AGROTECHNOLOGY & FOOD SCIENCES GROUP
WAGENINGEN UR

StarGreen: Optimal storage conditions for potted plants

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Report 833

Summary

Two experiments were performed to find optimal transport conditions for a selection of potted plants. It was find that suitable transport temperatures are 13-15°C for Hoya, Ficus and Carmona; 15-17 for Zamioculcas and Dracaena. Transport should take place under humid conditions and plants should not be watered immediately prior to transport. At optimal storage temperature and high humidity, treatments with plant hormones, fungicides, sleeving and CA conditions *did not* improve final plant quality.

A further improvement of storage outcome may be achieved by either selection, breeding or cultivation of plants with higher intrinsic resistance to long term dark storage. In the case of cultivation measures, a pre-storage adaptation period at lower light intensities and at storage temperatures (acclimatization) may increase the plants performance during the shipments. Alternatively, application of light intensities at or above the CO2-compensation point during transport may limit quality loss during shipment and may shorten recovery time after transport. In the latter case, special attention should be given to spectral properties of the light source, that presumably should be low in blue components and relatively rich in red components.

Content

1 Introduction

StarGreen project is a collaboration between Maersk and Feldborg and is executed by AFSG. Feldborg Tropical Plants produces potted plants in Thailand and ship these in Reefer containers to Denmark. At arrival problems with leaf drop and yellowing of leaves demand a period of recovery before these plants can be sold to wholesalers/consumers. When climate conditions during transport in containers could be set in a way that outturn quality is much better, than the recovery period might be shortened, hence production costs could be reduced.

As an example, the costs for recovery of potted plants is in the order of Euro 4.- per m2 per week. For a complete container load (200 m2 of greenhouse space) this would amount to approximately Euro 800.- per week.

2 Aim

The aim of the experiments is to find optimal storage conditions for several potted plants to be shipped in containers over sea. This includes investigation of different temperatures, humidities and pre-storage treatments.

3 Experimental plan

Two experiments were performed in which plants were stored for approximately 30 days under a variety of different conditions. Immediately following storage, quality of plants was rated based on severity of leaf yellowing, leaf abscission, leaf browning and appearance of "rot". Plants were subsequently transferred to Denmark and after an additional 4-6 weeks of recovery in greenhouse, quality was rated again. In the first experiment, 5 species were tested; in the second experiment, 3 species were tested.

In the **first experiment** plants (5 species) were stored at 8, 12 and 15°C at high humidity. Plants were also exposed to different controlled atmosphere conditions in special plant chambers at 15°C. In addition, Ficus plants were exposed to different CA conditions under high and low humidity at 15°C in a flow-through system. The effects of STS, anti-botrytis treatments and 1-MCP were also investigated.

In the **second experiment** plants (3 species) were stored at 13, 15 and 17°C at high humidity and at 15°C at low humidity and the effect of pre-storage watering and sleeving was investigated. In addition, the effect of a pre-storage fungicide treatment was tested within this set-up. Using plant chambers, the effect of CA conditions and STS and hormone treatments was investigated in Zamioculcas.

4 Results first experiment

The first experiment was carried out with 5 species (Ficus, Zamioculcas, Hoya, Carmona, Dracaena). The combined results of quality ratings immediately following storage by AFSG and the rating following recovery period in the greenhouse by Feldborg are presented in **attachment 1**. Summary of main conclusions is given below:

- Ficus: should be transported at 12°C or 15°C; CA conditions at 15°C were not beneficial; MCP, STS and anti-botrytis treatments were not beneficial. Plants treated in 70L stainless steel flow through containers with CA conditions were of best quality, irrespective the CA condition. Maybe the removal of "volatiles" or the high humidity with low air flow in this system caused the beneficial effect.
- Zamioculcas: Optimal temperature may be >15°C; STS was slightly beneficial at 15°C; Anti-botrytis and MCP treatments were not beneficial; CA conditions in static system were slightly beneficial.
- Hoya: Hoya can be transported at 8°C, maybe lower; CA conditions were damaging; no clear results from other treatments; maybe beneficial effect of STS.
- Dracaena: optimal temp may be > 15°C; no clear effects of all other treatments.
- Carmona: Can be stored at 12°C or 15°C; there were no treatments that increased quality compared to 15°C control.

