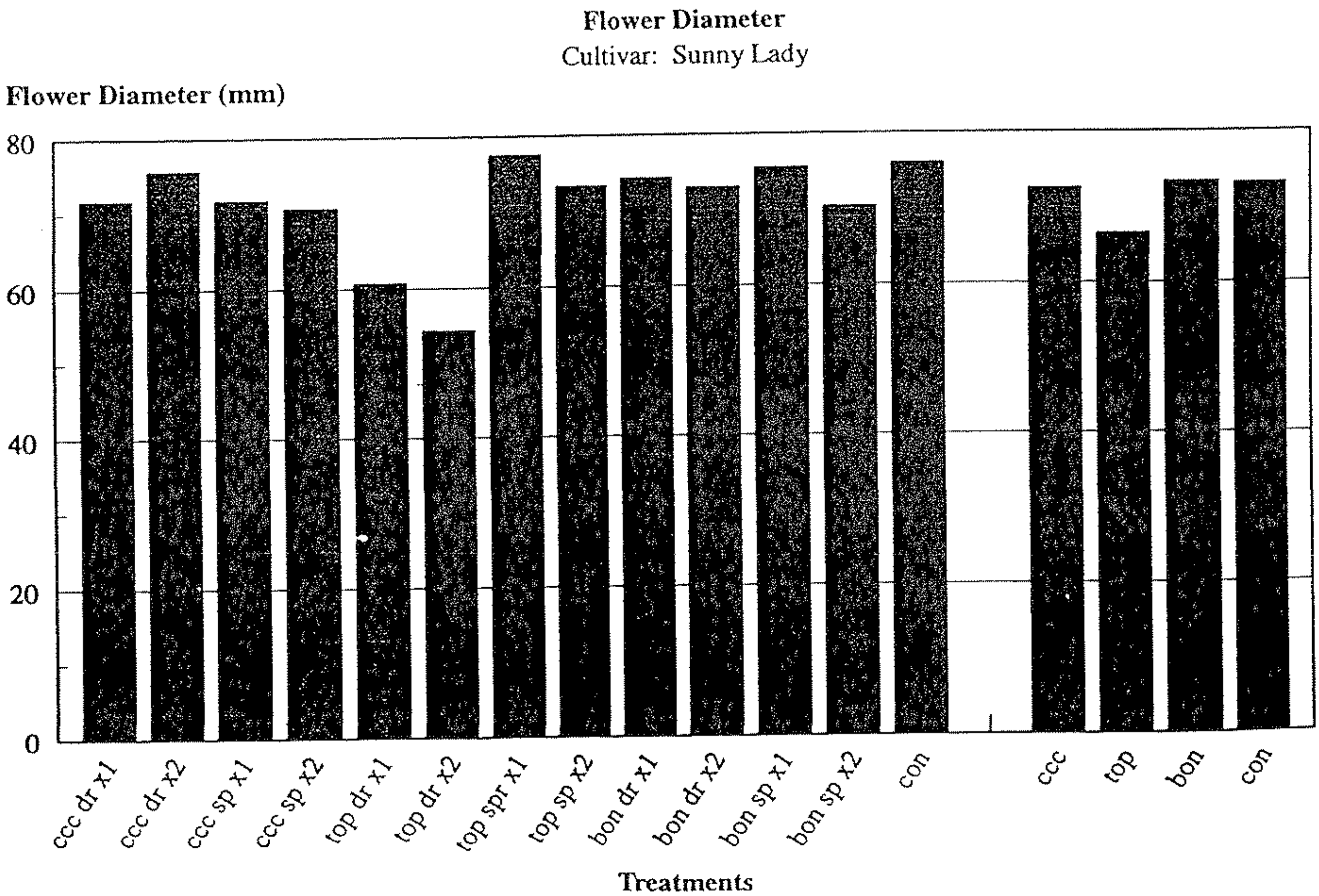


Plant Spread
Cultivar: Sunny Lady

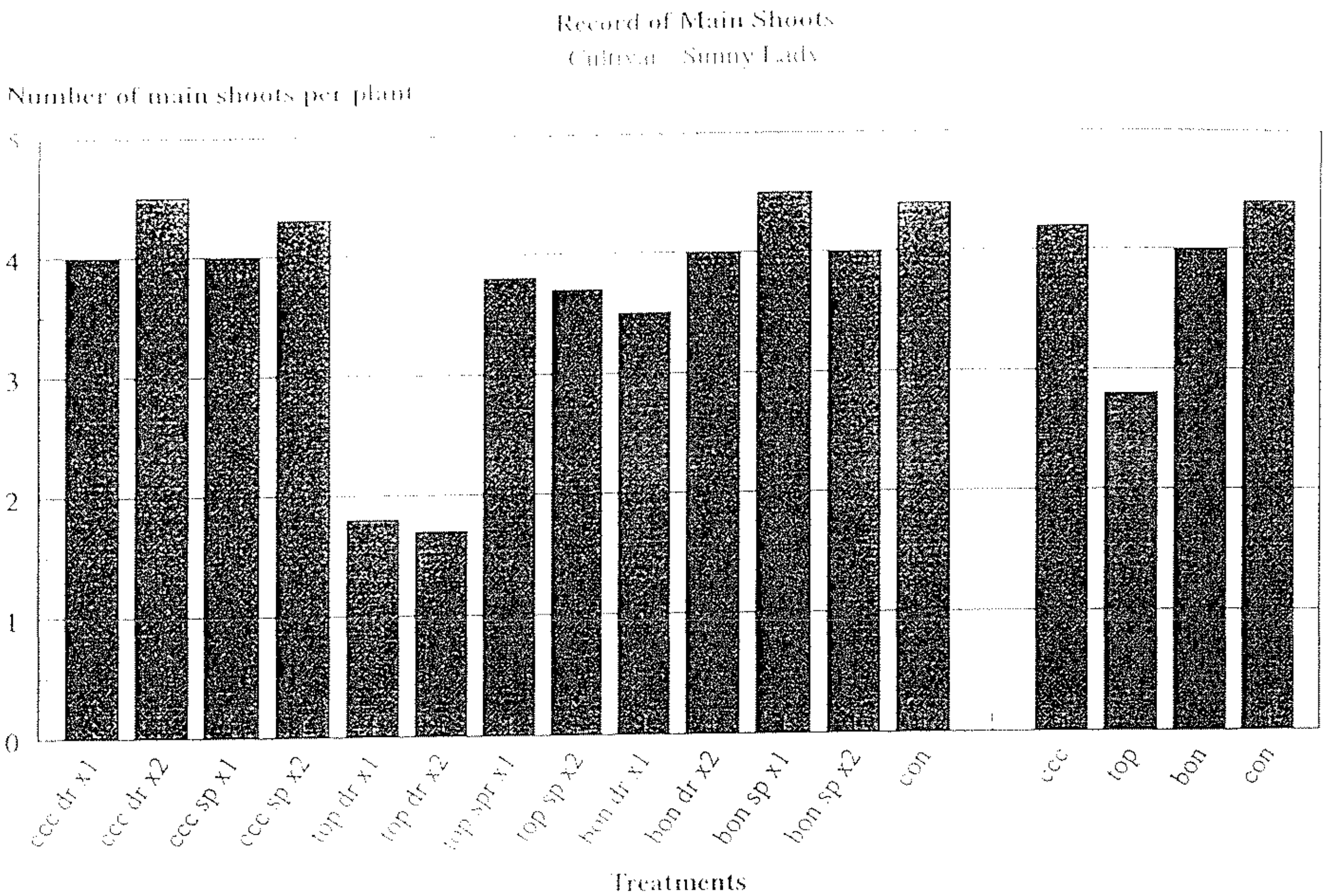


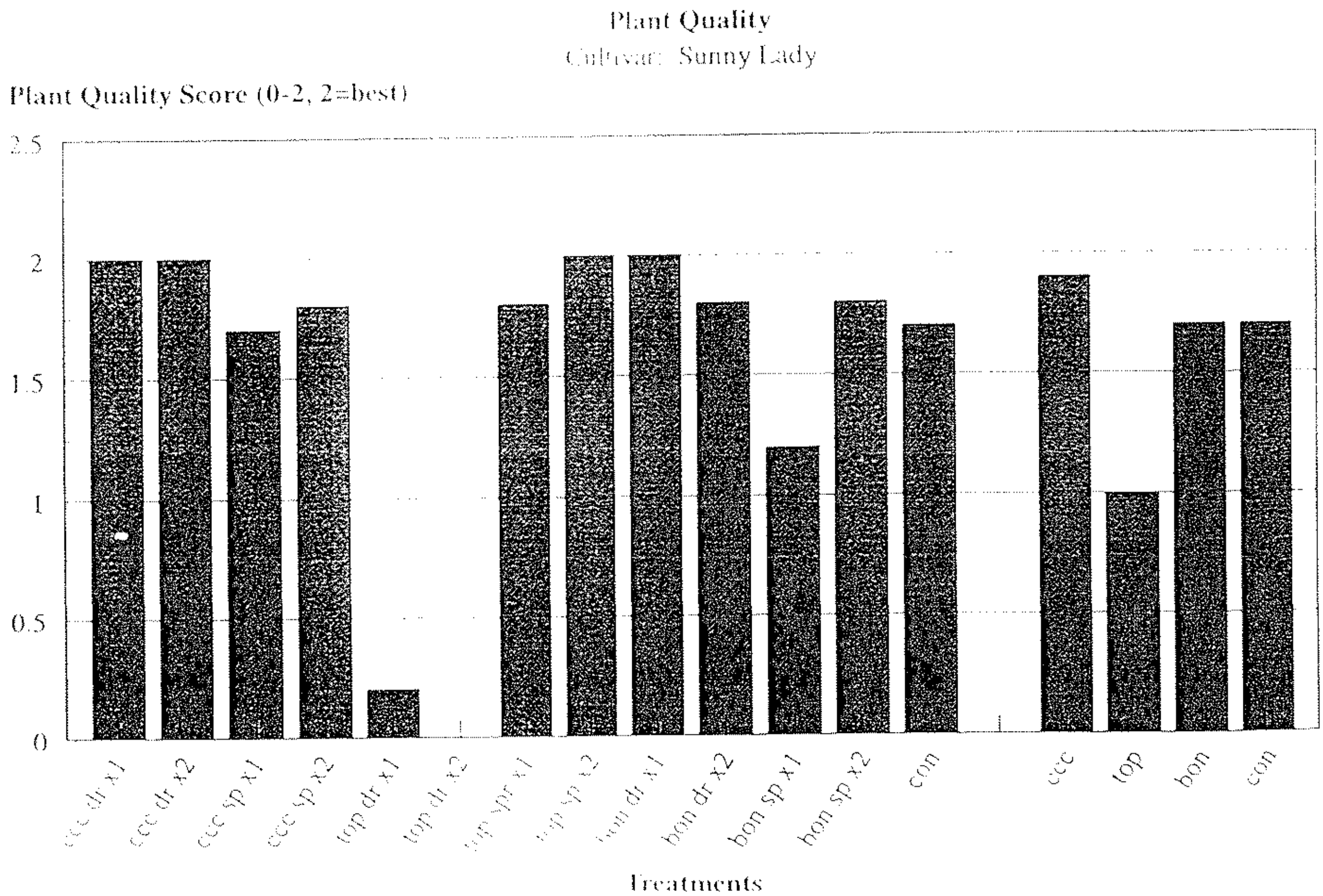
APPENDIX IV Trial One - Results



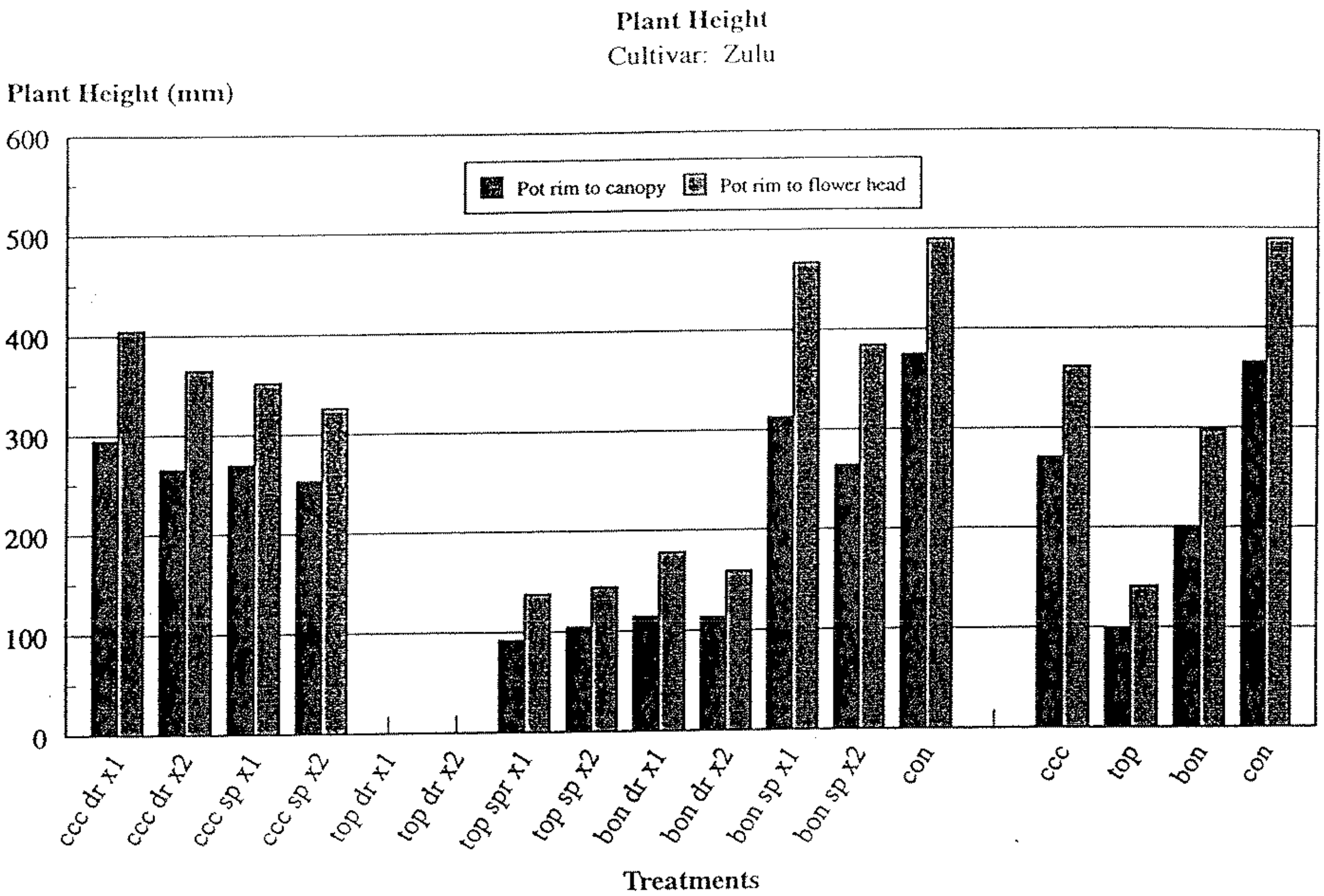


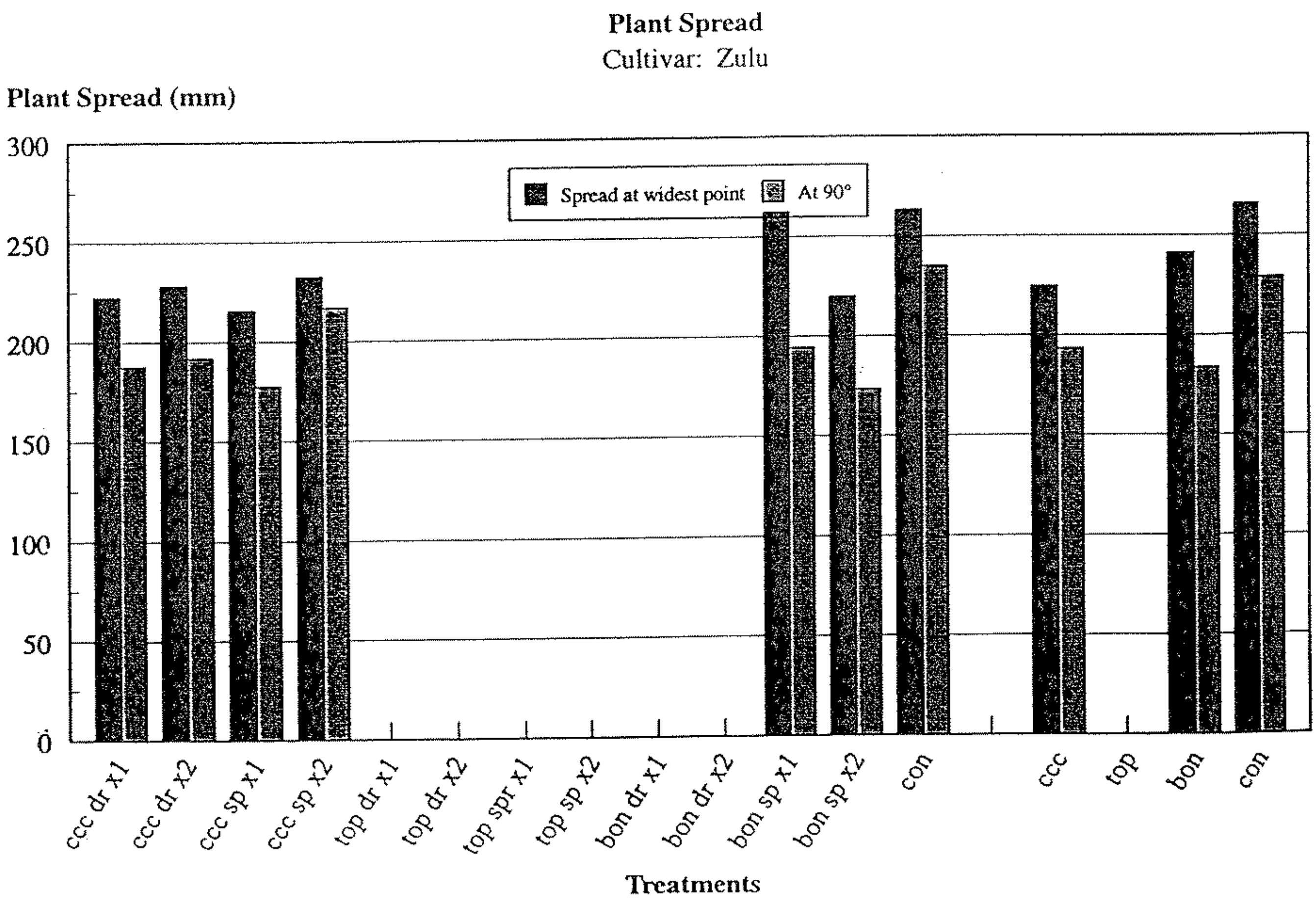
APPENDIX IV Trial One Results



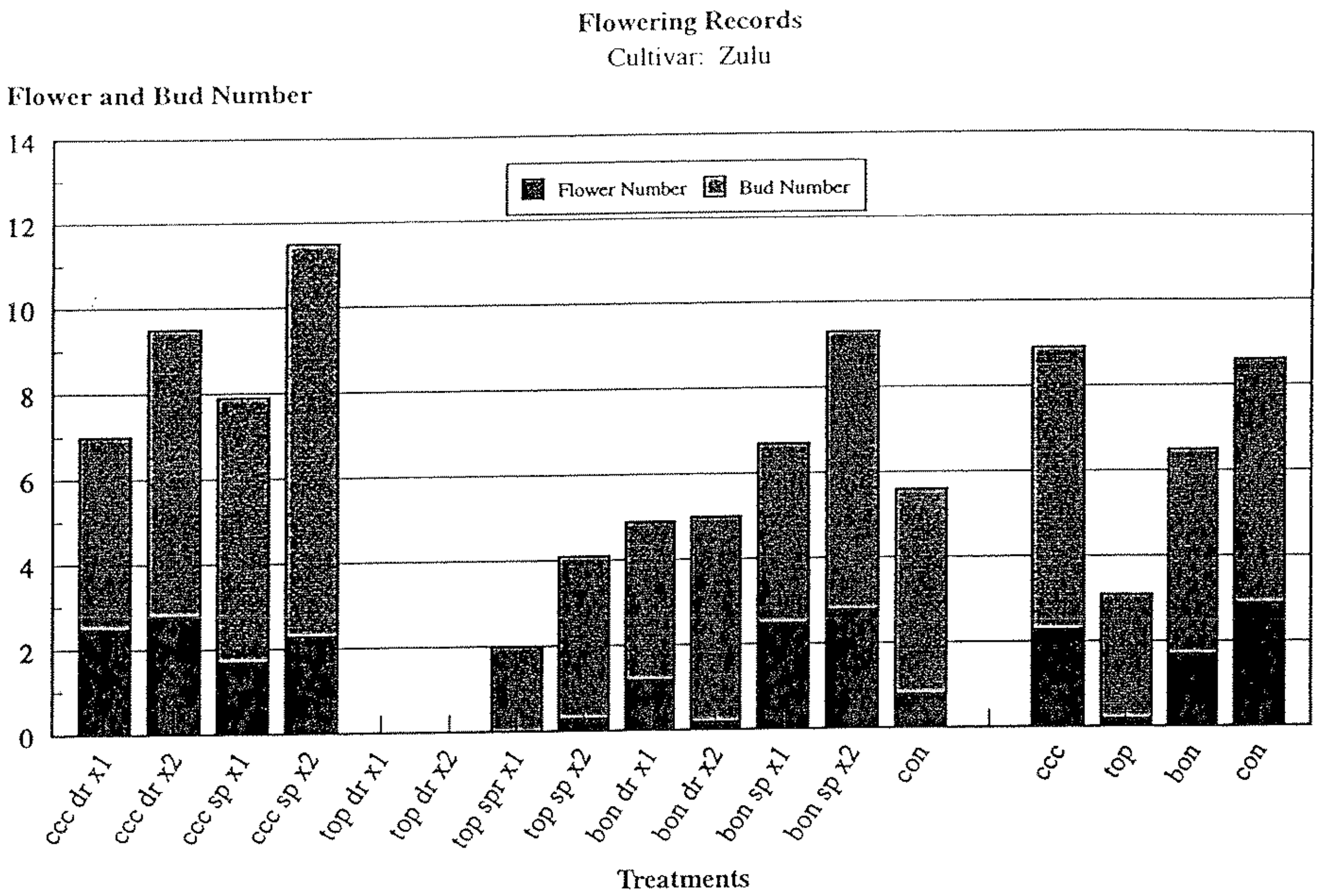


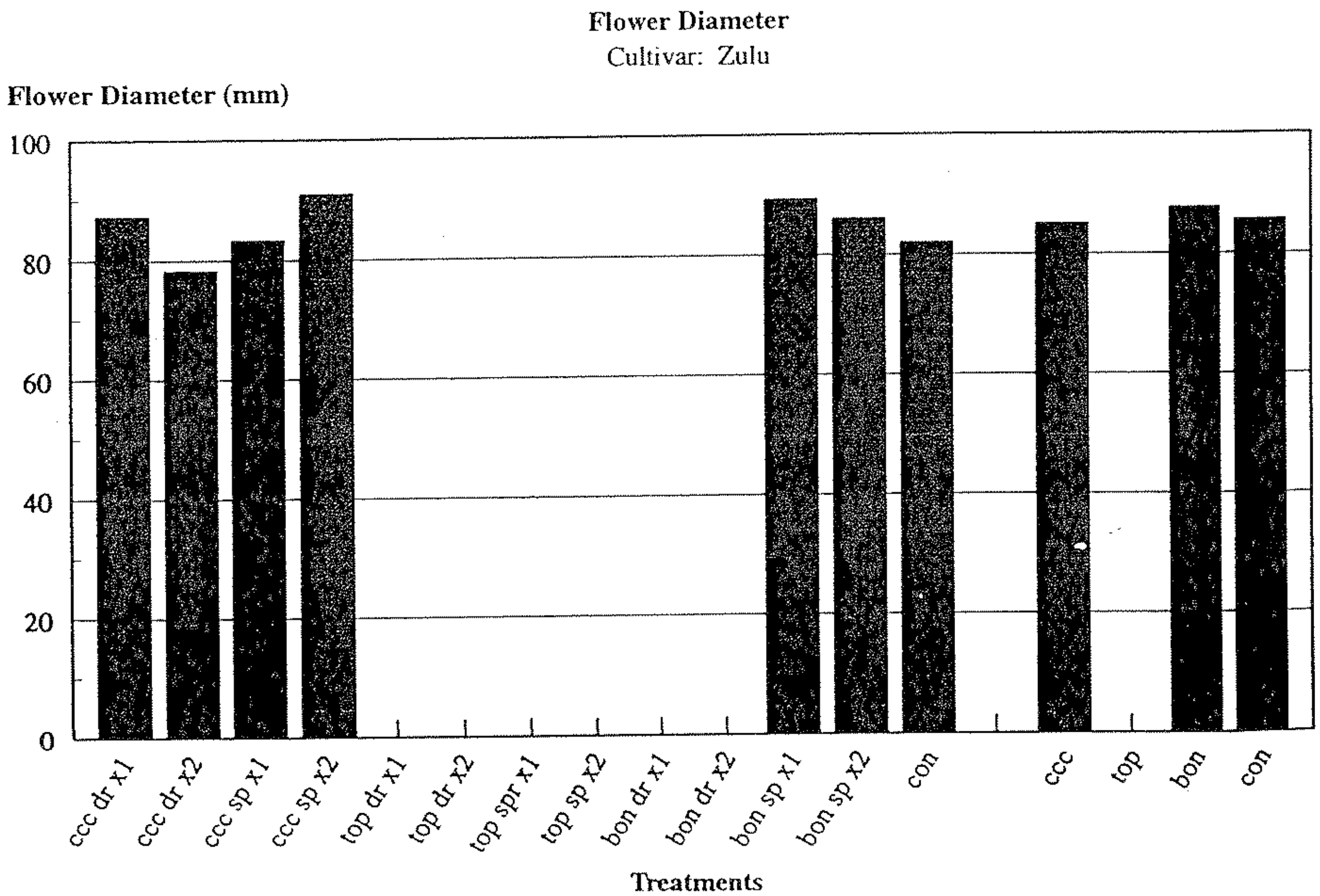
APPENDIX IV Trial One - Results





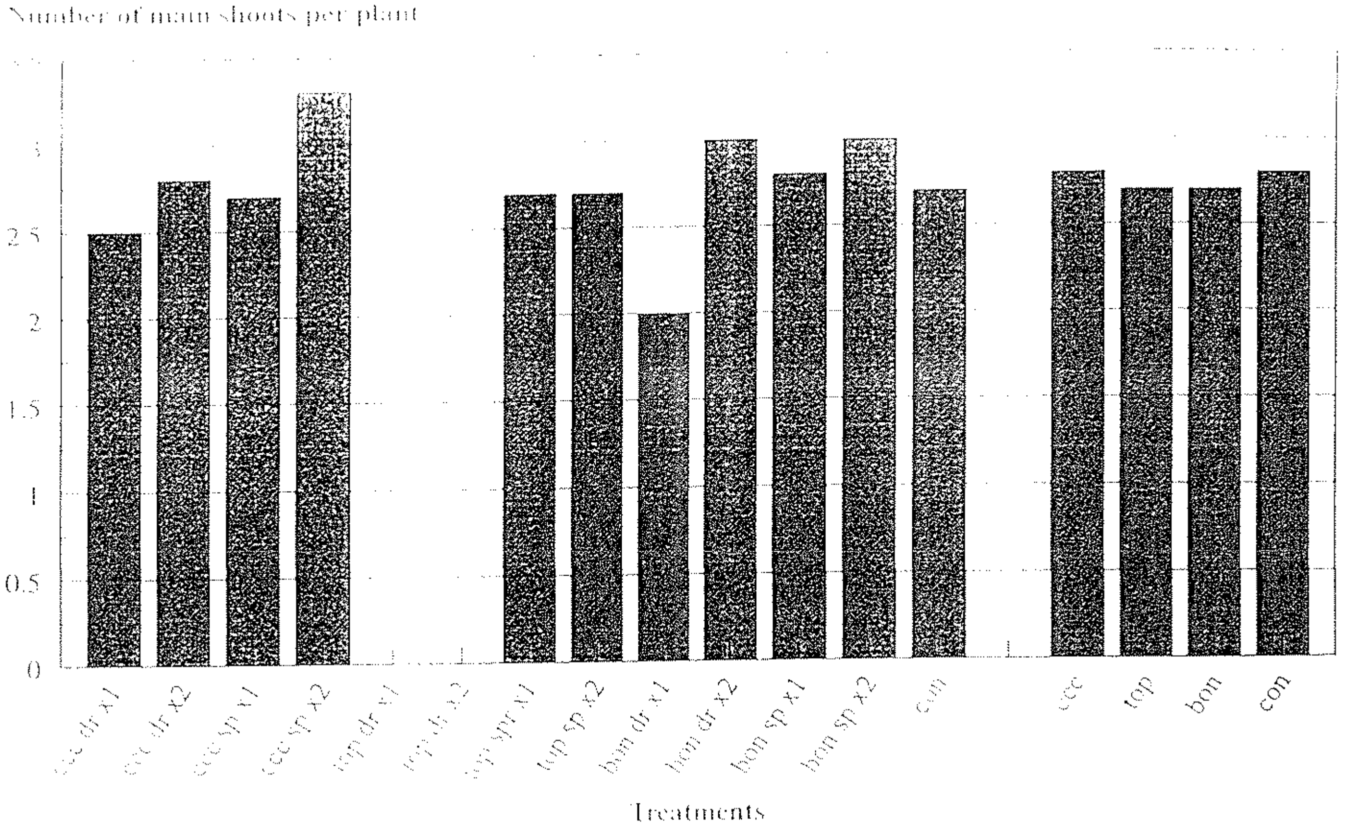
APPENDIX IV Trial One - Results



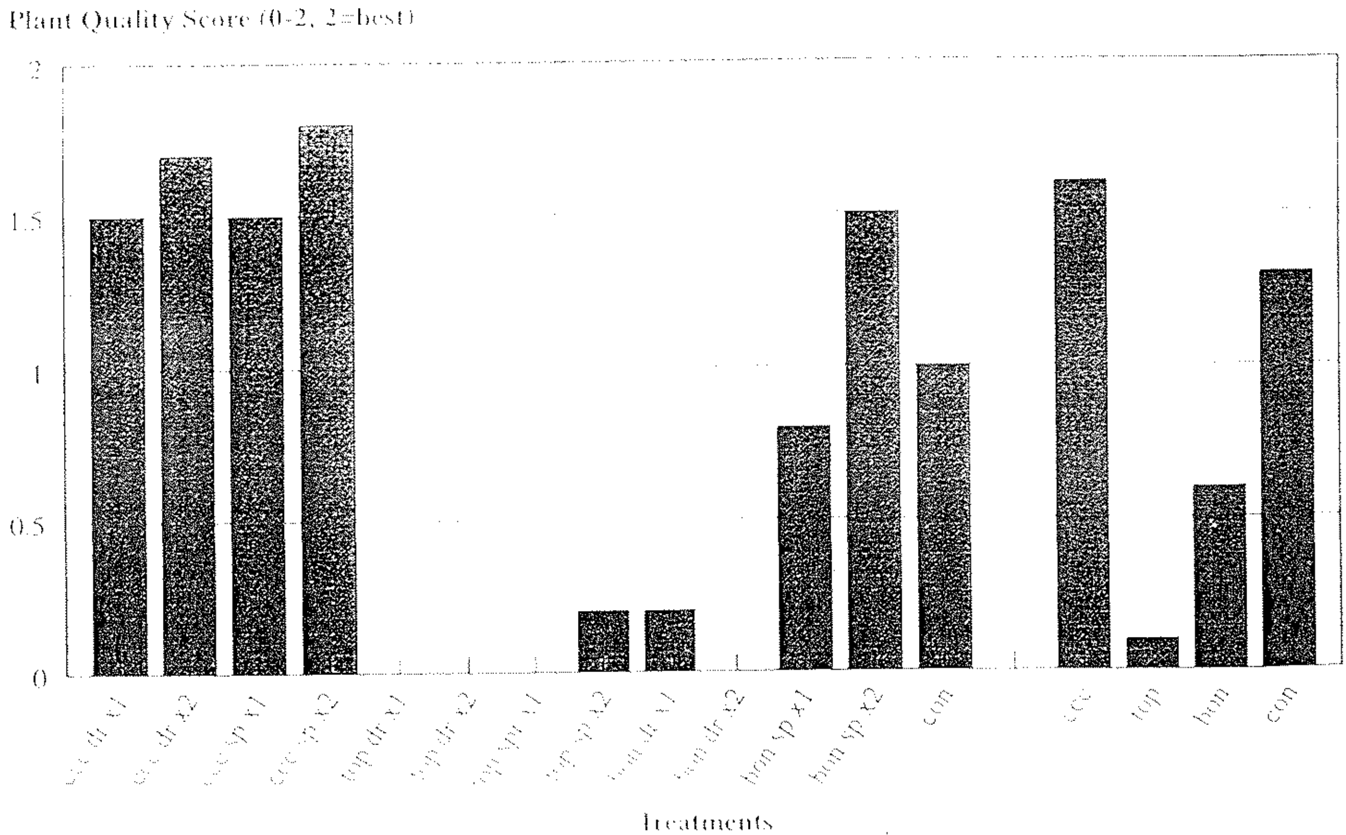


APPENDIX IV   Trial One - Results

Record of Main Shoots
Cultivar: Zulu



Plant Quality
Cultivar: Zulu

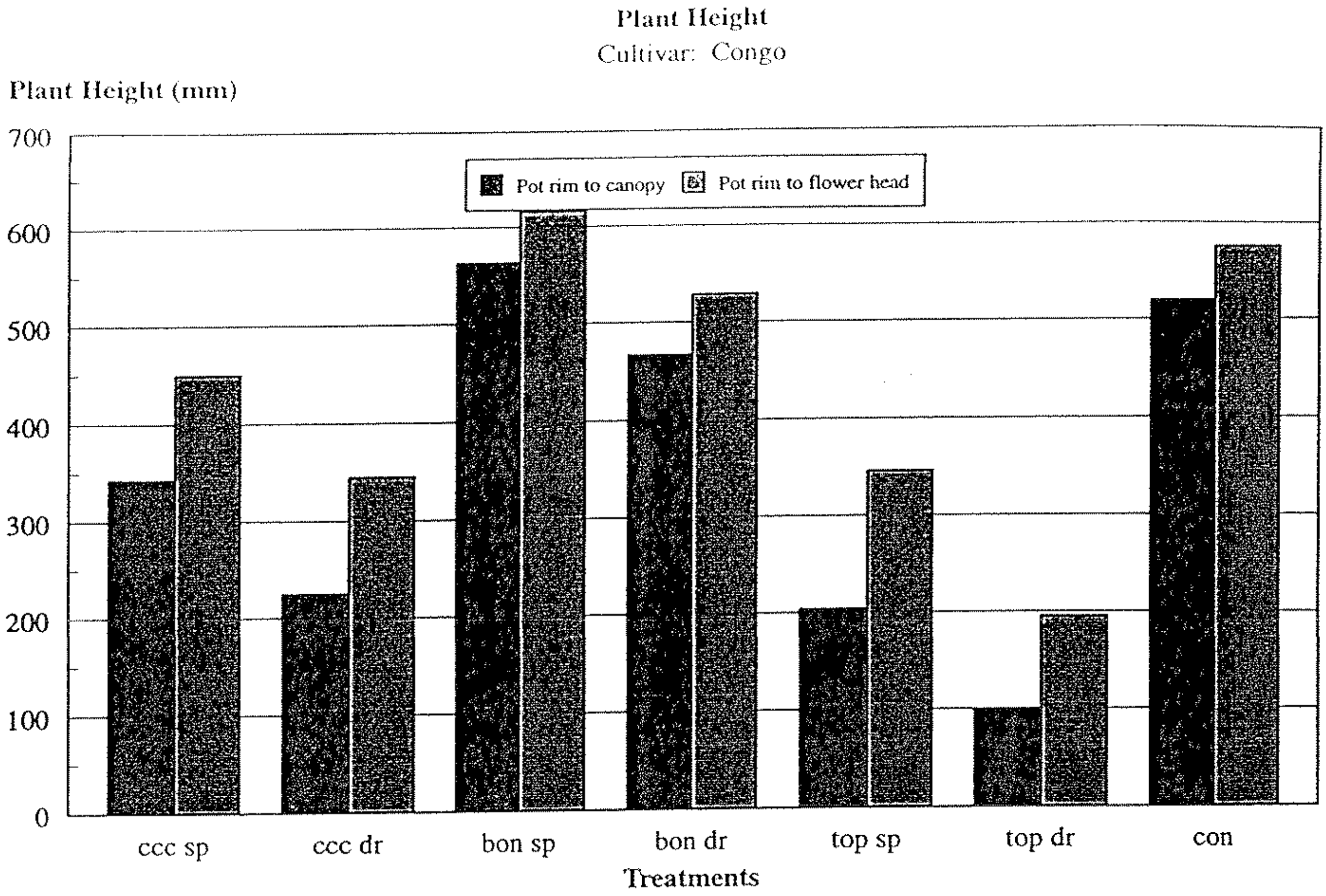


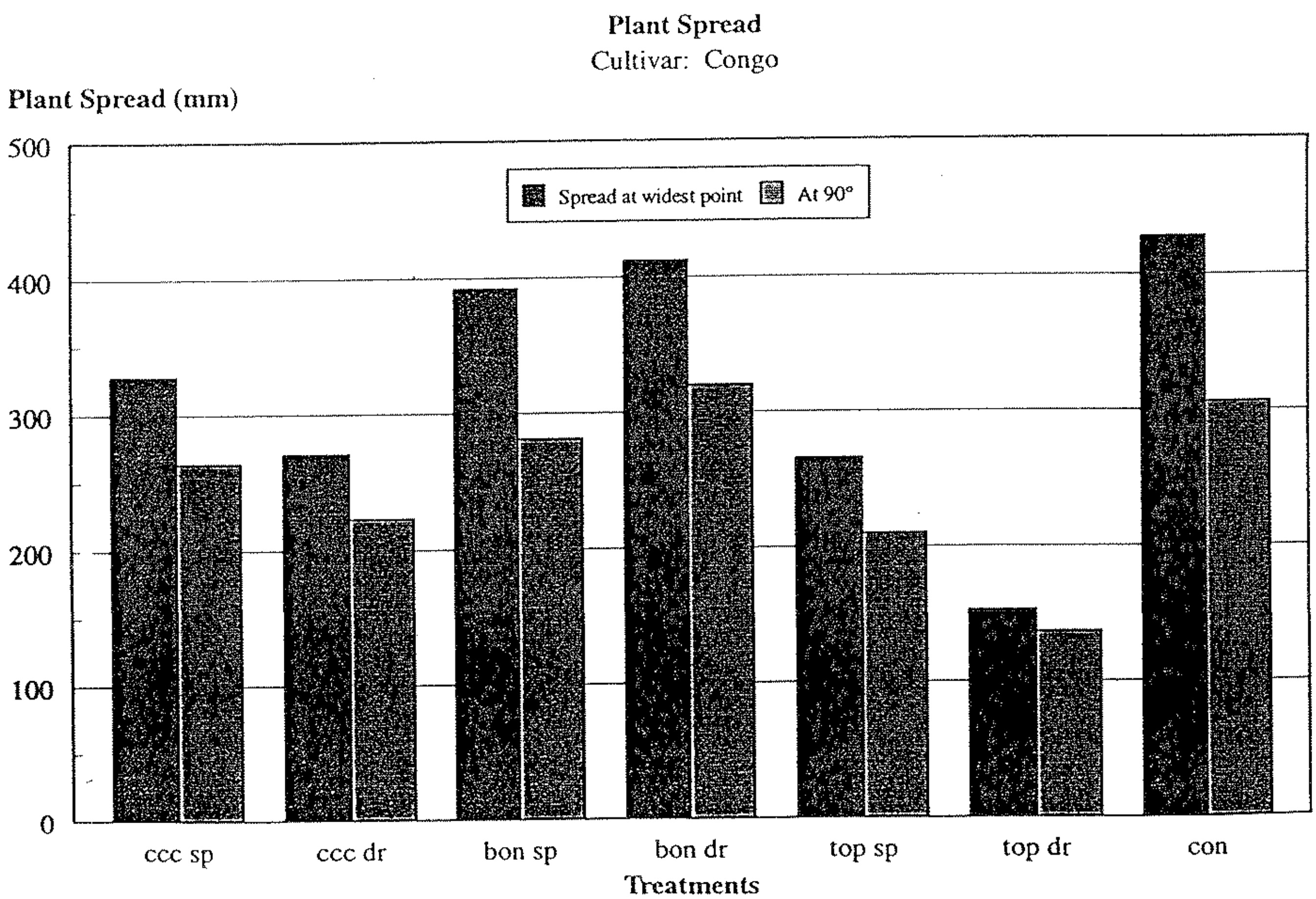
APPENDIX V

TRIAL TWO - Records of plant growth at marketing

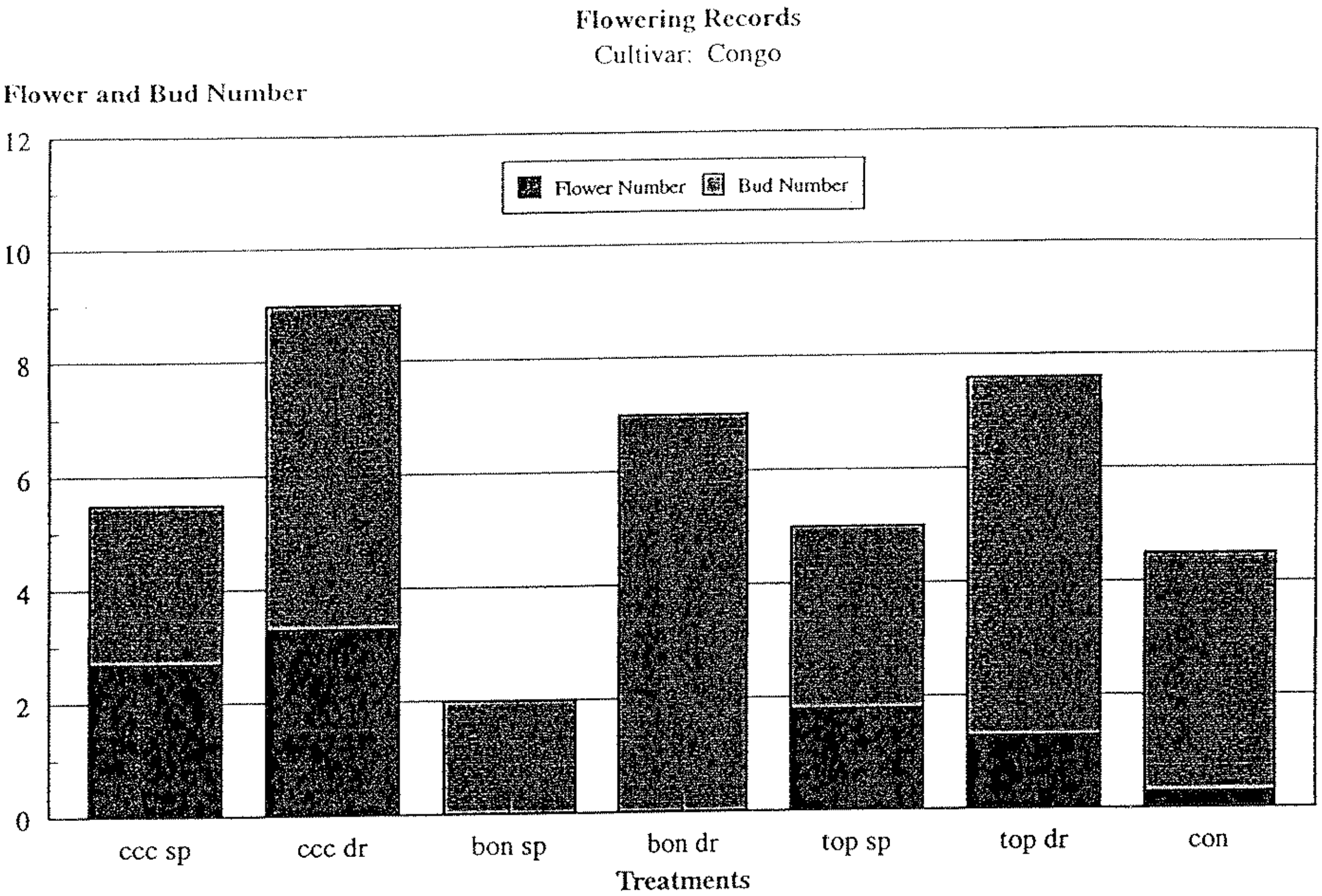
Key:	CCC	=	Cycocel
	Top	=	Topflor
	Bon	=	Bonzi
	Con	=	Control
	Dr	=	Drench
	Sp	=	Spray

