RESEARCH REPORT

HORTICULTURAL DEVELOPMENT COUNCIL

WORKING FOR GROWERS

PC 6

The effect of high humidity on
the growth and development of Poinsettia
Annual Report - Year 2 1998-89

HORTICULTURAL DEVELOPMENT COUNCIL
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Introduction The problems of high humidity faced by Poinsettia growers have increased in recent years with the advent of energy saving techniques such as plastic claddings and thermal screens. Energy saving techniques restrict the exchange of air inside with the air outside the glasshouse, and increase the surface temperature of the inner lining. These changes lead to an increase in humidity which affects important plant processes such as transpiration.

This investigation, funded by the the Horticultural Development Council, will look at the effect of constant high humidity and constant low humidity on the growth and development and quality of Poinsettias in controlled environment cabinets. The work will also assess the effect of a drastic change in humidity by transferring plants from one constant humidity to another.

1.0 Materials and methods Cuttings of Poinsettia (*Euphorbia pulcherrima*. Willd, cv.Annette Hegg Diva) were taken from stock plants grown on the nursery and stuck directly into Jiffy 7's. Once the cuttings had been rooted on a mist bench they were potted one per 13cm plastic pot containing a standard 2:1 peat and grit compost with AA-terra added. Seventy pots were then randomly selected for each of the four Saxcil growth cabinets used in the experiment to provide the constant environmental conditions required.

The four cabinets were divided into two pairs. In the first pair of cabinets plants were grown at constant high humidity (0.1kPa vpd, 96% rh) in one cabinet and at constant low humidity (0.8kPa vpd, 62% rh) in the other cabinet throughout the experiment. The second pair of cabinets was a replicate of the first pair. During the vegetative phase the plants were lit from above by 'warm white' fluorescent tubes at an irradiance of $40Wm^2$ PAR for twelve hours from 10.00–22.00hrs. The twelve hour night was interrupted by a four hour night break (6x30W tungsten lamps) between 02.00–06.00hrs to give a total of sixteen hours of day light. Temperature was maintained at 18°C day and night. It was found unnecessary to use any growth retardants.

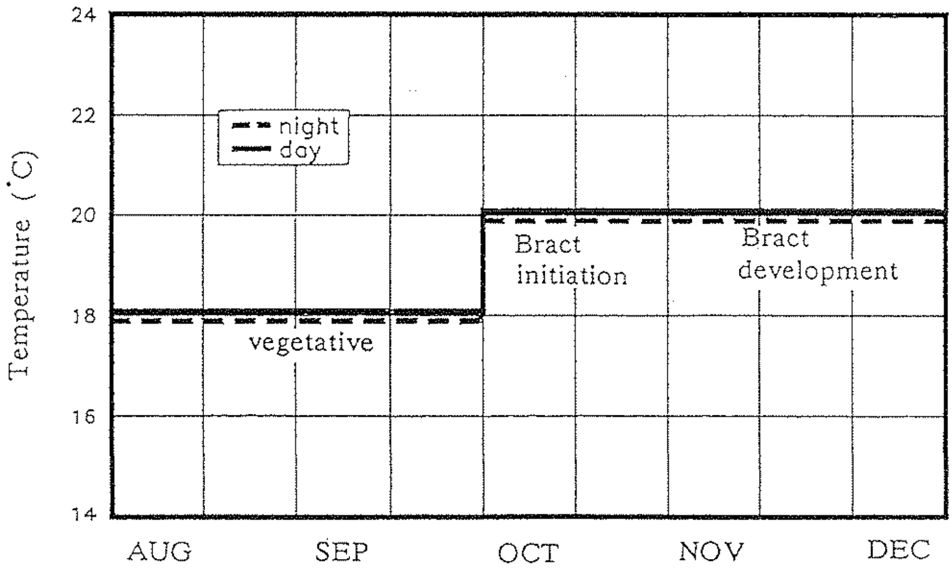
Poinsettias are short day plants which require nights longer than twelve hours in order to initiate 'flowers'. During the bract initiation phase the irradiance was kept the same but day length was shortened to eight hours from 10.00–16.00hrs with no night break. To stimulate initiation the temperature was increased to 20°C day and night.

During the bract development phase day temperature would normally be increased to 24°C and night temperature dropped to 16°C to promote the growth of large bracts. However, due to technical limitations in maintaining constant humidities in the cabinets, temperature at bract development was kept at 20°C day and night.

The plants were watered individually by hand to keep each pot moist but avoiding saturation. At each watering the plants were fed with a nutrient soloution (200 N: 50 P :200 K). Samples of compost were analysed regularly and the feed adjusted to compensate for any nutrient deficiency.

Each cabinet was enriched with CO_2 (1000 vpm) during the day time throughout the experiment.

2.1 Development schedule



Date	Event
15.06.88	600 cuttings taken
04.07.88	400 rooted cuttings potted up
01.08.88	280 plants into cabinets; initial sample
08.08.88	Plants pinched to seven leaves
05.09.88	First transfer, vegetative phase
05.10.88	Second sample, end vegetative and begin reproductive phase
01.12.88	Second transfer, reproductive phase
15.12.88	Final sample, end reproductive phase

3.0 Growth and development (Results)

3.1 Vegetative phase During the vegetative phase plants at high humidity grew at more than double the rate of those at low humidity. By the end of the vegetative phase all the plants had produced approximately seven side-shoots greater than 10mm. The side-shoots on plants at high humidity were on average 64% longer and the dry weights were 63% heavier than at low humidity.