Results of first experiment were discussed in a project meeting February 9, 2007.

Based on the discussion, the second experiment was planned.

5 Results second experiment

The second experiment was performed with 3 species (Ficus, Zamioculcas, Hoya). The selection of these species is motivated by the following considerations:

1. Zamioculcas: most difficult species with most post transport problems. Already small improvements are commercially attractive to Feldborg.
2. Ficus: worldwide biggest species in potted plants (meeting Maersk interests most)
3. Hoya: example of a CAM plant species. Is a representative for a specific group of plants.

The results of quality ratings immediately following storage by AFSG and the ratings following recovery period in the greenhouse by Feldborg are presented in **attachment 2**. Summary of main conclusions is given below:

- Optimal storage temperature for **Hoya** was 13°C when judged immediately after storage. At 13°C, plants from all treatments (dry pot, well watered pot, pre-storage fungicide) were of good quality. Following recovery, plants stored at 13 and 15°C were of equal quality.
- Optimal storage temperature of **Ficus** was 13-15°C when judged immediately after storage. At 13-15°C, plants from all treatments (dry pot, well watered pot, pre-storage fungicide) were of good quality with only minor leaf drop. Following recovery, this view was confirmed.
- Optimal storage temperature of **Zamioculcas** was 15-17°C when judged immediately after storage. Following recovery, this view was confirmed.
- Under conditions of low humidity (75-80 versus 95-97 % RH) sleeving improved quality of Hoya and Ficus but did not affect quality of Zamioculcas. At high humidity it had no effect on quality of the three species.
- Storage at low humidity of non-sleeved plants is detrimental for plant quality
- If plants are stored at optimal temperature, pre-storage fungicide treatment did not effect plant quality.
- Pre-storage watering did not affect quality of Hoya and Ficus but was slightly negative for quality of Zamioculcas.
- Immediately after CA storage, Zamioculcas plants stored under low O2 were of slightly better quality than plants stored under normal air; pre-storage BA or STS treatment seemed slightly positive whereas the combination of BA and GA did not positively affect quality. Following recovery, no beneficial effects of neither CA conditions nor hormone treatments were observed.

6 Overall conclusion

It can be concluded from the two experiments that suitable transport temperatures are 13-15°C for Hoya, Ficus and Carmona; 15-17 for Zamioculcas and Dracaena. Transport should take place under humid conditions and plants should not be watered immediately prior to transport. At optimal storage temperature and high humidity, treatments with plant hormones, fungicides, sleeving and CA conditions *did not* improve final plant quality.
A further improvement of storage outcome may be achieved by either selection, breeding or cultivation of plants with higher intrinsic resistance to long term dark storage. In the case of cultivation measures, a pre-storage adaptation period at lower light intensities and at storage temperatures (acclimatization) may increase the plants performance during the shipments. Alternatively, application of light intensities at or above the CO2-compensation point during transport may limit quality loss during shipment and may shorten recovery time after transport. In the latter case, special attention should be given to spectral properties of the light source, that presumably should be low in blue components and relatively rich in red components.

Attachment 1. Results first experiment

5 species (Ficus microcarpa, Zamioculcas, Hoya compacta, Carmona, Dracaena marginata)
4 plants per treatment for Ficus and 5 plants for the other species, stored at 8, 12 and 15°C and 95-97 RH
Start of storage 19-10-2006, end of storage 23-11-2006, final evaluation 9 -1-2007 at Feldborg.