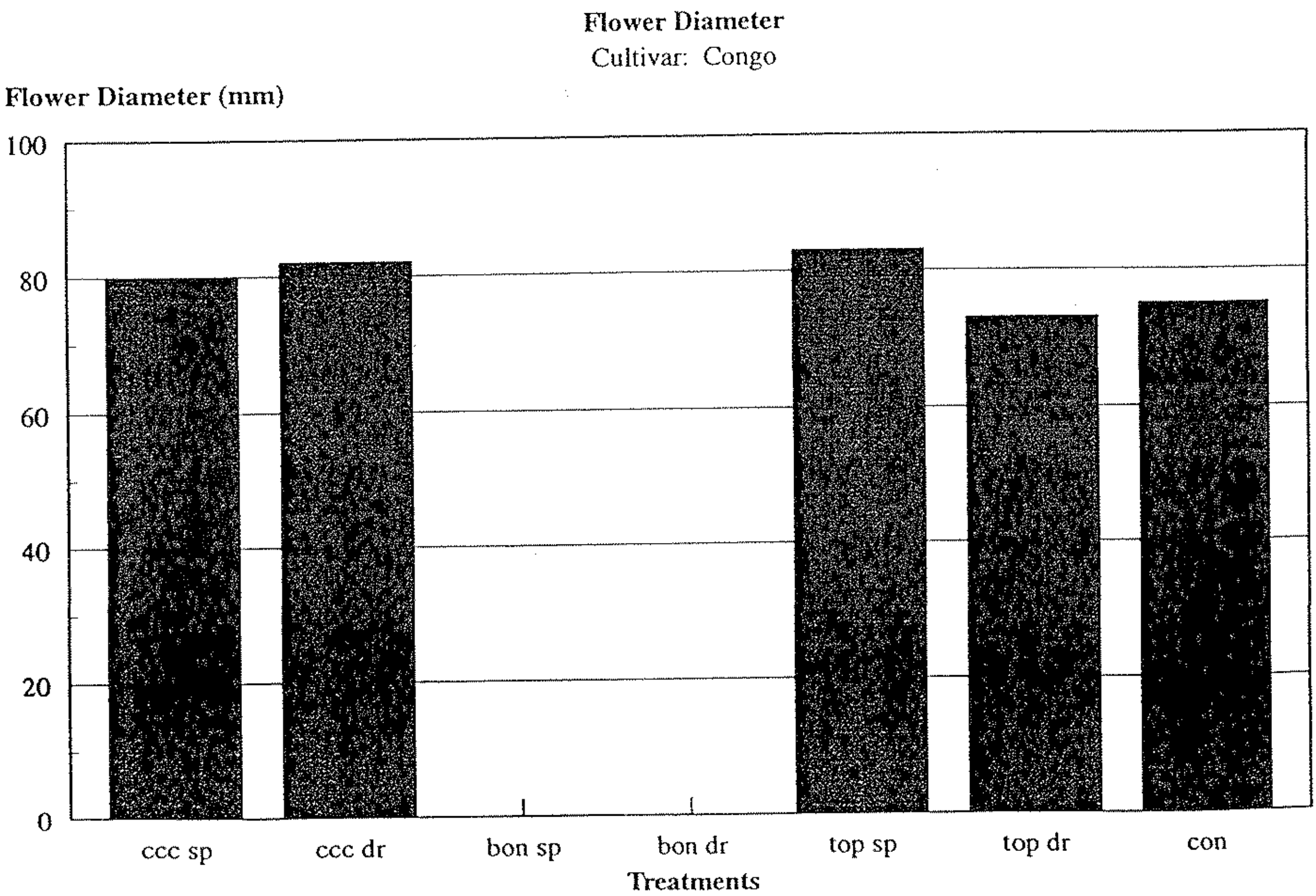
APPENDIX V Trial Two - Results



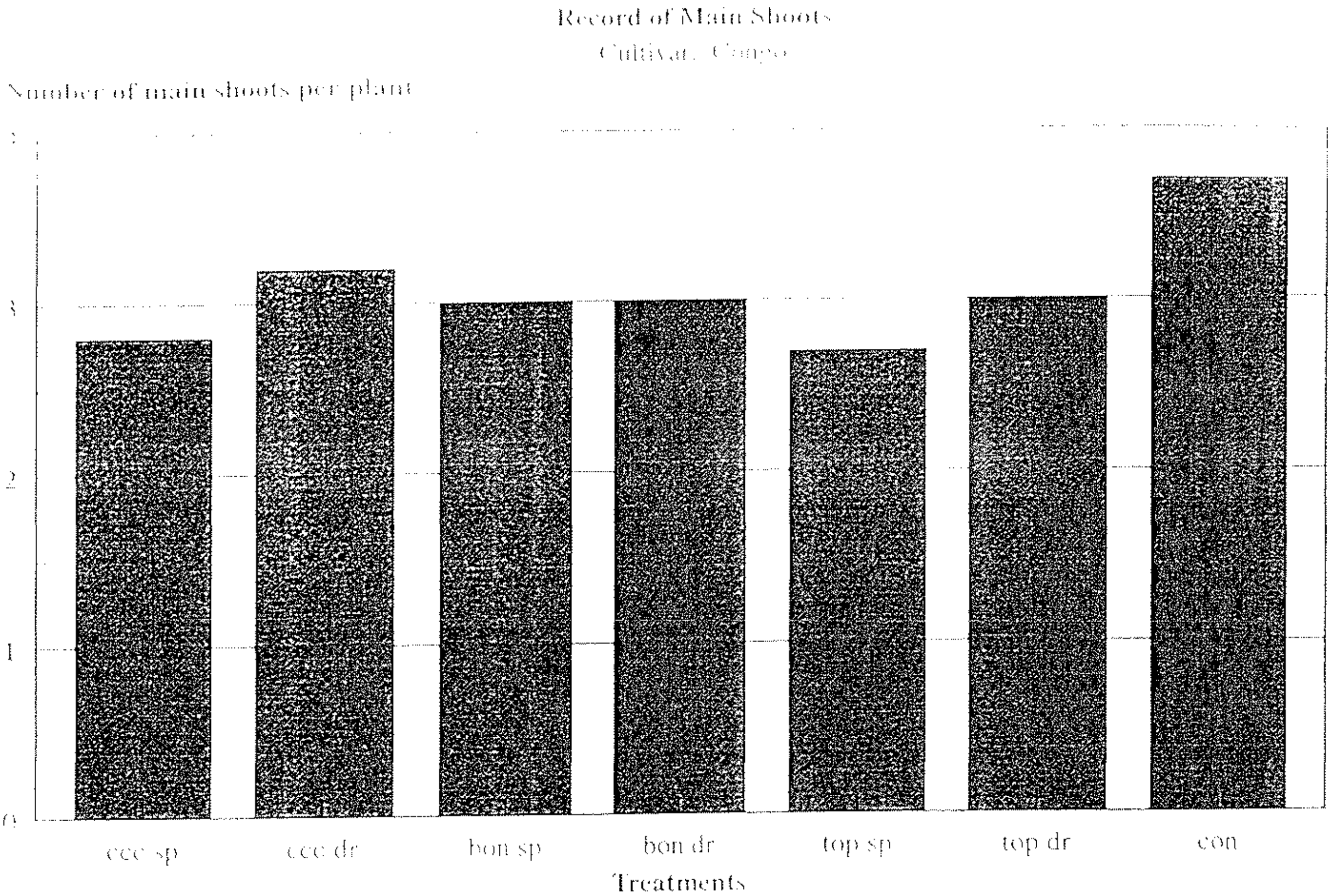


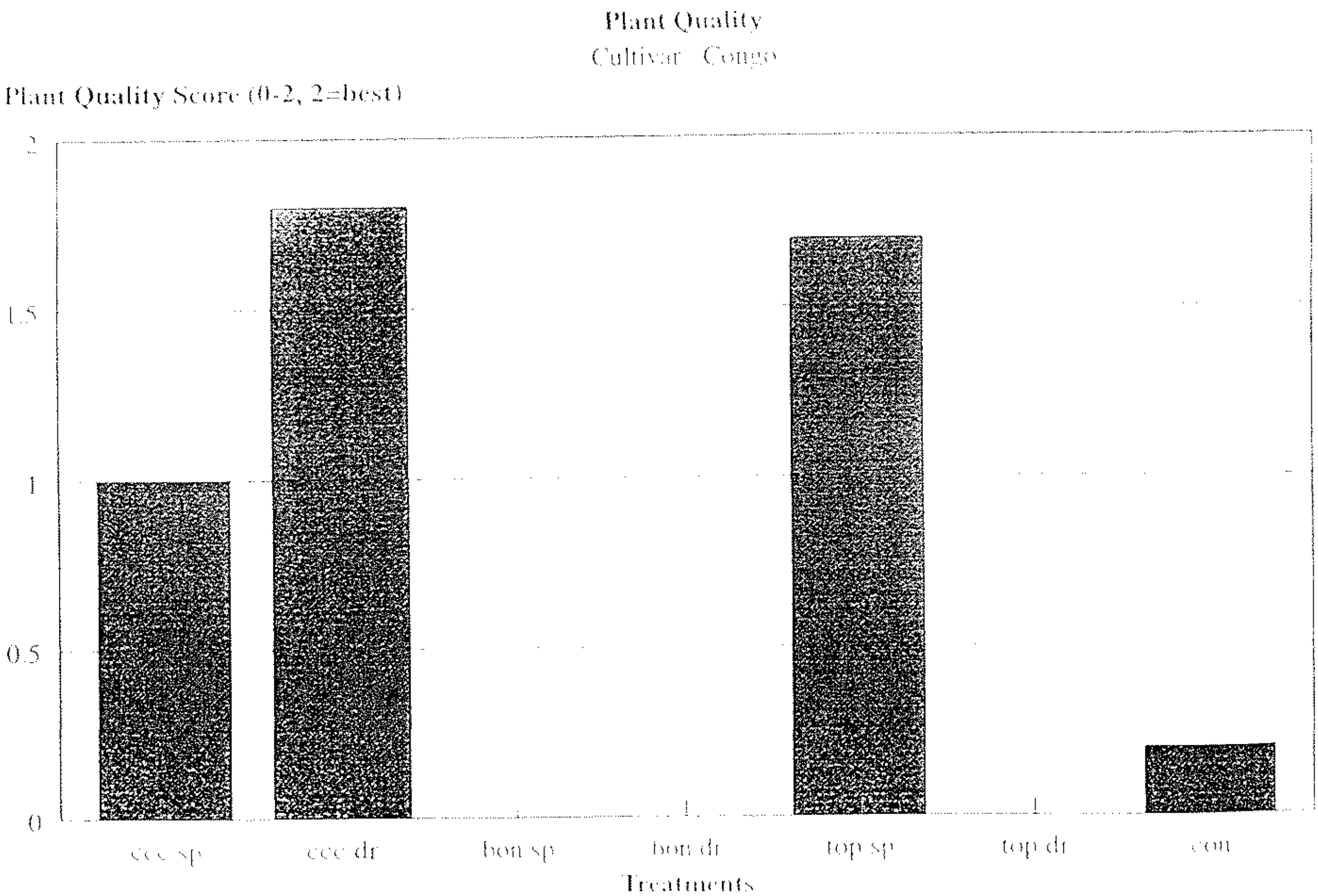
APPENDIX V Trial Two - Results



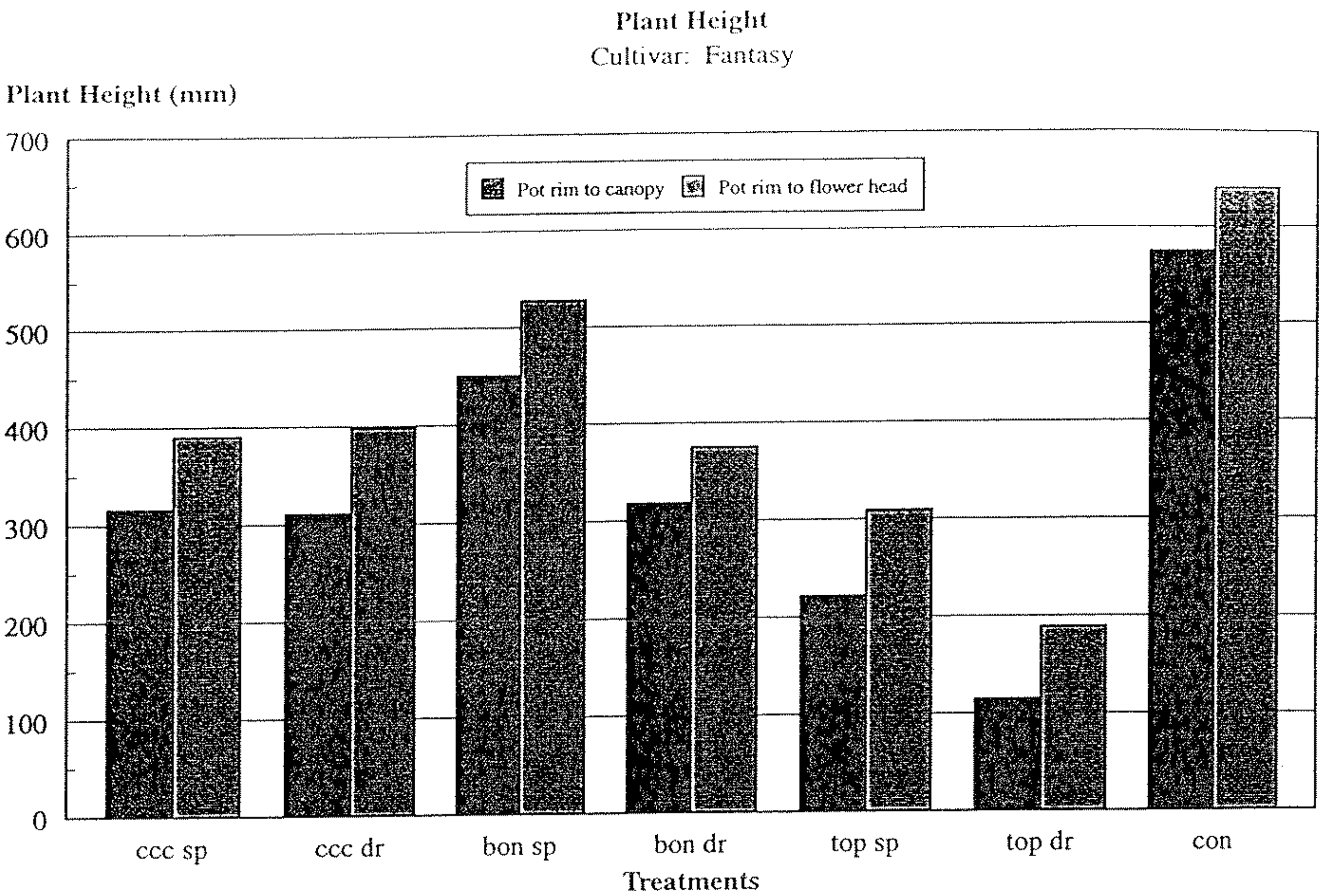


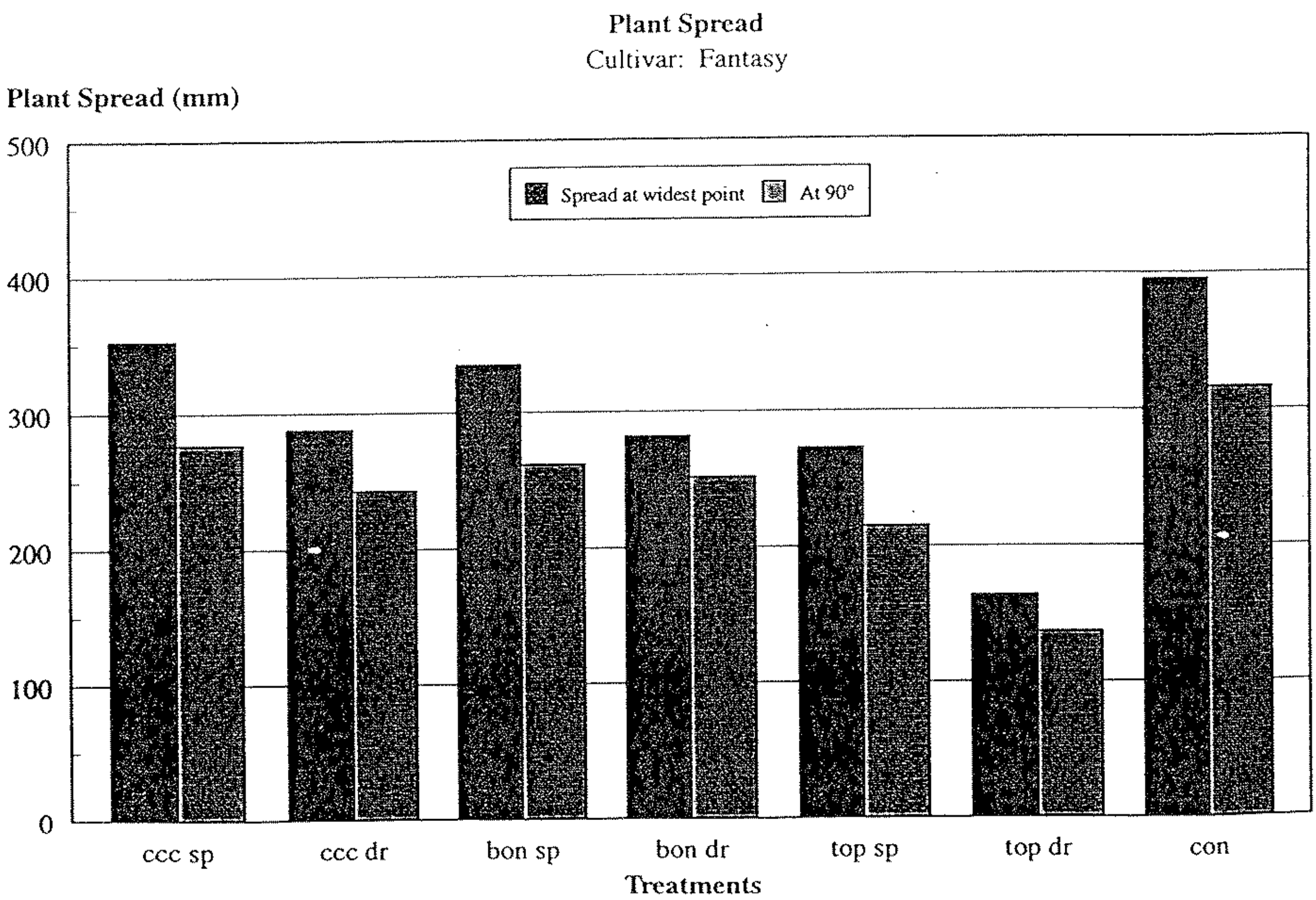
APPENDIX V Trial Two - Results





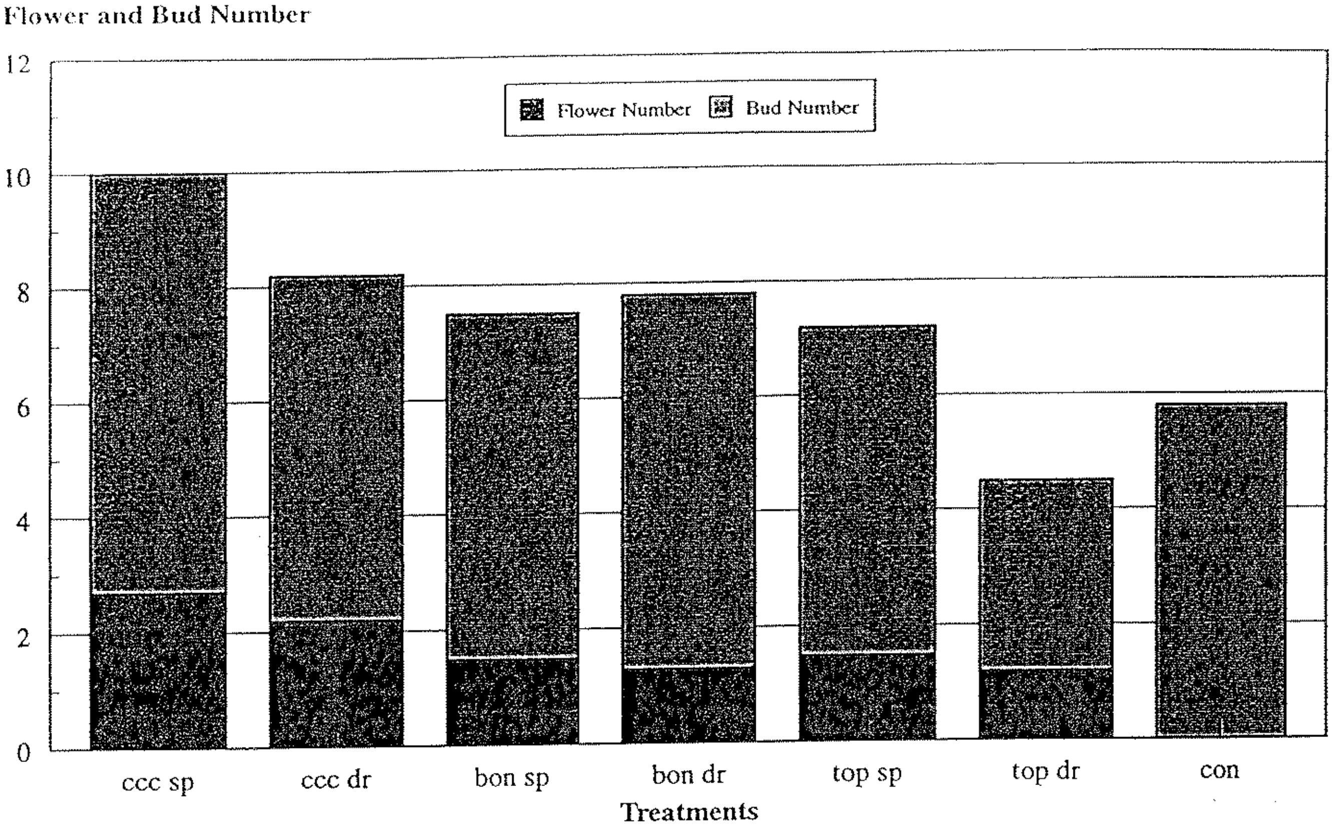
APPENDIX V Trial Two - Results



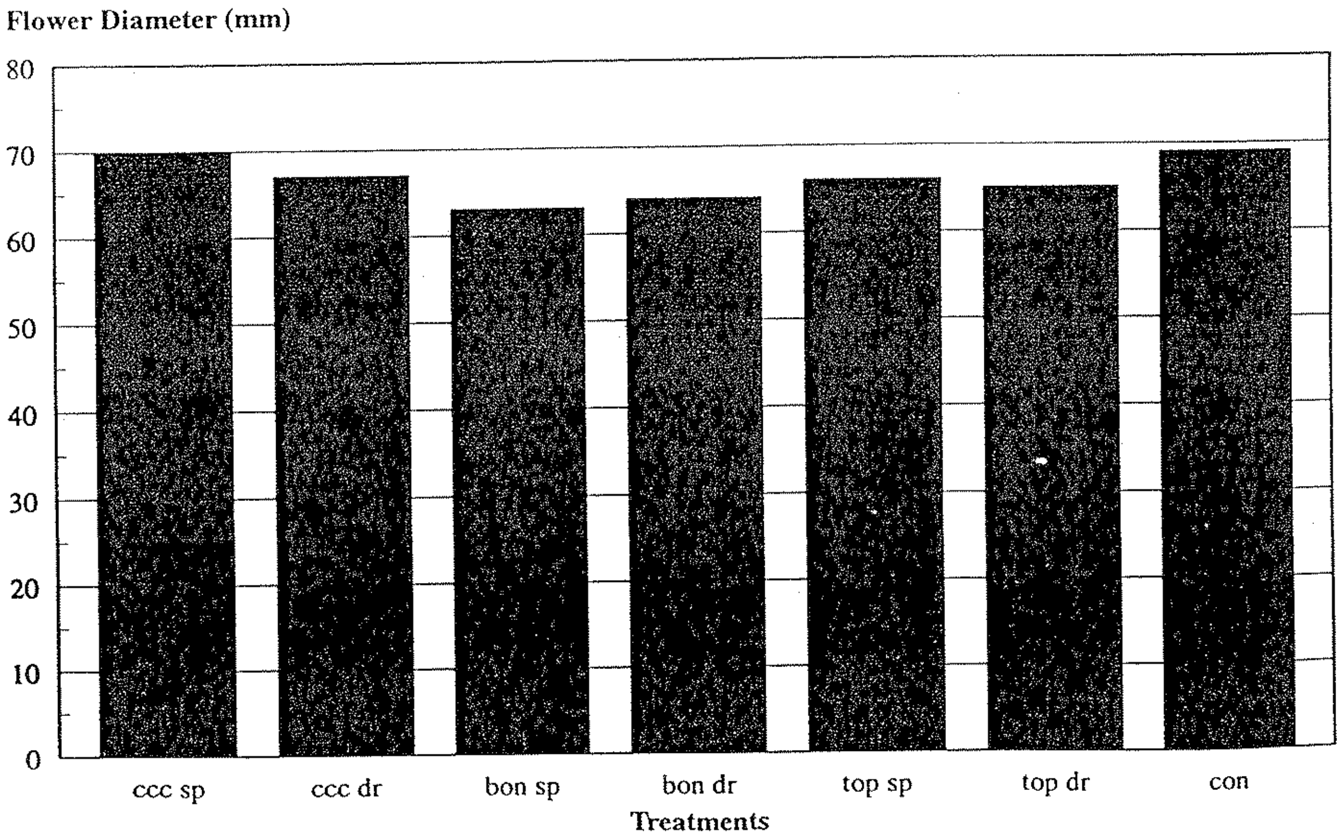


APPENDIX V Trial Two - Results

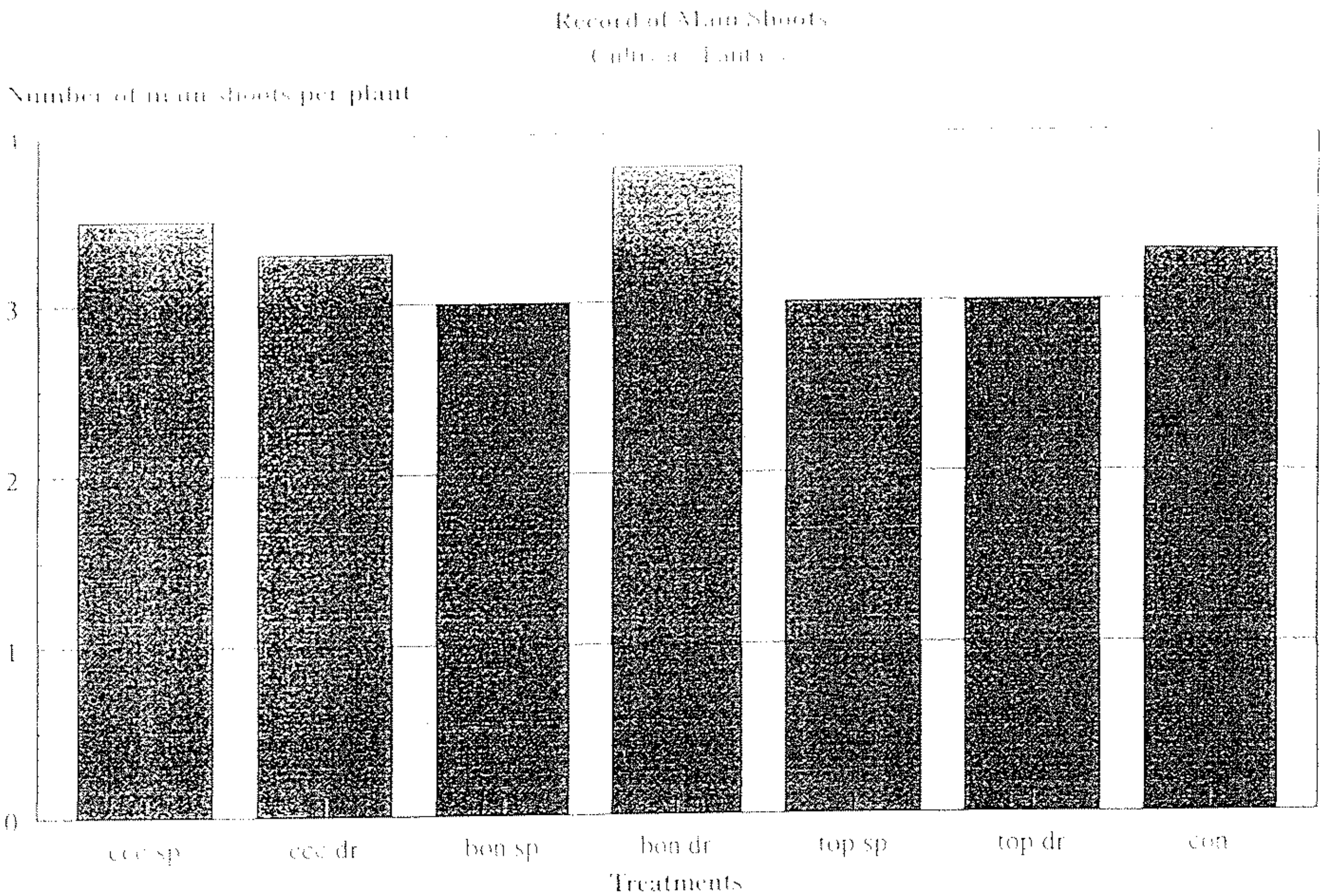
Flowering Records
Cultivar: Fantasy