At high humidity leaf area was on average 44% greater, and leaf dry weights were 35% heavier. This suggests there was a greater number of leaves on the longer side-shoots developed at high humidity, and that these leaves were larger and than those at low humidity.

At the end of the vegetative phase the plants at high humidity were over twice the size of plants at low humidity.

Table of mean values for initial sample, before pinching (n=6)

High humidity(0.1kPa vpd)

Variate	Rep1	Rep2	All
Leaf number	9.00	9.29	9.14
Leaf area (cm2)	173.86	229.71	201.79
Leaf fresh weight (g)	3.64	5.01	4.33
Leaf dry weight (g)	0.76	1.09	0.93
Stem length (mm)	89.29	90.71	90.00
Stem fresh weight (g)	1.79	2.07	1.93
Stem dry weight (g)	0.33	0.46	0.39

Low humidity(0.8kPa vpd)

Variate	Rep1	Rep2	All
Leaf number	8.00	8.86	8.55
Leaf area (cm2)	193.75	192.14	192.73
Leaf fresh weight (g)	3.98	4.23	4.14
Leaf dry weight (g)	0.87	0.97	0.94
Stem length (mm)	93.75	89.29	90.91
Stem fresh weight (g)	1.80	1.94	1.89
Stem dry weight (g)	0.36	0.42	0.40

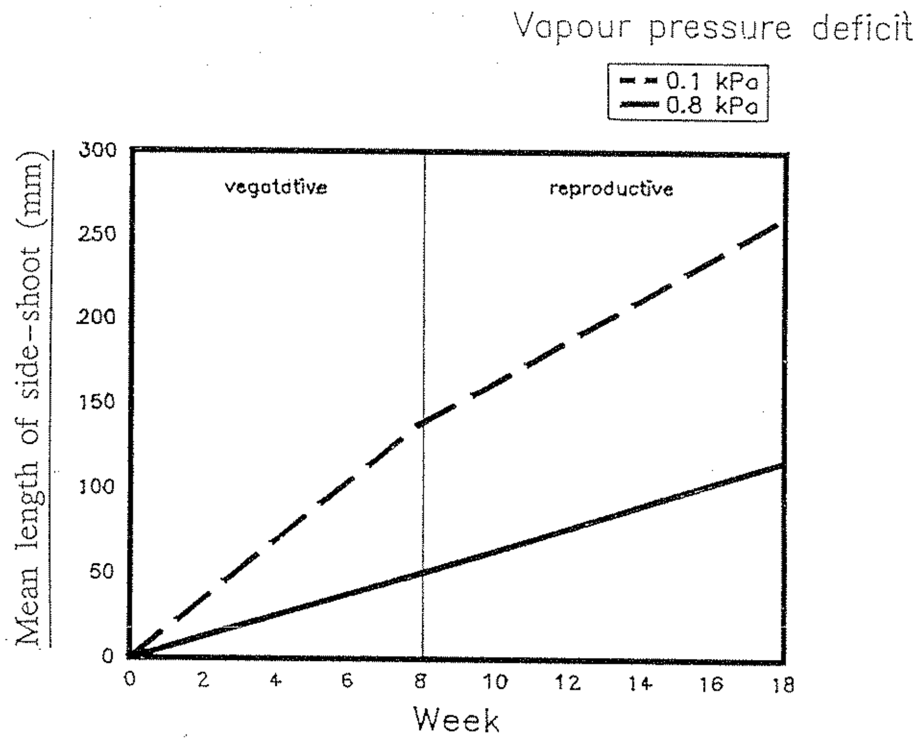
Table of mean values for end of vegetative phase (n=6)

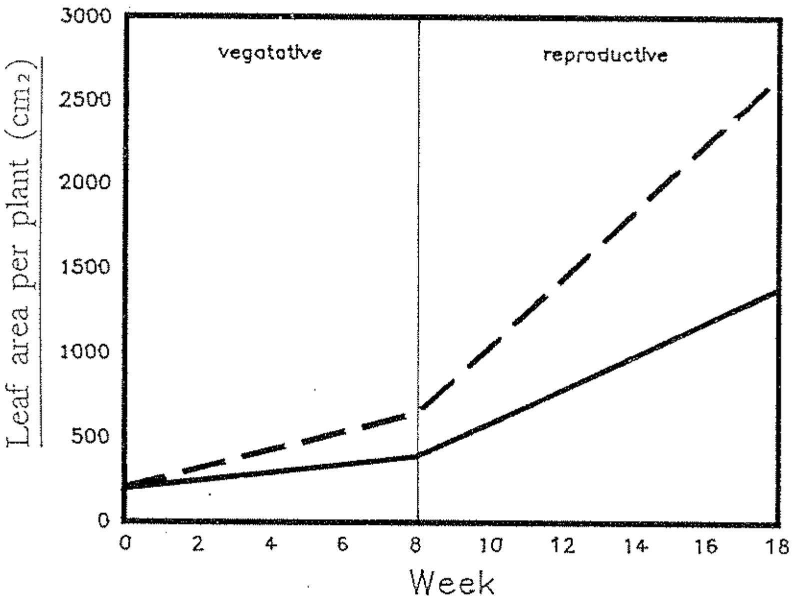
High humidity(0.1kPa vpd)

variate	Rep1	Rep2	All
Leaf area (cm2)	686.40	699.60	693.00
leaf fresh weight (g)	29.02	28.20	28.61
leaf dry weight (g)	4.90	4.59	4.75
length side-shoot(mm)	138.96	138.24	138.60
fresh wt side-shoot(g)	6.60	7.00	6.80
dry wt side-shoot(g)	1.40	1.45	1.42