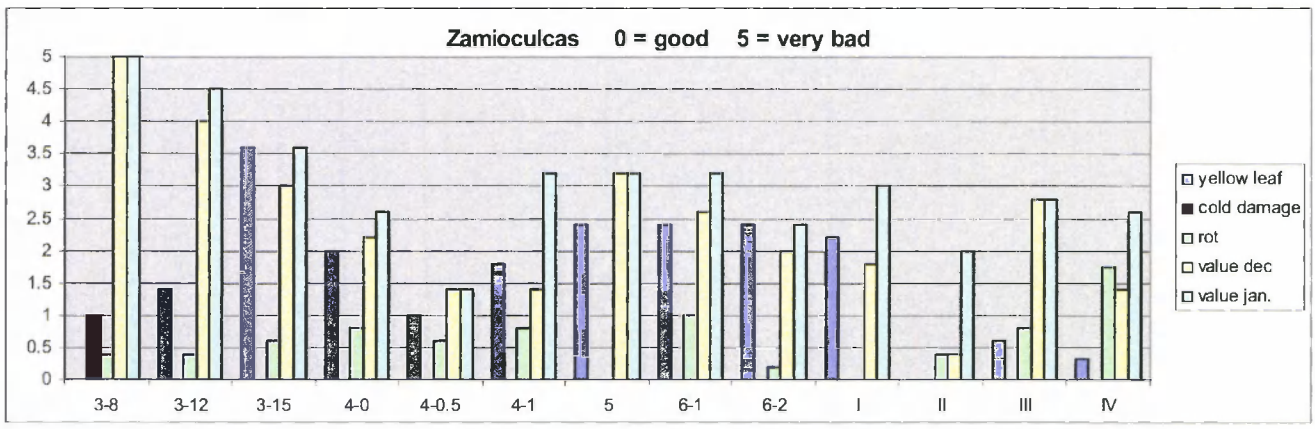
Table with treatments

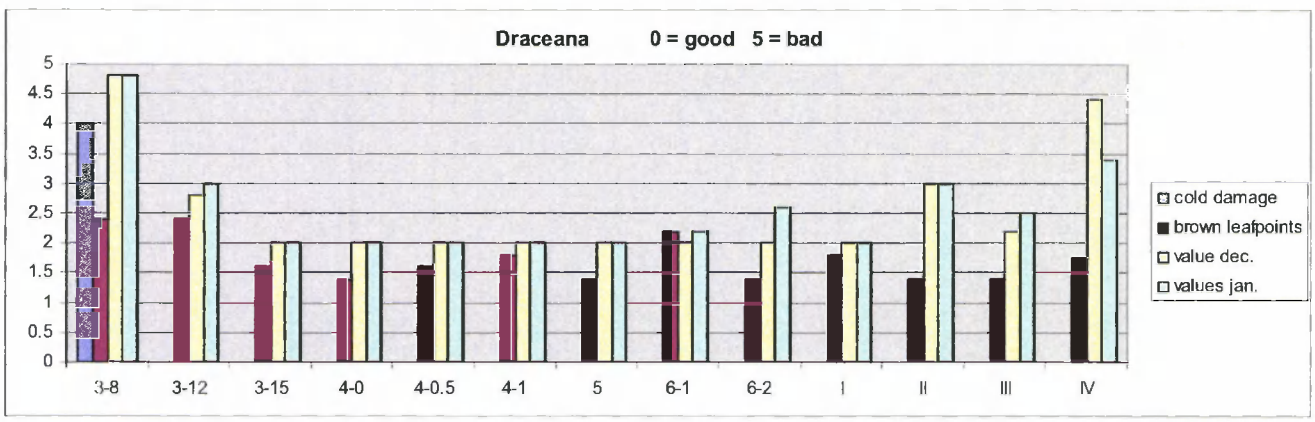
1	**AFSG control**		
2	**reference Feldborg**		
3-8	**3-8**	**8 °C**	
3-12	**3-12**	**12 °C**	
3-15	**3-15**	**15 °C**	
4-0	**4-0**	**STS dose 0**	
4-0.5	**4-0.5**	**STS dose 1**	
4-1	**4-1**	**STS dose 2**	
5	**5**	**anti-botrytis**	
6-1	**6-1**	**A&F dose 1**	Anti botrytis
6-2	**6-2**	**A&F dose 2**	Anti botrytis
I	**Cont 10**	**21%O2 - 0 %CO2**	
II	**Cont 13**	**2 %O2 - 0 %CO2**	
III	**Cont 11**	**2 %O2 - 5 %CO2**	
IV	**Cont 9**	**MCP**	
9-14		**2 %O2 - 0 %CO2, ± 92% humidity**	
9-15		**2 %O2 - 5 %CO2, ± 92% humidity**	
9-16		**21 %O2 - 0 %CO2, ± 92% humidity**	
9-17		**2 %O2 - 0 %CO2, > 97% humidity**	
9-19		**21 %O2 - 0 %CO2, >97% humidity**	
9-21		**2 %O2 - 5 %CO2, >97% humidity**	
10-22		**MCP, >97% humidity, low air refreshment**	