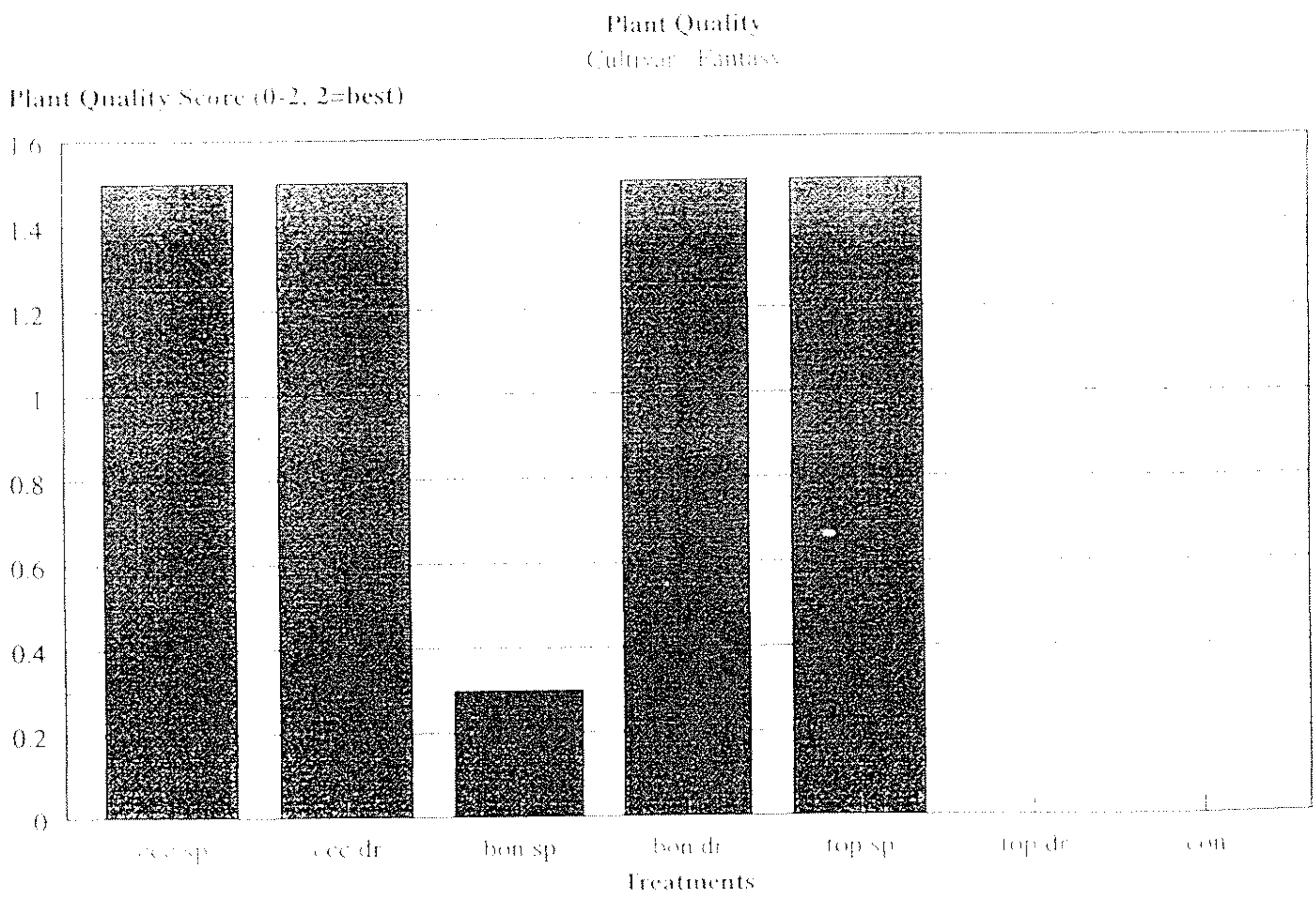


Flower Diameter
Cultivar: Fantasy

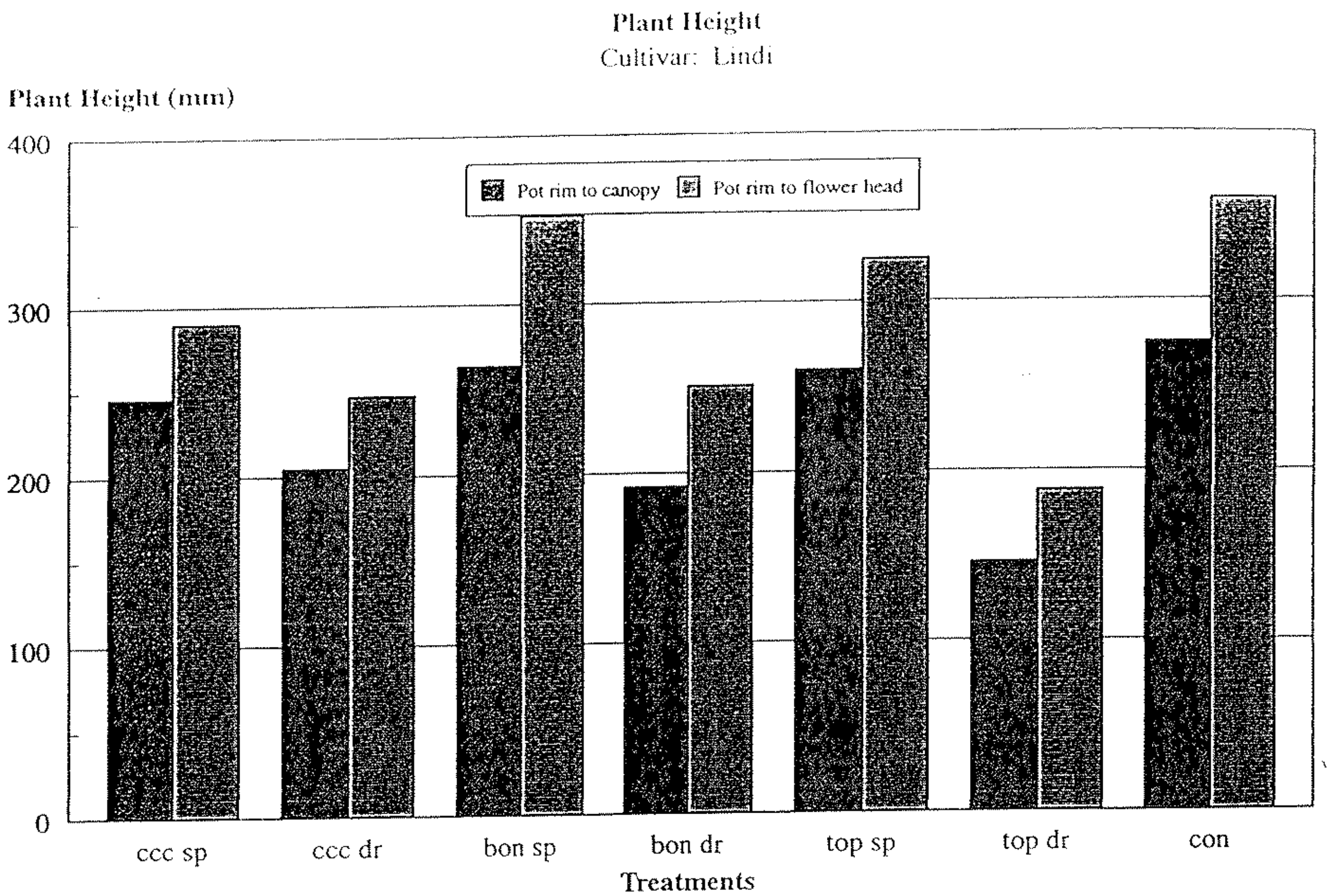


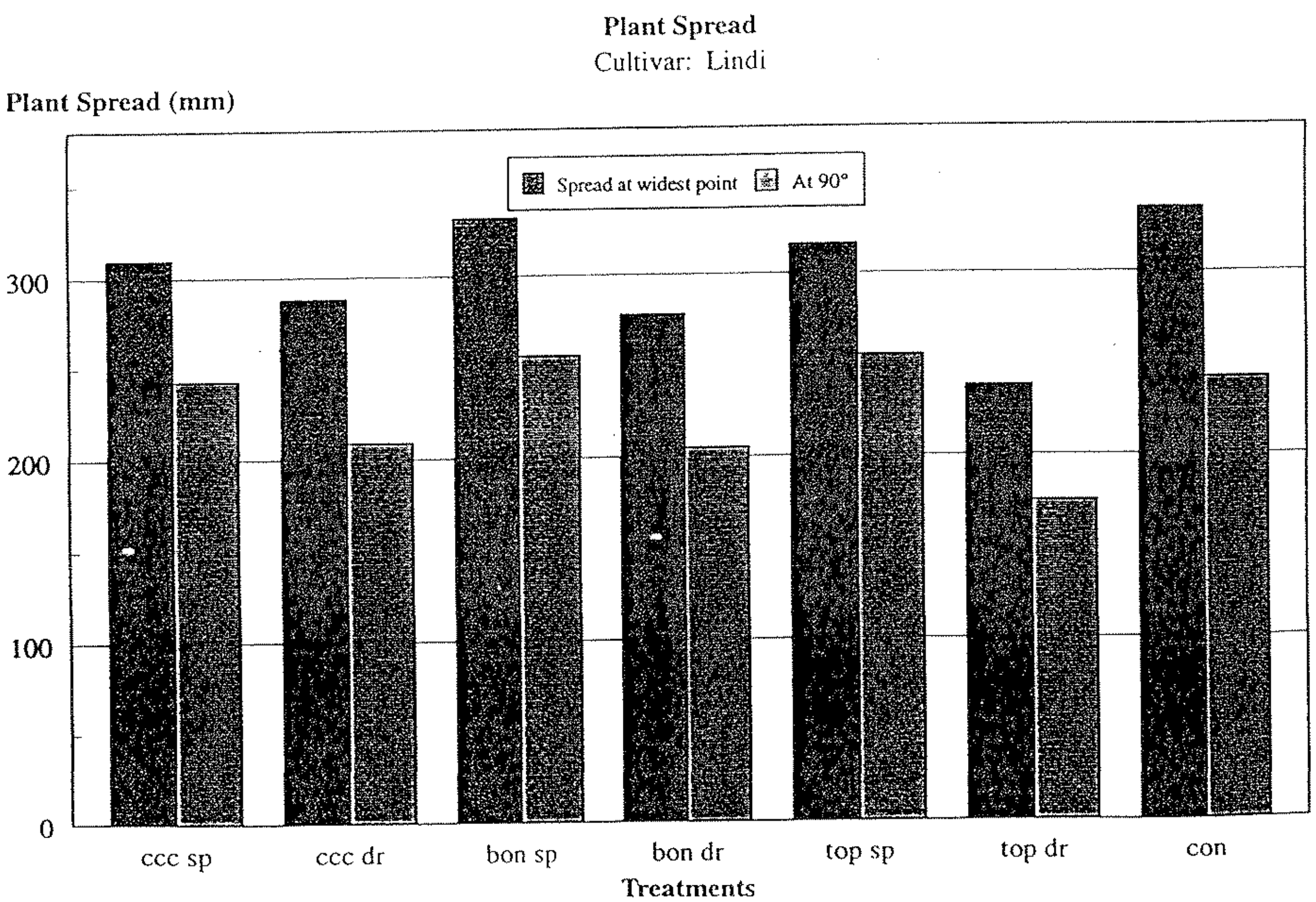
APPENDIX X Trial Two – Results





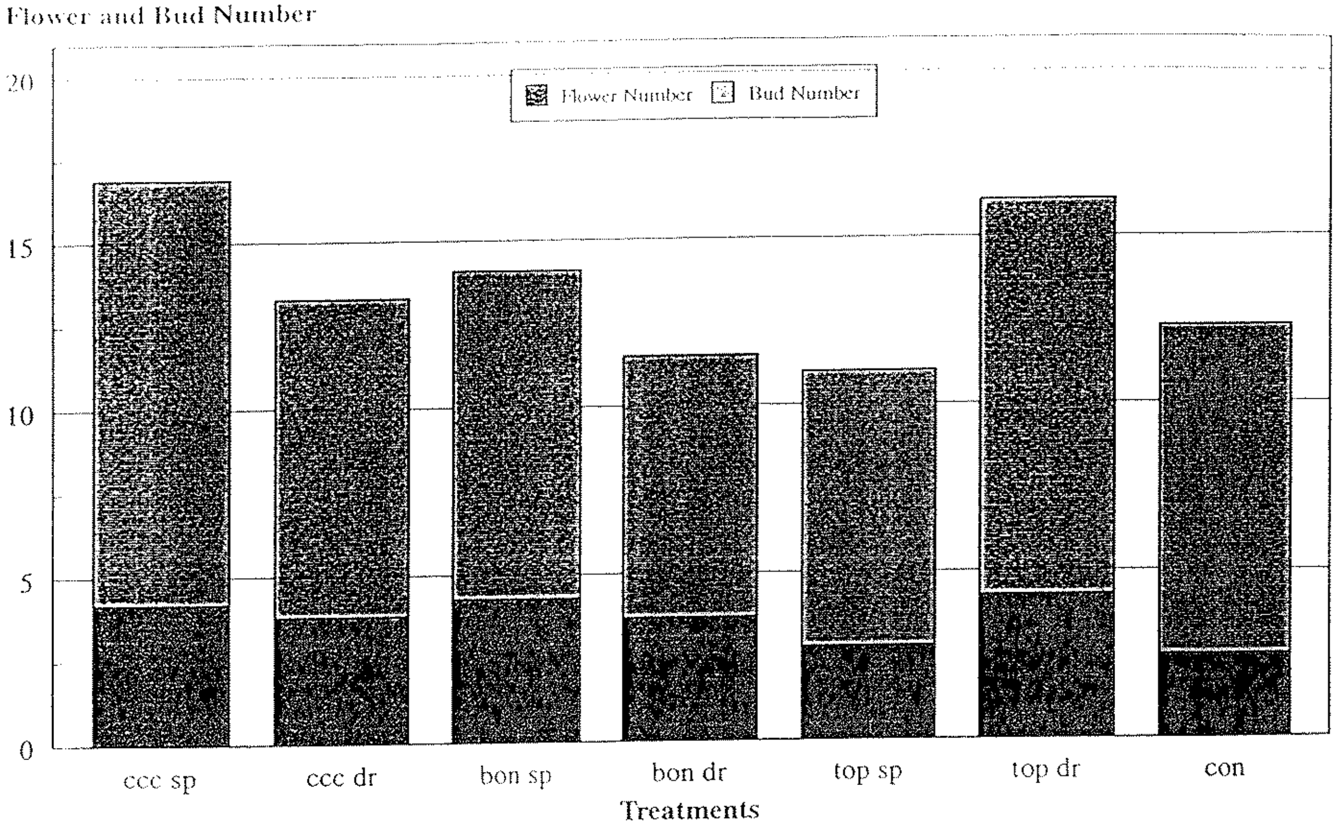
APPENDIX V Trial Two - Results



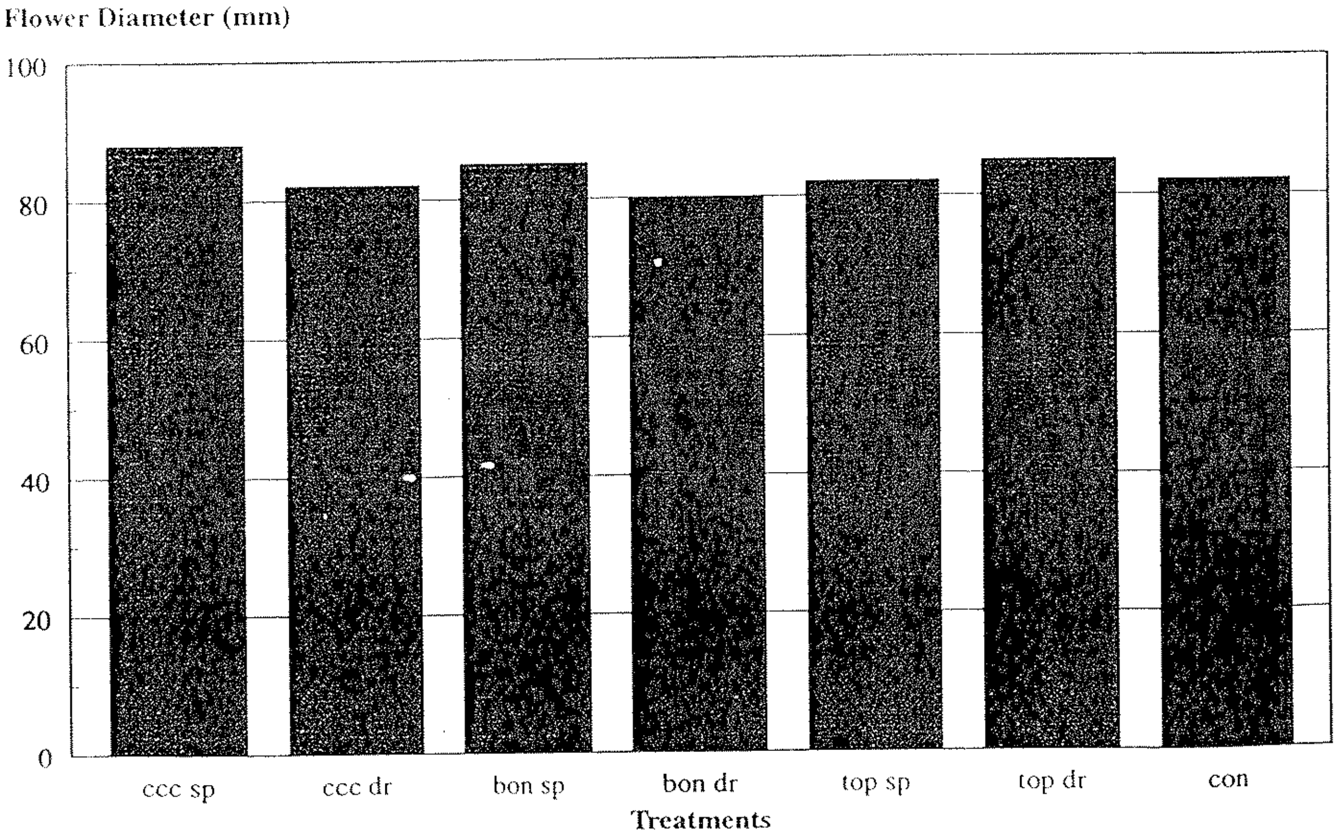


APPENDIX V Trial Two - Results

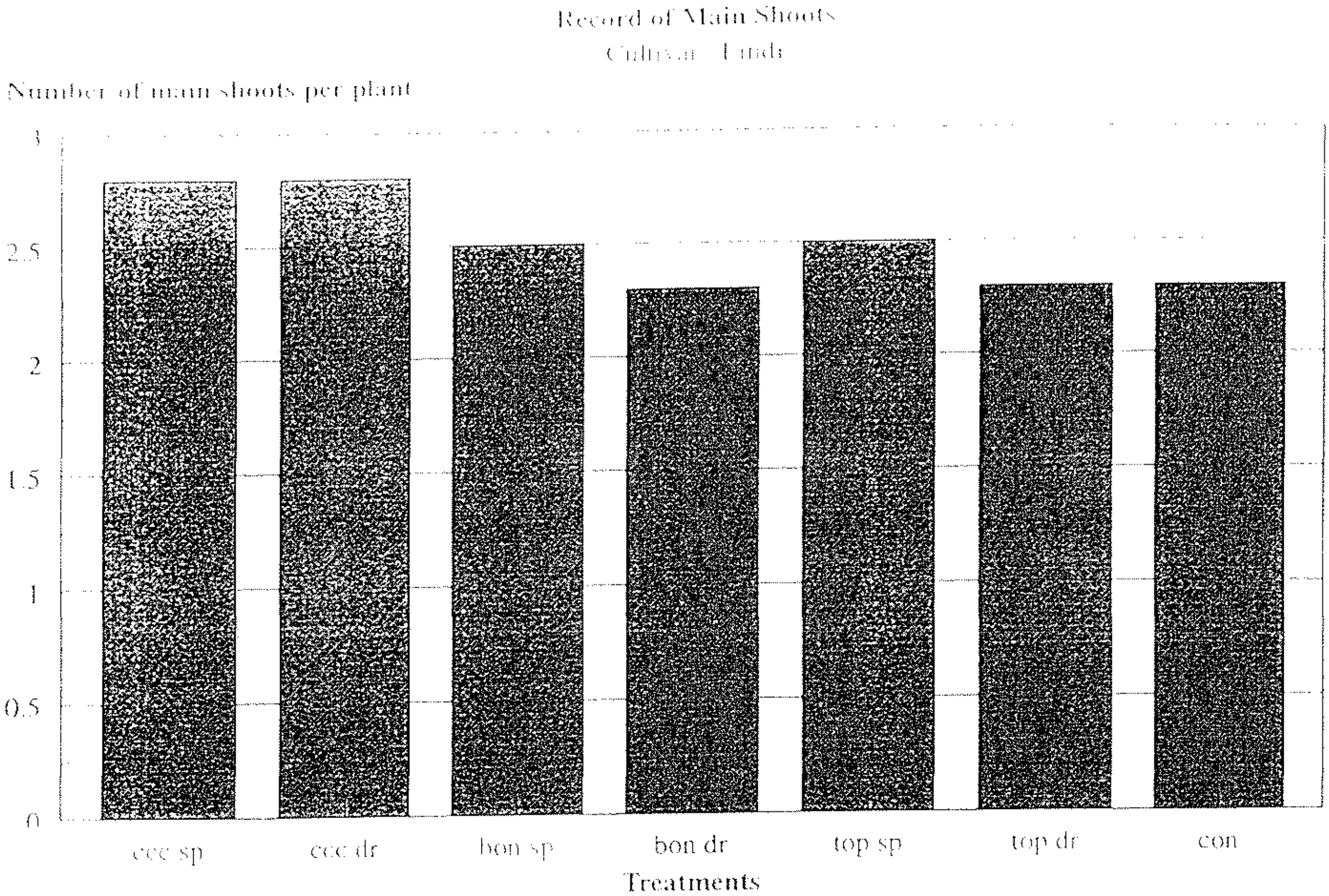
Flowering Records
Cultivar: Lindi

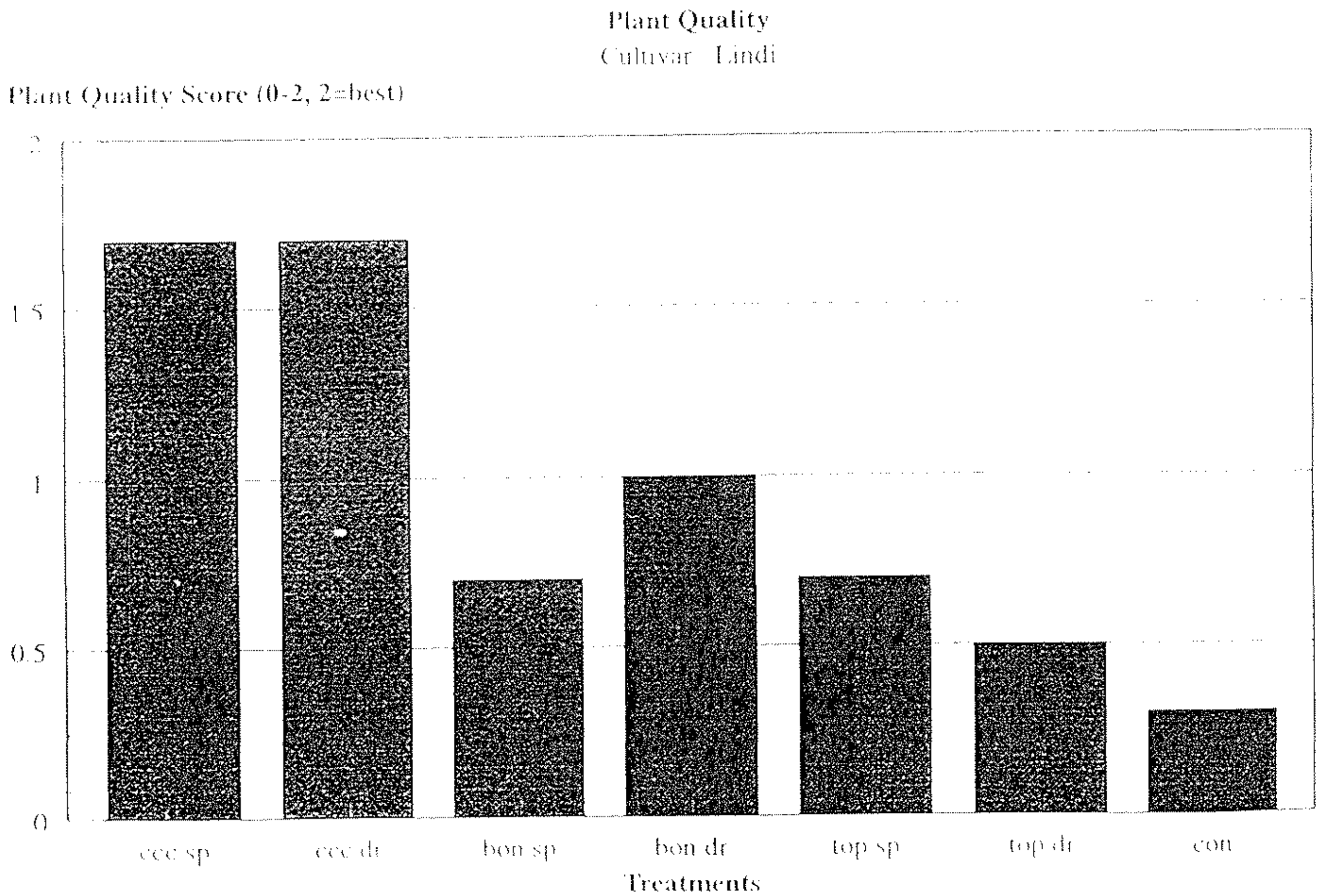


Flower Diameter
Cultivar: Lindi

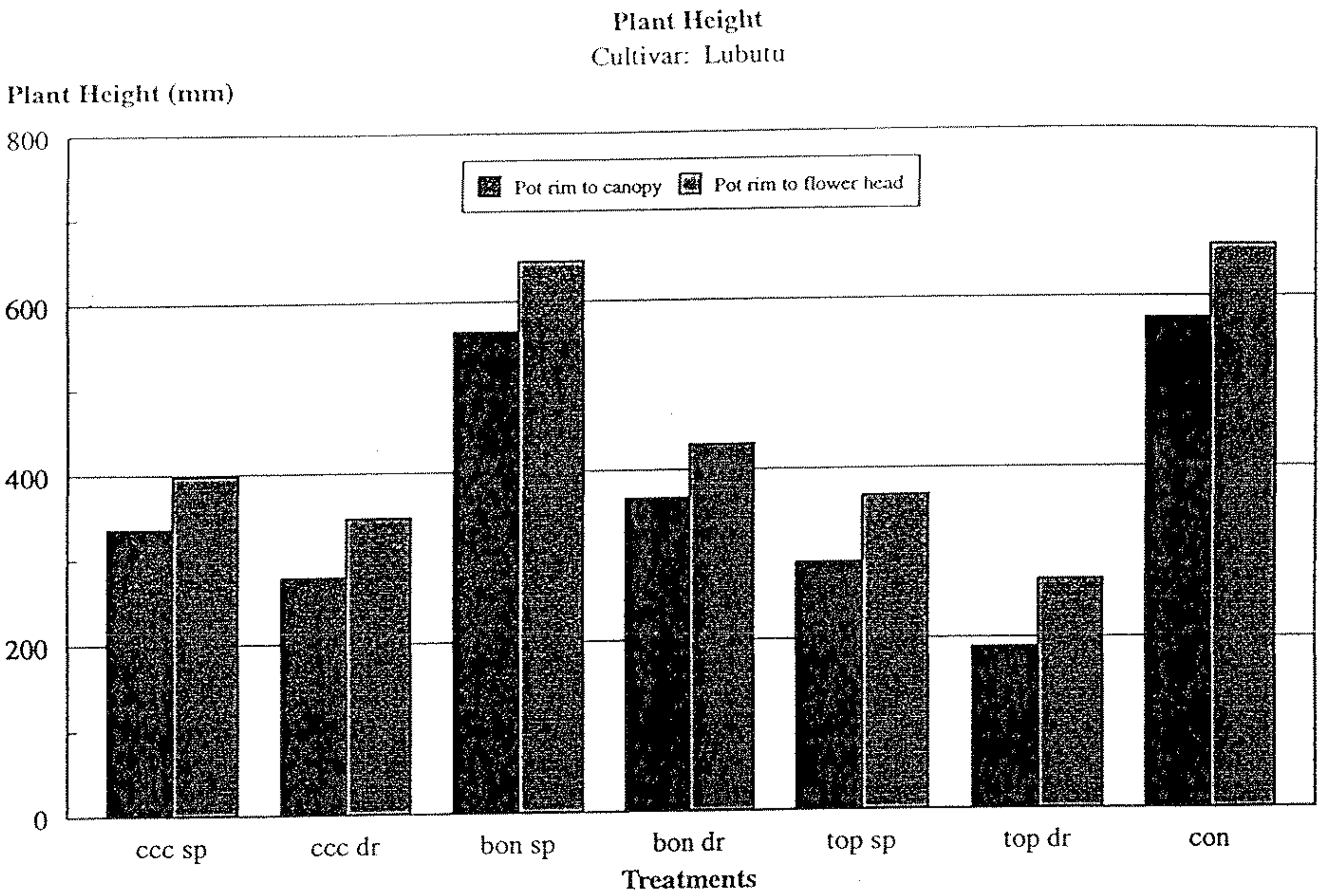