Low humidity(0.8kPa vpd)

variate	Rep1	Rep2	All
Leaf area (cm2)	457.60	322.80	390.20
leaf fresh weight (g)	20.71	14.38	17.55
leaf dry weight (g)	3.61	2.60	3.10
length side-shoot(mm)	59.88	40.98	50.43
fresh wt side-shoot(g)	6.20	7.00	6.60
dry wt side-shoot(g)	0.67	0.40	0.54





The effect of humidity on the vegetative growth of poinsettia

3.2 Reproductive phase After the vegetative phase the plants were given short days to initiate 'flowers'. During this phase the plants at high humidity continued to grow at a faster rate than those at low humidity. The results are described in terms of mean values for an average side-shoot (terminating with a 'flower'), and for the plant as a whole.

At high humidity the growth of side-shoots decreased slightly from the vegetative phase, but the average side-shoot still finished 55% longer than at low humidity. The dry weights of the side-shoots at high humidity were 70% heavier, suggesting the side-shoots were not only longer but were thicker and possibly more 'woody'.

Leaf area of the average side-shoot at high humidity was 39% greater, with leaf dry weights 43% heavier than at low humidity. These differences may be accounted for by plants having larger leaves, and producing on average three more leaves per side-shoot at high humidity. At high humidity an average plant as a whole had a leaf area which was 43% greater, and a leaf dry weight which was 52% heavier than at low humidity. This is mainly due to an average plant at high humidity producing twenty-one more leaves (ie. 3 more leaves per side-shoot x 7 side-shoots).

In short days the plants produced 'flowers' composed of cyathia (flower parts) arranged on red bracts (modified leaves). The average 'flower' at high humidity had a bract area which was 22% greater, with bract dry weights which were 12% heavier than at low humidity. These differences are partly due larger bracts, but also there was on average three more bracts per 'flower' at high humidity.

An average plant at high humidity had a total bract area that was 44% greater, with a total bract weight that was 26% heavier than those at low humidity. The differences in bract area over the whole plant can be explained by plants having larger bracts, and by producing on average thirty-eight more bracts at high humidity. The large increase in the total number of bracts at high humidity is due to plants producing on average one extra 'flower', and because there were more bracts per 'flower'.

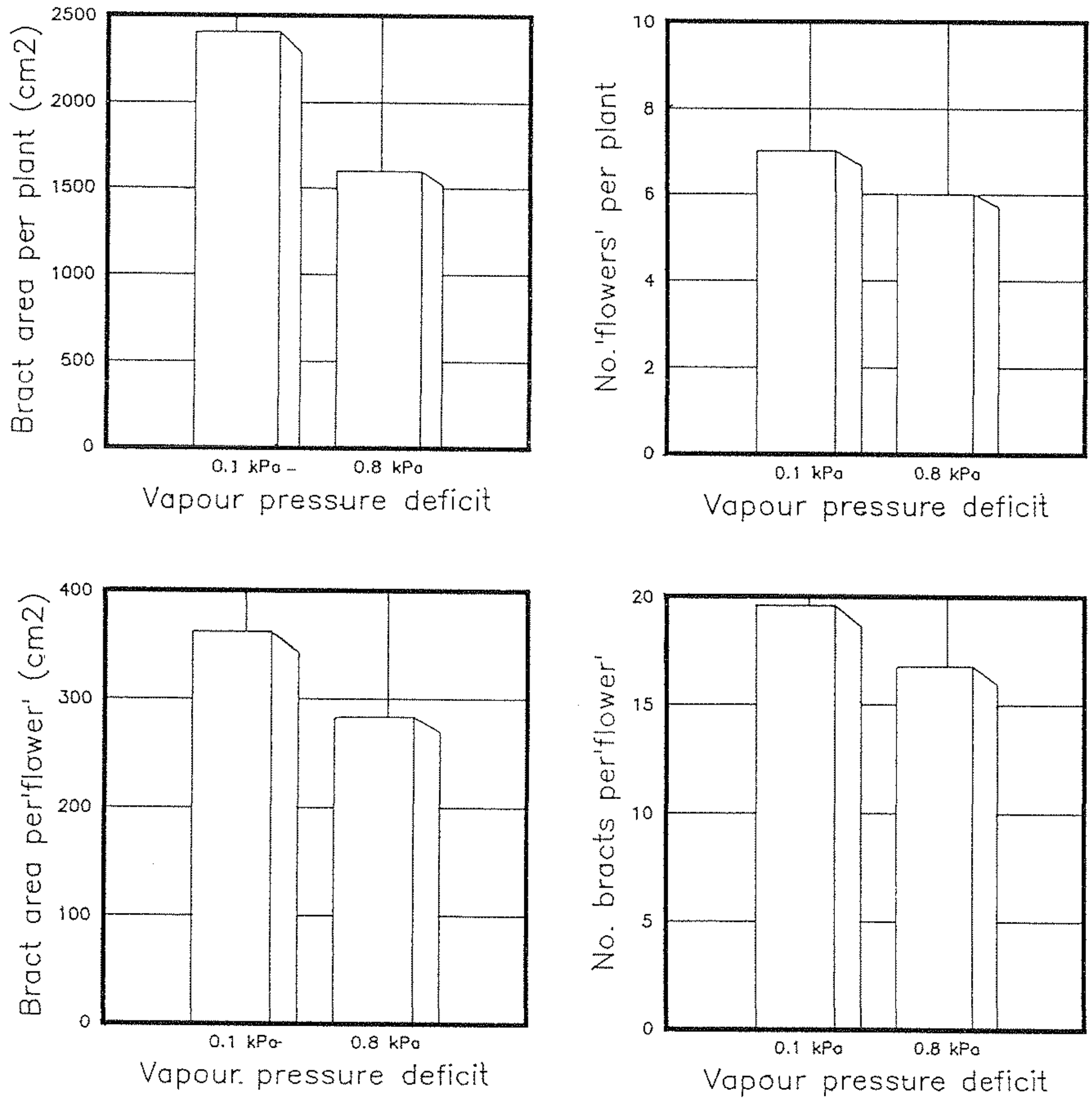
Table of mean values for an average side-shoot (n=6)