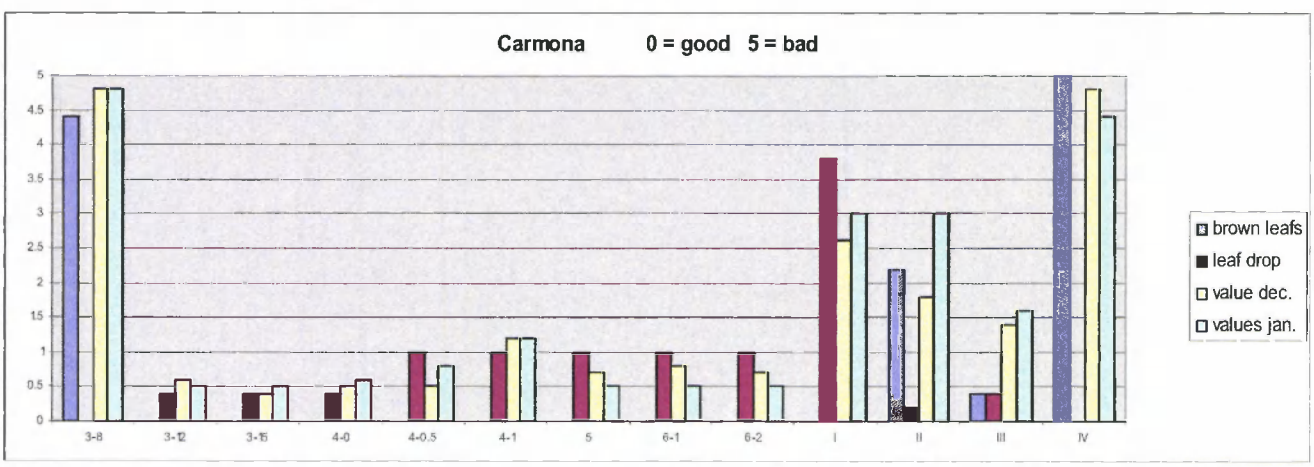
All additional treatments were done at 15°C.

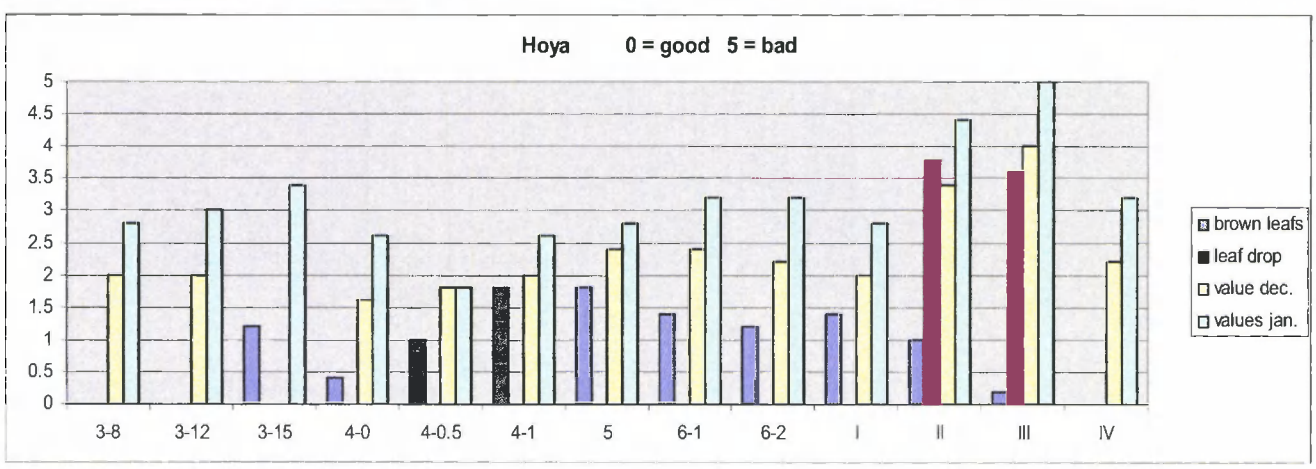
value end November = immediately following storage
value January = following recovery period