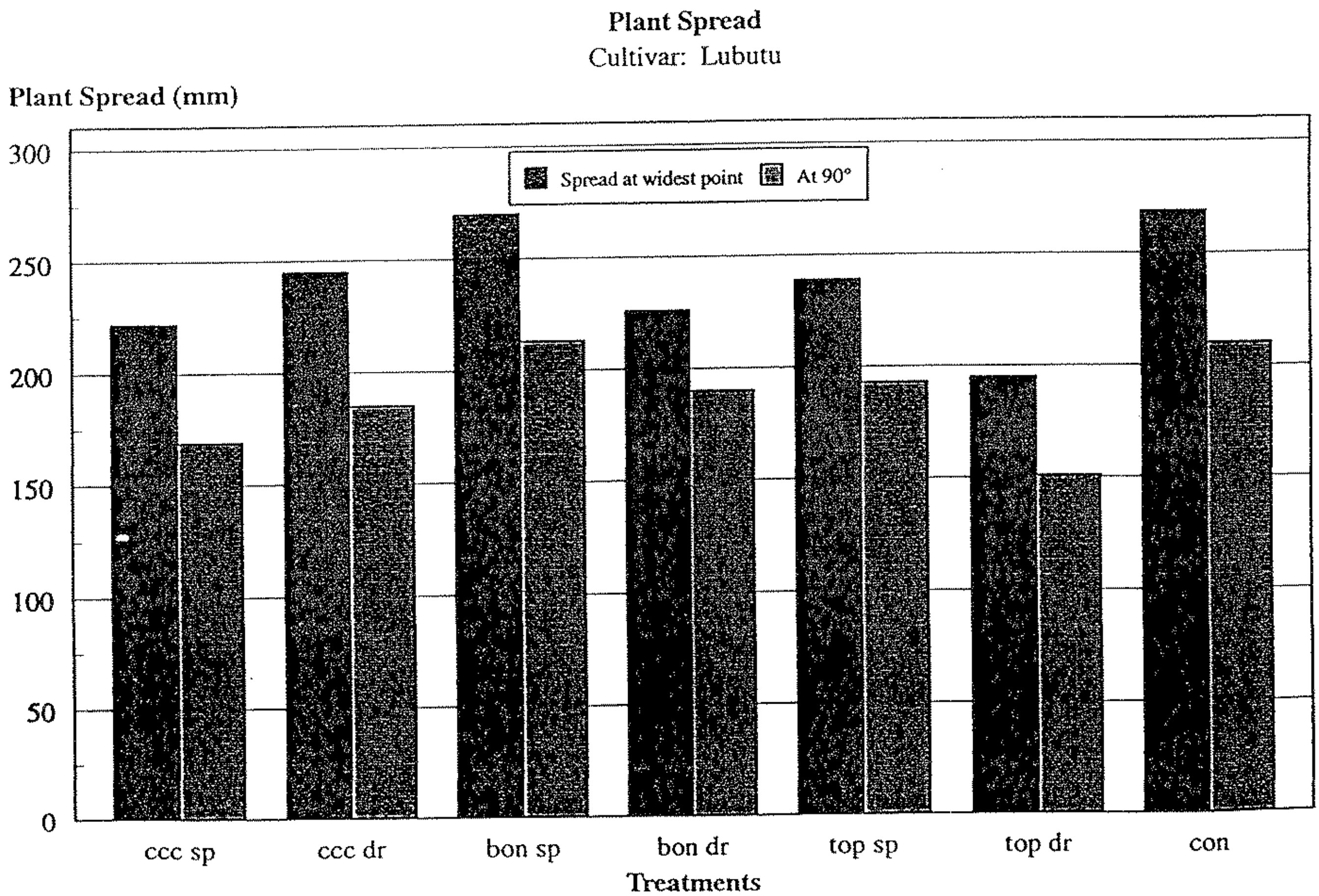
APPENDIX V   Trial Two - Results



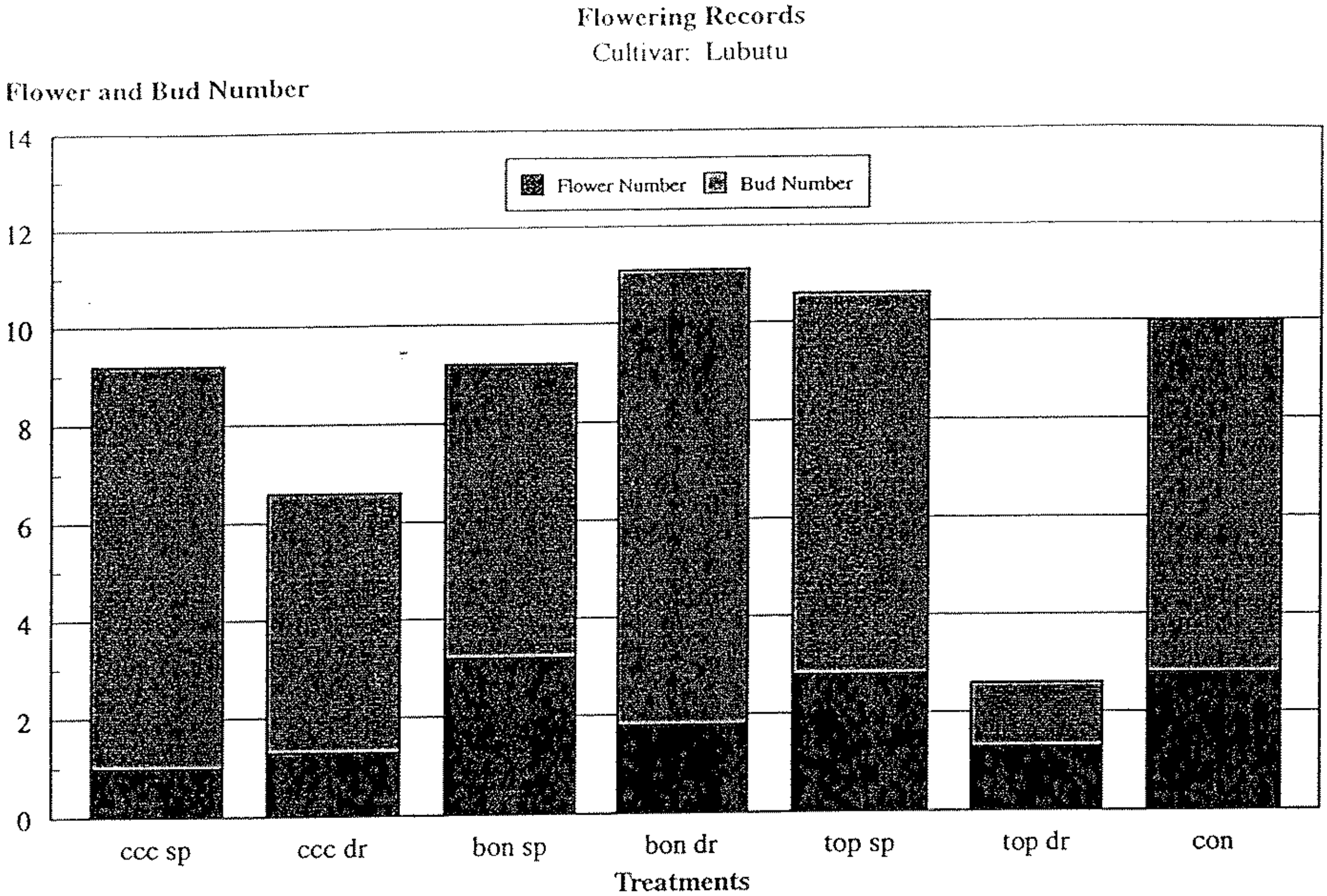


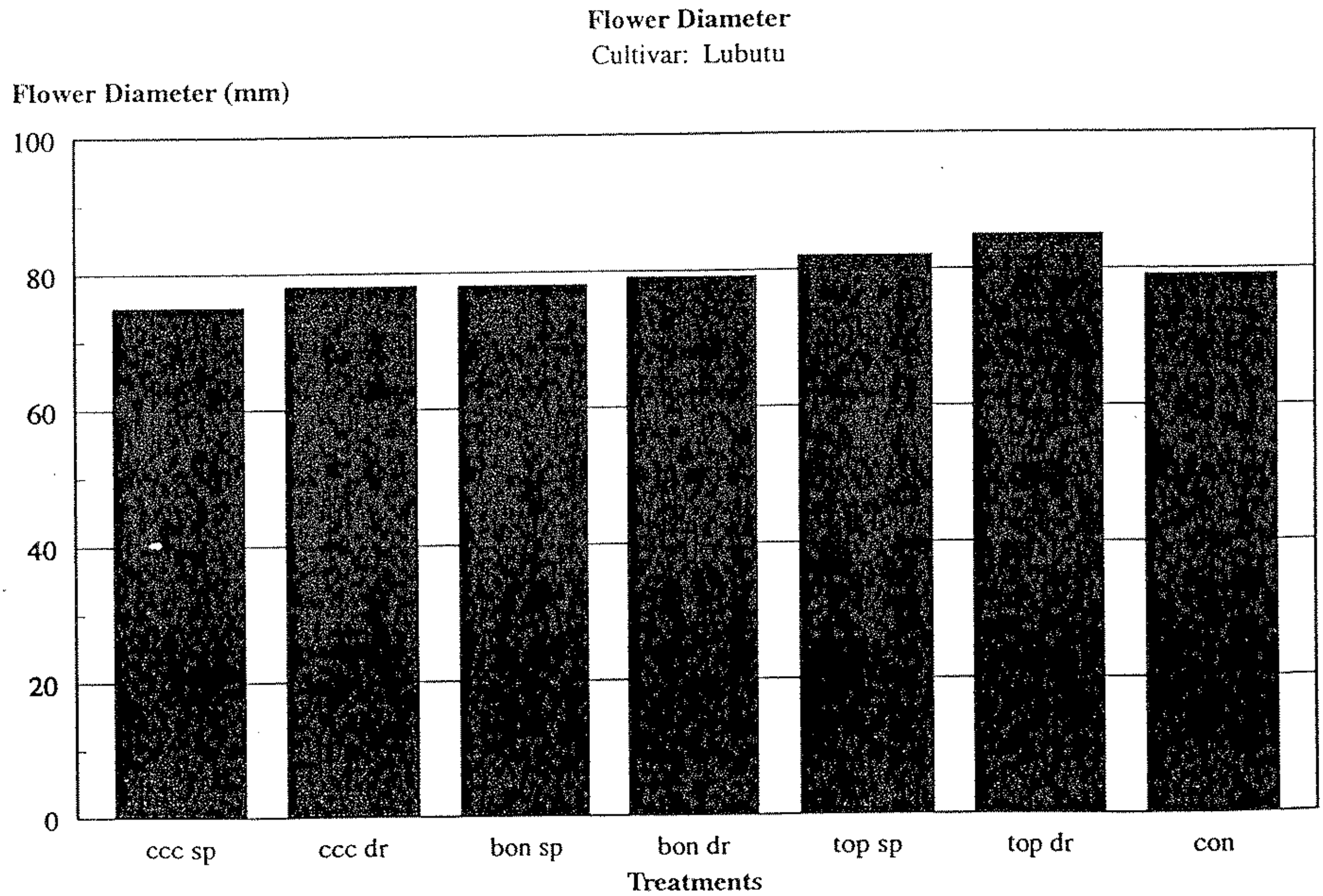
APPENDIX V Trial Two - Results



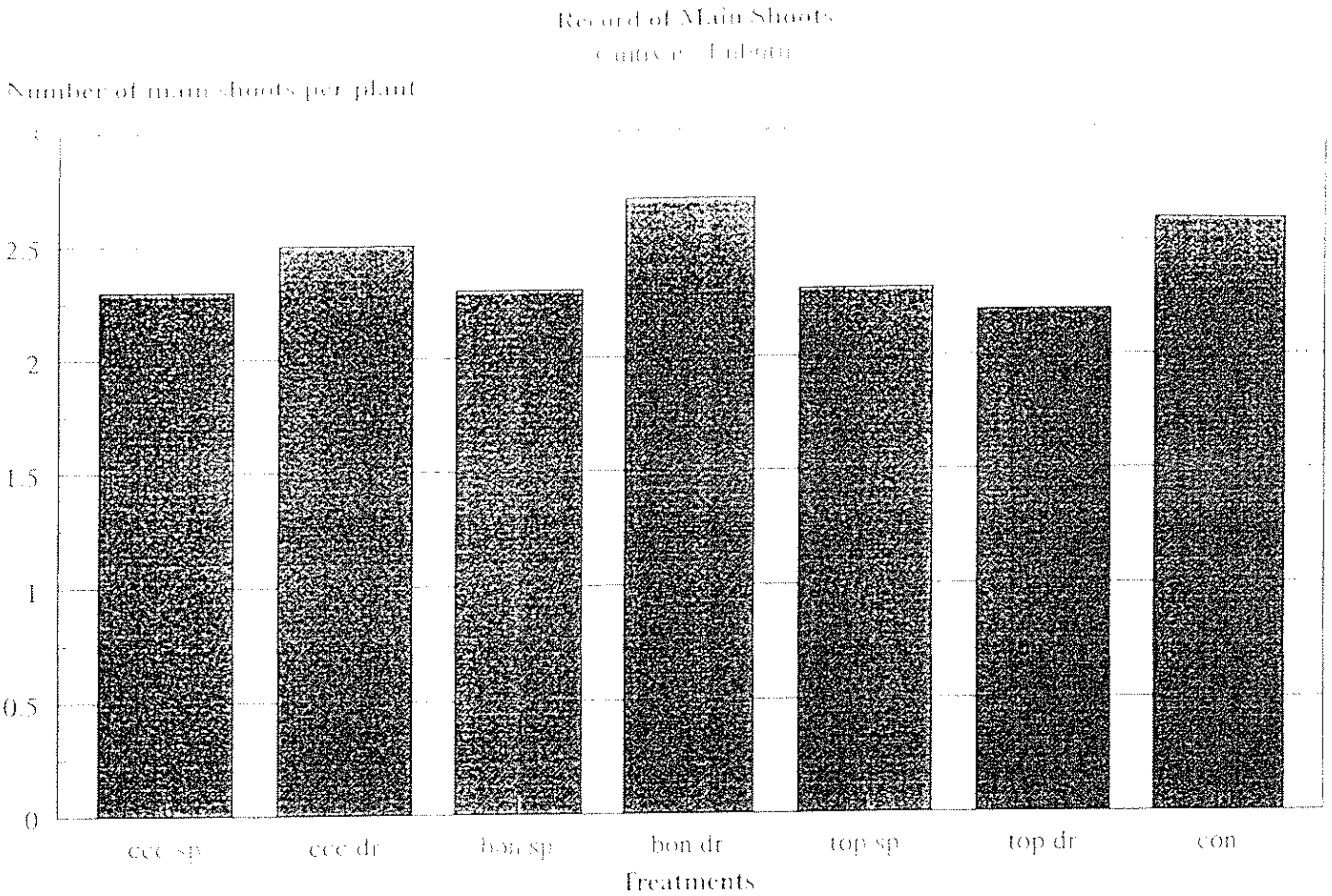


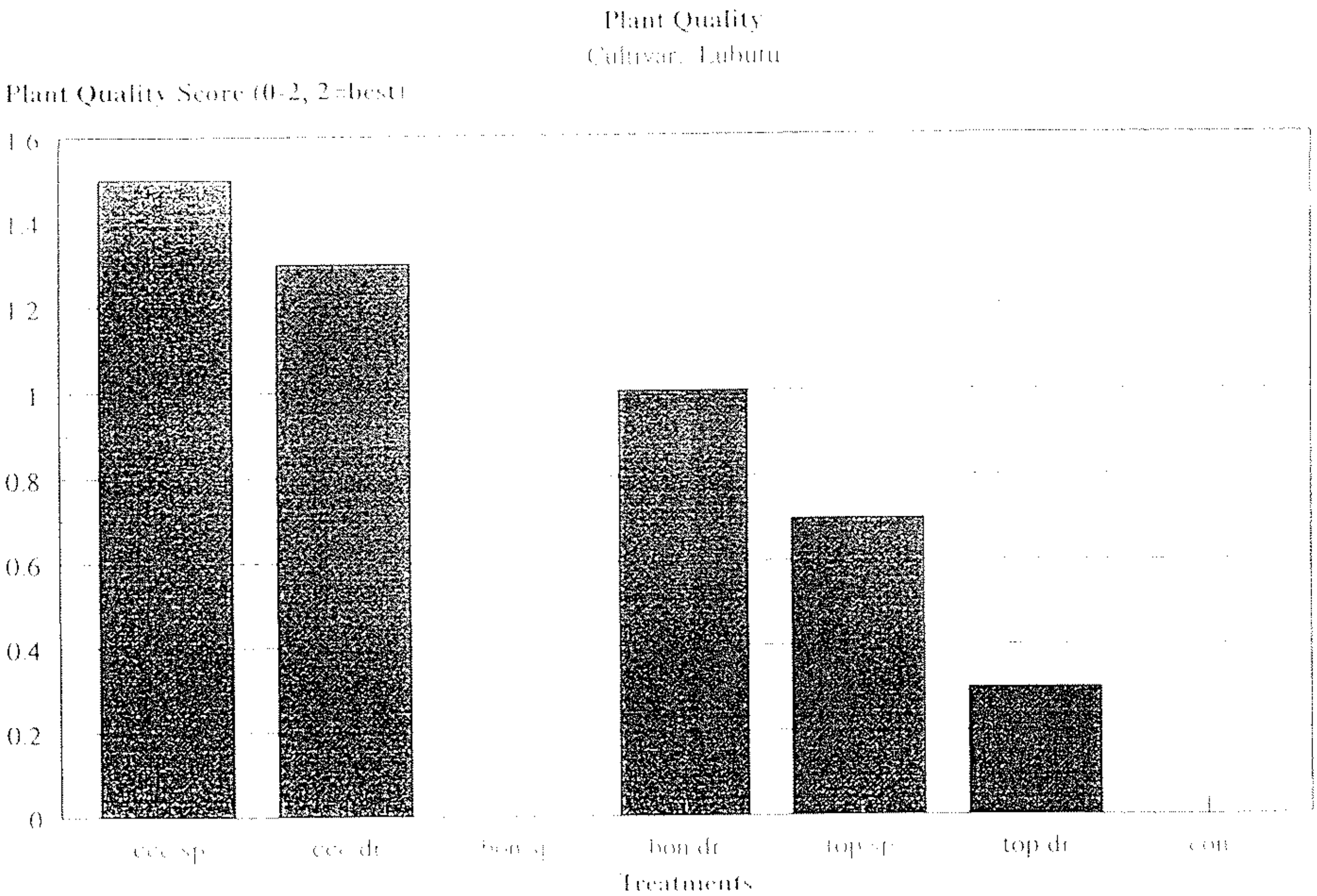
APPENDIX V Trial Two - Results



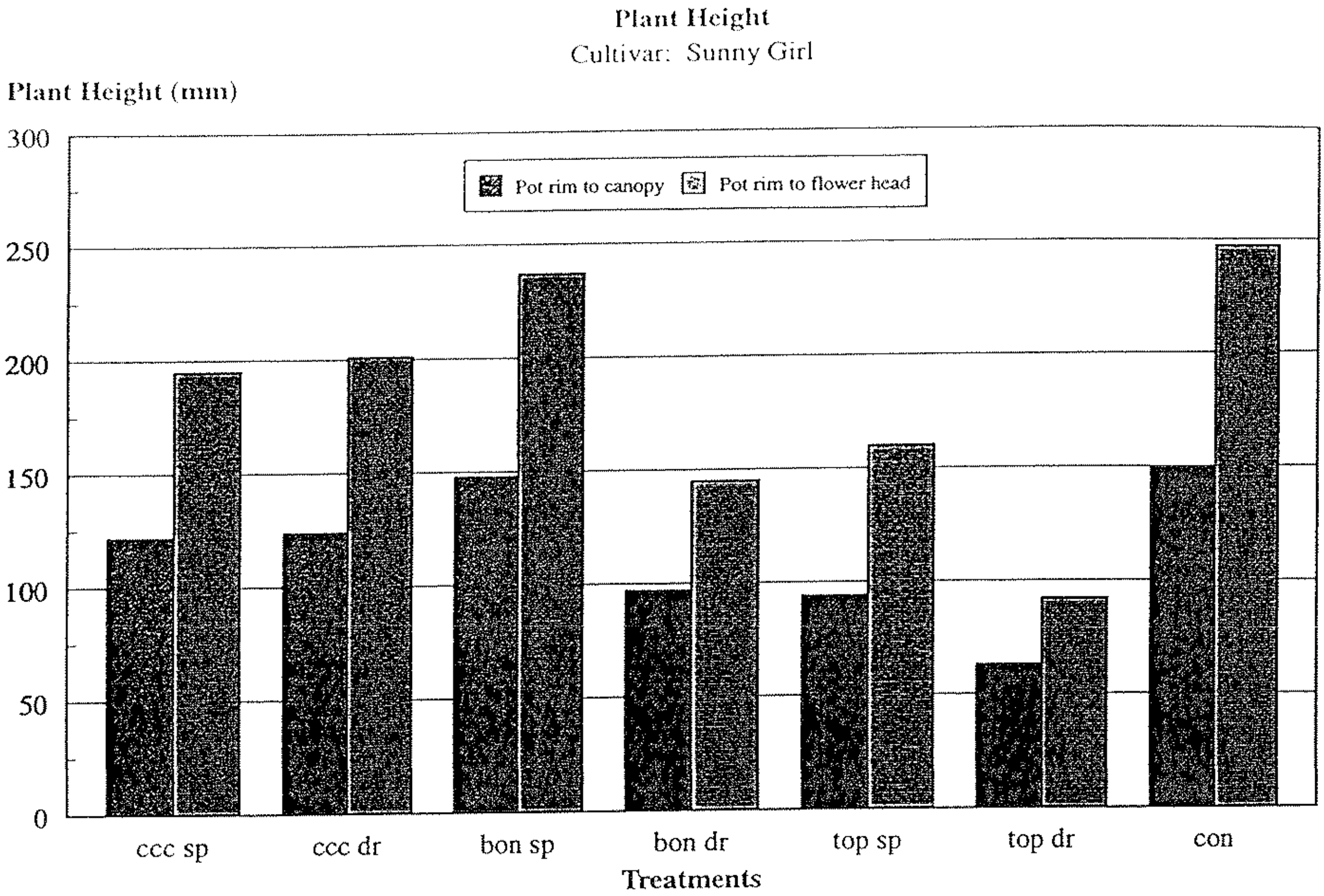


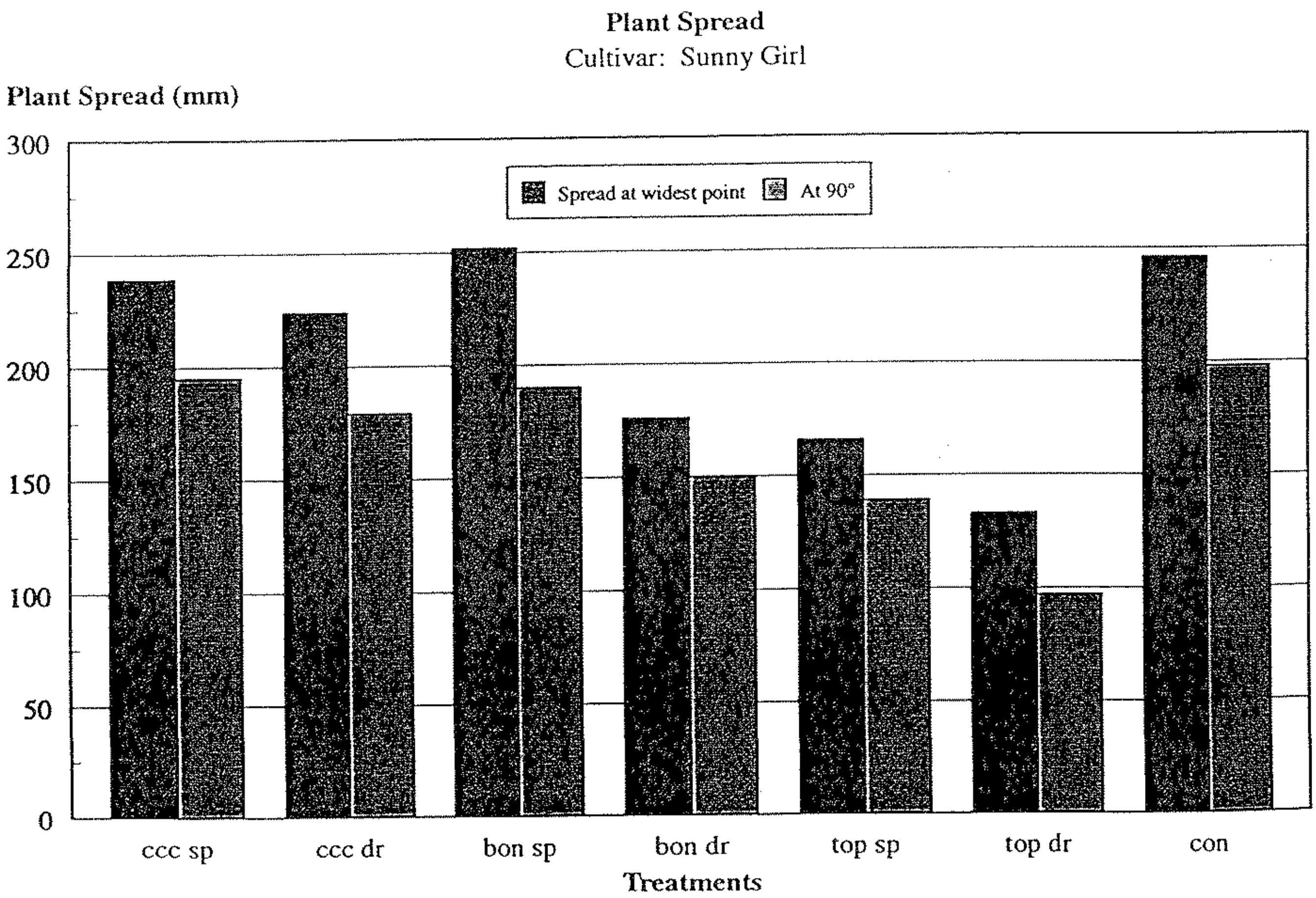
APPENDIX V   Trial Two - Results





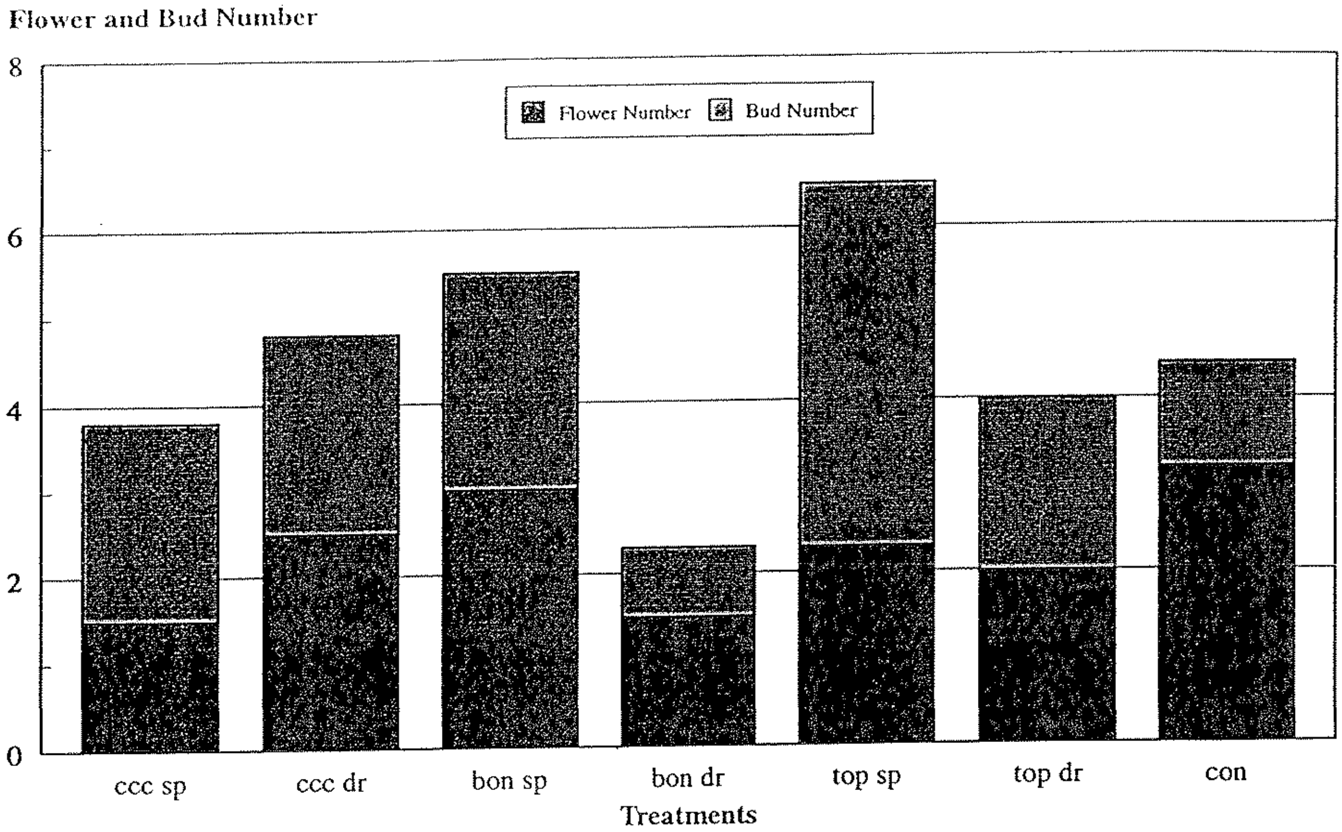
APPENDIX V   Trial Two - Results