High humidity(0.1kPa vpd)

Variate	Rep1	Rep2	All
Leaf number	11.27	10.29	10.79
Leaf area (cm2)	388.51	405.27	396.89
Leaf fresh weight (g)	8.18	7.99	8.08
Leaf dry weight (g)	1.39	1.37	1.38
Bract number	19.29	19.96	19.62
Bract area (cm2)	366.21	358.68	362.45
Bract fresh weight (g)	7.02	6.69	6.86
Bract dry weight (g)	0.87	0.85	0.85
Length side-shoot(mm)	255.93	266.55	261.24
Fresh wt side-shoot (g)	7.01	7.51	7.26
Dry wt side-shoot (g)	1.54	1.68	1.61

Low humidity(0.8kPa vpd)

Variate	Rep1	Rep2	All
Leaf number	9.03	8.47	8.75
Leaf area (cm2)	255.88	231.87	243.87
Leaf fresh weight (g)	5.53	4.87	5.12
Leaf dry weight (g)	0.79	0.79	0.79
Bract number	17.54	16.06	16.80
Bract area (cm2)	283.81	284.97	284.39
Bract fresh weight (g)	5.80	5.69	5.75
Bract dry weight (g)	0.75	0.75	0.75
Length side-shoot(mm)	125.78	107.58	116.68
Fresh wt side-shoot (g)	2.92	2.47	2.70
Dry wt side-shoot (g)	0.52	0.45	0.49



The effect of humidity on 'flower' development of poinsettia

Table of mean values for an average plant (n=6)

High humidity(0.1kPa vpd)

Variate	Rep1	Rep2	All
Leaf number	76.50	68.67	72.58
Leaf area (cm2)	2605.30	2681.70	2643.50
Leaf fresh weight (g)	54.78	52.67	53.72
Leaf dry weight (g)	9.38	9.01	9.19
Bract number	130.67	132.83	131.75
Bract area (cm2)	2458.00	2356.30	2407.20
Bract fresh weight (g)	46.92	43.92	45.42
Bract dry weight (g)	5.80	5.59	5.69
Length side-shoot(mm)	1737.70	1767.70	1752.70
Fresh wt side-shoot (g)	46.97	49.60	48.29
Dry wt side-shoot (g)	10.31	11.09	10.70

Low humidity(0.8kPa vpd)

Variate	Rep1	Rep2	All
Leaf number	49.67	49.17	49.42
Leaf area (cm2)	1411.30	1352.70	1382.00
Leaf fresh weight (g)	30.36	28.19	29.27
Leaf dry weight (g)	4.31	4.58	4.45
Bract number	96.50	92.33	94.42
Bract area (cm2)	1557.00	1633.00	1595.00
Bract fresh weight (g)	31.86	32.70	32.28
Bract dry weight (g)	4.14	4.34	4.24
Length side-shoot (mm)	691.70	632.30	662.00
Fresh wt side-shoot (g)	15.98	14.31	15.15
Dry wt side-shoot (g)	2.86	2.63	2.74

3.3 Analysis of variance When the data for the final sample was statistically analysed it was shown there were significant differences between growth and development of plants at high humidity and those at low humidity.