With Ficus an extra experiment was done under CA conditions in a flow through system (9-14 to 10-22)


Zamioculcas 0 = good 5 = very bad
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
3-8
3-12
3-15
4-0
4-0.5
4-1
5
6-1
6-2
I
II
III
IV
yellow leaf
cold damage
rot
value dec
value jan.


Draceana 0 = good 5 = bad
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
3-8
3-12
3-15
4-0
4-0.5
4-1
5
6-1
6-2
I
II
III
IV
cold damage
brown leafpoints
value dec.
values jan.


Carmona 0 = good 5 = bad
brown leafs
leaf drop
value dec.
values jan.


Hoya 0 = good 5 = bad
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
3-8
3-12
3-15
4-0
4-0.5
4-1
5
6-1
6-2
I
II
III
IV
brown leafs
leaf drop
value dec.
values jan.

Attachment 2. Results second experiment

3 species (Ficus microcarpa, Zamioculcas, Hoya compacta)

15 plants per treatment, stored at 13, 15 and 17°C and 95-97 RH

DU: dry unsleeved (plants were not watered prior to storage)

WU: wet unsleeved (plants were watered at A&F prior to storage)

F: fungicide treatment (1 week pre-storage by Feldborg) unsleeved (plants were not watered)

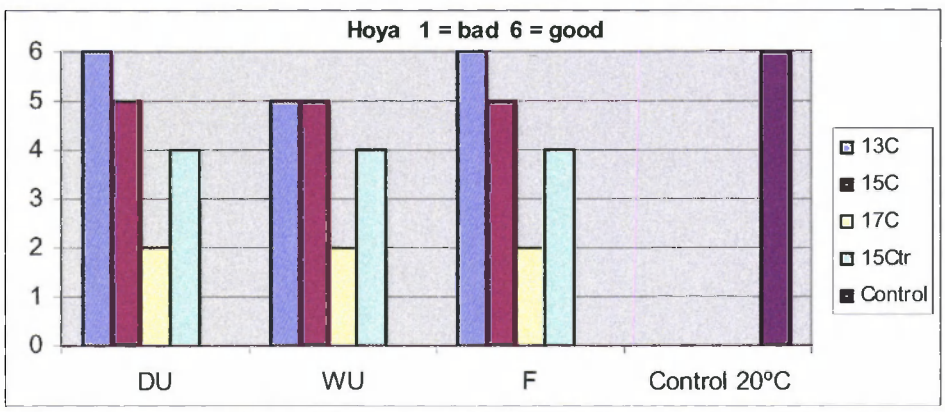
15Ctr: 15°C storage but with lower humidity (75-80 RH)