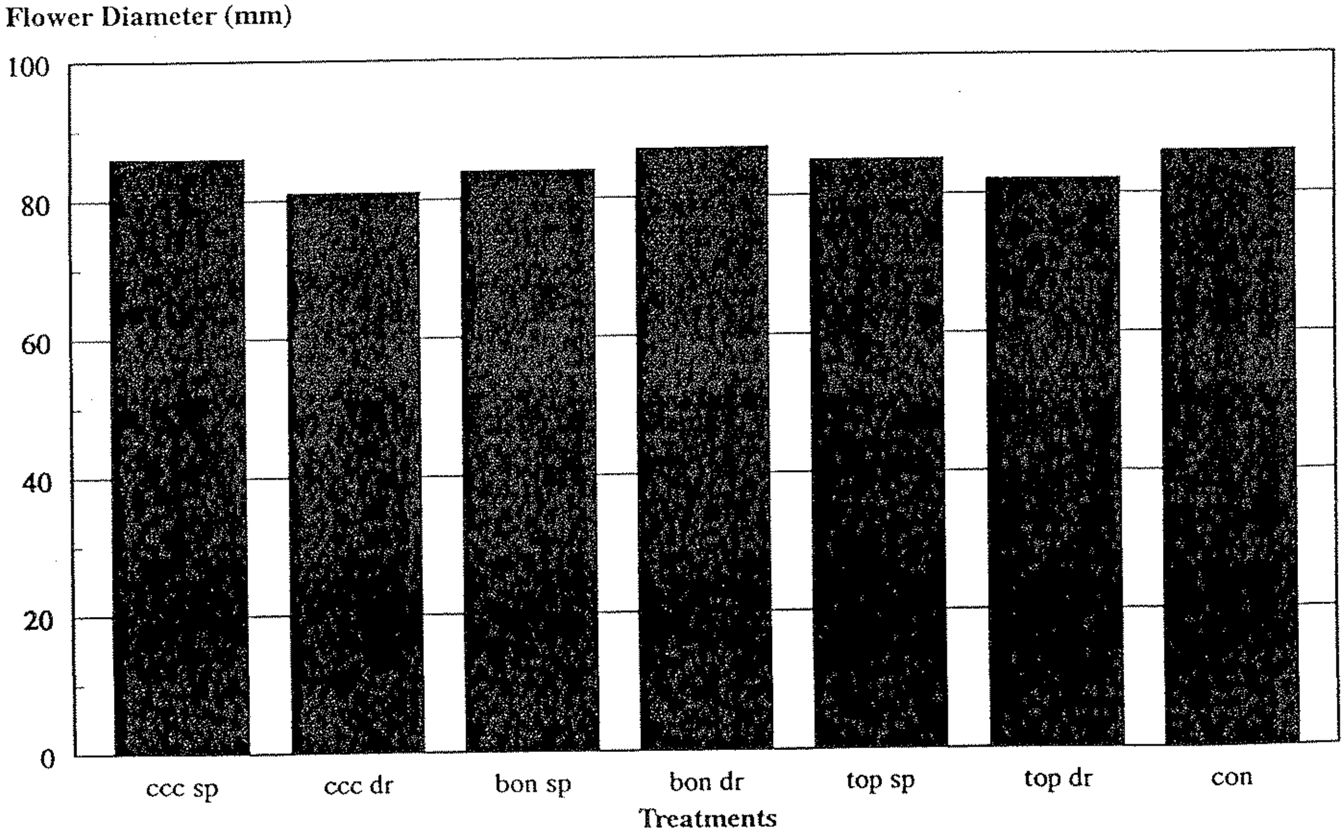


APPENDIX V Trial Two - Results

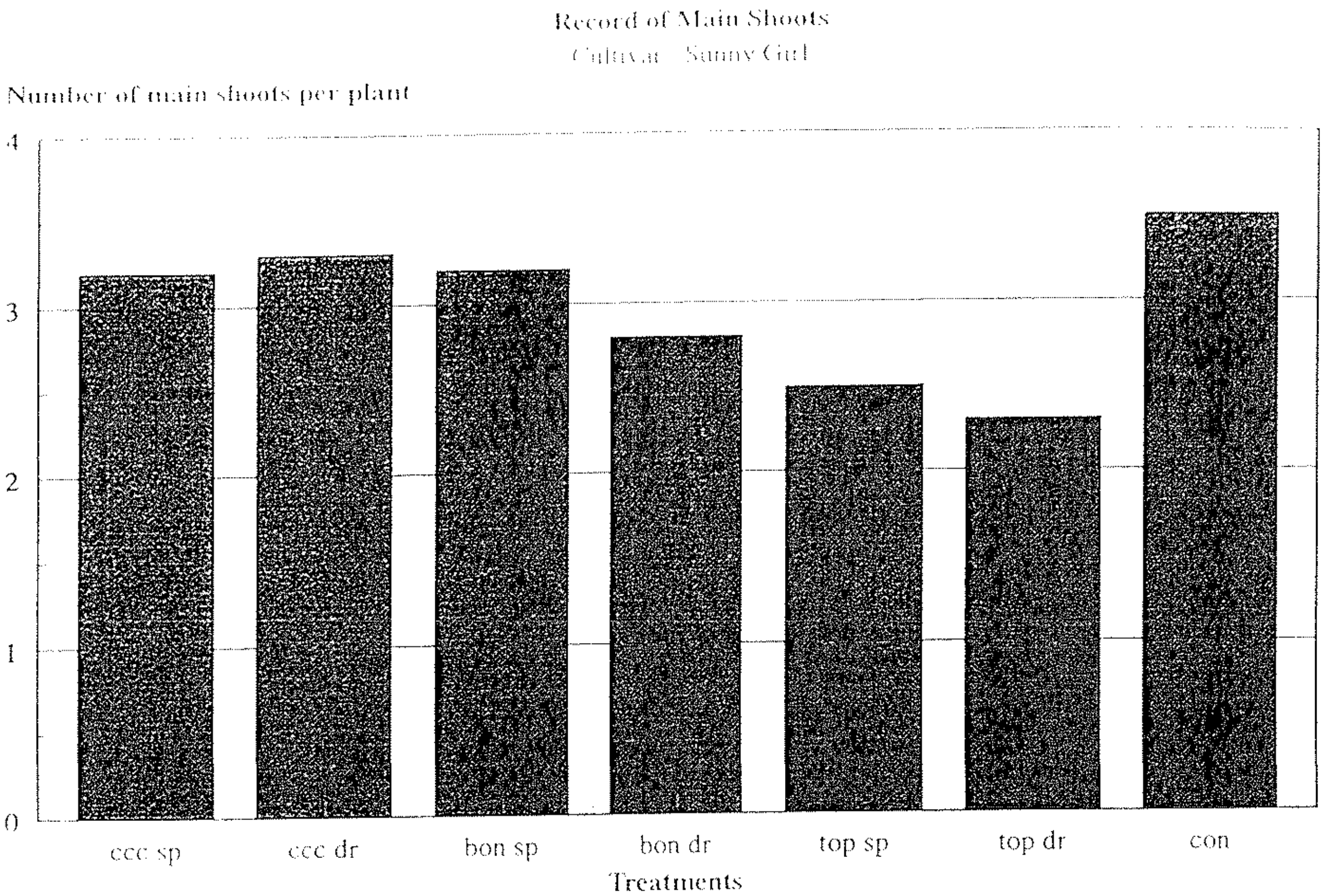
Flowering Records
Cultivar: Sunny Girl

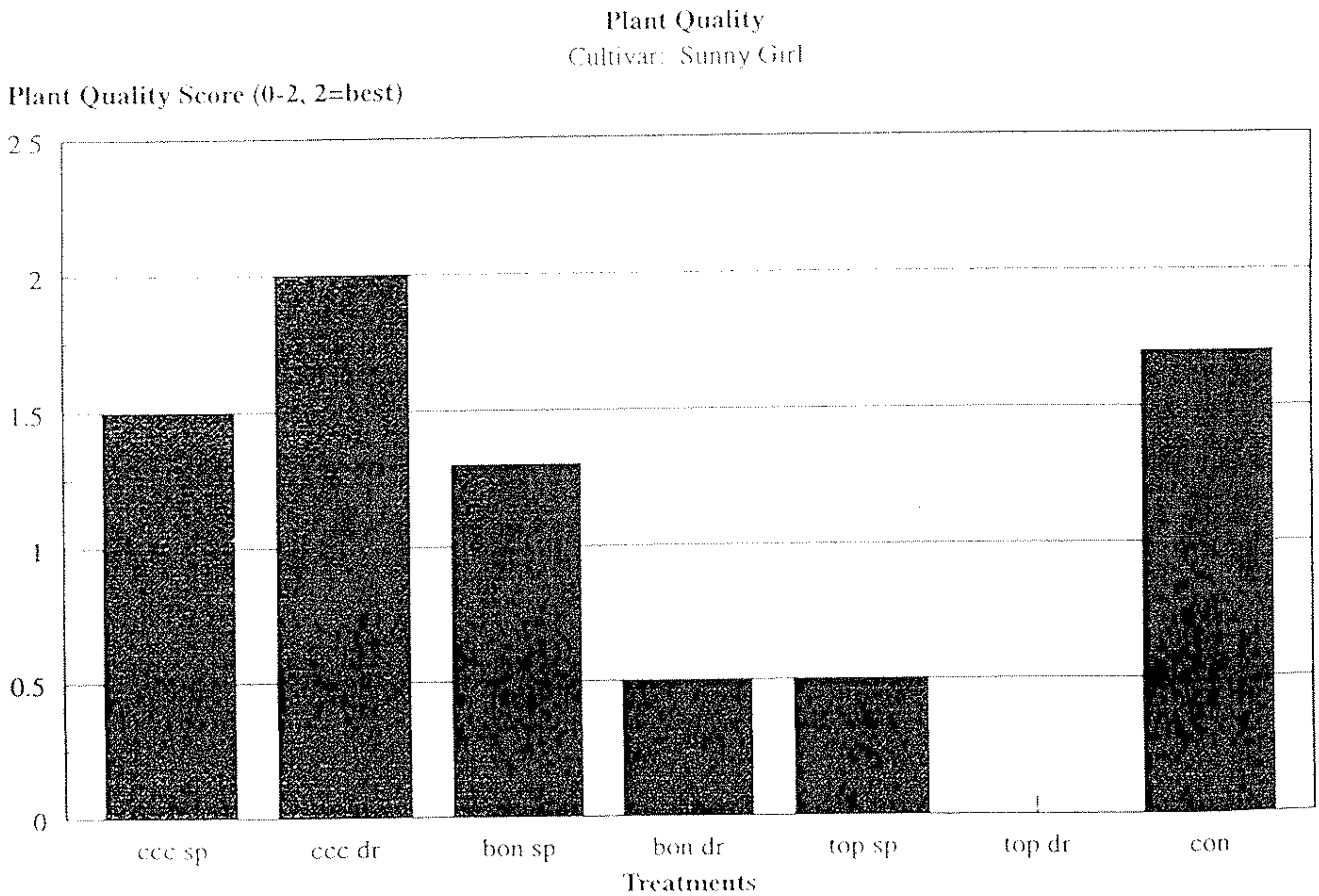


Flower Diameter
Cultivar: Sunny Girl

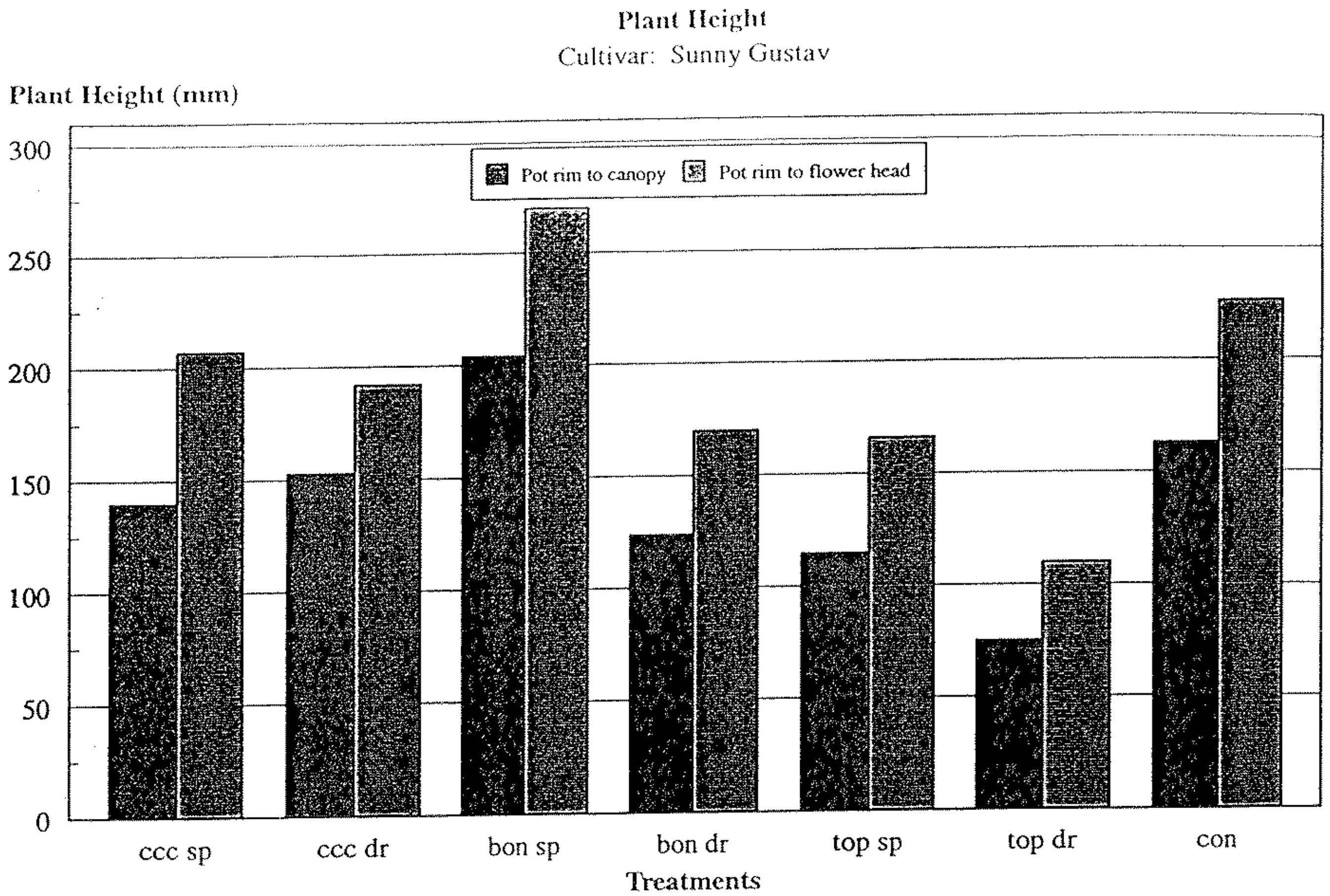


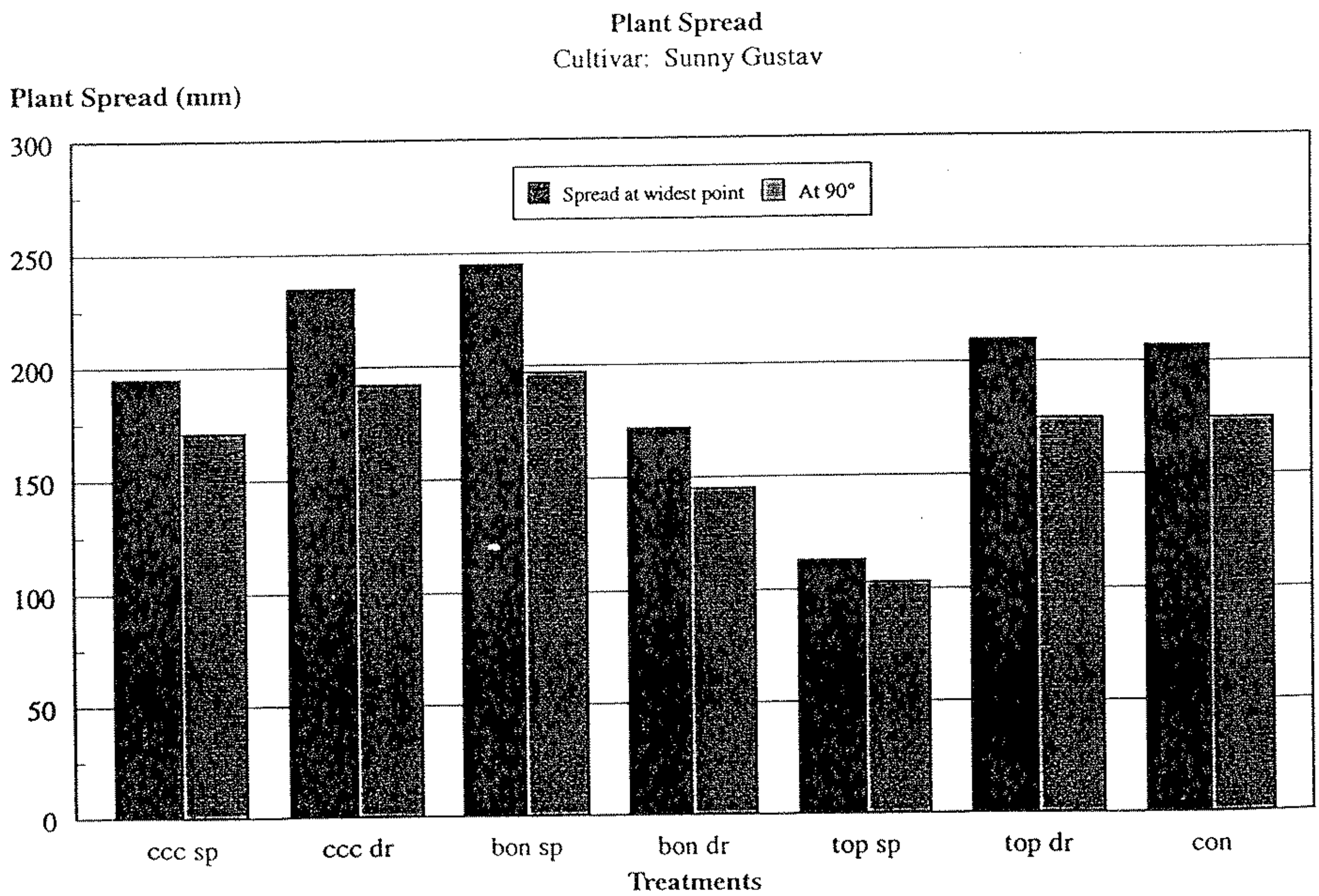
APPENDIX V Trial Two - Results



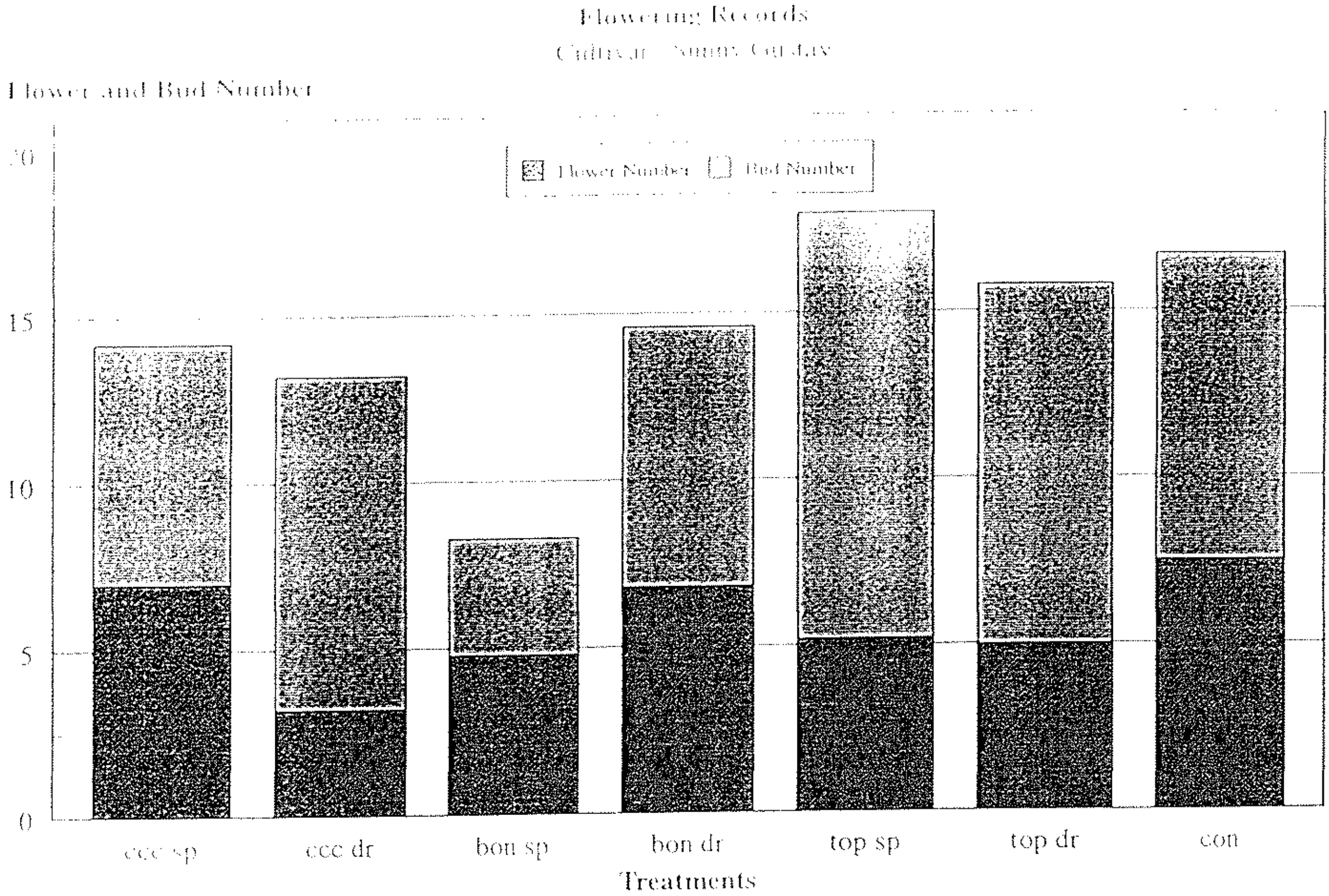


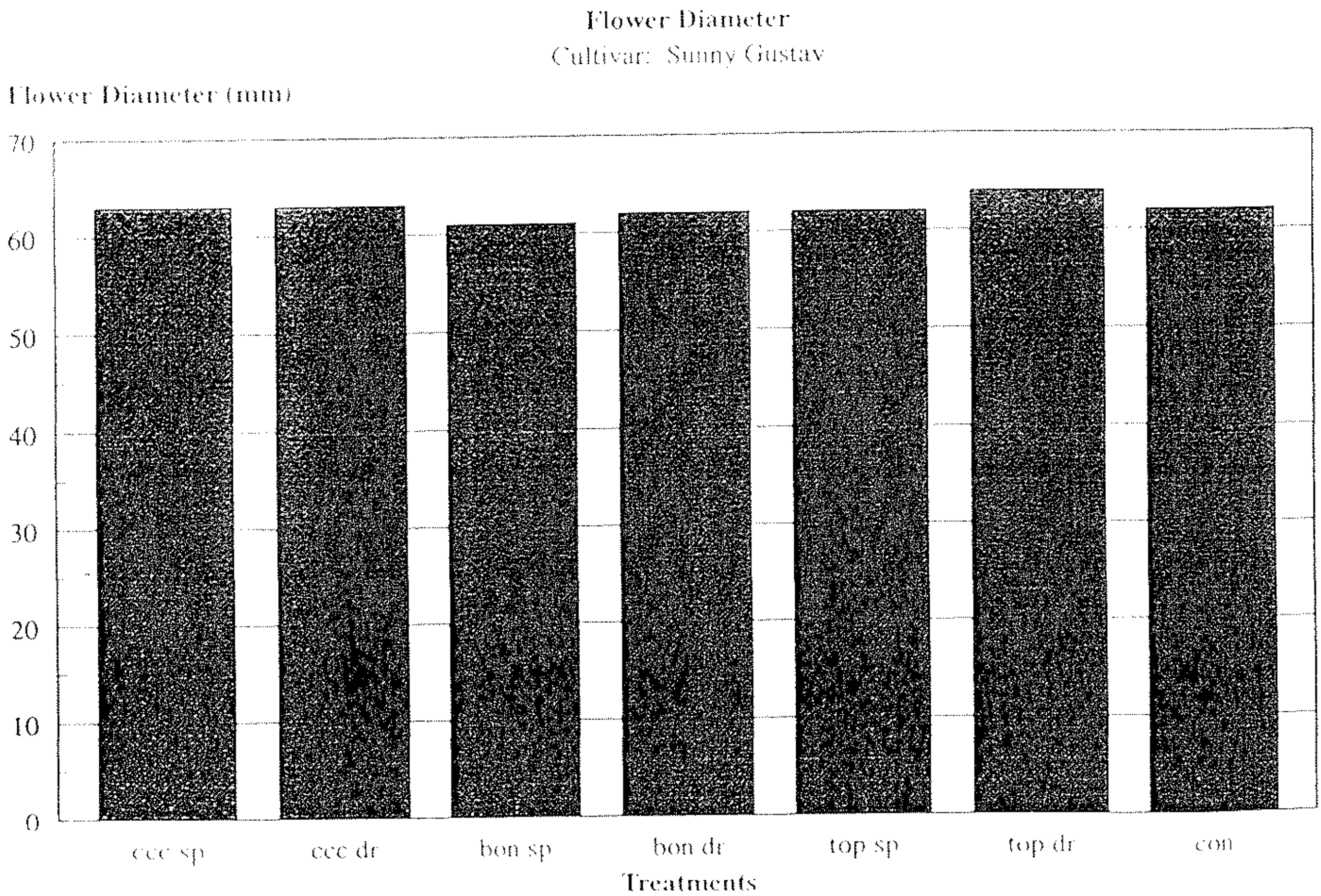
APPENDIX V Trial Two - Results



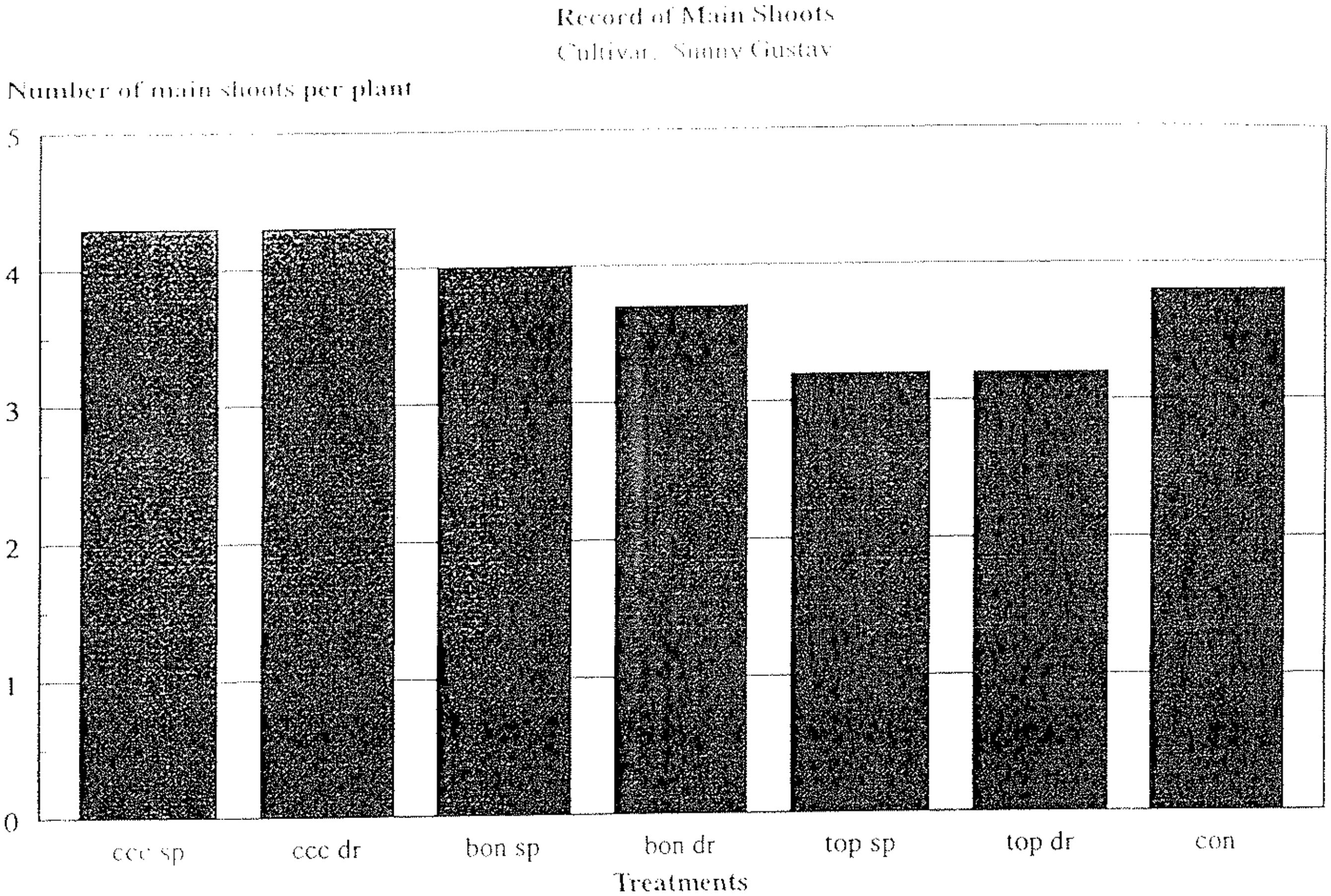


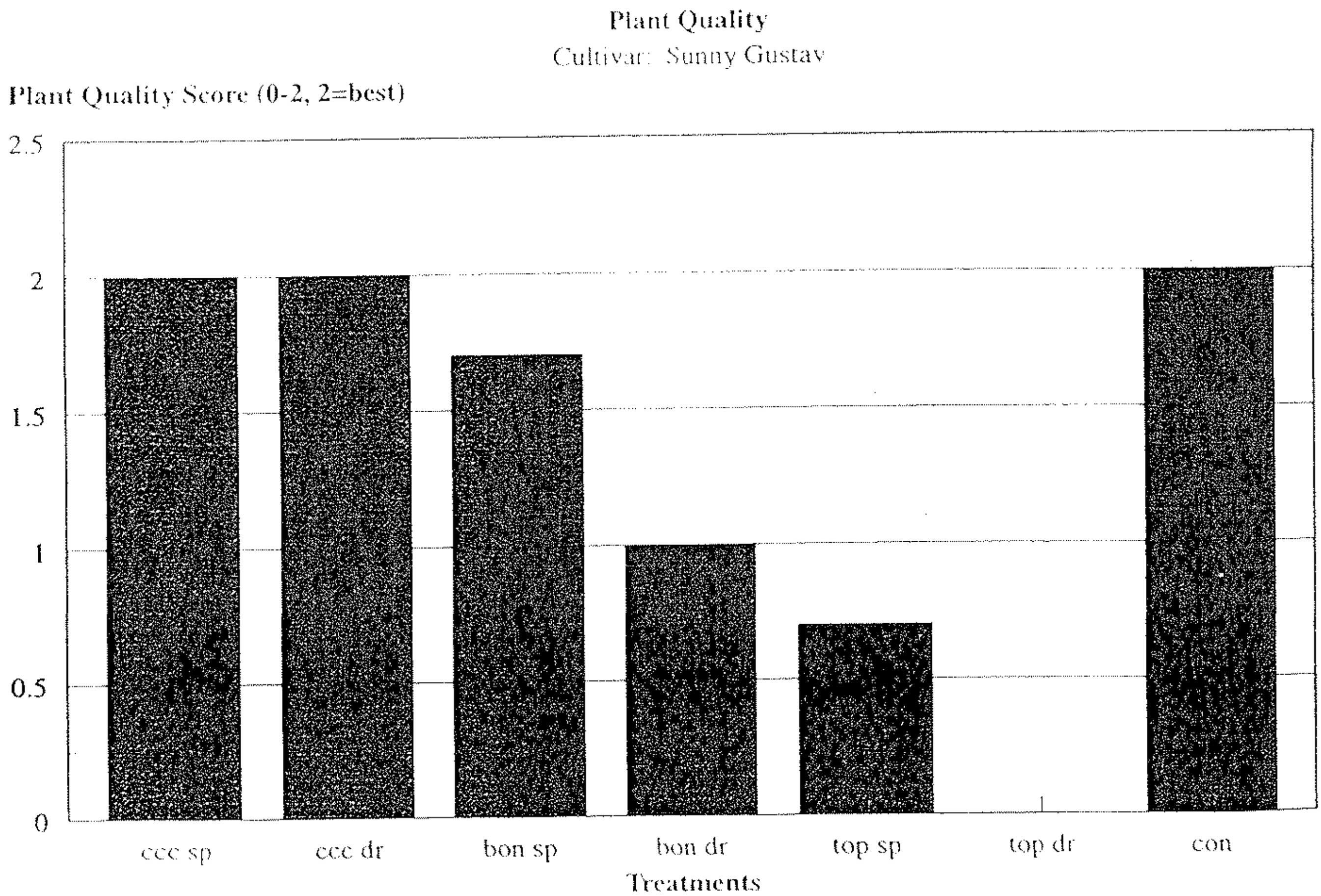