Variate\F pr	Side-shoot	Sig	Plant	Sig
Leaf number	<0.001	***	<0.001	***
Leaf area	<0.001	***	<0.001	***
Leaf fresh weight	<0.001	***	<0.001	***
Leaf dry weight	<0.001	***	<0.001	***
Bract number	0.003	**	<0.001	***
Bract area	0.002	**	<0.001	***
Bract fresh weight	0.036	*	<0.001	***
Bract dry weight	0.098		<0.001	***
Length side-shoot	<0.001	***	<0.001	***
Fresh weight side-shoot	<0.001	***	<0.001	***
Dry weight side-shoot	<0.001	***	<0.001	***

Significance: *** very strong significant differences (F pr=<0.001)
** strong significant differences (F pr=<0.01)
* significant differences (F pr=<0.05)

4.0 Disorders The disorders known as 'crudding', 'rabbit tracks', 'stem blisters', and 'cyathia drop' were scored for the degree of incidence (0=absent, 1=present). Thus, the results show to what extent the disorder was present and not necessarily the severity of the disorder.

4.1 'Crudding' (plate 1) Under certain conditions tissues rupture and exude drops of latex. The latex hardens and forms a blackend 'crud' on the tissue surface. At high humidity this crud often becomes infected with *Botrytis cinerea*. Where crudding is noticable on the leaves and bracts it detracts from the plants attractiveness and ultimately reduces the plants saleable value.

At high and low humidity there was no incidence of crudding on leaves. The bracts ,which are modified leaves, were found to be much more delicate and more susceptible to tissue damage with latex exudation. At high humidity there was a considerably higher incidence of crudding on the bracts than at low humidity. During this experiment there was no incidence of crudding on cyathia.

4.2 'Rabbit tracks' (plate 2) Towards the end of the bract development phase small white/translucent patches were observed on bracts at high humidity. These patches occurred interveinally either side of the the mid rib to give the appearance of rabbit tracks down the long axis of the bract. No rabbit tracks were observed at low humidity.

4.3 'Stem blisters' (plate 3) At high humidity there was a high incidence of small blisters (approximately 5mm diameter) which occurred on the upper, less woody, half of the side-shoot. In extreme cases the stem blister would rupture and exude latex which hardend to give the appearance of crudding. Stem blisters occurred at low humidity but at a much lower incidence.

4.4 'Cyathia drop' (plate 4) So far the disorders described have been exacerbated by high humidity. At low humidity there was a high incidence of cyathia drop where the 'flower parts' shrivelled up and fell off. This occurred at much lower incidence at high humidity.

Table of mean values for disorders (n=6)

High humidity(0.1kPa vpd)

Disorder	Rep1	Rep2	All
crudding on leaves	0.0	0.0	0.0
crudding on bracts	3.8	4.5	4.2
rabbit tracks	8.2	12.8	10.5
crudding on cyathia	0.0	0.0	0.0
cyathia drop	0.5	0.2	0.4
stem blisters	8.3	4.5	6.4

Low humidity(0.8kPa vpd)

Disorder	Rep1	Rep2	All
crudding on leaves	0.0	0.0	0.0
crudding on bracts	0.5	0.3	0.4
rabbit tracks	0.0	0.0	0.0
crudding on cyathia	0.0	0.0	0.0
cyathia drop	3.5	4.0	3.8
stem blisters	0.3	1.3	0.8

Horticultural Development Council Progress Report

The effect of high humidity on the growth and development of Poinsettia (*Euphorbia pulcherrima*, Willd).