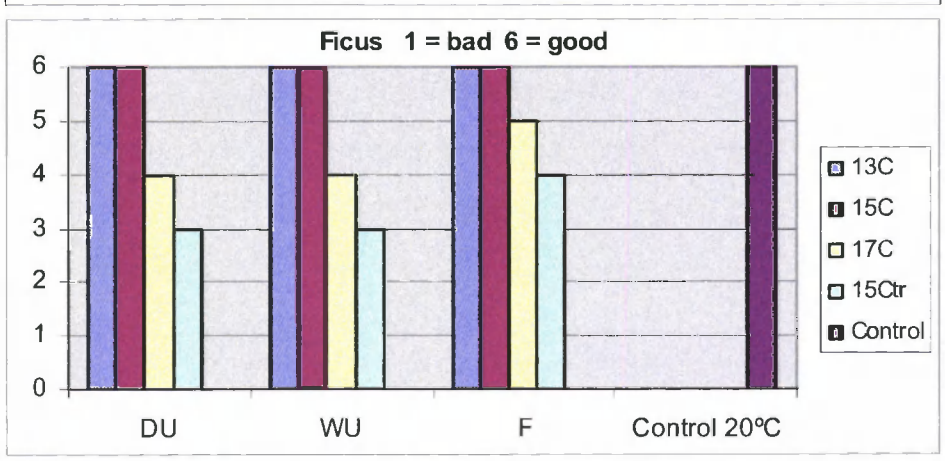
Control plants were not stored but kept at 20°C in light

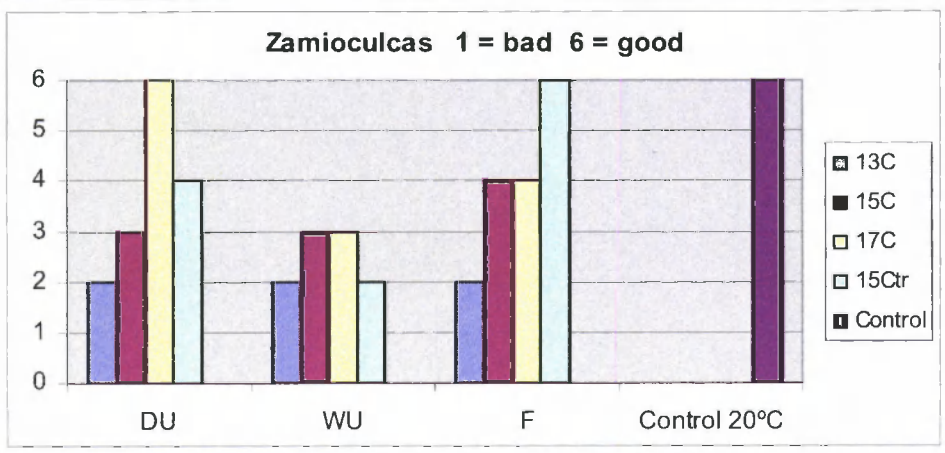
Sleeved plants (sleeves supplied by feldborg)were not rated immediately after storage as we did not unpack them.

Storage from 28-3-2007 till 7-5-2007, quality rating at the 7th of May and the 6th of July.

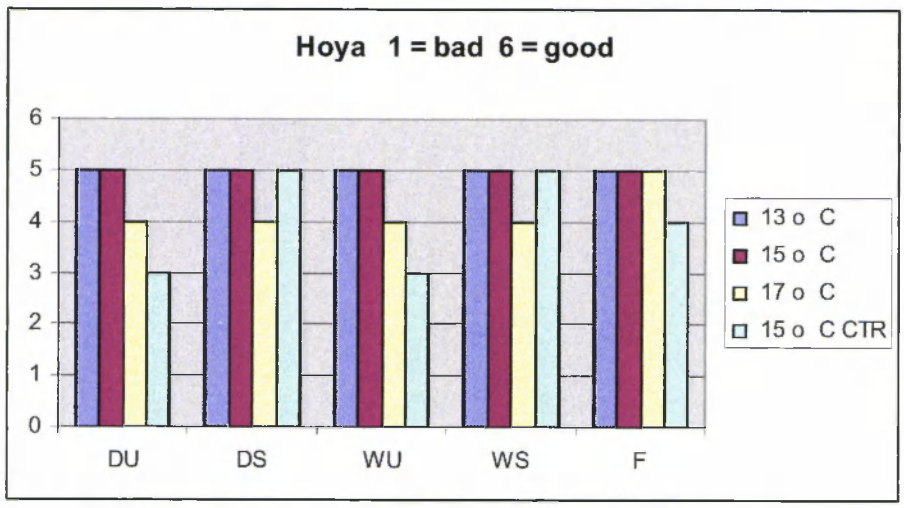
A. Quality ratings immediately following storage.