APPENDIX X Trial Two - Results



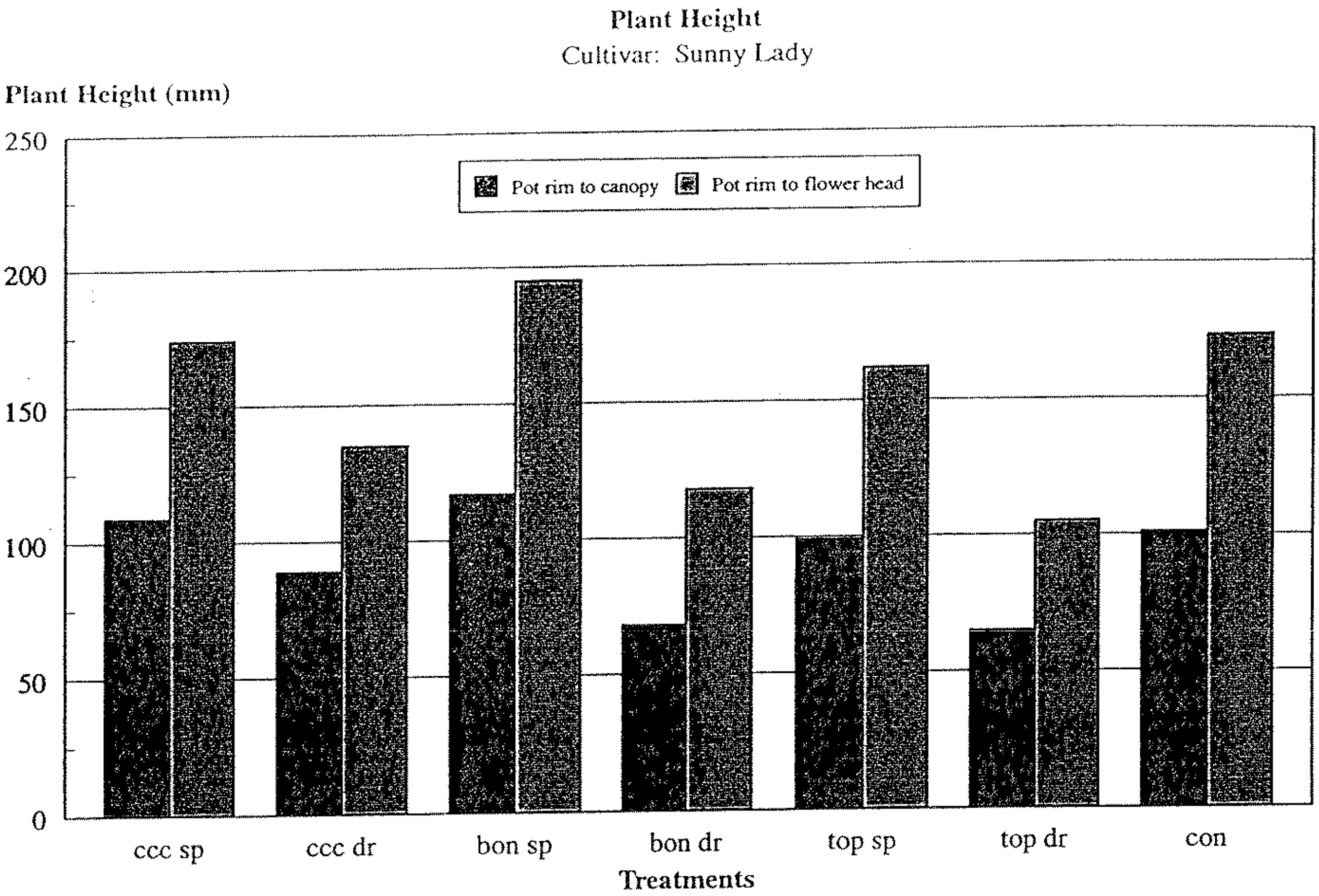


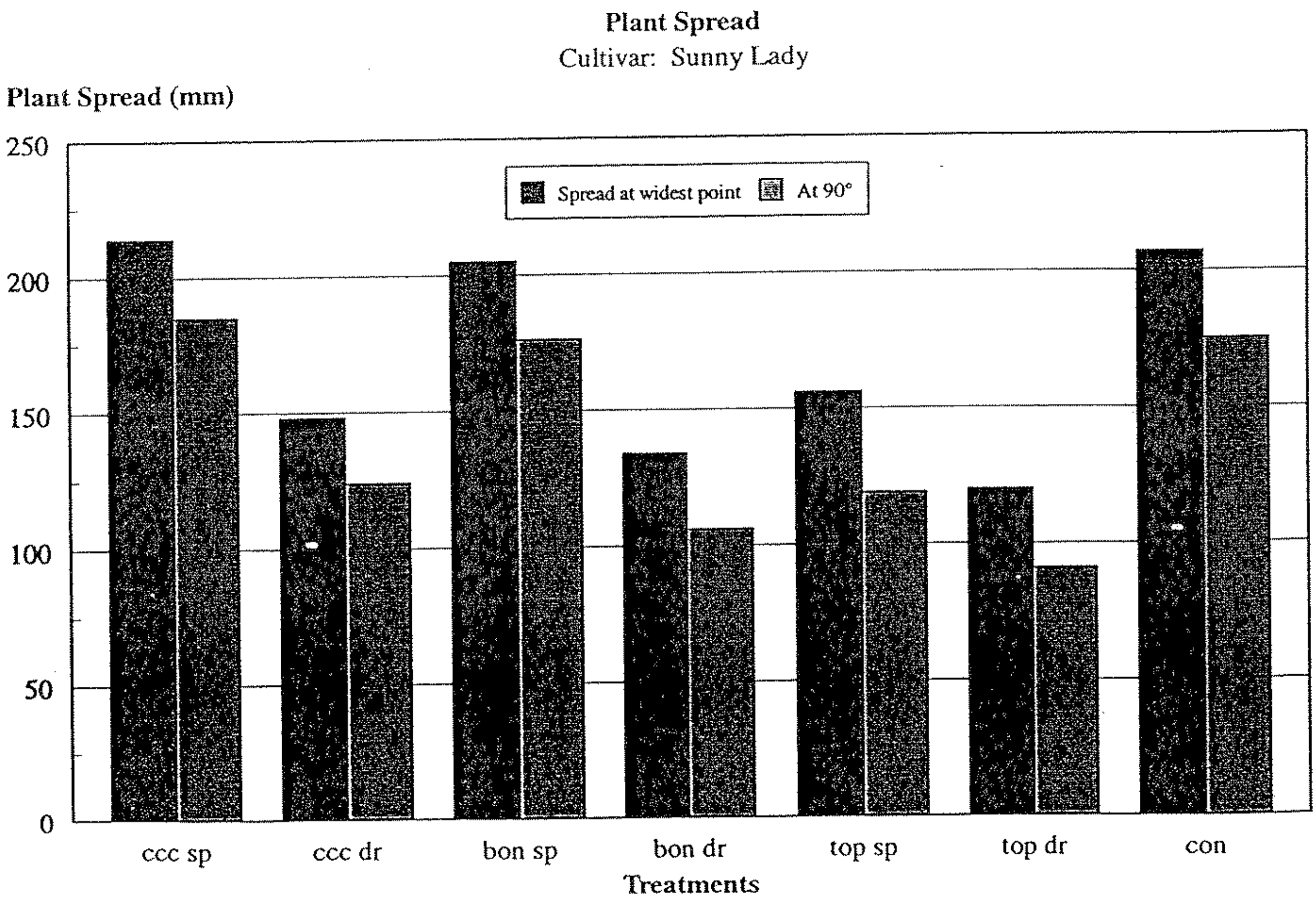
APPENDIX X Trial Two - Results



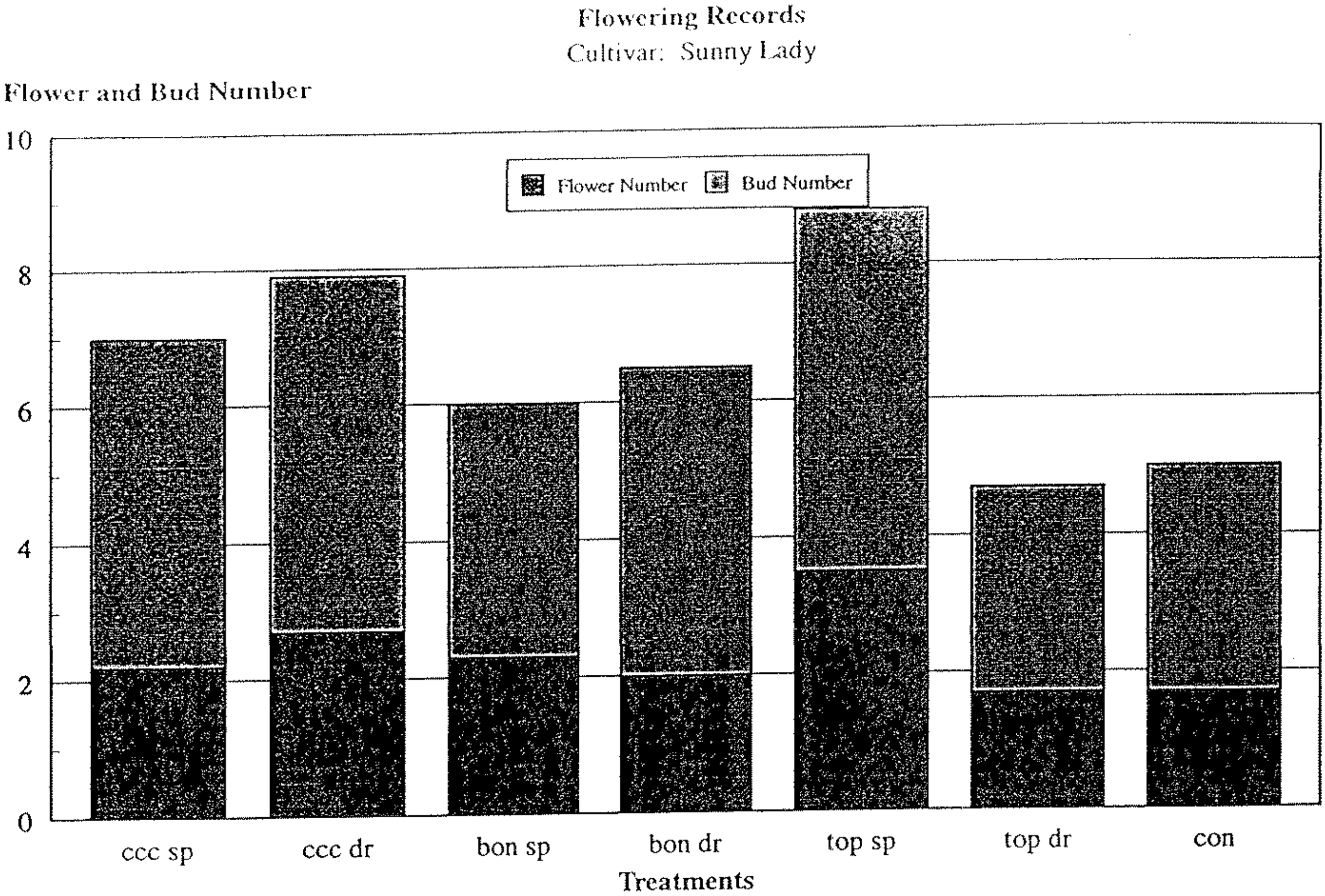


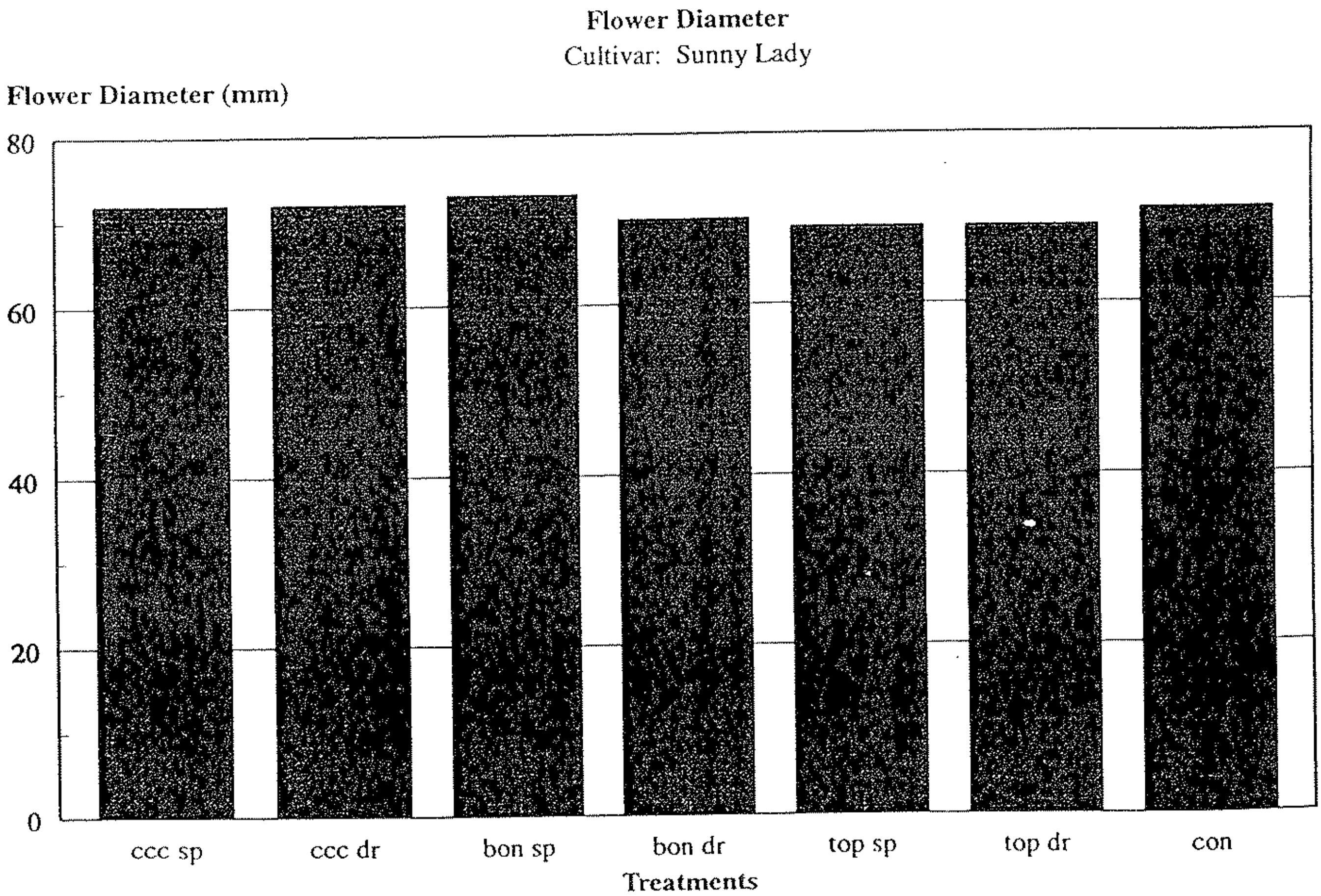
APPENDIX V Trial Two - Results



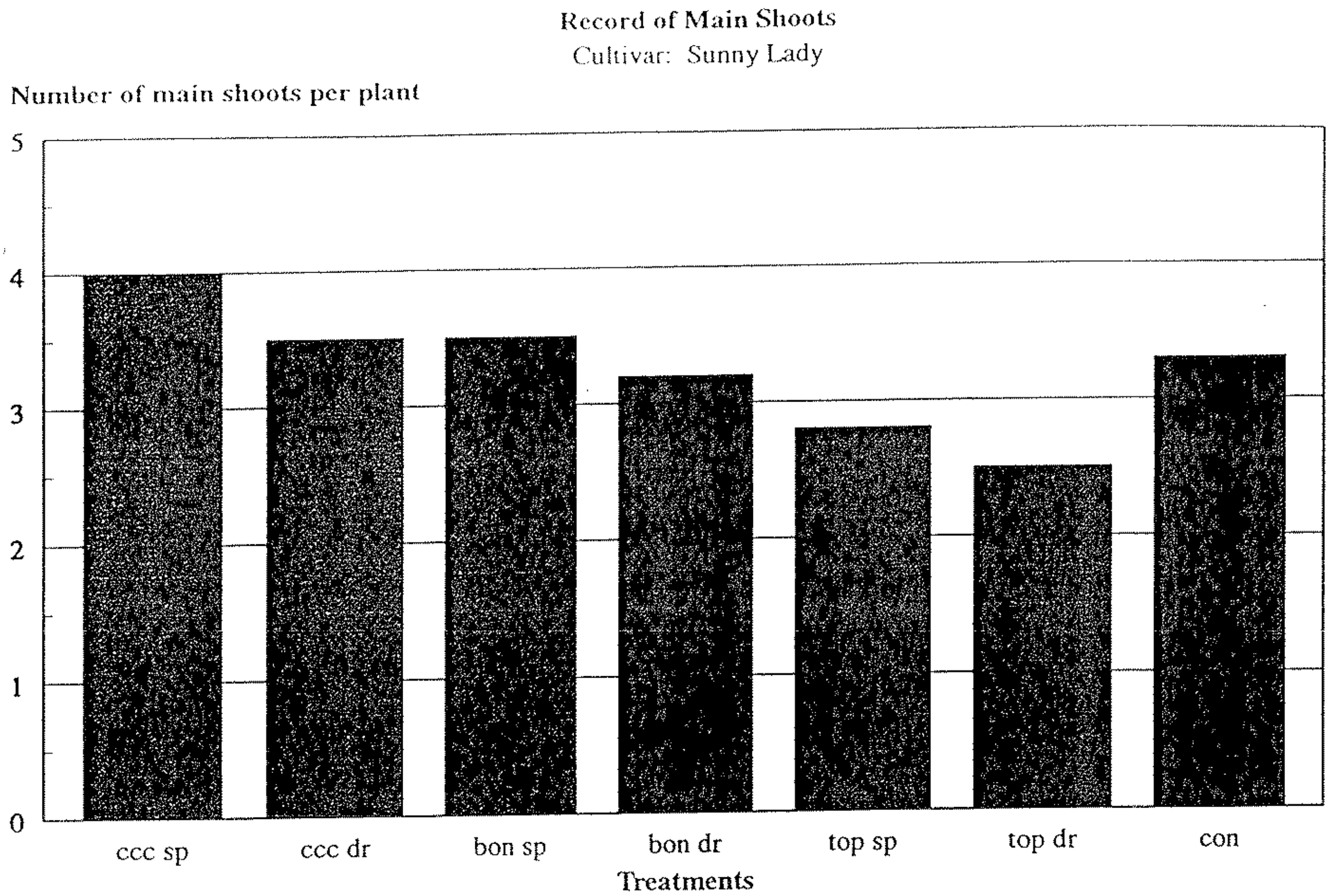


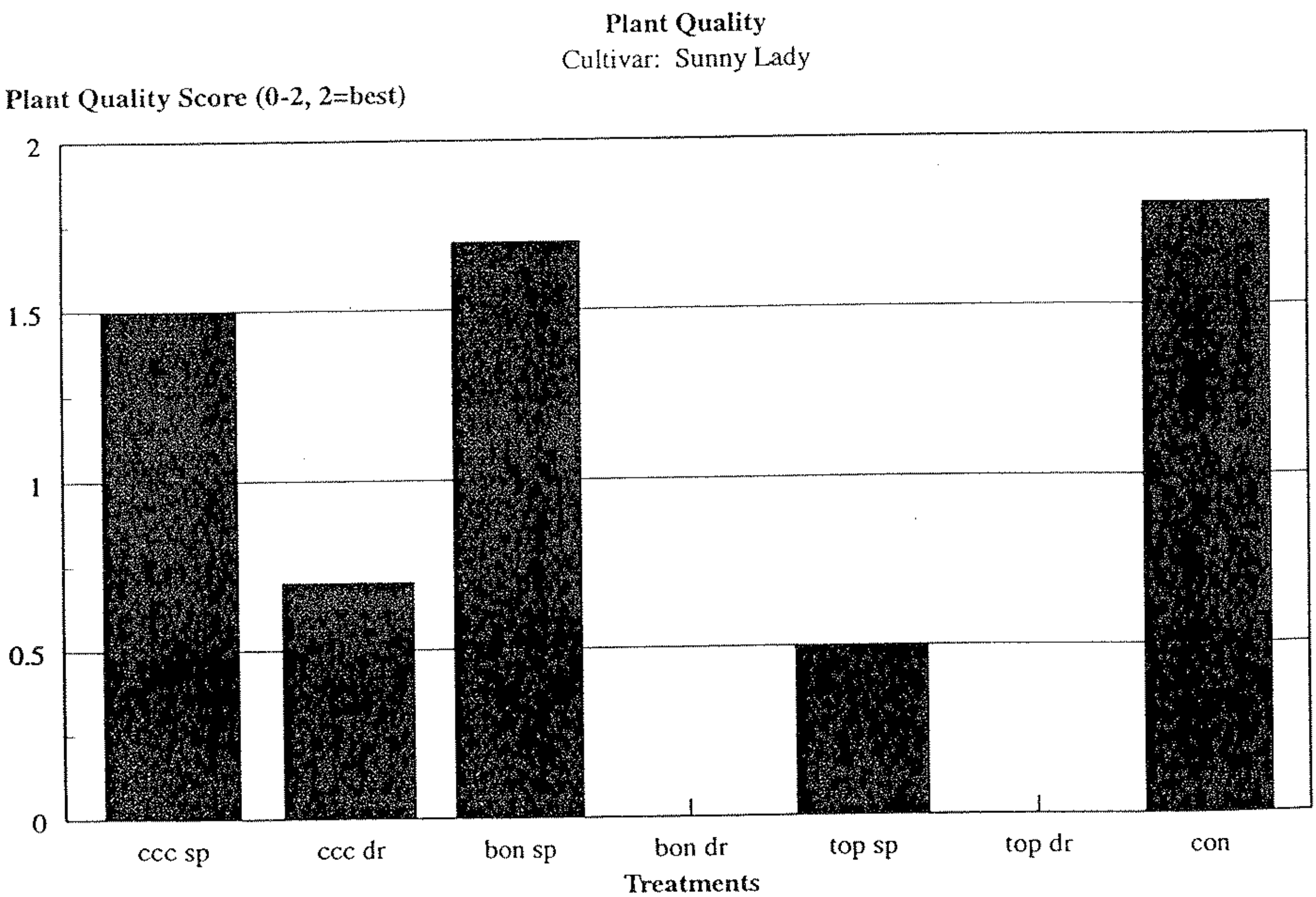
APPENDIX V Trial Two - Results





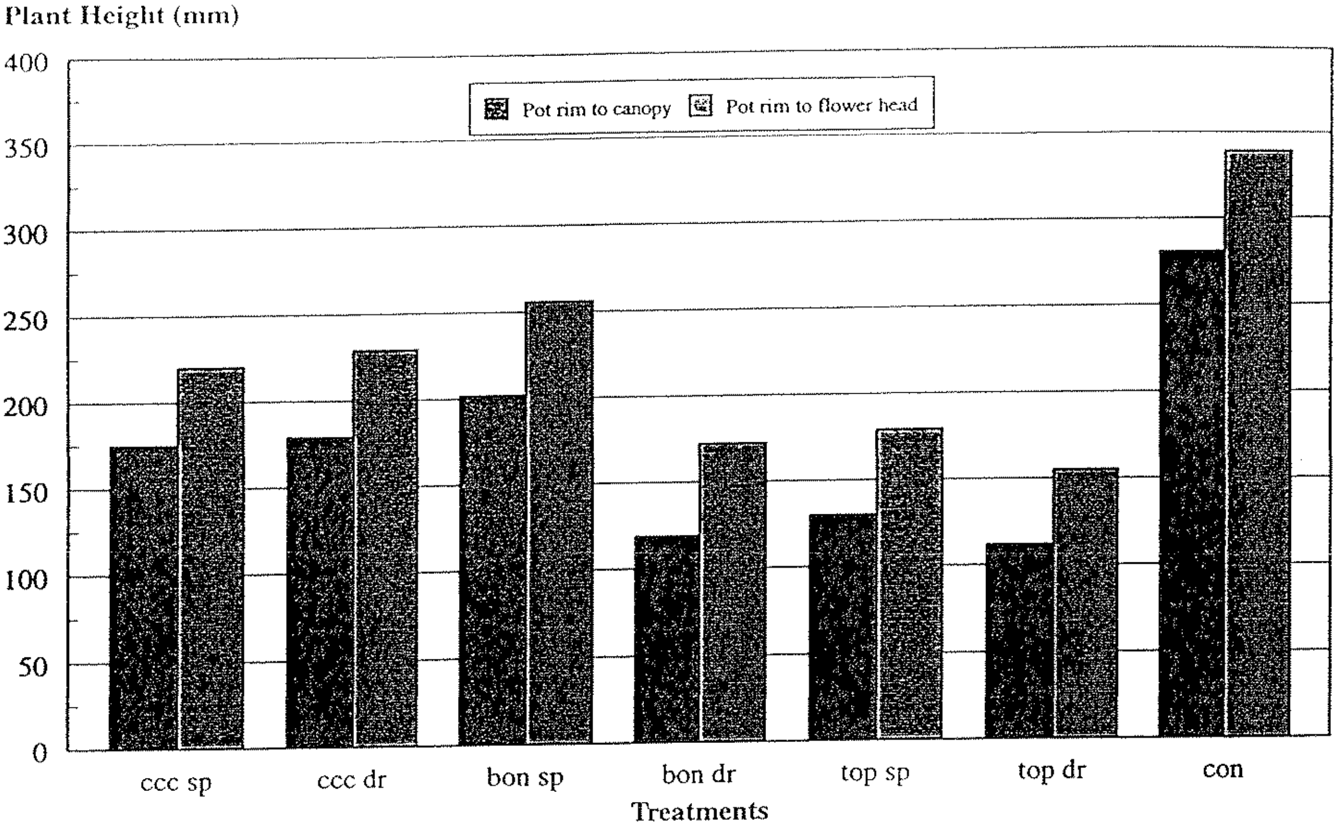
APPENDIX V Trial Two - Results



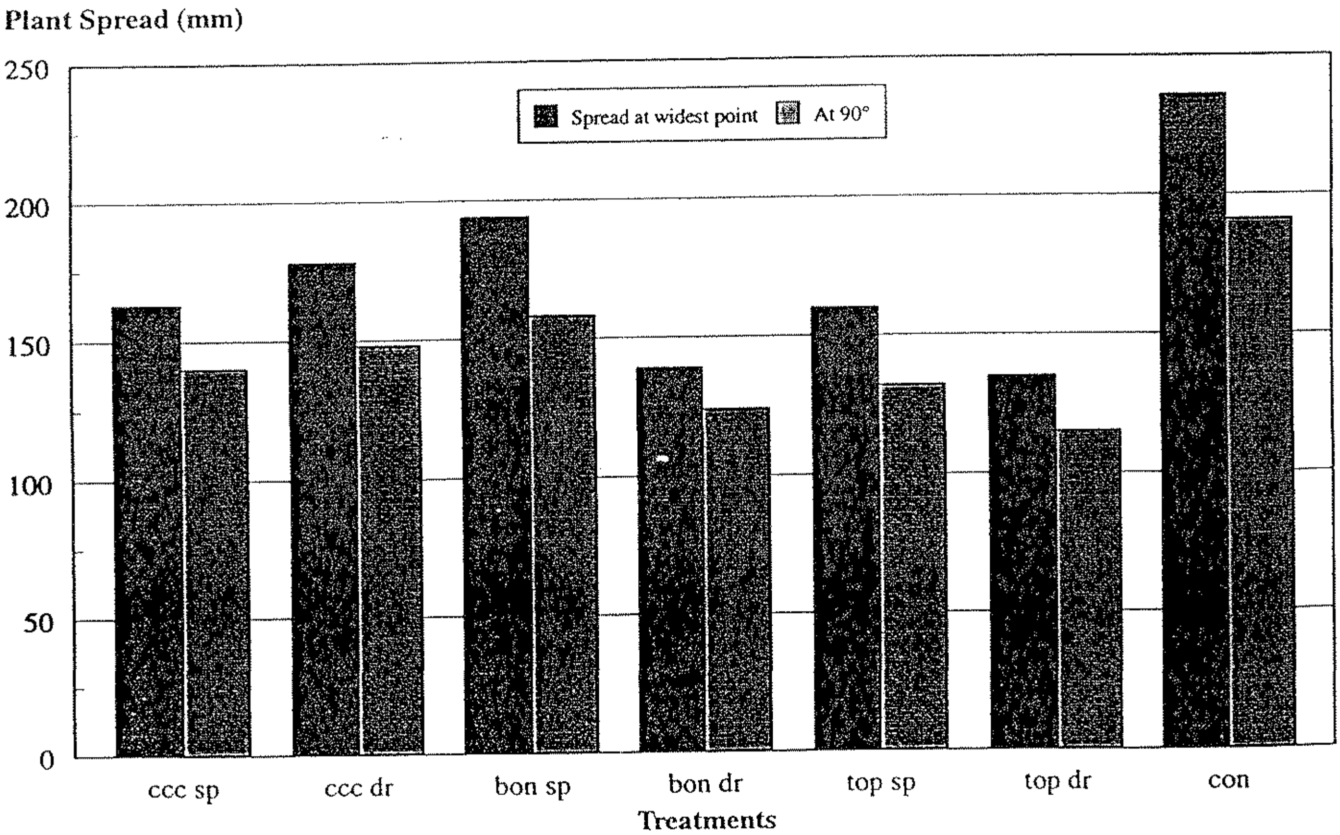