R.W. ASKEW, IHR-L

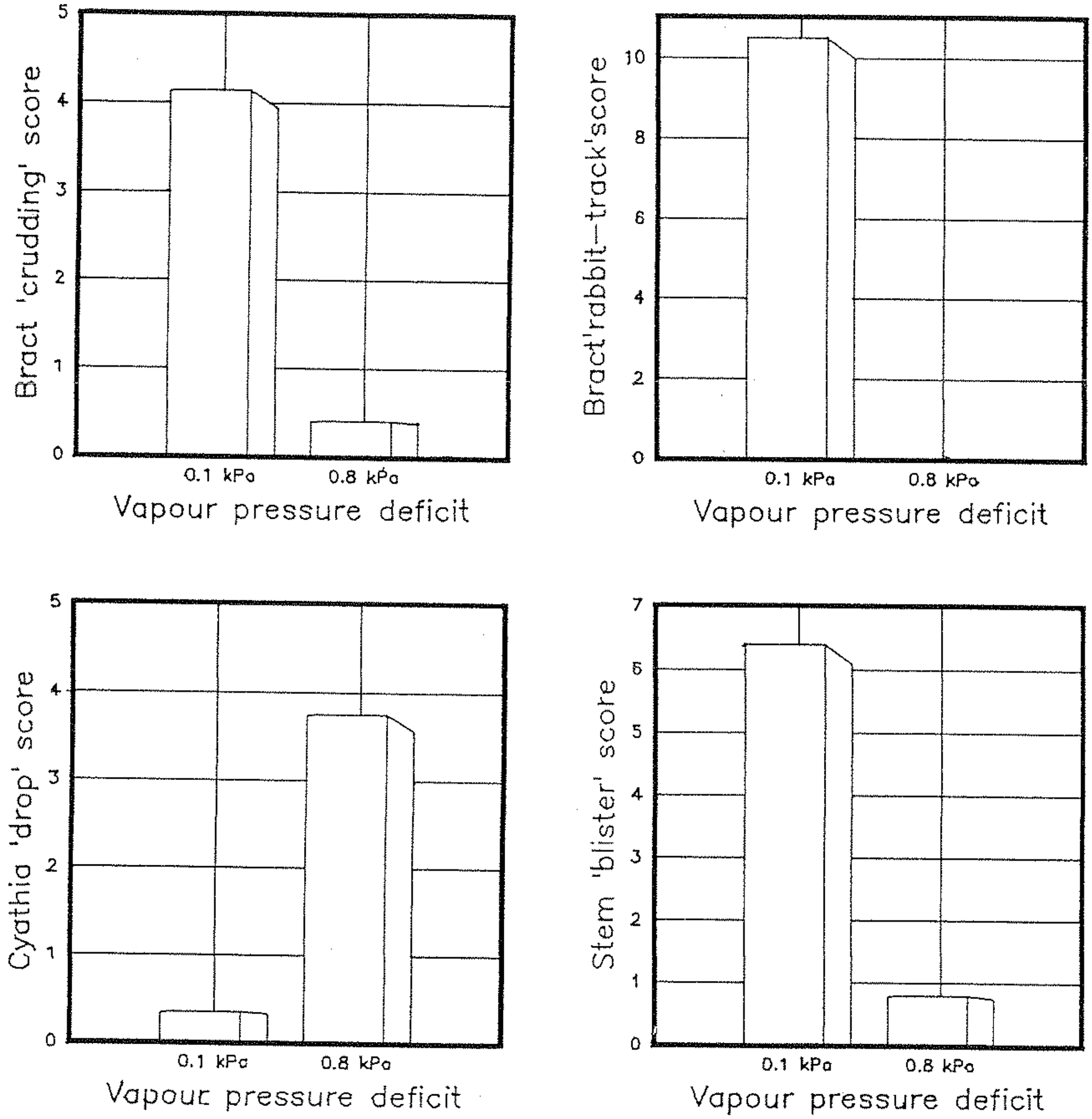
March, 1989

'Crudding' on bracts at high humidity (plate 1)

'Rabbit tracks' on bracts at high humidity (plate 2)

'Stem blisters' at high humidity (plate 3)

'Cyathia drop' on flowers at low humidity (plate 4)



The effect of humidity on the incidence of poinsettia disorders

Transfers Six plants from low humidity were transferred to high humidity , and *vice versa,* to assess the effect of a drastic change in humidity on the incidence of disorders. The plants were scored for disorders before and after the transfers as follows:

0= no incidence of disorder
1= low incidence of disorder on single side-shoot
2= low incidence of disorder on several side-shoots
3= high incidence of disorder on single side-shoot
4= high incidence of disorder on several side-shoots

During the vegetative phase plants were also assessed for the effect of a drastic change in humidity on the rate of water loss from the leaves (transpiration). This was achieved by encasing the pot in a plastic bag so that water could only evaporate from the leaves. The plants were accurately weighed and transferred at the start of the day, and then reweighed at the end of the day, and then again at the end of the night. The difference in weight at the end of the weighings was assumed to be water lost by transpiration. The results are based on a single twenty-four hour period.

5.1 Vegetative phase Plants were transferred early in the vegetative phase of development when no significant disorder symptoms were visible at high or low humidity. Over the first twenty-four hour period after the time of transfer there was no significant increase in the incidence of disorders in plants transferred from one humidity to another.

There was a considerable difference in weight loss between plants at high and low humidity. During the day plants at high humidity evaporated water from the leaves at rate which was 27% slower than at low humidity, whilst at night the rate was 42% slower.

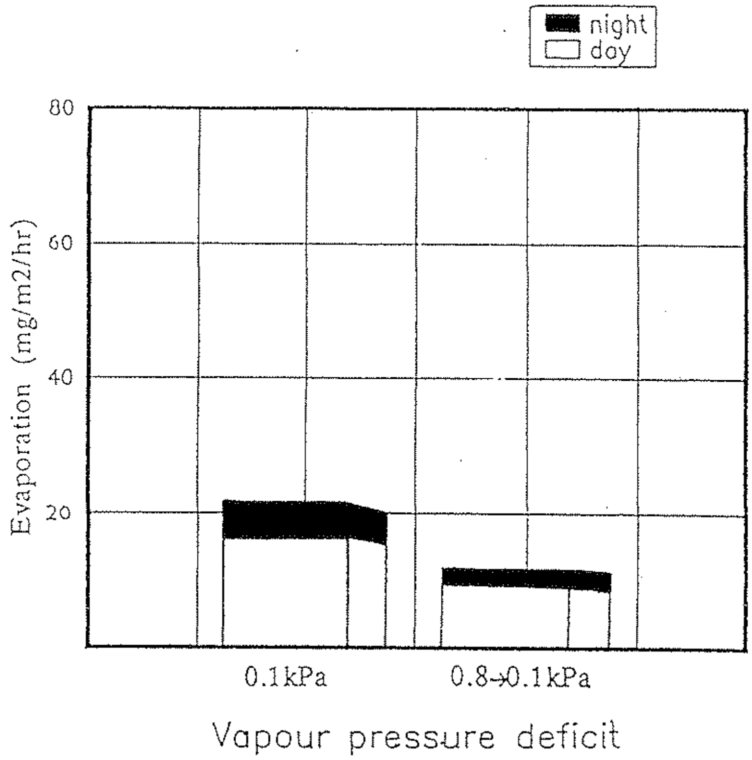
There was also a considerable difference in weight loss between plants maintained at a constant humidity and those transferred to a different humidity. Evaporation was increased more than three times by transferring plants from high humidity to low humidity compared with those maintained at high humidity, and was more than doubled compared with those kept entirely at low humidity for both day and night. When plants were transferred from low humidity to high humidity the rate of evaporation was decreased by 60% of those maintained at low humidity, and was 50% less than those kept entirely at high humidity for both day and night.