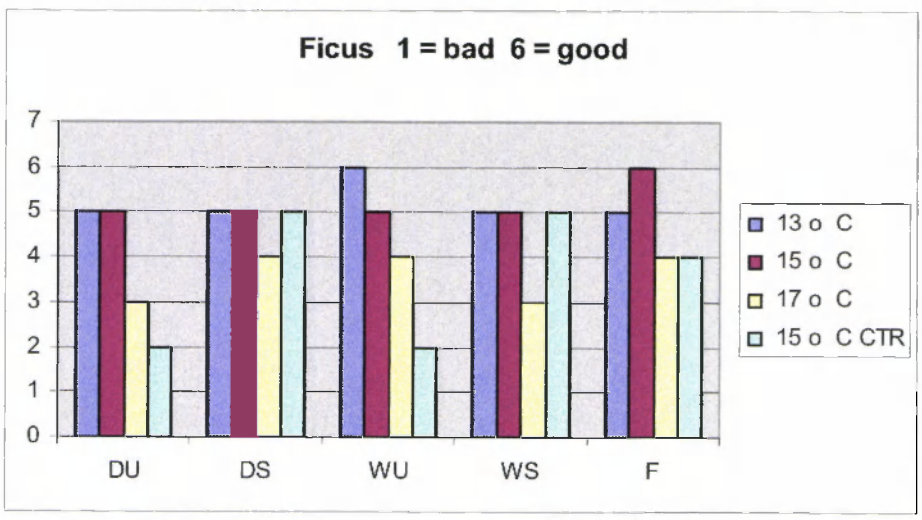


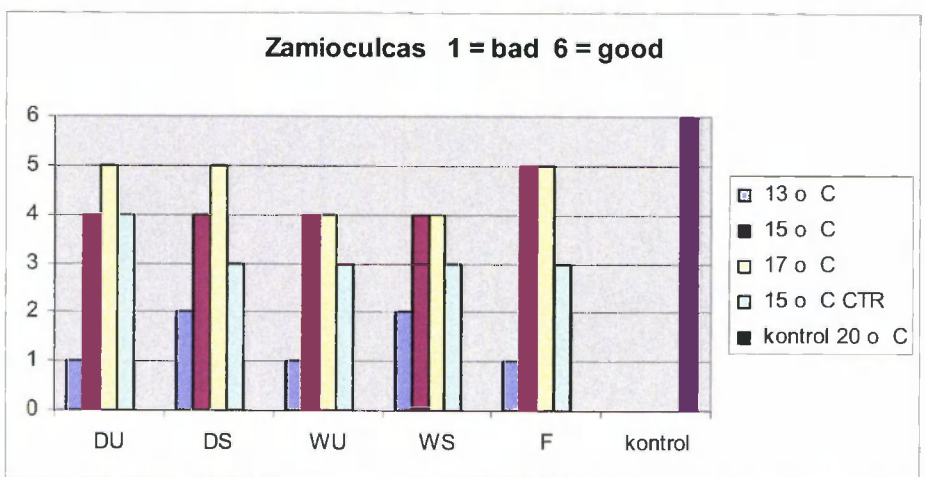




B. Quality ratings after recovery





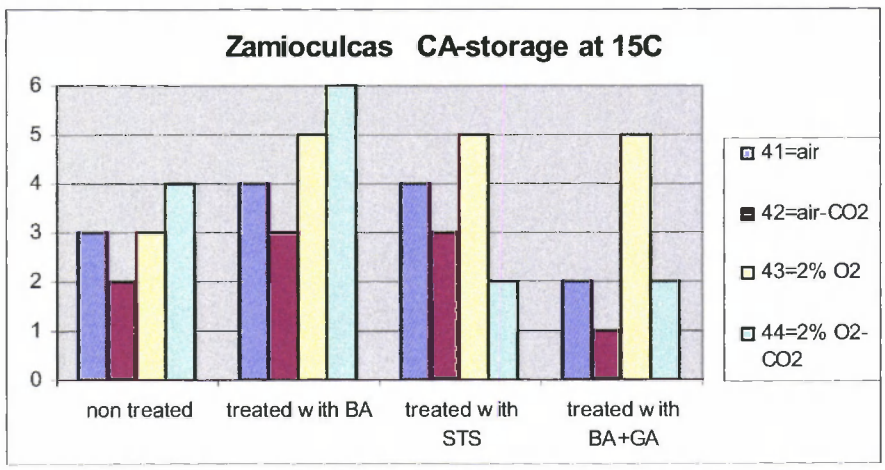


Results Zamioculcas in CA storage.