APPENDIX V Trial Two - Results

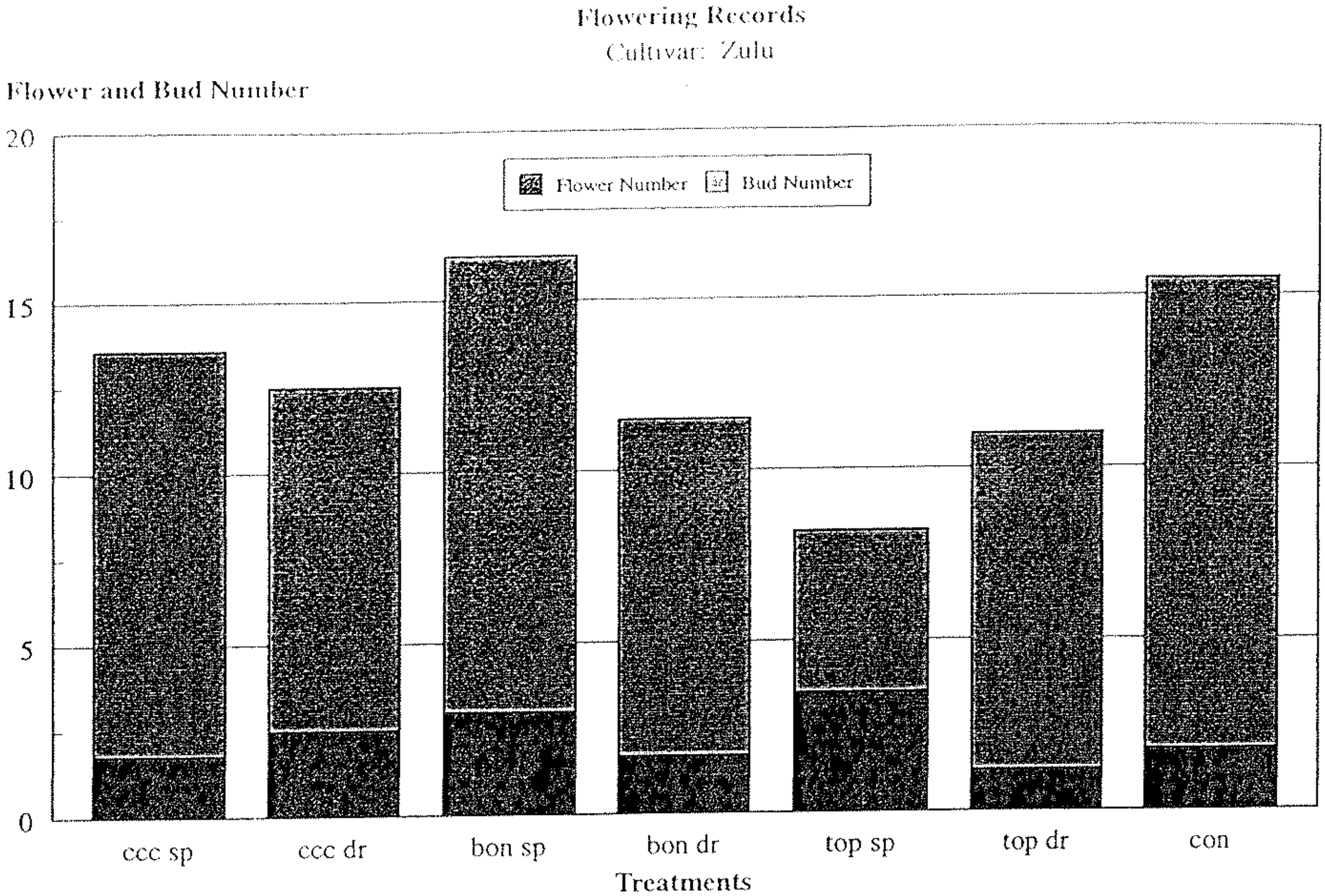
Plant Height
Cultivar: Zulu

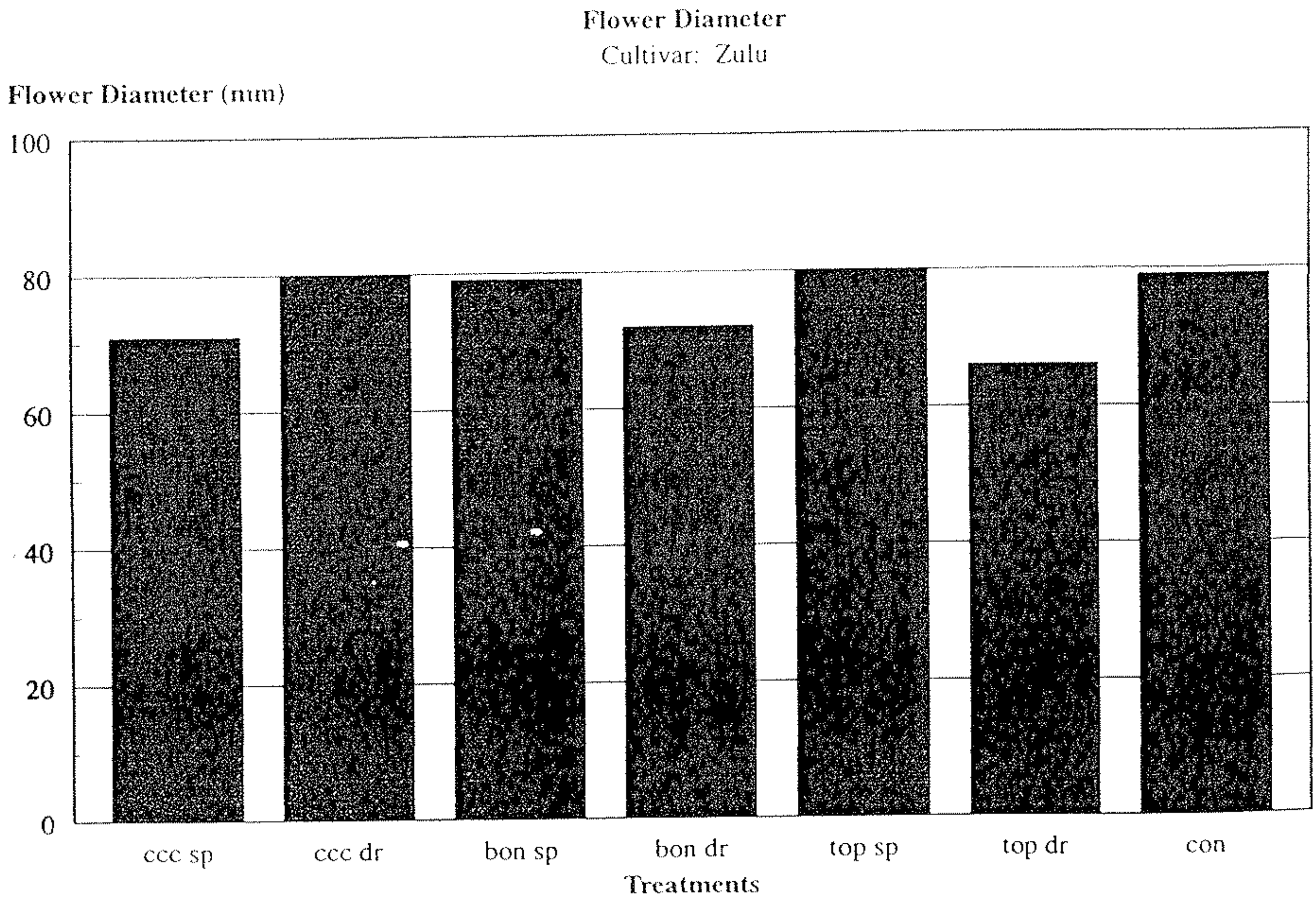


Plant Spread
Cultivar: Zulu

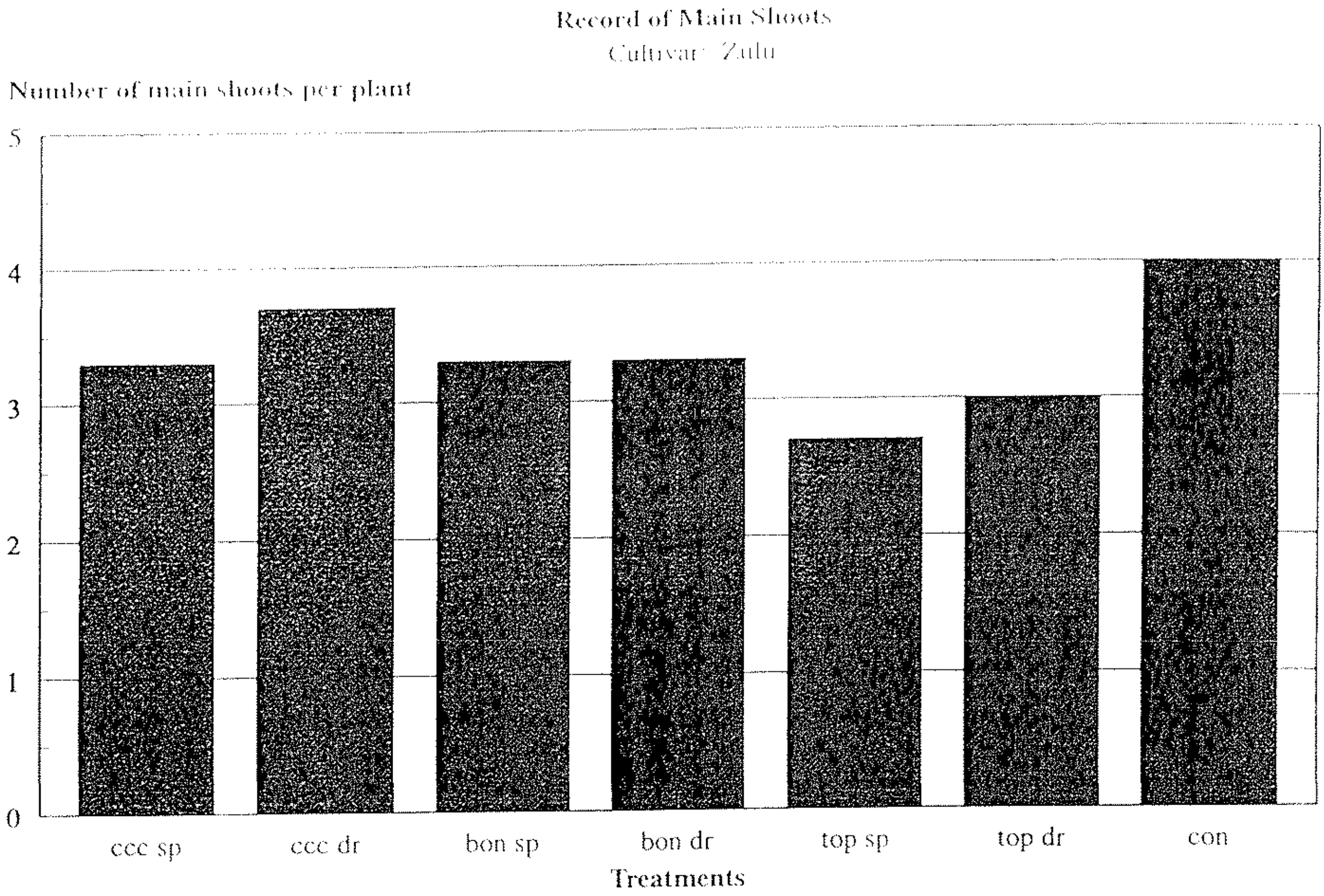


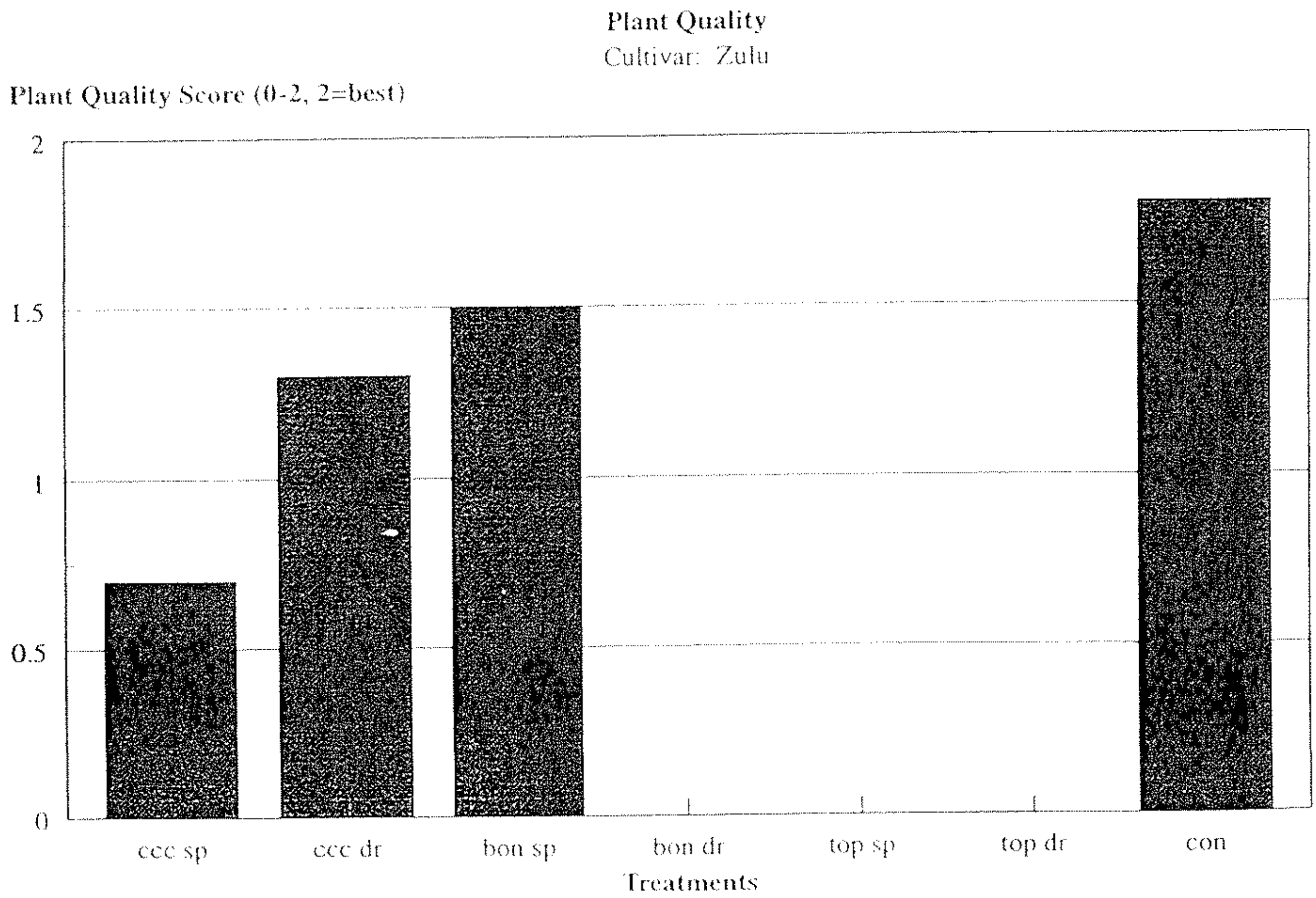
APPENDIX V Trial Two - Results



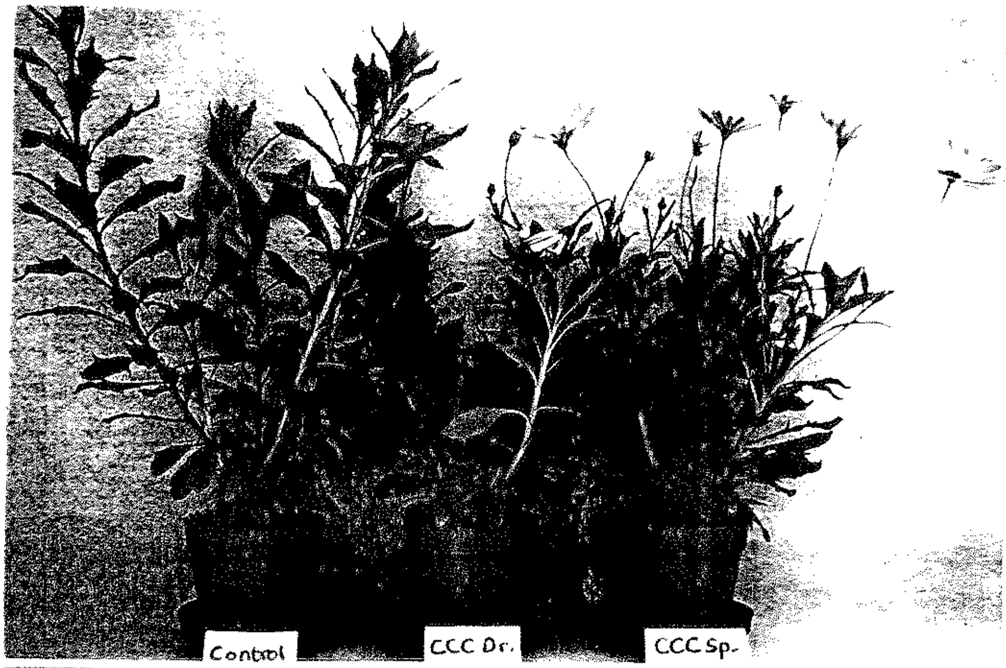


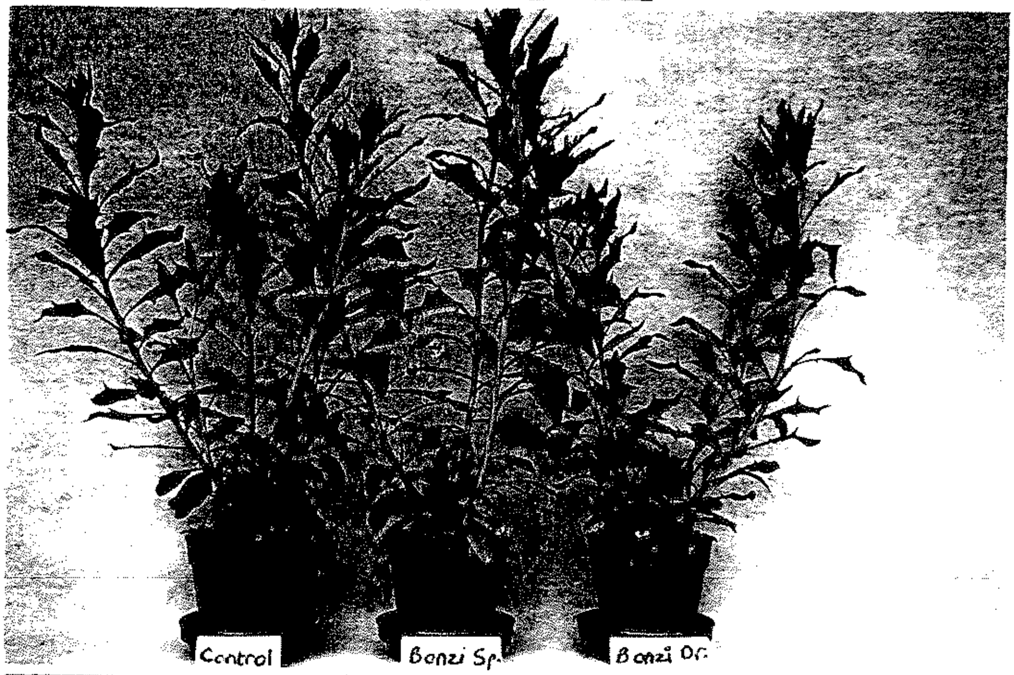
APPENDIX V Trial Two - Results

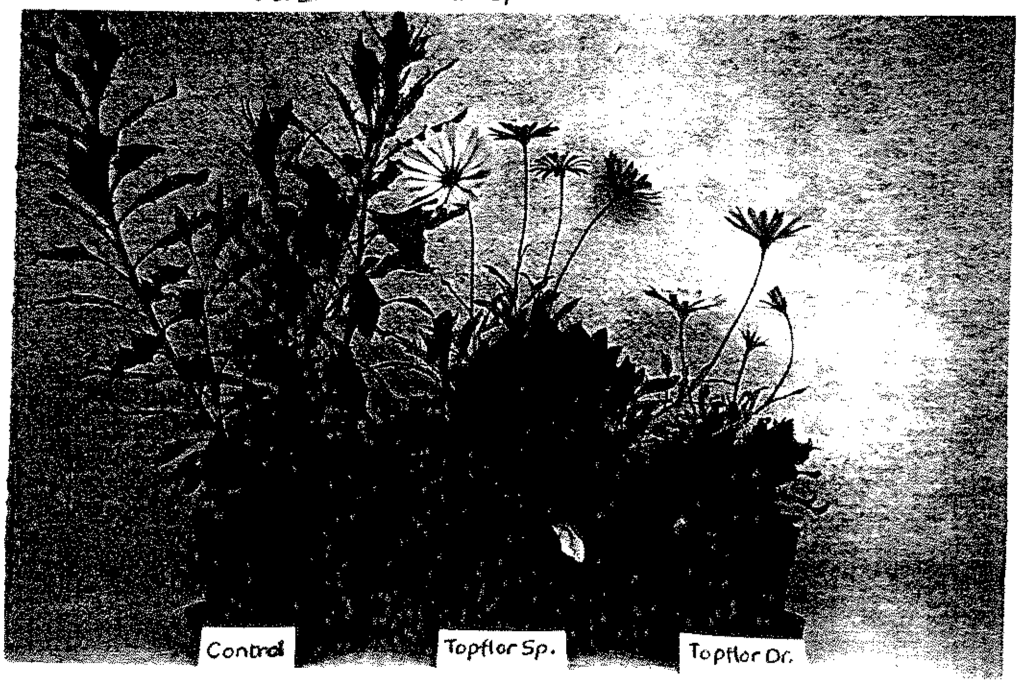




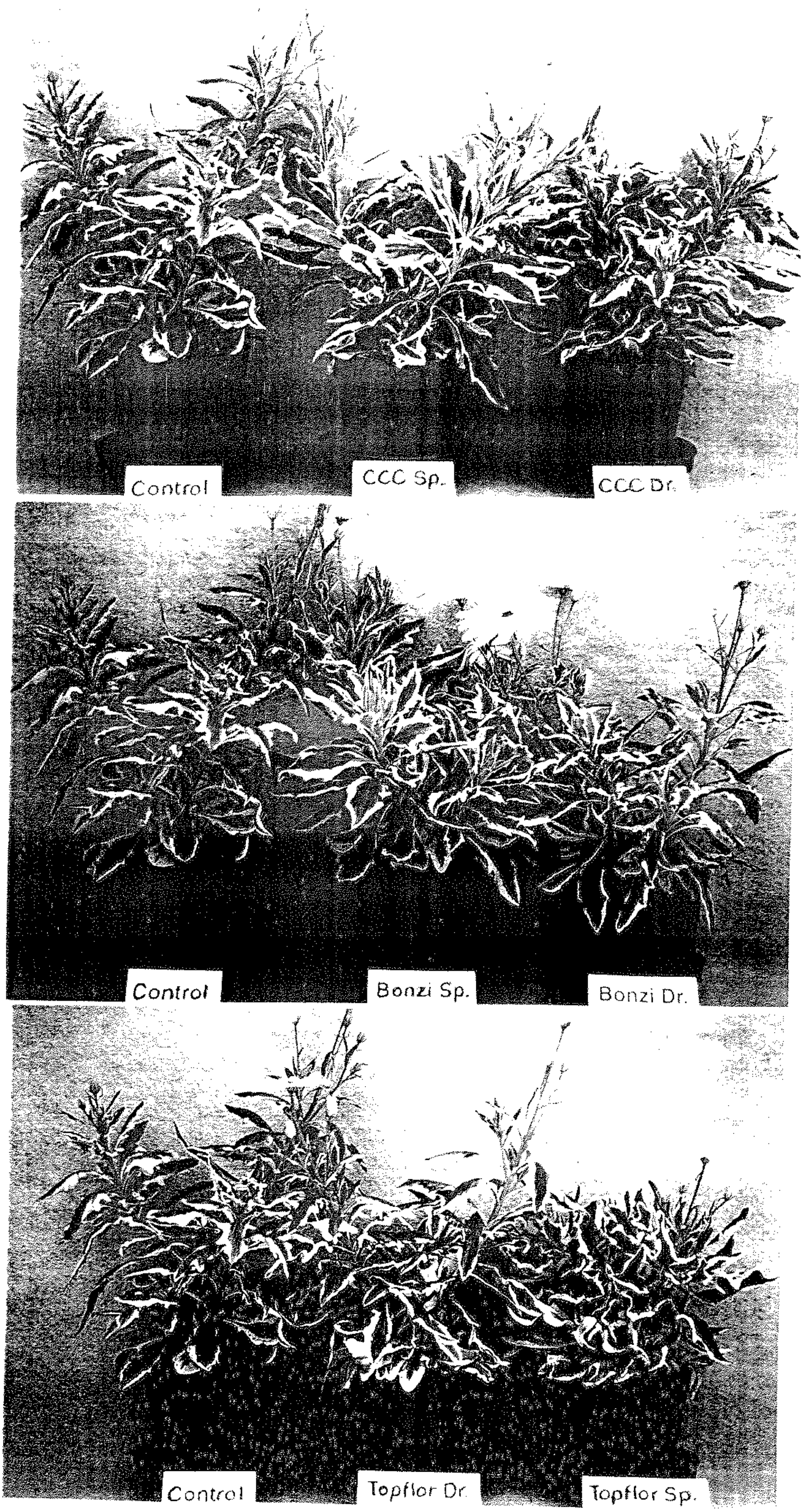
APPENDIX VI Plate 1: *Osteospermum* cv Congo