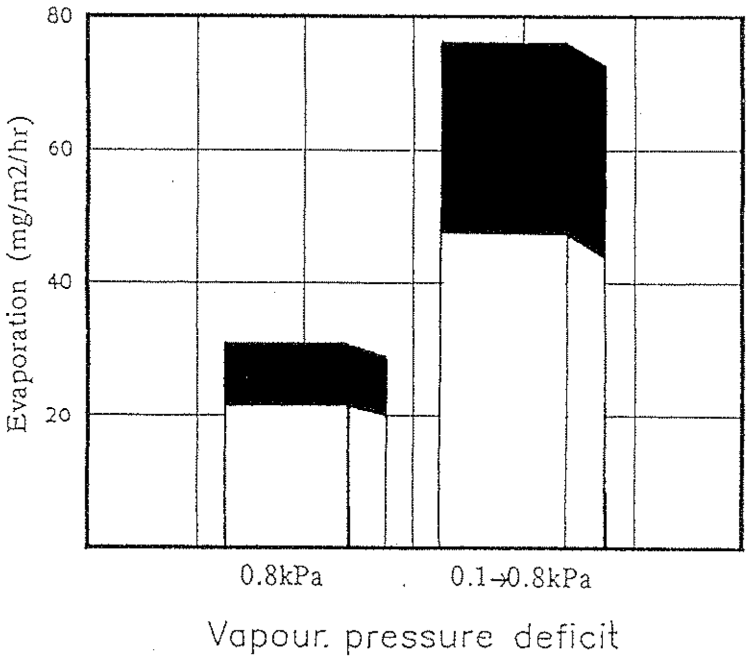
Table of mean evaporation rates over a twenty four hour period (mg/m2/hr)

Humidity(vpd)	Day	Night
0.1kPa	15.95	6.14
0.1→0.8kPa	47.64	30.46
0.8kPa	21.56	10.01
0.8→0.1kPa	9.07	2.28

Total evaporation from a Piche evaporimeter (ml)

vpd	0.1kPa	0.8kPa	0.1 : 0.8kPa
Day	4	21	0.19
Night	2	20	0.10
N:D	0.5	0.95	





The effect of humidity on the rates of evaporation from leaves of poinsettia over a twenty four hour period

5.2 Reproductive phase The second transfer of plants from one humidity to another was carried out when the bracts had fully developed. At this stage of development there were visible disorder symptoms on plants at high humidity, as described in the previous section, but these symptoms were unchanged by transferring plants from high humidity to low humidity.

There was a lower incidence of disorders at low humidity at the time of the transfer, but once transferred to high humidity there was an increase in the incidence of crudding on the bracts. New drops of latex exuded from the bracts over the first twenty-four hour period, but there was no significant increase in exudation after forty-eight hours from the time of transfer. There was no increase in any other type of disorder over the forty-eight hour period.

Table of mean bract score over a forty-eight hour period

Humidity(vpd)/hours after transfer	0	24	48
0.1→0.8kPa (rep 1)	2.3	2.3	2.3
0.1→0.8kPa (rep 2)	1.2	1.2	1.2
0.8→0.1kPa (rep 1)	1.0	1.8	2.3
0.8→0.1kPa (rep 2)	0.7	1.3	1.6

The effect of humidity on the growth and development of poinsettia

6.0 Discussion At high humidity bracts were susceptible to 'crudding', where cells at the bract surface ruptured and exuded drops of latex (1). It was shown how the rate of evaporation and transpiration was less at high humidity, and how under the controlled environment conditions the temperature of the compost equilibrated with the warm air temperature to give a high root temperature. In this situation it is evisaged that water would readily be taken up by the roots but would not be evaporated from the leaves at the same rate leading to an increase in root pressure. The bracts were found to be very delicate organs, and it is possible that an increase in root pressure may be the cause of cell rupture and latex exudation on the bract surface. The thicker cuticle on the surface of leaves (2) may exert a greater resistance to root pressure which could explain why there is a lower incidence of crudding on the leaves. A high root pressure may also be responsible for stem blisters which occur at a high incidence on a side-shoots at high humidity. The stem blisters were found on the upper, more green portion of the side-shoots, and were not observed towards the 'woody' base. It may be possible that cells swelled and ruptured in regions of the side-shoot which offered the least resistance to a high root pressure.

Poinsettias were found to be susceptible to *Botrytis*, particularly on the bracts during the latter stages of bract development. The bracts rapidly became infected when they became wet; at high humidity this could be more of a problem at night as heat radiating from the bracts could cool them in relation to the warm, humid air and cause condensation to form on the bract surface. Added problems may occur with high day and low night temperatures which have been recommended for optimum growth of the inflorescence (3). The reduction of night temperatures in a humid environment could cause condensation to form on the bracts, or to form on the inside of the greenhouse, or surface of a thermal screen for example, causing drops of water to fall onto the bracts. The exudation of latex at high humidity was also found to promote *Botrytis* infection. At high humidity *Botrytis* spread rapidly, and if left unchecked could devastate a crop.