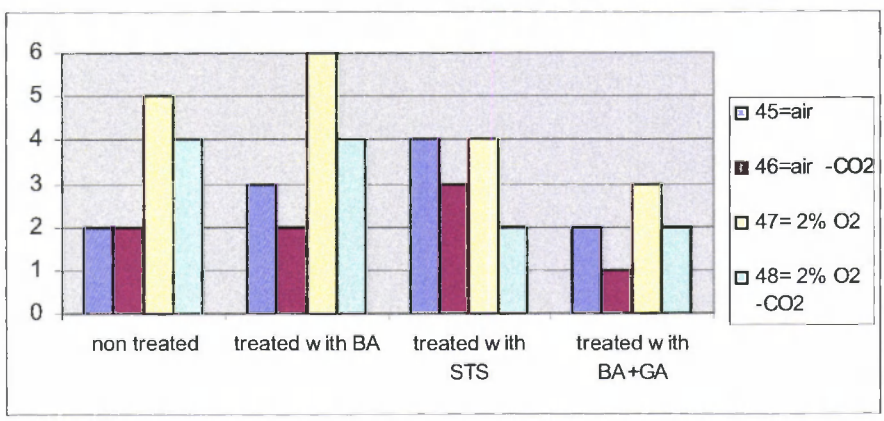
Each CA condition was done in two separate plant containers, so 8 containers in one climate room. Conditions were: Air (20% O2 with trace CO2); Air without CO2; 2% O2 with trace CO2; 2% O2 without CO2. Hormone treatments were done by spraying plants till run-off with 0.05 mM STS, 0.1 mM Benzyl adenine (BA) or a combination of 0.1 mM BA and 0.1 mM gibberellic acid (GA) prior to storage. 12 plants of each treatment per container.

A. Quality ratings immediately following storage.

Batch 1

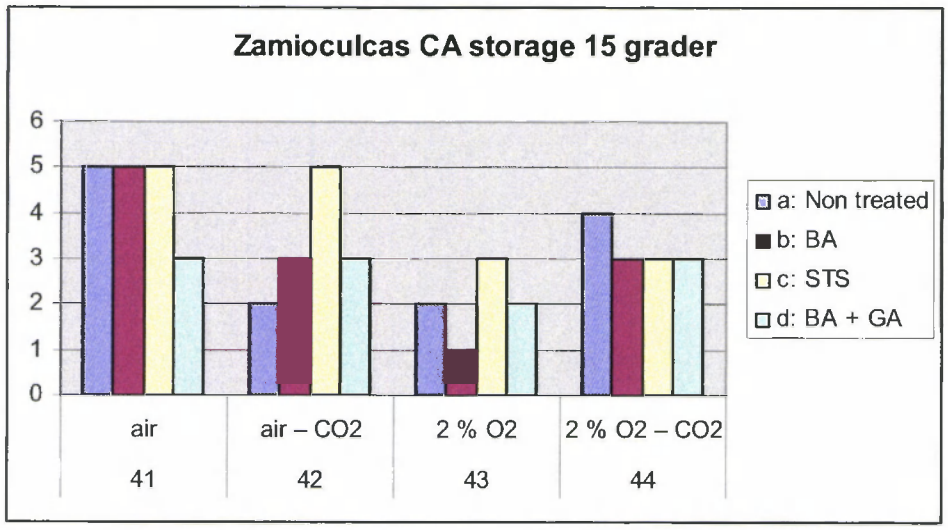


Batch 2



B. Quality ratings after recovery

Batch 1



Batch 2