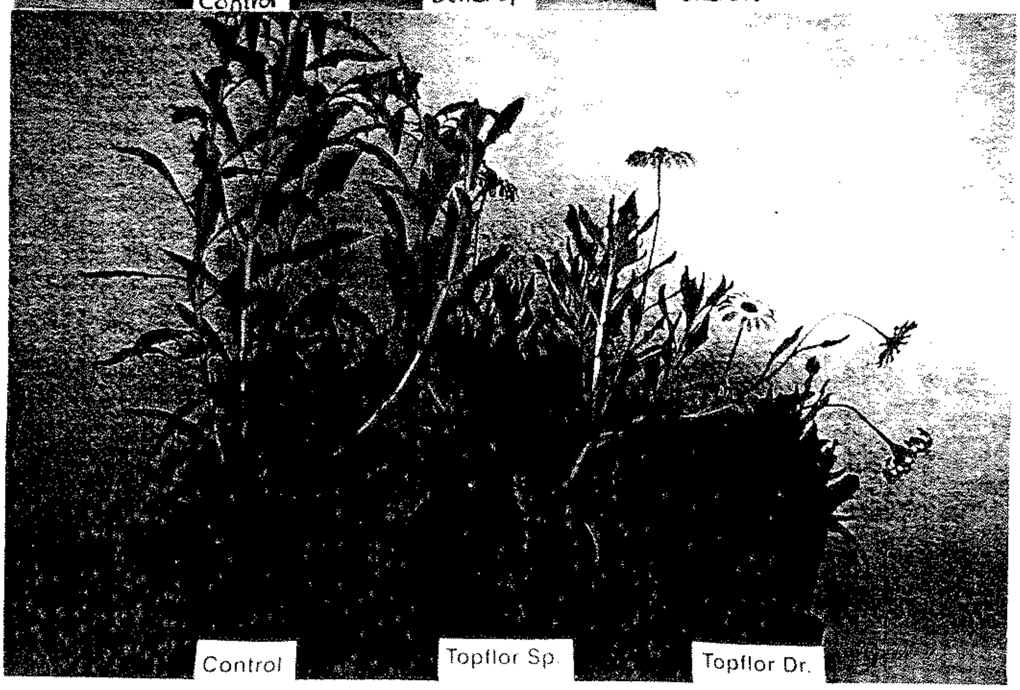
APPENDIX VI Plate 2: *Osteospermum* cv Lindi



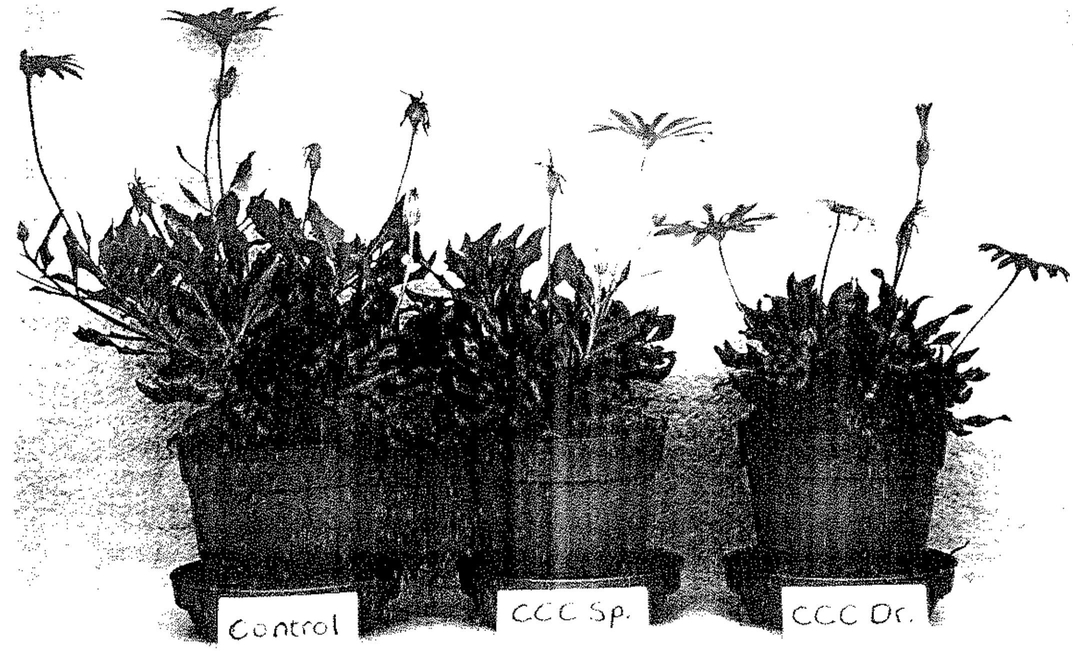
APPENDIX VI Plate 3a: *Osteospermum* cv Lubutu

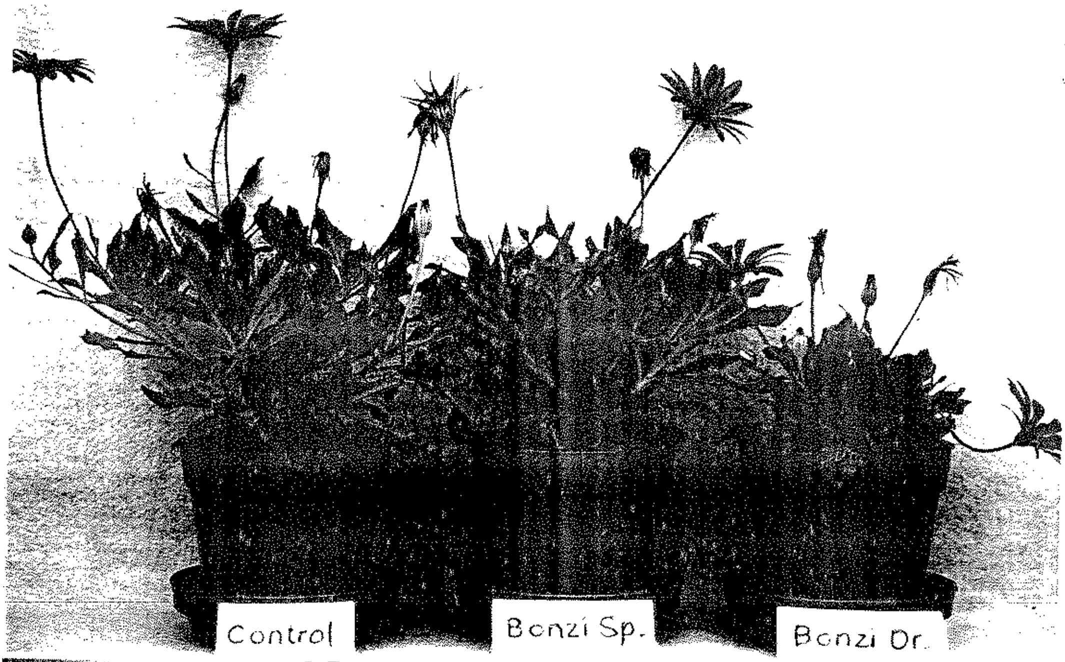
APPENDIX VI Plate 3b: *Osteospermum* cv Lubutu

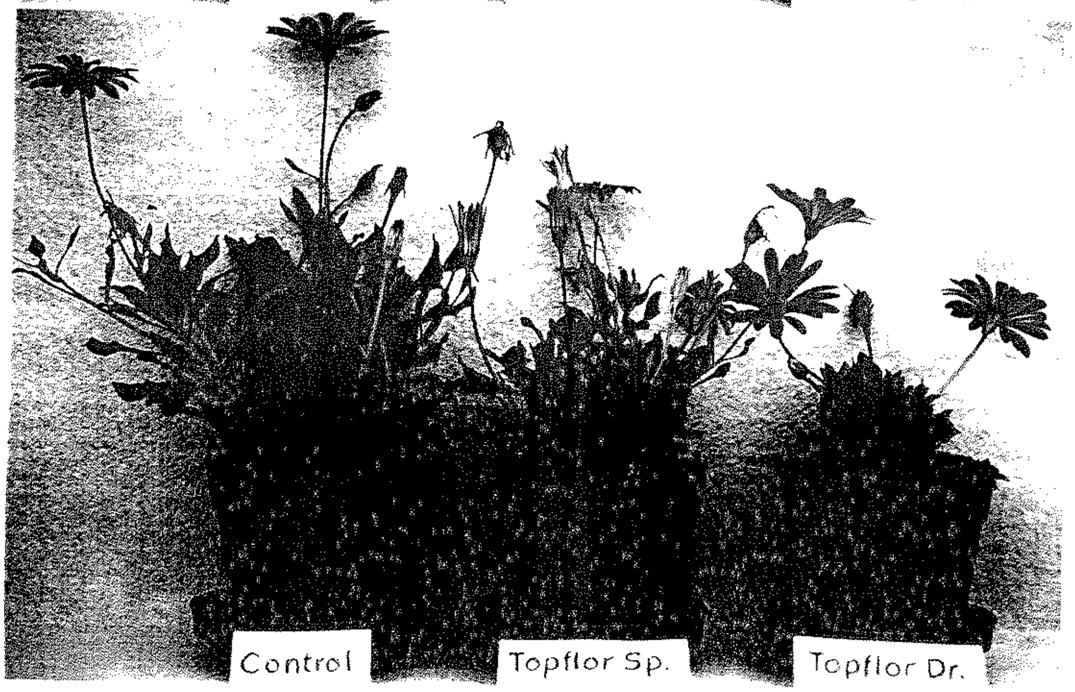
APPENDIX VI Plate 4: *Osteospermum* cv Pink Fantasy



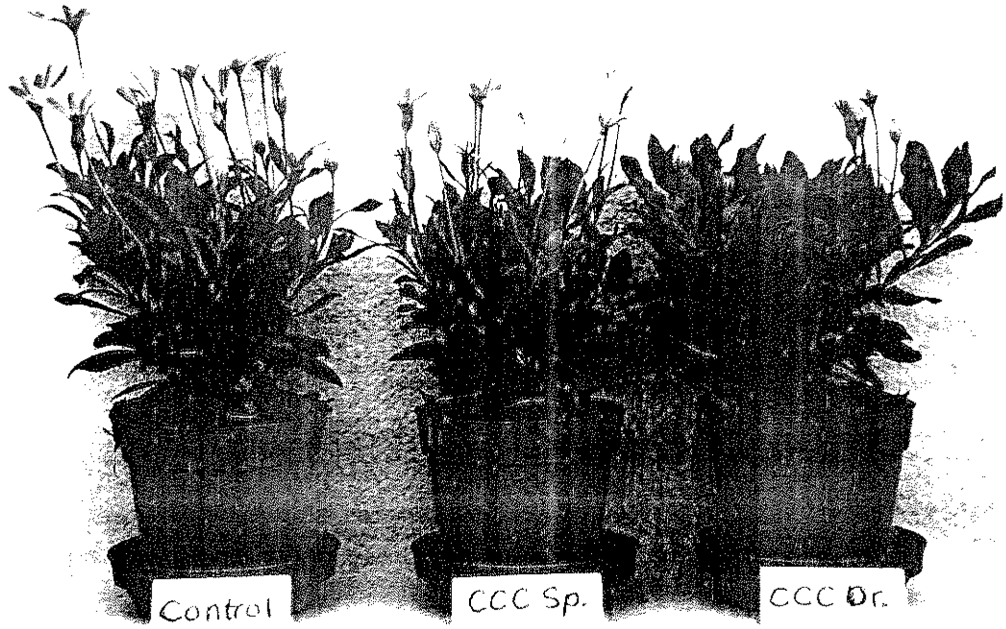
APPENDIX VI Plate 5: *Osteospermum* cv Sunny Girl

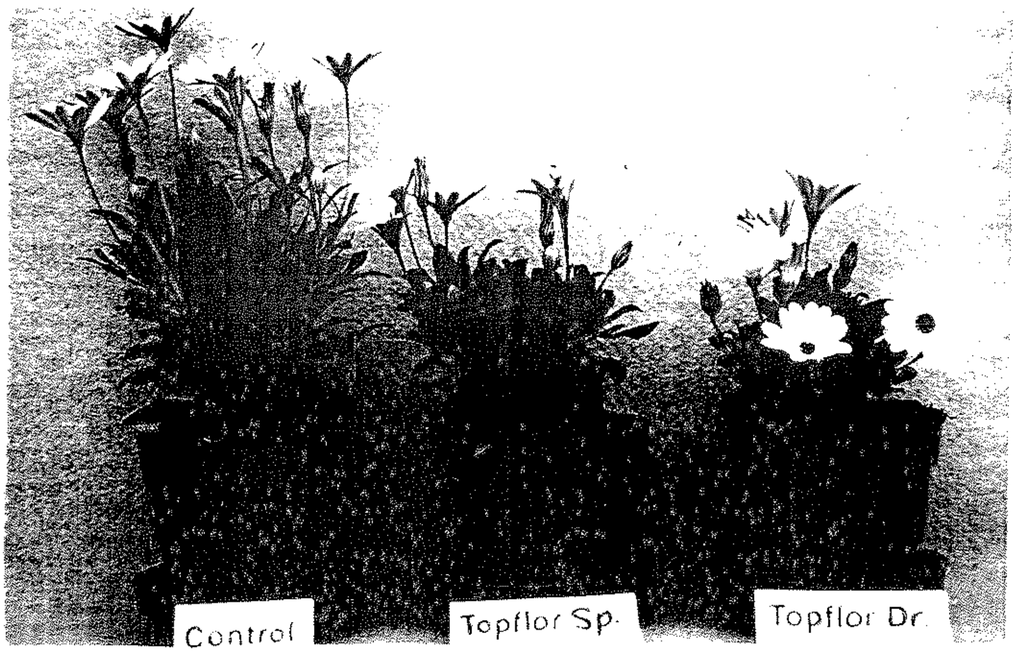




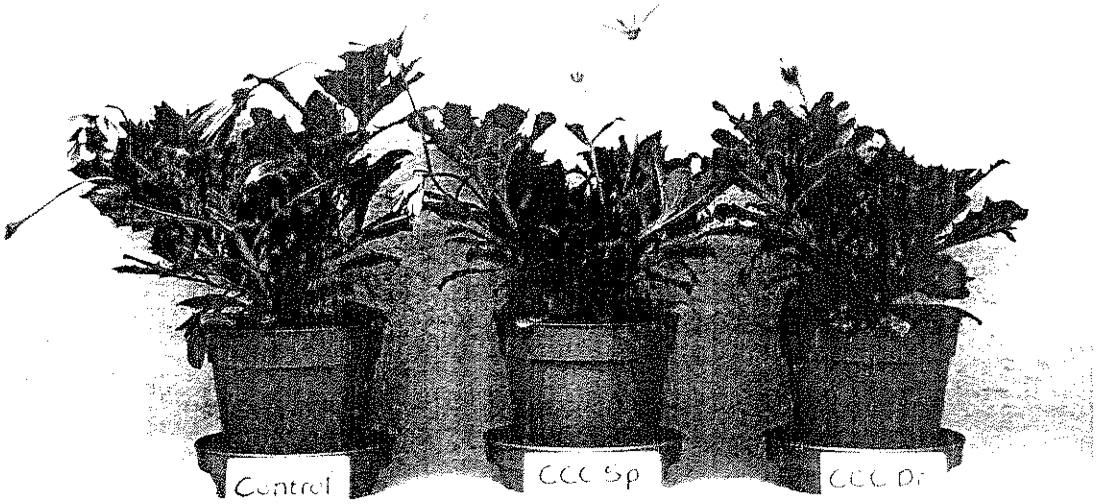


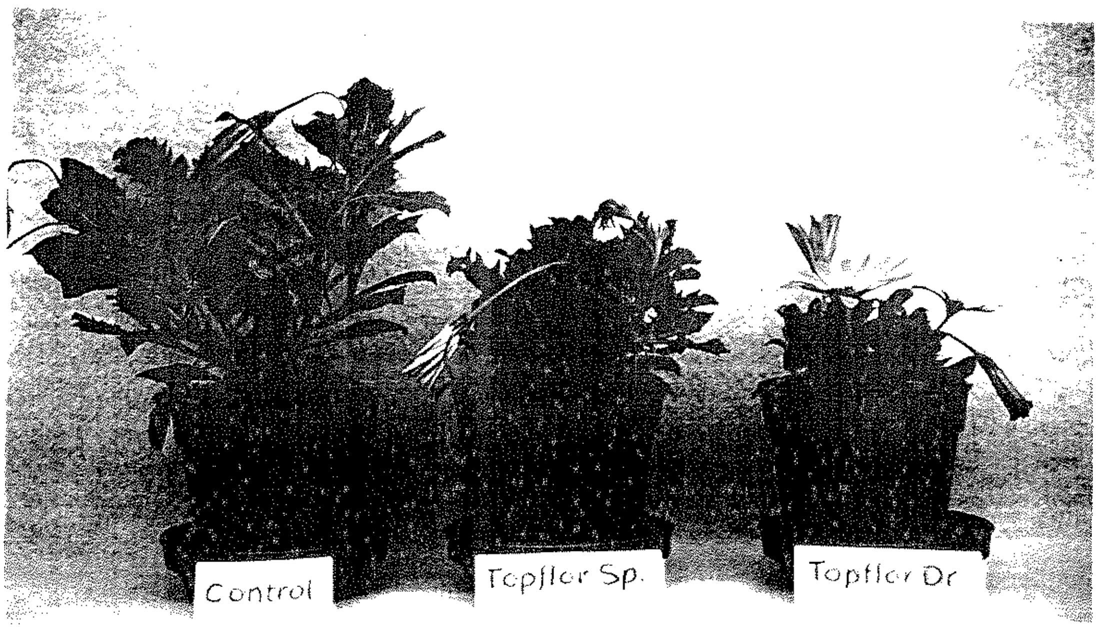
APPENDIX VI Plate 6. *Osteospermum* cv Sunny Gustav



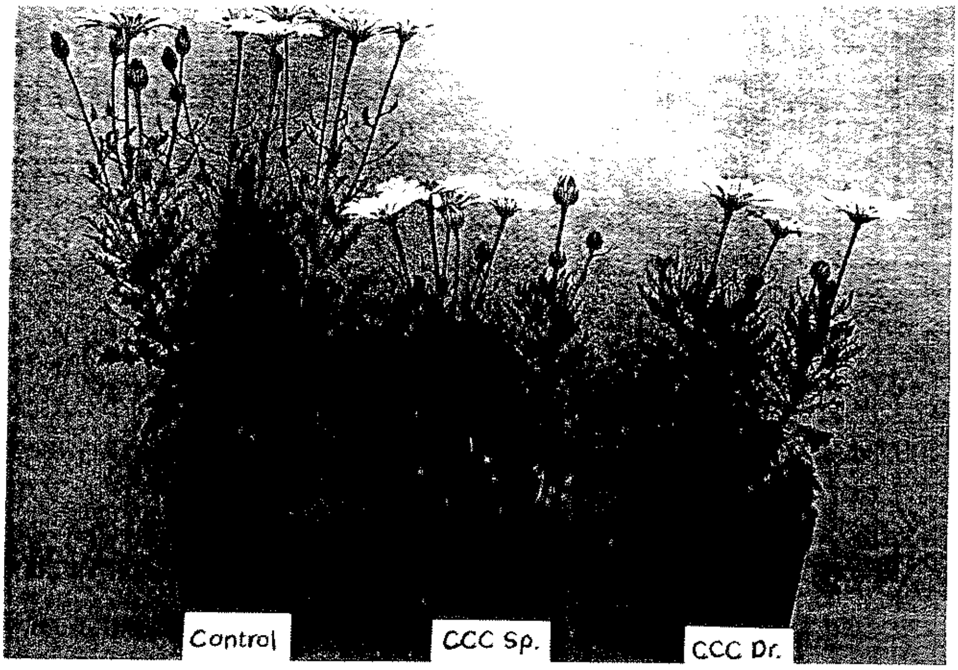


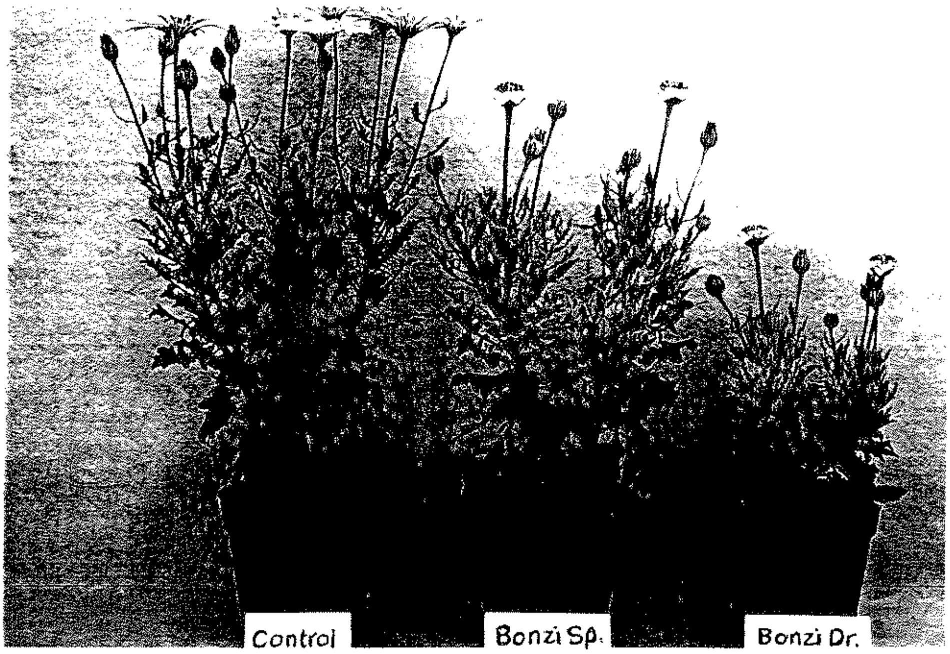
APPENDIX VI   Plate 7: *Osteospermum* cv Sunny Lady

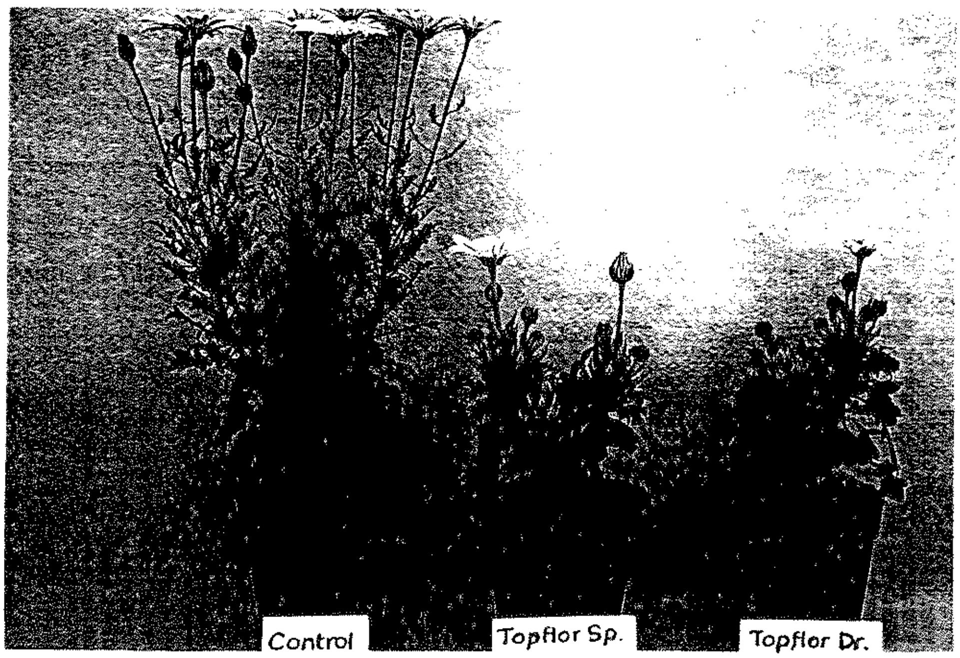




APPENDIX VI Plate 8: *Osteospermum* cv







APPENDIX VI   Plate 9: Cycocel spray damage on older leaves of the cv Congo

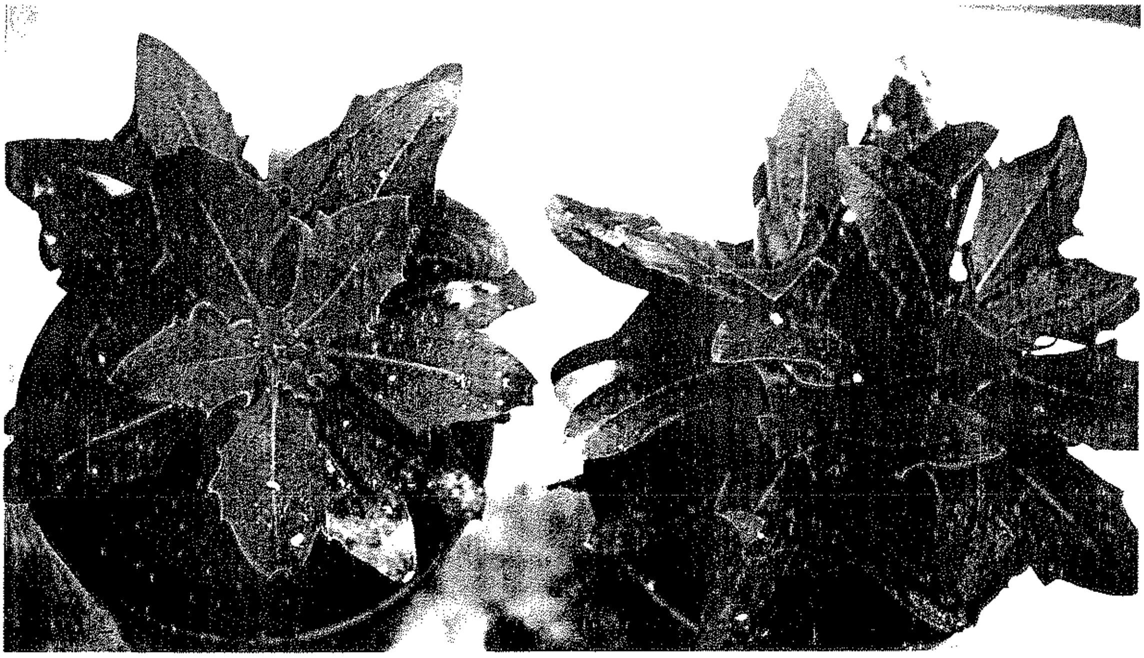


Plate 10:   Dwarfing habit of TopFlor drenches increased the risk of *botrytis*