Bracts at high humidity exhibited small white/translucent patches (approximately 5-10mm diameter) known as 'rabbit tracks'. In Germany this disorder, which is known as 'geisterfleken' , is thought to be caused by a deficiency of carbohydrate in the bracts due to rapid growth and maturity. The German workers suggest 'rabbit tracks' could be avoided by optimizing bract growth and carbohydrate store with high day ($\geq$24°C) and low night (<16°C) temperatures, and by reducing nitrogen fertilization (4). Due to technical limitations in maintaining constant humidities in the growth cabinets the day and night temperatures were kept the same at 20°C throughout bract development. The plants were also fed with nitrogen throughout bract development. It is possible that 'rabbit tracks' occurred on larger, more mature bracts at high humidity due to carbohydrate depletion as a result of high night temperatures and high nitrogen fertilization, and that 'rabbit tracks' did not occur at low humidity because the bracts were smaller and less mature, and had not suffered carbohydrate depletion at the time of observation.

The restriction of growth and development at low humidity may be due to two factors:

* drought-stress
* high fertilizer levels

Before the the advent of growth regulants drought-stress was often used commercially to control the height of poinsettias (8). Gilbertz *et al.* have since shown that drought-stress not only reduces the height of poinsettias, but reduces organ size, and promotes organ abscission (5). In this present investigation it has been shown how the rate of evaporation and transpiration at low humidity was far greater than at high humidity. Consequently, at low humidity the compost became a lot drier between watering compared with high humidity, which remained moist continually and where over-watering was a danger. Gilbertz *et al.* concluded that there was a narrow range between well watered conditions and stress levels which cause a reduction of crop quality. The high rates of evaporation and transpiraton, and reduction of growth at low humidity concur with the findings of Gilbertz *et al.* and suggest that the plants may have suffered some drought-stress.

At each watering plants at high and low humidity were fed with a nutrient solution. It is possible that evaporation from the pot could cause a build-up of salts in the compost. The high rates of evaporation and more frequent feeding led to higher nutrient levels in the compost at low humidity (see appendix). Nell and Barrett investigating bract necrosis in poinsettia grew plants at different fertilizer levels. They found the highest fertilizer levels produced the shortest plants, and concluded that short plants with a small bract diameter at the high fertilizer levels may have been caused by high salt levels in the growing medium (6). This would suggest that high fertilizer levels could have also restricted plant growth at low humidity.

At low humidity there was a high incidence of 'cyathia drop', where the flower parts shrivelled up and fell off. In much the same way as for 'rabbit tracks', German workers have attributed 'cyathia drop' to a depletion of carbohydrates, and indeed have found that 'rabbit tracks' and 'cyathia drop' are often associated with one another (4). American workers studying 'cyathia drop' suggest that low light and warm greenhouse temperatures during bract development are the main factors responsible, with light being the most important in promoting cyathia abscission (7). In this investigation 'rabbit tracks' and 'cyathia drop' often appeared independently of one another. It has already been suggested that 'rabbit tracks' occurred on large, mature bracts which were depleted of carbohydrates as a result of rapid growth and development, however, drought-stress has been found to cause organ abscission (5) and it possible that drought-stress increased the incidence of 'cyathia drop' at low humidity

By transferring plants from one constant humidity to another it was possible to observe the effect of a drastic change in humidity on the incidence of disorders. When plants from low humidity were transferred to high humidity the incidence of crudding on bracts was greatly increased during the first forty-eight hour period after transfer, suggesting that 'crudding' occurs spontaneously with a drastic increase in humidity. Plants transferred from high humidity to low humidity did not develope any disorders over the first forty-eight hour period after transfer, and so it is assumed that any disorder related to drought-stress would take a longer duration to manifest itself.

<u>6.1 Conclusion</u> In an attempt to reduce the costs of growing poinsettias by saving energy it is important to avoid high humidities (>90% rh), even for a short duration. In this investigation plants at high humidity grew well, but had a high incidence of disorders such as 'crudding'. The incidence of 'crudding' on plants transferred from low humidity to high humidity increased almost spontaneously with the drastic increase in humidity. Bracts at high humidity were particularly susceptible to *Botrytis* which spread rapidly if left unchecked.

At low humidity (62% rh) plants did not suffer from disorders such as 'crudding', and were less susceptible to *Botrytis*, but drought-stress is believed to have restricted growth and development and promoted organ abscission such as 'cyathia drop'.

The results would suggest that the two extremes of humidity (62% and 96% rh) investigated in this report should be avoided, and that best growth and development of Poinsettias without any humidity related disorders may be attained at an intermediate humidity of between 70-80% rh.

<u>6.2 References</u>

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APPENDIX

Final peat analysis (03/11/1989)

variate/vpd	0.1kPa		0.8kPa	
Replicate	1	2	1	2
pH	6.1	5.9	5.4	5.2
NH_4-N	0.6	0.6	21	61
NO_3-N	70	58	233	435
P	24	46	63	112
K	103	67	265	521

(parts per million)